Essentials of
Orthopedics for Physiotherapists

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Orthopedics for Physiotherapists

Second Edition

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To

God, who created me and the universe

My parents

and

Teachers

My wife, Dr Parimala

and

My children, Rakesh and Priyanka

Foreword

It gives me immense pleasure to write a foreword for Dr John Ebnezar's book *Essentials of Orthopedics for Physiotherapists*. Physiotherapy plays a very big role in treating orthopedic conditions, both traumatic and non-traumatic. Hence, it is mandatory for all physiotherapists to equip themselves with basic orthopedic knowledge and skills.

This book precisely aims to inculcate basics of orthopedic treatment principle and their physiotherapy management. In fact, he is the first orthopedic surgeon from the country to make such an effort. Each chapter is neatly written, adequate and comprehensive. I am impressed by his distinctive style of writing, clarity of subject matter, coverage of contents, good quality illustrative diagrams, lucid and simple language. I have helped him in the compilation and writing of the physiotherapy technique in orthopedics. This is a must-possess book by every physiotherapist and the teachers.

Dr John Ebnezar needs no introduction. He is the most prolific Orthopedic writer in the country today. His *Textbook of Orthopedics* is one of Jaypee's best sellers and has gained universal acceptance not only in our country but overseas too. In fact, this book has had a fantastic opening in the recently held World Book Fair in London and is being widely recommended in many physiotherapy colleges.

I sincerely hope this book will also goes on to become a best seller and benefit the physiotherapic community. I heartly congratulate and wish him well in this effort of his.

Dr Rajesh Kumar
Principal
Dr MV Shetty College of Physiotherapy
Mangalore, Karnataka, India
Senate Member, Rajiv Gandhi Health University

Preface

It is a matter of great pride and happiness for me that the second edition of this book has seen the light of the day. When I first wrote this book, I was very apprehensive about the kind of reception this book may get from the students and the teachers. I feared that it may sink without a trace. But the book was received with a lot of love and warmth by all concerned. That it became an unprecedented success is history. Students spoke in glowing terms about the book and said that it is bible for them. High praise indeed. They embraced the book with such whole heartedness that it left me spell bound and humble. Orthopedics is an integral part, in fact, it encompasses a major share of their work as physiotherapists and they were badly in need of a book that deals with orthopedics and physiotherapy. They were earlier reading the *Textbook of Orthopedics* to fulfill this need of theirs. But when a book exclusively for them was brought out by me, they embraced with open arms.

Physiotherapy students across the country wrote to me expressing their happiness for the book. In all conferences, CME's and Workshops students met me and told me that they were very happy and satisfied with the book and it is possessed by each and every physiotherapy student in the country. They also told me that their faculties also read and recommended the book. I received huge compliments wherever I went and that made me more responsible. There were some criticisms too. Some told me that the book should have been written by a physiotherapist and not an orthopedic surgeon. But I felt the other way round. I being an orthopedic surgeon helped me write a book on physiotherapy methods in orthopedic conditions better. I had extensive discussions with my physiotherapy friends, teachers and students regarding the various physiotherapy techniques and methods for each and every orthopedic condition. In fact for the second edition all my physiotherapists who are working in my center helped me update the book. So this lacuna has been addressed adequately.

The second edition has come out very well. It is a multicolor book now and is the first of its kind in physiotherapy books. In fact, I had to do a lot of convincing act to convince my publishers to go for the color edition. They were reluctant initially for the huge logistics involved and wanted to go with the present format. But I felt that the students deserved it for the kind of support they extended to this book. As a token of gratitude to their patronage for the book we needed to reciprocate them in a manner that would leave them happy and satisfied. Moreover, clinical photographs and x-rays can be appreciated better in a color book and it would be more pleasing to the eye and mind. So now the second edition comes out to you in a multicolor format and I am sure you all will like it and extend the same in fact more patronage for the new edition.

Highlights

- The book has been thoroughly revised and updated. In fact, it has taken more time to revise this book than when I brought out the first edition.
- It has been upgraded to a multicolor format.
- For the first time you will find real clinical photographs in the text. This will help you to understand orthopedic conditions better.
- Good surgical photographs have been put wherever necessary. This will be a great boon for the physiotherapy students for they seldom get a chance to witness live surgeries in their career. Getting an insight into the operative pictures will help them to understand the treatment of orthopedic conditions better and this will make them better physiotherapists.
- Lots of new X-rays have been added to enhance and enrich their clinical knowledge.
- Plenty of orthopedic techniques like reduction of a fracture or a dislocation have been shown for their understanding of the treatment of common orthopedic conditions.
- Two new chapters have been added on Arthroplasty and Arthroscopy
- All the attractive features of the first edition like short summaries, mnemonics, anecdotes, etc. have been retained as it has been very much appreciated by the physiotherapy fraternity.

You need to explore the book yourself to find out the many changes and additions made in this new edition. I always felt as a student that I should have a book that is readable, informative but at the same time make reading and studying a pleasant experience and not a drudgery routine. A book should not be just for reading and passing the exams but a permanent companion for the rest part of our lives. It should teach not only the subject, but life principles too. It should egg you on to read more and explore the subject more all on your own. It should generate more interest for the subject so that your pursuit of knowledge becomes an unending thirst. So this way you will learn your subject, cherish it, enjoy it, appreciate it and put the knowledge gained in the right treatment of your patients.

Unfortunately, I have seen many physiotherapy students not having the right kind of attitude, knowledge and goals in their profession. They are skeptical and jittery about their profession. There is a lot of cynicism and helplessness in most of them. Majority feel that they have not made the right choice by choosing physiotherapy as a career. They are confused and disillusioned a lot. My heart goes out for them. My only advice for them is that be proud of your choice, physiotherapy is a very good profession and has great prospects. It alleviates the pain and suffering of the patients and is indeed a very noble profession like all other medical specialties. Only thing you need to work hard, get the right kind of knowledge and attitude and get the right kind of passion going. You need to respect your profession only then others will respect you.

Hope you will extend the same kind of support and patronage for this new edition too. If there are any shortcomings and mistakes please do not hesitate to bring it to my notice so that I can incorporate all the suggestions in the next edition. I take this opportunity to thank the students and all the faculty members for their patronage for my book.

John Ebnezar

Acknowledgments

I need to thank a lot of people both the physiotherapy and orthopedic fraternity for their help and support in bringing out this new edition. Mr Shahbab Zafar Iqbal is a very hardworking and dynamic physiotherapist who is working with me for the past two years now. He has helped me a lot in all stages of the second edition. He has proofread the book not once but thrice. He has shown me what needs to be added and changed. He has thoroughly checked the contents of the book and advised me about the additions and deletions. He has spent a lot of time in helping me revise this book and I sincerely thank him for all his efforts. He has played a very big hand in bringing out the new edition. Another physiotherapist who helped me in revising this book is Mr Vishwanath. Apart from these, many faculty members wrote to me about the discrepancies in the first edition and helped me with making the right and necessary changes in this edition. This is their book and I thank all of them for their active support and encouragement. Dr Yogitha Bali, an Ayurvedic Surgeon and our Chief Yoga Therapist has given lots of inputs, support and encouragement and has actively helped me in revising the book. I express my sincere gratitude to her.

I thank my wife Dr Parimala for the active help extended to me emotionally and physically in making this dream a reality. I also thank my son Rakesh and Priyanka who have been supportive to all my works. I also thank all the staff members of Parimala Health Care Services and Ebnezar Orthopedic Center who helped in compiling the data, clinical materials, manuscripts, typing, etc. I would like to specially thank Mr Ravi, my OT assistant for the excellent photography of the clinical and surgical materials incorporated in the book.

My sincere thanks to Shri Jitendar P Vij (Chairman and Managing Director) who accepted to bring out the color version of the book. He has constantly encouraged and guided me. I would like to place on record the role played by Mr Tarun Duneja (Director-Publishing), Mr KK Raman, Mr Akhilesh Kumar Dubey, Mrs Yashu Kapoor and Mrs Samina Khan and his dedicated and efficient team for helping me bring out the second edition of the book. I like to thank each one of them for bearing with me and I also thank all the people who are behind the screen but have contributed enormously for the book. The entire credit of making this book a new experience goes to them.

I thank all my teachers right from the primary school to the recent times who have made me what I am today professionally. I thank all my patients who helped me with their clinical photographs. I thank my parents for the right upbringing. I never fail to thank God for bestowing me with knowledge and life that has enabled me to bring out the second edition of this project successfully. I thank everyone who is involved with this work directly or indirectly. Looking at the list of people who have contributed in making this gargantuan task a reality, I feel humble, I felt this earlier and I always will feel so for the rest of my life.

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1

Section

GENERAL PRINCIPLES OF PHYSIOTHERAPY TREATMENT

1

Chapter

General Principles of Physiotherapy

Orthopedics has come a long way since the days of Nicholas Andry—a French physician, who is credited for coining the term, orthopedics from two words, *Ortho= straight* and *Paedics = child* in 1741.

What was a primitive branch then restricted to correcting deformities in children, has developed into a full-fledged specialty with diverse scope ranging from simple treatment, as done by traditional bonesetters to highly advanced joint, spine and hand surgeries.

The development of orthopedics as a specialty was pedestrian till 18th century. The discovery of anesthesia and aseptic surgical techniques opened up new avenues of treatment like open reduction, debridement, etc. The discovery of X-rays by Roentgen and the introduction of the usage of plaster of Paris by Albert Mathysen in 1852 revolutionized the diagnosis and management of orthopedic disorders. Thus, orthopedics started breaking through the deadlocks of a crude branch to that of a science.

But what really set the ball rolling was the sudden surge of orthopedic cases firstly by the two World Wars and of late by the road traffic accidents which is on the rise, both in the developed and developing countries.

Polytrauma, multiple fractures, high-velocity injuries, severely exposed the limitations of the conventional treatment in orthopedics, as the fracture patterns were bizarre and complicated. Thus newer modalities of treatment like improved methods of internal fixation, the AO systems, the interlocking nail system, Ilizarov method, etc. were introduced into orthopedic management. Suddenly orthopedics was being considered a highly specialized branch with vast scope.

Needless to say many pioneers both at the international and national level have contributed enormously for the development of this branch to the present what is today. We salute them for their contribution. A fitting tribute to them is to carry on the good work done by them and to raise the level of this branch to such dizzy heights so that the sufferings of mankind due to orthopedic disorders are mitigated.

But orthopedic treatment does not end at merely fixing the fracture efficiently. The pre-injury functional status of the individual has to be restored back and further complications or recurrence of the problem has to be prevented. This is where the specialty of physiotherapy steps in to bridge the gap in treatment. In fact orthopedics and physiotherapy are two faces of the same coin. A good orthopedic surgeon is one who has a good physiotherapist within himself while a good physiotherapist is one who was a sound knowledge of orthopedics. While the orthopedician fixes the fracture, a physiotherapist rehabilitates the patient back to normal or as near normal as possible. Similarly in chronic orthopedic disorders merely managing the patient conservatively or surgically is not sufficient. Here also rehabilitation of the patient is extremely important and the role of the physiotherapist is sometimes more important than that of the therapist.

Thus, a perfect blending of the art of orthopedics and physiotherapy is what is required to put the patient back to the pre-injury status. While the role of an orthopedician begins after the fracture or after the disease strikes. The role of a physiotherapist does not start after the fracture is fixed or after the disease is healed but starts from day one of the onset of disease or fracture. Apart from the therapeutic role, physiotherapy has a restorative role in restoring the lost function but also has preventive role in preventing the recurrence of the problem. Here physiotherapy plays a very important role in the rehabilitation of a patient suffering from fractures or any other orthopedic related disorders.

Quick Facts

The triple role of orthopedic physiotherapy
1. Therapeutic role
2. Restorative role
3. Preventive role

Thus, orthopedic physiotherapy is an important branch of medicine which has come to occupy the centre stage of the treatment of orthopedic related disorders which is some he has to assist the orthopedic surgeon in treating a patient while in others he has to play a leading role.

Thus like never before, a physiotherapist needs to have a comprehensive knowledge of orthopedics to treat these patients better. He has to begin by making a proper diagnosis of the orthopedic problem before he embarks on treating them with the vast armamentarium of physiotherapy treatment modalities available at his disposal.

DIAGNOSIS IN ORTHOPEDICS

Approach to a Patient with Orthopedic Disorders

As in other branches of medicine, the diagnosis of orthopedic disorders revolves around the following fundamentals (Fig. 1.1A).

Fig. 1.1A: Fundamentals of diagnosing orthopedic disorders

Steps in the process of diagnosis

At the end of investigation	**Final**
At the end of examination	**Provisional**
At the end of history	**Guess**

So we will try to discuss in brief the three steps of diagnosis in orthopedics.

TABLE 1.1: Age *vs* orthopedic disease

Years	*Diagnosis*
< 1 year	Congenital dislocation of hip and cerebral palsy
1-2 years	Nutritional rickets Poliomyelitis Ewing's tumor
5-10 years	Tuberculosis of hip Perthes' disease
15-20 years	Slipped capital epiphysis
<15 years	Osteomyelitis
10-20 years	Bone malignancies
30-40 years	Rheumatoid arthritis
> 40 years	Degenerative disorders Protruded intervertebral disk (PIVD) Multiple myeloma, etc.

At the end of history

History is "His- Story", as told by the patient. History taking is an art. Caution has to be exercised in the story "told" and the story "untold". Everything told should be taken with a pinch of salt lest the examiner is misled.

Certain points of importance in the history

Age Certain diseases have predilection for certain age groups, e.g. Perthes disease and acute osteomyelitis are common in children. Avascular necrosis and degenerative disorders are common in the elderly. Some diseases may be seen in all the age groups, e.g. tuberculosis of bone and joints (Table 1.1).

Sex Congenital dislocation of hip (CDH) is common in females. Congenital talipes equinovarus (CTEV) is more common in males.

Quick Facts

Sex *vs* orthopedic disease
- Males: Perthes, slipped epiphysis, traumatic disorders, multiple myeloma, etc.
- Females: Rheumatoid arthritis, CDH, osteoporosis, etc.

Onset May is sudden or gradual.

Trauma could be a predisposing factor or the causative factor and it is usually due to road traffic accident (RTA), fall, assault, etc. (Fig. 1.1B).

Traumatic points

Role of trauma vs orthopedic disorders—trauma as a causative factor

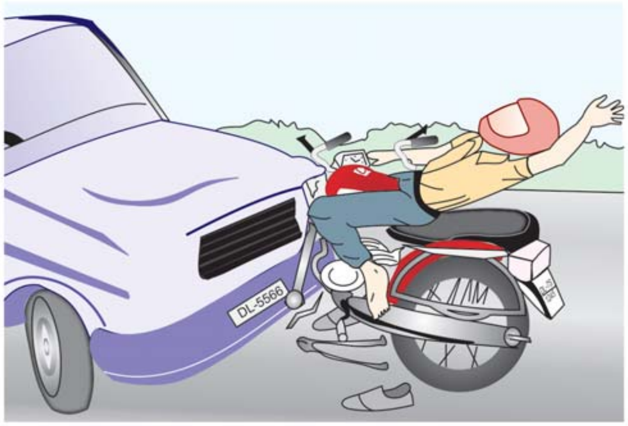


Fig. 1.1B: Road traffic accidents (RTA) are a common cause of bone and joint injuries

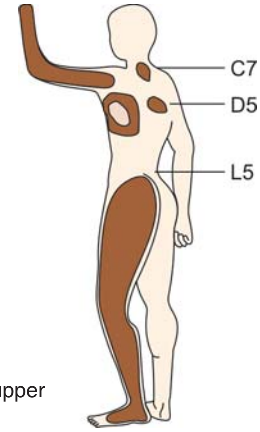


Fig. 1.2: Showing radiating pain at the upper limbs, chest and lower limbs

- Fracture
- Dislocation
- Sprain
- Strain
- Subluxation

Trauma as a predisposing factor
- TB hip
- Perthes' disease
- Slipped capital epiphysis
- Osteogenic sarcoma
- Acute osteomyelitis, etc.

Fever may be high as in acute osteomyelitis or low grade as in tuberculosis.

Pain This could be continuous or intermittent, low or high grade. One should be on guard about the radiating pains as these often mislead the examiner (Table 1.2).

Any constitutional problems like weight loss, anorexia, etc. if present are a pointer towards neoplasm, tuberculosis, etc.

Seasonal variation If present it is suggestive of rheumatoid disorders. Apart from these points, relevant past history, socioeconomic status and personal history should be taken into account.

TABLE 1.2: About radiating pains (Fig. 1.2)

	Region	*Radiation sites*
1.	Cervical spine	Shoulder, arm, forearm, and fingertips
2.	Upper limbs	
	a. Shoulder	Arm and elbow
	b. Elbow	Forearm
3.	Thoracic spine	Girdle pains
4.	Lumbar spine	Groin, buttocks, posterior thigh, legs and foot.
5.	Hip	Knee

TABLE 1.3: Diagnostic facts

History	*Diagnosis*
• Present since birth	Congenital
• During the development process	Developmental Process
• History of fever, chills, rigors	Infective
• Nutrition, socioeconomic status	Metabolic
• Other evidences of hormonal imbalance	Endocrinal
• Seasonal variation, multiple joint Involvement, etc.	Inflammatory
• H/o RTA, fall, assault	Traumatic
• Features of either benign or malignant	Neoplastic
• Advancing age, etc.	Degenerative
• If no obvious complaints	Idiopathic

An attempt should be now made to place the problem into one of the following categories at the end of history taking (Table 1.3).

Is the problem congenital?

If so, it will be present since birth or seen within few years from birth. A strong family history is elicited able.

Is it developmental?

Here the disease gets manifested during the process of development.

Is it an infective disorder?

History of fever, chills, rigors, sweating, etc. are present.

Is it inflammatory disorder?

Seasonal variation, remissions and exacerbation, multiple joint involvement, etc. are present.

Is it a metabolic disorder?

Nutrition, socioeconomic status, generalized skeletal disorder, etc. assume importance in this group.

Is it an endocrinal disorder?

Look for other evidences of hormonal imbalance, e.g. Hypothyroidism → cretinism Hypopituitarism → dwarf, etc.

Is it traumatic?

History of fall, road traffic accident (RTA), assault, etc. is elicited.

Is it degenerative?

Advancing age, slow progress is the hallmark.

Is it neoplastic?

Look for the features of either benign or malignant bone tumors.

If it cannot be categorized into any of the above, then it could be *idiopathic.*

Having made a tentative diagnosis at the end of history, next important step is resorted to.

EXAMINATION

A good systematic clinical examination will help to clinch the diagnosis with certainty. *No sophisticated technology can replace the value of a good clinical examination*. A good clinician will make the diagnosis clinically and will make use of the investigation armamentarium judiciously. *A clinician should command the investigation and not vice versa.*

Examination of the locomotor system involves four steps:

STEP I

Examination of Gait

An examination of the gait is extremely important as it gives vital clues regarding the diagnosis.

Definition *It is a term used to describe the style of walking.* This is dependent not only on normal muscles and joints but also upon an intact central nervous system (CNS), peripheral nervous system and normal labyrinthine function (*see* chapter 21 Human Gait for details).

STEP II

General Physical Examination

A good general physical examination (GPE) from head to toe gives vital clues in the diagnosis of most of the orthopedic disorders, particularly generalized disorders of the skeleton, e.g.

- Metabolic disorders, e.g. rickets, etc.
- Developmental disorders, e.g. osteogenesis imperfecta, etc.

STEP III

Clinical Examination

The following are the usual presenting symptoms in a patient with orthopedic disorders:

Pain This is the first and the most common complaint. It is a highly subjective complaint and can be classified as mild, moderate or severe.

The must-ask questions regarding the pain are: How did it start? Is it related to trauma? Site of pain? Does it radiate? What are the aggravating and relieving factors? Does it interfere with sleep? Etc.

Swelling It may precede or follow pain. Relevant questions to be asked are: Site of the swelling, painful or painless, is it rapidly growing (e.g. malignancy) or slow growing (benign growth), is it associated with fever, chills, etc. (e.g. infective origin), single or multiple (e.g. neurofibromas, etc.).

Deformity Sudden onset of deformity is usually seen in fresh fractures and dislocations. Long-standing deformities are usually seen in old fractures and other nontraumatic disorders like congenital, developmental, and metabolic conditions. Patient may complain of cosmetic and functional impairment due to the deformity.

Limitations of joint movements In the initial stages, it may be due to muscle spasm and in the later stages it may be due to intra-articular adhesions (e.g. TB, septic arthritis, rheumatoid arthritis, etc.) or extra-articular contractures (like post burn contractures, Volkmann's ischemic contracture, etc.).

Limp This could be painful (e.g. arthritis of hip, trauma, etc.) or painless (e.g. CDH, coxa vara, etc.). Patient may complain of difficulty or alteration in various day to day activities like walking, squatting, running, working, etc.

Limb weakness This may be due to disuse atrophy, motor problems like polio, motor nerve disease, etc. muscle problems like muscular dystrophies, etc. or due to peripheral or diabetic neuropathies.

Signs

General Look for the signs of anemia, fever, weight loss, etc.

Local Deformity may be due to an abnormality of bone or joint. If a joint is out of its anatomical position, a deformity is said to exist. And in case of bone, deviation from its normal anatomy is deformity. In cases of old fractures and dislocations, the deformity may be fixed.

Remember

> A fixed deformity is the angle between the neutral position of the normal joint and the position the deformed joint will reach

Temperature This is always compared with the normal side. Check with dorsum of the hand as this is the most sensitive part.

Tenderness (Fig. 1.3) This is elicited by examining from the normal to the affected area and is graded I to IV *(see* p. *42)*.

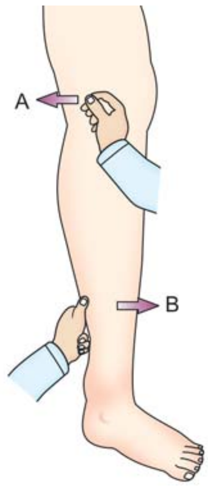


Fig. 1.3: Showing method of eliciting joint line tenderness (A) and bony tenderness (B)

Swelling The following things are noted in the examination of a swelling.

- Decide the anatomical plane. The plane of the swelling could be either bone (swelling decreases in size when muscle is put into contraction) or could be in the muscle (swelling slightly decreases in size and gets fixed on muscle contraction) or could be between the muscle and the skin (no change in the size at the swelling when muscle is put into contraction).
- Describe the shape as globular, oval or round, etc.
- Grade the consistency (*see* below).
- Decide whether it is congenital, neoplastic, etc. (*see* Table 1.3 diagnostic fact, p. 5).
- Look for slipping sign, sign of emptying, indentation sign and expansile impulse.

Remember

Grading of consistency:

- Grade I — Very soft (like jelly).
- Grade II — Soft (as relaxed muscle).
- Grade III — Firm (like a contracted muscle).
- Grade IV — Hard (as a contracted biceps).
- Grade V — Stony and bone hard.

Movements of joint

- *Active movement Patient* himself moves the joint in one direction and later in the other. The extent of active movement is noted. Both the joints should be tested.
- *Passive movement* of the joint is tested by the examiner without causing pain. The extent of passive movement is noted.

Remember

- Limitation of all movements of a joint indicates arthritis.
- Limitation of certain movements of a joint indicates an extraarticular lesion or mechanical block.
- If passive movements exceed active movements, paralysis of muscle is likely.

Measurements Accurate limb length measurements give vital clues regarding the diagnosis. Measurement should be taken for two purposes.

To know the limb length For this measurement is taken between two fixed bony points and is always compared with the normal.

Upper limbs

- *Arm length* From the angle of acromion to the lateral epicondyle of humerus (Fig. 1.4).
- *Forearm length* From the lateral epicondyle of humerus to the radial styloid process.

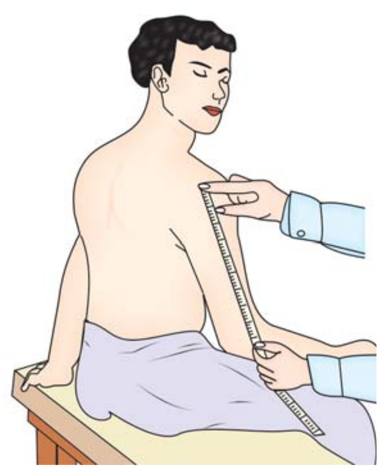


Fig. 1.4: Showing the method of upper arm length measurement

Lower limbs (Fig. 1.5)

- *Thigh length* from anterior superior iliac spine to the medial knee joint line.
- *Leg length* from the medial knee joint line to the medial malleolus.
- Entire lower limb length is measured from the anterior superior iliac spine to the medial malleolus below:

Fig. 1.5: Method of measuring lower limb girth and checking the movement

To know the girth of the limb To detect wasting of muscles, the circumference of the limb is measured at fixed points on both sides, e.g. 18 cm above joint line in the thigh (Fig. 1.6).

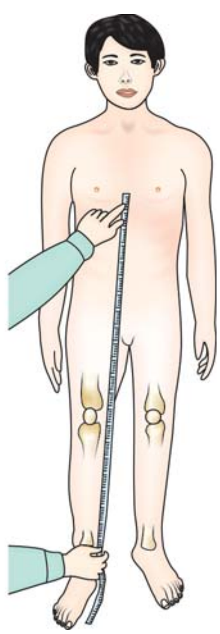


Fig. 1.6: Method of measuring the length of lower limb

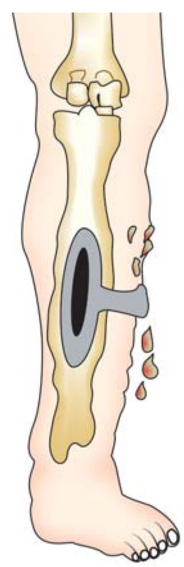


Fig. 1.7: Showing irregular thickening of bone and discharging sinus due to chronic osteomyelitis

Irregular thickening of bone and persistent discharging sinus (Fig. 1.7) If this is present along with scars fixed to bone, it indicates osteomyelitis (see box for causes of persistent sinus).

Peripheral, vascular and nervous system examination should be done next. This is discussed in appropriate sections.

Quick Facts

Causes of persistent discharging sinus:

- Unobliterated cavities
- Unabsorbed sequestra
- Epithelialisation of sinus tract
- Presence of foreign body
- Secondary infection
- Diabetes, steroid therapy, etc.
- Malignant change in the sinus

STEP IV

Investigations

These help to confirm the diagnosis and in some cases help to make the diagnosis (e.g. crack fracture, etc. can be diagnosed only by X-ray). One has to choose carefully from the following vast armamentarium:

Routine laboratory investigation This consists of blood investigations like routine haemogram, urine examination, ECG, chest X-ray, etc.

Special investigations:

- *Radiography* At least two views of the affected part should be taken, oblique views and some special views are required in some cases.
- *CT scan* To study the cross-section of the limb anatomy and bones.
- *MRI* This is the recent gold standard in the investi-gative armamentarium of bone disorders. It helps to study the bone, soft tissues, medullary spread, etc. with greater accuracy. The only problem is its prohibitive cost.
- *Angiography and biopsy* in tumor diagnosis.

Thus, a reasonably accurate diagnosis can be made by following the guidelines discussed above.

Treatment Methods

After having made a diagnosis, the orthopedic surgeon proceeds to treat the condition. The conventional treatment methods in orthopedics are conservative management, surgical management and physiotherapy. Treatment of fractures, their complications and other orthopedic disorders are discussed in relevant sections. Emphasis in this chapter is the role played by the physiotherapist and the various treatment modalities at his command.

Role of a Physiotherapist

In treating fractures and other orthopedic related disorders, a physiotherapist is required to play the following roles:

- Rehabilitation is a team effort and he is part of a team.
- He has to make a subjective and objective assessment of patient's condition and needs.
- To decide on the form of treatment and explain it to the patient.
- To do cardiopulmonary conditioning before subjecting the patient to the rigors of physiotherapy.
- To restore the lost functions.

Assessment

By careful clinical examination mentioned above he makes an assessment of the problems of the patient and how he should go about to rehabilitate him back to normal. His plan of treatment should aim to fulfill the following short-term and long-term goals.

Short-term Goals

These include:

- Limit the bleeding if any
- Further damage should be prevented at all cost
- Pain and swelling should be reduced
- Prevent joint stiffness and contractures
- Preserve the muscle power.

Long-term Goals

These include:

- Kinaesthetic and proprioceptive mechanism to be restored back to normal.
- Mobility of joint and soft tissue to be increased.
- Muscle power to be increased.
- Movement reeducation.
- Daily functional activities to be restored back.
- Prevention of swelling and recurrence of the injury
- Restoring back the post confidence to the affected limb and person.

Quick Facts

- *Short-term goals* (of physiotherapy): This is for simple fractures, strains, sprains, etc. This is given usually on an OPD basis.
- *Long-term goals* (of physiotherapy): This is required for patients with major orthopedic disorders like rheumatoid arthritis, OA, hemiplegia, quadriplegia, etc. Major complications of fractures like nonunion, avascular necrosis (AVN), etc.

Note There are two categories of patients who need long-term physiotherapy:

- *Prolonged physiotherapy for a short time:* For example, After hip/knee surgeries, etc.

  Here prognosis is good and patient may resume full or near normal function
- *Prolonged physiotherapy almost permanent:* For example, Patients with hemiplegia, paraplegia, etc. where the chances of recovery are extremely bleak.

After having made a thorough assessment of the problem and having determined the short- or long-term goals, the therapist plans the rehabilitation programme like exercises, physical agents, massage, etc. But before subjecting the patient to the rigors of prolonged or vigorous physiotherapy, he has to determine whether the heart, lung and general condition of the patient is fit enough to with start the stress. If not, he has to make the cardiac and the lungs fit through sustained efforts as follows:

CARDIOPULMONARY CONDITIONING (CPC)

CPC is defined as an exercise programme aimed to improve the cardiac and pulmonary efficiency of the patient.

Benefits of CPC

- It improves the functions of the heart and lungs.
- It improves metabolism, glucose tolerance, hormone production, hemodynamics, etc.
- It improves muscular strength, endurance, joint and muscle flexibility, neuromuscular skeletal system, coordination, exercise tolerance, etc.

Due to the various benefits of CPC, they are widely recommended before resorting to the routine orthopedic physiotherapy measures. A candidate for CPC is chosen after preliminary screening of risk factors for heart diseases, clinical examination and evaluation for assessing the existing heart conditions, exercise tolerance, etc. and then finally formulating the exercise program for the patient.

The exercises chosen are isotonic, isokinetic and isometric ones. The intensity, duration and frequency of exercises chosen are individualized depending on the patient's condition. The conditioning exercises chosen are done in three phases namely the warm-up phase, conditioning phase and cool-down phase.

Quick Facts

Phases of Exercises

1. *Warm-up phase*
   - Done for 5-10 minutes
   - Adapts the heart and lungs for future exercise
   - Stretches and loosens the muscles, ligaments, tendons, etc.
2. *Conditioning phase*
   - This is the most important phase of CPC
   - Done for 15-20 minutes, progressed to 30-45 minutes
   - Careful monitoring to maintain the heart rate.
3. *Cool-down phase*
   - Here the intensity of the exercise is gradually tapered off as sudden tapering may increase the heart rate, hypotension, dizziness, etc.
   - Done for 4-10 minutes.
   - Ideally should be followed by relaxation techniques.

After a thorough CPC, orthopedic physiotherapy can now be instituted by the therapist. Orthopedic physiotherapy consists of therapeutic exercises, physical agents, massage, traction, manipulation, assistive devices, ergonomics, ambulation, etc. Each of the above methods is now described in detail.

ROLE OF PHYSICAL AGENTS IN PHYSIOTHERAPY

Various physical agents like heat, cold, sound, hydrotherapy, electrical stimulation, etc. can be used to reduce pain and discomfort in patients. The primary role of these agents is to prepare the muscles and joints of a body for exercises.

HEAT THERAPY

Mode of action Heat helps in the following ways:

- It reduces pain
- It relieves the stiffness of the joints
- It reduces the muscle tightness
- It increases the blood flow to the area by causing vasodilatation.

Benefits The heat therapy warms up the tissues and readies it for the future exercise therapy. Its action is similar to that of the warm-up exercises before the main exercises by sports persons.

Goal It aims to increase the temperature and increase the blood flow to the area of treatment.

Time Optimal benefits are achieved within 20 minutes of application. Beyond this time, there is no further increase or raise of temperature noted.

Types Two types are described:

1. *Superficial heating agents* these heat only the skin and subcutaneous tissue (i.e. structures upto 10 mm beneath the skin).
2. *Deep heating agents* these heat the deeper structures like muscles and bones.

SUPERFICIAL HEATING AGENTS

In this category are included the hydrocollator packs, infra-red lamps and paraffin baths. These are the most popular and common form of heat therapy advised after fractures.

Hydrocollator packs these packs contain silica gel which is encased in a canvas bag. This can be contoured to the various body regions.

Note Silica gel is able to maintain a heat of 40°C (104° of Fahrenheit) for a period of about 30-40 minutes.

The heat delivered by the hydro collator pack is a form of conductive heat.

Contraindications

- Open wounds
- Anesthetic skin
- Significant edema
- Skin diseases and infections.

Infrared Infrared heating is delivered through an artificial source called the infrared lamp. This heats structures only 10 mm beneath the skin.

Advantages

- It induces relaxation in the patient.
- It mobilizes the skin and subcutaneous tissues.
- It provides no pressure on the body.
- The area under treatment can easily be inspected without interrupting it.
- It is easy and simple to use even by the patient.

Optimum time Twenty minutes. It may cause burns, if allowed to heat for long.

Contraindications These are the same as for hydro collator packs.

Paraffin wax bath (Fig. 1.8) this consists of a mixture of one part of liquid petroleum to seven parts of paraffin. It is most

Fig. 1.8: Showing paraffin or wax bath equipment

often indicated to treat small areas like hands and feet (as in rheumatoid arthritis, etc.).

Contraindications are the same as for hydro collator packs.

> *Note* Paraffin bath
> - Immersion for short time heats only the skin and subcutaneous tissue.
> - Immersion for a longer time heats the deeper structures like bones and joints.

Other superficial heating methods These include hot packs, hot water bottle and a small electric heating pad. They are found to be equally effective as the other sophisticated methods described so far. They have the advantage of being simple, clean and easy to use even by the patients.

Caution Patient should be educated that too hot may be too bad and may cause burns.

Mode of action, indications, timing and contraindications are the same as for the other methods mentioned earlier.

DEEP HEATING AGENTS

These agents include microwave,shortwave,ultrasound etc and they act through the electromagnetic or mechanical waves. They heat the structures 30-50 mm beneath the skin surface.

> *Note*
> - Electromagnetic waves generate heat by tissue's resistance to electric current.
> - Mechanical waves generate heat by causing tissue vibration.

Quick Facts

> Deep heating agents
> - *Diathermy* This term denotes deep heating by electromagnetic or mechanical waves.
> - Heating by electromagnetic waves, e.g. Microwave or short wave.
> - Heating by mechanical waves, e.g. ultrasound.

Microwave

- This is more frequently used method than the short wave.
- It is known to selectively heat muscles.
- It is indicated in muscle shortening following fractures.
- It is contraindicated if there is an implanted metal or if the patient has a cardiac pacemaker.

Shortwave

- These waves though called short, have a greater wave length than the microwaves.
- It heats the subcutaneous tissue more effectively than the superficial heat modalities.
- It is indicated in post fracture contractures and subcutaneous adhesions.
- Its usage now has declined in favor of microwave.
- The contraindications are the same as for microwave.

Ultrasound (Figs 1.9A to C)

- Ultrasound waves are mechanical unlike shortwave and microwave.
- Ultrasonic waves are not faster than sound but have a greater frequency.
- It heats the bone muscle junction effectively.
- It is indicated in post-fracture muscle shortening and joint capsule contraction.
- Fractures fixed with implants are not suitable for ultrasound therapy.

Quick Facts

> Deep heat facts
> - Microwave—selectively heats the muscle
> - Shortwave—selectively heats the subcutaneous tissue
> - Ultrasound—effectively heats the bone-muscle junction and the bones.

Figs 1.9A to C: Showing (A) TENS and IFT machines (B) Ultrasound machine (C) Technique of doing ultrasound

Note Both microwave and shortwave are not used frequently as it needs sophisticated equipment and greater technical expertise.

COLD THERAPY

This is usually given by an ice pack, ice cube or towels wrung in ice cold water. The following are some of the salient features of this therapy:

- The temperature is 0-2° centigrade or 28-32° F.
- It should be applied for a period of 10-15 minutes. After this patient has a feeling of numbness followed by local erythema.
- It effectively reduces pain, swelling, inflammation and spasticity when used immediately after an injury or fracture.
- It is less commonly used in the later stages of fracture rehabilitation. When used it reduces pain and spasm even in that stage.

HYDROTHERAPY

This includes whirlpool and therapeutic pools. When used along with heat and cold therapies, they act synergistically.

Whirlpool Therapy

- The whirling action of the water has a massaging effect on the body and improves the blood circulation.
- It is beneficial in post-fracture treatment and in disorders of wrists, ankles, knees, hands, etc.
- The temperature is 37-40°C (98-104° F).

Note If the temperature is more, it makes the patient delirious.

Caution The submission into whirlpool should not be more than 20 minutes.

Therapeutic Pool

- This pool has an inclining bottom with shallow and deep ends.
- The water is maintained at 37°C (98°F).
- Indicated in patients with lower limb disorders and also after hip, knee and back surgeries.
- The patient is instructed to float in the water, then stand in the deep end and gradually walk towards the shallow end. As he walks towards the shallow end, the weight on the lower limbs increase. This helps to increase the strength of lower limb muscles.

Fig. 1.10: Showing TENS apparatus (portable set)

Advantages of pool therapy

- It improves circulation
- Improves ROM
- Enhances wound healing
- Strengthens the lower limb muscles.

Note The buoyancy of water in the pool therapy, gives a sense of freedom from the effects of gravity. The warmth of water relieves pain and muscle spasm.

TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION (TENS)

- This is more useful in relieving intractable vertebral pains.
- It is applied by small electrodes attached to a portable stimulator (Fig. 1.10).
- The actual stimulation sites needs to be identified by trial and error methods.
- Similarly the intensity and duration of stimulation also is by trial and error.

MASSAGE

This is one of the age old methods of treatment. It is known to have the following beneficial effects:

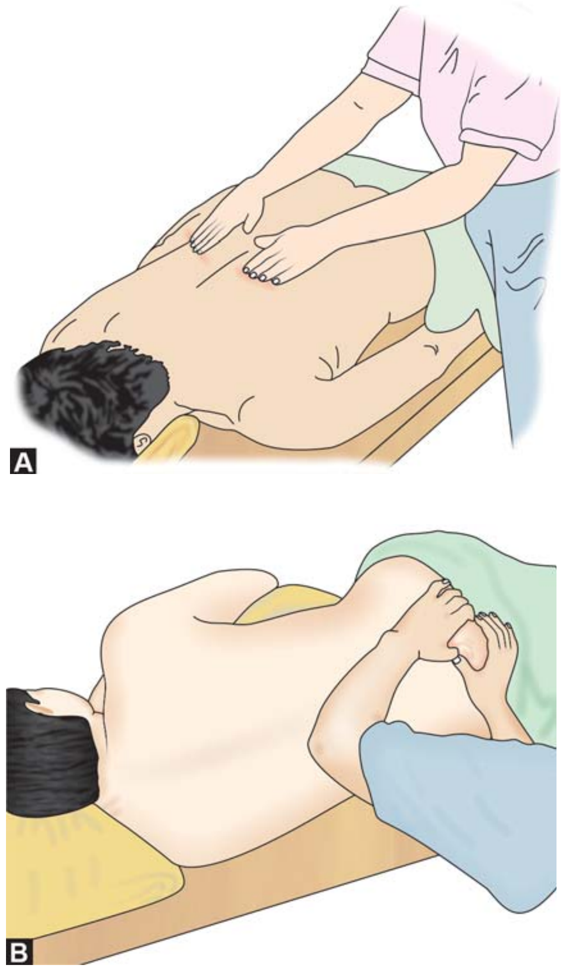
- It increases the blood supply to the part.
- It helps in the drainage of fluid from the affected part.
- It provides muscular relaxation.
- It decreases the chances of muscle atrophy.
- It is helpful in the treatment of arthritis, sprains and contusions.
- It is also helpful in the treatment of backaches.

Types These are five different types of massage:

Effleurage

- This consists of a superficial stroking towards the body or heart by slow, gentle and rhythmic movements.
- The pressure exerted must be light and repeated in the same direction.

  Depending upon the types of stroking, the following types are described:
  - *Using tips of the fingers* This is used to massage the joints.
  - *Using the thumb* Used between two muscles, between a muscle and tendon, interossei of the hand and feet (Fig. 1.11B).
  - *Using one hand* Used on the extremities, back of the head and neck.
  - *Using both hands* Used over chest, back, double neck massage or the lower limbs (Fig. 1.11A).



Figs 1.11A and B: Showing various techniques of massage

Deep stroking massage
- This technique involves striking in the same direction of flow of the lymph and venous blood.
- It is used to empty the contents of veins and lymph in their direction of flow.
- The muscles have to be relaxed while practicing this method.

Petrissage
- This consists of kneading, wringing, lifting or pressing a part to assist in the venous or lymphatic circulation.
- It helps in stretching the retracted muscles and tendons.
- It helps in stretching the adhesions.

Friction
- Here the part is pressed deeply in a circular direction with the hands.
- This loosens the deep adherent skin, scars or adhesions.
- It also helps in the absorption of effusions.
- It is used around hands, feet and face.
- It can also be given with the thumb, fingertips or hand.

Percussion (also called tapotement) This is a method of rapid massaging with the hand. Four types are described:
- Beating with a clenched fist.
- Tapping with tips of the fingers.
- Beating with ulnar borders of the hand.
- Clapping with the palms of your hands.

ASSISTIVE DEVICES

Various assistive devices are required to carry out acti-vities of daily living after the limb fractures. Upper limb fractures affect the activities of daily life whereas the lower limb fractures affect both functional activities and ambulation making the task of rehabilitation that more difficult.

Quick Facts

What are the activities of daily living?
- Dressing
- Bathing
- Grooming
- Toileting
- Ambulating

These are also known as functional activities. The following are some of commonly used assistive devices:

Upper Limbs

For shoulder injuries Devices are required to extend the reach of the patient to enable to hold or pick an object at height or below:

Fig. 1.12: Showing a reacher

- Reacher (Fig. 1.12)
- Grooming aids

  This eliminates the need for the shoulder to stretch or reach.

Elbow injuries here also reach is facilitated by grooming aids or reachers.

Forearm To decrease the torque while opening the doors, built in door handles are provided.

Wrist Again here built up door knobs and keys are provided to decrease the torque.

For the Spine

Following a spine injury, it is difficult to bend to carry out activities like wearing shoes, socks, etc. or to reach up. These activities now require certain aids:
- To reach up—Reachers (Fig. 1.12)
- To wear socks—Sock aid (Fig. 1.13)
- To wear shoes—long handled shoe horn
- To increase grasp and reach—Grabbers (Fig. 1.14).

Fig. 1.13: Showing a 'sock aid' to wear the socks

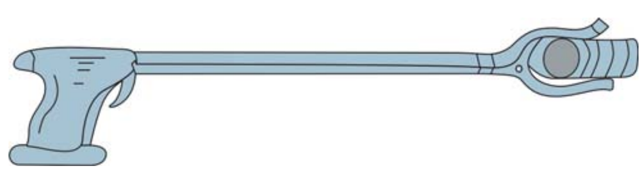


Fig. 1.14: Showing a grabber used to reach and grip the objects

For the Lower Limbs

In terms of rehabilitation lower limb fractures provide a greater challenge, for not only the functional activities are affected but even ambulation is disturbed.

Hip joint The toilet activities are severely affected after a hip injury. Ambulation is also rendered difficult. The following aids are now required to carry out the above functions:

• To reduce force and Torque during toileting	Raised toilet seats
• To reach objects	Reacher
• To reduce weight-bearing during ambulation	Walkers, crutches and cane

Knee joint/leg/foot and ankle

• To assist ambulation	Crutches, walkers, canes
• To extend reach to wear socks	Sock aid
• To wear shoes	Shoe horns
• To extend reach	Reachers

Walking aids like crutches, walkers and canes are discussed in detail in appropriate sections.

ROLE OF BRACES AND SPLINTS

These include:
- Cast braces
- Spinal braces
- Cervical orthoses
- Splints.

They are discussed in appropriate sections.

ROLE OF TRACTION

Traction occupies an important role in the conservative management of orthopedic disorders. These include:
- Spinal traction
- Cervical traction

They are discussed in appropriate sections.

AMBULATION AFTER A LOWER LIMB FRACTURE

An active mobile person suddenly becomes immobile after a lower limb fracture. Immobility takes a heavy toll on the body and mind of the victim. The goals and responsibility of a physiotherapist is lower limb rehabilitation is as follows:

Goal To put the patient back on his feet again.

Responsibility To restore the normal ambulation.

Making Ambulation Possible

When the child first learns to walk, it suddenly does not do so. It first learns to actively use the joints of the upper and lower limbs, thereby strengthening them. Then it slowly tries to stand up on its feet with the help of the parents or some, external support and tries to balance it. After having learnt to balance itself properly, it now starts to ambulate with the parental or some external aid. It first learns how to walk on a level ground and only after having mastered; it attempts to learn how to climb the stairs, jump, run, etc. This is how; you and I learnt how to walk.

Now when we make an attempt to make the patient walk again, we have to necessarily put him through the same walking process a child goes through namely:
- To have a strong and mobile joints (preambulation phase).
- Learning how to balance with appropriate support (ambulatory devices).
- Learning how to walk first with support and later without support.'
- Lastly after regaining sufficient skill in normal walking, the patient is then taught climbing, running, squatting, etc.

Nature taught a child how to walk; now you as a therapist should 'aid' nature to enable an injured person to walk again. A systematic lower limb rehabilitation protocol helps you achieve the goal of ambulation. The stages are discussed below:

Preambulation Measures

Before a person actually walks, he needs mobile, strong stable joints free of deformities. So the preambulation measures precisely aims to achieve these prerequisites.

Measures to obtain joint mobility By active and passive movements, efforts are made to regain the near 'normal' or at least 'functional' range of movements of hip, knee and ankle joints so necessary for ambulation (Table 1.4).

TABLE 1.4: The normal and functional range of movements of lower limb joints

Joints involved in ambulation	*Normal range*	*Functional range required for ambulation*
• Hip flexion	135-140°	20-25°
• Knee flexion	120-130°	60-70°
• Ankle		
— Dorsiflexion	20°	10-15°
— Plantar flexion	45°	40-50°
• Toes flexion	40-70°	20-25°

Fig. 1.15A: Method of re-educating a patient on pre-walking controlled co-ordination by supine cycling

Measures to Strengthen the Muscles

By sustained isometric, resistive and stretching, efforts are made to strengthen the hip extensors and abductors, knee flexors and extensors, ankle dorsiflexors and plantar flexors. These muscles help in ambulation.

After attaining adequate joint mobility and regaining the muscle strengths required for ambulation, the patient needs to be re-educated on pre-walking controlled co-ordination. Supine cycling (Fig. 1.15A) helps to achieve this goal.

Measures to Prevent Contractures and Deformities

A malaligned joint places enormous stress on the muscles, ligaments, cartilages and joints. This leads to early stress and fatigue. Hence efforts are made to obtain a deformity free joint by observing the following:

- Obtain an anatomic reduction of the fractures by closed or open reduction.
- Secure the reduction by stable internal or external fixations.
- Splint the joints in functional positions to avoid contractures.

After having obtained deformity free, mobile and strong joints of the limbs, a perfect platform is set-up for the therapist to realize the objective of the patient to walk again.

Ambulation Phase

Patient needs assisted ambulation before he attains independent ambulation. Assisted ambulation becomes necessary in the initial stages for the following reasons:

- Due to the structural damage to the skeletal system, the patient has difficulty in bearing weight on the lower limbs.
- The muscles of the trunk and limbs are weak.
- Balance in the upright posture is poor.

For these reasons, assistive devices become necessary during the initial phase of ambulation. The commonly used assistive devices are:

- Parallel bars
- Walkers
- Crutches
- Canes.

After having made the patient fit by a good pre-ambulatory therapy mentioned earlier, a therapist mobilizes the patient with suitable assistive devices.

The following are some of the more frequently used assistive devices:

Parallel Bars (Fig. 1.15B)

This is the first choice ambulatory device. The reasons being:

- It assists the patient in initial standing and walking.
- It gives the patient a sense of security.
- It helps the patient to get accustomed to upright posture
- Other assistive aids can be fitted easily while the patient stands between the parallel bars.

Regime within a parallel bar

- Adjust the height of the parallel bar such that the elbows of the patient are bent at 25-30° while standing within it.
- To propel forwards, patient first uses the hands than his legs by gripping the parallel bar firmly.
- Gradually, the patient is trained to put the body weight on the lower limbs by just placing the hands on the bars and not gripping it.

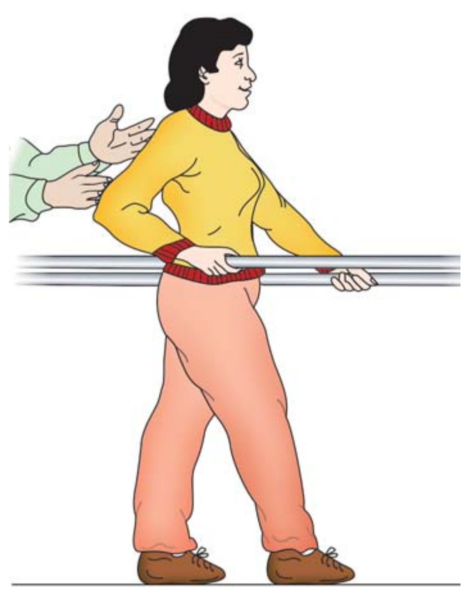


Fig. 1.15B: Ambulation within a parallel bar

Walkers (Fig. 1.16)

From parallel bars, the patient progresses to a 'Walker'. Though it serves the same function as the parallel bars, it is less stable.

The Frame
- It is made up of aluminum
- There are four adjustable legs
- Rubber tips are provided to the legs to prevent sliding.

The functions
- Same as that of the parallel bar
- It can be used both at hospital and home
- It can also be transported.

Tips of usage
- Adjust the height of the walker such that the elbow is bent to 25-30° while the patient is standing holding it.
- During walking, lift it first with both the hands and place it towards by 25-30 cm.
- Step into the walker first with the stronger leg and then with the weaker leg.

Limitations
- It is less stable when compared to the parallel bar.
- It is useful only on the level ground
- It cannot be used on stair cases.

Advantages
- It is very useful in the initial stages of ambulation.
- It is easy to use.
- Can be used as a permanent walking aid in the elderly people.
- It is not very expensive.

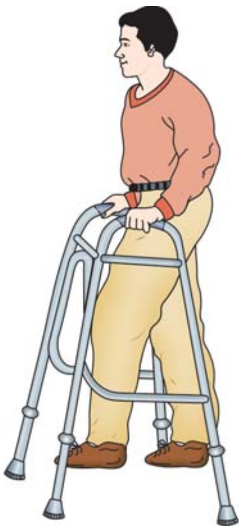


Fig. 1.16: Ambulation with walker

Fig. 1.17: Ambulation with a forearm crutch

Crutches

Crutches are the most popular walking aid used to ambulate a patient with lower limb fractures.

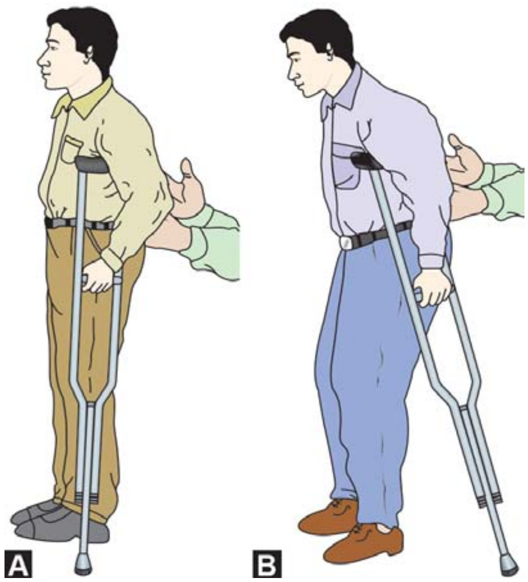
Types There are two types of crutches
- Axillary
- Forearm.

Axillary crutch
- This is made up of wood or aluminum.
- It is used in patients who require crutches for a short time.
- They are easier to use than forearm crutches.

Forearm crutch (Fig. 1.17)
- These are also called as lofstrand crutches.
- They are recommended in patients who need to use the crutches for a long time.
- They allow the patient greater freedom of movement.
- The demands on the patient's clothing are less.

Axillary Crutch Walking (Figs 1.18A and B)

The crutch structure
- It is made up of wood or aluminum.
- It is got two uprights.
- It has an adjustable bottom.
- The bottom is fixed to the uprights with the help of two screws.
- It has an adjustable hand grip.
- The bottom has rubber tips to prevent slippage.



Figs 1.18A and B: Types of axillary crutch walking: (A) Swing to gait, (B) Swing through gait

Measurements and position

- Measurement for a suitable crutch is taken from the anterior fold of the axilla to the medial malleolus.
  Note This prevents crutch palsy.
- Measurement can also be taken from a point 2" below the axilla to a point in the foot 6" in front and two inches lateral.
- In a standard positions, the tips of the crutches should be 15-20 cm in front and 15-20 cm to the sides of the foot. This forms a tripod base.

Important considerations in crutch walking

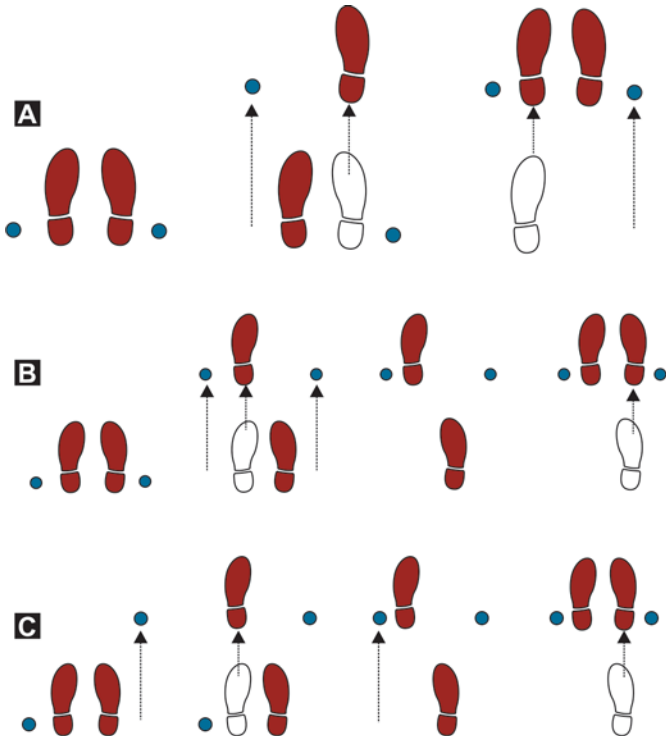
- Patient shifts 50 per cent of his body weight from the legs to his arms through a 30° flexed elbow.
- The following muscles need to be strengthened:
  — *The upper limbs* Shoulder muscles, triceps, wrist extensors and finger flexors.
  — *The lower limbs* the glutei, quadriceps, ankle plantar and dorsiflexors and the toe flexors.
- The patient should look straight ahead in the direction of his walk and not down.
- He should not bear the weight on the axillary crossbar for fear of crutch palsy.
- Posture in the crutch should be correct with the head erect, shoulder level, pelvis level, and knee joint extended and straight, feet should be below the hip joints.
- A limb length discrepancy should be corrected first before the patient stands and walks on the crutch.
- The patient is first taught to balance himself on a single crutch. This is practiced by standing on one crutch with one or both legs and moving the crutch freely in all directions. This is repeated on the other side also.
- The patient should learn to take even and steps at equal length and stride.
- Gradually, the patient should learn to walk forwards, backwards, sideward, turning and walking on slopes and stairs.

Gait Patterns

There are two types of gait patterns described in crutch walking:

1. *Based on the type of step taken* Here two types are described step-to or step-through.

   Now let us analyze each step in detail:
   - *Step-to-gait* In this the crutch and the fractured limb are advanced first and then the normal limb is advanced to the same position. E.g. Partial weight bearing or toe touch weight bearing after a tibial shaft fracture.
   - *Swing through gait* Here the intact leg is advanced first with the crutch and then the fractured leg is advanced towards it. E.g. oblique mid-shaft tibial fracture that is nonweight bearing practices this gait (*see* Figs 1.18A and B).
2. *Based on the number of contact points used to take a step* Here three types are described 2 point, 3 point and 4 point gaits.
   - *A two point gait (Fig. 1.19A)*
     – One point is formed by the fractured leg and crutches.
     – Second unit by the uninvolved leg.
     In this gait, the second unit is brought towards the first unit. E.g. a NWB fracture of femur.
   - *A three point gait*
     – First point—formed by the crutches.
     – Second point—involved leg.
     – Third point—uninvolved leg.
     In this, each crutch and the weight limb are advanced separately, with two of the three points touching the ground at any given point of time. E.g. In femoral neck fracture that are partially weight bearing. Here the crutches are advanced first, followed by the fractured and intact limb respectively (Fig. 1.19B).
   - *Four point gait*
     Point No 1 This is the crutch on the involved side.
     Point No 2 This is the uninvolved leg.



Figs 1.19A to C: Showing various types of gait patterns: (A) Two-point gait, (B) Three-point gait, (C) Four-point gait

Point No 3 The involved leg.
Point No 4 Crutch on the uninvolved side.
Here the crutches and the limbs are advanced separately. With three of the four points touching the ground at any given time. E.g. a partially weight bearing fracture with an additional problem like muscle weakness, anxiety, etc. (Fig. 1.19C).

Crutch Walking in Special Situations

1. *Walking on uneven surfaces like staircases*
   - Ascend the staircase with the unaffected leg first.
   - Then bring the fractured limb up to meet the first leg, either simultaneously with the crutches or by keeping the crutches on the step below until both the feet are level.
   - While descending the stairs, the reverse is done and fractured limb is brought down first.
2. *Getting in and out of a chair* the chair should be well supported to prevent it from slipping. Remove the crutches from under one arm thereby freeing it. Now with the freed hand, the patient pushes down on the chair set or armrest to support the body weight. Finally the patient gradually sits by flexing the elbow.

   The reverse technique is used while getting up from the chair.
3. *Climbing staircases with support (banister)* Hold one or two crutches on the uninvolved side. Hold the banister with the hands on the side of fracture. Climb the staircase first with the uninvolved leg then pull the body up to bring the affected leg on the same point as the unaffected leg.

   The opposite is followed to descend down the staircase with banister.

Quick Facts

Weight-bearing status in a lower limb fractures
- Non-weight-bearing (NWB)
- Toe-touch weight-bearing (TTWB)
- Partial weight-bearing (PWB)
- Weight-bearing as tolerated (WBAT)
- Full weight-bearing (FWB)

What is Shadow Walking?

This is a non-weight-bearing gait—here
- The crutch on the opposite side of NWB is put forward first.
- The non-weight bearing limb is advanced next.
- The second crutch is put forward next.
- This is followed by the advancement of the normal limb.

Ambulation with the Help of a Cane

Purpose of a cane To relieve one extremity of some weight bearing load. This also provides continuous stability to the patient (Fig. 1.20).

Types of cane
1. Standard cane
2. Axillary crutch can be used like a cane
3. Three or four legged cane can be used by the elderly. This provides greater stability (Fig. 1.21)
4. Hemi walker: Patient uses this walker like a cane by holding it on the opposite side.

Parts of a cane
- Hand grip
- An upright
- Bottom with a rubber tip.
- It is made up of either aluminum or wood.

Methods of walking with a cane
- The patient stands holding the wall or chair for support.
- The heel of the shoes should be about 1-1½″.

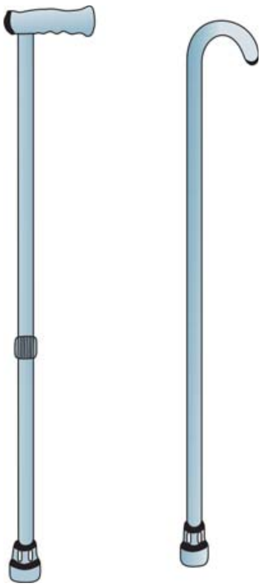


Fig. 1.20: Showing different types of cane

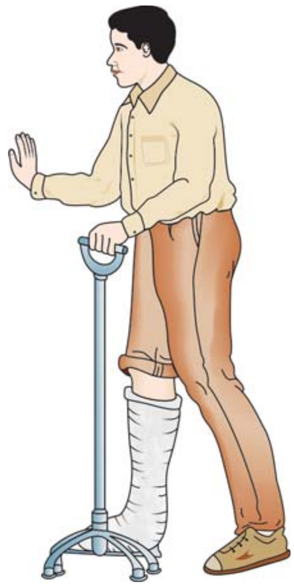


Fig. 1.21: Ambulation with a 4-legged cane

- The height of the cane should be such that, the elbow is flexed to 25-30°.
- The patient is instructed to hold the cane on the unaffected side.
- Patient is advised to take short steps.

Quick Facts

Why should the patient, hold the cane on the unaffected side:
1. In normal walking the leg and opposite arm move together.
2. It increases stability by providing a wider base.
3. The shifting of the centre of gravity is eliminated.

THERAPEUTIC EXERCISES

Goal The goal of any therapeutic exercise is to restore a symptom free movement and function.

Apart from this, efforts should also be made to restore strength, endurance, flexibility, relaxation, and mobility and coordination skill to the pre-injury levels.

Note An unused muscle loses strength at the rate of 5 per cent/day to 8 percent/week.

BASIC PRINCIPLES

Any therapeutic exercise, should aim to achieve the following basic principles:

- Determine at the beginning itself the purpose of the exercises, whether the general condition of the patient needs to be improved or whether the joint function or muscle strengthening.
- Determine the amount of stress the exercise places on the patient.
- Ensure that the type of stress imposed by the exer-cises should be relevant to that function that is to be increased.
- The intensity and duration of stress imposed on the joint or muscles should increase gradually to achieve increase in tolerance, endurance and strength.
- Last but not the least, the exercise regimen should not leave the patient exhausted and tired.

Quick Facts

- *Muscle strength* This is the ability of the muscle to contract against resistance.
- *Endurance* This is the ability to do the same movement repeatedly.

COMPREHENSIVE EXERCISE PROGRAM

A comprehensive exercise programme should include the following set of exercises:

- *Range of motion exercises (ROM)* This includes the exercises mentioned below:
  - — Full range of motion
  - — Functional range of motion
  - — Active ROM
  - — Active assistive ROM
  - — Passive ROM
- *Strengthening exercises* This further includes:
  a. *Basic strengthening exercises* three types are described:
     - — Isometric exercises
     - — Isotonic exercises
     - — Isokinetic exercises.
  b. *High performance strengthening exercises*
     - — Closed chain exercise
     - — Open chain exercise
     - — Plyometric exercises
- *Functional exercises*
- *Conditioning exercises*

Now, let us analyze each exercise in detail:

Range of Motion Exercises

This is the most basic form of exercise indicated in all phases of fracture rehabilitation:

Aim This aims to move the joints either partial or full.

Benefits The ROM exercises provide the following benefits:
- It prevents contractures from developing.
- It prevents muscle shortening.
- It prevents adhesions in capsules, ligaments and tendons.
- It provides the patient with sensory stimulation.

Principles
- In ROM exercises, the joint should be moved only with respect to its actual movement.
- The length of the muscles exercised should actually cross the joint.

Types of ROM Exercises

- *Full ROM* this is the anatomically determined range of motion in a joint, e.g. knee joint (0-120°, i.e. 0° to extension and 120° flexion).
- *Functional ROM* this is the range of movement in a joint just required to carry out a specific function, e.g. A 90° flexion of the knee joint is enough to enable a patient sit on a chair.
- *Active ROM* This is performed by the patient himself by his own efforts he tries to move a joint through its partial or full range.

  Indications
  — To prevent loss of available joint movements.
  — When a patient needs support due to weakness, pain, decreased muscle tone or cardiopulmonary problems.
  — In the early phase of bone healing when there is less stability at the fracture site.
- *Active assistive ROM* In this when the patient is performing an active ROM the therapist assists or provides additional force.

  Indications This is used where there is weakness, restriction of movements due to pain or fear, or, to increase the available ROM. To do this exercise, there should be some stability at the fracture site either in terms of bone healing or fracture fixation.
- *Passive ROM exercises* Here the joint movements are performed not by the patient but by the therapist.

Aim To maintain or increase the available range of motion at a joint.

Indications These are indicated when the active muscle contractions are not possible or strong enough to overcome the capsular contractures of a joint.

Contraindications If excessive joint movements affect the stability at the fracture site, these exercises are contraindicated.

Procedural Norms during ROM Exercises

- Support the part gently but firmly.
- Hold the part in such a way that the joint can be moved through its entire range.
- All the segments distal to the joint should be supported.
- The movements should be slow to moderate
- Each joint should be moved through its full range
- Stop the exercises if the patient complains of pain.
- Care should be taken not to damage the joints further.

Strengthening Exercises

These exercises aim to increase the strength of the muscles by increasing the amount of force a muscle can generate. These exercises not only make the muscle stronger but improve the coordination of the muscles.

Basic Exercises of Strengthening (Table 1.5)

1. *Isometric exercises (also called set exercises)* In this type of exercise the muscle is contracted without bringing about any joint movement (Fig. 1.22).
   Advantages
   - It can be used where active movements of the joints are either not possible or desirable.
   - Since it does not disturb the stability at the fracture site, these exercises can be used at the earliest possible time of fracture rehabilitation.

TABLE 1.5: Basic exercises of strengthening

Effects of exercises	*Muscle length*	*Tension of muscles*	*Joint motion*	*Gain of strength*	*ROM*	*Indications (fracture healing)*
Isometric	No change	↑	Nil	In one joint	No change	Early stage
Isotonic	Shortens and lengthens	↑	+	Maximal gain at ends of joint	Same or ↑	Intermediate stage
Isokinetic	Shortens and lengthens	↑	+ (constant rate)	Equal gain throughout ROM	Same or ↑	Late stage

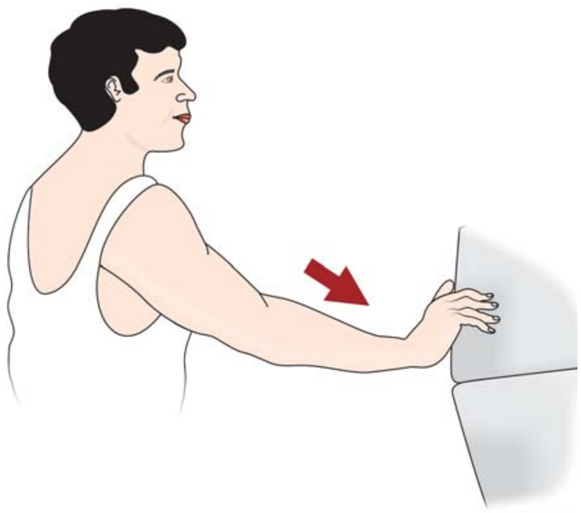


Fig. 1.22: Showing isometric exercise

- It alleviates the fear of pain and apprehension in the minds of the patient about exercises, e.g. quadriceps or biceps contraction in a long leg or long arm casts.

2. *Isotonic exercises* Here the muscle contracts and relaxes bringing about joint motion. This is a dynamic exercise performed using a constant load or resistance. Here the speed of movement is uncontrolled (Fig. 1.23).
   Indications These exercises are used in the intermediate and late stages of fracture rehabilitation, e.g. Progressive resistive exercises like biceps curls using increasing dumbbell weights.

Fig. 1.23: Showing isotonic exercise

Fig. 1.24: Showing isokinetic exercise

   These exercises result in greater strength and cannot be used when the cast is in place.

3. *Isokinetic exercises Here* joint movements are performed at a constant rate and the resistance is varied according to the muscle force (Fig. 1.24).
   This exercise helps to optimally strengthen the joint through its entire range of motion.
   Indications Indicated during the late stages of fracture healing when the fracture has already united.
   Disadvantages To maintain a constant rate of motion and vary resistance, it requires the use of a machine called the cybex.

High Performance Strengthening Exercise

Closed chain exercise:

- This requires the proximal and distal portions of the body being moved to be fixed.
- They are indicated when multiple muscle groups need to be strengthened simultaneously, e.g. Wall slide exercises and squats (Here ankle, knee and hip muscles are strengthened).

Open chain exercise Here there is no fixation of the distal limb unlike the closed chain, e.g. leg or biceps curls.

Plyometric exercise After a quick stretch, these exercises are performed by maximal muscle contraction. Useful only in the late stages of fracture rehabilitation.

The above three exercises are useful to achieve a specific task after the fracture has healed, e.g. returning a patient to athletic activity after the fracture has healed.

Functional exercises These exercises are aimed to improve the functional activity of a patient. They improve the agility, strength and neuromuscular coordination.

- Stair climbing after femoral fracture.
- Ball squeezing after removal of cast in Colles fracture.

Conditioning exercises These are aerobic exercises which aim to improve the overall cardiopulmonary function and overall endurance of the patient.

For example, Stationary bicycle, Treadmill, etc.

Types of Muscle Contraction during Exercise

Isometric This has already been explained. Here there is no change in muscle fiber length and no joint motion. It helps to stabilize a joint.

Concentric Here the muscle contracts to bring about a movement of the joint. This increases the joint movement.

Eccentric Here the muscle fibers lengthen and slows down the movement of a joint. They generate more force than the above two exercises. Useful only after the fracture has completely united, e.g. progressive knee flexion during squatting.

Chapter 2

Know Your Skeletal System

THE BONE SPEAKS

I am a specialized connective tissue. By providing a rigid skeleton I give the all important shape to the human beings. I am proud to be entrusted the job of protecting vital structures like brain, lungs and heart. I am the largest store-house of the all important mineral, i.e. calcium in the body. I am also concerned with hemopoiesis. I give attachment to the muscles and enable them to act on the joints by acting as a lever for their action. I am made up of 30 percent organic material (mainly type I collagen) and 70 percent mineral (calcium hydroxyapatite).

Remember

The functions of bone
- Protection of vital organs.
- Support to the body.
- Hemopoiesis.
- Movement.
- Mineral storage.

How I Start Developing?

My development begins with the condensation of the mesenchyme in the embryo. There are certain exceptions like the vault of the skull (membranous ossification), the clavicle (mixed ossification) and the mandible (Meckel's cartilage). From this condensation I rapidly form a cartilaginous model. Between the cartilaginous bone and plates, I form small clefts for the future joints. During this period of 12 weeks, I am particularly vulnerable to teratogenic influences.

As early as the fifth week of intrauterine life, I develop a primary centre of ossification which gradually replaces this cartilage model to bone by a process of endochondral ossification. During the late fetal stages or early few years of life, I develop secondary centers of ossification.

Growth plate which keeps the primary and secondary centers of ossification separated from each other till skeletal maturity helps me grow longitudinally and I increase my width from the growth of the thickened periosteum. In addition I keep remodeling myself from the fetal stage to the adult stage. Only the rate varies (50% during the first two years of life and 5% per year thereafter till adulthood).

Remember

- Bone development starts as a condensation of mesenchyme.
- Later a cartilaginous model develops.
- There are two types of ossification—endochondral and membranous.
- There are three types of bone cells.

About Osteon

Now let me tell you how exactly I am made up of internally. I am made up of many units called "*osteon*". I have three types of cells, osteoblasts which form the bone, osteoclast which remove the bone and is concerned with remodeling, osteocytes which are the resting cells. These cells are present in the lamellae, which surround concentrically the Volkmann's canal (which has the nutrient vessel) and each lamellae is interconnected by the canaliculi through which the nutrients pass. Osteoblasts lay down uncalcified matrix which is subsequently calcified as true bone. These various osteons amalgamate to form large haversian systems, loosely woven in the medullary bone and densely packed in the cortical shell.

Now having known my intrinsic structure, you will be interested to know that I have two major portions: *medulla* and *cortex*.

About Medulla

Medulla is my softer counterpart and has the dual role of structure and storage. It stores more than 95 percent of body's calcium and is a store-house for other minerals too. The other important component of the medulla is the marrow between the medullary bone lattices. This is the source from where the RBCs and WBCs originate. Initially present through out, it confines itself to the metaphyseal regions of the long bones and in some flat bones like pelvis, rib, etc. as age advances and is replaced by a *fatty white marrow*.

The medulla plays the structural role by its trabecular organization along maximal lines of stress and clearly identifies itself into *compression and traction trabeculae*.

About Cortex

Cortex gives me the remarkable strength which you all admire particularly during compression. Its periosteal cover allows remodeling throughout life. It also gives attachments to ligaments, tendons and muscles through the Sharpey's fibers.

Remember

About medulla
- Softer portion.
- Stores 95 percent of body calcium.
- Marrow is the other important component.
- Also plays a structural role.

About General Structure

Now let me explain to you my general structure. I have an epiphysis and epiphyseal plate (which disappears with growth), metaphysis and diaphysis (Fig. 2.1).

Epiphysis This is an expanded portion at the end develops usually under pressure and forms a support for the joint surface. It is easily affected by developmental problems like epiphyseal dysplasias, trauma, overuse, degeneration and damaged blood supply. The end result is distorted joints due to avascular necrosis and degenerative changes.

Growth plate (physis) Though mechanically weak it helps longitudinal growth. It responds to growth and sex hormones. It is affected by conditions like osteomyelitis, tumor, slipped epiphysis resulting in short stature or deformed growth or growth arrest.

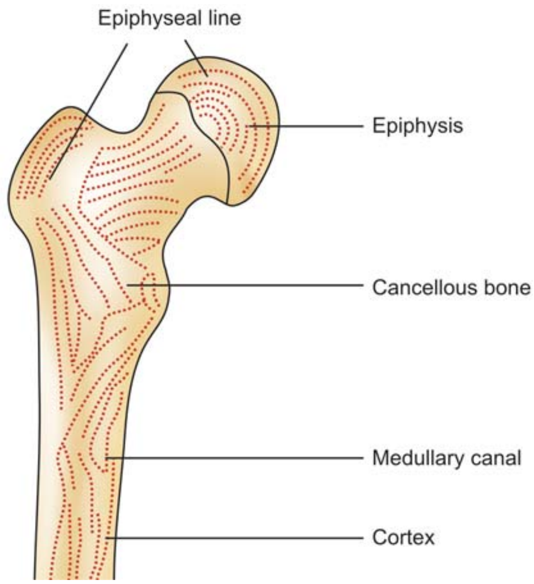


Fig. 2.1: General structure of a bone

Metaphysis This is concerned with remodeling of bone. It is the cancellous portion and heals readily. It gives attachment to ligament and tendons. It is vulnerable to develop osteomyelitis, dysplasias and tumors resulting in distorted growth and altered bone shapes.

Diaphysis This is a significant compact cortical bone which is strong in compression and which gives origin to muscles. It forms the shafts of the bones. Healing is slow when compared to metaphysis. In remodeling it can remodel angulations but not rotation. It may develop fractures, dysplasias, infection and rarely tumors.

Remember

Parts of a bone
- Epiphysis
- Physis (growth plate)
- Metaphysis
- Diaphysis

Organization of the Bones

We are 206 in number and are grouped into two subdivisions namely:
- Axial skeleton—80 bones (Table 2.1).
- Appendicular skeleton—126 bones (Table 2.2).

Axial skeleton Forms the upright axis of the body and the *appendicular skeleton* forms the appendages and girdles that attach them to the axial skeleton (Fig. 2.2).

TABLE 2.1: Bones in the axial skeleton

Bones	*No.*
Skull	
• Cranium	8
• Face	14
Vertebral column	
• Cervical vertebrae	7
• Thoracic vertebrae	12
• Lumbar vertebrae	5
• Sacrum	1 (5 fused bones)
• Coccyx	1 (3-5 fused bones)
Sternum	
• Manubrium	1
• Body	1
• Xiphoid process	1
Ribs	12 pairs
Hyoid	**1**
Ear ossicles	2
• Malleus	2
• Incus	2
• Stapes	2
Total	**80**

TABLE 2.2: Bones of the appendicular skeleton

Bones	*No.*
Shoulder girdle	
• Clavicle	2
• Scapula	2
Upper extremities	
• Humerus	2
• Ulna	2
• Radius	2
• Carpals	16
• Metacarpals	10
• Phalanges	28
Hip girdle	
• Os coxa	2
Lower extremities	
• Femur	2
• Fibula	2
• Tibia	2
• Patella	2
• Tarsals	14
• Metatarsals	10
• Phalanges	28
Total	**126**

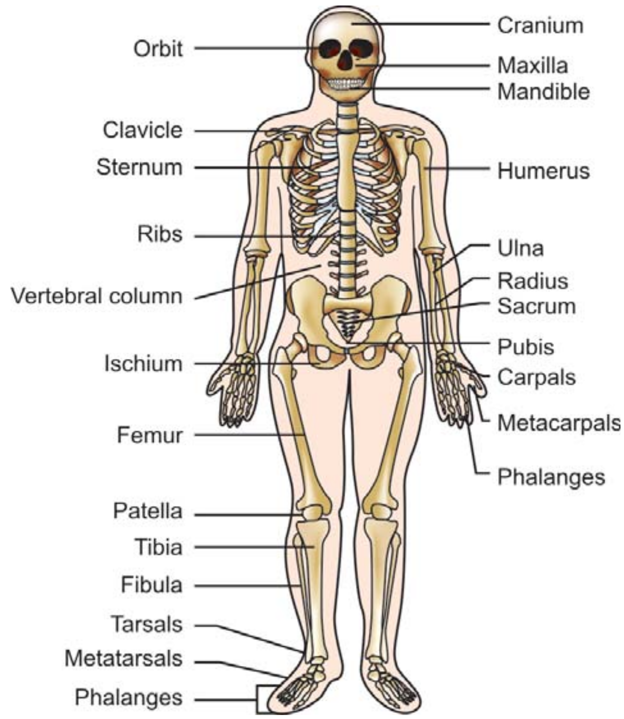
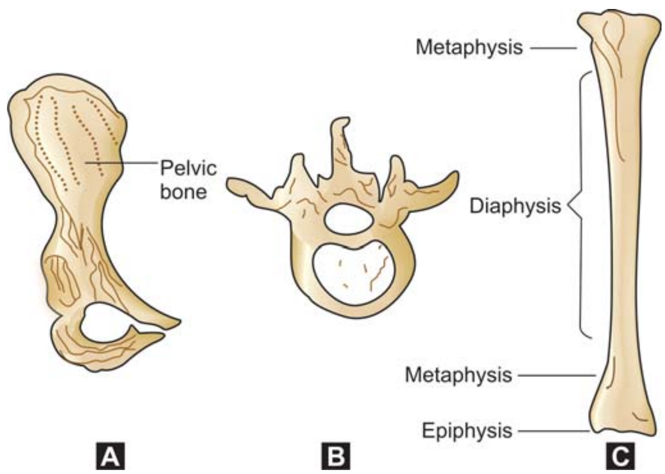


Fig. 2.2: Organization of bone: Axial and appendicular skeleton



Figs 2.3A to C: Types of bone: (A) flat bone, (B) irregular bone, and (C) long bone

Out of this 206, some of us are short and some are long. We have different shapes. The shape and size depend upon the functions attributed to us.

TYPES OF BONES

Long bones (Fig. 2.3C) These serve as levers for the muscle action, e.g. femur, tibia, etc.

Short bones These are generally cube-shaped and are found in areas where limited movements are required. Their principal role is to provide strength.

Flat bones (Fig. 2.3A) These consist of parallel layers of compact bone separated by a thin layer of cancellous bone tissue, e.g. scapula, skull, pelvic bones, etc.

Irregular bones (Fig. 2.3B) These have a peculiar and irregular shape and are unique in their appearance and functions, e.g. vertebra.

Sesamoid bones These are small, rounded or triangular bones which develop within the substance of a tendon or fascia. Their name is derived from their resemblance to “sesame seeds”, e.g. patella (largest and most definitive of the sesamoid bones).

Remember

Types of bones
- Long bones
- Short bones
- Flat bones
- Irregular bones
- Sesamoid bones

The above bones are arranged in two groups:
- Axial—80 bones
- Appendicular—126 bones

Thus, my duty is to serve you to the best of my ability, so that you lead a healthy skeletal life. Much depends on you in keeping me in a proper shape. You need to take good nutritious diet rich in calcium and vitamins to keep me healthy. Proper exercises, protection against injuries and infection enhance my efficiency in serving you, but there are certain inherent problems in me in which you can do precious little. Congenital problems, hormonal problems, metabolic problems, tumor conditions, etc. are some of these.

Though the above problems are troublesome I develop them infrequently. But the problem which poses a serious threat to my integrity is injuries due to trauma. As a child you are more playful and more prone to fall and this breaks me quite often. As an adult you are more prone for road traffic accidents (RTAs) and this subjects me to a plethora of different varieties of forces causing many complexes, grotesque and bizarre breaks. Though you pride in the fast-paced life of yours, I grieve at my misfortune and at my vulnerability to these vast array of incriminating forces which overcome me putting you out of action for months.

As you age, my faithful friends, proteins and minerals gradually desert me. I cannot provide you the same strength as earlier. In this phase, I am easily overcome by even trivial forces (pathological fractures). I am sad that I cannot provide you the same privileges as before but I hope you can realize that I am not being unfaithful to you, but I am made helpless by situations beyond anybody’s control.

About Joints

A joint exists where two or more skeletal components— whether bone or cartilage, come together to meet. Without joints in between the bones your whole body would be rigid and immobile. It is the existence of the joint that makes movement of the body parts possible. Joints are classified into three major groups:

Fibrous Joint or Synarthrosis

These are immovable joints, e.g. sutures of the skull. In these there are three varieties.

Syndesmosis This is characterized by a dense fibrous membrane that binds the articular bone surfaces very closely and tightly to each other, e.g. distal tibiofibular joint.

Sutures True sutures are found in the skull. Here the adjoining bone margins are united into rigid, jagged interlocking processes, e.g. sagittal suture of the skull.

Gomphosis Here a conical peg or projection fits into a socket, e.g. teeth and sockets of jaw bones.

Cartilaginous Joints or Amphorthosis

These are slightly movable joints with either hyaline or fibro cartilage in between. Two varieties are described.

Synchondroses Here hyaline cartilage is posed in between, e.g. articulations between rib and sternum.

Symphysis Here fibrocartilage is interposed in between and is usually found in the midline of the body, e.g. pubic symphysis.

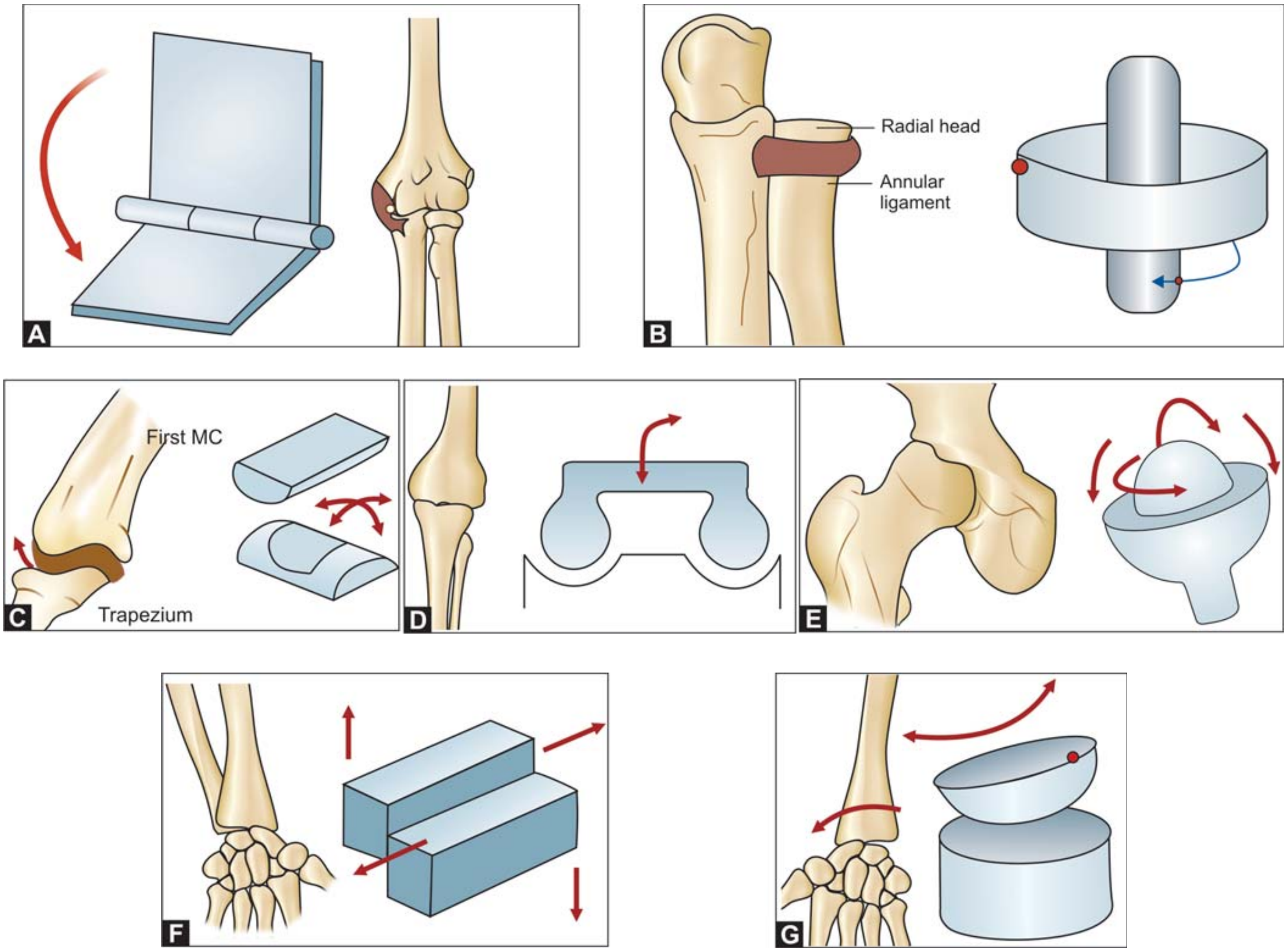
Synovial Joints or Diarthrosis

These form the majority of the joints in the body. They have between the bones, a synovial or joint cavity. They form the most mobile joints in the body and hence are more prone for injuries.

It consists of a fibrous joint capsule which helps to hold the articulating bones together. The synovial membrane lines the joint space and secretes the synovial fluid. This fluid serves to lubricate the joints and provides nourishment for the articular cartilage. The articular cartilage is formed by the hyaline cartilage which is a unique type of connective tissue formed by specialized cell called chondrocytes.

TYPES OF SYNOVIAL JOINTS (FIGS 2.4A TO G)

Uniaxial joints These permit movement in only one plane and one axis. In this there are two types.



Figs 2.4A to G: (A) Hinge joint, (B) Pivot joint, (C) Saddle joint, (D) Bicondylar joint, (E) Ball and socket joint, (F) Plane joint, (G) Ellipsoid joint

Hinge joints Here movement takes place around a horizontal axis, e.g. elbow joint (Fig. 2.4A).

Pivot joints Here movement takes place around a vertical axis which permits rotation, e.g. atlantoaxial joint and superior radio ulnar joint, etc. (Fig. 2.4B).

Biaxial joints Here movement occurs in two planes and two axes that are at right angles to each other. Two types are described:

Saddle joint Here the articular surface is concave in one direction and convex in the other while the articular surface of the opposing bone is exactly the opposite, e.g. carpometacarpal joint at the base of the thumb (Fig. 2.4C).

Condyloid joint In this an oval condyle fits into an elliptic socket or cavity, e.g. radiocarpal joints, knee joint, etc. (Fig. 2.4D).

Multiaxial joints Here there are two or more axes of rotation and movement takes place in three or more planes. Two varieties are described.

Ball and socket joint In this a ball-shaped head of one fits into a concave socket of another bone. Of all the joints in the body, these provide the widest freest range of movements in almost any direction or plane, e.g. hip joint, shoulder joint, etc. (Fig. 2.4E).

Gliding joints These are numerous and gliding movements occur in all planes, e.g. joints between the carpal and tarsal bones and all the joints between the articular processes of the vertebrae (Figs 2.4F and G).

3

Chapter

Soft Tissue Injuries

Soft tissue injuries are not quite ‘soft’ but ‘hard’ in terms of rehabilitation and management. The term soft tissue implies skin, subcutaneous tissue, fascia, muscles, ligaments, tendons, synovium, capsules, nerves etc. Undoubtedly they are more common than bony injuries. Sportspersons are more prone to suffer from soft tissue injuries than the normal population. Unlike in fractures, the soft tissue injury management is essentially conservative and physiotherapy appears to be the mainstay of treatment.

MECHANISM OF INJURY

Direct trauma Due to fall, RTA, assault, etc. contusion, hematomas, lacerations are some of the examples.

Indirect trauma Due to avulsion injuries, muscle pull, ligament sprain, etc. More commonly seen in sportspersons.

APPROACH TO A PATIENT WITH SOFT TISSUE INJURY

The patient’s story Listen to what the patient has to say about the problem. Do not be swayed by his story. He may be going overboard. Take his complaints with a ‘pinch of salt’. This is the subjective assessment.

Your observation This is your assessment of the problem based on ‘his’ story. Make an objective assessment of the injury with regard to site, nature, intensity of pain, etc. of the injury. Your evaluation may or may not correlate with ‘his’ story. Evaluate carefully the functional problem, interpret it analytically and individualize the treatment plan.

Goal setting A physiotherapist needs to set up goals while treating soft tissue injuries. These could be immediate or long term.

Execution of your plan Having made a careful evaluation of the injury; you have sized up the problem and formulated your modus operandi. Keeping both the short and long-term goals in mind. Unleash your plan of action now to bottle up this genie.

Goals of Soft Tissue Injury Treatment

Immediate goals This aims to ‘nip’ the problem in the bud or ‘prevent’ further damages from taking place. Look at the priorities:

- If there is blood loss—arrest it, prevent it, control it.
- If there is swelling—try to minimize it.
- If there is pain—try to alleviate it.
- If there is joint stiffness—try to prevent it.
- In all possibility try to see there is no further damage whatsoever once you are in charge of the injury!
- In the event of muscle weakness—try to maintain the power. Thus, immediate goals aim at ‘prevention’ of further damage and injuries to the soft tissues.

The distant goals Here your efforts are to put the derailed life of the soft tissues back on rails and restore the structures to their pre-injury state. No mean task this and calls for a sustained and skillful approach by the therapist. The priorities in this are as under:

- *Movements* Restore it.
- *Mobility* Ensure the affected joints are back to their best.
- *Strength* The affected muscles need to be given their strength and endurance back.
- *Kinaesthetic/proprioception mechanism* Restore it.
- *Daily or functional activities* Restore it back to the original.
- *Confidence* Boost the patient’s morale and also that of the affected part.

- *Keep away* The swelling, edema from raising its ugly head again. Once bitten twice shy, hence no more such injuries.
- *Last but not the least* Ensure that this problem will not surface again by practicing effective anti-recurrent methods.
- *Inculcate* A sense of discipline in practicing regular follow-up and valuing the medical advice. Drive home the advantages of 'home care' programs. Instill in them a thought that, "it pays to be your own doctor in the safe confines of their home!"

Classification of Soft Tissue Injury (STI)

The four broad classifications for STI are as follows:

1. Strains
2. Sprains
3. Ruptures
4. Contusions.

Let us now discuss each one in detail.

Strains

Injury to the muscle and tendons is called *strain*.

Reasons

- Sudden unaccustomed or abrupt action or movements may tear the muscles.
- Direct trauma can also injure the muscles and tendons.
- Overstretching of muscles due to indirect trauma especially in sportspersons.

Types

- *Acute strain* Due to sudden violent force or direct trauma.
- *Chronic strain* This is due to injury existing since a long period leading to muscle ischemia and fibrosis.

Severity of Strain

1. **First Degree Strain (Mild contusion)**
    - This is due to blunt injury and is due to direct trauma.
    - *Pathology* Few muscle fibers are torn. Bleeding is minimal and the fascia remains intact.

    Clinical Features

    - Localized pain and tenderness.
    - Pain and spasm prevents muscle stretching.
    - Function is not impaired to a greater extent.

    Management

    - First aid is by cryotherapy (by application of ice) for a period of 20 minutes.
    - Gentle active muscle stretch may be permitted after 20-60 minutes.
    - Compression bandaging with optimum pressure.
    - Low dose and low power ultrasound helps.
    - Gentle massaging of the surrounding area helps.
    - If pain is minimal, patient can do the light work the next day.
2. **Second Degree Strain**

    Cause Here trauma is more serious.

    Pathology

    - Greater number of muscle fibers is torn.
    - There is more bleeding.
    - The fascia is still intact.
    - Haematoma is still localized.

    Symptoms

    - Pain is more severe.
    - Tenderness is severe.
    - Severe muscle spasm.
    - The patient is unable to move the limb.
3. **Third Degree Strain**
    - Larger area and greater number of muscle fibers are involved.
    - More than one muscle group may be involved.
    - The fascia is partially torn.
    - Bleeding is widespread and more. There could be both intramuscular and intermuscular bleeding.
    - The patient experiences severe pain and loss of function.

    Treatment in Grade II and III Strains

    For first 24 hours

    - Immediate application of ice.
    - Compression bandage.
    - Limb elevation.
    - Limb immobilized in splints.
    - Isometrics to the muscles which are immobilized.
    - Active exercises to the unaffected joints.
    - Pulsed electromagnetic field therapy (PEMF) is known to help.
    - No active movements to the affected muscles.

    During 24-48 hours

    - The pressure bandage is removed and active muscle exercises are begun.
    - Stretching within the limits of pain is commenced.
    - Thermotherapy: Ultrasound, short wave diathermy and TENS helps to relieve pain.
    - Slow rhythmic massaging helps relieve the muscle spasm.
    - Nonweight bearing on crutches is slowly started.
    - Rest of the measures is same as above.

Between 48 and 72 hours

Apart from all the measures mentioned so far, the additional measures during this phase include:

- More vigorous active movements are encouraged.
- Deep transverse friction massage is added.
- Partial weight bearing can be permitted.

After 72 hours

- All the above measures are pursued in a more vigorous manner.
- Pressure bandage is totally removed.
- Progressive resisted exercises using the Fowler technique by taking out 10-12 repetition maximum (RM) is practiced.
- Full weight-bearing should be permitted in injuries of the lower limbs.
- After full movement is regained, patient is allowed to walk and jog.
- Full functional activity should be regained by 4-6 weeks.

4. **Fourth Degree Strain**

Cause This is due to severe trauma

Pathology

- Complete tear of the muscle.
- The fascia is torn.
- Considerable bleeding which is intermuscular and diffuse.
- Gross swelling is present.

Clinical Features

- Excruciating pain.
- Severe tenderness is present.
- A snapping sound may be heard by the patient.
- Palpable gap between the muscles felt.
- Severe loss of function.
- Active movements produced by the agonist are absent.
- Active muscle contraction is absent.
- Joint function is not lost.
- Muscle spasm is very severe.

Treatment

- Surgery is advised. This involves opening the ruptured site, evacuating the hematoma and suturing the fascial sheath. Direct muscle repair is avoided.
- Compression bandage is applied and the limb is immobilized for 2-3 weeks.
- Active exercises to the unaffected joints.
- Slow rhythmic isometric exercises to the affected muscles.
- Non-weight bearing after 48 hours.
- The use of low frequency current (faradism) to obtain passive contraction is very useful.
- Deep heating modalities like ultrasound, etc. helps
- Rest of the measures is same as for Gr II/III injuries.

INJURIES TO THE JOINTS

During an injury to a joint three things could happen:

1. Injury to the ligaments only.
2. Injury to the synovium.
3. Both (According to Bass, 1969).

LIGAMENT INJURY

A ligament injury is called “Sprain”. Depending on the severity, it could be mild (Grade I), moderate (Grade II) or severe (Grade III) (Fig. 3.1).

Anatomy

Ligaments are made of fibrous tissues which are arranged longitudinally. They are tough and elastic. Their vascularity is poor and heals always by scar tissue due to lack of special cells.

Function

Ligaments serve the following functions:

Support By reinforcing the capsule, they provide support to the joint.

Stability By holding the bony ends together it provides stability.

Protection The strength of the ligaments offers protection to the joints along with the muscles.

Problems of Healing

- Poor vascularity delays the healing.
- Repair is by scar tissue

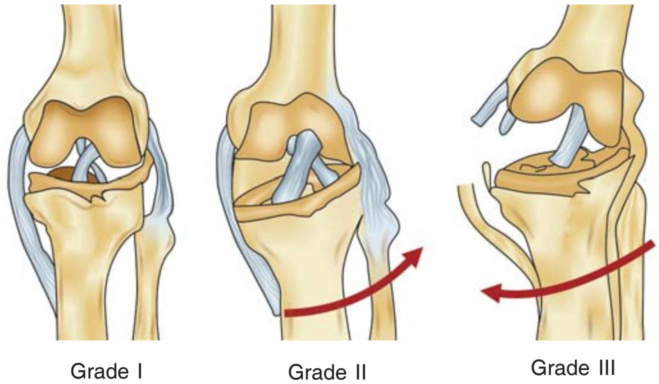


Fig. 3.1: Grades of sprain of medial collateral ligament of the knee

- Inadequate period of immobilization, results in healing with more fibrous tissue. This will result in excessive laxity making the joint unstable.
- Intermittent stretching strengthens the ligament while continuous stretch leads to adhesions due to periosteal irritation.

Types of Sprain

Grade I (Minor)

Clinical Features

- Slight pain and tenderness at the site of injury.
- Slight swelling and loss of function.
- Stretch test will be positive clinching the diagnosis.

Treatment

First day
- Cryotherapy to alleviate pain.
- Pressure bandage to prevent swelling.
- Limb elevation.
- Active movements of the unaffected joints.

Second day onwards
- Add thermotherapy, stop ice therapy.
- Begin isometric exercises to the affected muscles.
- Weight bearing may be permitted.
- Rest of the measures is same as mentioned above.

Grade II (Severe)

- More force results in this injury.
- The ligament may be partially torn or detached from the attachment.

Clinical Features

- Swelling is more severe.
- Pain and tenderness are also more acute.
- Movement is grossly restricted.
- Weight bearing is difficult.
- Function is severely affected.

Treatment

- Cryotherapy.
- Compression bandaging or knee cap (Fig. 3.2).
- Elevation.
- Rest of the measures same as in Grade I.

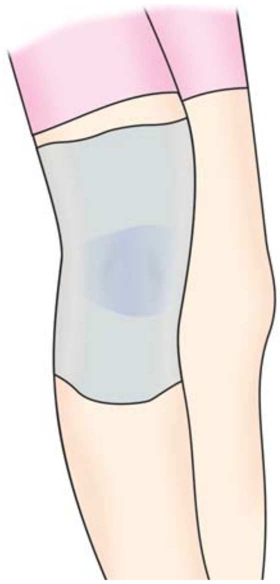


Fig. 3.2: Showing elastic knee braces to prevent and control joint swelling

Grade III (Complete Rupture)

Clinical Features

- It is due to severe violence.
- Gross swelling is seen.
- Pain and tenderness is quite severe.
- Joint is unstable.
- Patient is unable to bear weight.
- Severe loss of function.

Treatment

- Conservative
  — Immediate application of ice.
  — Compression bandaging.
  — Foot end elevation.
  — Isometric exercises to the affected limbs.
  — Active exercises to affected joints.
  — POP cast for 6-8 weeks if ligament tear does not cause displacement.
- Surgical
  — If the ligament is torn and displaced it needs surgical repair and immobilization with a POP cast for 6-8 weeks.
  — Isometric exercises are started after one week.
  — Non-weight-bearing.

After Removal of the POP Cast

- *Thermotherapy* Ultrasound, TENS or SWD helps to relieve pain.

- *Pressure bandage* To control swelling.
- *Limb elevation* To prevent edema.
- *Transverse friction massage* To relieve spasm.
- *Active exercises* To the affected joints are begun slowly and progressed gradually.
- *Isometrics* are done more vigorously.
- *Passive* ROM exercises.
- *Active, active-resisted and self-resisted exercises* are prescribed.
- *Weight-bearing* is slowly encouraged from partial to full.

With all the treatment measures enumerated above, the patient should be functionally independent by 8-12 weeks.

INJURY TO THE SYNOVIUM

Relevant Anatomy

Synovium is a lining covering the capsule of the joint, tendon sheaths, etc. It has a rich blood and nerve supply. It is present throughout the body.

Functions

Synovium produces synovial fluid which serves the following functions:
- Facilitates frictionless, smooth joint movements.
- Helps in the nourishment of cartilages.

Causes

Inflammation of synovium is called *synovitis*. It could be due to trauma, arthritis, chondromalacia, rheumatoid arthritis, TB, hemophilia, etc.

Types

- *Acute* Due to trauma.
- *Chronic* Due to diseases like TB, rheumatoid arthritis, trauma, etc.

Clinical Features

- Swelling of the joint (develops slowly) (2-24 hrs).
- The joint is warm and red.
- Pain present over the injured structure.
- Feeling of tension or pressure due to swelling.
- To accommodate the excess fluid the joint will assume a flexion attitude (position of ease).
- Muscle atrophy will be quite significant.

In the Event of Synovial Rupture
- Patient feels sudden pain at the back of the knee while getting up from a chair, getting down the stairs, etc.
- The swelling may spread rapidly to the calf muscles. Homan's sign will be positive.

Treatment

Aim To prevent muscle atrophy and joint contractures by a graduated exercise regimen.

Methods

During First 24 Hours
- Ice therapy
- Compression bandage
- Limb elevation
- Isometric contraction of the affected limb muscles
- Active movements of the ankle joint
- Active movements of the unaffected joints
- Splinting of the affected part.

After 48 Hours
- Aspiration of the joint if swelling persists even after 48 hours.
- Sustained isometric contraction.
- Small range gradual active movements with adequate support should now be begun.
- Partial weight bearing may be allowed.
- Gradually progressive resistive exercises should be started to achieve full function.

> *Note* Hemarthrosis *vs* Synovitis
> In hemarthrosis:
> - The swelling is rapid in onset (< 2 hours).
> - Swelling is more generalized.
> - Pain on extreme movements.
> - Joint instability may be present in cases of complete Rupture.

CHRONIC SYNOVITIS

Problems of chronic synovitis
- Firm swelling.
- Muscle atrophy may be gross.
- Joint stiffness may be considerable.
- Lax ligaments create instability.
- Mild pain unlike acute synovitis.

Treatment

- Resistive exercises to the affected limbs.
- Isometric exercises to the affected parts.

- Passive ROM exercises to over come joint stiffness.
- Proper gait training.
- Ultrasound TENS, SWD and other heat modalities to overcome pain and spasm.

INJURY TO THE BURSA

Bursa is thin membranous sac lined with synovial membrane situated at the ends or certain important locations of the bones where tendons, etc. pass over them.

Functions

- To prevent friction between two structures like tendons and bones that is liable to be rubbed against each other.
- To prevent wear and tear of muscles and tendons.
- To protect the structures from pressure and injury.

Types

True bursa They are normally present in the body at certain important situations like beneath the acromion, elbow, knee, heel, etc.

False bursa They are also called as adventitious bursa. They develop due to external trauma, pressure, etc.

Causes

The causes of bursitis are as follows:
- *Trauma* May be due to a single blow or repetitive trauma.
- *Infection* Acute or chronic (e.g. TB).
- *Metabolic disorders,* For example—gout, etc.
- *Abnormal external pressures,* etc. For example—hip ischial tuberosity, etc.
- *Inflammatory disorders*, For example—rheumatoid arthritis, etc.
- *Unaccustomed activity*, exercise or ill-fitting shoes etc.
- *Due to excessive pressure*, friction, etc. For example—Olecranon bursitis, Student's elbow, etc.

Common Sites

- *Upper Limbs*
  — Subacromion
  — Olecranon
- *Lower Limbs*
  — Prepatellar
  — Tendo-Achilles
  — Medial side of the great toe
  — Lateral side of the little toe.

Clinical Features

- Pain, more so if it ruptures.
- Swelling is tender and hot.
- Movements of the joint may be painful.
- Tenderness may be present.
- Limp due to gluteal bursitis, etc.

Treatment

In bursitis due to friction
- Rest to the part.
- Thermotherapy: US, SWD, TENS, etc.
- Cryotherapy in initial stages.
- Restricted weight bearing.
- Isometric exercises to the affected part.
- Muscle strengthening exercises.
- Joint mobilization if there is restriction.
- Injection of hydrocortisone in intractable cases.
- Excision of the bursa, if chronic and troublesome.

Infective bursitis
- Appropriate antibiotics
- Rest of the measures is same as above.

Chronic cases
- Appropriate supports like felt pad, footwear modifications, etc.
- Avoiding repeated frictional movements.
  For example—shoulder abduction in sub deltoid bursa.
- Relaxed passive movements to avoid friction.
- Active limited ROM exercises with strong isometrics.
- Progressive resistive exercises.
- Deep heating like US, SWD, TENS, etc.
- Deep friction massage.
- Active exercises to the unaffected joints.
- Isometrics with limb in elevation helps considerably.

TENOSYNOVITIS

This is due to inflammation of the synovial lining of the tendon sheath. The fibrous sheath is, however, not affected.

Types

Irritative Due to abnormal or excessive friction. There is pain and crepitus on palpation. The movements are not affected and there are no adhesions. There is watery effusion due to sheath inflammation.

Infective May be due to acute pyogenic infection or chronic infection like TB, etc.

Treatment

Irritative

- Rest to the part by appropriate splints.
- Avoid movements at the joints.
- Bandaging or POP cast.
- Thermotherapy US, SWD or TENS.
- Deep friction massage.
- Difficult cases, hydrocortisone injection.
- Intractable cases, surgical excision.
- Shoe modifications, etc.

Infective

- Appropriate antibiotics.
- Immobilization for 2-3 months.
- Rest of the measures is the same as mentioned above.

TENOVAGINITIS

Unlike in tenosynovitis, here the fibrous sheath and not the synovial sheath of the tendon are affected. Though patient may complain of pain, crepitus is conspicuous by its absence. E.g. de Quervain's disease (Fig. 3.3). Though the exact cause is unknown (Adams 1981), Cyrius (1978) says it may be due to repeated strains. Infection is not known to cause this problem.

Fig. 3.3: Showing de Quervain's disease

Treatment

This is similar to tenosynovitis.

SPECIAL TYPES OF MUSCLE INJURIES

Bruise or Contusion

It is nothing but the Grade I muscle strain. This has already been discussed and is called a superficial hematoma.

Hematomas

These are deep in nature and two types are described:

Intramuscular Hematoma

- Here blood is contained within the muscle and is bound by an intact muscle sheath.
- Following an injury, bleeding occurs and stops within two hours.
- There is localized swelling.
- If there is further trauma, more bleeding may occur.

Intermuscular Hematoma

- Here the sheath of the muscle is torn resulting in extravasations of blood between the muscle and fascial planes.
- The hematoma is more diffuse.
- Bleeding will be more as the tension does not build up to stop it.
- Due to gravity, it tracks down and may cause discoloration beneath the skin.
- For the first 48 hours it is difficult to differentiate between the above hematomas.

Quick Facts

Features of intermuscular hematomas

- Moderate pain
- Swelling reduces drastically by 48-72 hours
- Muscle contraction is regained first
- Due to tracking swelling may be seen at a distance away from the site of injury.

Treatment

Aim is to prevent further bleeding.

Methods

- Rest to the part.
- Immobilize the affected part with splint.
- Cryotherapy to relieve pain and spasm.
- Pressure bandage to control the swelling.
- Limb elevation to prevent edema.

Note In hematomas there is no loss of function. If there is loss of function then it may be a Grade II/III muscle strain.

FIBROMYALGIA

Introduction

This is a condition where pain is characteristically described as “Charley’s horses” scattered all over the body. It falls in the gambit of muscular endurance disorders with widespread musculoskeletal pain involving all the four quadrants of the body namely the right, left and above and below the waist.

Incidence After osteoarthritis this is the most common rheumatological disorder. The overall incidence is 2.5% with women suffering 8-10 times more than men.

Causative Factors

- In 5-10% it could be hereditary.
- In a majority, any condition that lowers the endurance of the muscles can trigger this condition. Notorious among them are sleep disorders loss of Stage IV, delta wave sleep), trauma, connective tissue disorders, infection, etc.

Clinical Features

- *Pain* Its features includes widespread gnawing pains, with increased activity, stress or poor sleep.
- Fatigue, stiffness, arthralgia, headaches, chest and abdominal pains, etc. are some of the other complaints.

Diagnostic Criteria

- Widespread pain for at least three months in all the four quadrants of the body.
- Pain should be elicited in at least 11/18 established tender joints when a digital pressure of 4 kg is applied.

Treatment

A multidisciplinary approach seems to be an effective strategy in tackling this troublesome problem and involves the following steps:

- *Initial phase* Treat the underlying cause like sleep disorder, infection, connective tissue disorders, etc.
- *Second phase* Myofascial release, massage and physical therapy are used to relieve the pain at the tender areas.
- *Final phase* Aerobic exercises are advocated to improve the muscle endurance.

Alternative therapies

- *Diet therapy* A diet rich in protein, amino acids and minerals are recommended.
- *Injection therapy* A trigger point injection into the tender are with dry needling or injecting normal saline, local anaesthetic and steroid injection helps.
- *Physiotherapy* Ultrasound, SWD,TENS, Manipulation and Massage are useful adjunctive measures,
- *Acupressure* Stimulating the reflex points and specific points helps to lower the pain.

IMPORTANT SOFT TISSUE PROBLEMS

Given below is a list of important soft tissue problems in orthopedics. Please refer the appropriate sections for details.

Upper Limb

Shoulder

- Rotator cuff injuries (page 274)
- Supraspinatus tendinitis (page 277)
- Infraspinatus tendinitis (page 276)
- Subscapularis tendinitis (page 276)
- Adhesive capsulitis (page 270)
- Tendinitis of the long head of biceps (page 276).

Elbow

- Student’s or miner’s elbow (page 288)
- Tennis elbow (page 278)
- Golfer’s elbow (page 282)

Wrist

- Ganglion (page 283)
- de Quervain’s disease (page 282)
- Dupuytren’s contracture (page 284)
- Trigger finger (page 282)
- Carpal tunnel syndrome (page 285)
- Mallet finger (page 138)

Lower Limbs

Hip and Pelvis

- Piriformis syndrome
- Iliofibial tract syndrome
- Gluteal bursitis
- Trochanteric bursitis.

Knee and Leg

- Bursae around the knee (page 310)
- Collateral ligament injury (page 170)
- Cruciate ligament injury (page 171)
- Meniscal injury (page 176)

- Quadriceps strain (page 184)
- Hamstrings strain (page 185)
- Calf muscle strain (page 185)
- Patellar tendinitis (page 184)
- Plica syndrome (page 184).

Ankle and Foot

- Ankle sprain (page 191)
- Plantar fasciitis (page 323)
- Calcaneal spurs (page 324)
- Morton's neuroma (page 321)
- Tendo-Achilles injuries (page 185)
- Tarsal tunnel syndrome

For

- Injuries to tendons please see the chapter on injuries of Flexor and Extensor Tendons of the Hand (Chapter 20, page 335 to 340).
- For injuries to the nerves, please refer chapters on Peripheral Nerve Injury (Chapter 17, page 229).

4 Chapter

General Principles of Fractures, Dislocations and their Treatment

It is not surprising if a bone breaks but what is surprising is the fact that bone does not break more often considering the amount of forces it is subjected to everyday by the muscle action, load transmission, etc. Bone has devised its own mechanism to ward off the unnatural forces and keep itself intact. But only when the force is too large and occurs suddenly (as in road traffic accidents, fall, etc.), or when a force is chronic and repetitive (e.g. prolonged standing as in a policeman, nurse, etc.) or when the natural resistance of the bone is eroded by a disease process (e.g. tumor, infection etc.), that a bone succumbs to the insult and breaks. When it breaks it is bound to injure the surrounding soft tissues like muscles, ligaments, etc.

DEFINITIONS

Fracture is a break in the surface of a bone, either across its cortex or through its articular surface.

Dislocation is a complete and persistent displacement of a joint in which at least part of the supporting joint capsule and some of its ligaments are disrupted.

Subluxation is a partial dislocation of a joint.

Sprain is the temporary subluxation of a joint and the articular surfaces return to normal alignment.

Strain is a tear in the muscle.

The bone can break within its soft tissue envelope and may not communicate to the exterior *(simple or closed fractures)* (Fig. 4.1) or it may rip through its soft tissues or the soft tissue itself may be damaged by the external forces, exposing the bone to the external atmosphere *(compound or open fractures)* (Figs 4.2A, B and 4.3). If the former event is bad, the latter event is catastrophic. In both the situations depending on whether the force is direct (as in direct impact in RTA) or indirect (e.g. through the muscle action), and depending on the amount of force applied, the direction of force, age and other factors, different fracture patterns are produced and each one poses a problem peculiar to its own.

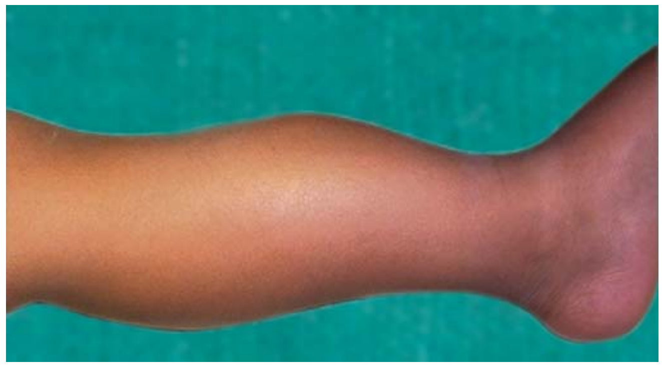
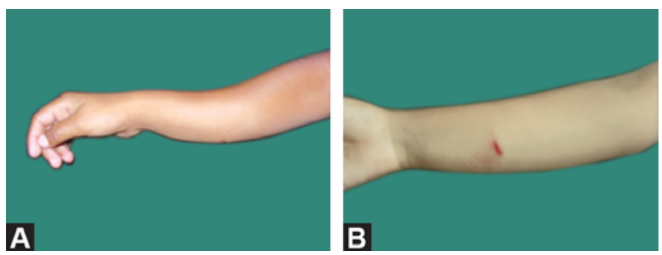


Fig. 4.1: Clinical photograph showing deformity in closed fracture

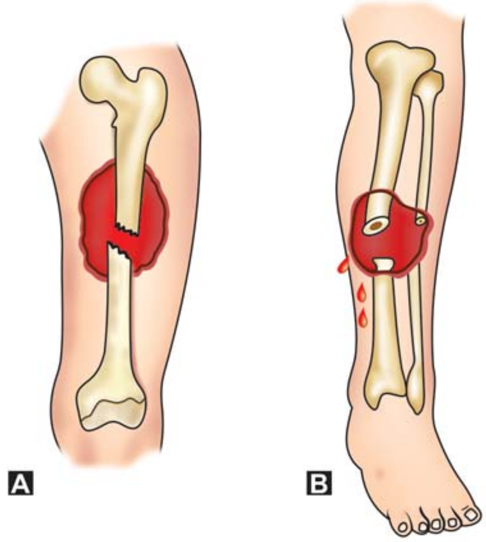


Figs 4.2A and B: Clinical photograph showing pin point compound fracture of the forearm

Remember

Force required to break a bone could be:
- Large and sudden (e.g. RTA)
- Repetitive (e.g. stress fracture)
- Trivial (e.g. pathological fractures).

Fig. 4.3: Clinical photograph showing Type II compound fracture of the femur

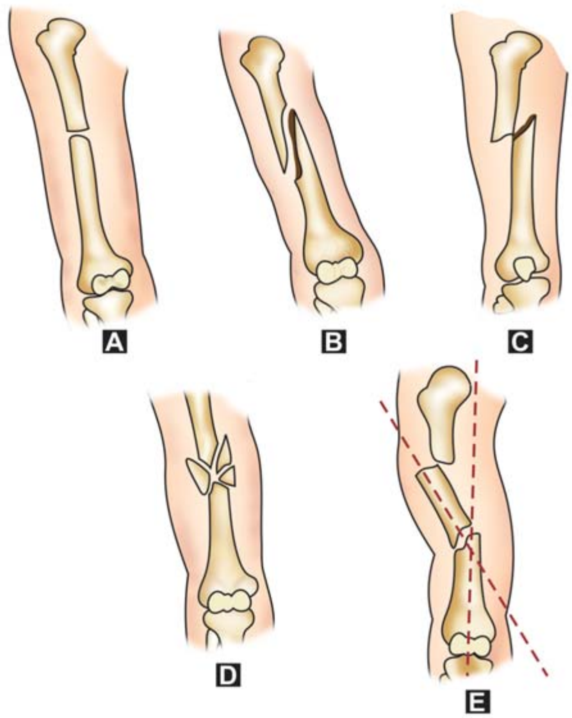


Figs 4.4A and B: (A) Simple and (B) Compound fractures

TYPES OF FRACTURE

- Simple or compound (Figs 4.4A and B) these have been already explained.
- Based on the extent of fracture line.
  - — Incomplete fractures—it involves only one surface or cortex of the bone.
  - — Complete fracture—here the fracture involves the entire bone. A complete fracture could be undisplaced or displaced.

Causes for displacement
- Muscle forces
- Gravity
- Obliquity of the fracture line
- Improper handling of the fracture.

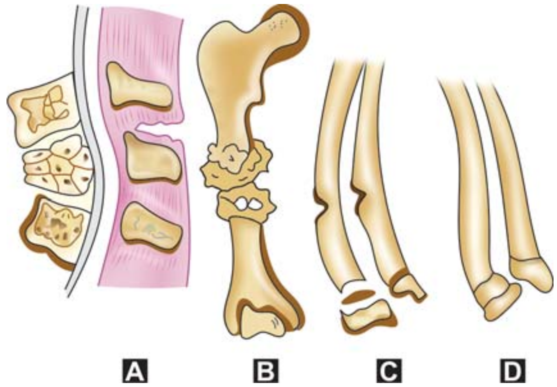


Figs 4.5A to E: Type of fracture based on fracture patterns: (A) transverse, (B) spiral, (C) oblique, (D) comminuted, and (E) segmental

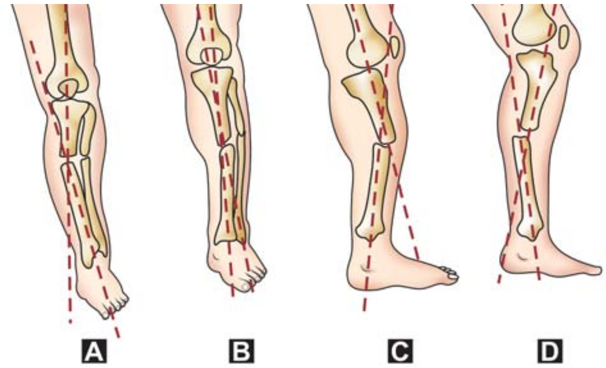
- Based on fracture patterns (orthopedic trauma association classification—Figs 4.5A to E).
  - — *Linear fractures* These could be *transverse*, *oblique* or *spiral*. Any fracture which forms an angle less than 30° with the horizontal line is called transverse. Angle equal to or more than 30° is termed oblique.
  - — *Comminuted fractures* Here the fracture fragments are more than two in number. They are further sub classified into < 50 percent comminution or more than 50% comminution. Butterfly-shaped fractures are also included in this group.
  - — *Segmental fractures* A fracture can break into segments and the segment could be two levels, three levels, and a longitudinal split or comminuted.
  - — *Bone loss* This could be a less than 50 percent bone loss or more than 50 percent bone loss or a complete bone loss.

Atypical Fractures

- *Greenstick fractures* It is seen exclusively in children. Here the bone is elastic and usually bends due to buckling or breaking of one cortex when a force is applied. This is called a greenstick fracture. Figures 4.6A to D show atypical fractures



Figs 4.6A to D: Atypical fractures: (A) compression, (B) pathological, (C) greenstick, and (D) torus fractures



Figs 4.7A to D: Types of angulation in fractures: (A) medial, (B) lateral, (C) anterior, and (D) posterior

- *Impacted fractures* Here the fracture fragments are impacted into each other and are not separated and displaced.
- *Stress or fatigue fracture* It is usually an incomplete fracture commonly seen in athletes and in bones subjected to chronic and repetitive stress (e.g. third metatarsal fracture, fracture tibia, etc.).
- *Pathological fracture* It occurs in a diseased bone and is usually spontaneous. The force required to bring about a pathological fracture is trivial.
- *Hairline or crack fracture* It is a very fine break in the bone which is difficult to diagnose clinically. Radiology usually helps.
- *Torus fracture* This is just a buckling of the outer cortex.

Remember

- Greenstick fracture-occurs in children
- Stress fracture-common in athletes
- Fatigue fractures-in occupations like police, nurse, etc.
- Pathological fractures-usually seen in elderly people
- Hairline or crack fracture-is a special variety of incomplete fracture.

DISPLACEMENT OF FRACTURES

A complete fracture usually gets displaced due to various factors already mentioned. Depending on the direction of force, mode of injury, pull of the muscles, a fracture can show any one of the following displacements or angulations (Figs 4.7A to D).

- Anterior angulations or displacement.
- Posterior angulations or displacement.
- Varus or medial angulations or displacement.
- Valgus or lateral displacement or angulations.
- Shortening.
- Translational.

APPROACH TO ORTHOPEDIC INJURY

Orthopedic injuries encompass a wide range of problems starting from bone and joint injuries, strains, sprains and damage to associated neurovascular structures.

The value of a systematic clinical approach to unravel the myth and mysteries of orthotrauma cannot be less emphasized. Time-honored and time-tested clinical formulae applied so successfully in the diagnosis of various system disorders can be applied for orthotrauma also and consists of the following.

History Contrary to popular beliefs, a proper history gives vital clues and goes a long way in arriving at a proper diagnosis.

Age Certain fractures have predilections for certain age groups (Table 4.1). Hence, the practice of first enquiring about the age of the patient is a step in the right direction.

TABLE 4.1: Fractures and dislocations in different age groups

Age	*Fractures and dislocations*
• Birth	Brachial plexus injury, fracture, Clavicle, fracture humerus, etc.
• Early childhood	Supracondylar fracture of humerus. Epiphyseal injuries.
• Late childhood	Posterior dislocations of elbow. Slipped capital epiphysis. Monteggia fractures.
• Adult	Fracture of long bones. Hip and shoulder dislocations.
• Elderly	Colles' fracture. Fracture neck femur.

Note: In spite of age predilections, any fracture can be seen in any age group as an aberration.

TABLE 4.2: Modes of injury in different age groups

Age	*Common modes of injury*	*Examples*
Children	• Fall on outstretched Hands usually while on play or from a height	Fracture clavicle, Fracture and dislocations of any upper limb bones.
Adults	• Fall from height	• Upper limb injuries, spine Injuries, etc.
	• Diving injuries	• Cervical spine injuries.
	• RTA	• Sny combination of Injuries.
		• Whiplash injury.
		• Dashboard injuries like fracture patella, posterior hip dislocation, etc.
	• Sports injuries	• Ankle and shoulder, elbow and knee joint injuries.
	• Assaults	• Long bone fractures (e.g. nightstick fracture of ulna).
Elderly	Trivial fall	• Colles' fracture
		• Fracture neck femur, etc.

Note: High-velocity trauma due to RTA can produce any combination of bone and joint injuries.

Sex Colles' fracture is more common in females and supracondylar fracture humerus, posterior dislocations of elbow are more common in males.

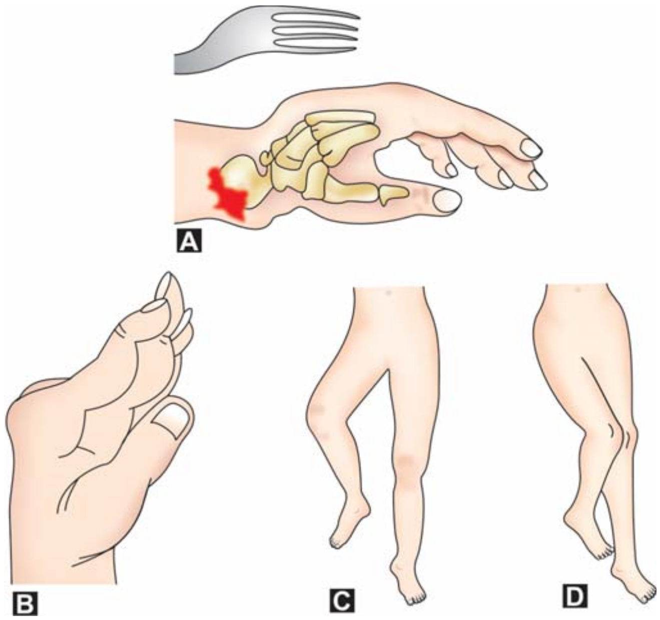
Mechanism of Injury

This could be different in different age groups as mentioned in Table 4.2.

Clinical Features

A patient with limb injuries may present with the following complaints.

- *Pain* This is very subjective symptom and is invariably the first and the most important complaint. It may be mild, moderate and severe and may be due to tearing of periosteum (which contains the nerve endings), soft tissue injury, nerve injury, etc.
- *Swelling* It is due to soft tissue injury, medullary, bleeding and reactionary hemorrhage. Swelling is usually more in fractures and less in dislocations.
- *Deformity* Patients with displaced fractures and dislocations usually present with some deformity.
- *Inability* To use the affected part is another frequent complaint.



Figs 4.8A to D: Some important deformities in orthopaedics: (A) dinner fork deformity, (B) swan neck deformity, (C) anterior dislocation of hip, and (D) posterior dislocation of hip

Having made a note of the history and presenting complaints, effort is now directed towards eliciting the signs, some of which are general and some are injury specific.

- *Tenderness* This is an important clinical sign in bone and joint injuries and is usually seen after trauma. Importance of tenderness, methods of elicitation and grading is mentioned in the box (*see* p. 42).
- *Swelling* The swelling is examined for shape, size, consistency, tenderness, fluctuation, etc.
- *Deformity (Table 4.3.)* This is usually seen in displaced fractures and dislocations. Undisplaced fractures, mild strains and sprains usually show no deformities. Some of the deformities are very characteristic (Figs 4.8A to D) and specific and help in making a spot diagnosis.

TABLE 4.3: Famous orthopedic deformities due to fractures

Deformities	*Fractures*
• S-shaped deformity	Supracondylar fracture humerus.
• Gunstock deformity	Malunited supracondylar fracture humerus.
• Cubitus valgus	Malunited lateral condyle fracture of humerus.
• Dinner fork deformity	Malunited Colles.
• Mallet finger	Avulsion tip of base of distal phalanx.
• Genu varum/valgus	Tibial condylar fractures.
• Varus-valgus at ankle	Ankle injuries.
• External rotation lower limb	Fracture neck femur, trochanteric fracture, fracture shaft femur, fracture tibia.

Fig. 4.9: Clinical photograph showing limb shortening and rotation

- *Abnormal mobility* Between fracture fragments is a sure sign of fracture.
- *Loss of transmitted movements* When one end of the limb is rotated, it automatically gets transmitted to the other end. Due to the break in the continuity this is no longer possible in displaced fractures.
- *Crepitus* This is an abnormal grating sensation produced by the friction between two ragged surfaces of the fracture fragments. Obviously it is elicitable only in displaced fractures. It should be elicited very gently and in the end.
- *Shortening* Limb shortening of various degrees is fairly common in bone and joint injuries (Fig. 4.9).

Note Crepitus, abnormal mobility, deformity and loss of transmitted movements cannot be elicited in undisplaced fractures, stress fractures, impacted fractures, etc.

Remember

Clinical manifestations in a fracture are due to:
- Fracture *per se*
- Its complications
- Or both

Clinical Signs

Various clinical signs are described in fractures. They can be best represented as follows in order of their importance (Table 4.4).

TABLE 4.4: Different clinical signs in fractures

Clinical signs	*Features*
Unfailing signs	• Abnormal mobility. • Crepitus.
Reliable signs	• Tenderness. • Shortening.
Important signs	• Bruise. • Swelling.
Other signs	• Loss of function. • Deformity.
Late or inconstant signs	• Blisters. • Ecchymosis. • Swelling due to callus.

Remember

"D" in fracture
- Deformity is seen often in displaced fractures.
- Displacement could be anterior, posterior, medial or lateral.
- Distal fragment is the reference point to suggest the type of displacement.
- Dislocation of joints usually presents a deformity.

About crepitus It is defined as an abnormal grating sensation either felt or heard. It could be
- Fine, e.g. osteoarthritis
- Coarse, e.g. fractures
- Snap, e.g. snapping tendons.

Remember It is unkind to elicit a crepitus in a fracture for fear of hurting the patient.

About tenderness

Remember

Tenderness may be the only evidence of fracture in
- Crack fracture
- Hairline fracture
- Stress fracture
- Fatigue fracture
- Torus fracture
- Pathological fracture.

Method of eliciting Proceed from normal area to the affected part for better patient compliance.

Grading
- Grade I-Just a suspect.
- Grade II-Patient winces on pressure.
- Grade III-Patient winces and withdraws.
- Grade IV-Patient will not allow to touch.

This grading of tenderness is superior to the conventional mild, moderate and severe grading.

Clinical manifestations due to neurovascular injuries Certain fractures are known to cause neurovascular damage quite frequently, e.g. supracondylar fracture of humerus in children. Impending vascular damage is detected by the familiar five Ps and nerve injuries are detected by the classical deformities and screening tests (as described in peripheral nerve injuries).

About five Ps

In detecting impending vascular damage
- **P**ain
- **P**allor
- **P**ar aesthesia
- **P**ulselessness
- **P**aralysis.

DEFORMITIES

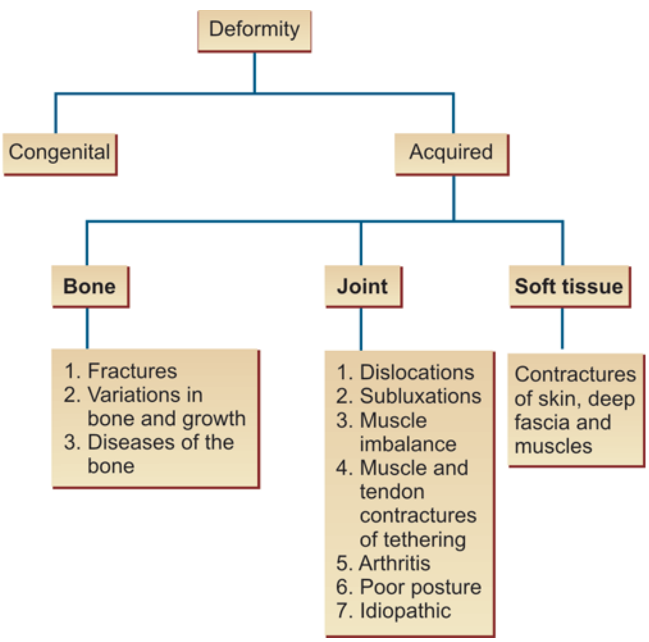
Definition

Any deviation from the normal anatomy of a bone and joint is called deformity.

Classification

The deformities can be classified as shown as Flow chart 4.1.

Flow chart 4.1: Showing different types of orthopedic deformities

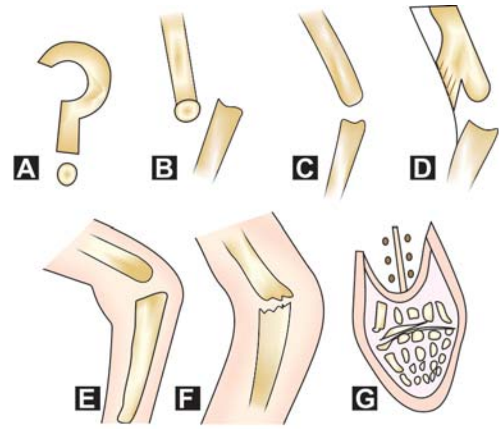


Acquired deformities are more commonly encountered than the congenital variety.

Congenital Deformities (Since Birth)

These are due to some genetic abnormalities or environmental variations or both. They may be obvious at birth or may be seen few years later. Incidence is around 2 to 3 percent. They may be so severe that the child is still born or may be so minor that it is not noticeable.

(See Chapter 23 on Congenital disorders for details).



Figs 4.10A to G: Causes for deformity: (A) idiopathic, (B) dislocation, (C) muscle imbalance, (D) muscle tethering, (E) soft tissue contractures, (E) fractures, and (G) postural

Acquired Deformities

These could be due to problems in the bone, joint or soft tissues (Figs 4.10A to G).

Bone Causes

The following causes are responsible for deformities in the bone.

- *Growth disturbances* Tumor, infections or trauma near the growth epiphysis can cause unequal stimulus, suppressions or stimulation of growth. This results in bending, shortening or lengthening of a bone respectively, e.g. osteomyelitis, epiphyseal injuries, tumor, etc.
- *Bone disorders* Endocrine disorders, metabolic disorders, developmental disorders are some of the examples with bone deformities.
- *Fractures* This is by far the most important cause for a bone deformity. All displaced and fresh fractures cause temporary deformity while malunion or nonunion of fractures lead to deformities at a later date (Fig. 4.11).

Joint Causes

The causes for the deformities due to joint are varied and the more commoner ones are:

- *Dislocation or subluxation* This is usually due to trauma. It may also be seen due to pathological conditions of the hip, e.g. TB hip.

Fig. 4.11: Clinical photograph showing deformity following fracture

- *Muscle misbalance* Muscles balancing the joint or either side, if they are either overactive (e.g. cerebral palsy) or under active, e.g. polio, deformity of the joint results.
- *Tethering of muscles and tendons* This can take place due to the growth of fibrous tissue following infections or due to callus following fractures. Tethering restricts the joint movements and if held for some time deformity results, e.g. VIC, tenosynovitis of finger flexors, etc.
- *Arthritis* of any joint may give rise to muscle spasm in the initial stages and fibrous or bony ankylosis in later stages giving rise to deformities, e.g. TB knee, rheumatoid hand, TB hip, etc.
- *Postural* This is due to improper postural habits like hallux valgus in women due to tight and rigid shoes.
- *Idiopathic* Here, there is no apparent cause for the joint deformities, e.g. idiopathic scoliosis.

Deformity due to Soft Tissue Contractures

Soft tissue contractures (skin and deep fascia) other than the muscle contractures can also cause joint deformities, e.g. Dupuytren's contractures, post burn contracture, etc. (Fig. 4.12).

Treatment Options

Conservative measures These include manipulative correction under anesthesia and retention by splints or casts, gradual correction by traction or splints, etc. (e.g. turn buckle splints). Correction by plaster wedging is hazardous.

Surgical measures There are various surgical options available.

- *Ilizarov* This is the gold standard for deformity correction in recent times.
- *Soft tissue* release.
- *Tenolysis*, tendon lengthening or tendon transfers are successfully employed in polio, cerebral palsy, etc.

Fig. 4.12: Clinical photograph showing soft tissue contracture

- *Arthroplasty* can be crude as a salvage procedure (e.g. girdle stone excision in TB hip) or sophisticated as is total hip replacement or total knee replacement in rheumatoid and other disorders.
- *Corrective osteotomy* This is a simple but effective procedure to correct joint deformities, e.g. French osteotomy in cubitus varus deformity, etc.
- *Arthrodesis* Fusion of the joints in functional positions in badly damaged joints, e.g. TB knee, rheumatoid arthritis, etc.
- *Epiphyseal growth arrests* When potential for growth is still left, stapling of the epiphysis can be attempted on one side to correct the bending deformity, e.g. in genu varum or valgum.

INVESTIGATIONS IN ORTHOTRAUMA

Radiography

It is an important diagnostic tool for fractures. Minimum two views, anteroposterior and lateral are required as bone is a cylinder (Fig. 4.13). Sometimes an oblique view and other special views are required depending upon the clinical situations and bone under study.

Role of X-ray

- Helps confirm the clinical diagnosis.
- Helps study the fracture anatomy.
- Helps study the fracture displacement.
- Helps to detect crack and stress fractures.

Fig. 4.13: Plain X-ray showing fracture of both bones tibia and fibula

- Helps to plan the treatment.
- Helps to detect fracture dislocation combinations, e.g. Monteggia.
- Helps to ascertain postreduction status of fractures.
- Helps in medico legal study.

Remember

The rules in X-rays:
- Better no X-ray than one view X-ray.
- X-ray is a shadow, it conceals and distorts. Hence interpret X-rays with caution.
- A joint above and joint below should be included with the fracture under study.
- The fracture should be in the middle of the film.
- Exposure should be adequate and the soft tissue shadow should be delineated properly.
- X-rays should be read by holding the film in an anatomical position.
- Proper protective measures against radiation should be adopted.
- Avoid unnecessary X-rays.
- Check X-rays are to be taken without disturbing the plaster cast.

CT Scan and MRI

These are the most sophisticated investigative methods available now in orthopedics. Both are noninvasive and are extremely useful in detecting both soft tissue and bony injuries.

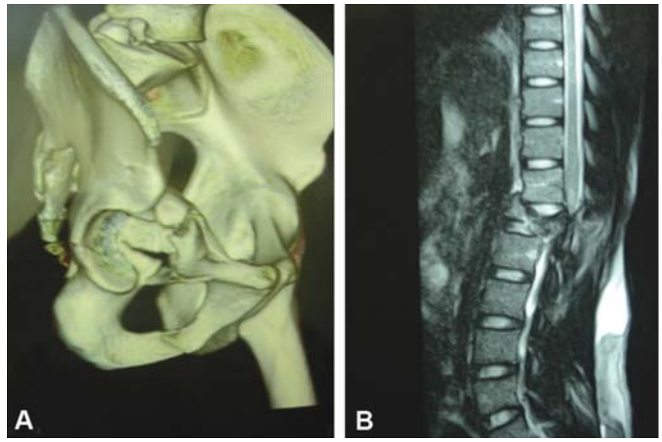


Fig. 4.14: CT scan showing acetabular fractures and MRI of the spine showing compressed fracture of the vertebra

Note

CT scan: This is helpful in detecting fracture of skull, pelvis, spine and identifying loose bodies in the joint (Fig. 4.14A).

MRI: This is useful to diagnose any fracture. In addition, it helps to identify soft tissue and ligament injuries. It is certainly the Gold Standard' but has its Achilles heel in being expensive (Fig. 4.14B).

MANAGEMENT OF FRACTURES

The goal of fracture management is to restore the anatomy back to its normal or as near to normal as possible.

The responsibility of an orthopedic surgeon is to ensure that there is no functional disability to the patient following the treatment of fractures.

Management of fracture can be broadly classified and discussed under the following heads:
- Management of simple fractures.
- Management of open fractures.
- Management of complicated fractures.

Management of Simple Fractures

Simple fractures are managed by conservative and operative methods.

Conservative Methods

- For undisplaced fractures, incomplete fractures, impacted fractures.
  - — Cuff and collar sling for upper limb fractures.
  - — Strapping For fracture clavicle, fracture ribs, etc.
  - — Plaster slabs Plaster of Paris slabs can be used to support the injured limb.
  - — Rest and non-steroidal anti-inflammatory drugs (NSAIDs) for impacted fracture neck of femur, etc.

- For displaced fractures here the aim is to restore back the normal anatomy of the bone by either closed or open reduction.

Management of Fractures by Closed Reduction

This consists of resuscitation, reduction, retention and rehabilitation (4Rs).

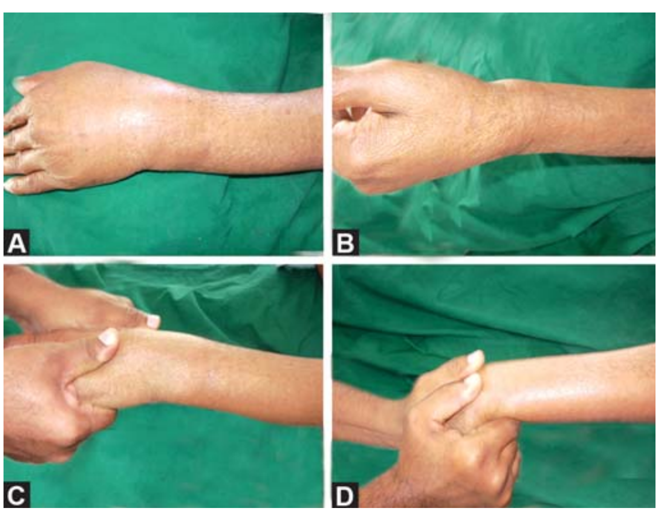
Resuscitation

Resuscitation is the top most priority if the patient is in shock following a fracture. A to F management proposed by Mac Murthy is to be followed in all situations of emergencies (*see* p. 205).

Reduction

Reduction of the fracture fragments if it is displaced. Usually it is done under general anesthesia after adequate radiographic study. Reduction methods are:

- *Closed reduction* It is adopted usually for simple fractures. The technique followed is traction and counter traction method. It is a blind technique and needs considerable skill and expertise. It commonly results in malunion (Figs 4.15 and 4.16).
- *Continuous traction* Certain examples where continuous traction can be used for reduction of tractions are Gallow's traction for fracture shaft femur in children, balanced skeletal traction for adult shaft femur fractures, etc.
- *Open reduction* It is done when the above methods fail or if there are specific indications.



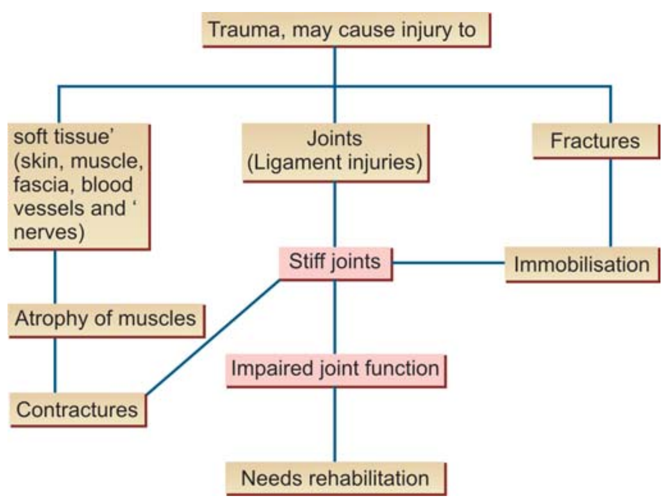
Figs 4.15A to D: Closed technique of reducing a displaced Colles fracture under general anesthesia by traction and counter traction methods

Figs 4.16A and B: Retention after closed technique of reducing a displaced Colles' fracture under general anesthesia by traction and counter traction methods

Rehabilitation

Reduction of displaced fractures by closed methods and retention of the fragments by plaster cast or slab, restores the anatomy of the bones, from here nature takes over to bring about union of the broken bones in a sound position. But this is not the end of the story of fracture healing. To have a happy climax for the injured, you have to return him to the pre-injury state both anatomically and functionally. This is where rehabilitation comes into picture in restoring back the lost function. Needless to say it is a vital cog in the fracture management which is absolutely indispensable. Flow chart 4.2 shows musculoskeletal injuries in trauma.

Flow chart 4.2: Showing musculoskeletal injuries in trauma



Note: All fractures may not need reduction or retention. But, all fractures need rehabilitation.

Principles of rehabilitation There are two important principles of rehabilitation, namely:

1. Restore the function and movements of the fractured limb.
2. Retrain other unaffected joints from losing their normal movement and function.

Note: Thus, rehabilitation has to not only cajole the affected part to limp back to normal but has to keep the romance alive with the unaffected part, so that it does not feel neglected and go astray!

Rehabilitation steps Fractures treated by closed reduction and splint age has to follow a rehabilitation protocol mentioned below:

During fracture immobilization

- Keep the limb elevated, so that gravity aids in keeping the swelling at bay!
- Joints not included in the immobilization should be actively exercised.
- Joint muscles which are immobilized also need to be exercised but the isometric way. This keeps the muscle atrophy at bay!
- Encourage the victim to carry out the functional and daily activities with the normal limb.
- Encourage the normal pattern of movement. In lower limbs during non or partial weight bearing by using walker or crutches the patient is taught to bear weight and walk.

During the post-immobilization phase

Aims

- Mobilize the immobilized joints.
- Restore the power of immobilized muscles.

Methods

- To alleviate pain, thermotherapy modalities like ultrasound, TENS, SWD helps.
- If the fracture has united firmly, isotonic exercises can be commenced.
- To mobilize the joints, active, active assisted exercises are commenced.
- To strengthen the muscles progressive resistive exercises are indicated.
- Gait training in lower limb fractures.

Note: Do not forget the all important 'plaster care' during immobilization:

- Trim the edges of the plasters.
- Keep the plaster neat and tidy.
- Avoid swelling like a plague.
- Look for and attend to any cracks, fissures, crevices, etc.
- Do not wet the plaster.
- Prevent the ants, bugs, mites, etc. sneaking beneath the plaster.

Quick Facts

Rehabilitation protocol for plaster treatment

During immobilization	*During mobilization*
• Limb elevation	• Elastic bandaging and limb elevation
• Active exercises for unaffected joints	• Active exercises for affected and unaffected joints
• Isometrics for immobilised muscles	• Isometrics and isokinetics for the muscles
• Functional activities by unaffected limb	• Encourage functional activities with affected limb
• Crutch walking training in lower limb fractures	• Gait training in lower limb fractures

Quick Facts

Role *vs* function of a physiotherapist

Role

- He is part of the team treating fractures.
- Make an assessment of patient's needs and conditions.
- To choose and explain the planned physical treatment to the patient.
- To restore the function back to normal.
- To explain and forewarn any likely complication during or after treatment.

Assess

This should be done, 'before' beginning of the treatment and also 'during' treatment:

- Mode of injury.
- Date and time of injury.
- Diagnosis
- Look for other injuries.
- Study the signs and symptoms of fractures.
- Study the neighboring joints.
- Study the general examination.
- Study the educational, occupational and domestic background of the patients.

Fracture Management by Open Reduction (Operative Management)

As mentioned earlier open method is indicated once the conservative methods fail and when there are specific indications. These indications could be absolute, relative or rare as mentioned in Table 4.5.

TABLE 4.5: Indications for open reduction and internal fixation

Absolute
- Failed closed reduction
- Displaced intra-articular fractures
- Type III and IV epiphyseal injuries
- Major avulsion fractures
- Nonunion
- Replantation of extremities

Relative
- Multiple fractures
- Delayed union
- Loss of reduction
- Pathological fractures
- For better nursing care
- To avoid prolonged bed rest
- Closed methods ineffective in Galeazzi fracture,
- Monteggia fracture, femoral neck fracture, etc.

Questionable
- Neurovascular injury
- Open fractures
- Cosmetic reasons
- Economic consideration

Principles of open reduction *(known after Lambotte)* Principles of open reduction as suggested by Lambotte includes:

Exposure The fracture is adequately exposed through a proper approach.

Reduction of the fracture fragments under direct vision is carried out.

Temporary stabilization of the fracture fragments by K-wire is done first.

Definitive stabilization of the fracture using plate and screws or intramedullary nail, etc. is done later.

Retention after open reduction After open reduction the fracture fragment invariably needs to be fixed internally.

The choice of implants

K-wire For epiphyseal injuries and for small bones of hand and feet (diameter of the K-wires varies from 1-3 mm) (Fig. 4.17A).

Screws For avulsion fractures and butterfly fragments.

Fig. 4.17A: Clinical photograph and X-ray showing K-wire fixation in phalangeal fractures

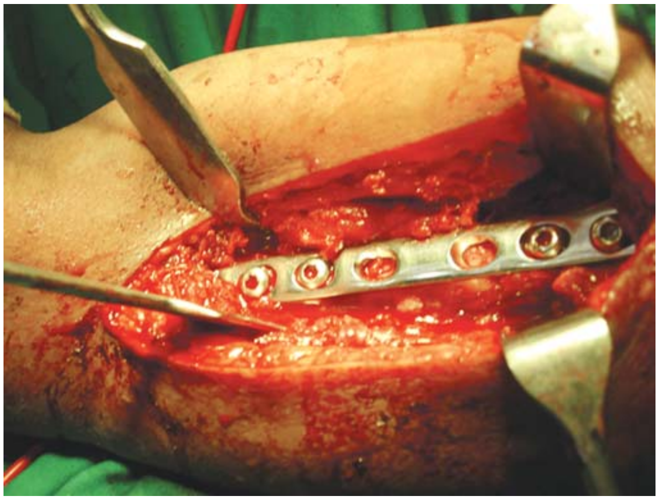


Fig. 4.17B: Clinical photograph of plate and screw fixation in long bone fracture

Intramedullary nails For fracture through the narrowest portion of a medullary canal of a long bone.

Plate and screws For proximal and distal third fractures of long bones (Fig. 4.17B).

Interlocking nails For segmental fractures comminuted fractures, etc. of long bones.

Hip implants For fracture neck femur. Smith Peterson's nail, Richard's compression screw, multiple cannulated screws, etc.

Spine implants Steffee plate and screws (VSP's), Luque's rod, Hart shill frame, Harrington's rods, etc.

Steel Wires No. 18-20 gauge Useful for tension band wiring for fracture of patella, olecranon, etc.

Rehabilitation in Fractures Treated by Internal Fixation

In fractures treated by open reduction and internal fixation, the period of immobilization is short. The various steps are:

Before Suture Removal

- Sutures are removed usually on 12-14th day.
- In some cases, till the sutures are removed some form of temporary immobilization by way of a plaster slab or brace may be required.
- Other measures like limb elevation, active exercises of the unaffected joints and isometrics for the affected joints are the same as for rehabilitation in closed fractures.

Note In some cases like closed interlocking nailing of every femur or tibia, external immobilization may not be required at all.

After Suture Removal

- Active ROM exercises can be begun for the affected joints.
- Weight bearing may be slowly permitted depending upon the rigidity of internal fixation.
- Rest of the measures is the same as for the closed fractures.

Contraindications for open reduction
- Infection
- Small fragments
- Weak and porotic bone
- Soft tissue damage
- Undisplaced or Impacted fractures
- Poor general and medical condition

Disadvantages of open reduction
- Closed fracture converted into an open fracture.
- Fracture hematoma is disturbed.
- Scar tissue.
- Anesthetic problems.
- Foreign body reaction due to metals.

Remember

Success by open reduction depends on:
- Proper indications.
- Proper timing.
- Proper surgical approach.
- Proper technique.
- Proper selection of implant.
- Proper surgeon.
- Proper rehabilitation protocol.

OPEN FRACTURES

Open fracture is a surgical emergency and presents as a problem which is much more difficult than closed fractures. It is defined as a fracture which communicates with the external atmosphere due to break in the soft tissue cover.

CLASSIFICATION (Gustillo and Anderson's Classification)

Type I Wound is less than 1 cm in size. It is usually due to a low-velocity trauma.

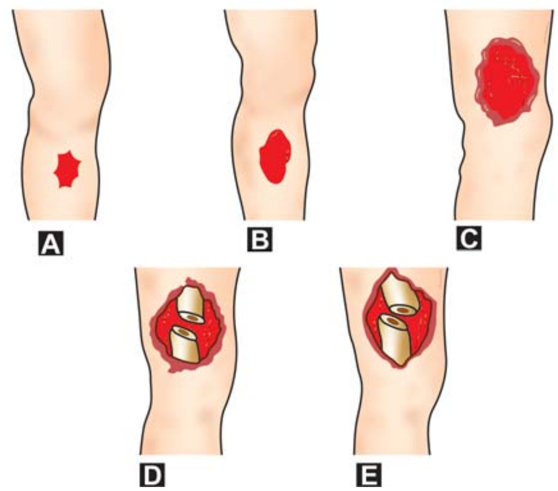
Type II Wound is more than 1 cm and less than 10 cm but there is no devitalisation of soft tissue and is associated with very little contamination.

Type III Wounds moderate and severe in size (> 10 cm). And the soft tissues are devitalized and contaminated.

Type IIIA Extensive soft tissue injury but with adequate soft tissue to cover the fractured bone.

Type IIIB Extensive soft tissue damage and loss. Bone cannot be covered and is exposed to the atmosphere.

Type IIIC Compound fractures with arterial injuries (Figs 4.18A to E).



Figs 4.18A to E: Varieties of compound fractures: (A) type I (< 1 cm), (B) type II (> 2 cm), (C) type IIIA, (D) type IIIB, and (E) type IIIC

APPROACH IN COMPOUND FRACTURES

Compound fractures are usually serious injuries and are due to high-velocity trauma. They may be associated with multisystem and multiskeletal injuries. The approach should be more cautious and the following protocol is recommended.

Fig. 4.19: Clinical photograph showing compound injury

General physical examination This is of vital importance since the patient is usually in shock. Levels of consciousness, pulse, blood pressure, breathing, etc. should be recorded.

Examination of other systems Examinations should be carried out for head injury, neck and face injury, chest injury, blunt injury abdomen, pelvic fractures and spine fractures.

Examination of the compound injury This usually proceeds in the same line as mentioned in examination of closed fractures. In addition to the usual clinical features one should look for soft tissue injury and wound, bone loss, absence of bone pieces, distal neurovascular status of the limb, etc. (Fig. 4.19).

Investigations

General investigations Hb percentage, blood group, bleeding time and clotting time, urine examinations, etc. are carried out.

X-ray of the part as for other fractures but look for missing piece of bone in open fractures.

Management Principles

Aims of treatment

- To convert a contaminated wound into a clean wound and thus help to convert an open fracture into a closed one.
- To establish union in a good position.
- To prevent pyogenic and clostridial infections.

Considerations

- First to stabilize the general condition of the patient as the patient is usually in shock. This consists of resuscitation, blood transfusion, intravenous fluids, antibiotics, oxygen administration, etc.
- To keep the wound covered with proper sterile bandages till patient is ready for surgery.
- Open fractures are surgical emergencies and surgery is to be done as soon as the patient is fit.

Treatment Plan

After stabilizing the general condition of the patient, surgical debridement is planned under strict aseptic measures in a major operation theater.

Debridement (known as unbridling) this is the most important step in the management of compound fractures. It consists of the following steps (4Es):

1. *Exploration of the wound* The wound should be sufficiently explored proximally and distally to have a proper assessment of the extent of the damage.
2. *Excision of all nonviable structures* A thorough excision of all the nonviable structures is important to prevent infection. The recognition of nonviable tissue before excision is of paramount importance. The tissues are dealt as follows:
   - *Skin* here the plan is to excise all the dead skin and yet be conservative.
   - *Muscle* Nonviable muscle should be removed but often it is overlooked hence the axiom, "when in doubt, take it out". 5Cs help in deciding the muscle viability (Table 4.6).

TABLE 4.6: Muscle viability and nonviability (5Cs)

Features	*Viable*	*Nonviable*
Color	Pink	Pale
Consistency	Firm	Flabby
Capacity to bleed	Preserved	Lost
Circulation	Present	Absent
Contractility	Present	Absent

   - *Bones* Small bits of loose bones devoid of soft tissues are removed. Large fragments with their soft tissue attachments are preserved.
   - *Nerves and vessels* Primary repair is done if the wound is clean. In contaminated wounds they are dealt at a later stage.
3. Evacuation of foreign bodies like dirt, glass, stones, pebbles, etc. These foreign bodies are a source for infection and may invite a foreign body reaction. Hence, they have to be removed by a thorough irrigation (normal saline is used).

About irrigation

- Dilution is the solution of pollution.
- Single most essential step.
- Minimum 10 liters of saline is used.
- Forcible streams are avoided.

- Swirling movements of the irrigation fluid is preferred.
- Irrigation or wound toilet helps to clear the foreign bodies and clots minimizing the chances of contamination.

4. External fixators are used to fix the fracture fragment after debridement. Plaster of Paris and internal fixation devices have little and controversial role in the fracture management of compound fractures. External fixator's help to stabilize fracture fragments, allow daily wound inspection and dressing, permit procedures like skin grafting, etc. to cover the wound, allow soft tissues to heal apart from providing early mobilization. In open tibial fracture, external fixator can be safely exchanged to internal fixation within 3 weeks with only 5 percent incidence of deep infection (Figs 4.20 and 4.21).

Fig. 4.20: Showing treatment of compound fractures using AO type external fixators

Fig. 4.21: Showing treatment of compound fractures using circular type of external fixators (Ilizarov)

OTHER FORMS OF FRACTURE IMMOBILIZATION

- Pins and plasters-limited use can be tried in type I fractures.
- Limited internal fixation-in grade I and some grade II, grade IIIC fractures
- Skeletal traction-overhead olecronon traction for compound supracondylar fractures. Bohler-Braun skeletal traction for open femoral shaft fractures is some of the examples.
- Plaster of Paris casts practically have no role.

Open facts in open fractures

About fixation methods in open fractures

• External fixators	liberally used.
• Internal fixators	sparingly used.
• Skeletal traction	rarely used.
• Plaster casts	occasionally used (type I).
• Functional brace	never used.

Poetic facts

James Learmanth's poem depicts the four major principles of debridement:

On the edges of the skin take a piece, very thin (1); the tenser the fascia, the more you should slasher (2); of muscles much more, until you see fresh gore (3); and the bundles contract at least the impact; hardly any of bone, only bits quite alone (4).

Remember

Problems peculiar to open fracture

- In open fractures soft tissue injury is a dreaded problem than the fracture itself.
- A surgical emergency.
- Three problems:
  — Infection from the environment.
  — Problems of soft tissue loss.
  — Active infection.
- Effective immobilization rendered difficult.
- Bone repair is delayed. Speed is the watchword in treatment.
- Nonunion, malunion, chronic osteomyelitis are very common.
- Difficulty in using the standard internal fixation methods renders managing the fractures very difficult.

Definitive wound care After resuscitation, debridement and application of external fixators attention is now given to the definitive wound care. This is an extremely important step as the primary objective of treatment in open fracture is to convert an open wound into closed wound. The wound closure could be primary or secondary.

Criteria for Primary Closure

- All necrotic material should be removed.
- Circulation should be normal.
- Nerve supply should be intact.
- Patient's general condition should be stable.
- Wound should be closed without tension.
- No dead space should be left after closure.
- There should be no multisystem injuries.

If all the above criteria are met the wound is closed by primary suturing. The following alternative measures are considered in the event of the above criteria not being met:

- Split skin graft.
- Pedicle or flap graft.
- Secondary suturing after 2-3 weeks.
- Relaxing incisions to mobilize the neighboring skin.
- Biological dressings (homologous or heterogonous skin).
- To leave it open and to follow by regular dressings wound inspection and closure at a later date.

Role of antibiotics It will not replace the wound debridement. Topical antibiotics have very little role. Parenteral administration is recommended. The choice of antibiotics is usually a broad spectrum, bactericidal hypoallergenic agent with adequate serum concentration.

Role of AGGS and ATS Patient has to be protected against tetanus and gas gangrene by effective immunization against them. Role of primary amputation in open fractures. This is controversial but can be considered in type IIIC with neural injury and if the warm ischemia is more than 6 hours.

Remember

In open fractures

- Debridement is the main stay of treatment
- The procedure is 4 Es:
  - **E**xploration of the wound.
  - **E**xcision of the devitalized tissues.
  - **E**vacuation of the foreign bodies.
  - **E**xternal fixators.
- Devitalized tissue recognized by 5 Cs.
- Wound irrigation is the single most important step.
- Primary aim is to convert an open wound into a closed one.
- Wound closure is to be decided with caution.
- Antibiotics cannot replace wound debridement.
- External fixators have definite role.
- Internal fixators and plasters have limited role.
- Ultimate goal is to restore the patient's limb and function as early as and as full as possible.

Rehabilitation in Compound Fractures

Rehabilitation in compound fractures poses a greater challenge due to soft tissue injury. This prolongs the rehabilitation time and is directly proportional to the type of compound injuries.

Most of the compound fractures are treated by external fixators. Of late interlocking nailing has come as a silver living in reducing the morbidity associated with these difficult fractures.

Rehabilitation Protocol in Compound Fractures

During skin healing

- Daily wound inspection and wound care.
- Care for the sites of pin insertion.
- Limb elevation to combat limb edema.
- Active exercises to the unaffected joints.
- Isometrics to the immobilized muscles.
- An effort should be made to mobilize the patient early with crutches, etc.

After soft tissue healing

- External fixator can be removed after bony consolidation.
- Active exercises to the affected joints can now be begun.
- Vigorous active exercises are advocated.
- Strengthening exercises are vigorously pursued.
- Patient should be mobilized at the earliest with the help of assistive devices.
- Independent walking with suitable training should be begun at the earliest.

Approach to a Polytrauma Case

This is as mentioned in the approach to a compound fracture. Speed is the watchword in the approach towards a multiple trauma case and should proceed in the following lines:

Initial evaluation The ABCDEs of initial examination of a polytrauma case are as follows:
A—airway, B—breathing, C—circulation, D—disability (neurologic examination), E—exposure, F—fracture examination, G—go back to the beginning for a secondary survey and H—help.

Secondary evaluation After the initial evaluation and resuscitation, a more systematic and detailed evaluation of the injuries mentioned above are done. Fractures are splinted externally and managed at a later date. But in few cases primary internal fixation is recommended in ipsilateral fractures, multisystem injuries, etc. for faster rehabilitation. Dislocations are promptly reduced.

Fracture examination This is done systematically as mentioned in the previous discussions.

Investigation

This includes routine blood examinations, radiographs of head, neck, chest, spine and affected parts. CT scan and MRI of injured structures are mandatory. Management of a polytrauma case is discussed in chapter on First Aid.

PATHOLOGICAL FRACTURES

When a fracture occurs through a bone which has already been weakened by a generalized or localized skeletal disorder it is called a pathological fracture. Unlike traumatic fractures, these fractures take place either spontaneously or due to trivial trauma (Table 4.7).

Clinical Features

The patient usually complains of fracture following a trivial trauma. He or she complains of having suffered pain or discomfort in the region of the affected bone some time before the fracture. The underlying cause for this could be either a generalized or a local skeletal disorder.

Practical point

Common causes for pathological fractures
Local disorders
- Metastatic carcinoma
  The primary could be in the lungs, breast, prostate, thyroid or kidney.
  Common sites
  — Vertebral bodies (thoracic/lumbar) (Fig. 4.22D)
  — Proximal half of femoral shaft (Fig. 4.22A).
  — Proximal half of humerus (Fig. 4.22B)
- Bone cyst of a long bone (Fig. 4.23A).

Generalized disorders
- Senile osteoporosis
  Common sites affected are
  — Lower end of radius (Fig. 4.22C)
  — Thoracic or lumbar vertebral body.
  — Neck or trochanteric region of femur (Fig. 4.23B).
  — Ribs (Fig. 4.22E)
- Paget's disease of bone
  — Shaft of tibia or femur.

Treatment

Conservative treatment has little role in the treatment of pathological fractures. The treatment recommended is open reduction, rigid, internal fixation with or without cement and bone grafting. The aim is to obtain quick union and mobilize the patient early. Pathological fractures due to Paget's disease, osteogenesis imperfecta, etc. unite in the usual time, fractures due to osteomyelitis, bone cyst unite late but fractures due to malignancy, metastasis do not unite at all though union is possible after chemotherapy or radiotherapy.

TABLE 4.7: Causes of pathological fractures

Localized diseases
a. *Infective disorders*
- Chronic pyogenic osteomyelitis
- Tubercular or syphilitic osteomyelitis

b. *Neoplasms*

Benign	*Malignant*
• Chondroma	• Osteogenic sarcoma
• Giant cell tumor	• Ewing's sarcoma
• Haemangioma spine (lung, breast prostate, kidney, etc.)	• Solitary myeloma
• Bone atrophy (e.g. polio, etc.)	• Metastatic carcinoma
• Tabes dorsalis, etc.	• Metastatic sarcoma

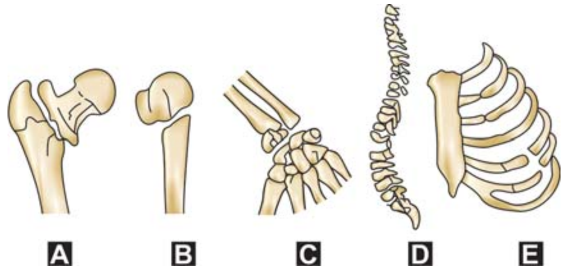
c. *Miscellaneous cause*
- Simple bone cyst
- Monostotic fibrous dysplasia
- Eosinophilic granuloma

General affections of bone
a. *Congenital disorders*
- Osteogenesis imperfecta.
- Fibrous dysplasia
- Gaucher's disease, etc.

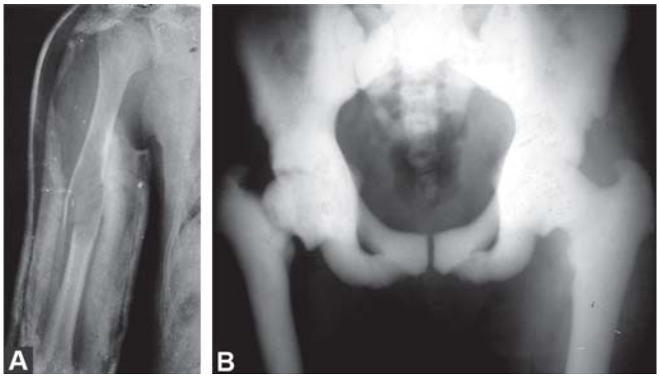
b. *Generalized rarefaction of bones*
- Senile osteoporosis
- Hyperparathyroidism
- Osteomalacia
- Nutritional rickets
- Scurvy

c. *Miscellaneous*
- Multiple myeloma
- Diffuse metastatic carcinoma

d. *Disseminated tumors*
- Paget's disease
- Fibrous dysplasia
- Gaucher's disease, etc.



Figs 4.22A to E: Showing common sites of pathological fractures (A) Neck femur, (B) neck humerus, (C) lower end of radius, (D) spine, (E) ribs



Figs 4.23A and B: (A) Pathological fracture humerus due to lytic lesion, (B) Intracapsular pathological fracture

Fig. 4.24: Showing stress fracture of III metatarsal bone

Fatigue or Stress Fractures

Fatigue or stress fractures occur due to repeated stress or minor trauma to a particular bone usually of the lower limbs and is most commonly seen in metatarsal bone (Fig. 4.24).

Fig. 4.25: Plain X-ray showing stress fracture

Here there is no single specific causative injury as in a traumatic fracture. The onset of pain is gradual or insidious. Activity increases the pain and rest relieves it. On examination, there is significant local tenderness, thickening of bone, local swelling, etc.

Radiograph

Radiograph of the part at first may not reveal any fractures but may be seen after 3 to 4 weeks. The fracture itself will be hairline, transverse and undisplaced. More striking than the fracture is a zone of callus that surrounds it (Fig. 4.25).

Treatment

Stress fractures usually heal by rest and support to the affected part.

Practical points

Common sites
- Second metatarsal bone-e.g. March fracture (due to repeated marching as in soldiers).
- Tibia or fibula-repeated running or dancing.
- Femur-occasionally.

Radiology
- I week-usually no fracture is detected.
- II/III week-faint hairline fracture, transverse/ undisplaced.
- Zone of callus that surrounds the fracture is more significant than the fracture itself.

Treatment is by rest

DISLOCATIONS

Dislocation is defined as a total loss of contact between the two ends of bones (Figs 4.26A and B). All dislocations are emergencies unlike fractures, for delay in reduction may damage the articular surface which is deprived of nutrition by the synovial fluid. Unlike fractures all dislocations need prompt reduction and early treatment because the patient will not be relieved of pain due to the persistent capsular stretch. The capsule contains nerve endings which give rise to pain.

Figs 4.26A and B: (A) Subluxation, and (B) dislocation

TABLE 4.8: Common traumatic dislocations

Area involved	*Types of dislocation*
1. Spine	Anterior, C_5 over C_6
2. Upper limb	
• Acromioclavicular joint	Type I/II/III
• Sternoclavicular joint	Anterior/posterior
• Shoulder joint	Anterior/posterior
• Elbow joint	Posterior
• Isolated dislocation of Superior radioulnar joint	Anterior
• Fracture dislocation of superior radioulnar joint	Monteggia fracture
• Fracture head of radius and dislocation of inferior radioulnar joint	Essex-, Lopresti fracture
• Wrist dislocations	Perilunar, lunar
• Kaplan injury	Carpometacarpal joint of the thumb
3. Lower limb	
• Hip dislocations	Anterior/posterior/central
• Knee joint	Posterior
• Patella	Lateral dislocations
• Ankle	Anterolateral
• Foot	Intertarsal
– Chopart's	
– Lisfranc's	Tarsometatarsal

Pathology

In a dislocation there could be damage to the capsule, articular cartilage, muscles, and ligaments in varying degrees. There could be osteochondral fractures and avulsion injuries.

Types of Dislocation-Congenital or Acquired

Congenital as in CDH and in acquired the following varieties are seen:

- Traumatic common in young adults due to high- velocity trauma (Table 4.8).
- Pathological, e.g. TB hip, septic arthritis, etc.
- Infective, e.g. Tom smith arthritis in infants.
- Paralytic, e.g. Poliomyelitis, cerebral palsy, etc.
- Inflammatory disorders, rheumatoid arthritis, etc.

Clinical Features

Traumatic variety is the most common type of dislocations one encounters in clinical practice. Patient gives history of trauma usually a road traffic accident (RTA) following which there is pain, swelling deformity and loss of movements. In dislocations of other varieties, clinical symptoms and signs pertaining to that particular disease are seen (Figs 4.27A and B).

Typical Deformities in Dislocations

- Shoulder-abduction deformity.
- Elbow-flexion deformity.
- Hip: Anterior-flexion abduction and external rotation deformity.
  Posterior-flexion, abduction and internal rotation deformity.
- Knee-flexion deformity.
- Ankle-varus deformity.

Figs 4.27A to C: Clinical photographs showing anterior shoulder dislocation and plain X-ray of the dislocation

Investigations

Radiograph of the affected part should include anteroposterior and lateral views of the joints (Fig. 4.27C). CT scan and MRI may be required in fractures dislocations.

Treatment

Since dislocation is an orthopedic emergency early closed reduction under general anesthesia is recommended. The part is immobilized for a period of 3 to 6 weeks to ensure adequate healing. Operative reduction is rarely required and is reserved for compound dislocations and irreducible dislocations.

Rehabilitation in Dislocations

In dislocations, the capsule and the ligaments are torn and hence the rehabilitation takes more time and has to be done more vigorously.

- The rehabilitation will be the same as for fractures.
- But more intensive physiotherapy may be required due to the factors mentioned above
- Exercises should be aimed to prevent muscle atrophy.
- After the period of immobilization, ROM exercises, resistive exercises, passive and strengthening exercises should be advocated on a war footing to prevent joint stiffness.

Complications

Acute

Injury to peripheral nerves and vessels can occur, e.g. Sciatic nerve palsy in posterior dislocation of hip.

Chronic

Unreduced dislocation Which is common in Asian countries due to ignorance, delay in seeking treatment, etc.?

Recurrent dislocations Due to inadequate and improper healing of soft tissues following initial trauma.

Traumatic osteoarthritis Due to damage to the articular cartilage following impaired nutrition by the synovial fluid.

Joint stiffness Due to capsular and other soft tissue damage.

Avascular necrosis Due to injury to the vessels.

Myositis ossificans More commonly seen than in fractures due to greater periosteal strip.

Remember

In dislocation

- It is an orthopedic emergency.
- Reduction should be quick and prompt.
- Reduction should always be done under general anesthesia to relax the muscles.
- Swelling is less when compared to fractures.
- Movements are more restricted than in fractures.
- Closed reduction is sufficient most of the times.
- Open reduction is resorted to if specifically indicated.
- Reduction technique should always be very gentle.
- Pain will not subside by splinting unlike fractures.
- Myositis ossificans is a problem more commonly associated with dislocation.

Subluxation

Subluxation is defined as partial loss of contact between the two ends of the bones. It poses a problem much less serious than dislocation.

Sprain It is a tear in the ligaments. The severity varies from grade I to III. Mild sprains are more common and heal by conservative treatment, whereas grade III sprains cause joint instabilities and need to be repaired surgically. Sprains are commonly encountered in knee joints and ankle joints. They are discussed in detail in appropriate sections (Fig. 4.28).

Strain It is tearing in the muscles and is more common in young athletes and usually heals by conservative methods.

Fig. 4.28: Clinical photograph showing ankle sprain

FRACTURE HEALING

Bone makes a valiant attempt to get back to its original shape and form after having suffered humiliating fractures due to a myriad of incriminating forces. Bone is unique in healing itself completely with a tissue that is indistinguishable from the original tissue hence there is no scar left. The term bone regeneration and not fracture healing is more appropriate.

Bone is repaired by callus which is a new tissue that may develop externally or internally. An external callus envelops around the outer aspect of the opposing ends of bone fragments. An internal callus forms between the bone ends.

During the first two days at the fracture sites and away from the fracture site, in the deep layer of periosteum the osteogenic cells proliferate and lift the fibrous layer of the periosteum away from the bone. Marrow cells also proliferate but to a lesser degree. These osteogenic cells differentiate into osteoblasts which form the bone trabeculae resembling the embryonic tissue. The osteogenic cells lying away from the fracture site due to inadequate vascularity differentiate into chondroblasts and chondrocytes which form the cartilage. The cartilage is finally converted into bone by endochondral ossification.

The internal callus is formed by the mesenchymal cells which convert into pro-osteoblasts and later to osteoblasts laying down new bone. Remodeling is an activity of osteoclasts which slowly remove the necrotic bone and create cavities. Osteoblasts line these cavities and lay new bone.

METHODS OF FRACTURE HEALING

A fracture heals by three ways, indirect, direct and distraction histogenesis as described by Ilizarov.

Indirect Fracture Healing

This is the common method of fracture healing where both external and internal callus are formed. Hunter has described six stages in this method of healing (Figs 4.29A to F).

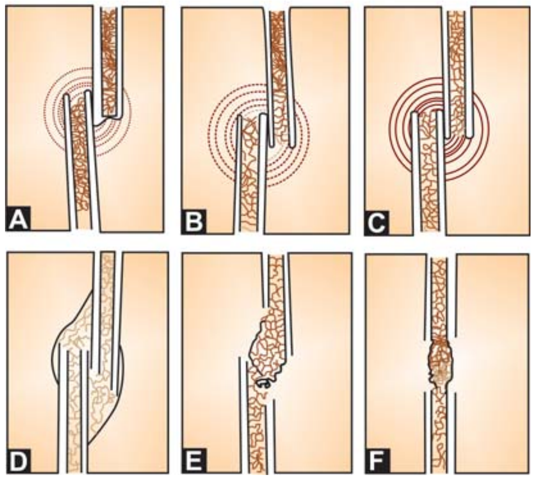
Stage of impact This stage extends from the moment of impact till the complete dissipation of energy causing fractures.

Stage of induction Following fracture cells possessing osteogenic potential are activated. Other inducing factors are BMP (bone morphogenic protein), fall in oxygen tension and bioelectric effects.

Stage of inflammation In this stage the disruption of blood supply results in necrosis of the bone ends. There is hemorrhage, cellular proliferation and vascular ingrowths.

Stage of soft callus Here the hematoma is organized with fibrous tissue, cartilage and woven bone. Fragments are united with fibrous or cartilaginous tissue or both.

Stage of hard callus Bone fragments are firmly united with bone. If immobilization is complete, membranous bone healing takes place. If incomplete bone heals by endochondral ossification.



Figs 4.29A to F: Hunter's stages of fracture healing: (A) stage of induction, (B) stage of inflammation, (C) stage of soft callus, (D) stage of hard callus, (E) stage of remodelling, and (F) normal

Stage of remodeling Here fiber bone is converted to lamellar bone. Medullary canal is reconstituted and callus diameter begins to decrease in size which takes few months to several years. However, there will be no remodeling of rotational misalignment.

Primary Bone Healing (Direct Bone Healing, Healing by Primary Intention)

This type of bone repair is seen when bone fragments are anatomically reduced and rigidly fixed. This cannot be obtained by closed methods of fracture treatment but can be achieved by operative reduction and fixation with special techniques of plate and screws. Here ideally no external callus forms and there is no interposing fibrous tissue or cartilage tissue between the fracture sites. The fracture site is bridged by direct haversian remodeling which is almost a direct osteon to osteon hookup. The osteoclasts act as cutter heads to remove the bone and are in the forefront promptly followed by osteoblasts behind laying down new bone. This type of bone healing usually occurs in fractures treated by AO techniques developed by Swiss association for osteosynthesis.

Remember

Problems in primary bone healing
- Risk of anesthesia.
- Fracture haematoma lost.
- Infection.
- Bone healing is slower.
- Bone healing is inferior to indirect healing.

- Difficult to assess radiological union as no callus is seen.
- Implant failure is a possibility.
- Needs another operation to remove the implants.
- Chances of refracture are high.
- The only advantage seems is good anatomic reduction and chances of early mobilization.

Distraction Histogenesis

Distraction histogenesis is a recent concept described by Ilizarov. Here bone repair is induced by gradual distraction of osteotomies and fracture after an interval of induction say 5 to 7 days. For osteogenesis to occur the fracture or osteotomy must be stabilized and a slow distraction at the rate of 1 mm per day should be given. For details see discussion on Ilizarov (*see* p. 86).

Factors Affecting Fracture Repair

Factors favoring union

- Adequate circulation
- Hormones like growth hormone, parathormone, thyroxin, etc.
- Good nutrition and mineral supplements help passively
- Bioelectric fixation

Factors detrimental to union

- Poor circulation
- Infection
- Distraction
- Segmental fractures
- Comminution
- Osteoporosis
- Soft tissue interposition
- Inadequate and improper immobilization, etc.

5

Chapter

Complications of Fracture

Fracture is a disturbing event more so if it develops complications. The complications could be immediate or delayed. Immediate complications are life-threatening and delayed complications are more morbid. Some complications develop at the time of injury and are beyond the control of the surgeon. They need to be accurately diagnosed and treated. Whenever a surgeon encounters a case of fracture he should look beyond the fracture and try to detect complications if any. The following are the common complications.

ACUTE RESPIRATORY DISTRESS SYNDROME (SYN: Fat Embolism)

Acute respiratory distress syndrome (ARDS) is defined as a post-traumatic distress syndrome occurring within 72 hrs of skeletal trauma. It usually manifests within 24 to 48 hrs but sometimes may be delayed for several days. It is a dreaded complication often associated with multiple fractures, major bone fractures, pelvic fractures, multisystem injuries like chest and abdomen, head injuries, etc. It is seen in 10 to 45 percent cases of multiple fractures and is an important cause of morbidity and mortality (11%) in multiple fracture and multisystem injuries (Table 5.1).

Etiology

Common etiological factor is a long bone fracture in young adult or a pelvic fracture in elderly.

Source of fat It could be from two sources:

1. From bone marrow (accepted).
2. From plasma by agglutination of chylomicrons which later acts as an embolus (less accepted).

TABLE 5.1: Complications of fractures

Acute	*Chronic*	*Complications peculiar to open fractures*
• Shock (Hypovolemic or neurogenic)	• Delayed union	• Infection
	• Nonunion	• Chronic osteomyelitis
• ARDS	• Malunion	
• Thromboembolism	• Shortening	• Gas gangrene
• Neurovascular injuries	• Growth disturbances	• Tetanus
		• Hypovolemic shock
— Radial nerve palsy in fracture shaft humerus	• Avascular necrosis	• Miscellaneous
	• Joint stiffness	• Implant failure
— Sciatic nerve palsy in post-dislocation of hip	• Post-traumatic arthritis	• Reflex sympathetic dystrophy, etc.
— Supracondylar fractures brachial artery injury	• VIC	
• Acute Volkmann's ischemia	• Myositis ossificans	(The complications emboldened in this table are discussed in detail)
• Crush syndrome		
• Deep vein thrombosis		

Management

There are a few important steps in the management of ARDS:

Non-specific consists of three vital steps:

1. Keep (a) airway patent, and (b) fracture immobilized by POP or external fixators.
2. Restore (a) blood volume, (b) fluid, and (c) electrolyte balance.
3. Avoid (a) careless handling of the injured, (b) unnecessary transportation.

Specific Again some vital steps are described:

1. Oxygen administration to restore back PaO_2.
2. Drug therapy
   - *Steroids* are given intravenously. These help gas exchange by decreasing inflammation in the lungs.
   - *Heparin* This acts as a lipolytic and antiplatelet agent.
   - *Low molecular weight dextran* acts by increasing plasma volume.
   - *Intravenous alcohol* is not universally advocated.
   - *Antibiotics* and other treatment.
3. *Definitive fracture treatment* Discussed in appropriate sections.
4. *Rehabilitation in ARDS*
   - The rehabilitation for fractures is the same as mentioned in appropriate section on fractures.
   - In addition patient needs active chest physiotherapy to prevent lung complications.

VOLKMANN'S ISCHEMIA OR COMPARTMENTAL SYNDROMES

Definition

Mubarak defined compartmental syndrome as an *elevation of interstitial pressure in a closed osseofascial compartment that results in micro vascular compromise* and may cause irreversible damage to the contents of the space.

Sites

- Anterior and deep posterior compartments of the legs.
- Volar compartment of the forearm.
- Buttocks, shoulder, hand, foot, arm and lumbar paraspinous muscles are relatively rare sites.

COMPARTMENTAL SYNDROME OF FOREARM

This is one of the most dreaded complications in orthopedics and ranges from mild ischemia to severe gangrene. Early recognition and prompt remedial measures is the key to successful countering of this problem. *Needless to say this is an orthopedic emergency.*

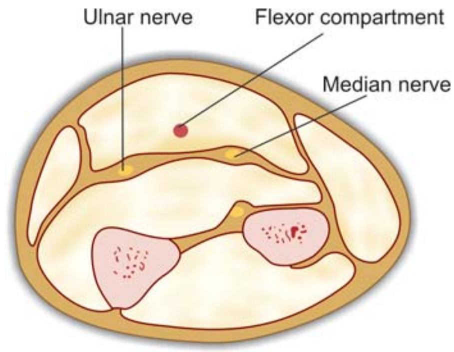


Fig. 5.1: Showing compartments of the forearm

Definition

It is an ischemic necrosis of structures contained within the volar compartment of the forearm (Fig. 5.1).

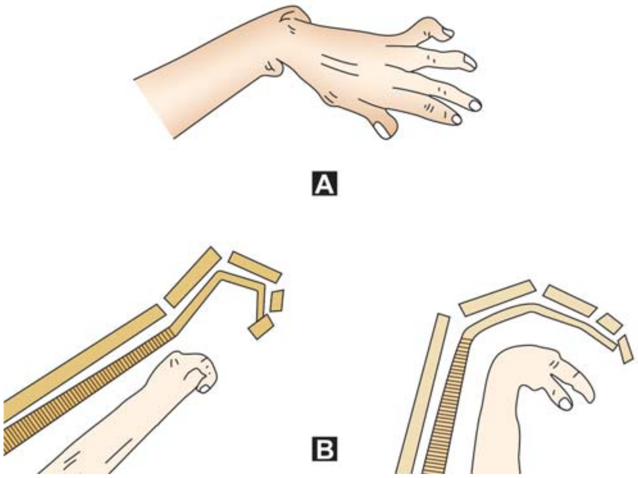
Incidence and Etiology

It is common in children less than 10 years of age. Supracondylar fracture is the most common cause in children. Crush injuries of the forearm are the most common causes in adults. Occasionally fracture of both bones of forearm may be the cause. More recently intra-arterial injections in drug addicts who lie on their forearm for prolonged periods in narcotized conditions are mooted to be a cause. Improper application of splints is another important cause.

Usually, the flexor muscles of the forearm, especially the flexor digitorum profundus and flexor pollicis longus and rarely flexor digitorum superficialis are involved. Volkmann's ischemic contracture (VIC) is due to the infarction produced by an arterial spasm of the main artery to an extremity with reflex spasm of the collateral circulation (Figs 5.2A and B). This produces ischemia of the muscle bellies which results in necrosis and is later replaced by fibrous tissue causing contractures.

Clinical Features

In the acute stages patient gives history of trauma and after an interval of few hours, severe, poorly localized pain develops in the forearm. The volar aspect of the forearm is swollen, red, warm, tender and tense. Fingers are held in flexion and attempt to extend the fingers increase the pain (stretch pain). Peripheral pulses which are present initially disappear later. Median nerve is more commonly affected than the ulnar nerve.



Figs 5.2A and B: (A) Volkmann's ischemic contracture (VIC) deformity, and (B) Volkmann's sign

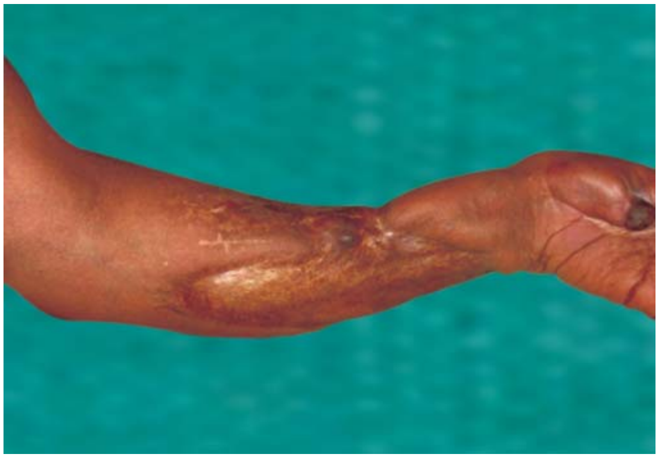


Fig. 5.3: Clinical photograph of VIC

Note In VIC patient complains of pain out of proportion to the injury.

Impending Volkmann's ischemia is detected by 6Ps
- **P**ain
- **P**allor
- **P**ar aesthesia
- **P**aralysis
- **P**ulselessness
- **P**ositive passive stretch test

In established VIC
Look for
- Claw and deformity.
- Volkmann's sign.
- Extensive scarring of the forearm.
- Joint and soft tissue contractures.
- Neurological deficits.
- Rarely gangrene.

Management

Acute stage It is a surgical emergency. All encircling tight bandages are removed if present. If there is no improvement, record the pressure within the compartment. If it is more than 30 mm Hg, an emergency surgical decompression is done by fasciotomy. If the pressure is less than 30 mm Hg continuous monitoring is done.

Established VIC

Late cases If mild, flexion contractures of flexor digitorum profundus and flexor pollicis longus develop but in severe cases all the finger flexors, thumb and wrist flexors are affected. The forearm is thin and fibrotic. Extensive scar tissue may be present. Peripheral nerves may be affected, amongst them median nerve is the most commonly involved. A *classical claw hand* deformity results. Of particular importance is eliciting the *Volkmann's sign* in established VIC. *This test consists of extending the wrist which exaggerates the deformities and on flexion the deformities appear less prominent*. Joint contractures and gangrene may also be seen (Fig. 5.3).

Here the contractures are well established and the treatment plan depends upon the severity of VIC (Table 5.2).

Mild type
- Dynamic splinting to maintain finger extension.
- Physiotherapy like active exercises, thermotherapy, etc.
- Total excision if single muscle is involved.

Moderate type
- *Max Page's muscle sliding operation* This consists of releasing the common flexor origin from the medial epicondyle and passively stretching the fingers. This slides the origin of the muscle down and releases the contractures

TABLE 5.2: Tsuge's classification of VIC

Mild	*Moderate*	*Severe*
• FDP • FPL involved	• Involvement of FDP+FPL • Superficial finger flexor • Wrist Flexors • Thumb flexors	• All flexors. • Few extensors. • Neurologic deficit. • Contracture of joint. • Skin scarred. • Bones deformed.

FDP—flexor digitorum profundus, FPL—flexor pollicis longus.

- *Excision of cicatrix*
- *Neurolysis* consists of freeing the peripheral nerves from the surrounding fibrous tissue.
- *Tendon transfers* are done if criteria are met (*see* p. 237).

Severe type
- Excision of the scar
- Seddon's carpectomy—it consists of excising the proximal row of carpal bones thereby shortening the forearm to overcome the effects of contracted muscles.
- *Arthrodesis* of the wrist in functional position.
- *Amputation* for very severe cases of VIC with gangrene.

Serial Splinting in VIC

Sir Robert Jones described three stages in serial splinting.

Aim To attain the functional positions of the wrist, which is maximum extension.

The splint It has three joints at the wrist, MCP and IP joints which can be easily adjusted to the desired angles.

Stages

Stage I
- All the fingers are separately splinted.
- Maximum extension is obtained and held at the IP joints.
- Wrist and MCP joints are held in full flexion.

Stage II
- IP joints are continued to be held in extension.
- Slowly the MCP joints are extended by a splint.
- Wrist is held in flexion.

Stage III
- IP joints and MCP joints are held in extension.
- The wrist is gradually extended with the help of a dynamic splint.

Adjunctive Measures

To improve the extensibility of contracted structures.
- Limb elevation
- Active exercises to the unaffected joints
- Thermotherapy
- Massage and ultrasonic etc.
- Vigorous exercises once the function is recovered.

Postsurgery Physiotherapy Measures in VIC

During Immobilization

- Hand elevation
- Thermotherapy
- Active exercises to the unaffected joints
- Connective splints to prevent recurrence of the contractures.

During Mobilization

- Active exercises to the shoulder, elbow and forearm muscles.
- Motor and sensory reeducation.
- Care of the anesthetic skin.
- Modified splints to obtain better function.

Chronic Compartmental Syndrome

Chronic compartmental syndrome is a pretibial pain induced by exercise seen in the anterior compartment of the leg in athletes. If the compartmental pressure is more than 15 mm Hg at rest, more than 30 mm Hg during exercise and more than 20 mm Hg for 5 minutes after exercises, chronic compartmental syndrome is suspected. Due to the herniation of fat or muscle through the fascial defect, a soft tissue mass is seen in the anterolateral aspect of the lower third of the leg. The patient is instructed to alter or decrease the level of activity, if no relief is forthcoming, surgical decompression is indicated.

NONUNION

The difference between delayed union and nonunion is of degree. In delayed union healing has *not advanced* at the average rate for location and type of fractures but healing can still take place if the limb is immobilized for a longer period. In nonunion there is evidence to show clinically and radiologically (Fig. 5.4) that healing has *ceased* and union is improbable and needs surgery. Final status of nonunion is pseudoarthrosis.

Figs 5.4: Radiograph showing nonunion fracture tibia and fibula (atrophic type)

Definition (FDA Panel)

Nonunion is said to be established when a minimum of nine months has elapsed since the injury and the fracture shows no radio logically visible progressive signs of healing continuously for three months.

Causes for Nonunion

Nonunion of fractures is a very notorious complication to treat. Infected nonunion challenges the clinical acumen of best of orthosurgeons. There are various causes leading to nonunion and the following are some of those.

Compound fractures There are extensive damage to the soft tissues in open fractures and there could be even loss of small pieces of bone. The former results in impaired blood supply to the fracture fragments jeopardizing the chances of union.

Infection This is commonly seen in compound fractures and in post-surgical infections. Hence, infections should be kept at a minimum in treatment of fractures.

Segmental fractures In this type of fractures there is a maximum risk of damage to the intraosseous vessels resulting in poor union.

Distraction of fracture fragments This happens when excessive weight is used during skin or skeletal traction.

Soft tissue interposition If soft tissues, like periosteum, muscles, tendons, nerves, vessels, etc. are interposed between the fracture fragments, it obstructs the growth of internal callus and thus jeopardize union.

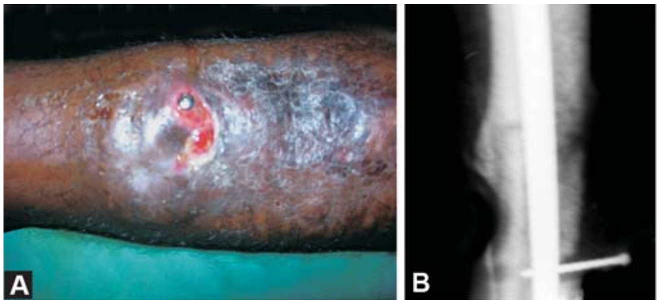
Ill-advised open reduction Open reduction damages favorable factors for fracture union like fracture hematoma. Periosteal stripping and intramedullary reaming disturbs the vascular supply. All these are detrimental to fracture healing.

Insecure and inadequate fixation of fracture fragments by plate and screws or intramedullary fixation allows micro-movements which prevent union.

Apart from these local factors, the general factors which contribute to poor healing of fractures are anemia, general debility, cachexia, steroid therapy, osteoporosis, malignancy, etc.

But it can be observed that most of the factors, general or local, responsible for poor fracture healing are preventable if one exercises utmost caution and care during the treatment of fractures.

Types Depending upon the amount of callus on plain X-rays. Nonunion can be classified as avascular nonunion (no callus) or hypervascular nonunion (excess callus) (Figs 5.5A and B).



Figs 5.5A and B: (A) Clinical photograph of infected nonunion (B) Plain X-ray of infected nonunion

Clinical Features

This can be discussed under three headings.

History Usually patient gives history of trauma resulting in fractures, multiple injuries, multisystem or head injuries. There could be history of open fractures, delay or improper or inadequate treatment. It should be noted that in nonunion the history is of a longer duration.

Symptoms The acute symptoms seen in fresh fractures are conspicuously absent in nonunion. There is usually history of no pain or minimal pain. There could be presence of a deformity or loss of function.

Signs The important clinical signs are painless abnormal mobility, no crepitus, shortening, scars and sinuses, deformity, wasting of limb muscles, etc.

Radiograph

Plain X-ray helps to identify the type of nonunion (Fig. 5.6).

Fig. 5.6: Plain X-ray showing hypertrophic nonunion tibia

Management

Principles

- Nonunion is an absolute indication for surgery and it requires open reduction, rigid internal fixation and bone grafting.
- There is no role of conservative treatment.
- Other methods of treatment include electrical stimulation, interlocking nails and Ilizarov.

Role of Ilizarov in Nonunion

This allows simultaneous correction of all deformities and bone loss. In hypertrophic nonunion gradual compression helps. In avascular nonunion corticotomy, bone transport and compression helps. Corticotomy provides some of the same biological benefits as bone graft. Segmental nonunion is also successful. Ilizarov provides dramatic results but is technically very demanding. It is still the best way to treat cases of infected nonunion.

Role of Physiotherapy in Nonunion

- Active exercises to the unaffected joints.
- Isometrics to the immobilized joints.
- Active ankle exercises to prevent DVT.
- After fracture union is achieved, the rehabilitation is the same as for other fractures.

AVASCULAR NECROSIS (AVN)

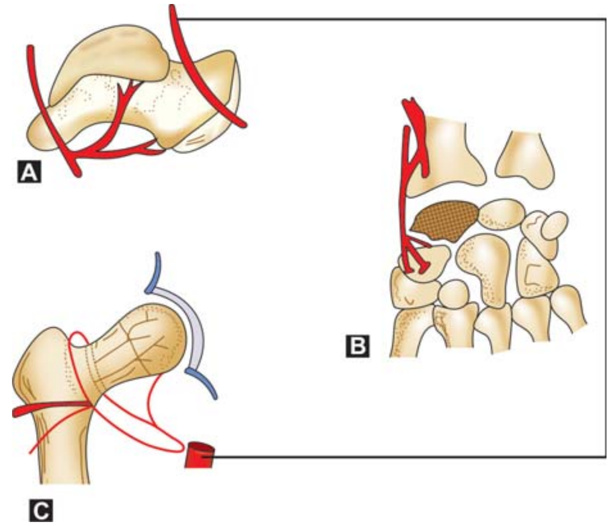
Avascular necrosis is a rare but severe complication of certain fractures. It occurs when the blood supply to a segment of bone is affected.

Causes

- Extensive stripping of soft tissues which damage the periosteal blood supply.
- In certain bones where the blood supply is unique and unidirectional, e.g. talus, scaphoid, neck of femur (Figs 5.7A to C).
- Other causes like steroid therapy, Caisson's disease, etc. which may cause on embolic block of the blood vessels.

Common sites of AVN are head of femur in fracture neck of femur and dislocations of hip, body of the talus in fracture through the neck of talus, proximal pole of scaphoid in fracture through the waist of the scaphoid.

Problems in avascular necrosis The loss of blood supply to a major bone segment impairs healing because the avascular segment cannot participate in the reparative process. This defective healing makes the bone weak and susceptible to external forces. This results in collapse of the bone and late osteoarthritis changes.



Figs 5.7A to C: Due to the peculiar blood supply avascular necrosis is common in the above three bones: (A) talus, (B) scaphoid, and (C) femoral neck

Clinical Features

Avascular necrosis of a bone is usually asymptomatic in the early stages. In the later stage patient may complain of pain, limp and slight loss of movements. In very advanced cases patient will show features of osteoarthritis.

Investigations

In the early stages avascular necrosis can be detected by bone scan, radioisotope study. In the later stages, radiograph shows dense changes in the bone, collapse and osteoarthritis features (Fig. 5.8).

Fig. 5.8: Plain X-ray showing extensive secondary OA changes

Treatment

Early stages require no treatment. Protective braces may be given to prevent bone collapse. Surgical decompression has a doubtful role. In the late stages total hip replacement is advocated for AVN head of the femur. AVN in scaphoid needs open reduction and bone grafting.

TRAUMATIC MYOSITIS OSSIFICANS

Definition

It is a reactive lesion occurring in the soft tissues and at times in the bone periosteum. It is characterized by fibrous, osseous and cartilaginous proliferation of the subperiosteal hematoma. This is later followed by metaplastic changes.

Causes

Trauma This has a definitive role in the causation of myositis ossificans. Injury to the muscles, ligaments, tendons, periosteum and bones results in bleeding within the soft tissues which in turn may lead to myositis.

Simple blow or repeated minor trauma This could also give rise to myositis due to the repeated and constant soft tissue damage.

Dislocations and avulsion injuries These are more prone to develop myositis than the fractures because of the violent stripping of the periosteum and damage to the muscles.

Ill-advised massage This is by far the most common cause for myositis. Vigorous and improper massage particularly the elbow joint by quacks, etc. explains the frequent occurrence of this problem in patients treated by traditional bonesetters and osteopaths.

Clinical Features

In the acute stages patient may complain of pain, swelling and loss of movements. On examination there may be tenderness. In the later stages there is no pain and a bony hard lump may be palpated. This may act as a mechanical block to the movements.

Remember

Areas commonly affected
- Elbow joint common in young athletes.
- Ankle joint—(known as footballer's ankle).
- Knee—(known as Pellegrini-Stieda disease).
- Shoulder.
- Hip.
- In head injuries it is more common.

Fig. 5.9: Plain X-ray showing myositis ossificans

Radiograph

Radiography has little role in the *acute stages* but in the later stages a bony growth may be evidently seen (Fig. 5.9).

Treatment

Acute stages Conservative treatment is the method of choice and consists of the following.
- *Immobilization of the part by splints, etc.*
- *Drugs* Diphosphonate therapy, calcitonin and non-steroidal anti-inflammatory drugs (NSAIDs).
- *Physiotherapy* Active physiotherapy is encouraged and passive stretching is avoided.
- *Manipulation is done under anesthesia*. It is a double-edged sword and has to be done very carefully. *Adhesions should snap abruptly and should not be broken gradually.*

Later stages
- Vigorous active ROM exercises using Roller skates etc.
- Gentle passive stretching.

Chronic stages Surgery is the treatment of choice and consists of soft tissue release and excision of bony spur when it is well formed.

Postsurgery Physiotherapy Management

First 2 Weeks
- Hand elevation to prevent limb edema.
- Active exercises to the unaffected joints.
- Isometric exercises to the elbow muscles.

After 2 Weeks

- Thermotherapy to reduce pain and swelling.
- Hydrotherapy.
- Isometrics to the elbow muscles.
- Elbow mobilization is done as follows:
  - — Gradual active flexion with sling suspension and maintaining the movement achieved by adjusting and tightening the sling.
  - — Active assisted elbow flexion using roller skates
  - — Gravity eliminated elbow flexion using modified knee ratchets.
  - — Gravity assisted elbow extension in prone lying.
- Self-assisted exercises for forearm supination and pronation by fixing the elbows by the sides of the trunk and placing the forearm on the thighs.
- Gentle passive stretching of the elbow using appropriate adjunctive measures is commenced.
- After three weeks all the above measures can be made more vigorous and PRE is started.
- The patient should regain full functional activity by the end of six weeks.

Remember

> The term myositis ossificans is a *misnomer* because skeletal muscle is often not involved and inflammatory changes are rarely seen.
>
> **Myositis ossificans progressiva** It is a different condition and has nothing to do with the traumatic one. It is a congenital condition affecting all the skeletal muscles

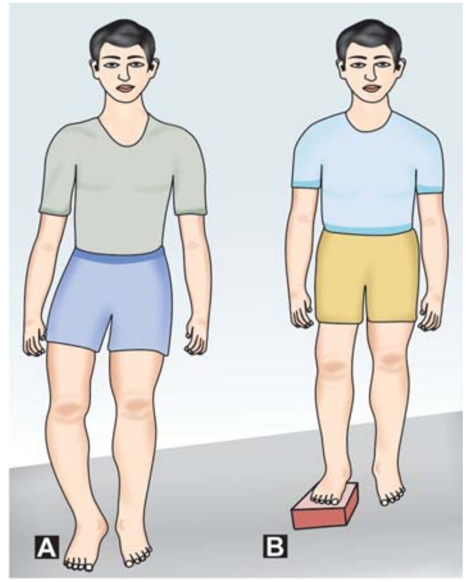
MALUNION

When fracture fragments heal in an abnormal position it is called malunion. It can pose the following problems:

- It may cause cosmetically unsightly deformity (Fig. 5.10A).
- May cause alteration in posture and balance in lower limb fractures.
- It may cause shortening (Fig. 5.10B).
- It may interfere with joint function.
- Altered weight bearing mechanism may lead to premature osteoarthritis.

Causes

Malunion is fairly common in fractures treated by closed reduction because it is a blind technique and it is very difficult to assess the accuracy of the reduction.



Figs 5.10A and B: Showing shortening (A) and deformity (B) due to malunion of tibia

Improper immobilization techniques Following reductions if the fracture is not immobilized properly and if immobilized for inadequate length of time, malunion usually results.

Treatment by quacks Due to poor knowledge of fracture anatomy, the osteopaths and the traditional bonesetters contribute significantly to the incidence of malunion.

Multiple and Multisystem Injuries

These are life-threatening and assume more importance during treatment and the fractures may go unnoticed by the treating physicians resulting in malunion.

In order to prevent the malunion from developing following closed reductions, certain post reduction criteria should be strictly adhered to like (in order of importance).

- Alignment of fracture fragments to be corrected first.
- Rotation of the fragments corrected next.
- Length of the limb is restored.
- Lastly position of the fragments is adjusted.

Classification

If there is improper correction of any one of the above mentioned criteria, the following types of malunion may be encountered.

- *Length malunion* This commonly results in shortening of the limb and rarely may give rise to lengthening.
- *Rotatory malunion* This may cause external or internal rotation deformities.

- *Angulatory malunion* This may cause varus or valgus deformities.

Of all the factors mentioned above the one factor which is not corrected by remodeling is rotation, while the other three are successfully overcome over the years by remodeling. Hence, all precautions should be taken to correct the rotation element during the initial treatment of fractures.

Types

Significant malunion This impairs both the function and causes a major cosmetic problem.

Insignificant malunion This does not interfere with function but causes only cosmetic problem.

Clinical Features

A patient with malunion of bones may complain of deformity and/or loss of function of the affected extremities (Figs 5.12A and 5.13). There may be shortening and wasting of the involved limbs.

Radiograph

Plain X-ray of the affected limb helps us to show the extent and degree of malunion (Figs 5.11 and 5.12B).

Treatment

Masterly inactivity if patient has no functional problems. Cosmesis alone does not form a sufficient indication for surgery unless the patient desires so. But operative treatment is highly justified when malunion affects the function. This can be done by a *corrective osteotomy* at the old fracture site or a *compensatory procedure* may be necessary to restore functions (e.g. Darrach's operation in malunited Colles). Sometimes pain may be the only predominant symptom necessitating *fusion of the joint.*

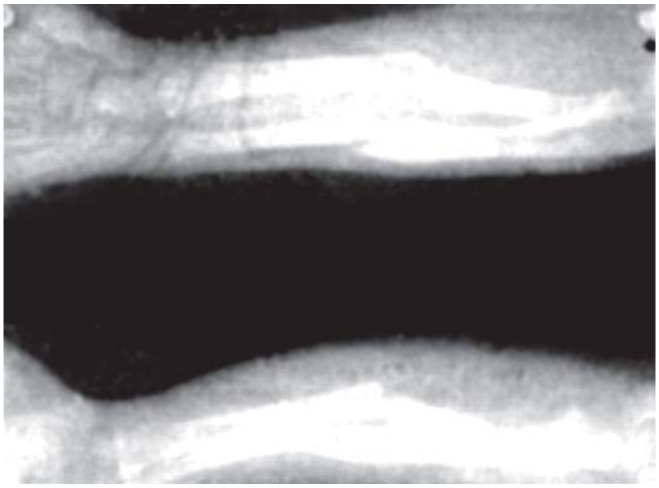
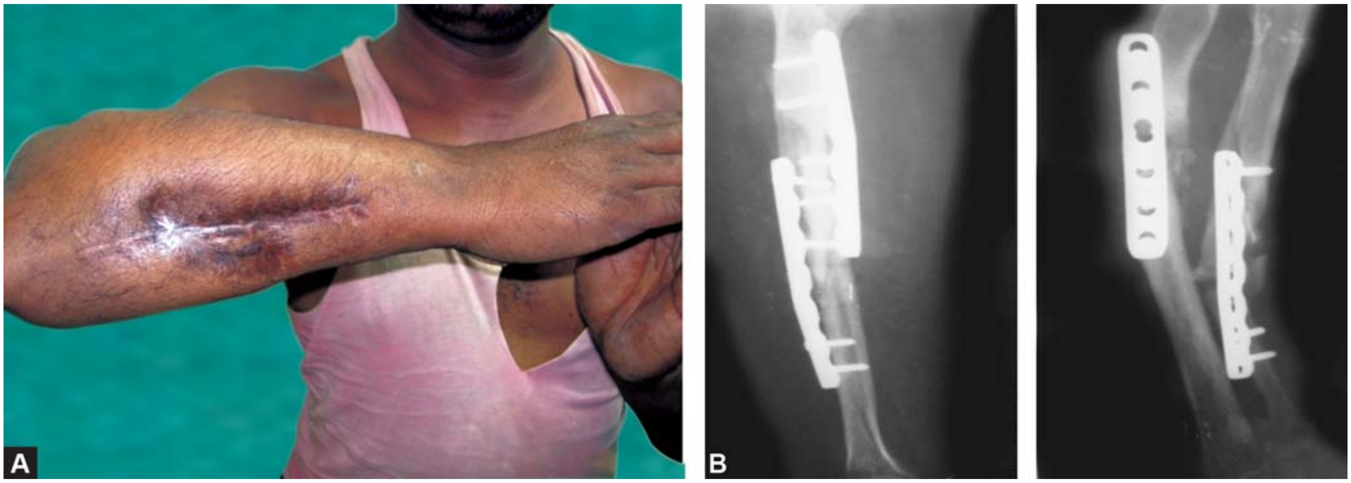


Fig. 5.11: Plain X-ray malunited fractures of both bones forearm

The optimum time to carry out surgery for malunion is 6 to 12 months after the fracture has occurred.

OTHER IMPORTANT COMPLICATIONS OF FRACTURES

Deep vein thrombosis (DVT) and pulmonary embolism Deep vein thrombosis is an important complication seen after fractures of spine, pelvis, femur, tibia, etc. The pathogenesis has been described by Virchow's triad of venous stasis, vascular damage and hypercoagulability.



Figs 5.12A and B: (A) Clinical photograph of infected malunion (B) Plain X-ray showing the malunion

Fig. 5.13: Clinical photograph of tibia nonunion

The patient complains of mild to severe calf pain, swelling, difficulty in standing or walking and cramps in the calf muscles or foot. The clinical signs include unilateral, leg swelling, increases temperature, tenderness, enlarged superficial veins, pitting edema, palpable cord along the involved veins, erythematic, etc.

Homan's sign When forced ankle dorsiflexion produces calf pain, Homan's sign is said to be positive and is pathognomonic of DVT (Fig. 5.14).

Treatment Prophylactic methods consist of early ambulation, foot elevation, elastocrepe bandaging, exercises, etc.

Anticoagulant therapy This consists of aspirin (600-650 mg), heparin (low dose), low molecular weight dextran, low dose warfarin (2.5-16 mg/day daily orally), etc.

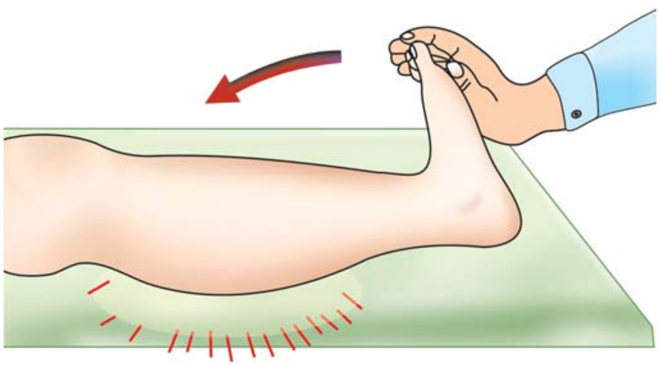


Fig. 5.14: Showing Homan's sign

Pulmonary thromboembolism is a serious complication of DVT. Patient with pulmonary embolism complains of unexplained dyspnoea, pleurotic chest pain, hypoxia, tachypnea, tachycardia, signs of cor pulmonale, etc. Heparin therapy is the treatment of choice.

Chronic venous insufficiency is the common long-term complication of DVT.

Embolic Facts

Other important predisposing factors for DVT

- Surgery—orthopedic/thoracic/abdominal/GU systems.
- Immobilization due to CCF, MI, stroke, etc.
- Neoplasm
- Estrogen therapy
- Pregnancy
- Obesity
- Age > 40 years
- TAO, Behcet's disease, etc.
- Hypercoagulable states.
- Total hip and knee replacement, etc.

Physiotherapy Measures

- Limb elevation to control edema
- Vigorous active ankle exercises to squeeze out the dependent edema
- Elastocrepe bandaging
- Active exercises to the unaffected joints.

INJURY TO BLOOD VESSELS

Blood vessels in close proximity to the bones are injured during *fractures* and *dislocations* (Table 5.3).

Causes of Injury

The blood vessels may be injured in one of the following ways: reflex vasospasm, compression by the fracture fragments or hematoma, incomplete tear, complete tear, partial tear, internal thrombus, tight encircling bandages, etc.

Effects of Injury

In the initial stages it may range from mild ischemia to gangrene. In the delayed stages ischemic contractures may develop.

Clinical Features

Apart from the usual features of fractures patient may show impending signs of vascular disaster recognized by 5Ps: pain,

TABLE 5.3: Injury to blood vessels

Injuries	*Blood vessels involved*
Upper limb trauma	
• Fracture clavicle	Subclavian vessels
• Proximal humeral fractures	Axillary vessels
• Supracondylar fracture of humerus (Fig. 5.15)	Brachial vessels
• Posterior dislocation of elbow	Brachial vessels
• Fracture both bones forearm	Anterior interosseous artery
Lower limb trauma	
• Dislocation of hip	Femoral vessels
• Fracture femur	Femoral vessels
• Supracondylar fracture femur	Popliteal vessels
• Dislocation of knee	Popliteal vessels
• Proximal tibial fractures	Posterior tibial vessels
• Fracture tibia and fibula	Posterior tibial vessels
• Ankle injuries	Posterior tibial vessels

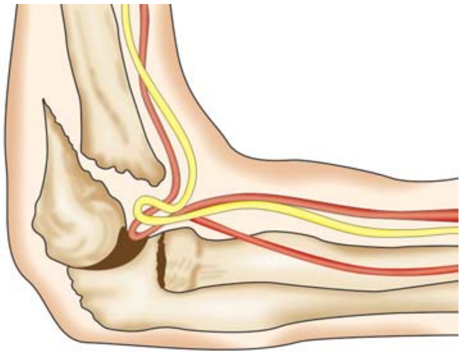


Fig. 5.15: Showing neurovascular injuries in supracondylar fracture of humerus

pulselessness, paraesthesia, pallor and paralysis. Cold extremities herald onset of gangrene.

Investigations

Investigations consist of radiograph of the part, Doppler, angiogram studies, etc.

Treatment

This consists of prompt reduction of fractures and dislocations and removal of all tight encircling bandages. Thrombectomy, direct end to end repair, injection of Xylocaine, papaverine, sympathectomy to relieve the vasospasms are some of the commonly recommended methods of treatment. Amputation is considered in irreversible loss of blood supply.

Physiotherapy Measures

This is the same as described for VIC.

INJURY TO NERVES

Forty percent of the bone and joint injuries are associated with peripheral nerve lesions.

Types

Two types are described:

1. *Primary* Here the nerve is injured by the same trauma that resulted in the injury to bone and joint.
2. *Secondary* This is due to involvement of the nerve in infection, scar, callus, etc.

Incidence Radial nerve (Fig. 5.16) is the most commonly injured peripheral nerve (45%), followed by ulnar nerve (30%), median nerve (15%), peroneal nerve, lumbosacral plexus (3%) and tibial nerve.

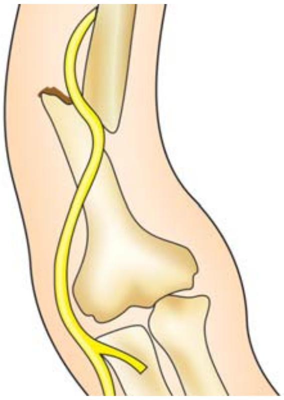


Fig. 5.16: Showing injury to the radial nerve in fracture shaft of humerus

Mechanism of Injury

The nerve may be damaged by the fracture fragments, entrapment between the fragments during fracture reduction, direct injury by the bullets, sharp cutting weapons, etc. In the late stages, the nerve may be trapped in the callus or fibrous tissue.

Types of Nerve Injury

This may be neuropraxia, axonotemesis or neurotemesis depending upon the severity of injury (Table 5.4).

Classification, diagnosis, clinical features and treatment of individual nerve injuries are discussed in Chapter 17 on Peripheral Nerve Injuries.

Rehabilitation Nerve Injuries

This is detailed in Chapter 17 on Peripheral Nerve Injury. However to prevent contractures passive full range movements and splints in functional positions should be applied. Limb

TABLE 5.4: Nerve facts

Trauma	*Nerves injured*
Upper limb	
• Fracture clavicle	Brachial plexus
• Proximal humeral fracture	Axillary nerve
• Fracture humerus	Radial nerve
• Supracondylar fracture humerus	Radial nerve
• Posterior dislocation of elbow	Median nerve
• Monteggia fracture nerve	Posterior interosseous nerve
• Hook of hamate	Deep branch of ulnar nerve
• Wrist injury	Median nerve
Lower limb	
• Dislocations of hip (posterior)	Sciatic nerve (Fig. 5.17)
• Anterior dislocation of hip and Shaft femur	femoral nerve
• Dislocation of knee	Common peroneal nerve
• Proximal tibial fractures and ankle injury	Posterior tibial nerve
• Fracture neck fibula	Lateral popliteal nerve

Fig. 5.17: Showing sciatic nerve injury in posterior dislocation of hip joint (foot drop deformity)

elevations, bandaging and carefully planned exercise regimes for strengthening, endurance etc. are some of the important other measures.

Crush syndrome Crush syndrome is seen in severe crush injuries of the limbs and muscles which result in massive release of myohemoglobin into the circulation which blocks the renal tubules and leads to myoglobinuria and acute renal tubular necrosis. Prolonged and improper application of tourniquet, acute compartmental syndromes, gas gangrene is some of the other causes of crush syndrome. Treatment is directed towards managing acute renal failure in case patient develops oliguria or anuria.

Joint stiffness This is due to improper technique of fracture immobilization. This can be fairly troublesome problem. Intra-articular fractures periarticular adhesions of soft tissues, capsules and muscle contractures are some of the other important causes of joint stiffness. Physiotherapy, exercises, manipulation under anesthesia, surgical excision and lengthening of contractures are some of the important treatment methods.

Reflex sympathetic dystrophy It is an abnormal sympathetic response following fractures. Commonly this is encountered in Colles' fracture.

Osteomyelitis It is common in compound fractures (*see Chapter 26 on Osteomyelitis for details*). The other complications peculiar to open fractures are tetanus, gangrene and hypovolemic shock.

Implant failure It can occur due to defective manufacturing, biological reactions within the body, improper implant selection, non-compliance of the patient, etc.

Post-traumatic osteoarthritis is commonly seen in intra-articular fractures, malunion, etc.

Growth alterations are due to epiphyseal injuries seen commonly in children.

Nerve injuries Discussed in detail in Chapter 17 on Peripheral Nerve Injury.

Vascular injuries especially brachial artery damage following supracondylar fractures and popliteal artery injury due to fractures around the knee causing compartmental syndrome and other ischemic complications.

Shortening of the long bones is the other important complication.

6 Chapter

Fracture Treatment Methods: Then, Now and Future

They, whose work cannot die, whose influence lives after them, whose disciples perpetuate and multiply their gifts to humanity, are truly immortal. This was how Watson Jones paid tribute to Hugh Oven Thomas.

HISTORY OF FRACTURE TREATMENT: THEN

Our forefathers were no less skilful in treating fractures (Fig. 6.1). The Egyptians were known to be skilled at the management of fractures and many healed specimens have been found. Hippocrates and Celsus described in detail the splintage of fractures by using wooden appliances. But a fascinating account of external splintage was given by Al Zabra, an Arabic surgeon. He used clay gum mixtures, flour and egg white for casting materials. In 1517, Gersdorf described a method of binding wooden splints using ligatures (Fig. 6.2) around the assembled splint and tightening it. Chinese described use of willow board splints for the treatment of tibial shaft fractures and Colles fracture. The Arabians described a technique of pouring a plaster of Paris mixture around an injured limb. Malgaigne was instrumental in popularizing this technique in Europe by early 19th century. The great disadvantage of all this extensive and heavy forms of immobilization of limb was the possibility of the fracture disease. In 1873, Sir James Paget described about fracture disease. Thus, he advocated the concept of early mobilization to prevent this problem.

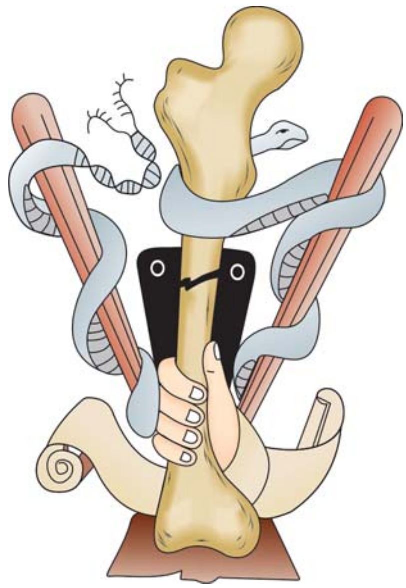


Fig. 6.1: Shows the logo depicting history of orthopedics

Fig. 6.2: Primitive methods of fracture immobilization

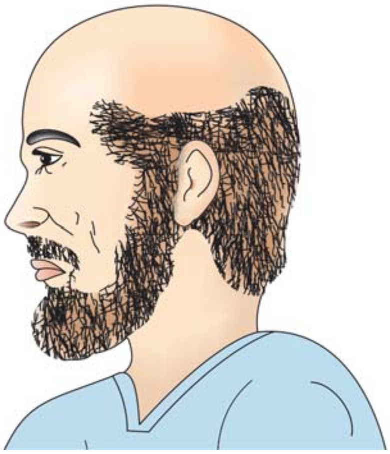


Fig. 6.3: Hippocrates
(A Greek physician called the Father of Medicine)

Remember

Hippocrates (Fig. 6.3) and orthopedics
- Hippocrates was born in Greece in 460 BC.
- He advanced the five concepts of fracture treatment, namely antisepsis, bandaging, reduction, splinting, and traction.
- He dissociated medicine from religion and philosophy.
- He wrote three books on skeletal system.

THE PLASTER BANDAGES

In Holland, 1852, Antonius Mathysen (1805-1878), a military surgeon, was on the look out of an immobilizing bandage that would permit the safe transport of patients with gunshot injuries to specialized treatment centers. He sought a bandage that could be used at once, would become hard in minutes and be adaptable to the extremity. Thus, he introduced Plaster of Paris (POP) in 1876 at the centennial exhibition in Philadelphia. The use of POP bandages as cast and slabs became popular after his death.

But the most brilliant discovery of a splint was by HO Thomas which came to be known as Thomas splint after his name. It is still used in many centers of the world for treatment of fracture of femur, though it was designed initially to assist in treatment in TB knee (*see* Fig. 6.7).

Remember

About HO Thomas
- He came from a family of unqualified bonesetters.
- He broke the family tradition by qualifying in medicine in 1857.
- His partnership with his father failed.
- He established his practice individually in the slum of Liverpool.
- He worked there for 32 years taking only six days vacation.
- He died in 1891 at the age of 57.
- He was a great believer of enforced, uninterrupted and prolonged rest in the treatment of fractures.

TRACTION

Galen (AD 130-200) first described the longitudinal traction to overcome the overriding of fracture fragments. The use of continuous traction in the management of diaphyseal fractures appeared around the middle of the 19th century. In 1800, Albert Hoffa of Wurzburg (the place of Roentgen who discovered X-rays) described the use of tractions for many types of fractures of femur and humerus. Dr Josiah Crosby of New Hampshire gave one of the earliest accounts of the use of continuous skin traction in the treatment of fractures. Professor George Perkins of London described the external splint and advocated a simple straight traction through an upper tibial pin (Fig. 6.10).

FUNCTIONAL BRACE

Gooch in 1767 first described the tibial and femoral functional braces. But surprisingly this concept was pushed into oblivion for over two centuries till Sarmiento revived it. He developed a patellar tendon bearing cast for the treatment of fractures of tibia after initial standard cast treatment. This heralded the renaissance of functional bracing. In 1970, Mooney described hinged casts for the management of femoral fractures (Fig. 6.8).

The widespread use of functional bracing has liberated countless patients from prolonged hospitalization and permitted early return to function and to gainful employment.

OPEN FRACTURES

Until 150 years ago an open fracture was virtually synonymous with death and generally necessitated an immediate amputation. Ambrose Pare, a French surgeon, first described the technique of ligating the bleeding vessels after amputation. Earlier it was cauterized. Le Petit in 1718. first described the use of tourniquet to control bleeding from amputation. This brought the mortality from amputation of the lower limbs from 75 to 25 percent. In 1561 it was Pare again who first described the concept of conserving the limb after an open fracture when he himself sustained an open fracture of tibia due to fall from the horse. The discovery of antisepsis by Pasteur, Koch, etc. brought down the rate of infection due to open fractures drastically (*see* Open Fractures in Chapter 4).

EARLY FRACTURE SURGERY

In 1770, Malgaigne was the first to describe the earliest technique of internal fixation of fractures by a ligation or a wire suture. The use of screws in bone started first around late 1840s by French surgeons Cucuel and Rigaud. Hansmann of Hampburg in 1886 was the first to describe the plate fixation of bone. Lambotte in 1909 designed a diamond shaped plate and coined the term osteosynthesis by which he meant stable bone fixation. *He is generally regarded as father of modern internal fixation.* Lane and Scherman devised their own plates. It was Denis in the year 1940 who by forming an association of Swiss surgeons heralded the modern era of internal fixation.

EXTERNAL FIXATION

Malgaigne in 1840 described the first external fixation device. Later in 1897, Dr Clayton Park hill of Colorado devised a new and improved apparatus. In 1902, Lambotte devised a more sophisticated type of external fixator in which the protruding screws were bolted to adjustable clamps linked with a heavy external bar. Pitkin for the first time devised transfixion pins with a bilateral frame as the earlier devices relied upon half pins with a single external linkage device. Ilizarov of Russia in 1952 first described the use of circular external fixator frame. He first showed that external fixator device can also be used for limb lengthening (see Fig. 6.5).

INTRAMEDULLARY FIXATION

Dieffenbac of Prussia in 1841 performed early intramedullary nailing with ivory pegs. In 1907, Lambotte emerged as a pioneer in intramedullary fixation for trochanteric fractures. Others who advocated intramedullary nails were Hey Groves of England in 1914, and Rush family.

The person who revolutionized the intramedullary nailing technique was the German military surgeon Gerhardt Küntscher who devised a clover leaf nail prior to World War II. The World was slow to accept Küntscher's design but slowly Sweden in 1943 and America in 1945 absorbed the technique.

In 1958 The Association for the Study of Internal Fixation (ASIF or AO) was born. They suggested many alterations and conducted plenty of educative courses. *They advocated with vigor the concept of rigid fixation and primary bone healing.* Livingston's I beam nail is the earliest example of interlocking nail in the year 1950. At present interlocking nail has made greater strides.

AO GROUP

Robert Denis of Brussels (1880-1962) is regarded Father of modern osteosynthesis. He described the interfragmentary compression and the concept of rigid fixation. In 1950, March 1st a young Swiss surgeon Dr Maurice Muller was so much influenced by the work of Denis that he started an association in Sweden in 1958 involving a group of young enthusiastic fracture surgeons. Educating young surgeons from all over the world in their technique was their aim. From 1960 to the present day they conduct regular annual training sessions.

Thus, it is to our forefathers we owe the tremendous achievements we have made of late in fracture treatment. Needless to say without their sweat and toil we would be way behind.

Remember

The pioneers in orthopedics
- Hippocrates—first described splinting of fracture.
- Galen—traction in orthopedics.
- Sarmiento—functional Cast brace.
- Malgaigne—technique of internal fixation.
- HO Thomas—Thomas splint.
- Lambotte—external fixator.
- Gerhardt Küntscher—intramedullary nail.
- Robert Denis—father of modern osteosynthesis.
- Ilizarov—circular external fixator.
- Mathysen—plaster of Paris.
- And a score of countless unsung heroes.

Remember

About AO or ASIF technique
- Advocated in 1960 by a group of Swiss surgeons.
- Aims at full and rapid recovery of the injured limb by open anatomic reduction and stable internal fixation.
- Healing is by primary intention.
- Eliminates the problem called the fracture disease.

FRACTURE TREATMENT: NOW

The faithful bones support the entire body till its integrity is broken by fractures. Ironically what was known to support, now requires to be supported either externally or internally to regain the lost integrity and revert back to its original role.

Before even the orthopedic surgeons interfere to plan and execute the treatment methodology to restore the bone anatomy, nature has initiated the healing process by immobilizing the fracture fragments by its two important mechanisms.

- **Pain** Patient loathes moving his or her injured limbs for fear of pain and thus keeps it immobile.
- **Muscle spasm** the surrounding muscles go into spasm after the injury and prevent mobility between the fracture fragments.

While pain and muscle spasm keep the fracture fragments immobile, SOS signals are sent by the bone induction agents (e.g. bone morphogenic protein, oxygen gradient, etc.) to the bone cells within the periosteum and endosteum to initiate the fracture healing process. The role of orthopedic surgeon is to merely assist nature in its mission of putting back the broken bones to normalcy. The ways and means how he or she can do it is described below.

Remember

- Bones known to support, requires support when broken.
- Pain and muscle spasm are nature's way of immobilizing fracture fragments.
- Role of physician is to merely assist nature to bring about proper fracture healing.
- Remember the adage *Orthosurgeon merely treats the fracture and God (nature) cures it.*

METHODS OF FRACTURE TREATMENT

No treatment Some fractures need no treatment. Non-steroidal anti-inflammatory drugs (NSAIDs) and rest suffices, e.g. rib fractures (because of the efficient splinting action of the intercostals muscles).

Strapping Merely strapping certain fractures to the adjacent normal structures like in undisplaced phalanx fracture of fingers (Fig. 6.4) and toes is sufficient.

Conservative methods Two modalities are described:

- *Merely support by splints* in undisplaced fractures, incomplete fractures, stress fractures, fatigue fractures, support by POP slab often suffices.
- *Reduction and support* Displaced fractures need to be reduced under general anesthesia before splinting. Reduction can be brought about by either manipulative traction or counter traction methods or by skeletal or skin traction. Principles of closed reduction have already been discussed. Plaster of Paris plays a big role in the conservative management of fractures. Traction plays a comparatively less important role. Both are discussed in detail in separate sections.

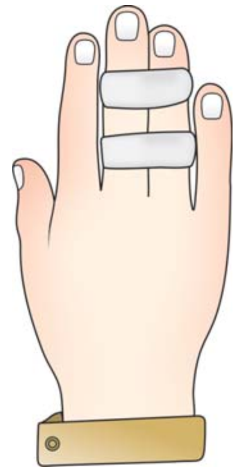
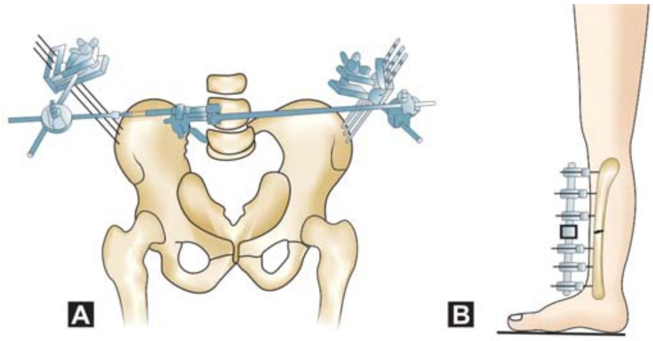


Fig. 6.4: Strapping in phalanx fracture

Operative treatment of fractures Operative treatment of fractures becomes mandatory once conservative regimen fails or when there are specific indications (see discussions on open reductions). Once fracture is reduced by operative methods, it invariably needs to be fixed internally by implants. Thus implants act as internal splints. The choice of implants available is as follows:

- *K-wire* Useful to fix certain fractures in children.
- *Screws* Used mostly to fasten the plates to the bones and rarely used independently to fix avulsion fractures, butterfly fragments, for interfragmentary compression, etc.
- *Intramedullary (IM) nails* Useful for long bone shaft fractures through the narrowest portion of the medullary canal which is usually the middle third. Intramedullary nails are not useful when the fractures are outside this ideal situation and in fractures in children.
- *Plates* are useful in situation where IM nail is not indicated. Proximal and distal third fractures can be treated by this method. It can also be used in children. However it has its own set of problems and limitations.

Treatment of fractures by external fixators (Figs 6.5A and B) Open fractures pose a tough problem in the choice of fixation methods. Loss of soft tissues makes application of plaster casts very difficult. At the same time the threat of infection discourages the use of internal fixation devices. It is here that the role of external fixators are clearly defined as it provides both stability and immobilization of fractures, so essentially required for both the soft tissues and the fracture to heal.



Figs 6.5A and B: Showing treatment of tractures by external fixators: (A) pelvic, (B) tibia fracture

Essentially all external fixators consist of pins which are passed through the bones above and below the fracture sites and are fastened to the external metallic frames. From the conventional pin fixator to the more recent Ilizarov circular fixator, the concept of external fixator has a definite place in the treatment of fractures especially the compound fractures.

Functional cast bracing It is a new concept developed by Sarmiento where in the fracture is mobilized once it becomes sticky after a period of 4 to 6 weeks. Thus, it is a secondary form of treatment and overcomes most of the problems of conventional conservative methods of fracture treatment.

SPLINTS, TRACTION AND IMPLANTS

Any material which is used to support a fracture is *called a splint*. From a folded newspaper, wood, card-board, etc. to the present day thermoplastics anything can act as a splint. The former is called an "unconventional splint" and is used more as an improvisation splints in carrying out the first aid for fractures in emergency where things are not ideal. The latter can be called "Conventional splint" which are more sophisticated and effective. In orthopedic practice POP splints are the most commonly employed splints.

Remember

- Anything acts as a splint including one's own uninjured part of the body.
- Splint is a material used to support fractures.
- *Unconventional splints* are crude, temporary and are used as a first aid measure, e.g. book, paper, umbrella, board wood, etc.
- *Conventional splints* are refined sophisticated and serve both as first aid and definitive measures, e.g. POP splint, Thomas splint, Böhler-Braun splint, etc.

To attain the goal of fracture treatment of restoring anatomy to normal, splints help a long way. They form the mainstay of conservative treatment of fractures.

ALL YOU WANTED TO KNOW ABOUT PLASTER OF PARIS SPLINT

Its History The name plaster of Paris originated from an accident to a house built on deposit of gypsum near the city of Paris. The house was accidentally burnt down. When it rained on the next day, it was noted that the footprints of the people in the mud had set rock hard. Plaster of Paris was first used in orthopedics by Mathysen, a Dutch surgeon in 1852. It is made from gypsum which is a naturally occurring mineral. It is commercially available since 1931.

Its chemical formula It is a hemi-hydrated calcium sulphate. To make plaster of Paris, gypsum is heated to drive off water. When water is added to the resulting powder original mineral reforms and is set hard.

$$2(CaSO_4 . 2H_2O) + Heat \leftrightarrow 2(CaSO_4 . ½ H_2O) + 3H_2O$$

POP Types

Indigenous Prepared from ordinary cotton bandage role smeared with POP powder.

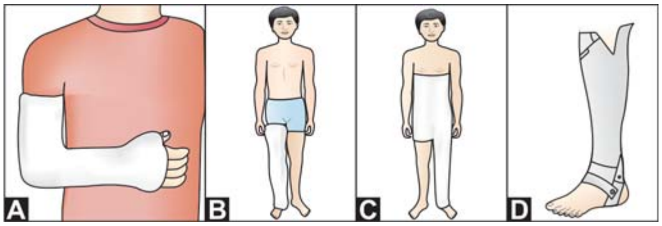
Commercial Plaster of Paris rolls commercially pre-pared consists of rolls of muslin stiffened by starch, POP powder and an accelerator substance like alum. This commercial preparation sets very fast and gives a neat finish unlike the indigenous ones.

Why is plaster of Paris an ideal splint?

- It is cheap.
- It is easily available.
- It is comfortable.
- It is easy to mould.
- It is quick setting.
- It is strong and light.
- It is easy to remove.
- It is permeable to radiography.
- It is permeable to air and hence underlying skin can breathe.
- It is noninflammable.

Its Various Forms

Plaster of Paris is used in four forms as slab, cast, spica, and functional cast brace.



Figs 6.6A to D: Various types of plaster immobilization, (A) above elbow cast, (B) above knee cast, (C) hip spica, (D) functional cast brace

Slab It is a temporary splint used in the initial stages of fracture treatment and also during first aid. It is useful to immobilize the limbs postoperatively and in infections. It is made up of half by POP and half by bandage roll and hence can accommodate the swelling in the initial stages of fractures.

Casts (Fig. 6.6A and B) Here the POP roll completely encircles the limb. It is used as a definitive form of fracture treatment and also to correct deformities.

Spica This encircles a part of the body, e.g. hip spica for fracture around the hip (Fig. 6.6C), thumb spica for fracture scaphoid.

Functional cast brace (Fig. 6.6D) This is used for fracture tibia after initial immobilization.

Rules of application of POP casts

- Choose the correct size, 8 inches for the thigh, 6 inches for the leg, and 4 inches for the forearm.
- A joint above and a joint below should be included. Accordingly we have an above elbow (Fig. 6.6A) or below elbow POP cast or slab and above knee (Fig. 6.6B) or below knee POP cast or slab. This is done to eliminate movements of the joints on either side of the fractures. However, this is not a hard and fast rule in certain fractures, like a below elbow cast in Colles fracture, which often suffices.
- It should be molded with the palm and not the fingers for fear of indentation.
- The joints should be immobilized in functional positions
- The plaster should just snugly fit and should not be too tight or too loose.
- Uniform thickness of the plaster is preferred.

Complications of POP

Due to tight fit

- Pain
- Pressure sores
- Compartmental syndromes
- Peripheral nerve injuries
- Cast syndrome

Due to improper application

- Joint stiffness
- Plaster blisters and sores
- Breakage

Due to plaster allergy

Allergic dermatitis

Rehabilitation Protocol

The rehabilitation after plaster of Paris application is discussed at length on page 46.

Remember

About POP

- Used first in city of Paris.
- The ideal splint.
- Slab for temporary and initial treatment.
- Casts for definitive treatment.
- Spica for hip fracture, etc.
- Functional cast brace for early mobilization.

FUNCTIONAL CAST BRACE

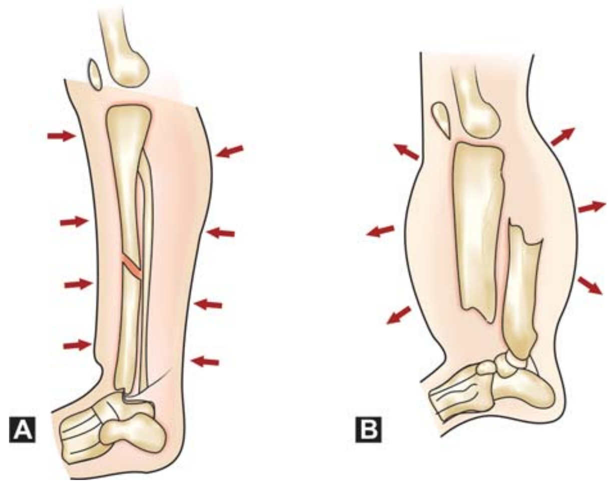
Introduction

If function is allowed during closed method of fracture treatment, it has been observed that, this stimulates osteogenesis, promotes soft tissue healing and prevents development of joint stiffness thus hastening rehabilitation. This concept accepts loss of anatomic reduction to rapid healing. It complements rather than replacing other forms of treatment. The observation that fracture ribs still unite inspite of continued movements due to the action of intercostals muscles showed that elimination of movements at fracture site is not mandatory for fracture to unite (Figs 6.7A and B). It was on this concept that Sarmiento devised functional bracing methods.

Remember

About functional cast brace (Fig. 6.8)

- Fracture ribs indicate that absolute immobility for fracture healing is not required.
- It is a secondary form of fracture treatment.
- Muscle action favors osteogenesis.
- Hydraulic action of muscles stabilizes the fracture in a closed compartment.
- Eliminates fracture disease like in AO technique.
- Not useful in compound fractures.
- Popularized by Sarmiento.
- Useful in fracture tibia and fracture femur.



Figs 6.7A and B: Principles of cast bracing: (A) with brace, and (B) without brace

Fig. 6.8: Showing a functional cast brace

The mode of action Here *the hydraulic action of muscles is brought into play*. The fracture brace allows movements of the joints and permits the load to be transmitted through the muscles. The muscles which are surrounded by the inelastic deep fascia if encased in a hard plaster cannot be stretched beyond the confines of the cast. On movements and bearing weight, the muscle forces are hence driven inwards towards the fracture and not outwards. This helps the fracture to be held firmly. These hydraulic forces control the fragments and resist overlap and angulations till callus forms. Rotation is also resisted by the brace and muscle contraction.

In compound fractures due to severe disruption of soft tissues this principle will not work until soft tissues have healed.

Rehabilitation Protocol

This is the same as for the rehabilitation protocol in closed fracture treatment with splints (*see* page 46). In addition, the physiotherapist needs to check the alignment of the knee joint (mechanical). Patient needs to reeducate in early walking.

IMPORTANT SPLINTS IN ORTHOPEDICS OTHER THAN POP

Thomas splint This is one of the very commonly used splints in orthopedics described by HO Thomas in 1876 to assist for ambulatory treatment of TB knee. It is now widely used for the treatment of shaft fractures of femur.

Parts of a Thomas splint (Fig. 6.9) A Thomas splint consists of four parts.

1. A padded metal oval ring with soft leather set at an angle of 120° to the inner bar
2. Two side bars—one inner and another outer bars of equal length. They bisect the oval ring.
3. Distal end—where the two side bars are joined in the form of a ‘W’
4. Outer side bar is angled 2 inches below the padded ring to clear the prominent greater trochanter.

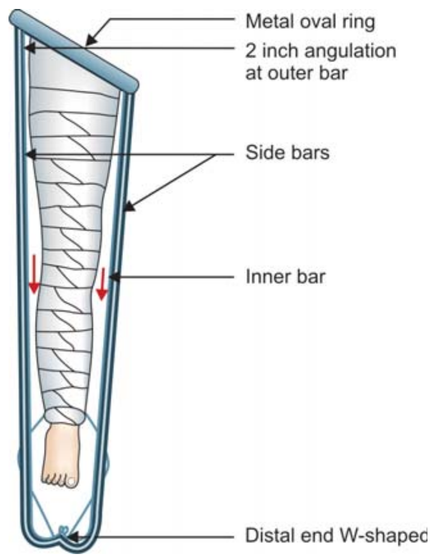


Fig. 6.9: Parts of a Thomas splint

Uses of Thomas splint

- To immobilize fracture femur anywhere
- as a first aid measure.
- for transportation of an injured patient
- in the treatment of joint diseases like TB knee, etc.

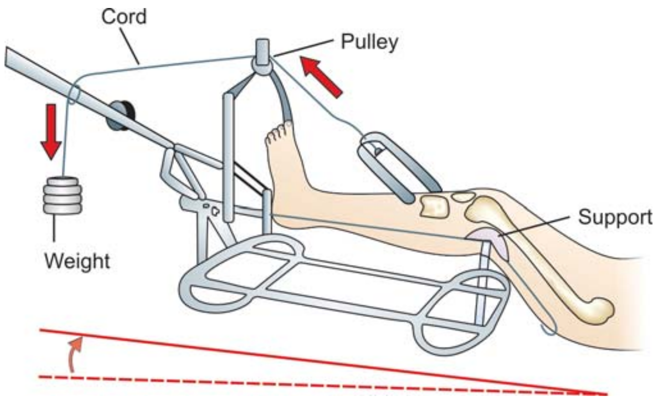


Fig. 6.10: Skeletal traction through Böhler-Braun splint

Böhler-Braun (BB) splint (Fig. 6.10) this is Böhler's modification of Braun splint. It consists of a heavy metallic frame with four pulleys:

1. Proximal pulley prevents foot drop.
2. Second pulley to apply traction in the line of femur.
3. Third pulley to apply traction in the line of supracondylar area of femur.
4. Fourth pulley to apply traction in line of the legs.

Indications

Skeletal traction is applied through this frame for comminuted trochanteric fractures of the femur. It is also used for the treatment of fracture shaft femur and supracondylar fractures of the femur. Rarely can it be used for the fracture shaft of tibia and fibula.

One important precaution which should be taken while using the BB splint is to provide support at the fracture site and not at the knee joint to prevent angulations especially in supracondylar fractures of femur.

Problems of BB Splint

- Makes nursing care difficult.
- It is a heavy and cumbersome frame.
- It is associated with recumbent problems like bed-sores—hypostatic pneumonia, renal calculi, etc.

Care of the Splints

- *Padding* The splint should be well padded at the bony prominences and at the injury sites.
- *Bandage* This should be tied with optimum pressure.
- *Exercises* Active exercises of the joints and muscles should be permitted within the splints.
- *Checking* Daily checking and adjustments of the splints are recommended.
- *Neurovascular status* Distal neurovascular status should be assessed daily.

Rehabilitation Protocol for Splints

Apart from the above mentioned measures, the following things need to be done:

- Isometric exercises to the immobilized muscles.
- Active exercises to all the unaffected joints of the body.
- Ensuring good nursing care to prevent bedsores from developing.
- Active ankle exercises to prevent deep vein thrombosis.
- To keep the patient cheerful to prevent mental depression.
- Chest physiotherapy to prevent lung problems.
- Passive mobilization of patella in lower limb tractions to prevent patella-femoral adhesions.

Practical points Other common splints used in orthopedics (Table 6.1).

TABLE 6.1: Orthopedics common splints

Region	Indications
1. *Cervical spine*	
• SOMI brace	Cervical spine injury
• 4 post collar	Neck immobilisation
2. *Upper limbs*	
• Aeroplane splint	Brachial plexus injury
• Cock-up splint	Radial nerve palsy
• Knuckle-bender splint	Ulnar nerve palsy
• Aluminium splints	Finger injuries
• Volkmann's splint	For VIC
3. *Spine*	
• Milwaukee brace	Scoliosis
• Boston brace	Scoliosis
• Taylor's brace	Dorsolumbar injury
• Anterior spinal hyperextension brace (ASHE)	Dorsolumbar
• Lumbar belts and corsets	Backache
4. *Lower limb*	
• Thomas splint and BB splints—mentioned already	
• Foot drop splint.	Foot drop
5. *Miscellaneous*	
• Thomas splint	
• Krammer wire splint	For emergencies

TRACTION IN ORTHOPEDICS

Traction plays an important role in the management of fractures in orthopedics.

Uses of Traction

- To reduce a fracture or a dislocation.

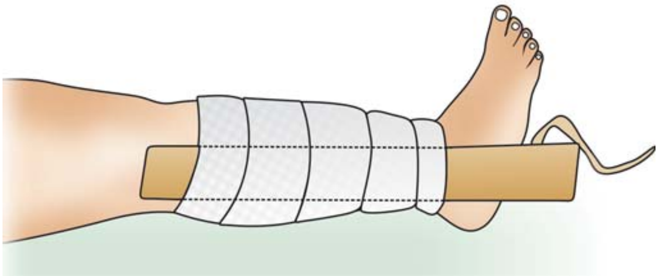


Fig. 6.11: Skin traction

- To retain the fracture after reduction.
- To overcome the muscle spasm.
- To control movement of an injured part of the body and to aid in healing.

Methods of Traction

There are four methods of applying traction, namely skin, skeletal, pelvic and spinal.

Skin Traction (Fig. 6.11)

Here traction is applied over a large area of skin. Maximum weight that can be applied through skin traction is 15 lbs or 6.7 kg. If the weight used is more than this, the traction will slide down peeling off the skin. When used in fracture, skin traction is applied to the limb distal to the fracture site.

Types of Skin Traction

Adhesive skin traction Here adhesive material is used for strapping which is applied anteromedial and posterolateral on either side of the lower limbs.

Nonadhesive skin traction Useful in thin and atrophic skin and in patients sensitive to adhesive strap. It is less secure than the former.

Contraindications for skin traction Abrasions, lacerations, impaired circulation, dermatitis, marked shortening, allergy to plaster are some of the important contraindications for skin tractions.

Complications Allergy, excoriations, pressure sores around the malleoli, common peroneal nerve palsy, etc. are some of the known complications in skin tractions.

Remember

Rotation of the limb is difficult to control with skin tractions.

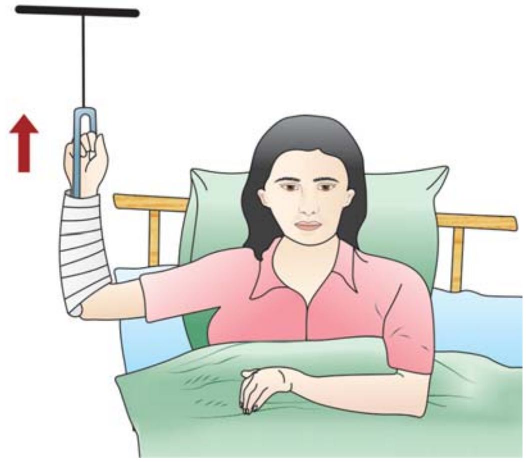


Fig. 6.12: Showing Dunlop's traction

Important Skin Tractions

Bucks extension skin traction This is the commonest type of traction employed for lower limbs. It is used for temporary treatment of fracture neck femur, undisplaced fractures of acetabulum, after reduction of hip dislocation, to correct minor fixed flexion deformity of hip and knee for low backache, etc.

Dunlop's traction Used in upper limbs and is indicated for supracondylar fractures, intercondylar fractures of humerus where elbow flexion causes circulatory embarrassment (Fig. 6.12).

Gallow's traction (Fig. 6.13) or Bryant's traction Used for fracture shaft femur in children less than 2 years. If used in children above 2 years, it causes vascular complications.

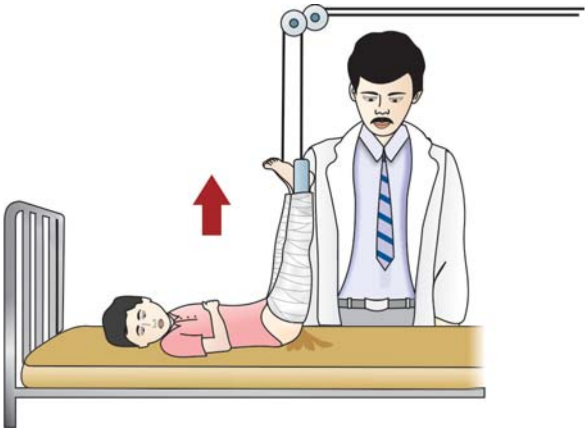


Fig. 6.13: Showing Gallow's traction in children (2 years age)

Rehabilitation in Skin Traction

- Care of the skin—to prevent pressure sores.
- Care of the back—to prevent bedsores.

- Active exercises to the unaffected joints.
- Isometrics to the immobilized muscles.
- Vigorous ankle movements to prevent deep vein thrombosis.
- Daily inspection of the traction sites for evidence of pin infection, loosening, etc.

Skeletal traction Here the traction is given through a metal or pin driven through the bone. It is seldom necessary for upper limb fractures but useful in lower limb fractures for reducing and maintaining the fracture reduction. It is reserved for those cases in which skin traction is contraindicated and where the need to be applied weight is more than 5 kg.

Know the pins used for skeletal traction

Steinmann pin It is a rigid stainless steel pin 4 to 6 mm in diameter. Böhler's stirrup (Fig. 6.14) allows the direction of the traction to be varied without turning the pin in the bone.

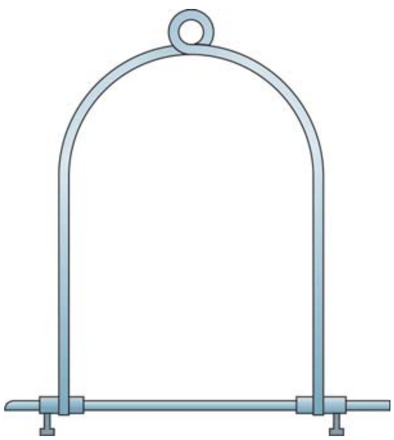


Fig. 6.14: Steinmann pin with Böhler's stirrup

Denham pin (Fig. 6.15) This pin is threaded in the centre and engages the bony cortex. It reduces the risk of pin sliding and is useful in cancellous bone like calcaneum and osteoporotic bones.

Fig. 6.15: Denham pin

K-wire It is of small diameter and is often used in upper limbs.

Know the rules of application

- Skeletal traction should be applied in a major OT under general or local anesthesia.
- Follow strict aseptic measures.
- Drive the pin from lateral to medial in case of upper tibial traction, to avoid injuring the lateral popliteal nerve.
- Pin should be at right angles to the limb and parallel to the ground.
- Cover the sharp tip on the medial side with a stopper bottle to prevent damage to the normal limb.

Know the complications of skeletal traction

At the time of application

- Anesthetic problems.
- Vasovagal shock.
- Very rarely death due to vasovagal shock.

During application

- Injury to the nerves (lateral popliteal nerve).
- Injury to the vessels.
- Injury to the muscles, ligaments and tendons.
- Injury to the epiphysis in children (upper tibial epiphysis).
- Pain due to equalization of intraosseus pressure and atmospheric pressure due to the hole made in the bone.

When pin is in situ

- Infection—due to improper aseptic measures.
- Migration—due to loosening.
- Breakage—thin pin or more weight.
- Bending—same reasons as above.
- Loosening—due to osteoporosis, infection, etc.
- Distraction of fracture fragments—due to excessive weight.

Late effects

- Pin tract infection.
- Chronic osteomyelitis with ring sequestra at the site.
- Genu recurvatum due to damage to the anterior epiphysis of tibia in children.
- Depressed scar.

Traction points Well-known traction in orthopedics (Table 6.2).

How to take care of a patient on traction?

- Patient on traction need to be looked after as they are unable to take care of themselves.
- Watch for petechial rashes, contusion, etc. which may suggest onset of fat embolism.
- Regular monitoring of temperature, pulse and BP.
- A balanced mixed diet is recommended.
- Use of bed pans is advocated.
- Use of NSAIDs for pain relief.
- Encouraged to keep a healthy mental state.
- Proper skin care.

Counter traction Traction force will overcome muscle spasm only if another force is acting in the opposite direction as counter traction.

TABLE 6.2: Indications for traction

Tractions	*Indications*
Head or cervical tractions	
• Crutchfield or Garden wells	cervical spine injuries
• Head halter	cervical spine injuries
• Halo pelvic	Scoliosis
Upper limb tractions	
• Dunlop's traction	Supracondylar fracture of humerus
• Metacarpal traction	Compound forearm injuries
Lower limb tractions	
• Gallow's or Bryant's	Fracture shaft femur (< 2 years)
• Russell's traction	Trochanteric fracture
• Perkin's traction	Fracture shaft femur in adults
• 90-90° traction	Fracture shaft femur in children
• Agnes Hunt traction	Correction of hip deformity
• Well leg traction	To correct abduction and adduction deformity of hip
• Calcaneal traction	Compound fractures of distal leg and ankle
• Buck's traction	Low backache, etc.
• Pelvic traction	Low backache, etc.

Types

Fixed traction Here counter traction is achieved through an appliance which obtains a firm purchase on a part of the body. *This can maintain but cannot obtain reduction,* e.g. fixed traction on a Thomas splint for a fracture shaft femur (*see* Fig. 6.9).

Sliding or balanced traction Here weight of all or part of the body acting under the influence of gravity is utilized to provide counter traction. This can be achieved by raising the foot end of the bed. *Unlike in a fixed traction, both reduction and maintenance of a fracture can be obtained* (Fig. 6.16).

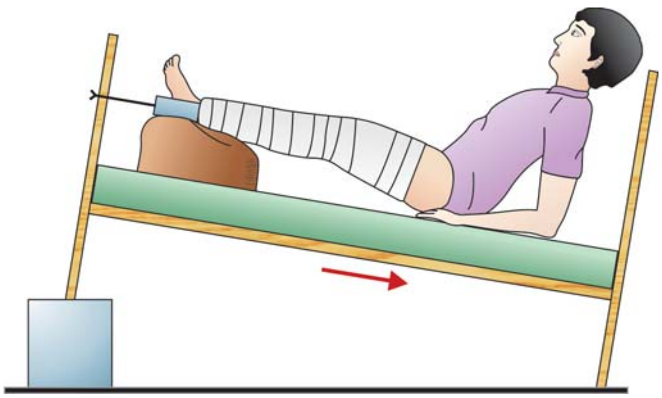


Fig. 6.16: Showing sliding or balanced traction

However, the initial traction weight required obtaining a reduction is greater than the traction weight required to maintain the reduction.

Weight Guide Lines

For femoral shaft fracture initial weight required is 10 percent of patient body weight. For every 1lb of weight the end of the bed should be raised by one inch. A weight of 10 to 20 kg can be applied through a skeletal traction unlike 6.7 kg in skin traction.

Rehabilitation Protocol for Patients Treated with Skeletal Traction

Physiotherapy measures for patients in skeletal tractions are as follows:

Measures to prevent chest problems Chest physiotherapy and deep breathing exercises.

Measures to prevent deep vein thrombosis Active ankle and toe exercises.

Measures to prevent bedsores Back care, frequent change of positions, use of water bed, etc.

Measures to the affected leg

- Isometric quadriceps exercises.
- Passive mobilization of the patella to prevent pin tract infection.
- Alignment of the traction cord, etc.
- To guard against injury to lateral popliteal nerve.

Measures to the unaffected extremities

- Active hip, knee, ankle and foot exercises to the unaffected leg.
- To prepare the patient for crutch walking, arms strengthening exercises are prescribed.

After removal of the traction

- Thermotherapy to prevent pain and spasm.
- Knee mobilization exercises.
- Active, active assisted knee flexion exercises.
- Speedy isometrics to the quadriceps, hamstrings, etc.
- Progressive resistive exercises to strengthen the quadriceps, etc.

Note The treatment by skeletal traction is now being replaced by improved methods of fracture fixation which helps in the early mobilization of the patients.

IMPLANTS

Definition

An implant is defined as a material inserted or grafted into intact tissues or body cavity with some specific purpose.

TYPES OF IMPLANTS

Metallic Generally alloys are used. Three varieties are described iron based, cobalt based or titanium based.

Remember

Characters of ideal implant

- Should be corrosion resistant.
- Should be biocompatible.
- Should have high tensile strength.
- Should have high fatigue limit.

***Three Ps** for implant selection*

- **P**roper material.
- **P**roper design.
- **P**roper size and fixation.

About polymethyl methacrylate (PMMA)

- Called as bone cement
- It has a polymer and a monomer.
- It is not glue and has no adhesive qualities.
- Called cement because it holds two materials bone and metal together by forming an interlocking network between the irregularities.

Nonmetallic implants usually are made up of plastic materials. Polyethylene, polymethyl-methacrylate (PMMA) and silicones are the commonly used nonmetallic implants.

Note Corrosion is a chronic reaction that weakens the implants. Addition of chromium and nickel makes the implant corrosion resistant.

Commonly used implants in orthopedics are screws, plates, intramedullary nails and K-wire.

Screws

Two types of screws are described.

Machine screws (Fig. 6.17) These screws are threaded whole length and may or may not be self-tapping. Used widely with standard bone plates.

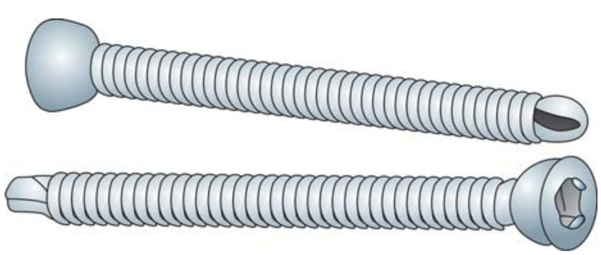


Fig. 6.17: Self-tapping machine screws

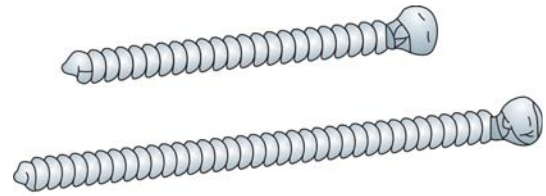


Fig. 6.18: Cortical screws—threaded whole length and not self-tapping

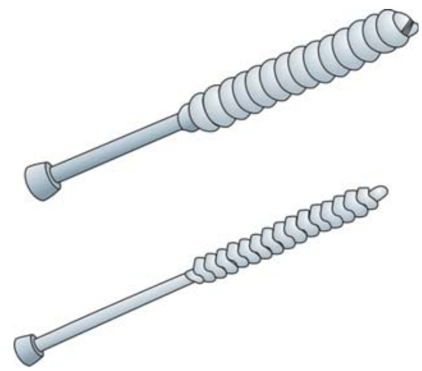


Fig. 6.19: Cancellous screw above and malleolar screw below

ASIF Association of the Surgeon of International Fixation (Swiss group).

ASIF screws or AO screws These screws are designed by AO group in which the threads are more horizontal, drill holes are needed as the screws are not self-tapping. Three varieties of ASIF screws are described.

1. *Cortical screws (Fig. 6.18)* These screws are threaded whole length and have a diameter of 2 to 6.5 mm. This functions as a positional screw or a lag screw for interfragmentary compression.
2. *Cancellous screws (Fig. 6.19)* These have larger threads for more purchase in the soft cancellous bone. It is available as 16 mm, 32 mm length and 4 to 6.5 mm diameter.
3. *Malleolar screws* These have a sharp pointed tip and may be inserted without predrilling. Used for internal fixation of malleolar fractures.

Remember

Uses of screws

- Used mostly to fasten the plates to the bone.
- Used to fix avulsion fractures, butterfly fractures, etc.
- By over drilling the cortex a cortical screw provides interfragmentary compression by producing the lag effect.
- A cancellous screw can produce compression without over drilling since it is half threaded.

PLATES

It is widely used for internal fixation of diaphyseal fractures (Fig. 6.20). Rigidity and strength depend upon the cross-section and the material used. Ranges from very rigid plates to merely positional plates. There is compensating thickness around the holes.

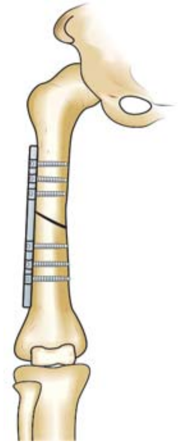


Fig. 6.20: Fracture shaft humerus fixed with DCP plate and screws

TYPES OF PLATES

Ordinary Plates

These just function as positional plate to hold the fractures but will not bring about any compression between the fracture sites. They are used in subcutaneous locations or where extreme rigidity is not required. The patients need prolonged immobilization once this plate is used, e.g. semi tubular plate (Fig. 6.21A), Scheurmann plate, etc. for forearm bones, clavicle, fibula, etc.

Remember

About ordinary plates

- Functions as merely a positional plate.
- Useful in subcutaneous situations.
- Needs prolonged immobilization.
- Hence role is limited and has given way to compression plating.

AO PLATES (FIG. 6.21B)

As described earlier AO techniques aim at early mobilization of the limb by providing a rigid compression at the fracture site and thereby prevent the possibility of fracture disease. Rigid fixation at the fracture site can be obtained by providing compression at the fracture site.

Fig. 6.21A: Semi tubular plate

Fig. 6.21B: AO plate

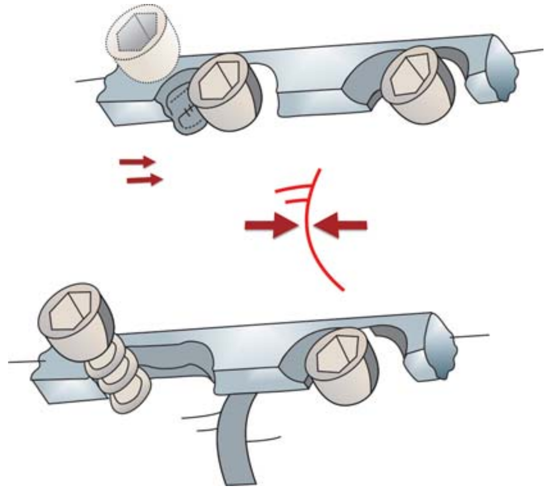


Fig. 6.22: In DCP fragment moves as the screw is tightened producing compression

DYNAMIC COMPRESSION PLATES (DCP)

In DC plates (Fig. 6.22) screw, holes are designed to utilize *spherical gliding principle* with inclined contour of the screw holes and the slope on the under side of the screw head. As the screw is tightened its head is guided by the contours of the screw hole in such a way that the head glides towards the centre of the plate until the deepest portion of the hole is reached. Result is that bone fragment into which screw is being driven is displaced at the same time and in the same direction providing rigid compression. It is called dynamic because the bone fragment moves while the screw is being tightened.

Advantages of DCP

- Less surgical exposure then the conventional surgery.
- Screw and plate fit congruently in any position.
- Screw may be inserted at any angle.
- All other advantages of rigid fixation.

Rehabilitation Protocol

This is the same as mentioned in rehabilitation for internal fixation (*see* page 46).

INTRAMEDULLARY NAIL

Salient features about intramedullary nail are as follows.

- Firmly fixes the fracture and permits early mobilization.
- Useful in diaphyseal fractures at the narrowest portion of the medullary canal.
- Very suitable in young adults.

TYPES OF INTRAMEDULLARY NAILS (*SEE* FLOW CHART 6.1)

Flow chart 6.1: Showing different types of intramedullay nail

- Intramedullary nails
  - **Standard IM nails of Centromedullary nails**
    - Five designs on cross-section.
      - Clover leaf nail (Küntscher nail) (Fig. 6.23)
      - Hansen's nail (diamond shaped
      - Schneider (double I-beam)
      - Samson's nail (cylindrical rod with flutes)
      - Lottes nail
    - Indications
      - Fracture shaft femur at the level of isthmus in adults
  - **Interlocking nails**
    - Dynamic
      - Locked at one end
    - Static
      - Locked at both ends
    - Indications
      - Comminuted fractures
      - Segmental fractures
      - Nonunion
      - Proximal and distal third fractures
      - Pathological fractures
      - Multiple osteotomies
    - Example
      - Russel-Tailor nail
      - Gross-Kempf nail
  - **Flexible medullary nails or Condylocephalic nails**
    - Passed from distal to proximal.
    - Fracture fixation to achieved by three point pressure system e.g. Rush nail and Ender's nail.

- Not indicated for children and adolescents as the epiphysis may be damaged while inserting the nail leading to future growth complications.
- Patient should be able to tolerate major surgery.
- Nails should be of suitable length and diameter.
- Suitable instruments, assistants and hospital required.
- Closed technique is better than open.
- Union is peripheral and no endosteal healing due to reamed medullary canal.
- Fat embolism is relatively more common.

Mode of Action of Intramedullary Nails

- It is a load-sharing device unlike a plate, which is a load-bearing device.
- It fills the medullary cavity.
- It provides three-point fixation (at the ends of nail and at the point where curve of the nail is in contact with the opposite cortex).
- It resists bending movement but is poor against torsional forces.

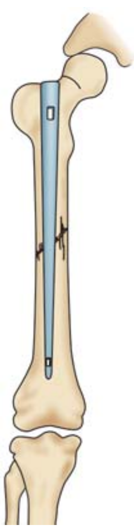


Fig. 6.23: Showing fracture femur fixed with Küntscher (IM) nail

Remember

About rigid fixation plates
- *Compression at fracture site obtained by*
  - — Lag effect.
  - — By using external compression device as in AO plating.
  - — Self-compression as in DCP.
  - — Tension band technique.

Advantages
- Early mobilization.
- No fracture disease.

Disadvantages
- Heals by primary intention hence callus is not seen on radiographs.
- Poor fracture welding as there is no external callus.
- Excessive compression causes osteonecrosis.
- Refracture is common after removal.
- Requires wide exposure.

Irony Rigid fixation no doubt permits early mobilization but this advantage is nullified by the prolonged immobilization required following implant removal to fill up the screw gaps.

Solution Interlocking nail emerging as an ideal replacement.

Rehabilitation Measures in IM Nailing

This has been discussed at length in the Chapter on Fracture Femur, Tibia and Fibula (*see* page 158).

RECENT ADVANCES IN FRACTURE TREATMENT

Advances are made in the existing methods of fracture treatment. The notable ones are mentioned here.

Improvements in plaster of Paris splints Now the days are of ultra short setting plaster casts or slabs made up of a material called polyurethane.

Functional cast brace Earlier application of casts or slabs confined the patient to the bed till the fracture united. Now the concept is to mobilize the patient on the plaster cast by using the functional cast brace, an idea developed by Sarmiento. Discussed at length in the previous section.

Improvements in AO technique Introduction of LCDCP (limited contact DCP) is considered as a step in the improvement of rigid fixation by AO technique.

Improvements in intramedullary nails These are the days of interlocking nails. Earlier intramedullary nails could not be used in proximal and distal third fractures because the wider medullary canal in these areas rendered it difficult to control the rotation of the nail. The only alternative left was to use a plate and screw. But the problems associated with plate and screws necessitated the discovery of newer intramedullary nail with the problem of rotation eliminated by locking. Thus, the concept of interlocking nail was born and has made greater strides in the management of difficult fractures.

INTERLOCKING NAILS

- Standard IM nails designed by Küntscher for shaft fractures leave two unresolved problems:
  - Rotation of the fracture fragments.
  - Telescoping at the fracture site.
- By locking the nail into the bone by means of self-tapping screw driven through holes located at both the ends, the above two problems are solved. Gross and Kempf locking nail is found to be successful (Figs 6.24A and B).

Advantages

- It can be used for both simple and compound shaft fracture from subtrochanteric to supracondylar area in the femur and from upper third to supramalleolar area in the tibia.

Figs 6.24A and B: Interlocking nail of femur and tibia

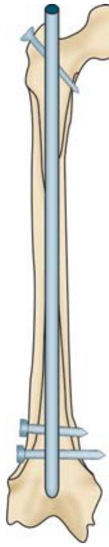


Fig. 6.25: Interlocking nail *in situ*

- It can be used in the treatment of segmental fractures, comminuted fractures, bone loss, etc.
- It can be used for the treatment of nonunion.
- For reconstructive surgery following tumor excision.
- Low blood loss, low risk of infection.
- Short operative time.

Principles

Static locking Here screws are placed both proximal and distal on either sides of the fracture. This neutralizes the rotation and restricts telescopy (Fig. 6.25).

Indications

- Comminuted or butterfly fractures.
- Spiral fractures.
- Comminuted fracture with bone loss.
- Lengthening and shortening osteotomies.
- Atrophic nonunion.
- Pathological fractures.

Dynamic locking Here screws are placed either proximal or distal depending on the site of fracture. It neutralizes rotation movements but allows certain movements at the fracture site favoring osteogenesis. It allows immediate mobilization and weight bearing. C-arm is required to carry out this procedure (Fig. 6.26).

Indications

- Proximal and distal fractures where there is good bone contact.

Fig. 6.26: Showing C-arm (image intensifier) which has revolutionized modern-day orthopedic surgeries)

- Proximal and distal nonunion.
- Proximal and distal osteotomies in malunion.

Remember

> **About interlocking nail**
> - It is a modification of standard IM nail.
> - It extends the indication of IM nail and can be used for a wide range of shaft fractures.
> - Low blood loss and low rate of infection.
> - Less operative time.
> - Technically demanding.
> - Requires sophisticated equipments.

Rehabilitation Protocol

This is the same as mentioned in rehabilitation for internal fixation (*see* page 46).

IMPROVEMENTS IN EXTERNAL FIXATION

Ilizarov Technique

Dr GA Ilizarov of Kurgan of Russia had developed a research centre on the role of external fixators in the management of orthopedic problems. Deviating accidentally from the routine of applying compression, his assistant applied a distraction force much to the discomfiture of Dr Ilizarov. *But he was surprised to see the bone growth in spite of the distraction force*. Little did he realize that he had discovered a new law which was to revolutionize the management of nearly 65 percent of orthopedic conditions? He had found an answer to complex orthopedic problems hither to unsolvable by conventional orthopedic procedures.

The use of external fixators in the management of fractures was first described by Hippocrates 2400 years ago. Conventionally there are two types of external fixator; pin fixator and ring fixator. The ring fixator was developed by Ilizarov in 1951.

Principles of Ilizarov Method

An important law of nature which was not known to the biologists was "distraction or pulling apart of living tissue creates a new tissue of its own kind". It was the beginning of a new era of successfully treating unsolved orthopedic problems. The following are the principles of his method:

Law of tension force When a living tissue is slowly pulled apart at the rate of 1 mm/day, it creates a new tissue. This is called as distraction osteogenesis.

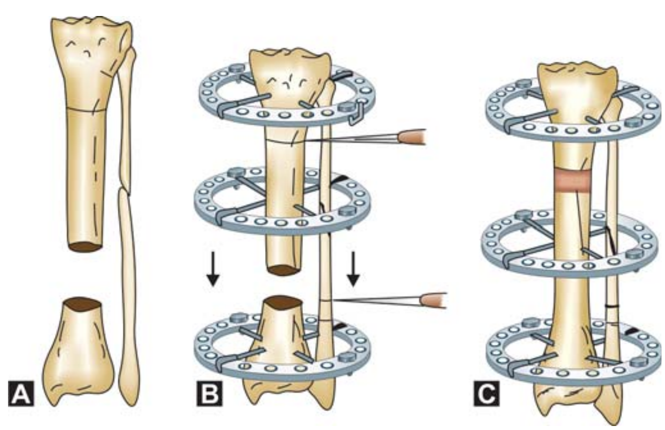
Use of a unique ring fixator which is multilevel, multidirectional, multiplane external fixator and hence it is superior to other external fixators.

Corticotomy In this procedure only the cortex of the bone is cut subperiosteally and intramedullary circulation is left intact. Preservation of periosteum and intramedullary circulation produces a better quality of new bone.

About Ring Fixator

Ring fixator is an exceptionally versatile circular external fixator. The system has good range of hard wires of various sizes and lengths, which can combine to produce fantastic combinations of around 500 types which allow a precise control of bone segments including angulations, rotation, translation, lengthening and compression.

Stages (Figs 6.27A to C) Distraction osteogenesis deve-loped by Ilizarov has four stages.



Figs 6.27A to C: Stages of distraction osteogenesis: (A) Bone gap, (B) Corticotomy and distraction, and (C) Union

1. Stable fixation of low energy corticotomy to preserve the blood supply.
2. A short latency period before distraction for local bridging of the gap by fibrous tissue.
3. Slow gradual distraction to stimulate ossification during elongation at the rate of 1 mm/day.
4. Newly formed bone extends from each end of the osteotomy in full cross-section parallel to the distraction force. When distraction is discontinued and relative compression is applied ossification bridges the central gap.

The osteogenic area rapidly remodels to normal macro-structure and microstructure that is indistinguishable from the host bone histologically and roentgenographically.

Benefits of Ring Fixator System

- Simultaneous correction of multiplane deformities.
- Wide variety of indications treatable with one system.
- Thin tensioned wires allow for stable purchase in small fragments and osteoporotic bones.
- Early patient ambulation.
- Single surgical procedure.
- Light weight, high strength, radiolucent, composite half rings.
- Relatively simple method, no major surgery required.
- Ilizarov calls this a bloodless surgery as no incision is required, if required it is only 1 to 2 cm.
- Removal of the assembly is very easy.

Indications

Complex fractures Ilizarov is very useful in treating some of the very complex fractures like open fractures, comminuted fractures, intra-articular fractures, etc.

Nonunion Ilizarov gives excellent result in the management of both infected and uninfected nonunion. It simultaneously attends to all the components of nonunion.

Limb lengthening As in achondroplasia and other shortenings.

Deformity corrections Due to polio, cerebral palsy, etc.

Other Important Indications

- Congenital pseudoarthrosis of tibia
- Stump lengthening
- TAO
- Tumor excision and lengthening
- Foot deformities.

Complications

- Poor patient compliance.
- Damage to nerves and vessels during insertion.
- Wire tract infection, loosening or breakage.
- Joint contractures.
- Inadvertent injury to the patient or operating room personnel caused by the K-wire.

Rehabilitation Protocol

This is the same as the rehabilitation protocol for fractures treated by external fixators.

Remember

About Ilizarov

- Makes use of the hitherto unknown principle that distraction stimulates osteogenensis.
- A single frame by arranging it in different combinations can be useful to solve 65 percent of orthopedic problems.
- The greatest boon is early ambulation and weight-bearing.
- Low rates of complications.
- Virtually a bloodless surgery.
- Very effective in the treatment of nonunion.
- Cost-effective.

FUTURE

The future undoubtedly belongs to you. Fast advancing techniques and invasion of computers promise much improved methods of orthopedic diagnosis and management. We will be practicing a more sophisticated hi-tech orthopedics in the near future. Some of the examples are LASER treatment for disc prolapse, etc.

7

Chapter

First Aid and Emergency Care of the Injured

First aid techniques in managing an injured patient should be learnt first and not last. Proper first aid is a skill which needs to be learnt and developed.

DEFINITION

First aid is the initial care of the injured at the scene of accident.

Anybody can give first aid, but to carry out cardiopulmonary resuscitation measures one should be trained in first aid and should possess a valid certificate issued by a competent body.

First aid executed by a medical person is called a *medical aid*.

GOALS OF FIRST AID TREATMENT

Goals of first aid treatment are aptly described by **three Ps**.

- **P**reserve life by carrying out appropriate resuscitative measures.
- **P**revent further injuries by careful handling.
- **P**romote recovery.

INITIAL CARE OF THE INJURED

At the Scene of Accident

- Remove the victim from the accident spot.
- Check his or her vital parameters quickly (pulse, BP, consciousness, etc.).
- Seek the help of bystanders if trained in first aid.
- Ensure that police and ambulance have been informed.
- Remember to carry out first aid according to Mac Murthy's A to F regimen (*see* page 205).
- Ensure personal safety.

MODUS OPERANDI IN FIRST AID

AIRWAY

First clear the airway as follows:

- Clear the mouth of clots, dentures, loose teeth, etc.
- Extend the neck slightly as this opens up the pharynx.
- If the patient is not breathing begin artificial respiration. First keep a thin cloth over the patient's mouth, blow into the patients mouth keeping his or her nostrils closed (Fig. 7.1). Blow at the rate of 16/min and see for the chest raise. Mouth to nose respiration is carried out if there is extensive injury to the mouth. If the patient has suffered extensive facial injuries, put the patient prone, turn the face towards one side and apply pressure over the lower aspect of the chest (Holger-Nelson's method).

Fig. 7.1: Mouth-to-mouth respiration to resuscitate a victim

Fig. 7.2: Chest compression and cardiac massage (to be done on a hard surface)

Fig. 7.3: Limb elevation to control bleeding

CARDIA

Examine the radial pulse and the carotid pulse for the function of cardia. If the pulse is absent initiate cardiac resuscitative measures as follows:

- Ensure that patient is lying on a hard surface.
- Then pressure (Fig. 7.2) is applied with the heel of the palm at the lower end of sternum.
- Optimum pressure should be applied and the depth of each pressure should be 11/4 inch.
- Perform external cardiac massage at the rate of 72/min.
- It is preferable to carry out both external cardiac massage and artificial respiration simultaneously by two persons trained in first aid. But if there is no assistance available then cardiopulmonary resuscitation should be carried out by a single person as follows:
  - First artificial respiration is given once and then the same person should quickly change position and carry out external cardiac massage 5 times. So, this 1:5 ratio should be maintained throughout.
  - The cardiopulmonary resuscitation (CPR) should be carried out till the patient recovers or at least for half an hour.

BLEEDING

It is advisable to arrest the bleeding by direct application of pressure over the bleeding points (Fig. 7.3). *Tourniquet should be avoided and used only as a last resort.*

EXAMINE THE VITAL STRUCTURES

Head injuries Examine the patient for head injuries, cover the skull injuries with a clean cloth, and examine pupils and the level of consciousness. Look for neurological deficits.

Chest injuries Open chest injuries are dangerous as they may cause tension pneumothorax. Application of a clean cloth with firm pressure over the open wounds is all that is required.

Abdominal injuries All injured patients should be examined for intra-abdominal injuries as it is an emergency. Board-like rigid abdomen suggests blunt injury abdomen and there could be damage to the liver, spleen, colon, etc. Arrangement should be made to shift the patient immediately to a hospital. In open wounds of the abdomen firm pressure should be applied by a clean cloth.

Pelvic fractures Suspect pelvic fracture if the patient complains of pain during compression test or distraction test which is performed by applying pressure over the iliac bones. Tenderness over the symphysis pubis is also suggestive.

Injuries to the genitourinary system Suprapubic swelling indicates bladder injury, injury to the scrotum or perineal hematoma indicates urethral rupture.

Spine injuries Cervical spine injury should be suspected if the patient is lying still and loathes turning the neck. Injuries to the thoracic and lumbar spine should be suspected if the patient has developed paraplegia or complains of pain when individual spinous processes are palpated. *Extreme care should be exercised in managing and shifting a patient with spinal injuries.*

Fractures Deformity, pain, swelling, loss of function of a limb are suggestive of fracture.

Fracture needs to be splinted with whatever material is available at the scene of accident (Figs 7.4 to 7.7). They can be managed electively after shifting the patient to the hospital.

Fig. 7.4: Showing method of splinting of leg fractures

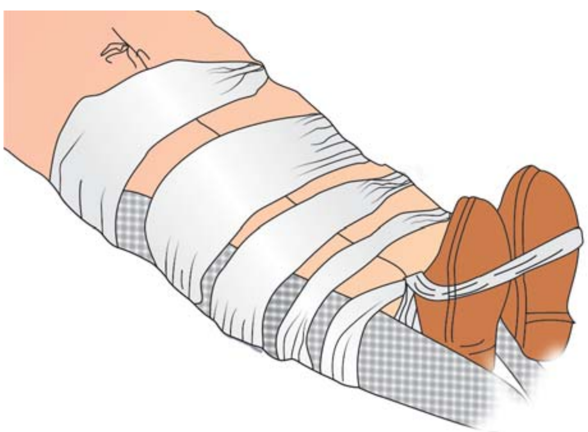


Fig. 7.5: Splinting by the support of the normal limb

Fig. 7.6: Splinting with a newspaper and handkerchief

Fig. 7.7: Splinting of the fracture sites: a make-shift sling

Remember

- Fracture is not an emergency.
- Most of them can be managed electively at a later date.
- In A to F management of injured fracture treatment comes last.
- Prepare and improvise splints with available materials at the scene of accident.

Remember

About fractures in first aid

The management of fractures at the scene of accident.

Five Ss

- **S**ling for clavicle fractures, shoulder fractures, etc.
- **S**trap for clavicle and rib fractures.
- **S**plint, usually improvised. Best would be a Thomas splint or a pneumatic splint.
- **S**hift the patient with utmost care.
- **S**eek professional help at the earliest.

Remember the priority in first aid

Three S's

- **S**hock to be corrected first.
- **S**ystemic injuries to be tackled next.
- **S**pine injuries call for extreme caution.

MANAGEMENT AT THE HOSPITAL

Mac Murthy has laid down the A to F management guidelines to be followed in the institutional care of the injured in the order of importance:

- Airway management
- Blood and fluid replacement
- Central nervous system management
- Digestive system management
- Excretory system management
- Fracture management.

Other emergency measures like administration of antitoxin, antibiotics, anti gas gangrene serum, wound debridement should be carried out. Appropriate radio-graphs should be taken before treating the fractures. The treatment of bone and joint injuries are discussed in detail in the relevant chapters.

Remember

The mnemonic

Aid as prerequisites of a good first aider

- **A**lertness
- **I**ntelligence
- **D**ecisions

Aid as mnemonic of a bad first aider

- **A**pathy
- **I**ndecision
- **D**elay

Remember in first aid

- Delay is dangerous.
- If improperly executed, first aid will become the last aid!
- Always aid the patient to recovery and do not send him to mortuary by being apathetic.
- Shifting a patient to a hospital is extremely important.
- Terminate first aid measure once medical assistance arrives or after shifting the patient to the hospital.

2

Section

TRAUMATOLOGY

8. Fracture Clavicle and Injuries around the Shoulder
9. Injuries of the Elbow
10. Injuries of the Forearm, Wrist and Hand
11. Injuries around the Hip
12. Fracture Femur, Tibia and Fibula
13. Injuries of the Knee Joints
14. Injuries of Ankle and Foot

8 Chapter

Fracture Clavicle and Injuries around the Shoulder

FRACTURE CLAVICLE

The term clavicle is derived from the Latin root *clavis* meaning *key* (Fig. 8.1).

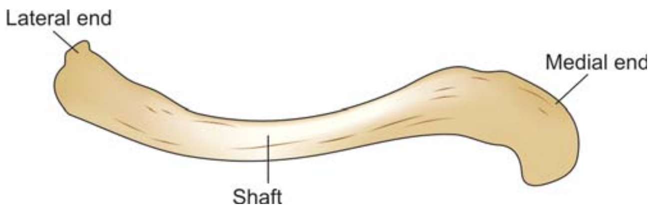


Fig. 8.1: Anatomy of clavicle

Mechanism of Injury

Direct Due to fall on the point of the shoulder. This is the most common mode of injury accounting for 91 percent of the cases.

Direct trauma Over the clavicle due to assault RTA, etc. accounts for 8 percent of the cases.

Indirect fall on the outstretched hands accounts for 1 percent of the cases.

Note The clavicle usually bends and breaks with the first rib as the fulcrum.

Sites of Fracture

- Eighty percent of the fracture clavicle occurs at the junction of middle and outer third
- One percent at medial end of the clavicle
- Lateral end fracture is uncommon.

Note In fracture of lateral one-third, coracoclavicular ligament could be intact or ruptured. If ruptured, the sternocleidomastoid muscle pulls the medial end up and the lateral end is pulled down by weight of the arm and gravity.

Clinical Features

Patient presents with pain, swelling, deformity and inability to raise the shoulder (Fig. 8.2). Rarely patient may present with pseudo paralysis of the affected arm.

Radiograph

Routine anteroposterior view of the clavicle helps in making a reasonably accurate diagnosis (Figs 8.3A and B).

Fig. 8.2: Clinical photograph showing fracture clavicle

Figs 8.3A and B: X-ray showing fracture clavicle of (A) middle-third (B) lateral third

Treatment

Principle of treatment This consists of neutralizing the gravitational and muscular forces already mentioned by bracing the shoulder back and supporting the arm in displaced fractures.

Goals

Orthopedic

- *Alignment* Since clavicle is a curvilinear bone, anteroposterior and lateral alignment is aimed at.
- *Stability* This can be achieved by external (common) or internal (by OR + IF) immobilization.

Rehabilitation Restore complete or at least 'functional' level of shoulder movements. Effort is made to improve the strength of the following muscles, sternocleidomastoid (neck rotators); pectoralis major (arm adduction), and deltoid (arm abduction).

Fig. 8.4: Methods of conservative treatment of fractures clavicle collar and cuff sling

Functional This aims at achieving activities of daily living, vocational and sports.

Treatment Methods

Most of the fracture clavicle is treated by conservative methods, while open reduction and internal fixation are reserved for specific indications.

For undisplaced fracture Simple collar and cuff sling or triangular bandage is sufficient (Fig. 8.4).

Displaced fractures

- Collar and cuff sling, with strapping of the fracture site with adhesive plaster (Fig. 8.5).

Fig. 8.5: Methods of conservative treatment of fractures clavicle strapping and sling suspension

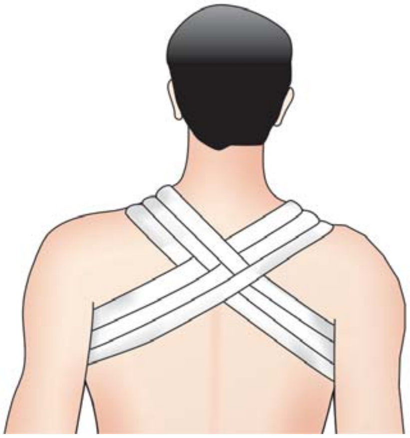


Fig. 8.6: Methods of conservative treatment of fractures clavicle Fig of 8 bandaging

- *Fig of 8 bandages* This is popularly used, as it acts by retracting the shoulder girdle, minimizes the overlap and allows more anatomical healing (Fig. 8.6).

  If improperly applied, it causes undue pressure over the axilla compressing the blood vessels and brachial plexus. Hence adequate padding in the axillae, frequent checks for proper fit and neuro-vascular evaluation is advised.
- *Surgery* This is rarely indicated in fracture clavicle and is considered in the following situations like open fractures, injury to neurovascular bundle, if fracture is threatening to perforate the skin, nonunion, etc. Surgery consists of closed reduction and percutaneous fixation with K-wires or open reduction and internal fixation with plates and screws.

Complications of Fracture Clavicle

Immediate

Neurovascular injury To the subclavian and brachial plexus *may* be immediate due to direct force or delayed due to a very large callus.

Malunion is very common and it causes only a cosmetic problem and does not usually impair function. Hence no treatment is required.

Nonunion is rare and requires open reduction, rigid internal fixation and bone grafting.

Rehabilitation Program

Rehabilitation program for clavicle fracture varies with the age of the fracture and whether the treatment is conservative or operative. Proper clinico-radiological evaluation is recommended during the entire course of the treatment.

Conservative Treatment

Immobilization phase During the first week of treatment either by sling, strapping or Figure of 8 bandages, shoulder is held in abduction and internal rotation and elbow in 90° flexion.

- No range of motion or muscle strengthening exercises is prescribed for the shoulder.
- The unaffected arm is used for dressing, self-care and personal hygiene.
- The patient is advised initially to sleep on a reclining chair and in later stages to roll over the unaffected side to come to the upright position. Weight-bearing is not permitted. However full active range of motion is advised for wrist, hand and digits.
- At the end of second week, gentle pendulum exercises to the shoulder in the sling as pain permits and gentle isometric exercises to the deltoid are begun.

Mobilization phase

- At the end of 4 weeks, gradual mobilization of the shoulder is begun.
- By 6 weeks, gentle active range of movements to the shoulder is allowed. Abduction is restricted to 80°. Pendulum exercises with gravity eliminated, isometric exercises to the rotator cuff and deltoid are begun.
- The patient is permitted to use the affected extremity for some self care and personnel hygiene. No weight-bearing is still permitted.
- By the end of 6-8 weeks, full active to active assistive range of motions is permitted in all planes. Resistive exercises to the shoulder girdle muscles are begun. Patient is advised to use the involved limb for personal hygiene, light works, self-care, etc. Gradual weight-bearing is allowed.
- After 8-12 weeks, full active motion, abduction, isometric, isotonic and resistive exercises are prescribed. Full weight-bearing and normal use of the affected limb is permitted.

During the conservative treatment, check the following:
- Fracture alignment.
- Tighten the sling.
- In Figure of 8 bandages, check for the pressure over the neurovascular structures in the axilla and skin pressure.
- Ensure that the scapula is braced back properly in Figure of 8.
- Check for reflex sympathetic dystrophy, parasthesiae due to pressure from hypertrophic malunion or nonunion on the brachial plexus or subclavian vessels.
- Frequent radiological evaluation, to check the status of callus and fracture union.

Surgery

- During the first week, stability of the fracture depends on the fixation. A check is made for the wound and proper fitting of the sling. Gentle shoulder pendulum exercises with active range of motion of elbow, wrist, hand and fingers are begun. Isometric exercises to the elbow and wrist are advised.
- Sutures are removed after second week, the sling is checked for comfort. Sling is discarded after 4 weeks. Rest of the management is same as for the conservative approach.

Quick Facts

Know the following (about clavicle)

- The clavicle acts as a strut to keep the shoulder from rolling.
- It has very little motion.
- 1/3 to 1/2 of the full range of movement are considered functional.
- The expected time of healing in clavicle fracture is 6-12 weeks.
- The expected time of rehabilitation is 10-12 weeks.
- Sling is the method of choice and is a stress-sharing device.
- Plate and screws are stress shielding device.
- Elderly patients are at higher risk for development of joint stiffness.
- Delayed union and nonunion are rare. Malunion is quite common after closed management. No functional impairment.
- Scars from open reductions though noticeable are non-cosmetic.
- Avoid contact sports for 2-3 months.

INJURIES OF THE ACROMIOCLAVICULAR JOINT

Acromioclavicular joint is a diarthrodial joint with a fibro cartilaginous disc between the two bones (similar to a meniscus). Two types of ACM joint injuries are described (Fig. 8.7).

Mechanism of Injury

Direct force This is the most common mechanism of injury as in RTA, assault, etc. (Fig. 8.7).

Indirect force is due to fall on the outstretched hands.

Downward indirect force through the upper extremity This is relatively rare.

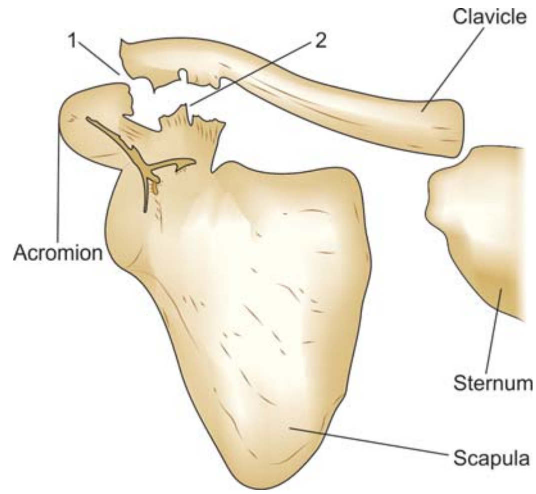


Fig. 8.7: Acromioclavicular joint injury shows: (1) ruptured acromioclavicular ligament (ACL), and (2) ruptured coracoclavicular ligament (CCL)

Clinical Features

Patient complains of pain, swelling, and difficulty in raising the arm up. On examination there is tenderness and the lateral end of clavicle is prominently felt (Fig. 8.8).

Fig. 8.8: Clinical photograph of ACM dislocation

Radiograph

X-ray of shoulder, AP view is required to make the diagnosis (Fig. 8.9).

Management

- *Conservative treatment consists* of rest, ice bags, etc. Sling for 10 to 14 days, adhesive strapping, elastic strapping, cast or harness. Surgery is required for persisting pain.
- *Surgical methods include*
  — Acromioclavicular repair.

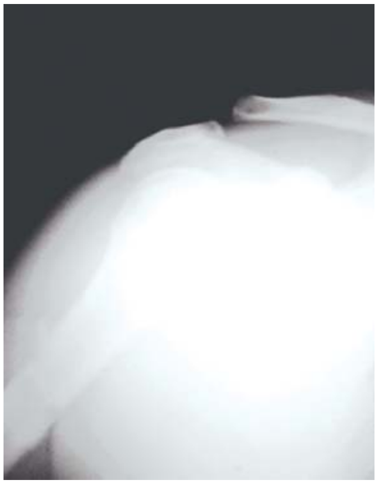


Fig. 8.9: Plain X-ray showing ACM dislocation

— Coracoclavicular repair.
— Excision of distal end of clavicle for old symptomatic cases.
— Dynamic muscle transfer—by transferring the coracoid process.

Complications

- Associated fracture clavicle.
- Coracoclavicular ossification.
- Osteolysis of distal clavicle.
- Complications after surgery like infection, etc.
- Complications after non-operative treatment like joint stiffness, etc.

Physiotherapy Measures

Goal As in clavicle fractures, the goal of physiotherapy management is to restore full range of active shoulder movements.

Conservative Treatment

First 3 weeks This is the phase of immobilization. During this phase no active shoulder movements are permitted. However full active movements of the elbow, forearm, wrist and fingers are allowed. The strapping and sling are inspected for slackness and tightened accordingly.

Three weeks later This is the phase of mobilization. Pendulum swing exercises within the limits of pain with the sling are commenced. With the patient supine, relaxed passive mobilization is attempted with stress on passive elevation, horizontal adduction and abduction.

At the earliest, greater than 90° of abduction needs to be achieved by assisted active movements. As an adjunct, heat therapy may be employed to induce relaxation and reduce pain. Self-resistive home exercises are later advised to the patients. By 6-8 weeks, patient should be able to regain full range active shoulder function.

Surgical Treatment

Here special emphasis is placed on strengthening the repaired coracoclavicular ligament. Shoulder mobilization is commenced only after 4 weeks and heat therapy helps to a greater extent in reducing the pain during mobilization. The regime is more or less similar to the method described in conservative management except that full range is expected after 8-10 weeks.

FRACTURE OF THE SCAPULA

Scapula is a flat bone thickly covered by muscles. From above downwards, the scapula may be fractured as follows (Figs 8.10 and 8.11):

- The coracoid process
- The spine of the scapula
- The neck
- The body

Mechanism of Injury

- Direct injury to the shoulder blade.
- Fall on outstretched hands.

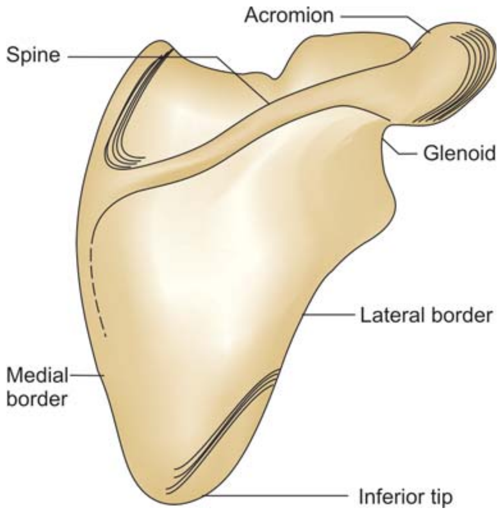


Fig. 8.10: Anatomical features of scapula

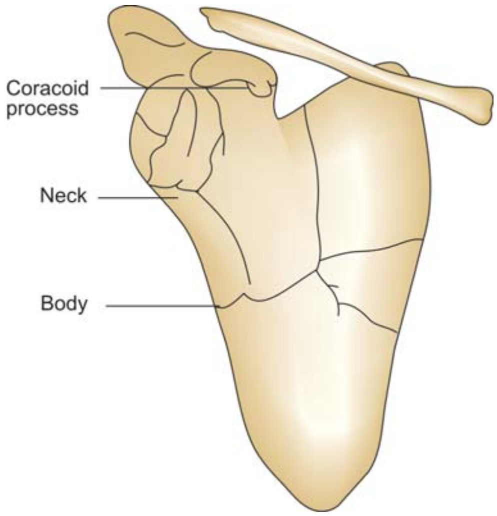


Fig. 8.11: Types of scapular fractures

Whatever may be the mechanism of injury, scapular fractures are seldom displaced, thanks to the thick muscles surrounding it.

Clinical Features

Patient complains of pain, swelling, inability to raise the arm, etc.

Radiograph

Plain X-ray of the scapula is required to make the diagnosis (Fig. 8.12).

Treatment

Conservative treatment by sling for a period of 2-3 weeks forms the mainstay of treatment. Surgery is seldom required. Early mobilization of shoulder is the 'mantra' in scapular fractures.

Fig. 8.12: Plain X-ray of the scapula

Rehabilitation Program

Aim to restore back the shoulder movements to normal or to achieve at least the functional range.

Steps

First 2 weeks This is the phase of immobilization. During this period, thermotherapy is done to reduce pain and isometric exercises to the shoulder girdle muscle are begun early.

Two weeks later mobilization is begun. The program is similar to the plan of treatment for fracture clavicle. Thermotherapy helps to reduce pain. Strengthening exercises, dumbbells and self-resistive exercises are advised.

PROXIMAL HUMERAL FRACTURES

This is common in elderly patients and it accounts for 4 to 5 percent of all fractures (Fig. 8.13).

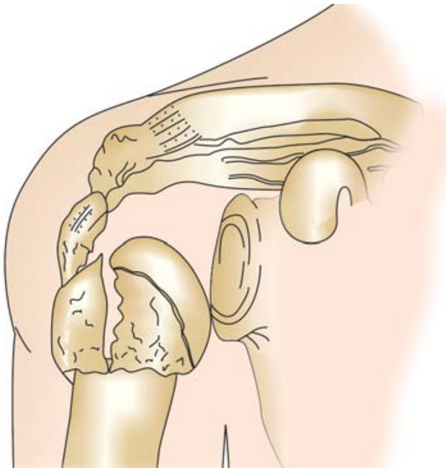


Fig. 8.13: Proximal humeral fracture

Mechanism

- Fall on outstretched hands is the classical history.
- Blow on the lateral side of the arm is the other mode of injury.

Classification

Four segments are described with respect to proximal humerus. They are:

1. Anatomical neck
2. Greater tuberosity
3. Lesser tuberosity
4. Shaft or surgical neck of the humerus.

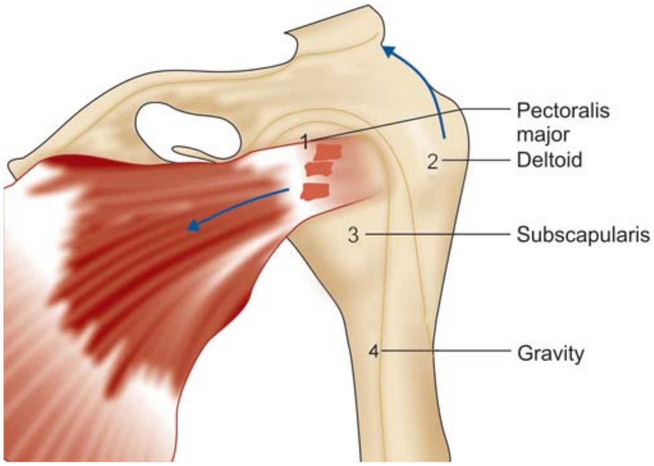


Fig. 8.14: Showing muscle forces acting on proximal humerus

Fig. 8.15: Clinical photograph of proximal humeral fractures

Neer has proposed a classification for fractures of the proximal humerus based on this 4-segment concept.

Role of Muscle Forces (Fig. 8.14)

- *Greater tuberosity* Supraspinatus, external rotators are attached here and displace the fracture segments.
- *Lesser tuberosity* Subscapularis inserted here which generates a deforming force.
- *Shaft* Gives attachment to pectoralis major.
- *Anatomical neck* These above muscles pull the fracture fragments in different directions leading to widespread displacements and angulations. When any of the 4 major segments is displaced more than 1 cm or angulated more than 45°, fracture is considered displaced. Eighty per cent of the fracture displacement is minimal and only 20 percent of the fracture displacement is significant.

Clinical Features

It consists of pain, swelling, deformity and loss of shoulder movements (Fig. 8.15).

Radiograph

Plain X-ray of the shoulder, trauma series consisting of different views are required to make an accurate diagnosis (Fig. 8.16).

Fig. 8.16: Plain X-ray showing proximal humeral fractures

Management

Un-displaced fractures: Since 80 percent of the fractures are minimally displaced early motion of the shoulder is the mainstay of treatment to prevent stiffness of the joint. Pendulum exercises, elevation, pulley, external and internal rotation and wall climbing exercises are some of the recommended methods.

Displaced fractures This is treated surgically by open reduction and internal fixation with buttress plate and screws or locked compression plates (Fig. 8.17). Table 8.1 gives the various treatment methods and fixation techniques in proximal humerus fractures.

Complications

- Joint stiffness is due to periarticular fibrosis.
- Malunion is due to the varying muscle forces.
- Avascular necrosis is seen in fracture of the anato-mical neck.
- Nonunion of surgical neck.
- Myositis ossificans due to vigorous massage and treatment.

TABLE 8.1: Summary of treatment followed in proximal humeral fractures

Pattern

1. *Two-part fracture*
   a. *Anterior neck* OR + IF (risk of AVN is high)
   b. Shaft
      - Impacted and angulated → Disimpaction and correction
      - Unimpacted → Closed reduction if reducible. Tension-band wiring if unreducible or T-plate
      - Comminuted → overhead skeletal traction
   c. *Greater tuberosity* If greater than 1 cm displacement, OR + IF
   d. *Lesser tuberosity*: requires OR+IF
2. *Three-part fracture*
   - Needs open reduction and replacement of the humeral head with Neer's prosthesis or a AO T-plate can be used for fixing the fracture fragment (Fig. 8.17).
3. *Four-part fracture*
   - Invariably require OR + IF
   - When fracture is associated with dislocation:
     Anterior dislocation with proximal humeral fracture
     a. 2 part → Closed reduction is successful
     b. 3 part → requires OR + IF
     c. 4 part → OR + IF + tuberosity repair
     Posterior dislocation with proximal humeral fractures
     a. 2 part: associated with avulsion of lesser tuberosity. Closed reduction sufficient
     b. 3 part: Requires OR + IF
     c. 4 part: Risk of AVN is high and needs early prosthetic replacement (Neer's prosthesis)

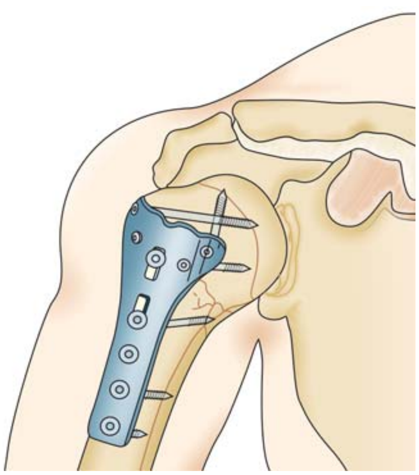


Fig. 8.17: Method of fixation of proximal humeral fracture with T-plate and screws

Rehabilitation Program

This aims to fulfill the following goals

Orthopedic In this, an attempt is made to these objectives:

- To obtain a neck shaft angle of 130-150° and retroversion angle of 30°.
- To reduce the greater and lesser tuberosities to maintain the rotator cuff function.
- To maintain a normal relationship between the glenoid and head of the humerus.
- To obtain stability at the fracture site either by external or internal immobilization.

Rehabilitation

- Attempt is made to restore full range of motion to the shoulder. However, there may be some residual loss in movements.
- Against maximum resistance, attempt is made to regain the strength of shoulder flexors, extensors, abductors, adductors, internal and external rotators, and rotator cuff muscles.

Functional goals To restore day to day activities like self-care, dressing, grooming, etc. and sports activities.

Physiotherapy Methods

Conservative treatment:

- **During the first week** All shoulder movements are avoided. For undisplaced fracture and hemiarthroplasty, gentle pendulum exercises are begun. No strengthening exercises to the elbow or shoulder are allowed. The patient needs assistance in doing day to day activities like dressing, grooming, etc. and is encouraged to use the uninvolved extremity. Weight-bearing is strictly prohibited.
- **2-4 weeks** Pendulum exercises with the sling are begun with active to gentle passive assistive exercises to the shoulder. Isometric shoulder exercises are commenced. Patient is instructed to use the uninvolved extremity for day to day activities and no weight-bearing is permitted.
- **4-6 weeks** Force should not be applied to regain the full range of motion. Pendulum exercises against gravity are advised. Flexion and abduction of shoulder is allowed up to a limited range. For elbow isometric and isotonic exercises are prescribed.

  Though patient still needs assistance to carry out day to day activities, the involved extremity could be used for these activities within the tolerable limits.
- **6-8 weeks** Patient is allowed to perform active, active-assistive and passive range of motion to the shoulder and elbow in all planes to the limit of his tolerance. Isometric exercises to the shoulder, isometric and isotonic exercises to the elbow are begun.

  Day to day activities can now be carried out with the involved extremity. Weight bearing as tolerated could be permitted.

- **8-12 weeks** By this time the fracture is well united, active and passive range of motion to the shoulder and elbow in all planes is permitted. Progressive resistive exercises with weights increasing from 2-10 lbs for the shoulder are recommended. To build up strength and endurance, isokinetic exercises using appropriate equipment are advised. Patient is permitted full weight bearing and all day to day activities can be done with the involved limb.

Surgery During the first week, a check is made for wound infection and stability of fixation. Sutures are removed after 2 weeks and the affected extremity is elevated to decrease the swelling. No active range of movements but only passive movements is permitted. After 6-8 weeks, active range of movements with terminal stretching is advised. By 8-12 weeks, resistive shoulder exercises are begun.

FRACTURE OF GREATER TUBEROSITY OF HUMERUS

This could be due to the following causes:
- Direct blow to the side of the shoulder.
- Fall on the side.
- Indirect trauma—Forceful contraction of supraspinatus muscle can cause avulsion fracture of the greater tuberosity (Fig. 8.18).

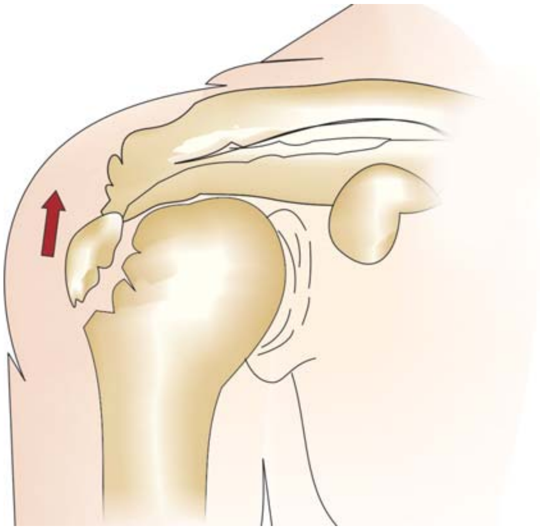


Fig. 8.18: Showing avulsion fracture of greater tuberosity of humerus

Clinical Features

The patient complains of pain, swelling, inability to abduct the arm, etc.

Fig. 8.19: Plain X-ray of the shoulder showing fracture of the greater tuberosity of humerus

Radiograph

X-ray of the shoulder helps in making the diagnosis (Fig. 8.19).

Treatment

Un-displaced fractures Immobilization by cuff and collar for a period of 3-4 weeks.

Displaced fractures Of > 1 cm is treated surgically by open reduction and internal fixation with screws.

Physiotherapy Measures

- Collar and cuff sling.
- Thermotherapy to reduce pain and swelling.
- Active movements of elbow, wrist and fingers.
- Gradual shoulder mobilization after 3-4 weeks.

ANTERIOR DISLOCATION OF SHOULDER (ADS)

Shoulder joint is vulnerable for dislocation more often than any other joint in the body. The extreme mobility it enjoys jeopardizes its stability. The shoulder has an “Achilles point” at the inferior part of the capsule providing the joint with a potential weak spot, so much so that 99 percent of anterior shoulder dislocation occurs here. Ninety-five percent of the shoulder dislocation is anterior and the remaining five percent is posterior (Fig. 8.20).

Mechanism of Injury

- Fall on outstretched hands.
- Direct blow on the posterior aspect of the shoulder.

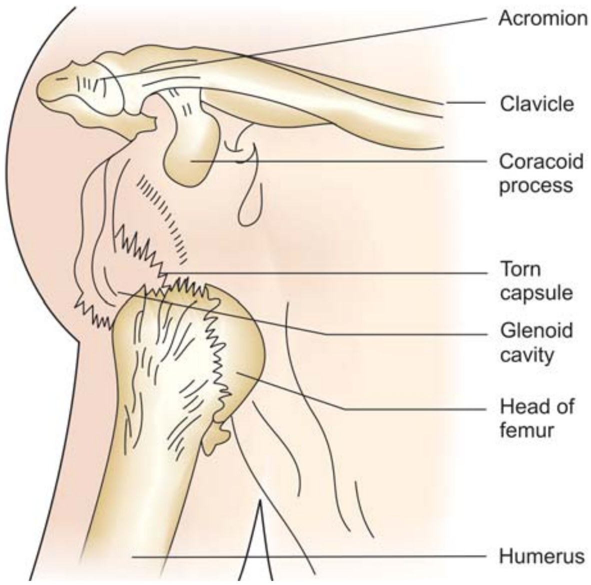


Fig. 8.20: Anterior dislocation of shoulder joint (subglenoid variety)

Types

The following types of ADS are described:
- Subcoracoid
- Subglenoid
- Infraclavicular
- Intrathoracic.

Clinical Features

Patient complains of severe pain and arm is held in abduction and external rotation. Normal contour of the shoulder is lost and there is anterior fullness of the shoulder. Adduction is severely restricted. There may be diminished sensation on the lateral aspect of the deltoid region due to axillary nerve palsy (Figs 8.21A and B).

Figs 8.21A and B: Clinical photograph showing clinical features of ADS

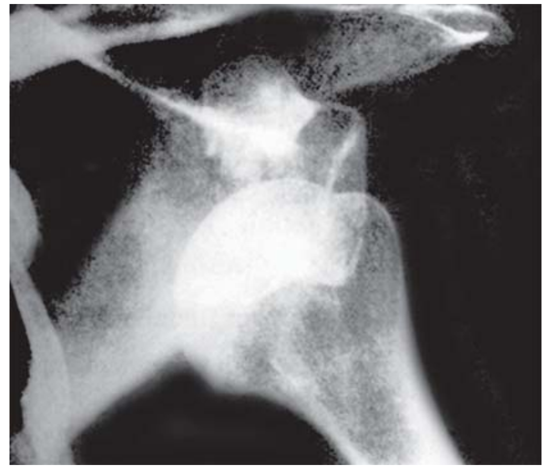


Fig. 8.22: Plain X-ray showing anterior dislocation of shoulder

Radiograph

X-ray of the shoulder helps in confirming the diagnosis (Fig. 8.22).

Treatment

Closed reduction under GA using the Kocher's method (Fig. 8.23) of reduction is the treatment of choice. Open reduction is reserved for cases of failed closed reduction.

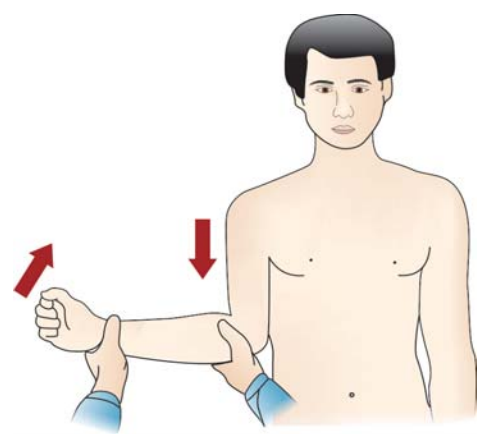


Fig. 8.23: Kocher's method of reduction of anterior dislocation of shoulder. The method consists of four important steps (mnemonic TEAM): T—traction (longitudinal), E—external rotatiion, A—adduction, M—medial rotation

Physiotherapy Management

Aim A complete range of active movements of the shoulder complex to be restored back to normal or at least achieve the 'functional' level.

Initial 3 weeks This is the phase of immobilization and the affected arm is fastened to the trunk in a position of adduction

Fig. 8.24: Showing method of shoulder immobilisation after reduction of ADS (failure to do this for at least 3 weeks is the prime cause of RDS)

and internal rotation. Wrist and finger are left free and the patient is instructed to exercise them actively (Fig. 8.24).

However, self resistive isometric contractions to the biceps, triceps and deltoid are begun in right earnest.

3-weeks later The strapping are removed and the limb is supported in a sling. Mobilization of the elbow joint to its full extent by intermittently removing the sling is advised. Mobilization of the shoulder is done in the following manner.

- *Flexion extension* With the arm in the sling which is loosened to facilitate greater range of motion, small range pendulum exercises with the patient in a forward stoop position is begun.
- *Abduction and external rotation* Extreme degree of caution is required during the mobilization technique for these two movements because they could lead to re-dislocation. The initial goal is to achieve relaxed passive abduction of 45°. With the patient in supine position and the arm in internal rotation, the physiotherapist passively carries out the abduction up to 45°. Similarly with the arm in adduction, external rotation is initiated.

Note It is important to achieve near full range passive relaxed movements of the shoulder to present adhesive capsulitis.

For various shoulder mobilization techniques also *see* p. 272 and 273.

Strengthening Exercises

Initially, self resistive isometric and isotonic exercises to the shoulder muscles are taught to the patients to be done at home. Only after 12 weeks it is safe to carry out heavy resistive exercises, passive stretching, forceful abduction and external rotation. Though it is difficult in some patients to achieve the terminal abduction and external rotations due to pain necessitating heat therapy, most of the patients regain full function after 12 weeks of injury.

Practical points

- Aim to achieve 90 percent shoulder function within 6-8 weeks following injury.
- Warn the patient against sudden abduction and external rotation to prevent recurrence.

RECURRENT DISLOCATION OF THE SHOULDER (RDS)

This is a very common complication of anterior dislocation of shoulder and accounts for greater than 80 percent of dislocations of the upper extremity. Age at the time of initial dislocation is an important prognostic factor, recurrence rate being 55 percent in patients 12-22 years old, 37 percent in 23-29 years, and 12 percent in 30-40 years old.

Causes

- Failure to immobilize the shoulder for 3 to 4 weeks after initial dislocation (Most common cause).
- Size and nature of damage at the time of initial dislocation.
- Greater the trauma, lower the incidence.
- Younger the patient, less is the recurrence.

Mechanism of Dislocation

In some individuals the dislocation can be predictable and can be avoided. In others the mechanism is unpredictable and thus makes it a very disabling prob-lem. *The usual mechanism of dislocation is external rotation in abducted position.*

Pathological Anatomy

No single deformity is responsible for recurrent disloca-tion of shoulder. Three important reasons have been cited and they have been called the essential lesions.

Triad of Essential Lesion

- *Hill-Sachs lesion* is a posterolateral defect in the head of the humerus.
- *Bankart's lesion* This was first described by Perthes as defect in the anterior part of the glenoid labrum and also the anterior capsule.
- Erosion of anterior rim of glenoid cavity.

How does RDS occur? External rotation of the shoulder in abducted position pops out the head of the humerus from the glenoid cavity due to the lax anterior capsular structures. The posterolateral defect now comes in contact with glenoid rim and is levered out of the socket, producing dislocation.

Clinical Features

Usually patient gives history of a previous episode of traumatic dislocation. After that, there could be one or two instances of repeated dislocations during abduction. There could be wasting of deltoid, supraspinatus and infraspinatus muscles.

Investigations

Plain X-rays of the shoulder helps to detect the triad of lesions mentioned earlier. CT scan and MRI are more useful in identifying the lesions but are expensive.

Treatment

There is no role of conservative treatment in recurrent dislocation of shoulder. Patient is advised to avoid abduction and external rotation of the shoulder. However, surgery is the treatment of choice and is indicated if the patient has more than three episodes of RDS.

Physiotherapy Management

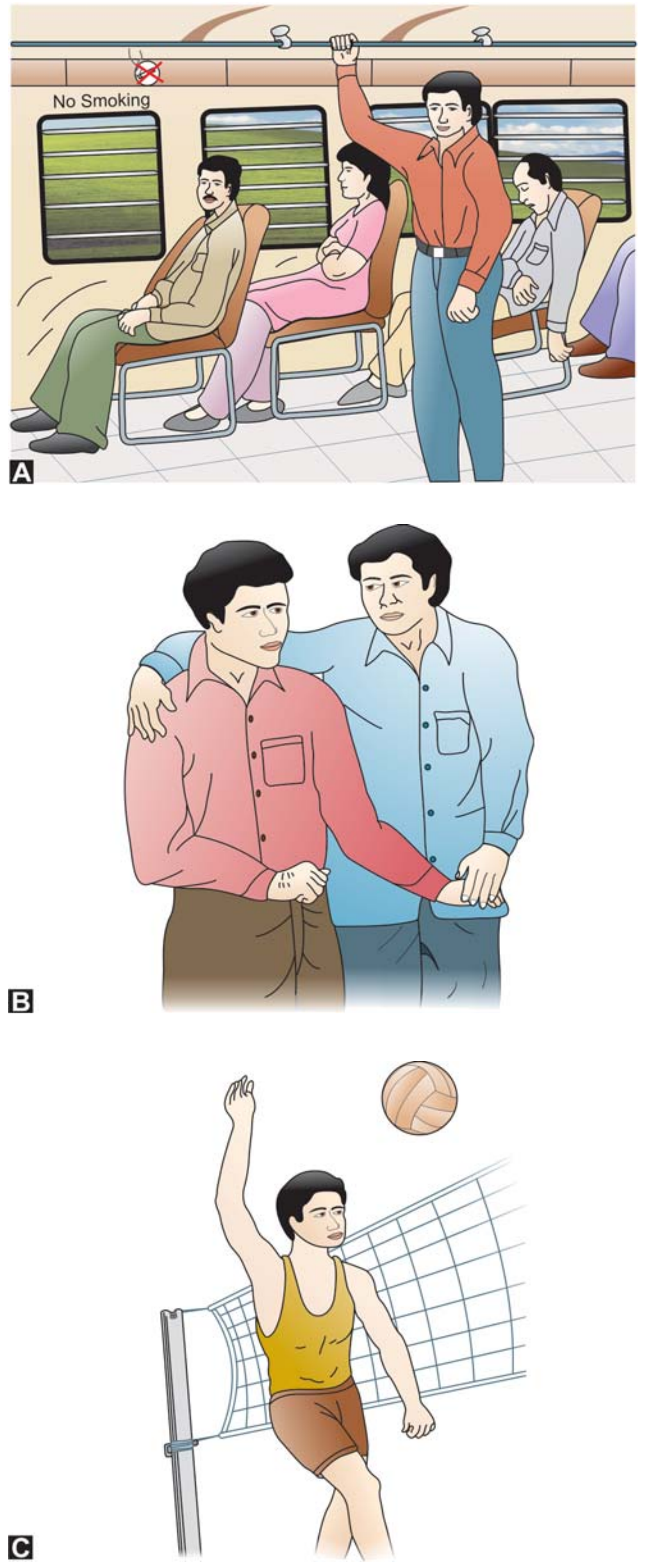
RDS is a disconcerting problem which keeps coming again and again at frequent intervals providing the patient with a harrowing experience of dismay and discomfort. What makes the situation of the patient more pathetic is that sometimes due to the slightest provocation the shoulder 'pops' out throwing the life out of gear. This problem makes its unwelcome entry when it is least expected and keeps the victim always on tenterhooks.

Points to ponder

Certain 'common' history given by a victim of RDS (Mechanism of occurrence) (Figs 8.25A to C).

- While commuting in a bus catching the upper railings, due to sudden jerk, my shoulder gave way.
- While trying to catch a falling object (may be book, ball pen, etc.), my shoulder popped out.
- While jostling through crowded train, market, etc. there was an unexpected push from some one behind and even before I could realize, lo and behold, my shoulder was in a quandary.

Note It is this extreme degree of uncertainly of occurrence, RDS makes the victim apprehensive.



Figs 8.25A to C: Are you a victim of RDS? If so, beware of routine innocuous activities like these that will knock out your shoulder joint repeatedly

Unfortunately, treating this notorious malady is equally unnerving to the orthopedic surgeons since conservative methods have negligible role to play and he has to take recourse to surgery. With more than 150 surgical operations described for RDS, the surgeon is as confused as the patient in choosing the right one!

It is here that the physiotherapy makes its welcome entry to 'rein' in this problem aiming at 'preventive' rather than the 'curative' part.

Points to ponder
Preventing RDS from happening is a far more sensible and easy option than mending it.

A simple 'three pronged' approach by a physiotherapist is enough to combat this otherwise tricky problem.

Approach No. 1 (Health Education)

Educate the patient about the proper and careful use of his shoulder. Extreme degree of shoulder elevation, abduction and external rotation is a strict taboo as it jeopardizes the shoulder into popping out. Hence instruct the patient to avoid all such movements.

Approach No. 2 (Muscle Education or Strengthening)

Laxity in shoulder muscles, ligaments and capsules due to improper and inadequate healing following the initial injury is the prime reason for RDS. Hence, training these structures to regain their strength and vitality is a very logical inevitability to prevent RDS.

Since frequent, repetitive exercises are required to retrain these structures, the most sensible option would be to train the patient himself to carry out the exercises with self resistance either in sitting or standing positions. If properly performed these 'self resistive' exercises are very effective and are popularly called 'reversal techniques.'

Approach No. 3 (Movement Training)

Help the patient to achieve full range of passive shoulder movements. This can be done by two steps.

Step 1 This involves the role of a physiotherapist. In a very gentle, gradual and restrained manner he is required to put the shoulder into entire range of movements like shoulder elevation, abduction and external rotation.

Step 2 Once the complete range of passive movements are attained, the physiotherapist now teaches and encourages the patient to himself carry out all these movements at home after carefully training him.

Physiotherapy for surgically managed patients is less demanding as the joint is made stable by repairing the defect and overlapping the subscapularis muscle. Due to this it may be difficult to achieve painless terminal range of movements but however passive sustained stretching is recommended as it is considered to be harmless and effective.

Points of caution
- Both the physiotherapist and the patient should guard against aggressive approach and should be especially careful during the terminal range of movements.
- Perseverance and patience should be the watchword as it may take 3-6 months of sustained and prolonged effort to be successful.

Quick Facts

Physiotherapy RDS
- Freak incidents are enough to bring the shoulder out of its safe confines in RDS.
- While conservative treatment option is unavailable, surgical option are available in plenty making the exercise confusing and difficult. Hence physiotherapy options a safe bet.
- Physiotherapy aims at 'preventing' than curing' RDS.
- Physiotherapy for RDS involves a three pronged approach.
- Reversal technique is the hallmark of RDS physiotherapy.
- Movement training by patient themselves at their homes provides good results.
- Prevent RDS; embrace physiotherapy should be the advice to the patients.

9

Chapter

Injuries of the Elbow

INJURIES AROUND THE ELBOW

Fall on outstretched hands is more common in children because they are more playful and hence more prone to fall. Thus, upper extremities are vulnerable to fractures. Sixty-five to seventy-five percent of all fractures sustained by children are seen in upper limbs (Table 9.1).

TABLE 9.1: Incidence of injuries around the elbow

Injuries around the elbow	*Percentage*
• Supracondylar fractures	65.4
• Condylar factures	25.3
• Fracture neck radius	4.7
• Monteggia fractures	2.2
• Olecranon fractures	1.6
• T-condylar fractures	0.8
In children forearm bone fractures rank first followed by fractures around the elbow region. The incidence of distal humeral fractures is as follows	
• Supracondylar	69
• Lateral condyle	16.8
• Medial condyle	14.1
• T-condylar	1

Classification of Fractures of Distal Humerus in Children

Supracondylar

- Flexion type
- Extension type

Physeal fracture

- Involving lateral condylar physis.
- Involving medial condylar physis.
- Involving total distal physis.
- Involving medial epicondylar physis.
- Involving lateral epicondylar physis.

'T' Condylar fracture

SUPRACONDYLAR FRACTURE

As mentioned earlier supracondylar fractures of the humerus is very common in children. The reason lies in the weak bony architecture of the supracondylar area in children. The mechanism of injury and the predisposing factors exploit this potential weakness in this area and break it more often than any other bones in children.

Mechanism of Injury

Fall on outstretched hand with hyperextension at the elbow with abduction or adduction, with hand dorsiflexed is the common mechanism of injury (Fig. 9.1).

Classification

Supracondylar fracture (Figs 9.2A and B) is broadly classified into *extension type* (Fig. 9.2A) and *flexion type* (Fig. 9.2B).

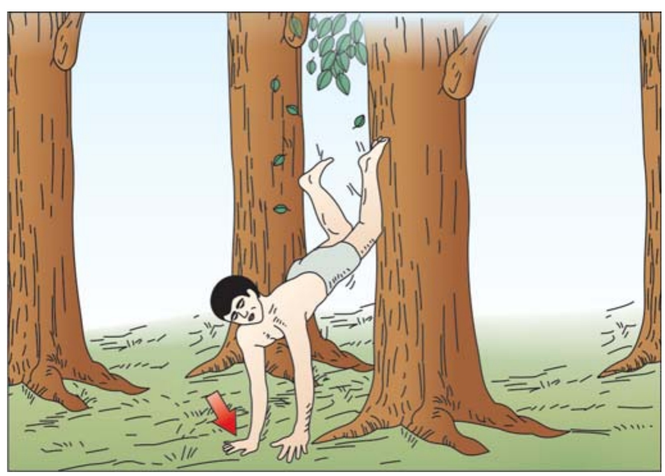
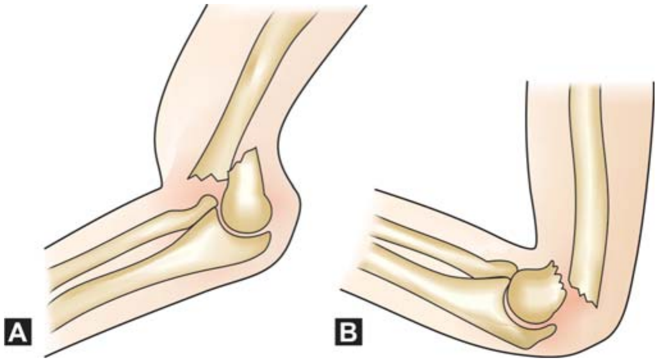


Fig. 9.1: Fall on outstretched hands is a common mechanism of upper limb fractures in children



Figs 9.2A and B: Showing types of supracondylar (SC) fracture: (A) Flexion type 2.3%, and (B) Extension type 97.7%

In extension type (97%) the fracture line runs *upwards and backwards* and in flexion type (2.3%) it runs *downwards and forwards*. Extension type of supracondylar fracture is further classified into the following subtypes.

Gartland's classification

- *Type I* Undisplaced
- *Type II* Displaced, but posterior cortex is intact.
- *Type III* Displaced, but no intact posterior cortex and the distal fragment could be either displaced:
  — Posteromedial or
  — Posterolateral.

Clinical Features

The patient complains of pain and swelling which is gross, "S"-shaped deformity of the upper arm is obvious and (*see* Fig. 9.2A) there is loss of both active and passive movements of the elbow. Symptoms relating to vascular and nerve injury may also be seen. Patient may also complain of pseudo-paralysis. Tests should be carried out for injuries to brachial artery and all the three nerves of the upper limb, namely the radial, median and ulnar nerves (Fig. 9.3).

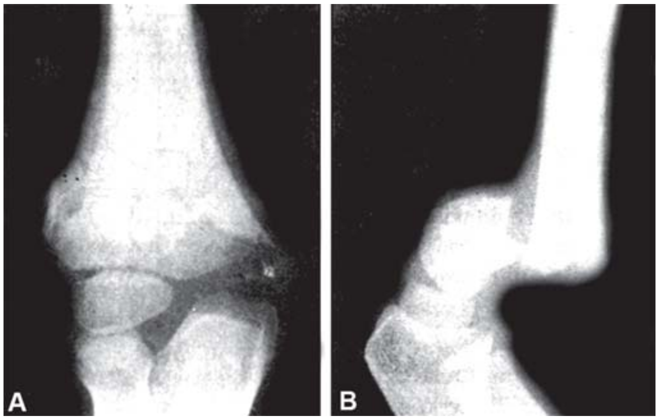
Radiograph

X-ray of the elbow, *AP and lateral views* helps in studying the fracture patterns and making the diagnosis (Figs 9.4A and B).

Management

Conservative management Initially closed reduction is tried under general anesthesia by traction and counter traction methods. The medial and lateral tilt is corrected first and posterior displacement next. Two to three attempts under the same anesthesia can be made till acceptable reduction is obtained and the elbow is immobilized in hyper flexion, as in this position the triceps acts as an internal splint (Fig. 9.5).

Fig. 9.3: Clinical photograph showing deformity in supracondylar fracture of humerus



Figs 9.4A and B: Plain X-ray of the supracondylar fractures (A) AP, (B) Lateral view

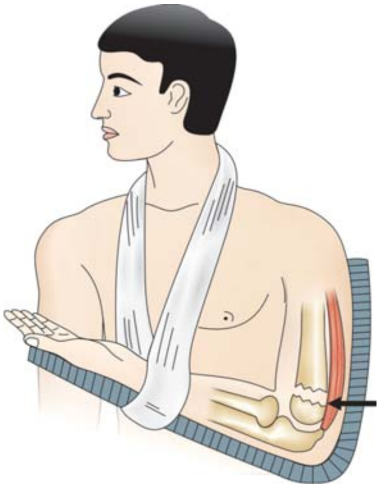


Fig. 9.5: Triceps muscle acts as an internal splint in supracondylar fracture humerus when flexed beyond 90°

Surgery or skeletal traction methods is indicated if conservative methods fail. Surgical methods consist of closed reduction and percutaneous k-wire pinning under C-arm control. Very rarely open reduction and internal fixation is required so is skeletal traction.

Complications

These are broadly divided into two categories:

1. Those that cause functional impairment of the extremity and is more serious.
2. Those that produce only a cosmetic sequel.

Complications Causing Functional Impairment

Neurological involvement Overall incidence is around 7 percent.

- *Radial nerve* Most commonly affected and is usually injured in posteromedial displacement.
- *Median nerve* Injured during posterior displacement.
- Anterior interosseous nerve injury can happen in posterolateral displacement of the distal fragment.
- *Ulnar nerve* Injured in overhead skeletal traction and in flexion type of supracondylar fracture.

Vascular injury The incidence is between 0.5 to 1 percent. Common with extension type and is usually due to direct injury of brachial artery by the fracture. The other causes are internal thrombus, intimal tear, brachial artery spasm, external compression by proximal fracture fragment of the humerus, fracture hematoma, partial or complete rupture of brachial artery (Fig. 9.6).

Loss of mobility Average loss of flexion is by 4° and is usually due to posterior displacement which unites in that position causing mechanical block for flexion.

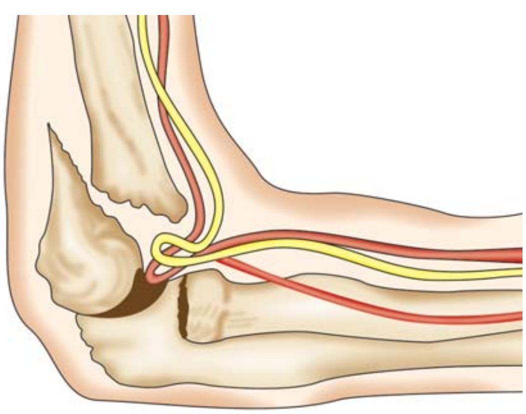


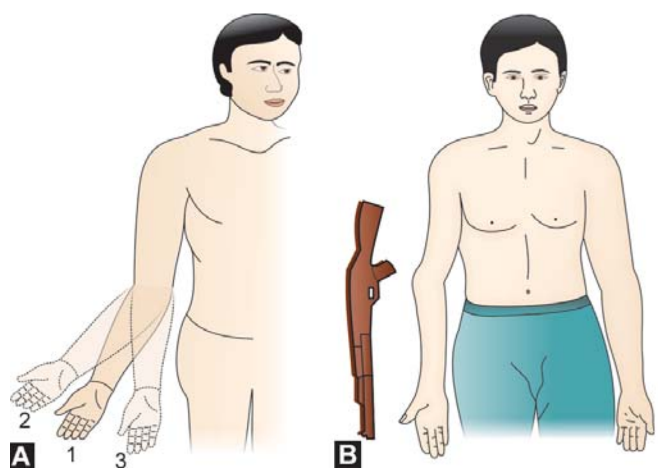
Fig. 9.6: Showing extension type of supracondylar fracture causing neurovascular injuries

Fig. 9.7: Clinical photograph showing cubitus varus deformity (Gunshot deformity)

Myositis ossificans is rare and is seen in forced manipulative closed reduction and open reduction.

Complications that Produce Cosmetic Abnormalities

Cubitus varus (Gunstock elbow) (Fig. 9.7) this is the most common complication of supracondylar fracture. Incidence varies from 9 to 58 percent. Cubitus valgus is relatively rare (Figs 9.8A and B).



Figs 9.8A and B: (A) Carrying angle of elbow (1) normal, (2) increased (cubitus valgus), (3) decreased (cubitus varus) and (B) Showing cubitus varus deformity (also called Gunstock deformity)

FLEXION TYPE OF SUPRACONDYLAR FRACTURE

This is extremely rare and has an incidence of only 2.5 percent.

Mechanism of Injury

The common method of injury is direct blow to the posterior aspect of the arm.

Clinical Features

Patient complains of pain, swelling, deformity, gross loss of functions and reverses S shaped deformity.

Radiograph

X-ray of the elbow, AP view and lateral views helps in making the diagnosis.

Treatment

Closed reduction and immobilization in above elbow cast in extension is undesirable as it causes elbow stiffness. If reduction can be achieved by closed methods the fracture can be stabilized in flexion with percutaneous pins. If reduction cannot be achieved then open reduction and internal fixation is contemplated.

Complications

Injury to ulnar nerve is common in this type of fracture. Loss of elbow flexion is another important complication commonly encountered.

Physiotherapy Management

Managing these difficult injuries is no child's play. Specific goals are set and effort is made to achieve them.

Orthopedic goals To accurately align the distal humerus and restore back the abnormal carrying angle. Unstable fractures are made stable by surgery.

Rehabilitation goals To restore complete range of elbow movements and carrying angle of the elbow and full range of shoulder movements too (Table 9.2).

Muscle strengthening exercises are carried out for triceps, biceps, forearm supinators and pronators, wrist flexors and extensors and deltoid muscles.

Functional goals To restore personal activities like feeding, hygiene, dressing, grooming, etc.

TABLE 9.2: Showing range of motion for elbow and forearm

Motion	Normal	Functional
• Flexion	135°	0-90°
• Extension	0-15°	-20-30°
• Supination	90°	50°
• Pronation	90°	50°

Rehabilitation Programs

With the above goals in mind rehabilitation program is executed as follows.

For the First One Week

Conservatively managed patients (cast/splint) Here the stability of fracture is poor. The cast is trimmed to the distal palmar crease so as to allow the fingers to move freely. Dependent edema is treated by elevation. Active range of movements is prescribed to the digits, active and active assistive exercises to the shoulder. Elbow movements, internal and external rotations of the shoulder are strictly avoided.

Children treated with percutaneous pinning Here only pins afford stability to the fracture site. The cast ends at the distal palmar crease to allow free finger movements. Dependent edema is treated by elevation. Active and passive range of movement's exercises to the digits, active and active-assistive range of exercises to the shoulder, isometric exercises to the biceps, triceps and deltoid are begun. No elbow, internal and external shoulder movements are allowed.

Children treated with open reduction and internal fixation Fractures treated by this method are quite stable and the arm is supported either by a sling, slab or a functional brace. Dependent edema is treated by hand elevation. Gentle active range of movements is begun to the entire extremity, involving the shoulder, elbow, wrist, forearm and fingers. To reduce the risk of myositis ossificans, passive range of motion exercises to the elbow are avoided.

For the Second Week

Conservative management continue The active range of motion exercises to the digits; active and active assistive exercises to the shoulder. Isometric exercises to the biceps, triceps, and deltoid and forearm muscles are begun. Grip strengthening exercises are commenced with ball or putty. No pronation, supination, shoulder internal or external rotation exercises are prescribed. Supervised elbow flexion from 90° onwards is commenced for extension type of supracondylar fractures.

Percutaneous pinning The regime is more or less similar to the one described above.

Open reduction and internal fixation The gentle active range of movement's exercises for the active extremity including shoulder, elbow, forearm, wrist or fingers are continued. Grip strengthening exercises are begun. Passive exercises to the elbow are avoided to prevent myositis ossificans.

For Four to Six Weeks

Conservative management At this stage, clinical stability and radiographic evidence of healing are assessed. If present, a supervised, rhythmic active elbow range of movements are commenced by using roller skates on a dining table. Passive elbow mobilization is avoided while the grip strengthening exercises with the ball or putty are continued.

To improve elbow flexion, mobilization technique in prone position or using roller skates or using a modified knee ratchet is suggested.

Thermotherapy modalities help to relieve pain and spasm. *Percutaneous pinning* Remove the pins and protect the arm with a posterior splint or brace. Rest of the regime is same as mentioned above.

Open reduction and internal fixation Functional cast brace or splint are discarded. Active and active-assisted exercises to the entire extremity and grip strengthening exercises are continued. Passive range of movements to the elbow is avoided.

For Six to Twelve Weeks

Conservative management Braces, splints, slings are discontinued. Continue active and add passive range of motion exercises to all the joints of the extremity. Grip strengthening exercises are continued. Beginning with 1-2 pounds weight in gradation, resistive exercises are commenced. Passive range of movements is permitted since the threat of myositis is considerably reduced.

Percutaneous pinning The regime is same as described above.

Open reduction and internal fixation The regime is same as mentioned above.

Points of Importance

Distal humeral fractures
- Expected time of bone healing 8-12 weeks.
- Expected duration of rehabilitation 12-24 weeks.
- Cast, splint, percutaneous pins are stress sharing device while plate, screws are stress shielding.
- Repeated examinations are required to assess the neurovascular involvement due to these injuries.
- Adjustment of the sling, removal and reapplication of the plaster slab may be required.
- Activities of daily living and personal care are carried out with the uninvolved extremities during the treatment period till 12 weeks.
- Weight bearing with the affected extremity is only advocated after 12 weeks.

INTERCONDYLAR FRACTURES OF THE HUMERUS

This is a *T* or *Y* fracture of the intercondylar region of the humerus and is seen commonly in adults (Table 9.3).

Mechanism of Injury

Direct trauma due to fall on a pointed elbow, with the olecranon being driven between the condyles of the humerus. More often than not these fractures are comminuted.

Clinical Features

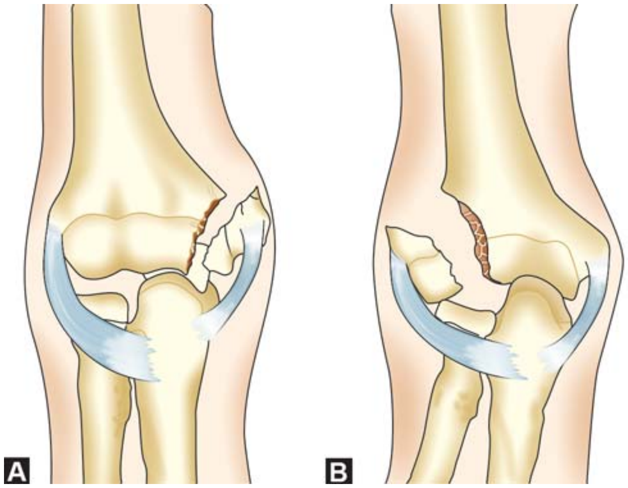
Patient complains of extreme pain, swelling, broadening of the elbow, loss of mobility at the elbow joint, crepitus, abnormal mobility, etc (Fig. 9.10). There may be features suggestive of injuries to the blood vessels and nerves.

Radiograph

X-ray of the elbow, AP view and lateral views helps in making the diagnosis (Figs 9.11A and B).

TABLE 9.3: Showing comparison between lateral and medial condyle fractures

Lateral condyle of humerus (Fig. 9.9B)	*Medial condyle of humerus (Fig. 9.9A)*
Accounts for 16.8 percent fractures of distal humerus can be associated with dislocation of elbow and fracture olecranon.	Rare in children (1%) Age 8-14 yrs
Clinical features This consists of little distortion of the elbow and less swelling. Tenderness and crepitus is present over the lateral condyle.	**Clinical features** Usual signs and symptoms of fracture, Tenderness and crepitus is present over the medial condyle.
Treatment	**Treatment**
Stages I and II Closed reduction and percutaneous pinning *Stage III or If the fracture is > 24-48 hrs old* Open reduction and K-wire fixation.	*Stages I and II* Above elbow cast or splint *Stage III* Open reduction and Internal fixation



Figs 9.9A and B: (A) Fracture medial condyle of humerus, (B) Fracture lateral condyle of humerus

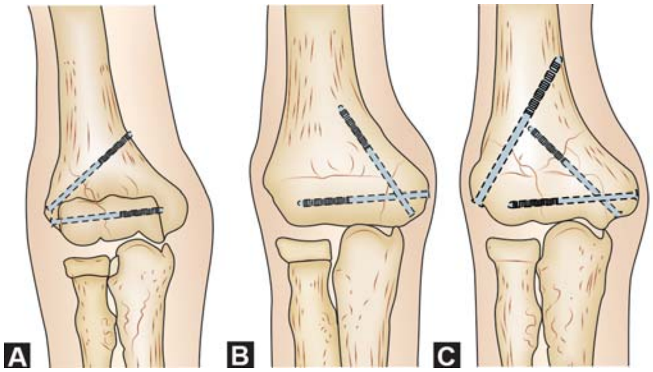
Fig. 9.10: Clinical photograph of intercondylar fracture

Figs 9.11A and B: Plain X-ray of the elbow showing communited intercondylar fracture of humerus (A) AP and (B) Lateral view

Treatment

Surgery is the treatment of choice and consists of open reduction and internal fixation with either screw only or by

Fig. 9.12: Plain X-ray showing plate and screws fixation in intercondylar fracture of humerus



Figs 9.13A to C: Internal fixation of fracture of (A) Lateral condylar (B) medial condyle and (C) Y-intercondylar fracture of humerus

plate and screws (Figs 9.12 and 9.13A to C). Overhead olecranon skeletal traction is the other method of treatment but is associated with recumbent problems. Conservative treatment has little or no role in this type of fractures.

Physiotherapy Management

This is more or less similar to the supracondylar fractures. The additional measures are:

- *Thermotherapy* This is used more extensively.
- *Mobilization of elbow* By roller skates etc. is done more gently and for a prolonged period of time.
- Collar and cuff stretching effect and maintenance of the corrected flexion obtained (Fig. 9.14).
- Passive stretching exercises after 6 months to regain further movements of the elbow.

Fig. 9.14: Showing maintenance of the corrected flexion so obtained by mobility and collar cuff stretching effect

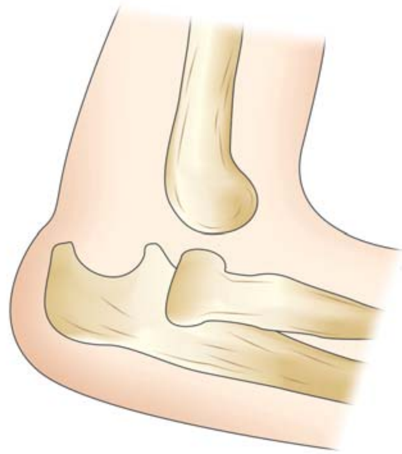


Fig. 9.15: Showing posterior dislocation of elbow

PHYSEAL FRACTURES

These are rare injuries and are commonly seen in children. Knowledge of the secondary growth centers around the elbow is important to judge the frequently subtle injuries to the condyles of the humerus. Radiographic comparison with uninjured site is mandatory. A comparative study of lateral and medial condylar fractures of the humerus is presented here for easy understanding.

Physiotherapy Measures

This is the same as for the supracondylar fractures of the humerus.

POSTERIOR DISLOCATION OF ELBOW JOINT

It is rare in children below 10 years of age:

- *Incidence*—3 to 6 percent
- *Males*—71 percent
- *Nondominant extremity*—62 percent

Fifty percent of all elbow dislocations occur in patients less than 20 years of age.

Mechanism of Injury

This is frequently due to fall on outstretched hands with elbow slightly flexed. A valgus twist is added to the longitudinal force by the projecting trochlea and thus the dislocation is usually postero-lateral. Commonly seen in sporting events and in RTA.

Classification (Stimson)

He described elbow dislocation with respect to the position of radioulnar unit to the distal humerus (Fig. 9.15).

Fig. 9.16: Clinical photograph showing posterior dislocation by elbow

Clinical Features

Patient presents with swelling, pain, deformity and gross restriction of elbow movements. The posterior elbow geometry is disturbed (Fig. 9.16). Clinical features are hereby compared with that of supracondylar fracture of humerus for better understanding in Table 9.4, as it is often confused with supra-condylar fracture of humerus.

Radiograph

Plain X-ray of the elbow, AP view and lateral views helps in making the diagnosis (Figs 9.17A and B).

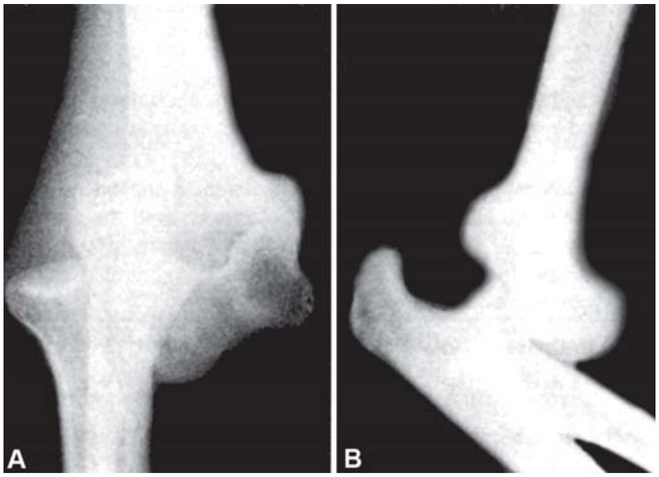
Treatment

Conservative treatment by closed reduction under general anesthesia is attempted first and reduction by operative methods is reserved for those rare cases of failed closed reduction.

An above elbow POP slab is applied with 90° elbow flexion and mid-pronation for a period of 3 weeks.

TABLE 9.4: Comparison of supracondylar fracture of humerus and posterior elbow dislocation

Supracondylar fracture humerus	*Postdislocation*
• Younger children	• Slightly older
• Arm is short	• Forearm is short
• Bony triangle maintained	• Triangle is disrupted
• Swelling is more	• Swelling is less
• Crepitus is present	• Crepitus is absent
• Olecranon is below Intercondylar line	• Olecranon is above the intercondylar line
• Step sign is negative	• Step sign is positive
• Movements are Restricted	• Movements are grossly restricted
• Radial nerve Commonly affected	• Medial and ulnar nerve injured frequently



Figs 9.17A and B: Plain X-ray showing (A) AP view, (B) Lateral view for elbow dislocation

Complications

Neurological injuries In these, the ulnar nerve is very commonly injured, followed by radial and median nerve in that order.

Myositis ossificans This has an incidence of 5 to 18 percent and is generally not due to the injury per se but due to the manner in which it is treated.

Causes Delay in initial treatment; use of hyper-extension force during reduction; vigorous active physiotherapy and massage are some of the common causes.

Arterial injuries are rare but brachial artery injury may be seen in open fractures.

Recurrent dislocation This is relatively rare but can be seen in males and is usually found to be confined to the pediatric age group.

Proximal radioulnar translation This is an extremely rare complication and is due to very vigorous force used during reduction methods.

Osteochondral fractures These are relatively uncommon.

Unreduced dislocation Though rare it is more often seen in Asians due to ignorance, treatment by quacks, etc.

Associated fractures with elbow dislocation

- Avulsion fracture of medial epicondylar epiphysis.
- Fracture proximal radius and coronoid process of ulna.
- Fracture olecranon, trochlea and lateral condylar physis.

Physiotherapy Management

Elbow joint is very notorious to develop stiffness following immobilization particularly in adults. Hence physiotherapy plays a very important role in preventing this complication from developing.

During the First 3 Weeks

This is the period when the elbow is immobilized in a plaster cast/splint after reduction. The steps to be followed during this critical period are enumerated as under:

- *Check* This involves checking the sling for slackness and tightening if necessary, checking the plaster cast/slab for cracks, loosening, etc.
- *Exercises* The uninvolved joints of the affected extremity need to be exercised continuously to prevent unnecessary and unwelcome stiffness of this joint. Accordingly full range of shoulder abduction, elevation, rotation in elevation is advised.

  To maintain an elevated position, the arm is kept on the table and the fingers and thumb are exercised vigorously.

  Note Elevated positions are preferred as gravity helps to reduce the swelling and thereby inflammation.
- *Teach* This is a futuristic approach, where in the patient is taught, on the normal unaffected extremity, all the exercise regime to be followed with the affected extremity. This helps in boosting the confidence of the patient as well as improving the patient compliance.

After 3 Weeks

The onerous task of putting the injured and immobilized elbow back to its pre-injured state, tests the dexterity and acumen of any physiotherapist. A systematic logical approach as briefed below could help solve the problem:

Premobilization phase Before putting the injured, stiff and painful elbow to a rigorous exercise regime, a good use of

Fig. 9.18: Active method of mobilization of elbow flexion and extension in prone position

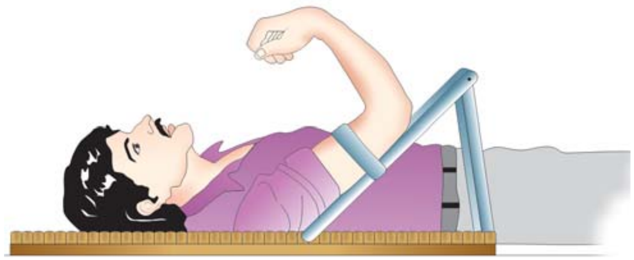


Fig. 9.20: Active mobilization of elbow flexion and extension using a modified knee ratchet

thermotherapy, paraffin wax bath, etc. could be made to alleviate pain and induce relaxation.

Mobilization phase The two important movements to be regained after elbow immobilization are flexion and extension of the elbow and pronation/supination of the forearm.

Elbow flexion/extension to regain these movements, the following regime could be envisaged:

- *Prone lying* The patient lies prone with the elbow hanging from the edge of the table. With the shoulder in 90° abduction, active flexion and extension of the elbow is carried out in a relaxed fashion (Fig. 9.18).
- *Roller skates* Roller skates could be put to good use either at home or department by the patient in gaining back the flexion and extension of the elbow. Roller skating could be done in a slow rhythmic fashion over the table with increasing range to actively flex and extend the elbow (Fig. 9.19).

> *Note* Roller skates are more effective if used on a powdered sunmica board.

- *Modified knee Ratchet* this also helps to achieve the same results mentioned above (Fig. 9.20).

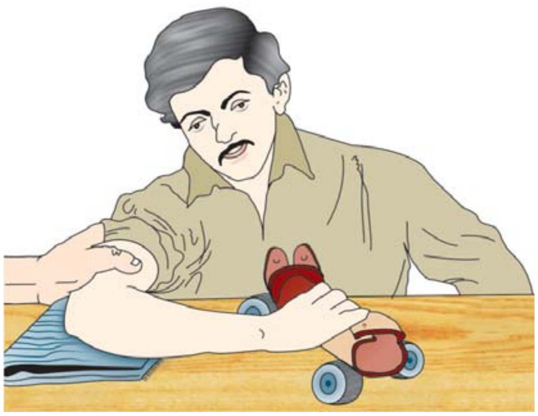


Fig. 9.19: Active mobilization of elbow flexion and extension using roller skates on a table

Forearm supination/pronation to regain the pronation and supination of the forearm, the exercises prescribed are active or active assisted ones.

Method In the sitting posture, both the elbows are fixed firmly towards the trunk and the forearm is kept resting on the thigh. Slow, rhythmic pronation and supination movements of the forearm are carried out. Once the pain has subsided, the four elbow movements should be exercised actively using a wand. To regain extreme range of all movements, gentle stretch needs to be affected by the contralateral hand (*see* Figs 10.9A to C, page 129).

SIDE SWIPE INJURIES

(Syn: Traffic elbow, Car window elbow)

Mechanism

It is due to the force applied to an elbow projecting from a car window by a passing vehicle or when it hits a fixed object or when it overturns (Fig. 9.21).

Fig. 9.21: Photograph showing mechanism of side swipe injuries

Shorbe's Classification

Group I Only soft tissue injury.

Group II Only tip of the elbow is injured and there is fracture olecranon.

Group III Fracture of both radius and ulna.

Group IV Variations of comminuted intercondylar fractures of the humerus.

Group V Severely injured, fracture of all bones around the elbow with considerable soft tissue injury. Extensive open wounds are not unusual.

Clinical Features

Patient complains of extreme pain, gross swelling, broadening of the elbow, loss of mobility at the elbow joint, crepitus, abnormal mobility, etc. There may be features suggestive of injuries to the blood vessels and nerves and patient can present with compartmental syndromes or even gangrene of the hand in extreme cases.

Radiograph

X-ray of the elbow, AP view and lateral views helps to identify the different fracture patterns and helps in making the diagnosis (Fig. 9.22).

Fig. 9.22: Plain X-ray of the elbow showing traffic elbow

Methods of Treatment

Treatment must be individualized. Various combinations of internal fixation, external fixation and traction should be tried. Initial debridement must be thorough. Primary nerve repair is indicated if the cut is clean. In crushed injuries, nerve should be repaired secondarily.

Primary amputation This is indicated in the following situations.

- Irreparable vascular damage and a non-viable extremity.
- Segmental disruption of all three nerves around the elbow.

But it should be remembered that a pain-free elbow (either stiff or unstable) is better than amputation.

Physiotherapy Treatment for Side Swipe Injuries

This is the same as for the posterior dislocation of the elbow but is pursued in a more vigorous manner. The following are some of the additional measures:

- Early functional use of the elbow and forearm are started
- Efforts are made to improve the functional range of pronation and supination, if it is difficult to attain elbow flexion and extension.
- Efforts are made to strengthen the shoulder forearm wrist and finger muscles to compensate for the loss of elbow movements.

RADIAL HEAD FRACTURE

Radial head fracture is a common injury in adults and is rare in children.

Mechanism of Injury

- Indirect trauma due to fall on an outstretched hand
- Direct trauma as in the case of RTA or Assault, etc.

Mason's Classification

Type I Undisplaced fracture (Fig. 9.23A)

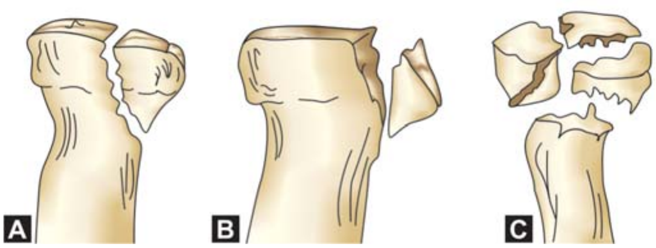
Type II Marginal fracture with displacement (Fig. 9.23B)

Type III Comminuted fractures (Fig. 9.23C)

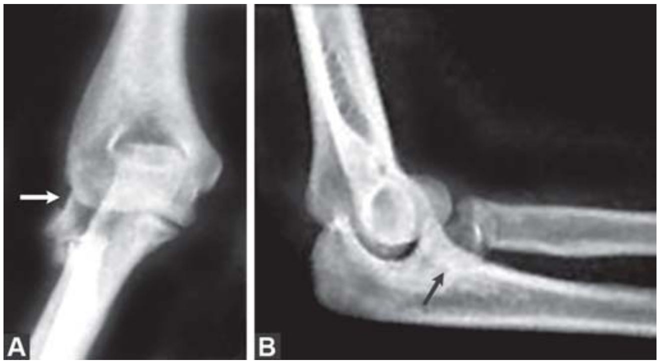
Type IV Radial head fracture with posterior dislocation of elbow.

Clinical Features

The patient with radial head fracture complains of pain on the lateral side of the elbow, minimal swelling, and restriction of elbow movements, supination and pronation of the forearm.



Figs 9.23A to C: Fracture head of the radius. Type III fracture with posterior dislocation of the elbow is called as type IV



Figs 9.24A and B: Plain X-ray of the elbow showing fracture head of the radius

There is tenderness over the radial head and crepitus can be elicited.

Radiograph

Plain X-ray of the elbow helps in making the diagnosis (Figs 9.24A and B).

Treatment

Undisplaced fractures and minimally displaced fractures are managed conservatively with above elbow plaster slab or cast. In badly communited fractures excision head of the radius is done.

Complications

Injury to the posterior interosseous nerve, secondary osteoarthritis and elbow, stiffness are the common complications of radial head fractures.

Physiotherapy

Treatment Goals

Orthopedic goal To reduce the fracture, to obtain a normal carrying angle (70° in males/130° in females). To prevent valgus instability and shortening of the radius as radial head is the secondary stabilizer of the elbow joint providing approximately 30 percent resistance to the valgus force.

Rehabilitation goals To restore normal or at least functional range of elbow movements. To maintain full range of motion of wrist, digits and shoulder. To restore and maintain the strength of elbow flexors, extensors, supinators, pronators wrist flexors and extensors.

Functional goals Apart from improving activities like dressing, grooming, and etc. efforts are made to improve functions requiring supination and pronation like opening doors, keys, etc.

Methods of Treatment

I. Conservative management The physiotherapy management for patients treated by conservative methods like sling/splint is as follows:

During the 1st week
- Check the sling for proper fit and padding.
- If necessary add padding to the splint.
- Ensure free range of movements to the MP joints.
- After 3-4 days, allow active range of motion to the elbow.
- Passive range of motion to the elbow is not allowed.
- Passive range of motion to shoulder, wrist and fingers is indicated.

2nd week
- Remove the sling/splint.
- Isometric exercises to the deltoid, biceps and triceps.
- Active motion to the elbow.
- Both active and passive range of motion to the shoulder/wrist.

4-6 weeks
- Partial weight bearing is permitted.
- Active and active assistive range of motion to the elbow.
- Strengthening exercises to the biceps, triceps, del-toids and fingers.

8-12 weeks
- Active and passive range of motion to the elbow.
- Resistive exercises to the elbow, flexors, extensors, supinators and pronators.

II. Excision of radial head/open reduction and internal fixation

During the 1st week
- Wound inspection is done.
- Pad and splint are checked.
- Rest of the treatment is same as above.

2nd week
- Wound inspected
- Sutures are removed
- Active range of movements is permitted.

4-6 weeks
- Continue active range of movements.
- Strengthening exercises to the biceps, triceps, deltoid and finger.
- No weight-bearing.

8-12 weeks
- Full activity is permitted
- Rest same as for the conservative treatment

Note
- Expected time of healing—6-8 weeks
- Expected time of rehabilitation—6-12 weeks

FRACTURE OF THE OLECRANON

Fracture olecranon is uncommon in children. Olecranon fracture in adults is comparable to fracture patella. Fracture reduction should be exact since any residual irregularity of the articular surface will cause limited motion, delayed recovery and traumatic arthritis of the elbow.

The fracture fixation should be strong enough to allow gentle active exercises even before radiographs show evidence of complete union.

As separation of the fracture of the patella causes quadriceps insufficiency so does displaced fracture olecranon causes triceps insufficiency.

Mechanism of Injury

- *Direct* Trauma due to fall on the point of elbow. This is the frequent cause (Fig. 9.25).
- *Indirect* Due to forcible triceps contraction.

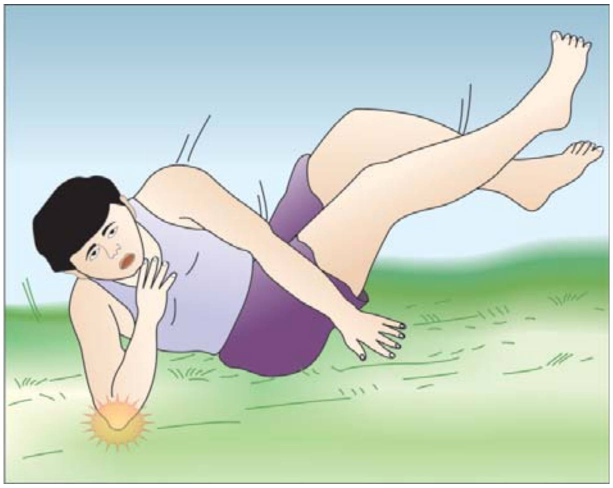
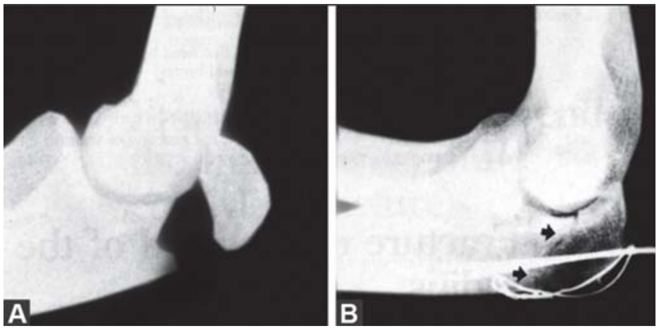


Fig. 9.25: Photograph showing mechanism of olecranon fracture (direct fall on elbow)

Colton's Classification (Figs 9.26A to C)

- Avulsion fracture
- Transverse/oblique fracture
- Fracture dislocation (Monteggia group)
- Comminuted fracture.

Figs 9.26A to C: Showing undisplaced fracture: (A) Displaced, (B) Communited, (C) Fracture of olecranon



Figs 9.27A and B: Plain X-ray showing olecranon fracture and the figure of 8 wire loop fixation

Clinical Features

The patient complains of pain, swelling and inability to extend the elbow. Clinically tenderness and crepitus can be elicited.

Radiograph

Plain X-ray of the elbow, AP view and lateral views helps in making the diagnosis (Figs 9.27A and B).

Treatment

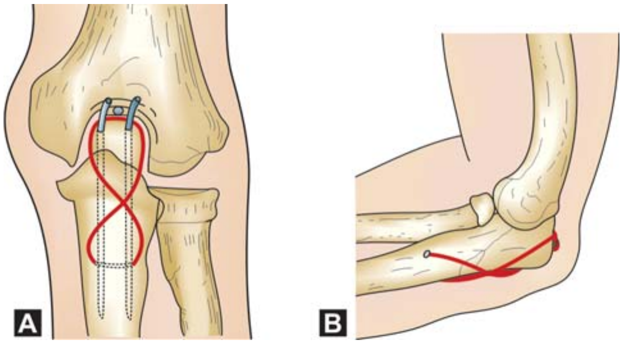
In children, closed reduction is done and is often successful. The elbow is immobilized in an above elbow POP cast in 90° flexion and forearm in supination.

In adults, repair of triceps is done for avulsion fractures. There is no place for conservative treatment, because closed reduction needs immobilization in extension for 6 to 8 weeks, which except in children causes permanent stiffness. Hence, surgery is the treatment of choice in adults.

Methods of Operative Treatment

There are three methods of operative treatment:

1. *Open reduction and internal fixation with fig of 8 wire loop* (Figs 9.28A and B). This method is used for avulsion and transverse fractures of the olecranon and for fractures which are uncomminuted and proximal to the coronoid fossa.
2. *Medullary fixation by a single interfragmentary screw* This is indicated in comminuted fracture of olecranon when its distal fragment and the head of the radius are dislocated anteriorly. Rigid fixation is required to prevent recurrence of dislocation.



Figs 9.28 A and B: Showing tension band wiring (TWB) in fracture olecranon

3. *Excision of the proximal fragments*
   Indications
   - In comminuted fractures.
   - In delayed union or nonunion of fractures in upper half.
   - If the patient is greater than 50 years of age and is not involved in heavy work.

   This method is useful only if enough of the olecranon is left to form a stable base for the trochlea. Thus it is not indicated when comminution extends as far as the coronoid.

Complications

Nonunion of the fracture, secondary osteoarthritis of the elbow, triceps insufficiency and restricted movements of the elbow are the common complications of fracture olecranon.

Physiotherapy Management

Conservative Management

During the first week
- No movements are permitted at the elbow.
- No strengthening exercises to the elbow.
- Isometric exercises to the wrist within the cast after 3-4 days.
- Unaffected extremity is used for daily care.
- No weight bearing is permitted.

During the second week
- Isometric exercises to the elbow are begun.
- Rest same as above.

Four to six weeks
- Active range of motion to the elbow is started.
- Isometric exercises to the elbow and wrist.
- The patient can use affected extremity for daily care activities.
- No weight bearing is permitted.

Six to eight weeks
- Full active range of movements to the elbow and wrist in all planes.
- Resistive exercises to the elbow and wrist.
- The involved extremity can be used for daily care activities.
- Gradual weight-bearing is permitted.

Eight to twelve weeks
- Same as above.
- Full weight bearing is permitted.

Surgery (Open reduction and internal fixation/Excision)

During First week
- Hand elevation
- Range of motion exercises to the shoulder, elbow and digits are started after 3-5 days but not in cases of excision.

Second week
- Sutures are removed.
- Remove splint in open reduction and internal fixation cases but apply splint or cast in cases of excision.
- Active range of motion to shoulder, elbow, wrist and digits
- No active movements for elbow in excision.

Four to six weeks
- Active elbow extension is begun while the active elbow flexion is continued.
- No range of active elbow movements is still permitted for excision cases.

Eight to twelve weeks
- Resistive exercises to the elbow.
- Gentle strengthening exercises to the elbow are begun.

Note
- Expected time of bone healing—10 to 12 weeks
- Expected duration of rehabilitation—10 to 12 weeks.

FRACTURE OF THE CAPITULUM

Due to fall on an outstretched head, the radial head may slice through the capitulum's fracturing it. It is commonly seen in adults.

Clinical Features

Pain, swelling, crepitus, loss of joint movements at the elbow.

Radiograph

This may show a small or big fragment including the entire capitulum's. Sometimes the fracture may not be seen on the X-ray (Fig. 9.29).

Treatment

Conservative treatment In fresh fractures, closed reduction under GA and an above elbow POP casting is done for 3-4 weeks.

Fig. 9.29: Plain X-ray showing fracture of the capitulum

Surgical management
- *Open reduction and internal fixation* This is done where closed reduction fails.
- *Excision of the fragment* In late cases, excision of the fragment causing a flexion block is advocated.

Physiotherapy Measures

During the cast treatment Active exercises to the fingers, shoulder, etc. is advised.

After the cast removal
- *Thermotherapy* to reduce pain and swelling.
- *Elbow mobilization* this is as described in posterior dislocation of elbow and consists of:
  - Roller skates mobilization of the elbow.
  - Prone lying elbow mobilization.
  - Modified knee Ratchet elbow mobilization.
  - Using an elbow mobilizer (Fig. 9.30A).
- Active assistive or free active forearm supination or pronation is advocated.

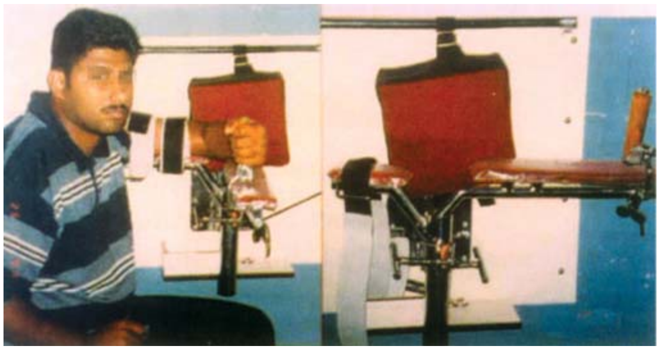


Fig. 9.30A: Showing method of mobilizing elbow with a mobilizer

Fig. 9.30B: Active mobilization at elbow flexion and extension using a wand

- Active movements of the elbow using a wand are begun after the pain subsides (Fig. 9.30B).

FRACTURE SHAFT HUMERUS

Fracture shaft humerus is more common in adults than in children.

Anatomic Considerations

The deformity is influenced by the muscles of the upper arm. If the fracture is between pectoralis major and deltoid, the proximal fragment is adducted by pectoralis major, teres minor and latissimus dorsi, while the distal fragment is pulled upwards by the deltoid.

If the fracture is below the insertion of deltoid the proximal fragment is abducted by the deltoid while the distal fragment is pulled upward by the coracobrachialis, biceps and triceps (Fig. 9.31).

Mechanism of Injury

- *Direct force* This may produce a transverse or comminuted fracture. Seen in RTA, assault, etc.
- *Indirect force* It is due to fall on an outstretched hand and this will produce an oblique or spiral fracture.
- *Birth injuries* This is the second most common birth fracture after clavicle.

Clinical Features

Clinical features shows pain swelling, deformity and all the signs and symptoms of a fracture (Fig. 9.32). A careful

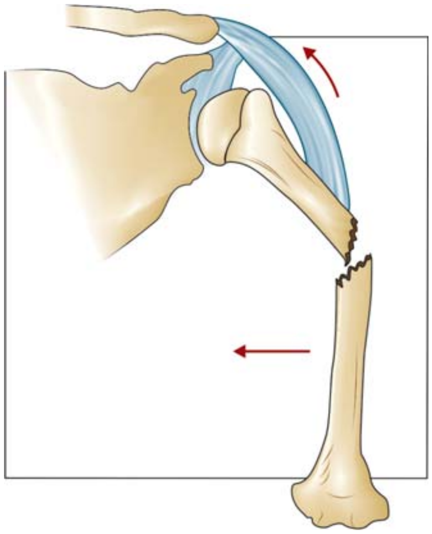


Fig. 9.31: Muscle forces causing deformity in fracture shaft humerus

Fig. 9.32: Clinical photograph showing fracture shaft of humerus

neurological and vascular assessment is important. Injury to radial nerve is common in fractures at the spiral groove or lower one-third of humerus.

Radiograph

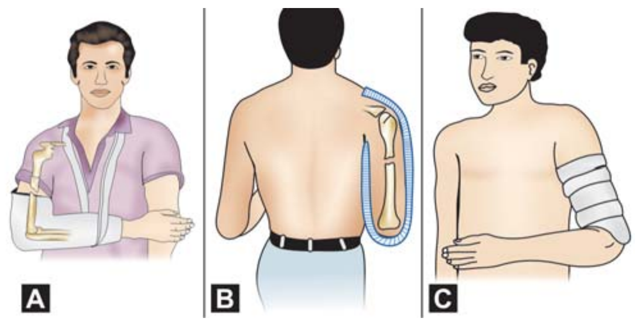
X-ray of the upper arm, AP view and lateral views including both the shoulder and elbow joints helps in making the diagnosis (Fig. 9.33).

Treatment

Conservative methods

- *Simple splint* in birth fractures.
- *Simple sling* may be sufficient in young children.

Fig. 9.33: Plain X-ray showing segmental fracture of the humerus and fixation by interlocking nail



Figs 9.34A to C: Showing different conservative treatment methods in fracture shaft of humerus (A) Hanging cast, (B) U-slab, (C) Cast brace

- *Hanging cast* (Fig. 9.34A) is useful in older children and adolescents. Here gravity aids in reduction of the fracture. They are not suitable if the level of fracture corresponds to the upper limit of the cast, because of the deforming effect of the proximal end of the cast. It is indicated in comminuted fractures of the distal third. If the cast is too heavy it may cause distraction and consequent delayed or nonunion.
- A plaster U-splint is sufficient in most of the situations of fractures of the proximal and middle third portions of the humerus (Fig. 9.34B).
- Functional cast brace (Fig. 9.34C).

Note
- U-slab—for proximal middle 1/3 fractures.
- Hanging cast for distal 1/3 fractures

Operative Treatment

Indications

- Failed conservative treatment.
- Multiple fractures and unstable fractures.

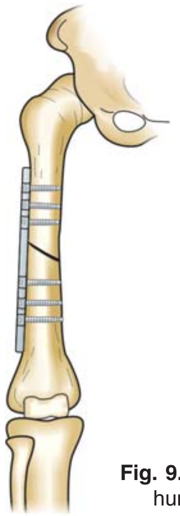


Fig. 9.35: Surgical fixation of fracture shaft humerus with DCP plate and scrubs

- Multi-system injuries.
- Radial nerve palsy after closed reduction.

Methods

- DCP plating for fractures at all levels (Fig. 9.35).
- Intramedullary fixation at middle third fractures.
- Interlocking nail fixation is being tried recently with good results.

Complications

Radial nerve injury This is common in lower one-third fractures and is usually of a high variety. It may also be damaged in the spiral groove. Closed fractures need observation, splinting of wrist and fingers. If a radial nerve deficit occurs after closed manipulations, immediate exploration is necessary (*see* page 238).

Vascular injury To the brachial vessels is unusual. It requires repeated assessment and prompt treatment.

Malunion In humeral fractures, angular deformity of 20° is acceptable in the middle and distal one-third; while in the proximal one-third 30° is acceptable. Thick muscles in the upper arm usually conceal the malunion.

Nonunion is not very common but may be seen due to over-weight hanging cast. This requires open reduction, excision of the fibrous tissue, rigid plating and bone grafting.

Operative methods In properly indicated cases, open reduction and rigid internal fixation with DCP plate and screws is the recommended method. Interlocking nail technique is now being more commonly used for comminuted fractures of the humerus.

Physiotherapy Treatment

During the first week This is the phase of immobilization. During this phase, no movements are allowed to the shoulder and elbow if the patient is in the cast or splint. However, if the patients are treated by open reduction and internal fixation with plate or rods or by external fixators, gentle active assistive range of motion movements to the shoulder and elbow are started. No strengthening exercises are allowed to the shoulder and elbow. For day to day activities, the involved extremity is made use of. No weight-bearing is permitted with the affected extremity. Because of pain there will not be any arm swinging at this stage. A check is made for splint integrity, position, axilla for abrasions and padding.

Quick Facts

During first week	
Do's	*Don'ts*
• Check splint	• Weight bearing
• Exercise digits	• No movement to shoulder/elbow
• Check wound in surgery	• No strengthening exercises
• Use unaffected extremity For daily activities	• Day to day activities with affected limb
• Do check X-rays	
• Mobilize elbow and shoulder If fixation is stable	

In case of treatment by surgical methods, wound inspection is done. Check X-rays are taken and examination for radial nerve function is carried out. To prevent hand swelling, active digit exercises are allowed.

During the second week Active and active assistive range of motion to the elbow and shoulder are started for patients in a cast or brace, shoulder abduction is not permitted beyond 60°. Gentle pendulum exercises to the shoulder are begun. Strengthening exercises to the shoulder are not advised. Unaffected extremity may be used for activities of daily living, while in stable open reduction and internal fixation, external fixation, involved extremity is used for day to day activities. Examine axilla, radial nerve and radiographs for loss of reduction.

Quick Facts

Second week	
Do's	*Don'ts*
• Check axilla/ Radial nerve • Gentle range of motion to Shoulder/elbow • Pendulum exercises to shoulder • Use unaffected extremity For day to day activities • Wound inspection/suture removal • Check X-ray are taken • Check for RSD (Reflex sympathetic dystrophy)	• No muscle strengthe-ning exercises • No weight bearing

Fig. 9.36: Under the physiotherapist guidance, the patient is performing a self-assisted passive elbow flexion and extension mobilisation within a sling

4-6 weeks This is the phase of mobilization. Heat therapy by way of ultrasound, SWD, etc. are carried out. Check the radial nerve, RSD, X-rays for callus, healed wounds. Active range of motion exercises to the elbow is begun. Isometric and isotonic exercises are advised to the elbow and shoulder. The shoulder should be mobilized within the sling by the other arm holding the affected hand and carrying out gentle rhythmic, active, active assistive or passive relaxed movements. This can also be done under the guidance of a physiotherapist (Fig. 9.36).

Codman's pendulum exercises are begun in the standing position. For active assistive exercises shoulder wheel, skates, dumbbells can be employed.

Quick Facts

During 4-6 weeks	
Do's	*Don'ts*
• Convert cast into brace by 4 weeks • Check radial nerve, RSD • Check the X-ray • Begin AROM to shoulder and elbow • Codman's pendular exercises are begun • Involved extremity may be used for self-care • Isometric and isotonic exercises to forearm • After 6 weeks, isometric exercises to biceps, triceps	• No heavy lifting with the affected extremity

8-12 weeks The fracture will be stable by this time irrespective of the method of treatment. Complete range of active, active assistive and passive movements to the shoulder and elbow are permitted. Patient is permitted to do all activities with the affected limb. Light weight lifting is allowed with the affected extremity. Full weight bearing is allowed. However re-examination of the radial nerve is done and EMG is done if necessary.

10

Chapter

Injuries of the Forearm, Wrist and Hand

FRACTURES OF THE FOREARM BONES

Isolated fracture of the ulna (nightstick fracture), isolated fracture of radius, fracture of both radius and ulna, galleazzi fracture, Essex lopressti fracture, Monteggia fracture dislocation are included in the category of fractures of the forearm bones.

A brief description of the above mentioned fractures are given below.

FRACTURE BOTH BONES OF FOREARM

This is a difficult problem especially in adults. The complex muscle arrangements makes retention of the fracture fragments very difficult.

Mechanism of Injury

The fracture could be due to either direct or indirect trauma (Fig. 10.1).

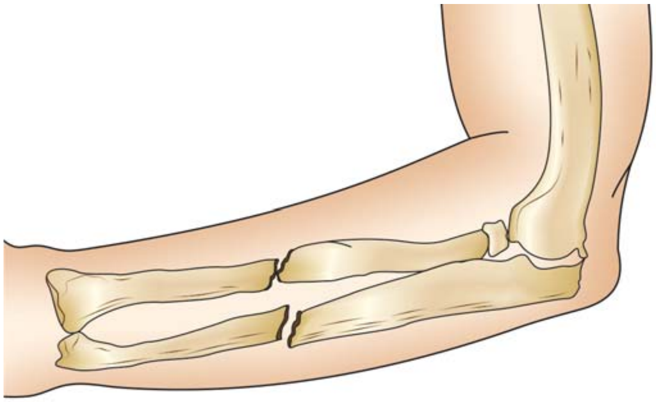


Fig. 10.1: Fracture both bones of forearm

Fig. 10.2: Plain X-ray showing fracture both bones and the forearm

Clinical Features

Pain, swelling, deformity, loss of forearm movements and other signs of fractures are usually seen.

Radiograph

Plain X-rays of the forearm by AP end lateral views helps to make a diagnosis (Fig. 10.2).

Management

Though conservative treatment, which consists of closed reduction by traction and counter traction methods under general anesthesia followed by an above elbow plaster cast, is usually successful in children, in adults open reduction and internal fixation (ORIF) is often indicated because it is difficult to regain length, apposition, axial and normal rotational alignment in adults by closed reductions. Open reduction is by two approaches, one for the radius and the other for the ulna. The choice of implants for ulna is either a medullary nail or plate and screws but for fracture radius, rigid compression plating is usually desired (Fig. 10.3). Cancellous bone grafting is done if the communition is more than one-third of the circumference of the bone.

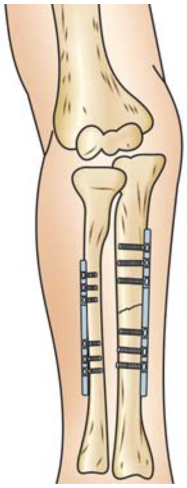


Fig. 10.3: Showing fixation of fracture both bones forearm with DCP plate and screws

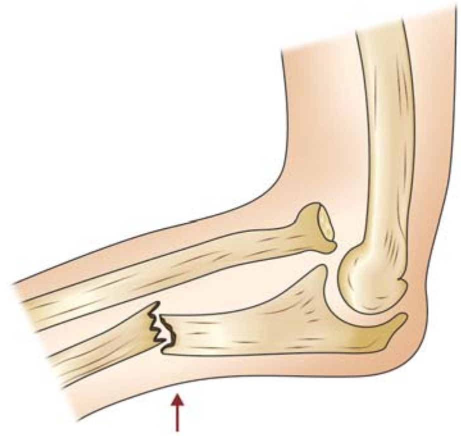


Fig. 10.4: Showing anterior Monteggia fracture

Complications of Fracture Both Bones of Forearm

- *Volkmann's ischemia* Because of the tight fascial compartment, a patient with fracture both bones of forearm are more prone to develop acute compartmental syndrome.
- *Delayed union and nonunion* This can be encountered due to soft tissue interposition, inadequate immobilization, etc. It has to be treated by open reduction, rigid internal fixation and cancellous bone grafting.
- *Malunion* Due to the complex muscular forces it is difficult to retain the position of both bones in perfect alignment after closed reduction. It is in this situation that malunion commonly results. It is treated by corrective osteotomy, plating and bone grafting.
- *Cross union* This is due to malunion of a radial fracture in a medially deviated position which occupies the interosseous space and blocks pronation and supination. If the cross union takes place in the middle third of the forearm, it can be left alone as the forearm is held in midpronation with less functional damage. Elsewhere it needs corrective osteotomy and rigid internal fixation.

MONTEGGIA FRACTURE

It is a fracture of upper third of ulna with dislocation head of the radius. *This is usually called a "treacherous lesion" because the dislocation is often missed.* It was first described by Monteggia in 1881.

Mechanism of Injury

Monteggia fractures are caused by direct blow or due to fall on outstretched hands with forced pronation or hyperextension.

Classification

Bado has classified Monteggia fractures in adults into four types like anterior, posterior, lateral depending upon the direction of the dislocation of head of the radius and angulations of fracture ulna. However, Type I (anterior) fracture accounts for more than 60 percent of the cases (Fig. 10.4).

Clinical Features

In all four varieties of Monteggia fractures patient complains of severe pain and tenderness about the elbow. There will be no flexion, extension, pronation and supination movements at the elbow. Paralysis of posterior interosseous nerve may occur (Fig. 10.5).

Radiograph

Plain X-rays of the forearm including both the elbow and wrist AP and Lateral views is recommended. This is called

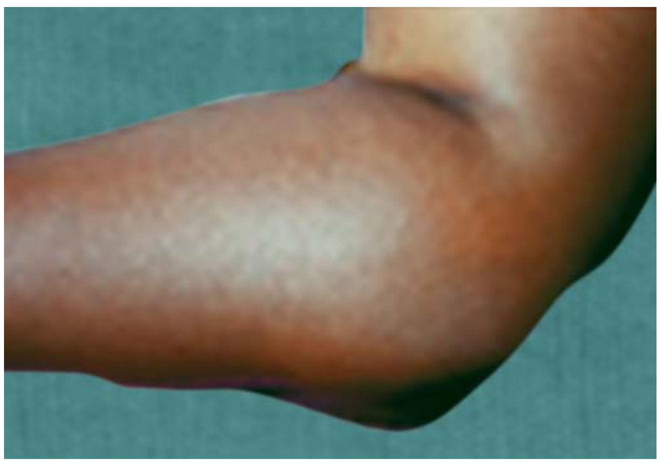
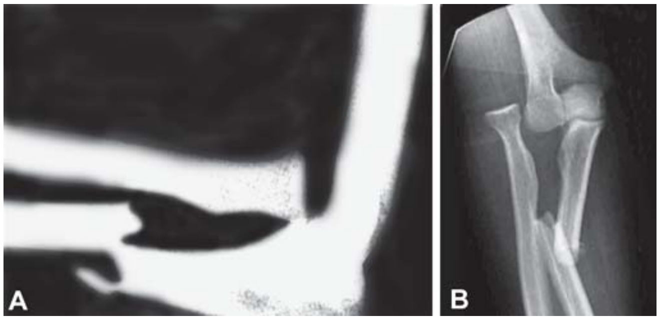


Fig. 10.5: Clinical photograph of Monteggia fracture



Figs 10.6A and B: Plain X-ray of the forearm showing (A) Anterior Monteggia, (B) Lateral Monteggia

treacherous lesions as they are frequently missed on X-rays. Hence, a careful interpretation of the X-ray is a must (Figs 10.6A and B).

Treatment

In children, closed reduction and above elbow POP cast give good results. However, in adults closed reduction of head of the radius and ORIF for fracture ulna with plate and screws are suggested. In failed closed reduction, open reduction and rigid internal fixation of ulna with plate and screws is indicated.

Complications

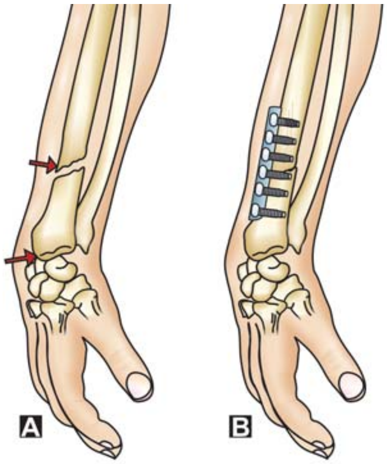
- Unreduced dislocation head of radius.
- Posterior interosseous nerve palsy.
- Malunion of fracture ulna.
- Nonunion of fracture ulna.
- Myositis ossificans.
- Synostosis between radial head and proximal ulna.
- Tardy posterior interosseous nerve palsy.
- Proximal migration of radius.
- Dislocation of inferior radioulnar joint.
- Cubitus valgus deformity.

GALEAZZI FRACTURE

This is a fracture of radius at the junction of middle and distal third with associated subluxation or dislocation of the distal radioulnar joint. Subluxation of this joint may be present initially or occur during treatment (Fig. 10.7A).

French people call this fracture *reverse Monteggia*. Campbell called it as *fracture of necessity* since it always requires open reduction and internal fixation (ORIF).

Incidence is three times as common as Monteggia fracture.



Figs 10.7A and B: Showing (A) Galeazzi fracture, (B) Fixation with DCP plate

Mechanism of Injury

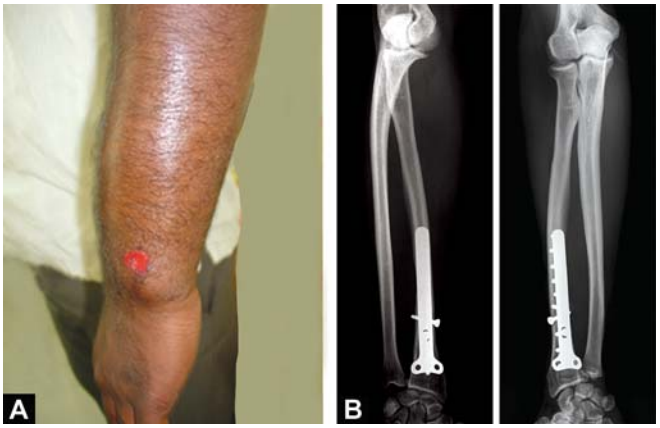
1. Fall on an outstretched hand with marked pronation of the forearm.
2. Direct blow on the dorsolateral side of the forearm.

Clinical Features

Patient presents with severe pain, swelling, tenderness and loss of forearm and wrist functions (Fig. 10.8A).

Radiograph

Plain X-rays of the forearm including both the elbow and wrist AP and Lateral views is recommended (Fig. 10.8B).



Figs 10.8A and B: (A) Clinical photograph of Galeazzi fracture, (B) Plain X-ray showing the fracture and fixation with plate and screws

Treatment

Closed reduction is usually not successful due to the deforming forces of the forearm muscles. Hence, ORIF is the preferred method of treatment. Intramedullary nails and small plates do not provide adequate fixation, long plate and screws are thus used and the dislocated distal radioulnar joint and may be fixed with K-wire (Fig. 10.7B).

Complications

Nonunion and malunion are notorious complications. Angulation of the fracture and subluxation of the distal radioulnar joint can also occur. Rarely entrapment of extensor carpi ulnaris tendon in distal radioulnar joint is encountered.

ESSEX-LOPRESTI FRACTURE

This is a fracture of the radial head with injury to the distal radioulnar joint. It is a relatively rare fracture and in order to avoid missing it, radiograph of the wrist joint should be taken in all cases of fracture of head of the radius. If there is disruption of distal radioulnar joint, excision head of the radius is likely to aggravate the proximal migration of the radius. Hence, if fracture radial head needs excision, it has to be replaced by silastic prosthesis.

Whatever may be the forearm bone fractures (whether fracture both bones forearm, isolated fractures of radius or ulna, Monteggia or Galeazzi fracture, or Essex-Lopressti fracture), the treatment goals remain the same and are described as below.

Treatment Goals in Forearm Fractures

Orthopedic Goals

The forearm bones fractures should be treated with the following orthopedic goals in mind:

- Reduction should be perfect.
- Malunion is unacceptable as it leads to loss of pronation and supination. Grip strength also becomes weak.
- To restore the interosseous space, radial bow, length and rotation.
- To attain good stability at the fracture site.

Rehabilitation Goals

To restore back the joint movements and muscle strength should be the prime objectives of the rehabilitation program of forearm fractures.

Movements Emphasis is placed on restoring at least functional if not 'full' pronation/supination, wrist and hand function (See Table 10.1).

Functional Goals

It is important to restore complete function of wrist, fingers, elbow, forearm supination and pronation requiring activities.

TABLE 10.1: Showing the normal and functional range of movements of elbow and forearm

Movements	*Normal*	*Functional*
Pronation	80°	50°
Supination	80°	50°
Flexion	135°	90°
Extension	0°	20-30°

Quick Facts

- Expected time of bone healing—8 to 12 weeks.
- Expected time of rehabilitation—12 to 24 weeks.
- Restoration of forearm supination/pronation is extremely important.
- Cast and external fixation is stress sharing device.
- Plate fixation is stress-shielding.
- Range of motion is to be obtained prior to muscle strengthening.

Methods of Rehabilitation in Forearm Bone Fractures

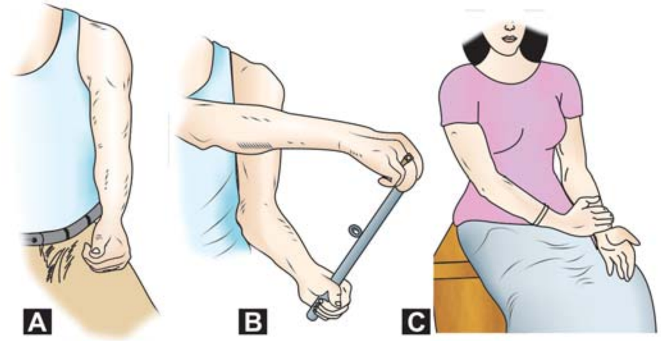
Conservative management Barring a few specific exceptions like isolated ulnar undisplaced fracture, undisplaced fracture of both bones forearm and Monteggia fractures in children, conservative management has limited role to play in forearm bone fractures. The methods of conservative management include short arm cast for isolated ulnar fracture, long arm cast for both bones fracture, closed reduction and above elbow cast for Monteggia fractures in children. The rehabilitation program in these situations proceeds on the following lines:

The plaster The plaster cast should be well-padded, snugly fitting and should not immobilize the unaffected joints unnecessarily. The plaster should be inspected for cracks, soiling, loosening, etc. and should be changed. By four weeks, the plaster cast can be removed and a functional brace given.

Note
- The cast should leave the MCP joints free to move.
- Dependent edema should be treated by hand elevation in mild cases and removal in severe cases.

Unaffected joints The uninvolved and unaffected joints like the fingers and shoulder should be kept mobile by a full active, active assistive and passive range of motion exercises.

The involved joints The elbow and the wrist joints and the forearm are mobilized only after four weeks after removal of the plaster cast. Active, active assistive and passive range of motion exercises are begun to the elbow after removal of the



Figs 10.9A to C: Measures to regain pronation—supination movements of the forearm: (A) Active, (B) Self-assisted passive stretching exercise using a wand, (C) self-assisted passive stretching using the contra lateral hand

plaster cast. However, to restore back the supination and pronation of the forearm, a methodical approach is required and is done as follows:

- In the initial stages, patient is instructed to carry out the supination, pronation actively with the forearm fully supported on the thigh (Fig. 10.9A).
- This is followed by active assisted stretching of the forearm by using a wand (Fig. 10.9B).
- Then passive stretching of the pronation/supination by the unaffected contralateral hand is carried out (Fig. 10.9C).
- Finally as the patient gradually gains the movements, full range exercises using weights in gradation is advocated.

Surgical management Postsurgical rehabilitation after forearm fractures proceeds in the following lines:

- *Plaster* There is no role of long arm cast in forearm bone fractures treated by open reduction and rigid internal fixation as the fracture is quite stable. However, a long arm cast is advised after open reduction and internal fixation in Galeazzi and Monteggia fractures. The care of the plaster is similar to the ones mentioned in conservative methods.
- *Unaffected joints* In forearm fractures which are rigidly fixed, gentle active range of exercises are prescribed for the joints of the entire extremity including fingers, wrist, elbow and shoulder.

  In cases of Monteggia and Galeazzi fractures, active and passive range of exercises is advised to the digits and shoulder. Isometric exercises are prescribed for the biceps, triceps and deltoid muscles.
- *The involved joints* Elbow and forearm are mobilized in the first week itself for forearm bone fractures which are fixed rigidly. But for Monteggia and Galeazzi fractures, they are mobilized only after 4-6 weeks and the rehabilitation program follows the same pattern as for conservative treatment. After 8-12 weeks, full active and passive range of exercises for all the joints of the extremity is begun. Resistive exercises using weights in gradation are also begun. During the same period, the affected extremity can be used for self-care and full weight bearing can also be allowed.

During all the above methods of mobilization for forearm supination-pronations, the patient is made to sit on a stool, with the elbow fixed to the sides and the forearm resting completely on the thigh.

This regime is found to be successful in restoring back the supination and pronation of the forearm.

Quick Facts

Conservative treatment *vs.* rehabilitation in forearm fractures:
- Conservative treatment in forearm bones fracture is employed in specific cases.
- Plaster cast should not hinder the movements of the fingers at MCP joints.
- Full range of active and passive exercises is advised to the joints not involved in plaster immobilization like the shoulder and fingers.
- Active exercises to the immobilized joints like elbow, wrist and forearm should be commenced only after removal of the cast.
- Restoration of pronation-supination of the forearm needs methodical approach.

Functional Rehabilitation

For 2-4 weeks, the unaffected extremity is used for activities of daily living. From 6-8 weeks onwards the patient may be permitted to use the affected extremity for self-care. Weight bearing is allowed after 8-12 weeks.

COLLES' FRACTURE

This is also called as **Poutteau's** fracture in many parts of the world. It was first described by Abraham Colles in the year 1814.

It is not just fracture lower end of radius but a fracture dislocation of the inferior radioulnar joint. The fracture occurs about 1½″ (about 2.5 cm) above the carpal extremity of the radius (Fig. 10.10).

Following this fracture some deformity will remain throughout the life but pain decreases and movements increase gradually.

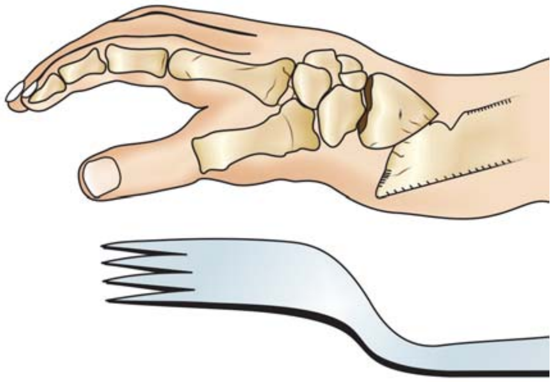


Fig. 10.10: Showing Colles' fracture and the dinner fork deformity

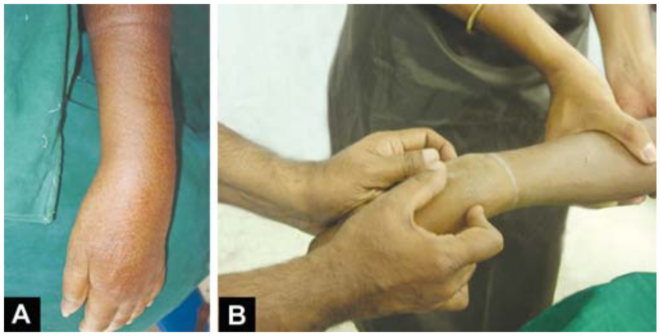
Fig. 10.11: Common mechanism of Colles' fracture

Mechanism of Injury

The common mode of injury is fall on outstretched hands with dorsiflexion ranging from 40 to 90° (average 60°) (Fig. 10.11).

Clinical Features

Usually the patient is an elderly female in her 60s and the history given is a trivial fall on an outstretched hand (Fig. 10.11). The patient complains of pain, swelling, deformity and other usual features of fracture at the lower end of radius (Fig. 10.12A). Though *dinner fork* deformity is a classical deformity in a Colles' fracture, however, it is not found in all cases but seen only if there is a dorsal tilt or rotation of the distal fragment. However, the styloid process test is more reliable. Normally radial styloid process is lower than the ulnar styloid process. But in displaced colles fracture both will be at the same level (Figs 10.12B and 10.14).



Figs 10.12A and B: (A) Clinical photograph showing dinner fork deformity, (B) Styloid process test

Figs 10.13A and B: Plain X-ray showing communited Colles' fracture

Radiograph

Plain X-ray of the wrist, AP and lateral views are recommended to make an accurate diagnosis (Figs 10.13A and B).

Treatment Methods

Aim The aim of treatment is to restore fully functional hand with no residual deformity. The treatment methods include conservative methods, operative methods and external fixators.

Conservative methods Here fracture reduction is carried out by closed methods under general anesthesia (GA) or local anesthesia (LA). Then the limb is immobilized by a below elbow cast called Colles cast and a check radiograph is taken.

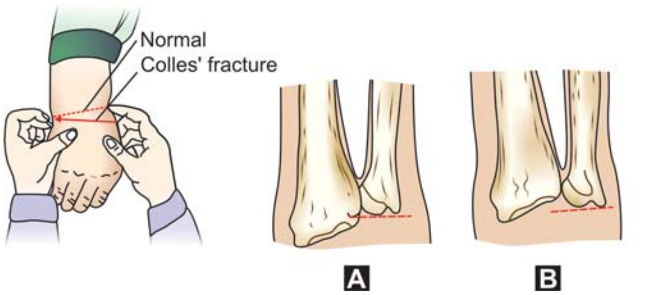


Fig. 10.14: Styloid process test: (A) Normal, (B) In Colles' fracture. It also suggests positive (A) and negative (B) ulnar variance

The plaster cast is removed after 6 to 8 weeks and physiotherapy is begun.

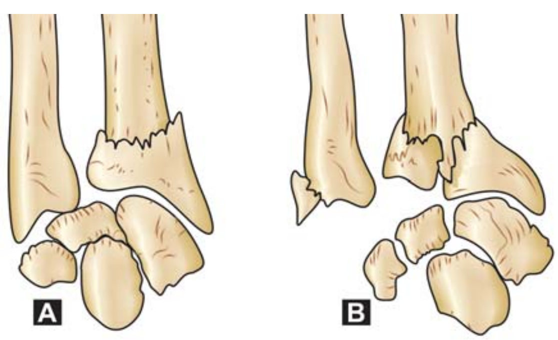
Operative methods This consists of closed reduction and percutaneous fixation with K wires or ORIF with plate and screws. However, operative treatment is rarely required for Colles' fracture.

Indications Operative treatment may be required in extensive comminution, impaction, and median nerve entrapment and associated injuries in adults.

External fixators are useful in highly comminuted fractures, unstable fractures, compound fractures and bilateral Colles' fracture.

Classification

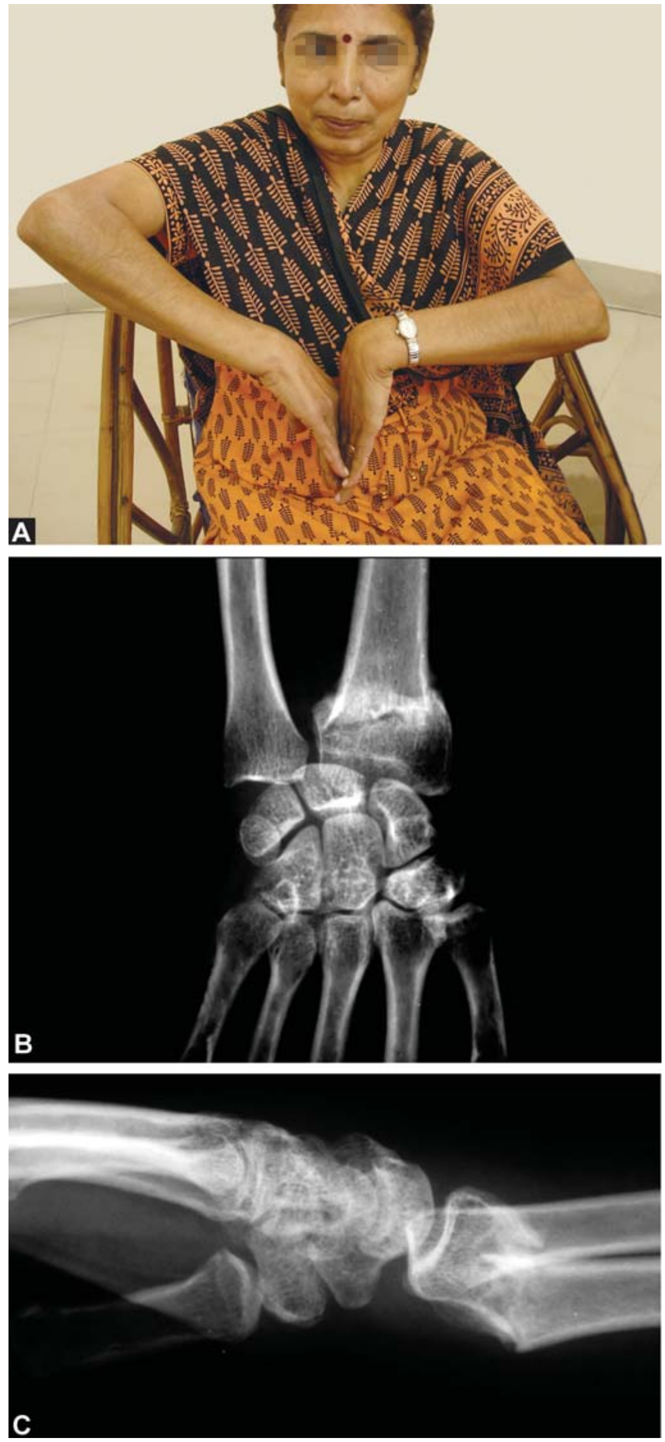
Contrary to popular belief Colles' fracture is both intra-articular and extra-articular and not only extra-articular. Frykmann's classification takes into consideration both and also the fracture of ulna (Figs 10.15A and B). This can be easily diagnosed on plain X-rays of the wrist.



Figs 10.15A and B: Showing (A) extra-articular and (B) intra-articular Colles' fracture

Complications

Malunion This is the most common complication of Colles' fracture (Figs 10.16A to C).



Figs 10.16A to C: Clinical photograph and X-rays showing malunited Colles' fracture

Rupture of extensor pollicis tendon This occurs due to the attrition of the tendon as it glides over the sharp fracture surfaces.

Fig. 10.16D: Clinical photograph of Sudeck's dystrophy

Sudeck's osteodystrophy This is due to abnormal sympathetic response which causes vasodilatation and osteoporosis at the fracture site (Fig. 10.16D).

Frozen hand shoulder syndrome This is a troublesome complication which develops due to unnecessary voluntary shoulder immobilization by the patient on the affected side for fear of fracture displacements. It is said that the patient has performed a *mental amputation* and kept the limb still.

Carpal tunnel syndrome Malunion of Colles' fracture crowds the carpal tunnel and compresses the median nerve (*see* page 285).

Nonunion This is extremely rare in Colles' fracture because of the cancellous nature of the bone which enables the fracture to unite well.

Rehabilitation Program

The rehabilitation following a Colles' fracture follows a planned program to attain the following objectives.

Orthopedic Goals

- To restore the radial length and the palmar tilt.
- To provide a stable wrist, free of pain.
- Normally, ulna is about 1-3 cm shorter than the radius (negative ulnar variance). This is reversed in Colles' fracture (positive ulnar variance) due to radial shortening following the fracture. This negative ulnar variance has to be restored (*see* Fig. 10.14).

Rehabilitation Goals

- To restore the range of motion of the wrist and digits either fully or at least the functional range (Table 10.2).
- To improve the muscle strength of the wrist, thumb, digit flexors and extensors, hypothenar, thenar, lumbricals and interossei muscles.

TABLE 10.2: Showing the normal and functional range of movements of wrist joint

Movements	*Normal*	*Functional*
Wrist flexion	75°	50°
Wrist Extension	70°	30°
Radial deviation	20°	10°
Ulnar deviation	35°	15°

Functional Goals

To restore hand functions like grip, grasp and pincer grip.

Vital facts
- Bone healing takes place by 6-8 weeks.
- The duration of rehabilitation is 12 weeks.
- Cast/acts as a stress sharing device.
- Plate/stress shielding device.

Rehabilitation Methods

The First Week

Conservative treatment methods by above or below elbow casts for undisplaced or slightly displaced, non-comminuted Colles' fracture, closed reduction and above (for intra-articular fracture) or below (for extra-articular fractures) cast is the preferred method of treatment. The rehabilitation program proceeds as under:

Plaster care
- The plaster should be snugly fitting and should not cross the proximal palmar crease and head of the metacarpals dorsally.
- The plaster should be checked for tightness, looseness, softening, cracks and swelling. If any of these is found to exist, it needs to be changed.
- The sling should be checked particularly for slackness and padding near the neck.
- Dependent edema should be treated by hand elevation and retrograde massage by milking the swelling from the fingertips to the palm.

Range of motion
- *Uninvolved joints* Active range of motion exercises are encouraged to the digits, thumb, elbow and shoulder joints to prevent stiffness.
- *Involved joints* Wrist movements, supination and pronation are not encouraged.
- Isometric exercises to the hand muscles are begun.

Activities of daily living are carried out with the normal unaffected hand and no weight-lifting is permitted with the affected arm.

External fixators are preferred for compound, comminuted fractures.

The rehabilitation programme for fractures treated by external fixators is more or less similar except cast care. In addition care of the wound and pin sites, skin tenting, skewing up of tendons, muscles, nerves and for evidence of infection is carried out. The pin sites should be cleaned with antiseptic swabs.

The rest of the treatment proceeds on the similar line as for conservative management except that supination and pronation can be allowed.

Open reduction In this, care of the wound takes precedence. Cast care is similar if applied. Rest of the management is similar as mentioned above.

Quick Facts

First week	
Do's	*Don'ts*
• Periodic cast care • Regular pin care • Regular wound care • Active range of motion for shoulder elbow, fingers and thumb • Use unaffected arm for daily care	• Weight bearing • Wrist function • Pronation/supination use of involved extremity for day care activities

The Second Week

Conservative Recasting is advised if the cast is loose, cracked or slipped distally. Check X-ray is taken. Continue range of motion exercises to the shoulder, elbow, digits and thumb.

External fixators Pin sites are evaluated for signs of infection. Active supination, pronation along with those mentioned above is permitted.

Open reduction and internal fixation The cast/splint is removed, wound is inspected and the sutures are removed. If fixation is rigid there is no need for further immobilization.

Fourth to Sixth Weeks

Conservative methods The cast is removed and a check is made for stability, tenderness and range of motion. X-ray is also taken to assess the fracture status. If there is tenderness, motion at fracture site, poor callus over X-ray, a short arm cast is re-applied. However, if the above findings are absent, then the cast could be discontinued and full active range of motion exercises can be encouraged.

Fig. 10.17: Showing method of active wrist dorsi and palmar flexion of the wrist joint

Methods of wrist mobilization

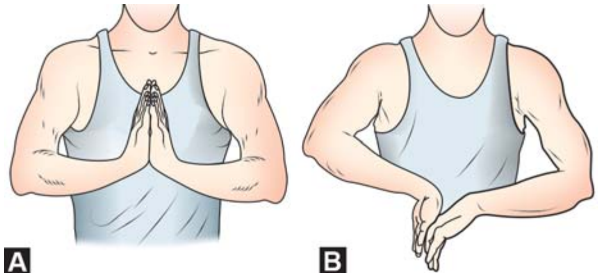
Step 1 To reduce pain, edema and discomfort, hydrotherapy, thermotherapy, etc. is given in the initial stages of wrist mobilization.

Step 2 *Active wrist mobilization* is initiated. Patient is made to sit on a chair and keep his forearm in midpronation over a table. With the affected forearm fixed by the other hand, patient is instructed to activity flex and extend the wrist with gravity eliminated (Fig. 10.17).

Step 3 *Self assisted passive wrist mobilization* This is begun after about 7-10 days of the above treatment. The patient sits with the affected hand resting on the edge of the table. Fixing it with the normal hand, the affected arm is lowered below the table (palmar flexion) and raised above the table (dorsiflexion) periodically (Fig. 10.18).

Alternatively, the Indian Salutation Method of Namaskar (for dorsiflexion) and reverse salutation (for palmar flexion) achieves the same results (Figs 10.19A and B).

Fig. 10.18: Self-assisted passive wrist flexion and extension with the hand at the edge of a table



Figs 10.19A and B: Self-assisted passive wrist extension: (A) Palmar flexion, (B) Exercises

Step 4 Pronation supination exercises as mentioned in earlier sections are carried out (*see* Figs 10.9A to C).

Step 5 *Exercises through activity* like turning the keys, doorknobs, scooping beans and putting them in a box, etc. are very helpful in putting the patient back to normal.

Step 6 To improve the grip and writing skills, ulnar deviation exercises are encouraged.

Step 7 To regain the muscle strength, gentle resistive exercises like ball squeezing is encouraged (*see* Fig. 10.25).

Apart from the above steps it is very important to instruct the patient to carry out the day to day functional activities through the affected hand. In cases of pain and discomfort, night splints could be used.

External fixator The pins are inspected and cleaned, if infected, they are removed and a cast is applied. It is important to continue the pins for 6-8 weeks if there is no infection.

Open reduction and internal fixation The cast is removed and the above mentioned exercise regimen is started promptly.

Sixth to Eighth Weeks

Conservative method By now the cast is removed and vigorous exercise regimen as mentioned above is carried out.

External fixator If the fracture is stable, the pins are removed and the above exercise regimen are carried out. However, if the fracture is unstable, a short arm cast is further applied for a period of four weeks.

Open reduction and internal fixation If the fracture is stable all the above mentioned exercises are pursued vigorously. Full weight bearing with the affected extremity could be commenced now.

The patient is warned about these possible complications and is advised to make suitable adaptations.

Fig. 10.20: Showing method of wrist mobilization

Wrist Mobilizer

All the movements of the wrist can now be mobilized using a wrist mobilizer. This instrument is user friendly and is supposed to give better results (Fig. 10.20).

Quick Facts

Residual problems following a Colle's fracture
- OA changes in the wrist
- Residual deformity
- Loss of ulnar deviation
- Loss of supination
- Persisting swelling

METACARPAL FRACTURES

These are usually due to direct trauma and could involve the head, neck, shaft or base. Fractures involving the head and base could either be intra-articular or extra-articular (Fig. 10.21).

Quick Facts

Metacarpal fractures with eponyms
- *Bennett's fracture* It is a 2 part intra-articular fracture of the base of the thumb.
- *Rolando's fracture same* as above, but it is a 3 part fracture of the base of the thumb.
- *Reverse Rolando fractures* 3 part intra-articular fracture of the base of the 5th metacarpal bone.
- *Boxers fracture Fracture* of the V metacarpal neck.

Investigation: X-ray (Fig. 10.22).

Fig. 10.21: Clinical photograph of a metacarpal fracture

Fig. 10.22: Plain X-ray showing oblique fracture of the metacarpal shaft

Goals of Treatment

Orthopedic Goals

To achieve stability of fracture with no rotational deformity and acceptable level of angulation and articular step off (*see* box below).

Quick Facts

Acceptable levels

- Rotational deformity—Nil
- Articular step-off—1-2 mm
- Angular deformity (apex dorsal angulation)
  - a. *For fracture neck*
    1. I digit—10°
    2. II digit—20°
    3. III digit—30°
    4. IV/V digit—40°
  - b. *For shaft fracture*
    1. I digit—30°
    2. II/III digit—10°
    3. IV digit—20°

Rehabilitation Goals

To restore full range of motion of the digits and wrist and re-establish the muscle strength of hypothenar, thenar, interossei, lumbricals, long and short flexors (*see* box).

Quick Facts

Do you know the normal finger joint movements?

Intraphalangeal joints	*Flexion*	*Extension*
Proximal	0-100°	0-7°
Distal	0-70°	0-8°
Thumb	0-80°	0-5°
Metacarpophalangeal joints		
• II, IV, V fingers	0-90°	0-5°
• Thumb	0-80°	0°

Functional Goals

To restore hand function namely grip, grasp and pinch.

Note
- Normal bone healing time—4-6 weeks
- Normal rehabilitation time—6-12 weeks

Treatment Methods

Conservative Treatment with Cast or Splints (Stress Sharing)

Indications
- Stable metacarpal neck and shaft fractures.
- Severely comminuted head fractures.
- Intra-articular basal fractures of II, III, IV fingers.

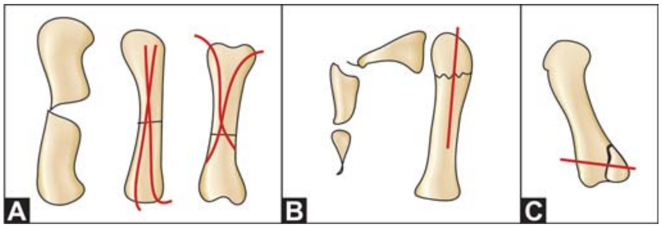
The hand should be immobilized in functional position and the affected hand should be immobilized in a below elbow plaster slab or splints.

Closed Reduction and Percutaneous Fixation with K-Wire

Indications
- Unstable metacarpal neck fractures (Fig. 10.23B).
- Unstable shaft fractures (Fig. 10.23A).
- Intra-articular fractures of I and V metacarpal bones (Fig. 10.23C).

Method of fixation There are three methods of fixation (Figs 10.23A to C):
- Intramedullary.
- Transfixation to adjacent metacarpals.
- Oblique and crossed k-wires.

Note Pins are usually kept for 3-4 weeks.



Figs 10.23A to C: Percutaneous K-wire fixation is: (A) Shalft fracture, (B) Neck fracture, (C) Base fracture

Open reduction and internal fixation After open reduction, fixation is usually done with small plate and screws, K-wires or just screws.

Indications
- Unstable metacarpal shaft fractures.
- Intra-articular basal metacarpal fractures.
- To restore articular surface in minimal comminuted head fractures.
- *External fixation these* are specially used for compound comminuted fractures of the digits.

Note Rigid fixation helps in early mobilization.

Rehabilitation Protocol in Metacarpal Fractures

During the I Week

Cast/splint The cast/splint should be put in such a way that the tip of the finger is visible to evaluate the capillary refill. The cast has to be evaluated for tightness, loosening, cracks, padding, etc. and appropriate steps are to be taken.

If there is any dependent edema patient should be instructed to keep the hand elevated and to perform retrograde massage by milking the edema from fingers towards the palm.

Rotational deformity, which is totally unacceptable, if found, should be immediately corrected.

Isometric exercises and active range of motion are permitted for the non-splinted fingers, wrist, elbow and shoulder joints. No passive range of motion and weight bearing is allowed while the unaffected hand is used for daily care activities.

Percutaneous pinning The pin sites should be inspected for discharge, erythema, skin tenting, etc. The skin tenting if present should be released, pin sites should be cleaned with antiseptics and if infected appropriate antibiotics should be given.

Rest of the treatment program is the same as discussed above.

Open reduction and internal fixation The above treatment regimen holds good in this case except that the wound has to be inspected for infection and if present suitable measures should be employed.

During the II Week

Cast/splint The care of the splint and hand should be continued as mentioned previously. For the Non-splinted digits, wrist, elbow and shoulder, active, active-assistive, and passive range of motion exercises and isometric exercises are advised. However, no movements including passive range of motion are permitted to the affected digits.

Percutaneous pinning The regime is the same as mentioned earlier.

Open reduction and internal fixation Wound is inspected and sutures are removed. If the fixation is rigid, active movements of the affected digits are carried out. Rest of the treatment proceeds on similar lines mentioned previously.

During the 4-6 Weeks

Cast/splint The cast/splint is removed and the affected digits are mobilized. The mobilization program is carried out as follows.

- *Active exercises* Full range of active exercises to the affected digits is begun and the patient is instructed to do the fist exercises as follows.
  a. *Complete fist* When the patient makes a complete fist, there is simultaneous flexion of the metacarpophalangeal and interphalangeal joints (Fig. 10.24A).
  b. *Partial fist* Here either flexion of MCP and PIP joints with DIP joints in extension is done (sublimis fist) or the PIP and DIP joints are flexed with MCP joint in extension (claw fist) are carried out by the patient (Fig. 10.24B).
- *Passive exercises* These exercises help to regain a better range of finger movements.
- *Resistive exercises* These are usually begun after four weeks.
- *Muscle strengthening exercises Gentle* ball squeezing exercises help to regain the strength of hand muscles (Fig. 10.25).

  Supportive hydrotherapy, wax bath, thermotherapy, tens, etc. help to control pain and edema.

  Patient can carry out the day to day activities with both the hands at this stage. However, weight bearing is still not permitted.

Fig. 10.24: Active fist exercises
(A) Complete fist exercise,
(B) Partial fist exercise

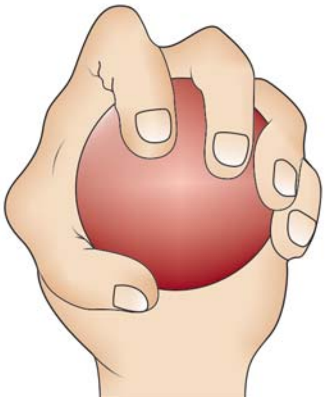


Fig. 10.25: Showing ball squeezing hand exercise

- *Closed reduction and percutaneous pinning* The pins are removed and supportive splints are given for 1-2 weeks. Rest of the rehabilitation procedure is the same as for cast.
- *Open reduction and internal fixation* Additional splint support, if required, needs to be given while rest of the management is the same. By 8-12 weeks, full active and passive range of movements for the affected fingers and the entire extremity is permitted. All day care activities and weight bearing can now be done with the affected fingers.

FRACTURES OF THE PHALANX

Phalanx is a short long bone and could break either at the head, neck, shaft or base. Fractures of the head or base could either be intra or extra-articular. Phalangeal fractures could be either stable or unstable and are usually due to direct trauma.

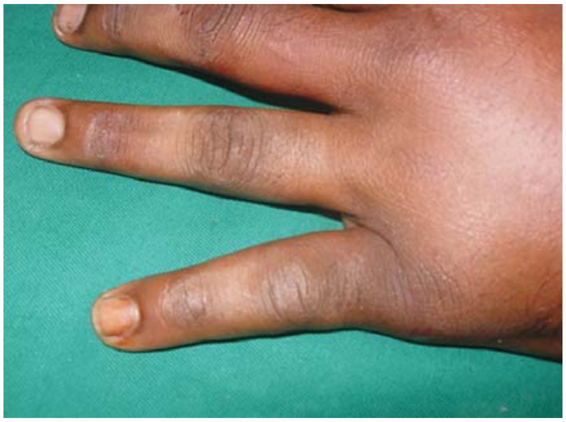


Fig. 10.26A: Clinical photograph of phalangeal fracture

Fig. 10.26B: Plain X-ray showing K-wire fixation of phalangeal fracture

Clinical Features

Patient presents with pain, swelling, deformity and loss of functions of the affected finger (Fig. 10.26A).

Radiograph

Plain X-ray of the affected finger or hand, AP, lateral and oblique views are recommended (Fig. 10.26B).

Treatment

As in the treatment of other fractures, the goals of treating phalangeal fractures are as follows:

Orthopedic Objective

To attain a stable fracture with no rotational or angular deformity and in case of intra-articular fractures the displacement should not be more than 1 or 2 mm.

Rehabilitation Goals

To restore the full range of movements of the MP and IP joints and the strength of finger flexors, extensors, interossei, lumbricals, thenar and hypothenar muscles.

Functional Goals

To restore hand functions like grasp, pinch, opposition, grip, etc.

> ***Note***
> - Normal bone healing time—3-6 weeks
> - Normal rehabilitation time—6-12 weeks

Methods of Treatment

Conservative Treatment

Two important methods of conservative treatment are buddy taping and treatment by cast or splints.

Buddy taping This is a simple effective and convenient method of treating the following phalangeal fractures:

- Undisplaced fractures
- Impacted fractures
- Distal phalanx tuft fractures

This method involves taping the affected finger to the uninvolved finger (Figs 10.27A and B).

> **Vital facts:** Buddy taping
> - *Advantage* Allows for early range of motion exercises.
> - *Disadvantage* Stiffness could develop in the unaffected finger.

Closed reduction and cast or splint For fractures which are stable after closed reduction.

Indications:

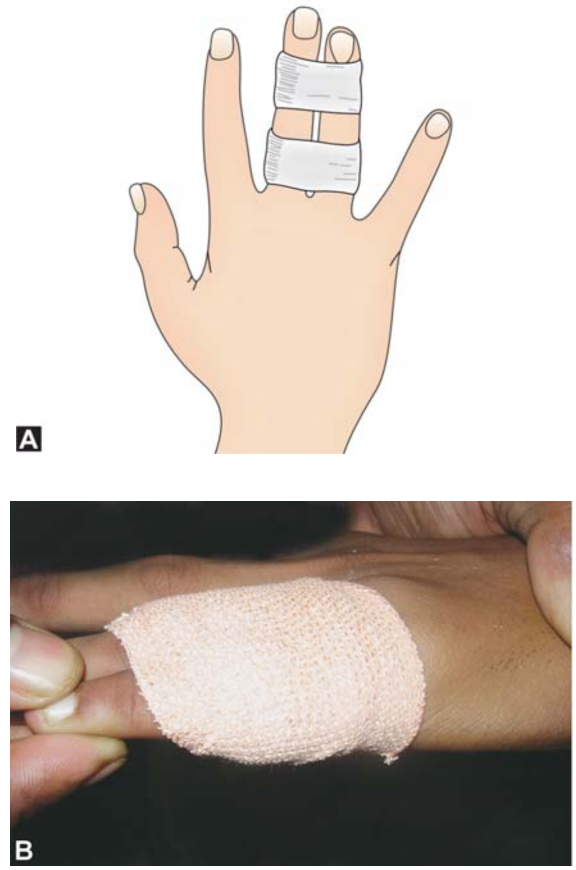
- Unstable transverse fractures
- Dorsal fracture dislocation of PIP joint

> *Note* The hand should be immobilized in Jones position.

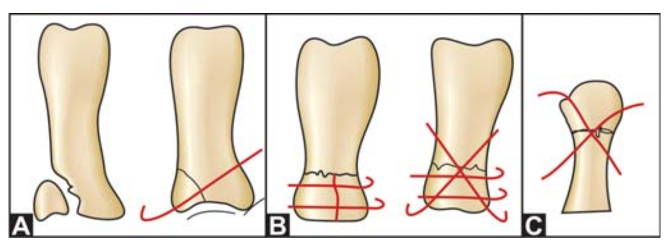
Percutaneous pinning If the fractures are unstable after closed reduction, percutaneous pinning is indicated.

- Unstable transverse fractures
- Comminuted fractures (Fig. 10.28B).
- Condylar fractures (Fig. 10.28C)
- Oblique/spiral fractures (Figs 10.26B and 10.28A).

Open reduction and internal fixation This is rarely indicated and is reserved for highly comminuted, oblique or spiral fractures.



Figs 10.27A and B: Showing buddy taping



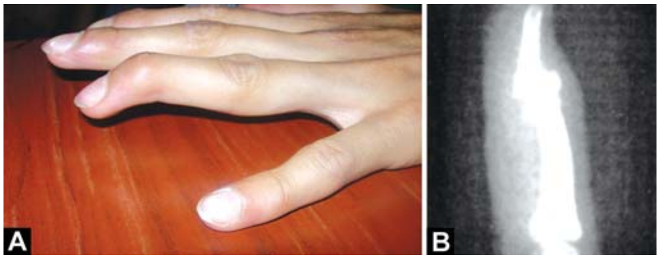
Figs 10.28A to C: Closed reduction and percutaneous fixation of various phalanged fractures: (A) Unstable short oblique fractures, (B) Communited fracture, (C) Condylar fracture

External fixators These are indicated for compound and highly comminuted fractures in which open reduction and internal fixation is not possible.

SPECIAL PHALANGEAL FRACTURES

Mallet Finger

This is a flexion deformity of the DIP joint due to loss of extensor mechanism of the distal phalanx either due to an



Figs 10.29A and B: Clinical photograph showing: (A) Mallet finger and plain, (B) X-ray showing the avulsion fracture

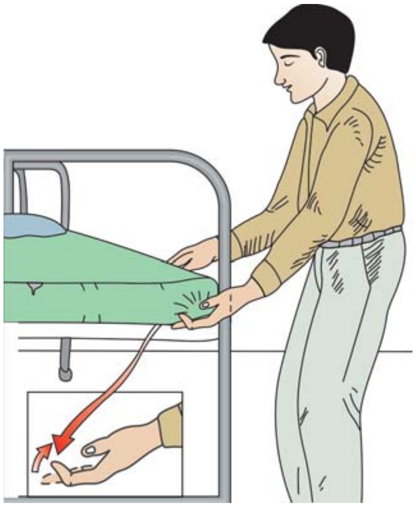


Fig. 10.30: Showing a common mechanism of injury in mallet finger (bed tucking)

avulsion fracture or soft tissue rupture (Figs 10.29A, B and 10.31A).

Mechanism of Injury

It is due to forced fixation of an extended finger as in bed tucking, catching a cricket ball, etc. (Fig. 10.30).

Clinical Features

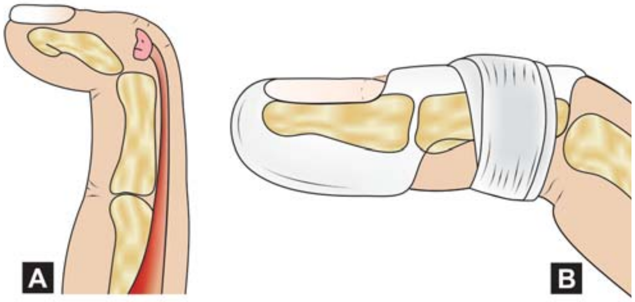
Patient complains of pain, swelling, typical mallet deformity and inability to extend the tip (Fig. 10.29A).

Radiograph

Plain X-ray, lateral view of the affected finger may show an avulsion fracture (Fig. 10.29B).

Treatment

This consists of closed splinting of the DIP joint in hyper-extension for 6-8 weeks followed by night splinting for 4-6 weeks (Fig. 10.31B).



Figs 10.31A and B: Showing: (A) Mallet finger, (B) Treatment by a dorsal splint

If the bony avulsion fracture is > 2-3 mm open reduction and internal fixation is indicated.

Nailbed Injury

These are due to direct crush injury of the tip of the fingers. If the subungual hematoma is > 25 percent of the nailbed, the nail should be removed.

Boutonnière Deformity

This is a middle phalanx injury with either rupture of the central slip dorsally or avulsion fracture from base of the middle phalanx. This causes flexion of the PIP joint with compensatory hyperextension of the DIP joint (Fig. 10.32).

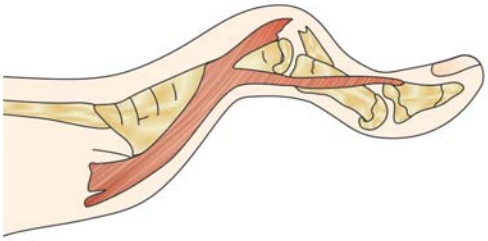


Fig. 10.32: Showing Boutonnière deformity

The treatment requires the PIP joint to be splinted in hyperextension, for a period of 4-6 weeks.

Proximal IP Joint Fracture Dislocation

Three types are described:

Type I Volar plate avulsion with congruous articular, surface. It is due to hyperextension injury.

Type II Same as above but within congruous articular surface.

Type III

- < 1/3 articular surface is involved and is stable after reduction.
- > 1/3 articular surface is involved and is unstable after reduction.

Treatment

1. Type I/II stable type III fractures require buddy taping and a dorsal extension block splint for 4-6 weeks.
2. Type III unstable fractures are treated by open reduction and internal fixation.

Physiotherapy Measures in Phalangeal Fractures

During the I Week

Conservative treatment If fracture is stable, active range of exercises is allowed to the entire extremity including the affected and taped fingers. No movements if the fracture is unstable.

Isometric exercises to all non taped digits. No weight bearing by the affected fingers and the uninvolved hand is used for functional day to day activities. If the splint is put, the edges of the splint should be trimmed to visualize fingertips.

Percutaneous pinning The pins are inspected for erythema, discharge, discoloration and cleaned with antiseptics. Rest of the treatment is same as above.

Second Week

Conservative Active range of motion exercises to all fingers including affected ones. Trim the splint and rest of the management is same as above. No range of movements for splinted fingers.

Percutaneous pinning The pin sites are inspected for discharge, etc. Rest of the treatment is same as for the splint.

Three to Six Weeks

Conservative Buddy splint is removed. Active range of exercises to the entire extremity including the affected fingers is commenced. By the end of 6 weeks along with the active, active assisted and passive range of exercises are also begun.

Finger strengthening exercises are initiated. Weight bearing with the affected fingers is also begun.

Percutaneous pinning The pins are removed and if required a splint or buddy taping can be done for 1-2 weeks. Rest of the treatment is the same.

Four to Six Weeks

Conservative In addition to the above mentioned treatment, resistive exercises to the fingers are commenced. Full weight bearing is allowed with the affected extremity.

Percutaneous pinning The splint is discontinued and the rest of the treatment proceeds on the lines already discussed.

Supportive Therapy

After removal of the buddy tape, splint, pins, etc. thermotherapy, wax bath, hydrotherapy, etc. helps in controlling pain, edema and stiffness of the fingers.

SCAPHOID FRACTURE

Interesting Features

- This bone forms the radial part of the carpus.
- Lies obliquely at 45° to longitudinal axes of 2 rows.
- Articulates with 5 bones (radius, lunate, triquetral, trapezium, capitulum).
- Central indentation is called waist.
- Since it crosses two rows of carpus, it is more susceptible to fracture.

Anatomical peculiarities

- It articulates with distal radius and with four carpal bones. It moves in all the movements of the wrist.
- It has a precarious blood supply (Fig. 10.33).
  — About percent of blood supply to scaphoid is through branches of radial artery.
  — Sixty-seven percent of the scaphoid have arterial foramina throughout its length.
  — Thirteen percent have predominant blood supply in the distal one-third.
  — In about 20 percent most of the foramina are in the waist with no foramina in the proximal one-third.
  — Eighty percent surface is covered by articular cartilage.

This suggests that one-third of the fractures occurring in the proximal one-third is without adequate blood supply resulting in avascular necrosis in 35 percent and nonunion in 30-40 percent of cases at this level.

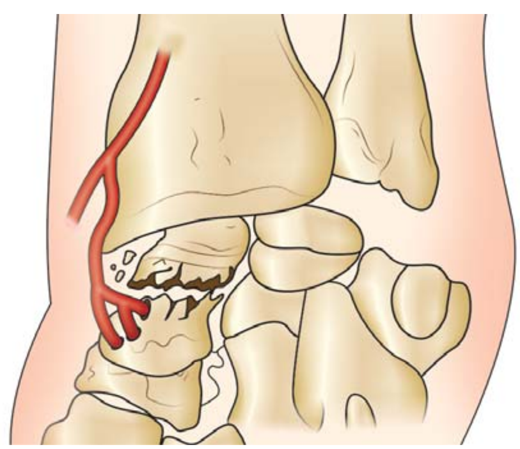


Fig. 10.33: Showing fracture of scaphoid and its peculiar blood supply

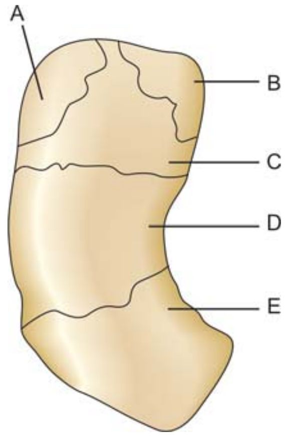


Fig. 10.34: Showing different levels of scaphoid fracture: (A) Fractures of the tuberosity, (B) Distal articular fracture, (C) Distal one-third fractures, (D) Waist fractures, (E) Fractures of the proximal pole

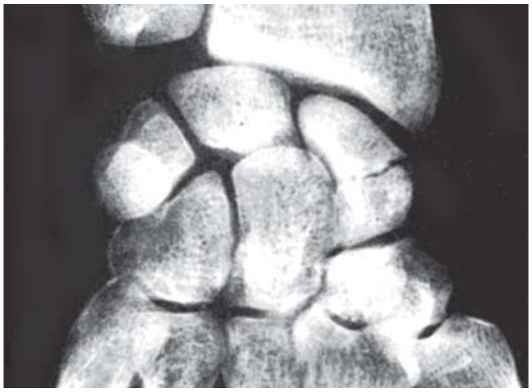


Fig. 10.35: Plain X-ray showing fracture waist of scaphoid

Mechanism of Injury

It is common in young adults though it can be seen in patients of 10 to 70 years of age.

- The common mode of injury is fall on an outstretched hand with the wrist in 95-100° of hyperextension, the proximal pole remains fixed, while the distal pole moves dorsally causing the 'wrist' fracture due to hyperextension and slight radial deviation at the wrist.
- It is associated with other fracture of carpus and forearm bones in about 17 percent (for different levels of fracture scaphoid Fig. 10.34). Transverse fracture of the waist is more common.

Clinical Features

Patient complains of pain and swelling of the wrist. Tenderness in the anatomical snuff box is a characteristic finding. The movements of the wrist may be painful.

Radiograph

Plain X-ray of the scaphoid in various views like AP, Lat and oblique views helps to make a diagnosis. However, in few cases, X-rays fail to detect a fracture. In such cases repeat the X-rays after 2-3 weeks (Fig. 10.35).

Conservative Management

Conservative management consists of application of Thumb Spica Cast.

Indications

- Undisplaced fracture
- Minimally displaced fracture

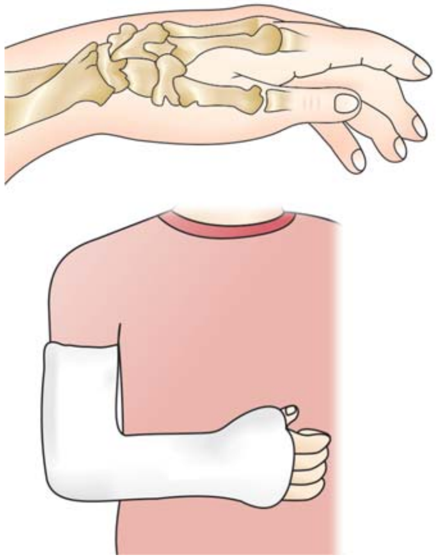


Fig. 10.36: Showing scaphoid fracture which commonly occurs at the wrist being treated by a "scaphoid cast" (thumb spica cast)

The cast should be put in neutral wrist position, with neutral or slight radial deviation and the thumb and fingers in semiflexed position and is called the cup or glass holding position (Fig. 10.36).

> *Note* Inclusion of thumb in the spica reduces motion at the waist of the scaphoid.

Types

- *A short-term thumb spica* This is indicated for tuberosity fracture which has a high union rate.
- *A long-term thumb spica* This is indicated for all other fractures. The duration of immobilization is for 6 weeks, followed by 6 weeks of short cast (Fig. 10.36).

Surgical Management

Indications

- Operative treatment has no place in the management of acute scaphoid fracture except for displaced fractures.
- In delayed union and nonunion.
- Preiser's disease which is an ischemic necrosis of fracture scaphoid.

Surgical Methods

Osteosynthesis It consists of internal fixation or bone grafting or both. K-wire and small corticocancellous screws along with cancellous bone grafts are also used.

Fusion techniques are used if the patient is young, the opposite hand and wrist are normal and if much stressful activity is required.

Arthroplasty This is useful for older patients, with significant osteoarthritic changes in the wrist, e.g. radial styloidectomy, silastic implants, etc.

Arthrodesis is less commonly indicated.

Excision of proximal fragments is indicated when fragment is less than ¼" in size and when bone grafting has failed.

Complications

- Nonunion due to delayed diagnosis, displacement and associated carpal injuries.
- Forty per cent cases are undiagnosed in the initial stages of fracture.
- Incidence of avascular necrosis is as high as 40 percent.

Quick Facts

Scaphoid fracture
- Accounts for 70 percent of carpal injuries.
- High incidence of AVN.
- Fracture may not be seen on initial radiograph.
- Treat according to symptoms and repeat radiograph at 10 to 14 days.
- If still painful and if still suspicious, cast it.
- If undisplaced, cast it including the thumb.
- If displaced, cast after manipulation.
- Open reduction if gap is more than 2 mm or if still a step remains after reduction, if union is slow or if AVN develops open reduction, internal fixation and bone grafting is done.

The Goals of Treatment in Scaphoid Fractures

Orthopedic Goals

To obtain a stable anatomic reduction of the scaphoid fracture.

Rehabilitation Goals

To restore thumb and wrist movements. To improve and restore the muscle strength of abductors, extensors and flexors of the thumb, flexor carpi radialis and ulnaris muscles.

Functional Goals

To restore the hand and wrist functions.

Physiotherapy Measures

During first 2 Weeks

Conservative management The cast should extend upto the MCP heads dorsally and distal palmar crease volarwards. Dependent edema is treated with hand elevation.

Gentle active and active assistive range of motion exercises to the digits except the thumb, elbow if in short arm cast and shoulder cast.

Isometric exercises to biceps, triceps and deltoid muscles are begun. Day care activities are done with the unaffected hand and no weight bearing is permitted with the affected extremity.

However, pronation and supination of the forearm is strictly avoided.

Operative treatment A short arm cast is applied and the dependent edema is treated with hand elevation. Rest of the treatment regimen is the same as for cast. Suture removal is done after 2 weeks.

During 4-6 Weeks

Conservative The long arm cast is changed to short arm cast. Active and passive range of motion exercises to the digits except the thumb, active and active assistive motion to the shoulder and elbow are begun. Rest of the management is as mentioned earlier.

Operative The short arm cast is removed and a night splint is given. Gentle active range of motion exercises are started for the wrist and thumb. No passive exercises are still started. Rest of the management is the same as discussed earlier.

During 8-12 Weeks

Conservative short arm cast is removed after 10-12 weeks and gentle exercises to the wrist and thumb are commenced. The active and active assistive exercises to the shoulder, elbow, and digits are continued. Gentle supination and pronation exercises to the forearm are begun. Grip strengthening exercises are commenced.

Operative Gentle active, assistive and passive range of motion exercises of the wrist, opposition, flexion and extension of the thumb, shoulder and elbow are continued.

Note
- In cases of delayed union by 8 weeks, EMF stimulation is advised.
- If nonunion is seen by 12-14 weeks, open reduction and internal fixation with bone grafting is done.

Adjunctive therapy Thermotherapy, TENS, wax bath, hydrotherapy, etc. help in the reduction of pain, swelling, edema and helps in mobilization.

During 12-16 Weeks

Conservative active, active assistive and passive range of motion exercises to the digits, thumb, wrist, elbow and shoulder are begun. Grip strengthening exercises with squeeze ball or putty. Progressive resistive exercises to the wrist and thumb are commenced. Strengthening exercises to the shoulder girdle and biceps muscles are commenced. Adjunctive therapy as mentioned above is continued.

Operative The treatment regimen proceeds in the same manner as mentioned above. At this juncture, patient can use the affected extremity for day care activities and weight-bearing.

11

Chapter

Injuries around the Hip

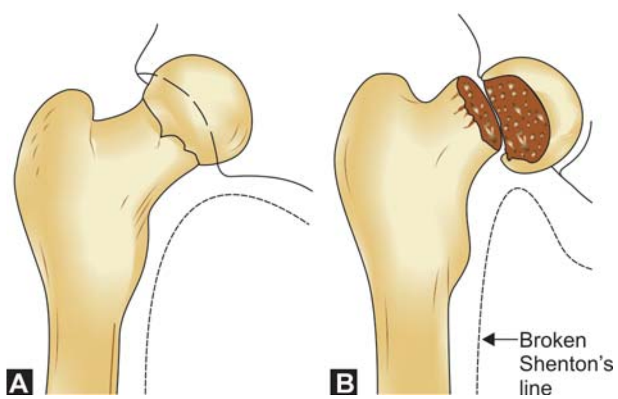
FRACTURE NECK FEMUR

We come to the world under the brim of pelvis and go out of the world through the fracture neck of femur.

Fracture neck femur could be intracapsular or extra capsular. Intracapsular fracture neck femur is notoriously known as an orthopedic enigma, since a permanent solution for its treatment still eludes the orthopedic surgeon. Hence, it is infamously termed as an unsolved problem. Fracture neck of femur does not unite readily and this makes it a difficult problem to tackle (see box below for the reasons). Fracture neck of femur could be intracapsular of extracapsular (Figs 11.1A and B).

Problems of healing, why?

- No cambium layer in the intracapsular area, so no peripheral callus. Healing is only by endosteal callus.
- Synovial fluid lyses blood clot at the fracture site and thereby destroys another mode of secondary healing.
- Displaced fracture leads to avascularity.



Figs 11.1A and B: Showing intracapsular fracture of neck femur: (A) Undisplaced, (B) Displaced

Etiology

- It is common in older patients with osteoporosis or osteomalacia (12%) and in them usually it is fracture through a pathological bone.
- It is common in elderly women secondary to senile osteoporosis. It also causes marked comminution of the posterior cortex and thus decreases the quality of reduction.

Mechanism of Injury

- Majority are due to trivial fall, as a result of direct blow over the greater trochanter.
- Second mechanism is mainly due to lateral rotation of the extremity which causes marked posterior comminution of the neck.
- Recent suggested mechanism is cyclical loading due to muscle force and torsion.
- Major trauma in young adults like road traffic accident (RTA) fall, etc.

Clinical Features

Usually patient is an elderly female and gives history of trivial trauma like slip and fall in a bathroom (Fig. 11.2). Patient complains of pain and restriction of movements of the affected hip. On examination there is tenderness over the anterior hip joint line. There is minimal shortening and external rotational deformity of the affected limb due to the fracture being intracapsular. The capsule prevents the muscular forces from displacing the fracture fragments grossly. Active straight leg raising is difficult. In impacted fracture neck of femur, patient complains of groin pain, antalgic gait and restriction of hip movements.

Fig. 11.2: Fracture neck femur is common in elderly females due to trivial fall like a slip in the bathroom

Fig. 11.3: Plain X-ray showing intracapsular fracture neck of femur

Radiograph

Plain X-ray of the hip, AP and lateral views helps to make a diagnosis (Fig. 11.3).

Treatment

Fracture neck femur is an orthopedic emergency which needs to be reduced and fixed within 24 hours to get an optimum result. Hence *speed is the watchword* in managing fracture neck femur and invariably needs to be operated because of the small proximal fragment accurate reduction is required, which is usually not possible by conservative methods (Table 11.1).

Aims of Treatment

- Early anatomical reduction which helps prevents further vascular damage.
- Impaction of the fracture fragments.
- Rigid internal fixation: enables revascularization from the surrounding soft tissues and uninjured bones which helps in early callus formation.

TABLE 11.1: Broad treatment guidelines

Age group	*Undisplaced*	*Displaced*
> 70 years	• Dynamic hip Screws (DHS)	• Prosthesis • Total hip replacement (THR) • Bipolar arthroplasty
Young adults	• DHS • Cannulated Screws (ASNIS)	• DHS • Later osteotomy or prosthesis • Birmingham hip resurfacing
Children	• HIP spica • Multiple Moore's pinning	• Multiple Moore's pinning • Osteotomy • Arthrodesis

Methods of Internal Fixation

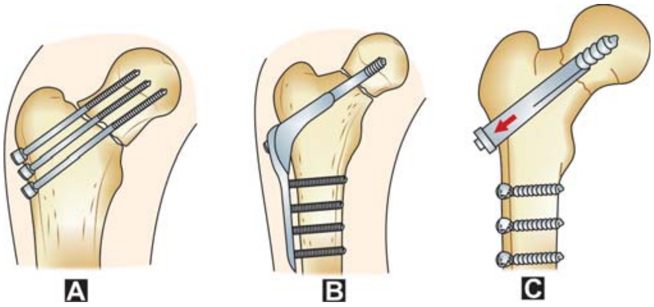
After having accurately reduced the fracture and ascertained the accuracy, the fracture neck femur can be fixed by any one of the methods mentioned below. However, no ideal internal fixation methods are available.

Multiple Pins (Knowles, Moore) This is indicated for impacted fracture, percutaneously for medically unfit persons, and for fractures in children (Fig. 11.4A).

ASNIS screws This is a system of cannulated screws that provide improved pullout and bending and torque strengths as compared to Knowles pins. These are the commonly preferred screws for the intracapsular variety.

Fixed angle nail has fallen into disrepute because the nail is rigid and may penetrate the joint (Fig. 11.4B).

Sliding or telescoping nails (dynamic hip screws) It has replaced the fixed angle nail. The nail offers collapsibility which ensures continuous impaction at the fracture site and which lessens the chance of nail penetration through the femoral head. *This is the most commonly employed fixation*



Figs 11.4A to C: Showing methods of internal fixation of intracapsular fracture neck of femur: (A) Multiple pins, (B) Blade plate fixation, (C) Dynamic hip screw

method for fracture neck femur especially the extra capsular variety (Fig. 11.4C).

Meyer's Muscle Pedicle Graft

A mention has to be made about the posterior muscle pedicle grafting technique. Muscle pedicle graft from the gluteus maximus or quadratus femoris (Meyer's technique), is particularly useful in posterior wall comminution. This technique has been popularized by Dr Bakshi of Kolkata.

Other Treatment Options

These include hemi replacement arthroplasty, osteotomy and very rarely THR. However, they are not recommended as the primary modality of treatment in fresh fracture neck of femur. They are indicated in special situations like nonunion, AVN, etc. and are discussed below:

Bipolar arthroplasty is the other standard procedures giving good results in properly indicated patients.

COMPLICATIONS OF FEMORAL NECK FRACTURE

Thromboembolism

Thromboembolism is a leading cause of death within first 7 days. Incidence is 40 percent.

Nonunion

Only one-third of the fracture neck femur is known to heal with open reduction and internal fixation. Nonunion rate is 85 to 95 percent. If there is no evidence of radiological healing taking place between 6 to 12 months at treatment on a radiograph, it is declared as nonunion.

Causes

- Inaccurate reduction.
- Poor internal fixation.
- Lack of cambium layer in the periosteum of the neck.
- Avascularity of femoral head.
- Posterior wall comminution.

Clinical Features

Patient is unable to bear the weight on the affected side. Trendelenburg test, telescopic test will be positive (Fig. 11.5). Wasting of the muscles and minimal shortening of the affected lower limb are the other features.

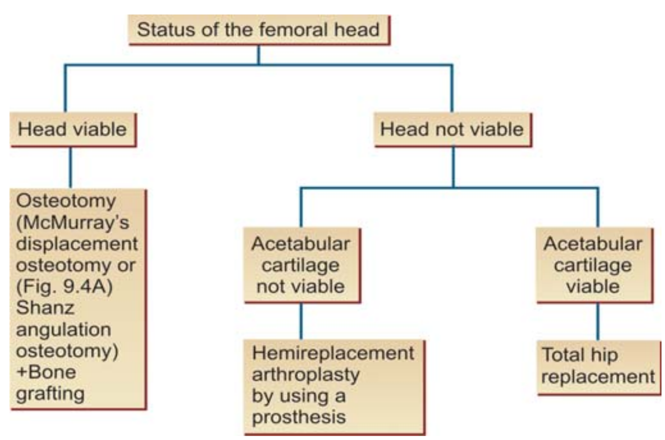
Radiograph

Plain X-ray of the hip, AP and lateral views helps to confirm the diagnosis (Fig. 11.6).

Fig. 11.5: Clinical photograph method of performing telescopy test

Fig. 11.6: Plain X-ray showing nonunion fracture neck of femur

Flow chart 11.1: Showing the choices of treatment



Treatment

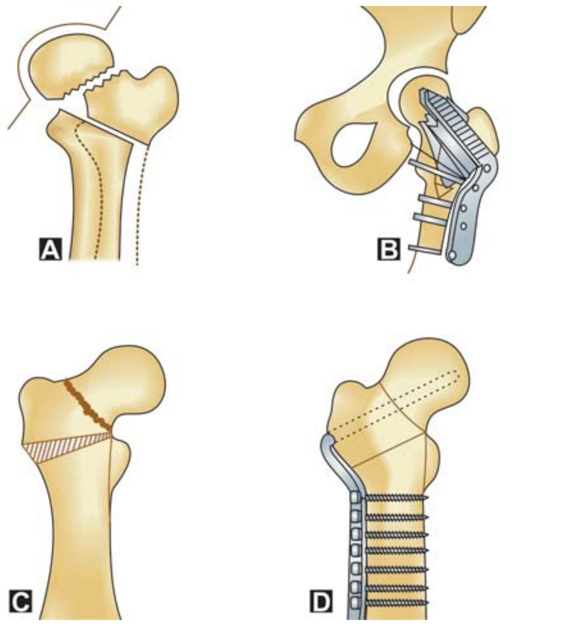
Surgery is the treatment of choice. The method chosen takes into account the viability of the head (Flow chart 11.1).

Osteotomy

To treat nonunion of fracture neck femur, two types of osteotomies and their modifications have been described and they are as follows:

McMurray's displacement osteotomy (Figs 11.7A and B) In this the osteotomy is made just proximal to the lesser trochanter and the distal fragment is pushed medially and fixed internally.

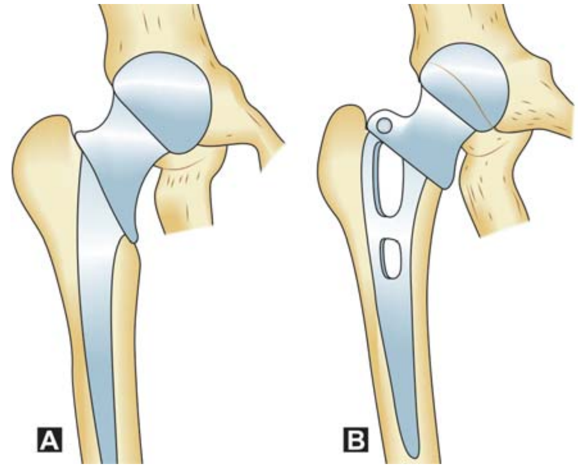
Shanz angulation osteotomy (Figs 11.7C and D) In this the osteotomy is made through or just distal to the lesser trochanter. A laterally based wedge of bone is removed and the varus angulation is corrected and fixed with plate and screws.



Figs 11.7A to D: (A) McMurray osteotomy, (B) Shanz angulation osteotomy, (C) Angulation osteotomy, (D) Pauwell osteotomy

Hemi Replacement Arthroplasty (HRA)

As mentioned earlier if the head is not viable but the acetabular cartilage is viable, and if the patient is over 60 years of age, hemi replacement arthroplasty is the treatment of choice. However, the choice of prosthesis depends upon the existing calcar femori. If sufficiently present (at least 1 to 3 cm), *Austin Moore's prosthesis is the choice and if it is inadequate **Thompson prosthesis is preferred (Figs 11.8A and B). Bipolar arthroplasty is preferred in the young (Fig. 11.9).



Figs 11.8A and B: Showing types of HRA: (A) Thompson's prosthesis, and (B) Austin Moore's prosthesis

Fig. 11.9: Bipolar arthroplasty

Bipolar Arthroplasty

It is another effective option in young patients (Fig. 11.9).

Total Hip Replacement (THR)

If both the femoral head and the acetabular cartilage are not viable and if the patient is more than 60 years old total hip replacement is the surgery of choice (Fig. 11.10).

AVASCULAR NECROSIS

It is the next important complication. Two types are described:

1. *Due to actual AVN* This is secondary to ischemia and is an early phenomenon. It shows characteristic microscopic appearance.

*****Austin Moore** (1957), USA. He described: (a) Self-locking hip prosthesis. (b) A new low posterior approach for hip (Southern approach).

******Frederick and Thompson** (1955), USA.

Fig. 11.10: Plain X-ray showing THR

Fig. 11.11: Plain X-ray showing avascular necrosis head of femur

2. *Late segmental collapse* It is due to collapse of subchondral and articular cartilage that overlies infarcted bone. It occurs late.

Incidence

- Aseptic necrosis—66 to 84 percent.
- Late segmental collapse—7 to 27 percent.

In displaced femoral neck fracture, femoral head survival is dependent on vessels of ligamentum teres which is absent in one-third cases and subfoveal artery anastomosis which is variable and incomplete. All vessels within femoral neck and most of the retinacular vessels are disrupted in displaced fracture. Hence, survival of head depends on:

- Uninjured vascular supply
- Revascularization.

Vascular injury occurs

— At the time of fracture commonly.

— During reduction or internal fixation.

Hence, good anatomical reduction and stable internal fixation is required to preserve the remaining blood supply, which helps in revascularization.

Clinical Features

Patient complains of pain limp, reduced hip, movements, etc.

Radiograph

Plain X-ray shows sclerosis in the head of femur and secondary OA changes in the hip (Fig. 11.11).

Treatment

- Symptomatic treatment like bed rest, non-steroidal anti-inflammatory drugs (NSAIDs), etc.
- Displacement or angulation osteotomy in early stages.
- If acetabular cartilage is viable, hemi replacement prosthesis is preferred.
- Total hip replacement if acetabular cartilage is not viable.

Fracture neck of femur at a glance

- An unsolved problem.
- Fracture of the elderly.
- Majority due to trivial fall.
- Garden's classification widely accepted.
- It is an orthopedic emergency.
- Speed is the watchword in management.
- Early anatomical reduction, impaction, and rigid internal fixation are the aim of treatment.
- DHS and multiple cannulated cancellous screws are the currently accepted method of fixation.
- Nonunion and AVN are very common.

There is a limited role of conservative treatment in fracture neck of femur (intracapsular), open reduction and rigid internal fixation with multiple cannulated screws is the treatment of choice while hemiarthroplasty is reserved for fractures in the elderly or for nonunion.

Physiotherapy Management

Orthopedic goals To obtain a rigid fixation of the fracture with lag screws after restoring the anatomy back to normal.

Note 10° anteroposterior angulation and 15° valgus could be accepted.

Rehabilitation goals

- To restore back the hip and knee movements to normal or at least obtain the 'functional' range (Table 11.2).
- To improve and regain the strength of hip flexors, extensors, adductors, abductors, internal and external rotators, quadriceps and hamstrings group of muscles.
- To attain the functional if not normal limits of hip and knee movements.

TABLE 11.2: Functional range of hip and knee movements

	Knee		*Hip*					
Movements	*Flexion*	*Ext*	*Fl*	*Ex*	*IR*	*ER*	*Ad*	*Ab*
Normal	135-140°	0°	125-130°	0-20°	40-45°	45°	40-45°	45-50°
Functional	110°	0°	90-110°	0-5°	0-20°	0-15°	0-20°	0-20°

Note
- Required healing time—12-16 weeks
- Required rehabilitation time—15-30 weeks

Physiotherapy Management after Surgery

During the 1 week The wound is inspected for evidence of infection and the drains are removed after 24 hrs. Pulmonary embolism and hypovolaemia are a distinct possibility and a careful watch is kept. To prevent bedsores from developing, the patient is frequently turned in the bed. Derotation bar helps prevent external rotation of the affected limb. Patients treated with hemiarthroplasty should avoid keeping the hip in adduction or internal rotation to prevent redislocation.

- **Movements** full range active movements of the ankle, gentle active movements of flexion and extension of the knee and hip (once the pain subsides) is permitted.

Caution No passive range of motion at this stage.

- **Exercises** After the pain subsides; isometric glutei and quadriceps exercises are begun. Isotonic exercises are prescribed for the ankle as it helps to strengthen the gastro-soleus muscle and reduces the chances of thrombophlebitis and deep vein thrombosis.
- **Weight-bearing** By the end of first week, weight-bearing with the help of a crutch or walker using a 3-point gait may be permitted. However, it is deferred in unstable fractures. For patients with endoprosthesis, weight-bearing as tolerated is permitted.
- **Activities of daily living (ADL)** Certain modifications are brought about in the activities of daily living. Use of raised toilet seat and chair, wearing the trousers from the affected limb first and removing it from the unaffected limb, rolling on to the unaffected side before getting up from the bed are some of the recommended modifications in daily living.

Quick Facts

During the first week
- No passive movements
- Wound inspection
- Isometrics to quadriceps, glutei muscles
- Isotonic exercises to ankle
- Modifications in daily living
- Weight-bearing as permitted.

During 2-4 weeks

- **Movements** Active and active-assistive movements of the hip, knee and ankle can now be started.
  However, no passive movements are still recommended.
- **Exercises** Ankle isotonic exercises are continued. Isometric exercises for the hip and knee are prescribed.
- **Weight-bearing (Flow chart 11.2)** this has to be gradual and is done on the following lines:
  — First the patient is advised prone lying.
  — Next as a preclude to weight-bearing, four point kneeling is advised (Fig. 11.12).
  — Then patient is advised to bear weight on the knees.
  — Next, knee walking is encouraged (Fig. 11.13).
  — Patient may now be allowed to bear the weight on the affected extremity either partially or fully depending on the stability of the fracture. A 3-point gait using crutches or walker is advised.

Flow chart 11.2: Showing weight-bearing methods after HRA

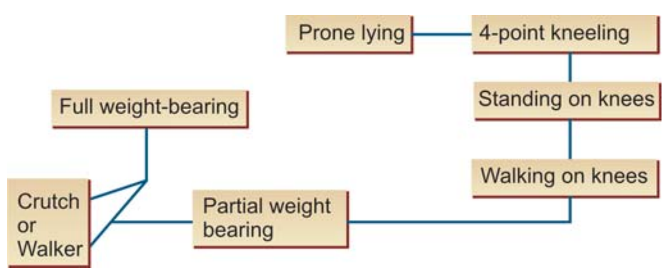


Fig. 11.12: Gradual weight-bearing on the operated hip by four points kneeling and walking

Fig. 11.13: Complete weight-bearing on the operated hip by adopting the knee standing and walking

Fig. 11.14: By dragging the heel towards the buttocks (heel drag test) patient begins to initiate active self-assisted hip flexion

- **Activities of daily living** Modifications in activities of daily living are the same as mentioned earlier.

During 4-8 weeks The treatment regimen is more or less the same as discussed above. The patient can now flex the hip upto 90°, by the self-assisted "heel drag", (i.e. dragging the heel upto the buttocks with the help of the normal leg) (Fig. 11.14). The patient can now be encouraged to sit with the legs hanging over the edge of the bed and supporting and lifting the affected limb with the unaffected leg. Assisted and self-resistive exercises for the hip and knee muscles can be carried out.

After 8 weeks Passive range of movements by the physiotherapist or by continuous passive motion apparatus is begun to the hip and knee. Isotonic and isokinetic exercises to the hip and knee are initiated along with progressive resistive exercises. Weight-bearing with the affected extremity with the help of crutches or walker using a four point gait can be initiated as the patient can bear more weight now. Activities of daily living can be allowed normally with the help of assistive devices.

However, excessive adduction and internal rotation should be avoided in patients treated with endoprosthesis.

By 12-16 weeks, full weight-bearing is allowed. Full active and passive range of motion exercises are permitted to the hip and knee joints. Isometric, isotonic and progressive resistive exercises are continued to the hip, knee and ankle joints. Patient can now carry out all the activities of daily living independently.

The physiotherapy regimen is more or less the same for patients treated with hemiarthroplasty (the emphasis is on to prevent excessive adduction and internal rotation to prevent redislocation), McMurray's osteotomy, Meyer's muscle pedicle graft, etc.

SUBTROCHANTERIC FRACTURE

Subtrochanteric region is defined as an area between the lesser trochanter and a point 5 cm distal to it. Subtrochanteric fracture (Fig. 11.15) is a difficult fracture due to problems like malunion, delayed union, nonunion, shortening, angular deformity, rotational malalignment, etc. Two factors responsible for slow union are:

- Fracture through the cortical bone.
- Large biomechanical stress at the fracture site results in implant failure.

Mechanism of Injury

It is usually due to direct trauma due to RTA or fall and is common in young individuals.

It can be broadly considered fewer than two headings.

Fig. 11.15: Subtrochanteric fracture

Fig. 11.16: Clinical photograph showing complete external deformity in subtrochanteric fracture

Stable fracture Intact or possible to re-establish bone to bone contact of the medial and posterior femoral cortex anatomically.

Unstable fracture Posteromedial cortex apposition is not obtainable.

Clinical Features

The patient presents with pain, swelling, shortening, external rotation deformity and other usual features of fractures (Fig. 11.16).

Radiograph

X-rays of the hip and the upper femur helps to make the diagnosis (Fig. 11.17).

Fig. 11.17: Plain X-ray showing subtrochanteric fracture

Treatment

Conservative methods are advocated if the patient is young. In severely communited fractures, modified cast brace with pelvic band is used.

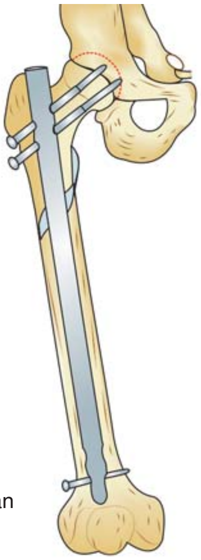


Fig. 11.18: Subtrochanteric fracture fixed by an interlocking nail

Surgery This is the preferred method of treatment in adults and ORIF with various implants like Interlocking nails (Fig. 11.18), Zickel nail, sliding compression screws, proximal femoral nails etc is chosen for those fractures which can be made stable by closed or open reduction.

Physiotherapy Measure

This is the same as described for fracture neck of femur.

INTERTROCHANTERIC FRACTURE

SALIENT FEATURES

- An intertrochanteric fracture occurs along a line between greater trochanter and lesser trochanter with variable comminution.
- Totally extra capsular. Internal rotators of the hip remain attached to the distal fragment; short external rotators are attached to proximal head and neck. Hence, limb has to be kept in external rotation after reduction to align the distal fragment with proximal one.
- Cancellous bone heals well by 8 to 12 weeks.
- Four times more common than intracapsular fracture.

Age Seen in elderly patients 10 to 12 years older than intra-capsular fracture neck femur.

Sex More common in females (2.8:1).

Mechanism

Direct trauma as in RTA, fall, etc.

Indirect due to muscle pull, etc.

Fig. 11.19: Complete extend rotation deformity in trochanteric fracture alongwith limb shortening

Fig. 11.20: Palin radiograph showing communited trochanteric fracture femur

Clinical Features

The patient will have pain, marked shortening of the lower limb, complete external rotation deformity, swelling, ecchymosis and tenderness over the greater trochanter (Fig. 11.19).

Radiograph

Plain X-ray of the hip helps confirms the diagnosis (Fig. 11.20).

Treatment

Conservative treatment There is 10 percent mortality associated with conservative treatment.

Indications
- Poor medical and surgical risk patients.
- Terminally ill-patients.
- Very old patients.

Methods
- Simple support with pillows
- Buck's traction
- Plaster spica
- Skeletal traction through distal femur or tibia for 10 to 12 weeks.

Surgical Though not an emergency, there is an urgent need for surgery as there is a ten-fold increase in mortality if surgery is delayed for more than 48 hrs.

Advantages of surgery include increased comfort, good nursing care and hospitalization stay is considerably reduced.

Goal is to fix a stably reduced fracture internally.

Choice of an Implant

Once stable reduction has been obtained either anatomically or by any one of the non-anatomical means (e.g. by osteotomy, etc.), implants are chosen. For stable fractures choice of an implant does not matter. For unstable fractures sliding hip screw (DHS) is most suitable and the 135 to 150° angle side plates are most commonly used. Placement of the DHS screw in the neck should be either central or posterorinferior.

Dynamic hip screw (DHS) allows securing fixation of the fracture and permits controlled impaction at the fracture site thereby reducing the risk of fixation failure seen in rigid nail-plate like SP nail, etc.

Complications

Due to the cancellous nature of bone, these fractures unite well unlike fracture neck femur but malunion is quite common. Coxa vara, nonunion is less than 2 per cent (rare) and traumatic osteoarthritis is also seen. These fractures also carry a higher incidence of mortality (more than 10%). Avascular necrosis is very rare (0.8%).

Physiotherapy Management

This proceeds on the same lines as described for fracture neck of femur.

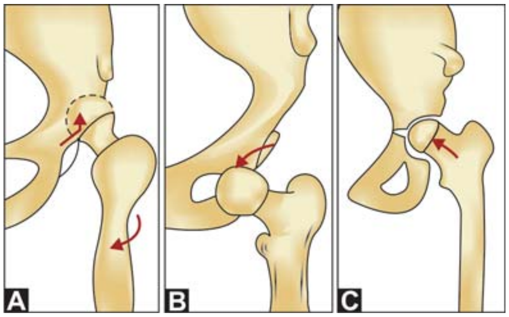
DISLOCATION AND FRACTURE DISLOCATION OF THE HIP

Dislocation and fracture dislocation of the hip are severe injuries and are due to major forces. These are associated with the disruption of the head-acetabular relations (broken Shenton line), significant soft tissue damage, etc. If associated with fractures (seen in 50%), small osseous or cartilaginous fragments often remain in the joint space and prevent reduction. These injuries are usually associated with significant injuries elsewhere. *Dislocation and fracture dislocation of the hip are orthopedic emergencies and are easily missed when there are associated ipsilateral fractures of the femur.*

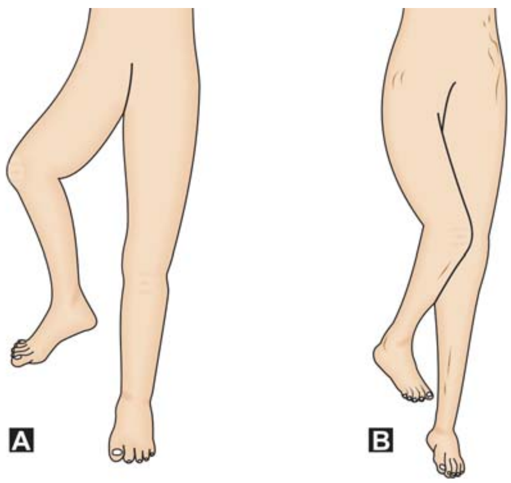
The dislocations are labeled as anterior, posterior, and central depending upon the relationship of the femoral head to the acetabulum (Figs 11.21A to C). A comparative study of the dislocation is presented (Table 11.3) for easy understanding and better remembrance.

TABLE 11.3: Comparative features of dislocations of hip

		Posterior Dislocation	*Anterior dislocation*	*Central dislocation*
1.	**Incidence**	Common (70%)	10-15%	Rare
2.	**Mechanism of injury**	• Dashboard injury as in RTA • Flexed knee + neutral adduction results in simple dislocation. • Flexed knee + slight abduction results in fracture dislocation	• Dashboard injury with thigh abducted • Fall from height • Blow to the back in squatted position	• Due to direct blow over trochanter • Common in patients with epilepsy, convulsions, etc.
3.	**Classification**	*Thompson and Epstein* • *Type I* with or without minor fracture • *Type II* with a large single fracture of rim acetabulum • *Type III* comminution of acetabular rim with or without major fragment. • *Type IV* with fracture of femoral head	*Type I* (superior) • *IA* No fracture • *IB* Associated head fracture • *IC* Associated fracture acetabulum *Type II* (inferior) • *IIA* No fracture • *IIB* associated Head fracture • *IIC* Associated fracture acetabulum	*Judet's* Dislocation associated with • Undisplaced fracture • Inner wall fracture of acetabulum • Superior rim fracture of acetabulum • Bursting fracture of acetabulum
4.	**Clinical features**	• Limb shortening • Flexion/add/IR deformity (Fig. 11.22B) • Thigh rests on the contralateral limb • Head felt in the gluteal region. • Vascular sign-ve (Narath). • Movements of Hip ↓ • Injury to sciatic nerve	*Superior type* flexion + abd + external rotation deformity (Fig. 11.22A) *Inferior type* hip is extended and externally rotated • Head felt superiorly or inferiorly reveals head of femur • Vascular sign (Narath) +ve • Injury to femoral nerve artery or vein	• No limb shortening • Limb is neutral in position • Bruising over the greater trochanter • Per rectal examination
5.	**Treatment**	*Four methods of Closed reduction* 1. *Stimson's gravity method* least traumatic but associated injuries prevent prone positioning 2. *Allis* Traction is given in line of deformity 3. *Bigelow's method* reduction is done by causing the opposite methods of ext/abd/ER 4. *Classical Watson-Jones method* Limb is brought to the neutral position first then longitudinal traction in the line of femur is given.	1. *Stimson's gravity method* 2. *Allis method* 3. *Reverse Bigelow's method* Here position of hip is flexion and adduction 4. *Classical method* is as described for posterior dislocation	Reduction is attempted through skeletal traction on greater trochanter in line of the neck of femur. If it fails, open reduction is indicated.
6.	**Complications**	*Early* • Sciatic nerve palsy • Irreducible fracture dislocation • Missed knee injuries • Recurrent dislocations *Late* • Myositis ossificans • Avascular necrosis of bone • Post-traumatic arthritis • Unreduced posterior dislocation	*Early* • Neurovascular injuries • Femoral artery, vein, nerve injury • Irreducibility *Late* • Post-traumatic osteoarthritis • Aseptic necrosis • Recurrent dislocation	*I Early* • Sciatic nerve palsy • Superior gluteal artery injury • Bowel obstruction • Thrombophlebitis • Infection • Recurrent dislocation *II Late* • Post-traumatic arthritis • AVN • Nonunion • Myositis ossificans



Figs 11.21A to C: Types of dislocation of hip joint: (A) Posterior dislocation of hip, (B) Anterior dislocation of hip, and (C) Central fracture dislocation of hip



Figs 11.22A and B: Appearance of classical deformities in dislocation hip: (A) Anterior, and (B) Posterior

POSTERIOR DISLOCATION OF HIP JOINT

It is an interesting observation that if anterior dislocation is common in shoulder joint, it is the posterior dislocation which is common in the hip joint. Traumatic posterior dislocation is usually a car dashboard injury or is due to fall of weight on the back of a stooping miner.

Mechanism of Injury

It is usually due to a backward directed force along the line of femur in a flexed hip (Fig. 11.23). If the femur is more adducted at the time of impact, pure dislocation results and if the femur is slightly abducted fracture dislocation results.

Clinical Features

There is usually history of trauma and the patient has a flexion, adduction and medial rotation deformity of the affected limb

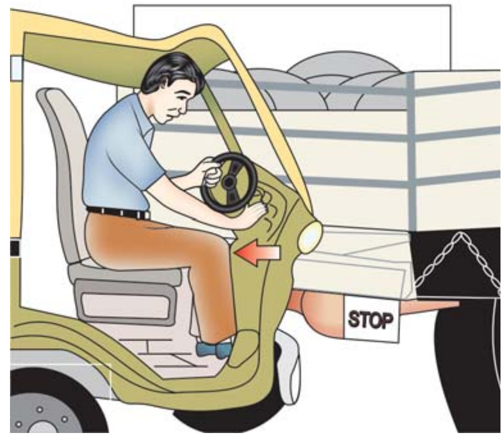


Fig. 11.23: Showing a dash board injury (common mode of injury in posterior dislocation of hip)

Fig. 11.24: Clinical photograph showing flexion, adduction and internal rotation in posterior dislocation of hip

(Fig. 11.24). There is marked shortening and gross restriction of all hip movements. Head of the femur is felt as a hard mass in the glutei region and it moves along with the femur. There could be features of sciatic nerve palsy (*see* page 238).

Radiograph

Plain X-ray of the hip joint, the AP and lateral views, helps to make an accurate diagnosis (Fig. 11.25).

Treatment

In order to prevent early onset of secondary osteoarthritis and also to reduce pain, immediate reduction of the hip has to be carried out under general anesthesia (Fig. 11.26).

Fig. 11.25: Plain X-ray showing posterior dislocation of hip

Fig. 11.26: Showing classical Waston-Jones method of closed reduction for both anterior and posterior dislocation of hip. Arrow indicating lines of force

Note Posterior dislocation of hip should be reduced early to prevent post-traumatic osteonecrosis and relieve compression on the sciatic nerve.

The physiotherapy management for the above injuries proceeds more or less in the same lines as discussed for fracture neck of femur.

12
Chapter

Fracture Femur, Tibia and Fibula

FRACTURE SHAFT FEMUR

Fracture shaft femur is a serious injury and is usually due to severe violence. It may be associated with severe blood loss (up to 1500 ml), multiple fractures and multisystem injuries but however heavy musculature provides unlimited blood supply and thus the fracture heals well (Fig. 12.1).

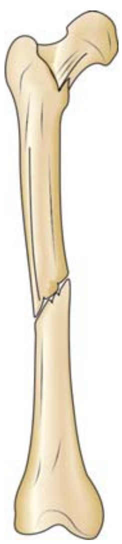


Fig. 12.1: Showing fracture shaft of femur at the middle third

Mechanism of Injury

Usually it is due to major violence, and is common in young adults because the strong metaphyseal areas transmit the forces to the shaft causing fracture. In old age, the metaphyseal areas are brittle and hence the shaft fracture is rare, but fracture of metaphyseal region is common.

Clinical Features

Apart from all the features of fractures, there could be shortening of the lower limb and complete external rotation deformity

Fig. 12.2: Clinical photograph of fracture shaft femur

(Fig. 12.2) such that the lateral border of the foot touches the bed. Since the fracture femur is usually due to major violence, the patient may also present with features of shock: unconsciousness, pallor, cold nose, tachycardia, cold and clammy skin, hypotension, etc.

Radiograph

Plain X-ray of the femur, AP and Lateral views helps confirms the diagnosis (Fig. 12.3).

Management

General Principles

- Almost 100 percent union occurs whether fracture is treated by closed or open reduction methods.
- By internal fixation, hospital stay is reduced.

Fig. 12.3: Plain X-ray showing fracture shaft of femur

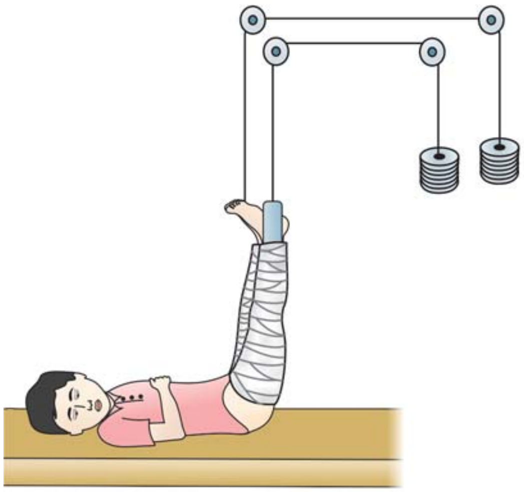


Fig. 12.4: Gallow's traction (in children < 2 years)

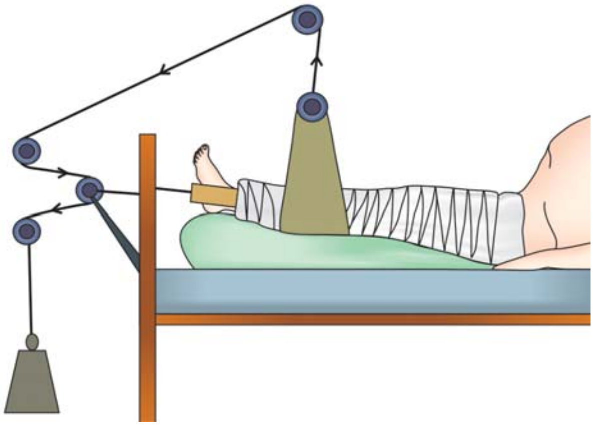


Fig. 12.5: Russel traction useful method in children between 2-10 years

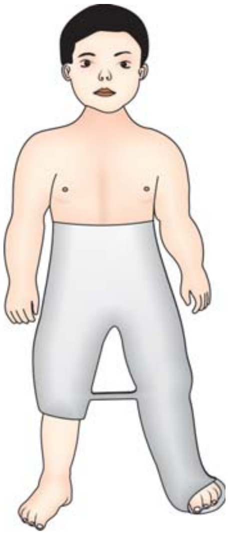


Fig. 12.6: Treatment of fracture shaft femur in children by hip-spica

- Simpler the fracture, more likely to be treated by open reduction and internal fixation (ORIF).
- More comminuted the fracture less likely is the internal fixation attempted. For severely comminuted fracture and extensive soft tissue damage, traction is the safest. Interlocking nailing is the other popular alternative and is the gold standard.

Treatment Methods

Children It is mainly conservative in children.

0 to 2 years	—	Plaster spica in human position1 or modified Bryant's or Gallow's traction (Fig. 12.4).
2 to 10 years	—	most femoral fractures are seen in this age group. Here split Russell traction (Fig. 12.5) was used earlier.
10 to 15 years	—	90 to 90°. Earlier femoral skeletal traction or hip spica or both earlier (Fig. 12.6). Now Surgery using TENS (Titanium Elastic Nail System) is preferred in this age group.
More than 15 years	—	Treatment is as in adults.

Note Human position is 90° of flexion and 45° of external rotation at the hip.

Adults Three modalities of treatment are preferred in adults.

1. *Traction* this could be:
   - *Skin traction* It is useful only during transportation as a first aid measure.

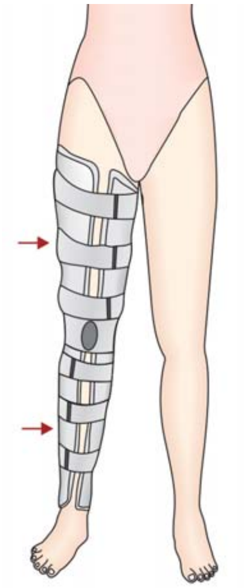
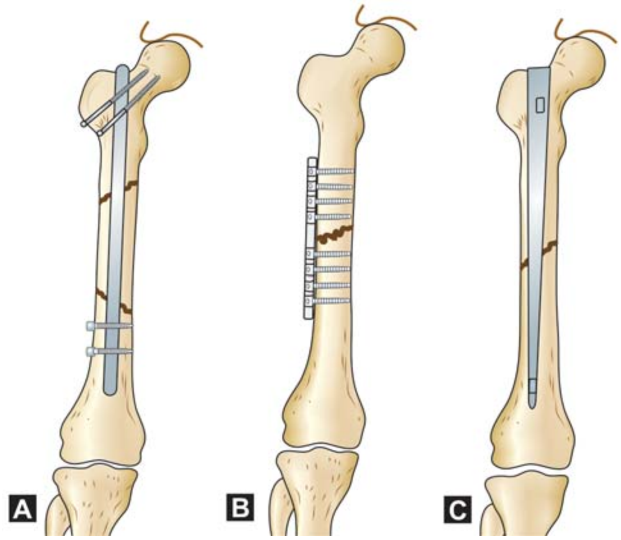


Fig. 12.7: Fracture shaft of femur treated by a functional cast brace



Figs 12.8A to C: Methods of internal fixation for fracture shaft femur: (A) Interlocking nail, (B) DCP plate and screws, and (C) Kuntschner's intermedullary nails

- *Skeletal traction* It is useful only in certain situations and hence its role is limited.

However, patients treated in traction show 100 percent union, but it causes shortening, and hence is not acceptable. The average time of traction required is 12 weeks and this gives rise to recumbency complications like bedsores, pneumonia, renal calculus, etc.

2. *Cast bracing* This method causes an unacceptable varus of more than 8° and hence is not recommended (Fig. 12.7).
3. *Internal fixation* The best method of managing a fracture shaft femur in adults is by closed or operations and internal fixation. The choice of the implants could be as follows: Intramedullary (IM) nails can be used for fractures 2.5 cm below the lesser trochanter to that 8 to 10 cm above the knee joint. It can be used in simple or comminuted fractures. It can be done immediately or delayed. Infection and nonunion is rare (0.8%).

ORIF in fracture femur is also done using DCP plates and screws (Fig. 12.8B).

Types of Intramedullary Nails

- *Standard IM nails (Küntschner's nail)* The ideal indication for this nail is the fracture shaft femur in adults at the level of isthmus (Fig. 12.8C).
  Isthmus is the junction between the upper and middle one-third and is the narrowest portion of the shaft.
- *Interlocking nails (Gross-Kempf nail) (Fig. 12.8A)* These extend the indications of standard IM nail and can be used in the following situations where IM nail is less successful:
  — Comminuted fractures
  — Segmental fractures
  — Proximal and distal fractures
  — Nonunion etc.
- *Flexible medullary nails* Like Ender's nail, which is usually passed from below upwards through the distal femur.

Complications of Fracture Shaft Femur

- *Immediate complications* These are life-threatening and the common ones are shock, fat embolism, neurovascular injury to the femoral artery, sciatic nerve, etc.
- *Delayed complications* These are more common and include:
  — *Refracture* This is a most embarrassing complication and is commonly seen in simpler fractures due to poor welding of the fracture site by the callus and after plate removal due to the holes left over by the removal of screws which takes time to fill up leaving a potential weak spot for refracture. The incidence of this complication is around 9 to 15 percent.
  — *Complications of fixation devices* The problems usually encountered with intramedullary nails are breaking, loosening, proximal or distal migration, jamming, bending, infection, etc. These may be due to faulty implants, techniques or choice.
  — *Nerve injury* Injury to the common peroneal nerve is more often seen in these fractures. However, it is not a very common occurrence.

— *Malunion* This is one of the most common complications seen in fracture shaft femur and is due to the strong and variable muscular forces already described. Malunion is more often seen following conservative treatment and traction than in operative treatment.

— *Nonunion* It is not that common as fracture shaft femur is known to unite well.

— *Joint stiffness* In fracture shaft femur knee joint may become stiff due to quadriceps atrophy following prolonged immobilization and due to intra-articular or extra-articular adhesions.

Physiotherapy Management for Fracture Shaft Femur

The goals of treatment are as follows:

Orthopedic goals To restore the cortical contact, length and rotation of femur.

Rehabilitation goals To restore full range of movements or at least functional range of both hip and knee joints (*see* page 145, Table 11.1).

To improve the strength of quadriceps and hamstring muscles.

Functional goals To restore the activities of daily living and gait pattern.

> *Note*
> - Required time for bone healing—4-16 weeks
> - Required time for rehabilitation—12-16 weeks

To achieve the above goals, physiotherapy treatment should proceed on the following lines:

Physiotherapy Regimen after Surgery

During the First 10 days

General Wound inspection is carried out for evidence of infection. The operated leg is kept elevated to prevent edema, care of the back, etc. is done.

Movements To restore the range of movements, active exercises to the hip, knee and ankle are started.

However, care should be taken to prevent rotation of the affected limb on the firmly planted foot. No passive range of movements is advised at this stage.

Muscle strength Isometric exercises are recommended to strengthen the glutei and quadriceps muscles. Isotonic ankle exercises help strengthen the gastrocnemius (to prevent venous stasis and phlebitis) and dorsiplantar flexion exercises to prevent plantar flexion contractures.

Functional activities (ADL) This is the same discussed for fracture neck femur (*see* page 149).

Gait A 2-point gait with crutches or walker if the patient is non-weight bearing, and a 3-point gait if the patient is allowed to bear weight.

> *Note* Stair climbing is not advised.

Quick Facts

> Rehabilitation for fracture femur for first 10 days.
> - Wound inspection and other general precautions.
> - Isometric exercises to the glutei/quadriceps.
> - Isotonic exercises to the ankle.
> - Active ROM exercises to hip and knee once pain subsides.
> - Modified daily living activities.
> - A 2-point or 3-point gait.
> - No passive movements.

After 10 days

Movements Along with the active movements, active assisted movements are begun to the hip and knee. By the end of four weeks, passive range of movements is begun.

Exercises Isometric exercises to the glutei and quadriceps, active isotonic exercises to the ankle are continued. Active straight leg raising exercises are commenced.

Weight-bearing For unstable fractures, partial weight-bearing is permitted. For stable fractures, weight-bearing as tolerated can be allowed.

Gait Depending upon the weight-bearing status, patient may be allowed ambulation.

For climbing stair cases, patient is instructed to climb up with the affected extremity and get down with the unaffected extremity first. With the help of crutches a 2-point or 3-point gait is permitted.

Functional activities The modifications in the functional activities are the same as mentioned earlier.

Resistive isotonic exercises to the hip and knee can be prescribed after 4-6 weeks. Full weight-bearing may be permitted after 12-16 weeks.

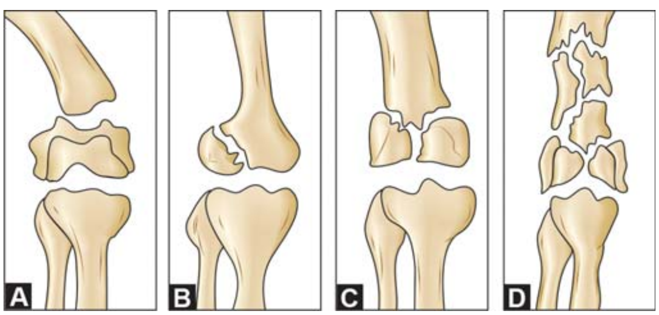
Quick Facts

After 10 days

- By the end of 4 weeks, passive range of movement exercises.
- Resistive isotonic exercises along with isometric exercises could be commenced after 6 weeks.
- Full weight-bearing after 12-16 weeks.
- Torsion loading of femur after 16 weeks.
- Functionally independent after 12-16 weeks.

FRACTURE DISTAL FEMUR

The distal part of the femur encompasses the lower one-third. It varies between 7.6 cm and 15 cm of distal femur. The supracondylar area is a transition zone between the distal diaphysis and the femoral articular surface. The distal femur is subjected to the quadriceps force anteriorly and the flexion force of the gastrocnemius posteriorly. The fractures of the distal femur could be classified into supracondylar, intercondylar, unicondylar and comminuted fractures (Figs 12.9A to D). The distal femur fracture accounts for 4.7 percent of all femoral fractures.



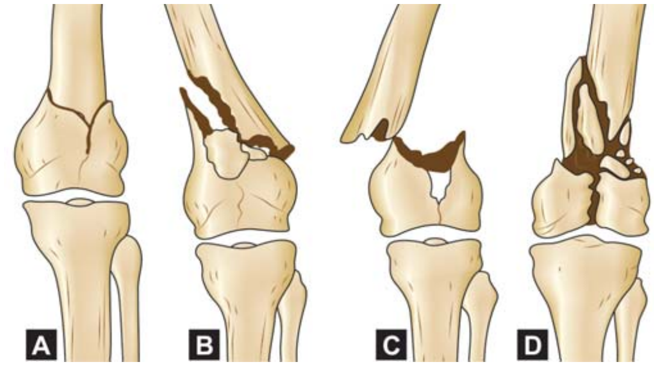
Figs 12.9A to D: Fractures of distal femur: (A) Supracondylar fracture, (B) Unicondylar fracture, (C) Intercondylar fracture, (D) Comminuted fracture

SUPRACONDYLAR FRACTURE OF FEMUR

Supracondylar region extends from the femoral condyles to the junction of metaphysis with femoral shaft. The distal fragment is displaced and angulated posteriorly due to the pull of gastrocnemius muscle.

Mechanism of Injury

These fractures are usually due to severe valgus or varus forces with axial loading and rotation due to RTA, fall, etc.



Figs 12.10A to D: Neer's classification for supracondylar fractures: (A) Undisplaced, (B) Displaced and medial, (C) Displaced and lateral, (D) Comminuted

Classification (Neer's) (Figs 12.10A to D)

- Undisplaced fracture
- Displaced fracture
  - — Medial displacement
  - — Lateral displacement
- Comminuted fractures.

Clinical Features

It consists of the usual features of fractures but what is specific to this fracture is the flexion deformity caused by the pull of gastrocnemius. Haemarthrosis is commonly seen especially with fractures extending into the joint.

Radiograph

Plain X-ray of the femur including the knee joint AP and Lateral views helps confirms the diagnosis (Figs 12.11A and B).

Figs 12.11A and B: Plain X-ray of supracondylar fracture of femur (A) AP view, (B) Lateral view

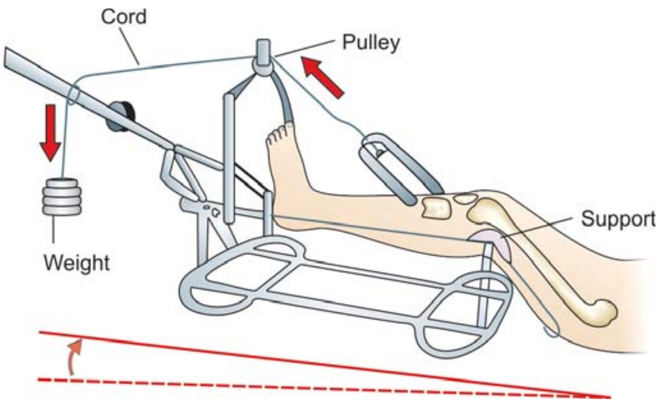


Fig. 12.12: Skeletal traction through Böhler-Braun frame for supracondylar fracture. Note the support is given at the fracture site and not the knee to prevent angulation

Treatment

The treatment usually consists of conservative methods, traction and operative methods.

Conservative methods This has a limited role and is usually useful in impacted and undisplaced fractures. In the former, a long leg or spica cast is sufficient and in the latter a long above knee cast after an initial period of skin or skeletal traction is all that is required.

Traction methods The choice is mainly skeletal traction and two methods are described:

1. *Upper tibial traction (Fig. 12.12)* Here the skeletal traction is applied through the upper end of tibia. Initial weight used is around 15 to 20 lbs and is subsequently reduced. The traction is given for a period of 8 to 12 weeks and the patient is put on cast braces. To prevent the knee stiffness from developing the patient is encouraged to carry out the knee movements during the traction itself.
2. *Two-pin traction method* In this method traction is added through the distal femur apart from the traction given through the upper end of tibia. This helps in accurate reduction of the fracture and also maintains the reduction so obtained. The disadvantage of this technique is that it is cumbersome and may cause neurovascular compressions in and around the knee.

Operative methods This consists of ORIF and is preferred as closed reduction is associated with troublesome complications like limited knee motion, residual varus and internal rotation deformities. The advantages of open reduction are early mobilization of the knee joint and a fairly accurate reduction and rigid fixation.

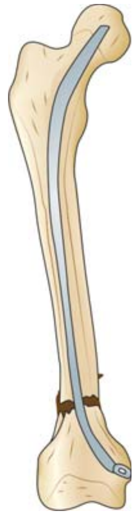


Fig. 12.13: Methods of internal fixation for supracondylar fracture of femur—Enders nail

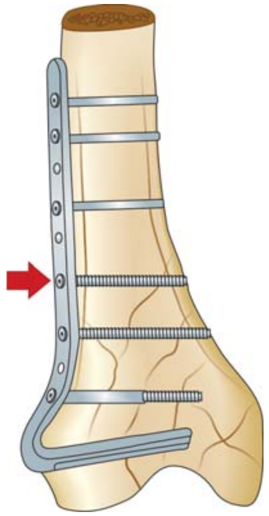


Fig. 12.14: Methods of internal fixation for supracondylar fracture — Blade-plate fixation

Fixation methods The choice is between medullary fixation and blade plate fixation. Rush pins, Ender's nail, medullary nails, split nails, etc. are some of the commonly used medullary fixation methods (Fig. 12.13). While AO plates, Elliott or Jewett plates comprise the blade fixation methods (Fig 12.14).

Complications

The complications commonly encountered in supracondylar fractures are delayed union, malunion, nonunion, injury to the popliteal vessels and common peroneal nerves, knee stiffness, deep vein thrombosis, infection, implant, etc.

PHYSIOTHERAPY MANAGEMENT

The goals of treatment are as follows:

Orthopedic goals To restore alignment and keep the articular step off in the knee joint to less than 1-2 mm.

Rehabilitation goals To restore the hip, knee (normal flexion-135°, Functional-110°), and ankle movements to normal.

To restore the strength of quadriceps, hamstrings, hip adductors and gastrocnemius muscles.

Functional goals To achieve a knee flexion of 90° for proper sitting and to restore back the normal gait.

Note
- Required time for fracture healing—12 to 16 weeks
- Required time for rehabilitation—15 to 20 weeks.

During the First 10 Days

- **General measures**
  - — Foot end elevation to prevent limb swelling.
  - — Inspection of wound for erythema and infection.
  - — Check the distal neurovascular status.
  - — Keep a watch for evidence of compartment syndrome of the legs.
- **Movements** For the hip, knee and ankle gentle active range of movement exercises are commenced. At the knee joint, the goal is to achieve 60-90° of flexion and full extension.

> *Note* No passive range of movement exercises at this stage.

- **Exercises** No muscle strengthening exercises are allowed at this stage.
- **Functional activities** The patient is advised non-weight-bearing for at least 3 months. The patient can stand or transfer the weight by using a walker or crutches. A 2-point gait using a crutch or walker with no weight-bearing on the affected extremity. The patient is instructed to climb with the unaffected leg first and descend with the affected leg first. For wearing trousers, patient is instructed to do with the affected extremity first and remove it from the unaffected leg first.

Quick Facts

During first 10 days
- Active exercises to the hip/knee/ankle
- No strengthening exercises
- No weight-bearing
- No passive ROM exercises

Further Management

By the end of 2 weeks, isometric quadriceps is commenced. At the end of 4-6 weeks an active knee flexion of more than 90° can be aimed at and active assistive knee movements are prescribed.

After 8-12 weeks, gentle passive movements to assist knee flexion can be commenced. Isometric and isotonic exercises to the quadriceps and hamstrings can be initiated.

After 12-16 weeks, weight-bearing can be progressed from partial to full. Isometric, isotonic and isokinetic resistive exercises to the hip, knee and ankle and gentle progressive exercises are continued.

Quick Facts

Supracondylar fractures
- Knee mobilization commenced after 10 days.
- End of 2 weeks—isometric quadriceps.
- End of 4-6 weeks—active knee flexion > 90° aimed at.
- End of 8-12 weeks—gentle passive knee movements.
- End of 12-16 weeks—weight-bearing allowed.

PROXIMAL TIBIAL FRACTURE

Proximal tibia consists of the medial and lateral condyles along with the upper tibial articular surface and includes the proximal 10 to 12 cm of the tibia. These fractures are frequently intra-articular and usually unite well considering the cancellous nature of the bone.

Causes

- 52 percent—due to auto-pedestrian injuries.
- 17 percent—due to fall from heights.
- 31 percent—miscellaneous causes.

Types

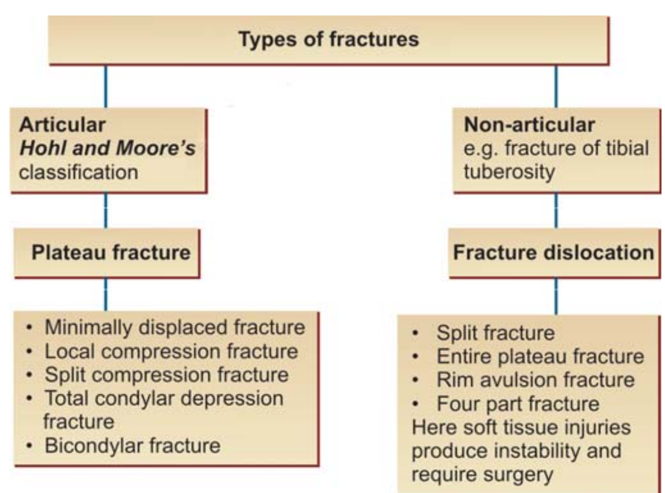
There are two varieties of proximal tibial fracture (Flow chart 12.1).

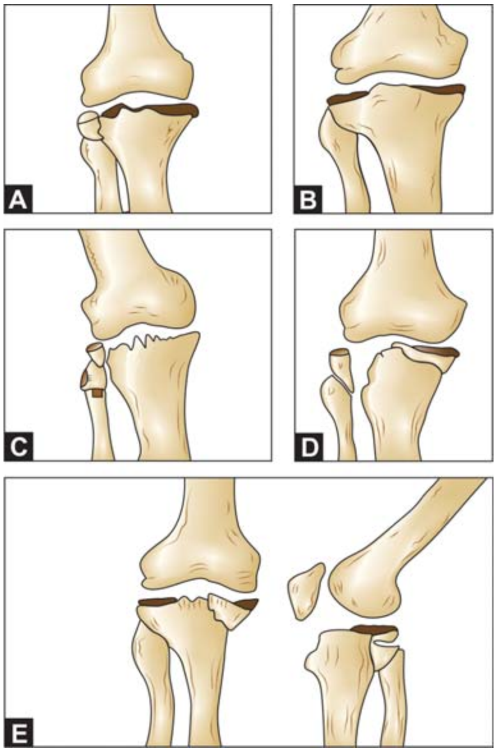
- Articular variety
- Nonarticular variety

Classification

This classification is based on Hohl and Moore as shown in Figures 12.15A to E.

Flow chart 12.1: Showing classification of proximal tibial fractures





Figs 12.15A to E: Hohl and Moore's classification of proximal tibial fractures: (A) Minimally displaced fracture, (B) Local compression fracture, (C) Split compression fracture, (D) Bicondylar fractures, (E) Total condylar depression

Clinical Features

The patient with proximal tibial fractures presents with pain, swelling, deformity, hemarthrosis, decreased movements of the knee and instability in valgus or varus (Fig. 12.16).

Investigations

- The routine AP and lateral radiographs of the knee help to demonstrate majority of tibial condyle fractures. Oblique view may be required to localize the fractures (Fig. 12.17A).

Fig. 12.16: Clinical photograph of proximal tibial fractures

Figs 12.17A and B: (A) Plain X-ray showing fracture of tibia, (B) Plain X-ray showing ORIF with B-plate and screws in tibial plateau fracture

- To study the depth of depression CT scan is excellent but 10° caudal plateau view also helps. To know the knee ligament injuries, valgus or varus stress films are required.
- Aspiration may reveal blood or fat. If fat is present, it indicates a fracture.

Management

Aim

- To produce a knee that extends fully and flexes to at least 120°.
- Restoration of normal articular surface and ligament repair are both important in preventing late instability.

In plateau fracture Conservative treatment is indicated for fractures with < 4 mm depression or displacement.

Undisplaced fracture Above knee POP cast is used.

Displaced fracture Closed reduction and traction, later a cast brace is used.

In depressed fractures For less than 8 mm depression above knee cast. For depression of more than 8 mm with a large split fragment skeletal traction is applied. For more than 8 mm with smaller split fragment ORIF with buttress plate and screws is done with bone grafting after elevation of the depression (Figs 12.17B and 12.18).

In split fracture Here closed reduction is not useful. Open reduction and internal fixation with cancellous screws, buttress plate, etc. are used. Skeletal traction is useful in grossly comminuted fractures.

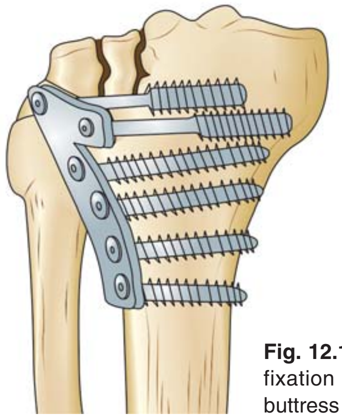


Fig. 12.18: Photograph showing internal fixation of proximal tibial fracture with buttress plate and screws

Complications

These include compartment syndrome, peroneal nerve palsy, popliteal artery laceration, nonunion (rare), malunion and degenerative arthritis.

Physiotherapy Treatment

Orthopedic goal To restore the anatomy back to normal any knee joint depression > 4 mm is unacceptable and should be treated by open reduction and internal fixation.

Rehabilitation goals To restore the normal knee flexion of 135-140° or at least attain the functional level (110°). To improve the muscle strength of quadriceps, sartorius, hamstrings and gastrocnemius.

Functional goals To restore the stability and normalize the gait pattern.

Note
- Required time of bone healing—10-12 weeks
- Required rehabilitation time—14-16 weeks

To achieve the above goals the physiotherapy management should proceed on the following lines:

During the First 2 Weeks

- **Conservative treatment (treated with cast brace)** Limb is kept elevated to prevent and minimize limb edema. Active and gentle passive flexion and extension of the knee allowing 40-60° of knee flexion with the patient sitting at the edge of bed is allowed. No strengthening exercises to the knee are allowed, however, hip and ankle active and passive range of motion exercises are allowed. Non-weight-bearing with crutches or walker is permitted. Assisted SLR also helps.
- **Open reduction and internal fixation** in these cases, regular wound inspection is done and the sutures are removed after 2 weeks. Patient is put in a cast brace and the rest of the treatment is the same as mentioned above.

After 2 Weeks

By 8-12 weeks, the brace can be discontinued and the patient can be put on a knee immobilizer or hinged orthosis. Active, active assistive and passive knee flexion and extension to at least 90° is allowed. Isometric and gentle resistive exercises are advised to the quadriceps, hamstrings and ankle joints. Weight-bearing is deferred till the end of 12 weeks and can later be started with assistive devices.

After 12-16 weeks, full active, active assisted, passive and progressive resistive exercises are allowed to the hip, knee and ankle musculatures. Full active and passive ROM is allowed to the knee. Full weight-bearing subject to patient's tolerance is permitted.

Quick Facts

Physiotherapy management of tibial condylar fractures:
- Knee mobilized during the first week.
- Sutures removed after 2 weeks.
- By 8-12 weeks, cast brace is discontinued.
- Assisted SLR in the early stages, quadriceps strengthening exercises in the later stages.
- Adjunctive measures like hydrotherapy, thermotherapy CPM, electrical stimulation helps.
- After 12 weeks full active and passive hip, knee and ankle movements allowed.
- After 16 weeks full weight-bearing is allowed.

FRACTURE TIBIA AND FIBULA

Features

- Most common of all long bone fractures. Next common to intracapsular fracture neck femur.
- More controversial, exceeded only by fracture neck femur.
- Subcutaneous and hence incidence of open fracture is high.
- Distal one-third has a deficient blood supply and a fracture in this area is known for delayed union and nonunion.
- Bounded above and below by hinge joints and hence no malunion is acceptable.
- Responds well to conservative treatment.
- Only 5 percent need operative treatment.

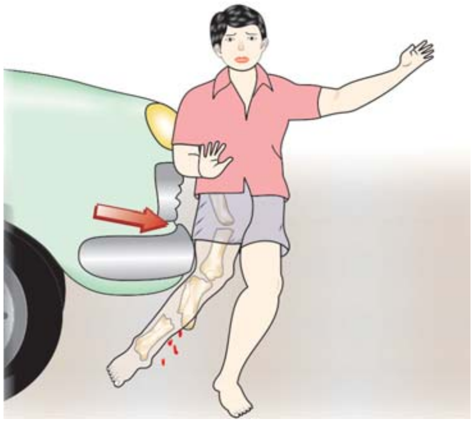


Fig. 12.19: Bumper injuries in road traffic accident (RTA) commonly cause open fracture femur and tibia

Mechanism of Injury

Direct violence Due to road traffic accident (most common mode of injury), fall, etc. Open fractures are common in this mode of injury (Fig. 12.19).

Indirect violence Due to falls, twisting force, usually cause spiral fractures.

Clinical Features

In these fractures, the common symptom is pain and the obvious sign is the deformity, apart from other features of fractures. Damage to the blood vessels and nerves is not that common but fibular neck fracture may injure the lateral popliteal nerve and if the posterior tibial vessels are injured, compartmental syndrome may develop (Fig. 12.20).

Radiograph

Plain X-ray of the leg including both the knee and ankle joints AP and Lateral views helps confirm the diagnosis (Fig. 12.21).

Fig. 12.20: Clinical photograph of fracture of tibia and fibula

Fig. 12.21: Plain X-ray of leg showing fracture of tibia and fibula

Methods of Treatment

Conservative management This consists of closed reduction under general anesthesia and a long leg cast application (Fig. 12.22).

Indications

- Most closed fractures
- Undisplaced fracture
- Fractures with minor or moderate displacements.

Sarmiento's total contact below knee cast After reduction of the fracture and application of a long leg cast for several weeks, a total below knee cast which is moulded around the tibial condyles and patella in the fashion of patellar tendon bearing prosthesis is applied (Fig. 12.23).

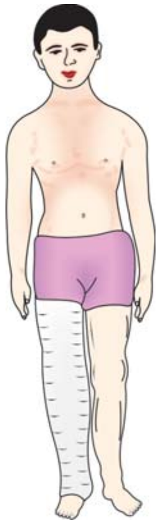


Fig. 12.22: Fracture tibia treated with long leg cast

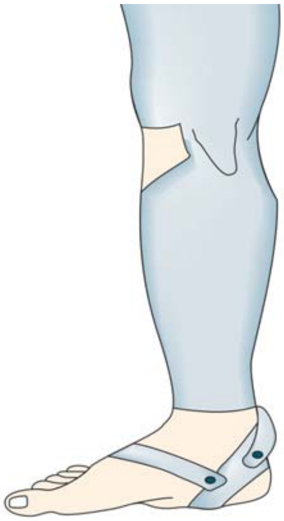


Fig. 12.23: Sarmiento total contact below knee cast

Advantages
- Allows knee movements.
- Sitting can be permitted early.
- Ease of ambulation for patients with bilateral fracture.
- Decreases the incidence of delayed union and nonunion.

Pins above and below the fracture Here two Steinmann pins are passed above and below the fracture site and incorporated within the plaster cast.

Indications
- For moderate and severe fracture
- Unstable fracture
- Open fracture.

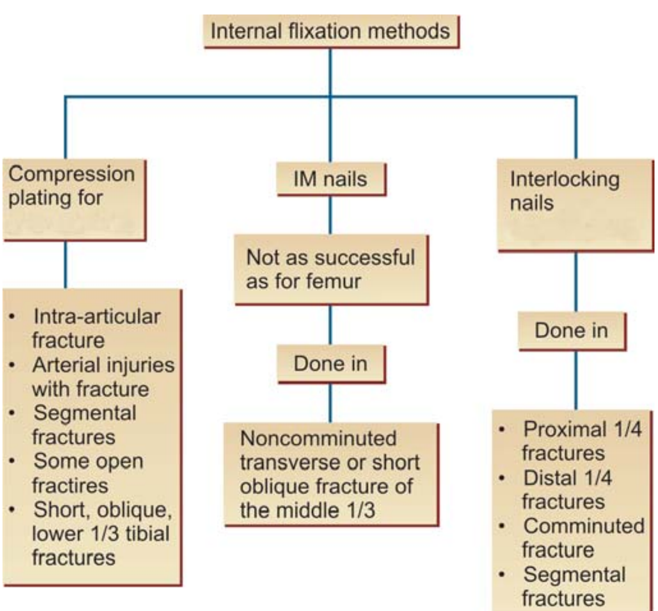
Open reduction and internal fixation As mentioned earlier only 5 percent of the cases require operative treatment in tibial fractures.

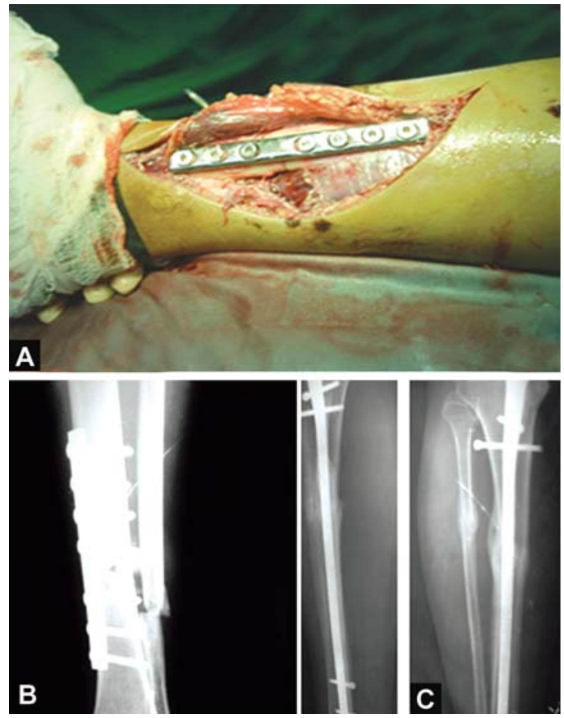
Advantages
- Definitive form of treatment.
- No loss of position or shortening.
- No post fracture deformity.
- Joint movements obtained early.

Absolute indications
- Tibial fracture with vascular or neural injuries.
- Segmental fractures.
- Inadequate reduction.
- Associated knee problems.
- Associated tibia plafond fracture.

Internal Fixation Methods (Flow chart 12.2)

Flow chart 12.2: Showing internal fixation methods in tibial fracture





Figs 12.24A to C: (A) Intraoperative photograph of fixation with DCP plate and screw, (B) Plain X-ray of DCP plate fixation, (C) Interlocking nailing of tibia

Fixation by plate and screw The choices of plates are DCP LCDCP and locked compression plates that are closed to fix the tibial shaft fractures (Figs 12.24A and B).

Interlock nails This is the gold standard in the method of internal fixation of tibial fractures (Fig. 12.24C).

Role of external fixators This is useful in compound fractures of the tibia (Fig. 12.25A) as it enables to stabilize the fracture and also helps to take care of the wound (Fig. 12.25B).

Figs 12.25A and B: (A) Plain X-ray showing compound comminuted fracture of tibial and fistula, (B) Fixation with external fixators

Complications

- *Delayed union* This is a common complication and has an incidence of 1 to 17 percent. If there is no evidence of union of the fracture even after 20 weeks, delayed union is suspected and is treated with cancellous bone graft.
- *Nonunion* This is a notorious problem usually encountered in fractures at the junction of middle one-third and lower one-third. It can be treated by electric stimulation or rigid internal fixation with compression plating and cancellous bone grafting.
- *Infected nonunion* It posses a tough challenge to the orthopedic surgeons and is best managed by Ilizarov's method of external fixation.
- *Malunion* Because of the parallel hinge knee and ankle joints above and below, malunion of tibia is an unacceptable problem as it may cause early degenerative arthritis. Corrective osteotomy is the treatment of choice.
- *Shortening* This may be due to malunion or overlap of the fracture fragments, less than 2 cm shortening is acceptable and may be corrected by footwear adjustments while more than 2 cm shortening may require bone lengthening procedures.
- *Infection* Due to the subcutaneous location of the bone, infection is a fairly common complication in these fractures due to a higher frequency of compound fractures following Rats.
- *Other complications* Compartmental syndromes, joint stiffness, refractures, fat embolism and claw toes due to tethering of the long extensors over the callus are the other common complications.

Physiotherapy Treatment

Orthopedic goal To restore back the length, angulations and rotation of the affected limb.

Rehabilitation goals To restore the knee movements back to normal (135°) or to functional levels (110°). Similarly to restore ankle movements back to normal or at least functional range (DF-25°, Functional-10°, PF-40°, F-20°)

Muscle strength To improve the muscle strength of dorsiflexors, plantar flexors, invertors and evertors of the foot.

Functional goals To normalize the gait pattern.

> *Note*
> - Required time of bone healing—10 to 12 weeks.
> - Required time of rehabilitation—12 to 24 weeks.

To achieve the above goals, the physiotherapy management should proceed on the following lines:

For fractures treated conservatively with plaster casts The plaster should be inspected for adequate padding, edges should be trimmed and examined for cracks, softening, etc. The limb should be kept elevated to decrease the swelling. Isometric exercises for the glutei quadriceps and hamstrings are started. Assisted straight leg raising is advised. Strong isotonic ankle plantar flexion and dorsiflexion exercises are carried out.

As soon as the leg hanging becomes painless on standing (by 2 weeks) non-weight-bearing crutch walking is permitted. By 8-12 weeks, the plaster cast can be removed and active range of movement exercises to the knee and ankle joints are gradually begun and progressed to active assistive and resistive exercises.

Full weight-bearing may be permitted once there is evidence of radiological union (12-24 weeks).

Functional activities Modification of the life-style is advised. The patient is taught to use crutch/walker with a 2-point or 3-point gait. With the help of these he is taught transfer from bed to chair and vice versa. He is advised to wear the pant with affected extremity first and remove it from the unaffected extremity first. Stair case walking may be deferred till the pain subsides, and later he is advised to climb with the unaffected leg first and get down with the affected leg. Care has to be exercised during these activities.

> *Note of caution* Rotatory movements with the foot planted on the ground should be strictly avoided.

Fractures treated by cast bracing In this case the long leg cast is changed to cast brace by the end of 4 weeks. The physiotherapy management is more or less the same as mentioned above, except that knee joint can be mobilized early and weight-bearing can be initiated earlier.

Fracture treated by surgery Wound inspection is done regularly and the sutures are removed at the end of 2 weeks. In fractures rigidly fixed by DCP plates or by dynamic interlocking nails, knee can be mobilized by 1-2 days in interlocking nailing 1-2 weeks in plating and weight-bearing can be permitted safely by the end of 2 weeks. Rest of the physiotherapy management is the same as for the cast.

Fractures treated by external fixator Pin sites are inspected and tendon functions are evaluated. Knee joint can be mobilized by the end of 2 weeks. Patient can start non-weight-bearing crutch walking by the end of 2 weeks.

Rest of the management is the same as discussed above.

Quick Facts

Physiotherapy for Tibial Fractures

- Limb elevation to reduce edema.
- Isometrics for glutei, quadriceps, hamstrings.
- NWB crutch walking by the end of 2 weeks.
- Knee mobilized by 8 weeks in cast treatment and by 2 weeks in open reduction and internal fixation.
- Full weight-bearing after evidence of radiological union.
- Modification in activities of daily living.
- Wound inspection and pin site inspection for fractures treated by external fixators.
- Knee mobilized and early weight-bearing in cases treated by open reduction and internal fixation, external fixators and by cast brace.

13 Chapter

Injuries of the Knee Joints

KNEE LIGAMENT INJURIES

This consists of injuries to the collateral and cruciate ligaments of the knee.

GENERAL PRINCIPLES

Etiology

- *Athletes* Knee ligament injuries are very common in athletes who are involved both in contact and non-contact sports. The injury could be either direct due to collision with another athlete or indirect due to rotation and twisting injuries.
- *Road traffic accident (RTA)* Here the mechanism is usually direct and could be due to a dashboard injury.
- *Fall* From a height with a twisting force.

Mechanism of Injury (Palmar)

The following are the common mechanism of knee ligament injuries.

Abduction, flexion and internal rotation of the femur on tibia (Ab FIR) This causes damage to medial structures, like tibial collateral, medial capsule and if more force is applied ACL and medial meniscus may also tear.

O Donoghue's unhappy triad (Fig. 13.1) Indicates injuries to medial structures + ACL tear + medial meniscus injury.

Adduction, flexion and external rotation of femur on tibia (Ad FER) Causes damage to fibular collateral, lateral capsule, arcuate complex, popliteus, iliotibial band, biceps, common peroneal nerve, anterior, posterior or both cruciates.

Hyperextension force May cause either anterior or posterior cruciate ligament injury.

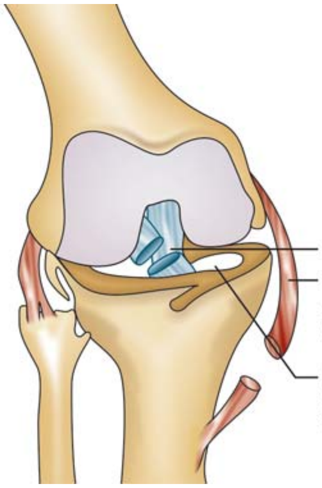


Fig. 13.1: Unhappy triad of O'donoghue

Anteroposterior displacement Either anterior (dashboard injury) or posterior cruciates may be injured due to a direct force in RTA (Table 13.1).

Goals of Treatment

The goal of treatment in knee ligament injuries is restoration of anatomy and stability to normal or near to normal. Now let us study the individual knee ligament injuries in detail.

TABLE 13.1: Combined instabilities of knee

Structures torn	*Types of instability*
• If anterior, medial and lateral structures are torn	*Anteromedial and anterolateral instabilities*
• If anterior, posterior cruciates lateral structures are torn	*Anterolateral and posterolateral instabilities*
• If anterior, posterior cruciates and medial structures are torn	*Anteromedial and posteromedial instabilities.*

Fig. 13.2: Avulsion of lateral collateral ligament from the head of the fibula

COLLATERAL LIGAMENT INJURY

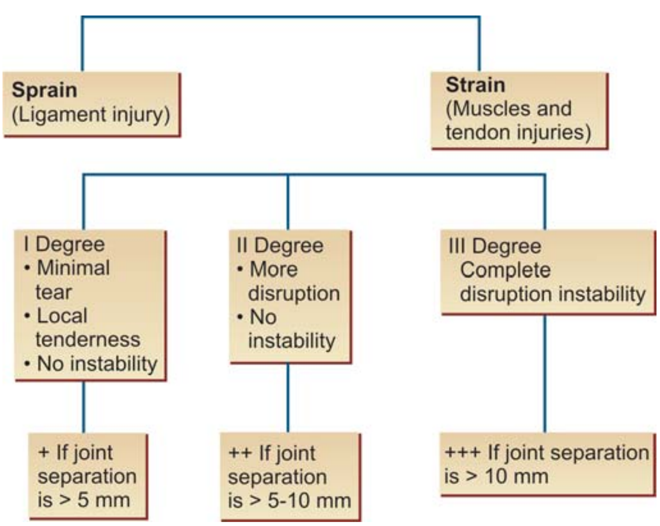
Collateral ligament injury is due to direct or indirect violence as described earlier. Medial collateral ligament injury is more common due to the valgus stress caused by striking the lateral aspect of the knee joint during collision in sports. The varus force on the medial side required to cause the lateral collateral ligament injury is less common because of the protection offered by the other leg. However, a severe varus force may cause avulsion of the lateral collateral ligament from the head of the fibula (Fig. 13.2).

Classification

Figures 13.3 shows grades of medial collateral ligament injuries.

American Medical Association (Flow chart 13.1)

Flow chart 13.1: Showing American Medical Association classification of soft tissue injuries



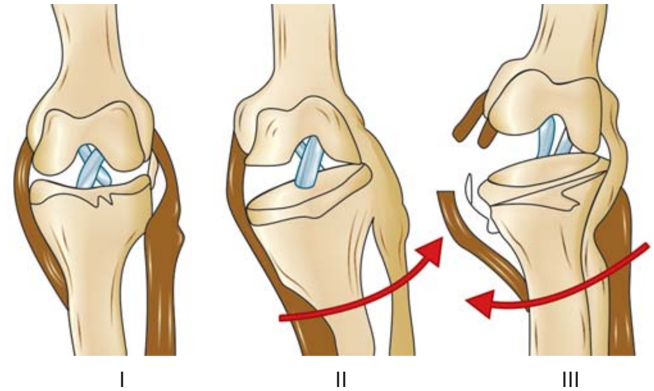


Fig. 13.3: Sprain of medial collateral ligament of the knee

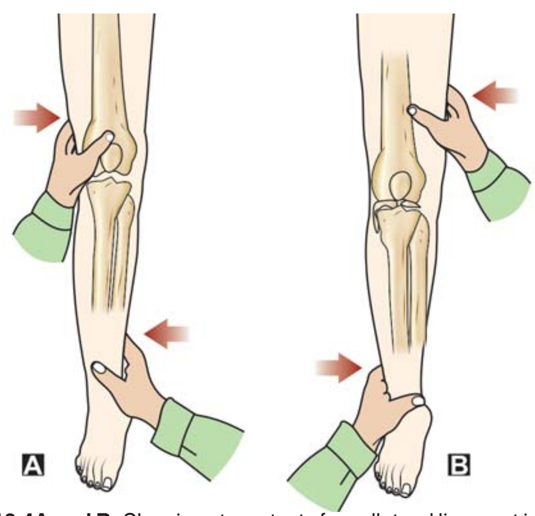
Medial Collateral Ligament Tear

Patient gives history of valgus and external rotation force in mild sprains. In severe sprains, patient gives history of valgus stress force due to the direct blow on the lower thigh or upper leg seen commonly in contact sports like football, rugby, etc. It may be associated with ACL tear or meniscal injury and the patient may present with pain, swelling, hemarthrosis, etc.

On examination the point of local tenderness could be at adductor tubercle, joint line or at the insertion of tibial collateral ligament. About 10 to 20 percent of patients have damage to the extensor mechanism of the knee.

Clinical Tests

These are abduction stress, test for medial collateral tear (Fig. 13.4A) and adduction stress test for lateral collateral injury (Fig. 13.4B). Anterior Drawer test and Lachman's test (*see* page 172) helps to diagnose associated ACL tear.



Figs 13.4A and B: Showing stress tests for collateral ligament injuries: (A) Valgus or abduction stress test, (B) Varus or adduction stress test

Investigations

- Stress radiographs at 15 to 20° of valgus.
- MRI helps to localize the MCL tear.
- Arthrograms and arthroscopy to evaluate and rule out menisci and cruciate pathology.

LATERAL COLLATERAL LIGAMENT TEAR

As mentioned earlier, LCL tears are less common. There is tenderness over the lateral joint line and the adduction stress test will be positive.

Treatment of Collateral Ligament Injuries

General Principles

Fresh injury
- *I° sprain* Symptomatic treatment, non-steroidal anti-inflammatory drugs (NSAIDs), etc.
- *II° sprain* Long leg cast for 4 to 6 weeks with knee in 30 to 40° of flexion.
- *III° sprain* Surgical repair.

Old cases Here it is mainly reconstruction.

Tibial collateral ligament (TCL) injury If TCL is intact but lax then distal transfer is done. If ligament is destroyed, reconstruction using hamstrings or semitendinosus is done.

Fibular collateral ligament injury If adequate and thick, distal transfer is recommended. If destroyed, reconstruction using fascia lata, biceps tendon, etc. is done.

Physiotherapy Treatment

This is discussed under physiotherapy measures of internal derangement of knee (IDK) on page no 195.

CRUCIATE LIGAMENT INJURIES

ANTERIOR CRUCIATE LIGAMENT (ACL) TEAR

Mechanism of tear has already been discussed. The most common mode of injury is external rotation with abduction of the flexed knee or hyperextension of knee in internal rotation. The tear could be a mid-substance tear or an avulsion from the tibial spine (Fig. 13.5).

Fig. 13.5: Showing ACL tear

Clinical Features

This is a disabling injury and the knee may immediately collapse and is painful. Popping sensation felt or heard at the time of injury signifies ligamentous injury (ACL tear). The patient also tells that the knee "gave away" or buckled at the time of injury. Swelling of the knee could be either due to hemarthrosis or traumatic synovitis and the distended knee is held in partial flexion by the hamstrings (see box for differential diagnosis).

Always examine the normal knee first and form a basis for "comparison." Clinical findings depend on associated ligamentous injury or meniscal injury or bone damage. Depending on the combination there will be specific instabilities that will allow anterior displacement of tibia on the uninvolved side. Anterior subluxation of more than 5° suggests lax or disrupted ACL. Isolated injury is rare. Various clinical tests to detect ACL tear are depicted in Table 13.2 and Figures 13.6B to F. The crucial test in diagnosing ACL tear is the Anterior Drawers test (Fig. 13.7). Lachman's test (Fig. 13.8) is useful in diagnosing fresh ACL tear.

Quick Facts

ACL TEAR

Differential Diagnosis: Hemarthrosis
- Ligamentous tears (ACL, PCL, etc.)
- Osteochondral fracture
- Peripheral menisci tear
- Capsular tear
- Patellar dislocation

Investigations

Radiograph of the knee The views recommended are anteroposterior (AP) view, lateral view, intercondylar notch view, sunrise views, etc. Radiographs are usually normal in

TABLE 13.2: Clinical tests to diagnose various knee ligament injuries (Figs 13.6A to F)

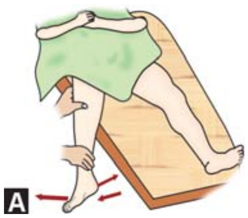
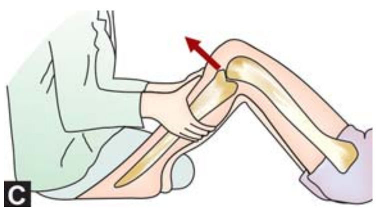
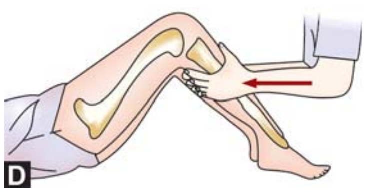
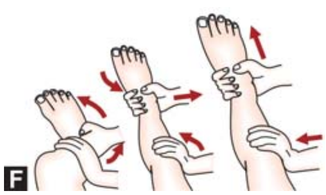
	Tests	*How to perform*	*Inference*
I.	**Adduction or varus:** **Abduction or valgus stress test** (Fig. 13.6A) 	Patient is supine, knee is flexed to 30° **For abduction test** One hand is on the lateral aspect of the knee and the other at the ankle, force is applied outwards. **For adduction test** Change hand to the medial side of the knee and give an adduction force.	Positive in injury to the medial structures of the knee like tibial collateral ligament. Positive in injuries to lateral structures of knee like fibular collateral ligament.
II.	**Lachman's* test** (Fig. 13.6B) 	This is an anterior drawer's test done at 20 to 30° of knee flexion with patient in supine position.	Indicates ACL tear. This test is used in acute injuries of knee to test ACL tear where knee cannot be flexed to 90°.
III.	**Anterior Drawer's test** (Fig. 13.6C) 	Patient is in supine position. Hip is flexed to 45° and knee to 90°. Examiner sits on the dorsum of the foot and pulls the tibia forwards. The anterior drawer's test is done in 3 positions: • Foot in neutral position—if positive it indicates ACL tear etc. • Foot in 15° internal rotation—if position, indicates damage to anterolateral structures. • Foot is 15° external rotation—if positive, indicates damage to anteromedial structures.	If the tibia shifts anteriorly more than 6 to 8 mm, then it indicates torn ACL and the test is considered as positive. This should always be compared with the normal knee.
IV.	**Posterior Drawer's test** (Fig. 13.6D) 	Same as above but tibia is pushed backwards. Positive test is indicated by the movement of the tibia backwards.	Indicates posterior cruciate ligament tear.
V.	**Jerk test of Hughston** (Fig. 13.6E) 	Patient is supine, knee is flexed to 90°, Tibia is internally rotated with a valgus force applied at the knee, it is slowly extended. *Lateral tibial condyle subluxates at 30° and spontaneous relocation occurs as knee extends.*	*Inference* indicates anterior cruciate ligament tear and is more specific than Drawer's test in detecting ACL tear.
VI.	**Pivot shift test** (Fig. 13.6F)  **Figs 13.6A to F**	Patient is supine. The knee is extended, with a valgus stress applied on the knee and the tibia is internally rotated. The knee is slowly flexed. Subluxation occurs at 30-40°.	A positive test indicates anterior cruciate ligament tear.

Fig. 13.7: Showing anterior Drawer's test

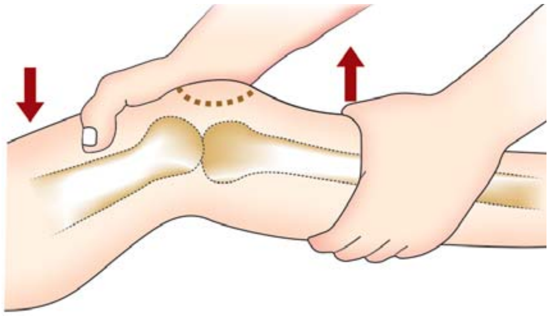
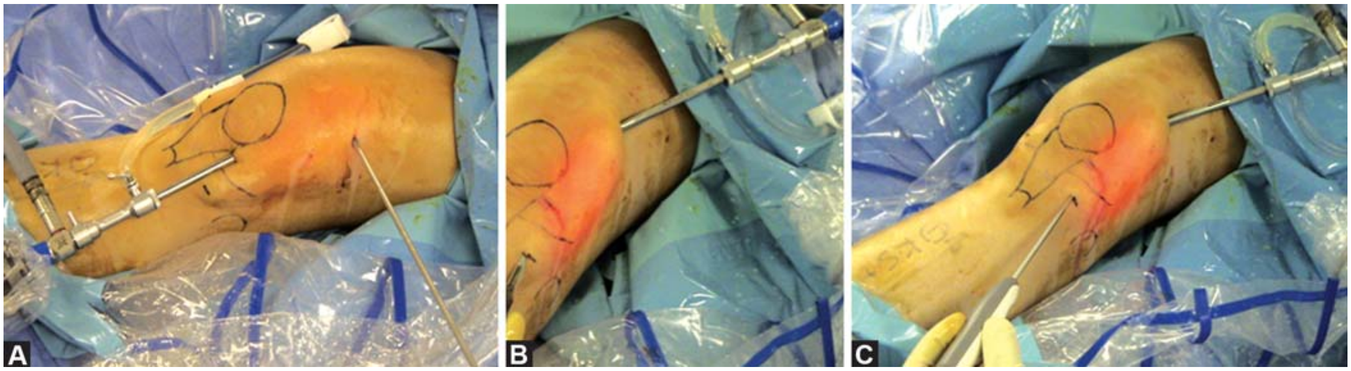


Fig. 13.8: Showing Lachman's test



Figs 13.9A to C: Clinical photographs showing arthoscopic surgery in case of ACL tear

ACL tear. Avulsion fracture of tibial spine if present indicates ACL tear.

MRI This is the best diagnostic tool. It is noninvasive and demonstrates the ACL tear with remarkable accuracy.

KT-1000 This is a measuring system that documents anteroposterior tibial displacement by tracking the tibial tubercle in rotation to the patella. More than 3 mm anterior displacement at 20 lbs predicts an ACL tear with 94 percent accuracy.

Vital points: ACL tear

- Common in young active people usually athletes may interfere with activity or it may make activity impossible.
- Usually it does not tear in isolation.
- Associated with other ligament injuries.
- May predispose to menisci lesions.
- May predispose to OA changes.

Treatment

Conservative This consists of rest, long leg casts for 4 to 6 weeks NSAIDs, physiotherapy, etc.

Surgical Arthroscopic repair and reconstruction is the mainstay of surgical treatment and has totally replaced the open method of repair (Figs 13.9A to C). The following are the different types of arthroscopic procedures in ACL surgeries:

Fresh cases Primary repair is indicated in young adults and athletes. Repair is successful if ACL is torn at its femoral or tibial attachments. It is not successful in mid-position tears. Failure rate is as high as 50 percent.

Old cases

- Reinforcement of ACL tear should be augmented except when avulsion is with a fragment of bone. Reinforcement could be either intra-articular or extra-articular or both by using iliotibial band, semitendinosus tendon, etc.
- Reconstruction in chronic ACL insufficiency could be either intra-articular or extra-articular replacement by using quadriceps, tendon, patellar tendon (central 1/3), semi-tendinosus tendon, etc.

Note For cruciate injuries repairs in fresh cases and reconstruction in old cases. Arthroscopic procedure is the method of choice in ACL tears.

TABLE 13.3: Instability of knee ligament tear

If only medial structures torn	*One plane medial instability*
If only lateral structures torn	*One plane lateral instability*
If ACL and medial structures torn	*Two plane anterior and medial instability*
If ACL and lateral structures torn	*Two plane anterior and lateral instability*
If PCL and medial structures torn	*Two plane posterior and medial instability*
If PCL and lateral structures torn	*Two plane posterior and lateral instability*

Posterior cruciate ligament (PCL) tear is less common than ACL tear. It is ruptured due to severe rotational injury, dashboard injury or complete dislocation of the knee. Isolated PCL tear is rare and is accompanied with other ligament injuries (Table 13.3).

Clinical Features

Patient complains of pain, swelling and tenderness over the popliteal fossa. Clinically posterior drawer test and *Sag Sign* will be positive (Fig. 13.10).

External rotation recurvatum test (posterior sag sign) When the leg is passively lifted by holding the toes, the knee sags posteriorly indicating injury to PCL and posterolateral structures.

Investigations: These are similar to the ones mentioned in ACL injuries.

Treatment: Repair in fresh cases as in ACL tears and reconstruction is done in old cases by using medial head of gastrocnemius, etc.

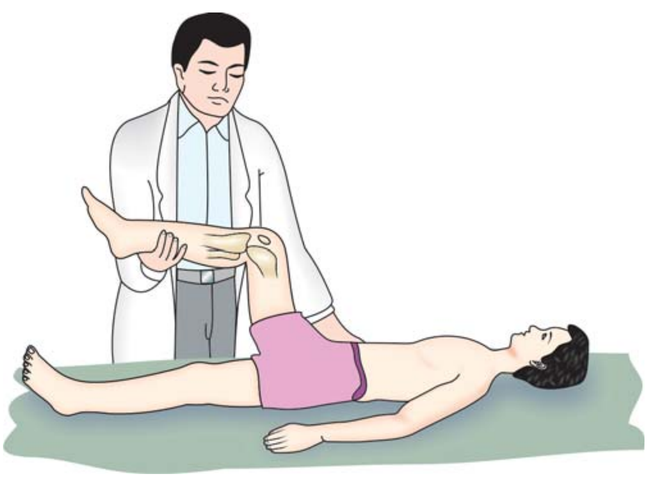


Fig. 13.10: Showing posterior *Sag sign* for PCL tear

Rupture of the cruciate and collateral ligaments either singly (rare) or in combination (common) makes the knee unstable. Depending upon the combination of injuries knee instability could be either one plane, two plane or both.

Physiotherapy Measures for Internal Derangement of Knee (IDK)

IDK is a broad term denoting ligament injuries, cruciate injuries, menisci injuries, etc. Physiotherapy management for IDK proceeds on the following lines:

During the Initial Stages

Here the emphasis is on efforts to reduce pain, inflammation and stiffness of the knee joint. The following measures are suggested:

- *Measures to control pain and inflammation*
  - — Thermotherapy—this includes ultrasound, SWD, TENS, interferential therapy, etc.
  - — Cryotherapy—ICE packs or ice massage for 15 mts every hour for 24-48 hours.
- *Measures to control limb edema* Leg elevation, compression bandage to control limb edema.
- *Measures to control stiffness*
  - — Isometric quadriceps exercises at 5 mt/hour are advised.
  - — Self-assisted gentle knee swinging exercises with the patient sitting at the edge of the bed or chair.
- *Measures to control deep vein thrombosis*
  - — Limb elevation
  - — Compression bandage
  - — Active exercises to the ankle and toes.

During Postacute Stage

Here the pain and inflammation have come down and efforts are made to mobilize the knee as follows:

- *Initiation of knee movements* Patient is instructed to sit at the edge of the bed or chair with the leg hanging. Small rhythmic active knee flexion and extension is carried out. The speed and arc of this movement is gradually increased to gain greater mobility (Fig. 13.11).

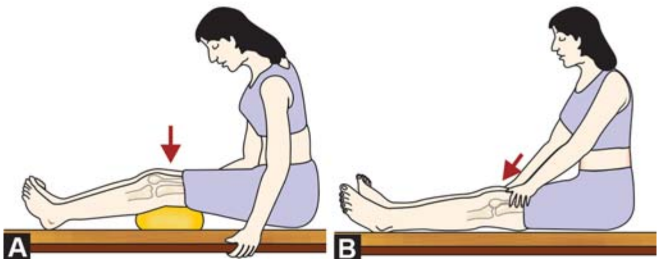
  Alternatively the affected leg could be supported by the normal leg in carrying out the above movements or CPM could also be employed.
- *Isometric quadriceps exercises* This can be done by various methods.
  - — Patient is in sitting position and contracts the quadriceps muscle.

Fig. 13.11: Self-assisted active knee swinging exercises for early knee mobilization

Fig. 13.13: Body weight resistive quadriceps exercises by the halfway floor squatting method

— Patient is in sitting position, keeps a soft roll beneath the knee, and presses it downwards (Fig. 13.12A).
— Patient is in sitting position, contracts the quadriceps and as the patella moves upwards, resistance is offered by pushing it down with the web of the hand between the thumb and index finger of the normal hand by the patient himself (Fig. 13.12B).
— As the above maneuver is being done, ankle can be dorsiflexed to make it more effective.
— Body weight resistive quadriceps exercises. This is done by continuous halfway floor squatting (Fig. 13.13).

- *Passive exercises* The ROM of the knee can be considerably improved by the passive ROM exercises. It will be more effective if practiced as follows:
  — Free heel drag: Here the heel is dragged to the buttocks by self assistive methods.
  — After doing the heel drag, the patient pulls the scarred and contracted tissues.



Figs 13.12A and B: Showing isometric quadriceps exercises: (A) Pushing against a soft pillow placed beneath the knee (B) While contracting offering resistance by pushing down with the web of the hand

- *Assistive devices for ambulation*, weight transfers, etc.
- *Deep ultrasonic massage* for adherent scars.
- *Strengthening isometric and isokinetic*, isotonic exercises for the quadriceps and hamstrings muscles.
- *Range of motion exercises*, both active and passive, for the affected and unaffected joints.
- *To improve the muscle strength of the lower limbs* Assisted SLR is advised during the initial stages. In the later stages patient is instructed to do the SLR actively and later by addition of weights to make it more effective.

Specific Physiotherapy Measures

After ligament repair

- After the surgical repair of the ligaments, patient is immobilized in an above knee POP cast for a period of 6-8 weeks.
- Non-weight bearing crutch walking is permitted at once.
- Active toe movements.
- Isometric exercises to the quadriceps and hamstrings are commenced within the cast.
- After 7 days assisted SLR is commenced.
- After 10 days, functional cast brace is applied.
- Cast is removed after 8 weeks and active knee exercises are begun.
- Progressive resistive knee exercises are allowed gradually.
- Gradual weight-bearing and gait training is permitted.

SEMILUNAR CARTILAGES

Anatomy

The semi lunar cartilages are two crescent-shaped plates of fibro cartilage that are placed on the condylar surface of the

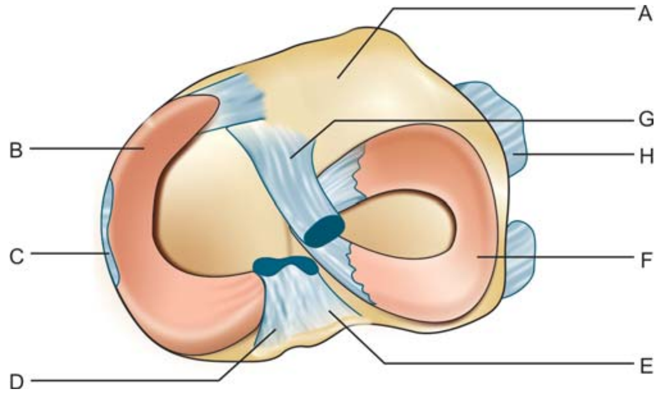
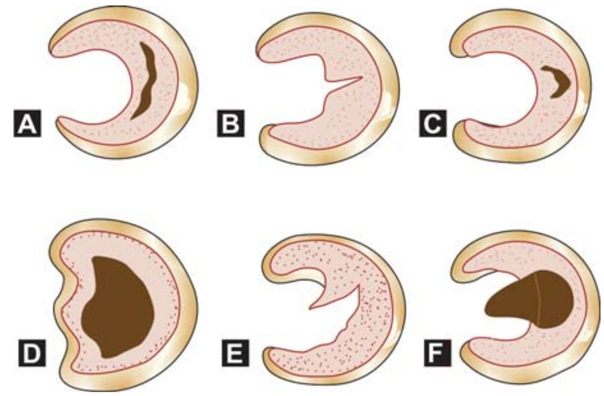


Fig. 13.14: Showing anatomy of two menisci: (A) Tibial tubercle, (B) Lateral meniscus, (C) Fibular collateral ligament, (D) Posterior cruciate ligament, (E) Ligament of Wrisburg, (F) Medial meniscus, (G) Medial collateral ligament, and (H) Tibial collateral ligament



Figs 13.15A to F: Different types of menisci injuries: (A) Longitudinal tear, (B) Radial tear, (C) Horizontal tear, (D) Bucket handle tear, (E) Parrot beak tear, and (F) Segmental tear

tibia. *They are commonly known as medial and lateral menisci and are unique in that not all species have menisci in their knees and not all joints have menisci*. They are vital for the function of the knee joint (Fig. 13.14). The vascular supply to both the menisci is from the lateral, medial and middle geniculate vessels. The depth of vascular penetration at the periphery is 10 to 30 percent width of medial meniscus and 10 to 25 percent width of lateral meniscus. In cross-section they appear triangular, the thicker peripheral portion is vascular and heals well and the thin central edge is avascular, receiving nutrition by diffusion and hence heals poorly.

Functions of the Menisci

- Contributes towards the stability of the knee joint.
- Weight transmission of 40 to 70 percent of the load across the knee joint.
- Acts as a shock absorber.
- Deepens the tibial condyles on which the femoral condyles roll by increasing the contact area by 40 percent.
- Assists in nutrition of the articular cartilage by distribution of the synovial fluid.
- Helps the knee in locking mechanism.
- Assists and controls gliding and rolling motion of the knee.

Smillie's Classification

Medial meniscus injury (Figs 13.15A to F) is seen in over 71 percent of the cases. In 5 percent of cases injury of medial meniscus is bilateral. Lateral meniscus is less commonly injured than the medial meniscus because it is smaller in diameter, thicker in periphery, wide, more mobile, attached to both cruciate ligaments and stabilized posteriorly to the femoral condyle by popliteus.

- *Longitudinal tears* (35%)—in these peripheral attachments tear 10 percent, complete tear 23 percent (bucket handle tear), and segmental tear 2 percent (ant/post).
- *Horizontal tears* (48%)—could be posterior, middle, or anterior.
- *Cystic degeneration* (12%).
- *Congenital abnormalities* 5 percent.
- Regenerative lesions.

MEDIAL MENISCUS INJURY

Medial meniscus is more commonly injured than the lateral and is usually associated with other ligament injuries of the knee.

Mechanism of Injury

Mechanism of injury is a rotational force when a flexed knee extends.

- In young, it can occur only when weight is being taken, knee is flexed and there is a twisting strain. Young active athletes are more prone
- In middle life, fibrosis has decreased the mobility of meniscus and hence tear occurs with less force.

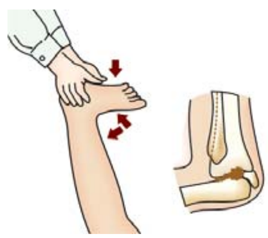
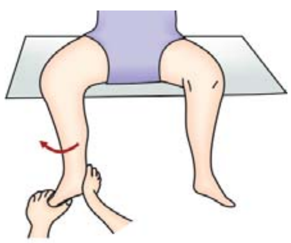
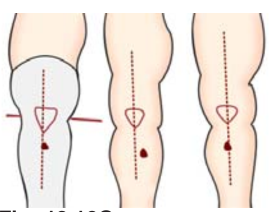
Predisposing factors These could be abnormal menisci shape, abnormal stress due to chronic ligament laxity, etc.

Clinical Features

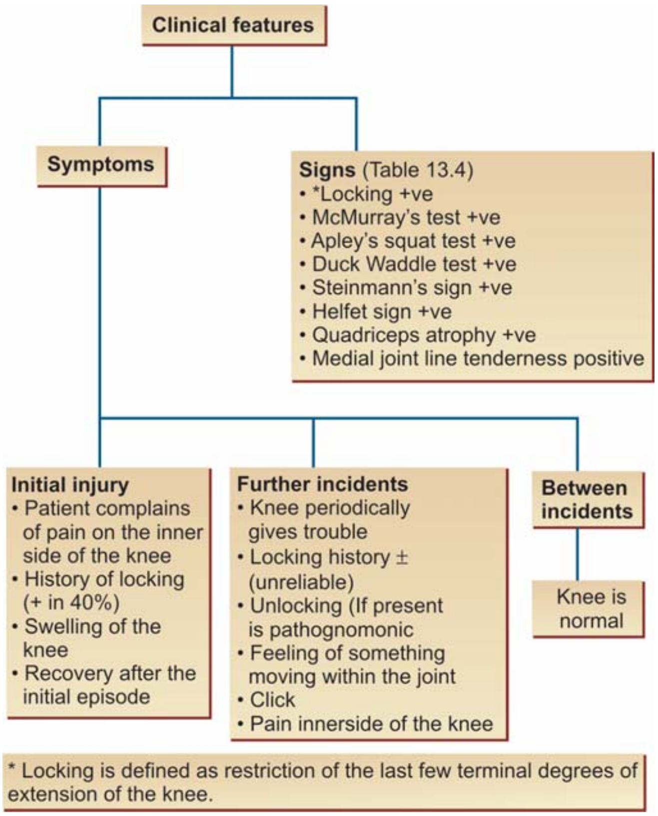
Patient complains of pain, limp, locking, swelling, painful restricted knee movement, etc. (Flow chart 13.2).

Clinical tests To diagnose medial meniscus injury and associated knee structures one shown in Table 13.4, Figures 13.16A to G.

TABLE 13.4: Clinical tests for diagnosis of meniscal injuries (Figs 13.6A to G)

 Fig. 13.16A	**Joint line tenderness** The medial joint line tenderness is an important clinical sign in detecting medial meniscus injury. It is positive in 74% of the cases (Fig. 13.16A)	 Fig. 13.16B	**McMurray's test** Here forced flexion and internal rotation as shown in 1 and external rotation as shown in 2 is done to test the lateral meniscus and the medial meniscus respectively. A positive McMurray test requires both pain and clunk to be felt by the examiner's finger on the medial side (Fig. 13.16B).
 Fig. 13.16C	**Duck waddle test** (Fig. 13.16C) The patient assumes a squatting position with heels touching the buttock and is asked to perform a duck walk. Patient will be unable to assume full squatting position in medial meniscus injury This is called as *childress sign* and is a diagnostic test for posterior horn tear of medial meniscus.	 Fig. 13.16D	**Apley compression test** (Fig. 13.16D) The patient is prone, fixing the thigh against the table the examiner presses the foot and leg downward while rotating the tibia (grinding test) Pain noted during axial compression implies a meniscal lesion.
 Fig. 13.16E	**Steinmann I sign** (Fig. 13.16E) Meniscal pathology may be suspected if medial pain is elicited on lateral rotation (medial meniscus injury) and lateral pain on medial tibial rotation (lateral meniscal injury).	 Fig. 13.16F	**Apley distraction test** (Fig. 13.16F) The technique is the same as above but here the examiner pulls the foot and leg upward to distract the joint while again rotating the tibia. Pain noted during axial distraction of joint implies a ligamentous lesion.
 Fig. 13.16G	**Helfet sign** (Fig. 13.16G) In normal knee in sitting position tibial tubercle lies in line with midline of the patella. When extended, lateral tibial rotation puts it in line with lateral border of patella. *Positive sign occurs when the rotation is blocked by a torn meniscus and the tubercle remains centred over the patella in extension.*	***Note***	• *The Apley test is unique among the meniscus tests because of its ability to distinguish between ligamentous and meniscal lesions.* • *Positive meniscus test confirms the suspicion of meniscal lesion. However, negative tests do not rule out a tear with absolute confidence.* • *No one test is diagnostic, hence a combination of tests are carried out. With this the accuracy rate* for *diagnosis raises by 60 to 95 percent.* • *The routine work-up could best include joint line tenderness, McMurray's test and Steinmann's sign.*

Flow chart 13.2: Showing clinical features in medial meniscus injuries



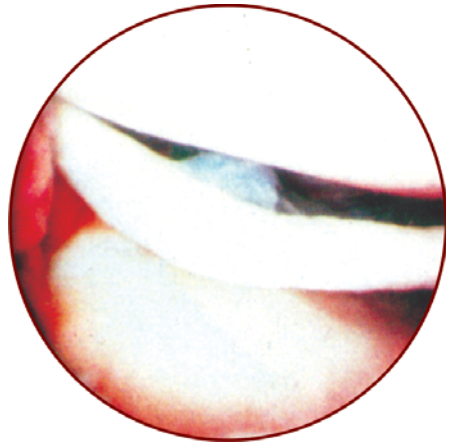


Fig. 13.17: Arthroscopic views of a bucket handle of medial meniscus injury

Differential Diagnosis of Locking

True locking	*Pseudolocking*
• Loose bodies	• Ligament injuries
• Recurrent dislocation of patella	• Chondromalaciae patella
• Fracture of tibial spine	
• Meniscal injuries	

Investigations

- Radiograph is usually normal. The views recommended are anteroposterior, lateral, intercondylar notch and sunrise views of the patella.
- Arthroscopy helps to identify the torn meniscus (Fig. 13.17).
- Arthrography may reveal the tear. Double contrast arthrography is 95 percent accurate.
- MRI expensive but useful.

Differential Diagnosis

Fracture of tibial spine if present may give clue to the possible ACL tear. It also helps to exclude osteochondritis dissecans, osteocartilaginous loose bodies, etc.

Treatment

Conservative This is indicated in patients soon after injury with no locking and with infrequent attacks of pain.

Measures
- Abstinence from weight bearing.
- Rest, ice packs, compression bandage.
- Buck's skin traction.
- Joint aspiration.
- Quadriceps exercises.
- If symptom persists a cylindrical cast may be considered.

Manipulations under anesthesia If joint is locked due to the torn menisci manipulation under anesthesia is recommended.
Surgery indications If joint cannot be unlocked and if symptoms are recurrent.

Procedures

Partial menisectomy by open methods was recommended in the earlier days. Now it is mainly done by an arthroscopy.

Physiotherapy Measures After Meniscectomy

First 24 hours Circumduction exercises to the ankle joint. Assisted SLR is indicated

48 hrs to 5th day Isometric exercises to the quadriceps and hamstrings. Gradual weight-bearing.

After 14 days
- Active flexion—extension knee exercises are begun.
- Vigorous isometrics to the quadriceps and hamstrings.
- Progressive resistive knee exercises.
- Hamstring stretching exercises.

PHYSIOTHERAPY MEASURES AFTER ARTHROSCOPY

Introduction

Arthroscopy is an instrument used to visualize and inspect the structures of a joint through a key hole incision. Though commonly used for knee joints, it is also useful in shoulder, elbow, wrist and ankle joints. The procedure of using an arthroscope is called arthroscopy. It has a diagnostic and therapeutic role.

Closed partial meniscectomy via an arthroscopy is better than total removal of the menisci by open surgery. Complete removal of the menisci incapacitates the knee; hence, the emphasis is on conservative surgery than the radical removal. Suture of a peripheral tear either by open or arthroscopy is also tried (Fig. 13.17).

Preoperative Physiotherapy

This is aimed to make the postoperative rehabilitation program more effective, so that the patient can have a faster recovery. The following are some of the important preoperative physiotherapy measures:

- Quadriceps exercises to reduce the swelling.
- Knee swinging for early return of function.
- Raised SLR to strengthen the knee.
- To improve the posterior stability of the knee resistive exercises to hamstrings and calf muscles.

Postoperative Physiotherapy

Here the physiotherapy is given in stages (Zairns, 1985).

First 5 days

- Measures to reduce pain—thermotherapy.
- Measures to reduce effusion—speedy quadriceps exercises, resistive ankle and foot movements, SLR, etc.
- Measures to prevent reflex inhibition—sustained quadriceps exercises with 5-10 seconds hold.
- Measures to improve the range the movements—Relaxed knee swinging.

5-15 days

- The above measures are made more vigorous.
- Knee ratchet and ped-o-cycle regime.
- Ambulation with supported or full weight bearing
- Patient is taught weight transfers.
- In this phase, patient should be able to achieve 90° knee movements.

2-3 weeks

- Knee movements should be around 120°.
- Patient should be able to stand alone on the unaffected leg.
- PRE to the quadriceps.
- Patient is allowed floor squatting, cross leg sitting and prone kneeling.
- Ambulation with minimum or no support.

3-5 weeks

- Isotonic knee exercises are commenced.
- ART to the quadriceps are continued.
- Balancing activities to improve proprioception.
- Gait training.
- Patient may be permitted to resume work.

After 6 weeks Patient is allowed spot running, straight jogging, jumping, hopping, etc. Patient can be allowed to return to active sports.

FRACTURE OF PATELLA

Patella is the largest sesamoid bone in the body.

Incidence is around 1 percent.

Mechanism of Injury

Direct trauma This is due to dashboard injuries and direct fall over the patella. They usually cause comminuted fractures, and are the common causes.

Indirect trauma (quadriceps contraction) Sudden forceful contraction of the quadriceps as in sports person and athletes can cause patellar fractures. Here the fracture is usually transverse and sometimes avulsion fractures of the proximal or distal poles may also be seen.

Age Common in 40-50 years age group.

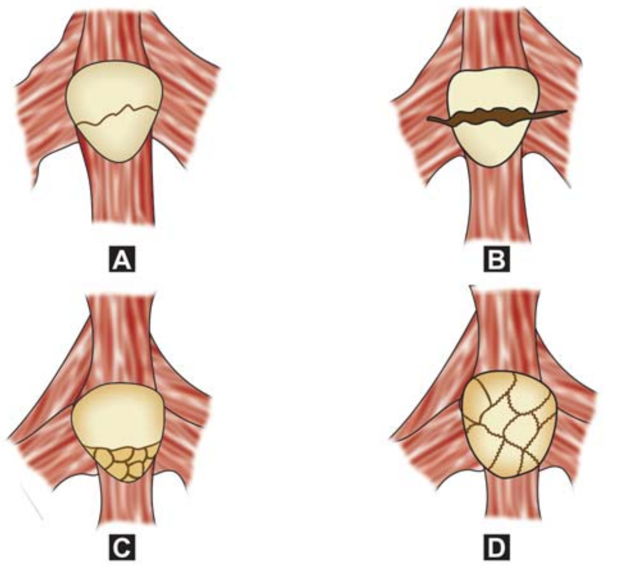
Male: Female = 2:1

Classification (Figs 13.18A to D)

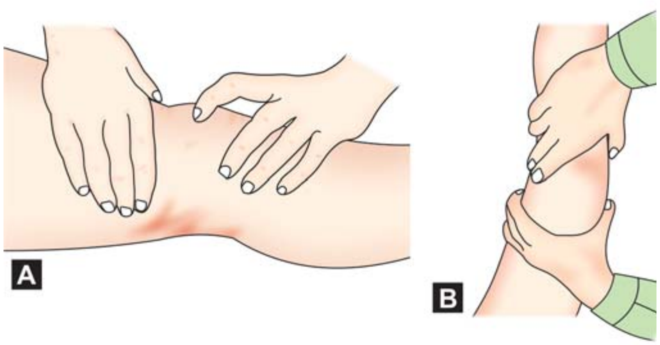
- Undisplaced
- Displaced
  - — Transverse—involving upper or lower poles (50-85%).
  - — Oblique fracture
  - — Vertical fracture (12-27%).
  - — Comminuted fracture (30-35%).

Clinical Features

Patient gives history of trauma following which there is pain and swelling at the knee joint. Patient is unable to extend the



Figs 13.18A to D: Showing types of patellar fractures: (A) undisplaced fracture, (B) transverse fracture, (C) distal pole fracture, and (D) comminuted fracture



Figs 13.19A and B: (A) Showing method to eliciting patellar tap (B) Showing method of eliciting fluctuation test to defect gross knee effusion

knee and both the active and passive movements are restricted. On examination there could be a palpable gap, tenderness, signs of effusion, a positive patellar tap (Fig. 13.19A), positive fluctuation test (Fig. 13.19B), etc.

Radiograph

Plain X-ray of the knee, AP and lateral views help to study the fracture of the patella (Figs 13.20A and B).

Management

Undisplaced fracture Nonoperative treatment will produce good results in undisplaced fracture and if displacement is less than 1 to 2 mm and the methods include compression bandage, ice applications, aspiration of hemarthrosis,

Figs 13.20A and B: (A) Showing transverse fracture of the patella and (B) TBW for patella fracture

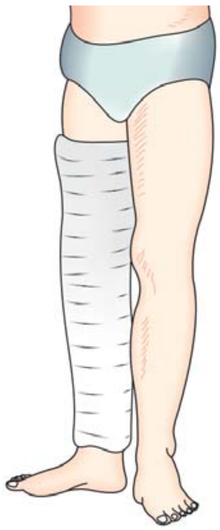


Fig. 13.21: Showing cylindrical cast

cylindrical cast (Fig. 13.21), early weight bearing and quadriceps exercises.

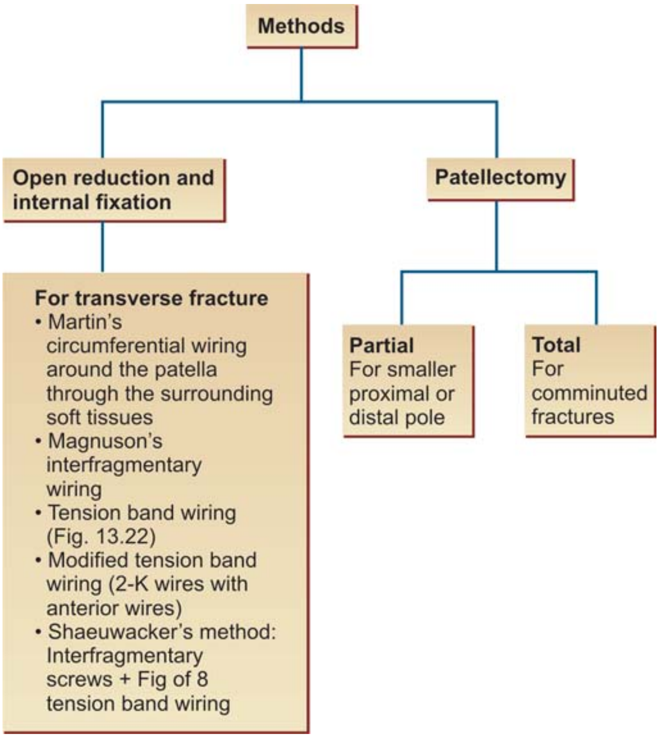
Displaced fracture In this variety surgery is the treatment of choice. Surgery is performed as early as possible preferably within seven days (Flow chart 13.3).

Surgical Methods

Open reduction and internal fixation This is indicated in transverse fractures of the patella. Internal fixation is done either by the circumferential wiring or by tension band wiring (Figs 13.20B and 13.22) as shown the following flow chart.

Patellectomy This is done for communited fractures and could be either partial (for smaller distal or proximal pole fracture)

Flow chart 13.3: Showing treatment methods in patella fracture



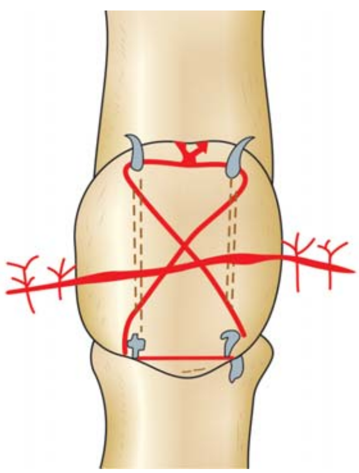


Fig. 13.22: Showing tension band wiring (TBW) for displaced transverse fracture of patella

or complete (for comminuted fractures). The emphasis is now on preserving as much patella as possible.

Complications

Postoperative complications Early fracture dehiscence, postoperative infection, refracture (1-5%), avascular necrosis (25% incidence in proximal pole) are some of the common postoperative complications.

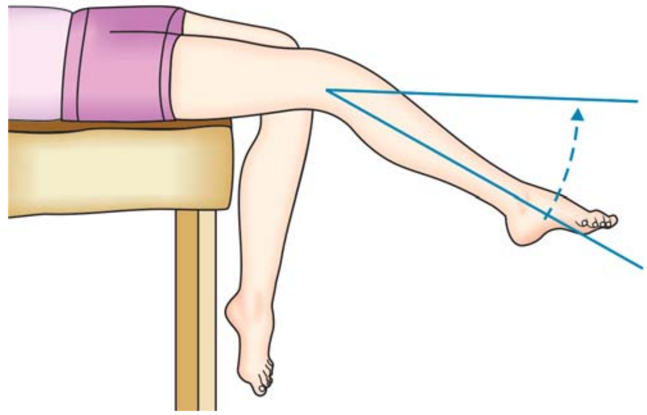


Fig. 13.23: Showing extensor lag following patellectomy

Delayed complications This is like knee stiffness, osteoarthritis of the patellofemoral and knee joint extensor lag, etc. can also occur.

Disadvantages of patellectomy

- Strength of quadriceps returns slowly although knee motion is regained quite fast.
- Obvious atrophy of the quadriceps muscle persists for months and often permanently.
- Protection of the knee by the patella is lost.
- Pathological ossification may develop where the patella is excised.

Extensor lag This is inability of the patient to perform the last 10° of extension. About 80 percent of quadriceps strength is required to bring about the last 20° of extension. After patellectomy, due to the decreased lever arm the efficiency of quadriceps is reduced and the patient will be unable to bring about the terminal extension of the knee (Fig. 13.23). *Thus, an attempt is made to save as much of patella as possible, all of the patella or at least the proximal or distal half, if practical to preserve the quadriceps efficiency.*

Physiotherapy Management

The physiotherapy management following patellar fractures aims to achieve the following goals:

Orthopedic goal To restore the anatomy back to normal or less than to 2 mm gap on the articular surface of patellofemoral joint.

Rehabilitation goals To restore full range of knee movements both in flexion and extension and to prevent extensor lag. To improve the strength of quadriceps, hamstrings and glutei muscles.

Functional goals To restore the gait pattern back to normal.

> *Note*
> - Required time for bone healing—8-12 weeks.
> - Required time of rehabilitation—12 to 15 weeks
> - Vastus medialis is the first muscle to be affected and the last to recover

Physiotherapy Management for Patella Fractures Treated Conservatively

Undisplaced patellar fractures or fractures with articular congruity < 2 mm are treated with a cylindrical cast for a period of 3-4 weeks. The treatment proceeds on the following lines.

During the first 2 weeks The cast is inspected for any breakages and is trimmed above the malleoli. The limb is kept elevated to prevent edema. No knee range of motion is allowed. Straight leg raising exercises with the cast slab or knee immobilizer is allowed and held up to a count of 10. Isometric glutei and isotonic ankle exercises are permitted. Weight-bearing with crutches or walker is allowed after 24 hrs.

After 2 weeks The cast is removed after 3-4 weeks and a knee immobilizer is worn as a night splint. Active knee movements are commenced and slowly progressed to active-assistive and passive range of movements. Isometric and isotonic exercises of the quadriceps and hamstrings are begun. Hip and ankle exercises are continued. Full weight-bearing is allowed.

> *Note* Knee movements.
>
> No movements ⟶ Active movements → Active
> Assisted → Passive
> ↓
> First 2 weeks All movements together
> After 2 weeks

Quick Facts

> Conservative management for fracture patella:
> - Frequent cast inspection.
> - Limb is kept elevated.
> - Cast removal after 3-4 weeks.
> - Knee movements commenced and gradually progressed from active to passive.
> - SLR and isometric quadriceps exercises are done regularly.

Physiotherapy Management for Surgically Treated Patellar Fractures

Displaced fracture, patella > 2 mm, are treated with open reduction and tension band wiring while the comminuted fractures are treated with patellectomy. The physiotherapy regime is done as follows.

During the first 2 weeks Wound inspection is done regularly and the sutures are removed after 10-12 days. Limb is kept elevated to prevent edema. Initially the limb may be protected by a cast, posterior splint or a knee immobilizer. Active knee movements are commenced if the fixation is stable. However, no passive range of motion exercises is allowed. Isometric glutei, isotonic ankle exercises are carried out vigorously. Weight-bearing is allowed in the cast or immobilizer, initially with the help of crutches or walker.

After 2 weeks Knee movements are progressed from active flexion, to active assistive and passive range of movement exercises. Isometric and isotonic quadriceps and hamstrings exercises are begun. Hip and ankle exercises are continued. Full weight-bearing is allowed after 4-6 weeks.

Types of Isometric Quadriceps Exercises

Indirect Here the knee is pressed against a pillow kept underneath. This is used in the initial stages of quadriceps strengthening exercises (see Fig. 13.12A).

Direct This is the conventional quadriceps exercises, where the patient makes voluntary contractions of the quadriceps muscle in standing or sitting positions.

Self-assisted or resistive isometric quadriceps exercises This is done by the patient himself using the web between the thumb and the index finger for pushing the quadriceps down, while contracting it (*see* Fig. 13.12B).

Quick Facts

> Open reduction and internal fixation with TBW
> - Wound inspection, sutures removed after 10 to 12 days
> - Active knee movements within 2 weeks
> - Isometric quadriceps commenced after 2 weeks
> - Full weight-bearing by 4-6 weeks
> - 8-10 weeks may be required to regain full ROM

For those patients treated with patellectomy, along with the above measures, more vigorous exercise is advocated to strengthen the quadriceps, hamstrings and knee ligaments as they are considerably weakened after the removal of patella. Progressive resistive exercises are carried out. Adjunctive measures like hydrotherapy, thermotherapy, electrical stimulation, etc. are of great help. Assisted SLR and proper gait training are the other recommended measures.

ACUTE DISLOCATION OF PATELLA

Lateral dislocation of patella is very common and is due to lateral force acting on a semi flexed knee.

Clinical Features

Patient complains of severe pain, swelling and inability to bend the knee. Patella is seen and felt on the lateral side.

Radiograph

X-ray of the knee both AP and lateral views are recommended.

Treatment

Conservative Closed reduction and above knee POP casting is done under GA. Immobilization may be required for a period of 4 weeks.

Physiotherapy Measures

During the period of cast immobilization:

- Isometric quadriceps exercises are initiated at the earliest.
- Active toe flexion exercises.
- Assisted SLR.
- The patient can be mobilized on a crutch and partial weight-bearing may be permitted once the pain comes down.

After Removal of the Cast

- Thermotherapy.
- Vigorous isometrics to the quadriceps.
- Active, active assisted knee flexion exercises.
- PRE is advised to the knee.
- Passive ROM helps.
  By 8 weeks patient should be functionally independent.

ACUTE DISLOCATION OF KNEE

This is an uncommon injury and is due to severe violence as in RTA, fall, etc. It is usually associated with injuries to collateral cruciates and meniscus. Patella may also be fractured or dislocated (Fig. 13.24).

Clinical Features

Patient complains of severe pain, swelling and inability to bend the knee. There could be severe loss of functions of the knee joint.

Radiograph

X-ray of the knee both AP and lateral views are recommended (Fig. 13.25).

Fig. 13.24: Showing posterior dislocation

Fig. 13.25: Plain X-ray showing dislocation of knee

Treatment

Conservative An attempt may be made for closed reduction under GA. An above knee POP cast is applied for 12 weeks.

Surgery Open reduction may be required if closed reduction fails or if there is extensive ligament injuries which may require repair, reconstruction or both. Knee is immobilized in an above knee POP cast for 12 weeks.

Physiotherapy Measures

During the period of cast immobilization:

- Active ankle, toe exercises.
- Isometrics to the glutei and quadriceps are begun at the earliest.
- Non-weight bearing crutch walking from 3rd to 4th day.
- Assisted SLR by the therapist after 7 days.

After removal of the POP cast

- Thermotherapy to control pain and swelling.
- Vigorous isometrics to the quadriceps.
- Active and active assisted knee flexion.
- Passive knee exercises.
- PRE to the knee.
- Gradual weight-bearing is allowed.

SOFT TISSUE INJURIES AROUND THE KNEE AND THE THIGH

Injury to the Extensor Apparatus of Knee

The extensor apparatus of the knee is comprised of the following structures:

- The quadriceps muscle with a group of six extensor muscles and the quadriceps femoris tendon.
- Patella.
- Ligamentum patellae (Patellofemoral and patellotibial ligaments).
- Patellar bursa and the fat pads.
- Capsule and the synovial membrane.

Note The quadriceps muscle consists of rectus femoris, Vastus medialis, lateralis, intermedius, and articularis genu and ligament patella.

Quadriceps Strain

Causes
- Direct blow to the muscle.
- Indirect due to violent sudden contractions.

Sites
- Rectus femoris is the most commonly injured muscle.
- This is followed by vastus medialis, lateralis and intermedius.
- Avulsion may occur at the upper pole of patella or tibial tubercle and rarely through the patella.

Symptoms
- In rectus femoris injury patient complains of pain during hip flexion and knee extension as this muscle is known to act on both these joints. Tenderness is present at the site of injury.
- In grade III sprain a gap may be felt at the site of rupture and ambulation is difficult.
- In injuries to the vastus medialis, intermedius and lateralis patient may complain of pain and limp. Terminal stage of flexion and resisted knee flexion is extremely painful.

Treatment In general, grade I and grade II injuries can be managed conservatively while grade III injury may require surgical suturing in the event of complete rupture and loss of function.

Physiotherapy in Grade I and II Strain

- Ice therapy and ice packs.
- Compression bandaging (Jones).
- Limb elevation.
- Mild isometric exercises.
- Relaxed passive knee movements.
- To improve the strength and mobility of the knee joint, active and active-assisted knee exercises are begun.
- PRE to increase the endurance of the knee muscles.
- Gradual weight-bearing with assistive devices.
  Patient should be functionally independent by 6 weeks.

Grade III Strain

- Quadriceps exercises are begun by 5-6 days.
- Self-assisted SLR.
- By 2nd or 3rd day non weight-bearing and partial weight-bearing by 3 weeks, full weight-bearing by 6 weeks.
- For extensor lag, electrical stimulation helps.
- Rest of the measures is the same as mentioned above.

Fracture Patella

This has already been discussed.

Patellar Tendinitis (Jumper's Knee)

Cause repeated Trauma to the tendon bone junction at the lower pole of the patella as in athletes especially jumpers. Hence the name

Clinical features
- Patient complains of pain at the inferior pole of the patella
- Limp
- Tenderness is present over the inferior pole.

Treatment
- Ice therapy in the initial stages
- Rest
- Compression bandage
- Limb elevation
- Thermotherapy in later stages
- Gentle isometrics to the knee
- Knee is then gradually mobilized as mentioned in quadriceps strain.

Prepatellar Bursitis

This is discussed on page 311.

Plica Syndrome

This is injury to the intrapatellar fat pad and the associated synovial lining.

Cause Usually injured indirectly due to violent muscle contractions.

Clinical features
- Patient complains of pain at the medial border of the patella at the lower end.
- Usually patient experiences pain after prolonged sitting with knee flexed.
- Diagnostic tests:
  — Medial displacement of patella with knee at 30° flexion causes pain.
  — During active extension of the knee, patella slips between 45-60°.

Treatment

- In mild cases, routine knee rehabilitation measures discussed so far.
- In addition, transverse friction massage and hamstring stretching sessions are recommended.
- In unresponsive cases, arthroscopic excision of the plica is recommended.

Other Thigh and Leg Muscle Strains

Hamstrings Strain

This is a common injury in sports persons.

Cause

- May be due to direct trauma.
- Indirect trauma may be due to pull or avulsion injury.

Sites Hamstring injury commonly occurs at the insertion of the biceps femoris muscle near the fibular head.

Clinical features

- Patient complains of pain at the fibular head.
- Tenderness is present over the head of the fibula.
- Due to the spasm of the hamstring muscle, the knee assumes a slightly flexed position.
- Patient complains of pain during active extension and resisted flexion.
- In severe strains, weight-bearing is severely affected
- There may be injury to the common peroneal nerve.

Treatment

- Ice packs in the initial stages.
- Compression bandaging.
- Patient is encouraged to adopt the resting position recommended for injured hamstrings (Fig. 13.26).
- Limb elevation.
- Drug therapy with analgesics, muscle relaxants, etc.
- Thermotherapy in the later stages.
- Early isometrics to quadriceps and hamstrings.
- Relaxed knee swinging initiated as soon as pain permits (see Fig. 13.11).
- Gradual strengthening exercises are commenced. Patient should resume full functional activity by 4-5 weeks.

Fig. 13.26: Showing the resting position for the injured hamstrings

- Hamstring stretch exercises are commenced after the pain subsides (*see* page 501).

Calf Muscle Strain

Sudden overstretching of the calf muscle occurs commonly in sportsmen causing calf muscle strain.

Symptoms

- Pain in the calf muscle.
- Resisted plantar flexion is painful.
- There is loss of toe push off while walking.

Treatment

- Ice therapy.
- Compression bandage.
- Limb elevation.
- Drugs like pain killers muscle relaxants, etc.
- Knee rehabilitation program as mentioned earlier.
- Calf muscle stretch exercises are gradually commenced (see Figs 14.10A to C).

Tendo-Achilles Injury

Though tendo-Achilles is the thickest and strongest tendon in the body, it is quite susceptible to injury.

Site It is commonly injured about 4-5 cm proximal to the insertion at the calcaneum. This is the site of relative poor blood supply and also the abrupt changing of muscle to tendon. Two varieties of tendoachilles injury are commonly described:

Tendinitis Constant pressure and friction due to ill-fitting footwear can cause tendinitis. Patient may complain of pain, swelling, nodule and tenderness over the injured site. Tip-toe standing or resisted plantar flexion causes pain.

Treatment

During the initial stages

- Ice therapy in the initial stages
- Limb elevation
- Compression bandaging
- Pain killers and muscle relaxants
- Deep transverse friction massage
- Thermotherapy in the later stages
- Heel raise and heel cushion to absorb shocks
- Passive ROM to the ankle and foot
- Resisted toe flexion with foot in neutral position
- Non-weight bearing.

Later stages

- Ultrasound therapy
- Passive stretching to prevent adhesions

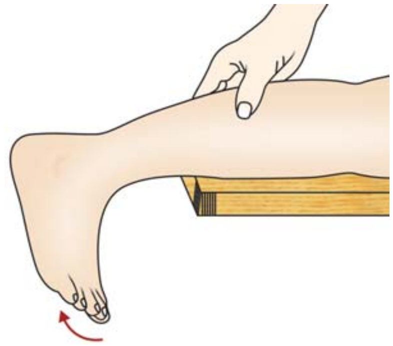


Fig. 13.27: Showing method of performing Thompson's test for TA rupture

- Gradual weight bearing, first on one leg and then both
- Gait training.

Rupture of Tendo-Achilles This is commonly seen in:
- Athletes and sportsperson
- Middle aged persons
- Accidental slip of the foot into an Indian toilet closet (characteristic history).
- Direct trauma with a sharp cutting weapon.

Clinical features Patient complains of pain, swelling, palpable gap and difficulty in standing on the toes.

Diagnostic tests
- Patient is unable to stand on the tip toes and raise the heels.
- *Thompson's test* Patient is prone and the foot is brought outside the edge of the table or bed. If the TA is intact, squeezing the calf muscles will cause plantar flexion of the foot. This is not seen in TA rupture and is sluggish if there is partial rupture (Fig. 13.27).

Treatment

Conservative methods
- Above knee POP cast, with knee in 30° flexion and the foot in plantar flexion.
- After 8 weeks the cast is removed and high heeled footwear is given for another 8 weeks.
- Active exercises to the toes are begun.

Surgery This is the method of choice in treating TA ruptures. Fresh ruptures may be sutured directly while an old rupture needs repair or reconstruction from a strip of fascia lata or the proximal part of the same tendon, etc. After the surgery, knee is immobilized in an above knee POP for a period of 6-8 weeks with the foot in full equinus. A further period of immobilization in a below knee cast may be required for 2-3 weeks.

Postoperative physiotherapy
- Non-weight bearing for 6-8 weeks.
- Relaxed, gentle passive dorsiflexion.
- Gradual partial weight-bearing with a heel raise of 2 cm.
- Deep ultrasound therapy.
- Deep transverse friction massage.
- Partial weight bearing after 8-10 weeks.
- Gradually full weight-bearing is permitted and proper gait training is instituted.
- Calf muscle stretch exercises as mentioned on page 190.

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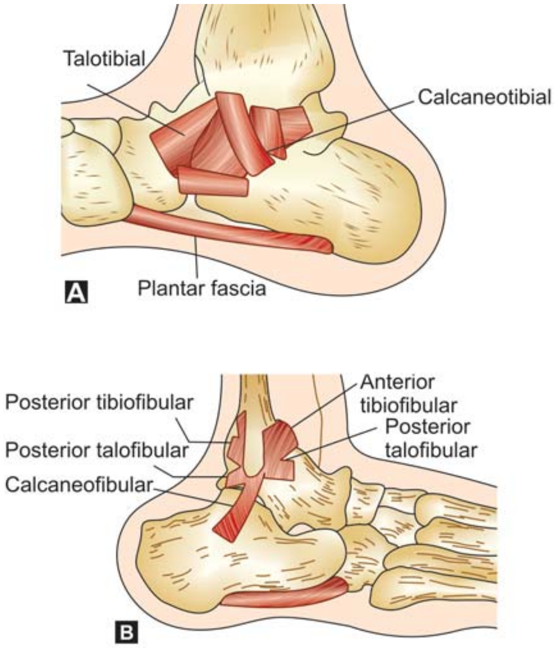
14 Chapter

Injuries of Ankle and Foot

ANKLE INJURIES

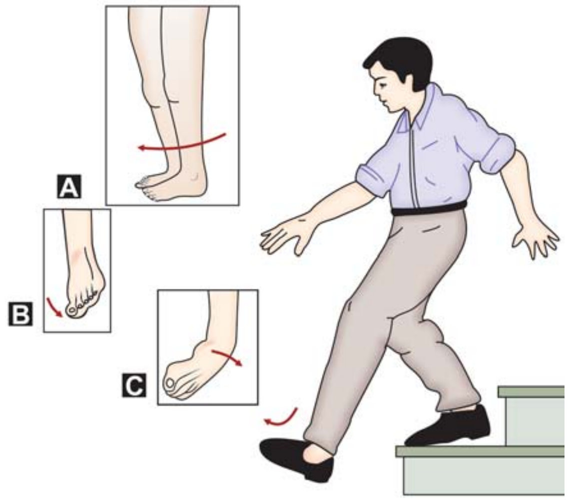
Pott described ankle injuries for the first time in 1768. The ankle joint is made up of distal end of tibia fibula and the talus. It is bounded on either side by strong ligaments (Figs 14.1A and B).



Figs 14.1A and B: Showing anatomy of ankle ligaments: (A) Medial side, (B) Lateral side

Mechanism of Injury

- Twisting injury while walking, running, sports, athletes, etc. are the most common mode of ankle injuries (Figs 14.2A to C).
- Fall from a height: Ankle injuries are indirect injuries here brought about by the displacing talus.



Figs 14.2A to C: Showing common mechanism of ankle injuries: (A) External rotation force, (B) Abduction force, (C) Adduction force

Ankle injuries could be due adduction, abduction or external rotation forces.

Adduction force Causes transverse fracture of lateral malleolus, tear of lateral collateral ligament and fracture of medial malleolus (Fig. 14.3).

Fig. 14.3: Fractures due to adduction force

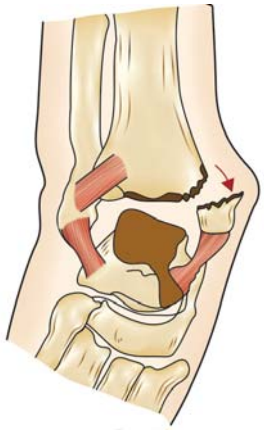


Fig. 14.4: Fractures due to abduction force

Fig. 14.6: Clinical photograph showing bimalleolar fracture

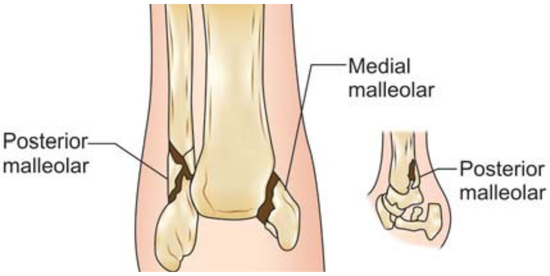


Fig. 14.5: Trimalleolar fracture (due to external rotation force)

Fig. 14.7: Plain X-ray of the ankle showing bimalleolar fractures

Abduction force Causes transverse fracture of medial malleolus, deltoid tear and oblique fracture of lateral malleolus (Fig. 14.4).

External rotational force Fracture of both malleoli and posterior malleolar fracture (Fig. 14.5).

Clinical Features

Patient usually gives history of inversion injury, following which there is pain, swelling, deformity of the ankle. Movements are decreased, Drawer's test, inversion and eversion stress tests may be positive (Fig. 14.6).

Radiograph

Plain X-ray of the ankle, AP and lateral views of the ankle helps to identify the malleolar fractures (Fig. 14.7).

Treatment

Goals

- Anatomical positioning of the talus.
- To obtain a joint line that is parallel to the ground.
- Smooth articular surface.

If these goals are not achieved, post-traumatic osteoarthritis results.

For stable injuries no reduction is required, immobilization with only plaster splints till the swelling decreases and then a below-knee plaster cast is applied with foot in neutral position.

Unstable injuries require reduction and immobilization in plaster casts. The commonly encountered unstable injuries are:

Fracture due to external rotation This is more common and can be managed both by conservative and operative methods.

Conservative method This consists of reversal of the injuring forces by closed reduction and a below-knee plaster cast application. A walking cast is applied after a period of one month.

Surgical method In these both the malleoli are fixed, first the lateral malleoli is fixed with pin or screws and later the medial malleolar fracture is fixed with a single screw perpendicular to the fracture line. Below knee splint is given initially and later a cast is applied.

Fracture primarily due to abduction These are less common than the fractures due to external rotation. But, however, the principles of the treatment remain the same. Abduction force is required to bring about reduction and if closed reduction fails, open reduction is preferred. During the open reduction, both the malleoli are fixed.

Fracture primarily due to adduction Unlike external rotation and abduction, adduction violence is more frequently an isolated event. Wedging of small comminuted fragments into the fracture line often prevents closed reduction, so that open reduction and internal fixation (ORIF) is required more frequently.

Medial malleolus is approached first, since it is more unstable, and the fracture is fixed with two screws—one at a right angle to tibial cortex and another at right angle to the fracture line (Figs 14.8A and B). Lateral fibular fracture is stabilized with plate and screws.

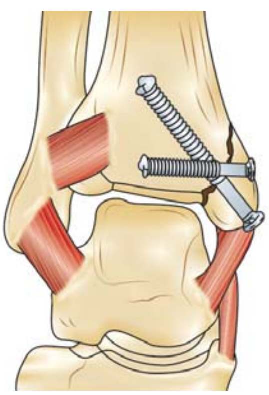


Fig. 14.8A: Two screw fixation of medial malleolar fracture

Fig. 14.8B: Plain X-ray showing fixation of medial malleolar fracture

Fracture resulting from primarily vertical compression This may be isolated or associated with other forces described above. The anterior and posterior tibial plafond margins are fractured. Two types are described:

1. *Posterior marginal fracture* For undisplaced fracture below knee cast is sufficient. For more than 25 percent of articular surface involvement, ORIF with two screws is preferred.
2. *Anterior marginal fracture (tibial plafond injury)* It may include a crush of the anterior lip or it may include a major fragment. If crushed, calcaneal traction is given and if there is a large fragment, ORIF is required.

Complications

Complications of ankle fractures include post-traumatic arthritis, reflex sympathetic dystrophy, neurovascular injury (injury to posterior tibial vessels and nerve), nonunion (due to soft tissue interposition), malunion, etc.

Physiotherapy Management of Ankle Injuries

Orthopedic goals To restore the ankle mortise back to its normal anatomy and to restore the position of the talus underneath the tibial plafond.

Note Even 1 mm loss of articular congruity is unacceptable in ankle joint.

Rehabilitation goals Ideally full range of movements should be restored back to normal. If not at least functional level should be attained (Table 14.1).

TABLE 14.1: Showing the normal and functional range of ankle movements

Movements	*Plantar flexion*	*Dorsi-flexion*	*Foot inversion*	*Foot eversion*
Normal	45°	20°	35°	10°
Functional	20°	10°	25°	10°

To regain the strength of the plantar flexors and dorsiflexors of foot and ankle, invertors and evertors of the foot.

Functional goals To restore the normal gait.

Note
- Required time of healing: 6-12 weeks
- Required time of rehabilitation: 12-24 weeks

Physiotherapy for Ankle Injuries Treated Conservatively

The cast is inspected for adequate padding. It is inspected for cracks, softening, breakage, etc. and is accordingly reinforced and repaired. During the first week, active exercises for the metatarsophalangeal joint are instituted. By 2nd week, isometric quadriceps exercises are commenced. By 4-6 weeks, the cast may be changed to patellar tendon bearing (PTB) cast. During the same time, isometric quadriceps and ankle plantar-dorsiflexor group strengthening exercises are commenced.

After 6-8 weeks, the cast is removed, active, active assistive range of movement exercises to the knee, ankle, subtalar and metatarsophalangeal joints are prescribed. Isotonic and isokinetic exercises to the ankle joint are also commenced. Self-assisted relaxed passive movements to the ankle and foot are also commenced after 8-12 weeks.

Technique of self-assisted passive ankle movements The patient sits with the affected extremity crossed over the knee of the normal leg. Grasping the foot with both the hands fall range passive ankle and foot movements are carried out by the patient himself. Circumduction of the ankle also helps considerably (Fig. 14.9).

> *Note* Caution should be exercised in not overdoing the passive range of exercises.

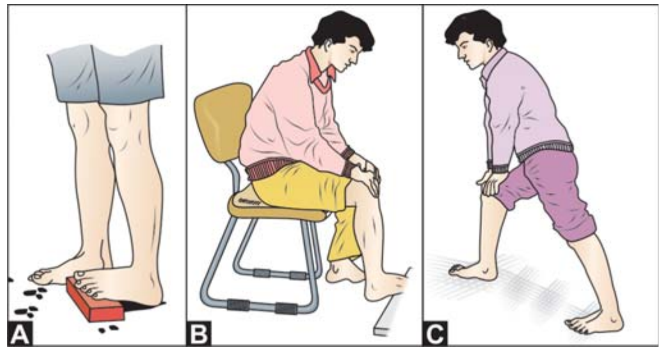
Fig. 14.9: Patient performing a passive ankle and foot movements during mobilization. Ankle circumduction can also be done passively

Adjunctive measures

- Thermotherapy helps to reduce ankle pain and edema.
- Calf muscle stretching exercises in the standing, step standing and sitting positions also helps considerably (Figs 14.10A to C).

After 8-12 weeks, progressive resistive exercises to the ankle joint muscles are commenced.

Weight-bearing All ankle fractures are advised non-weight-bearing with a 2-point gait in the crutches. The patient climbs the stair case one step at a time with the good leg first and descends with the bad leg first. By 6-8 weeks, partial weight-bearing may be allowed. Normal gait using a cane may also be allowed. If there is sufficient evidence of callus over the X-rays full weight-bearing may be gradually allowed by 8 weeks.



Figs 14.10A to C: Methods of stretching the calf muscles in positions of: (A) Standing, (B) Sitting, (C) Standing with a step forward

Functional activities Patient is taught to transfer weight using assistive devices such as crutches with NWB on the affected extremity. The patient should wear the trousers first with the affected extremity and remove it from the unaffected extremity. By 4 weeks, toe-touch to partial weight-bearing is gradually allowed. By 8 weeks, the patient can dress with the affected limb first.

Physiotherapy for ankle injuries treated surgically by open reduction and internal fixation For rigidly fixed ankle fractures, active range of motion exercises to the knee, ankle and MTP joints, isometric quadriceps and ankle exercises are commenced during the first week itself. By 2nd week isotonic ankle exercises are commenced. Progressive resistive and passive exercises to the ankle and subtalar joints are started by the end of 8-12 weeks.

Weight-bearing Toe touch weight-bearing for rigidly fixed fractures by the end of 1 week. By 4-6 weeks partial weight-bearing and by 8 weeks progressive weight-bearing is permitted. FWB is allowed after 12 weeks.

Quick Facts

Ankle injuries

- Aim of treatment is to restore the normal ankle mortise and range of ankle movements.
- For casts, PWB by the end of 4-6 weeks.
- Cast is removed after 6-8 weeks.

- Self-assisted passive ankle movements are very effective.
- Calf muscle stretching exercises are very beneficial.
- All ankle injuries are non-weight-bearing with a two part gait using crutches.
- Partial weight-bearing by 6 weeks and full weight-bearing by 8 weeks.
- In rigidly fixed fractures, weight-bearing and ankle movements are commenced in the first week itself.

ANKLE SPRAIN

These are common injury in sports. If improperly treated, it may result in chronic laxity, pain or delayed recovery.

Lateral Ligament Sprain

This is the most common musculoskeletal injury with an incidence of 1/10,000/day. In 85 percent of cases it is due to inversion of a supinated plantar flexed foot. The lateral ligament commonly injured is anterior talofibular ligament followed by calcaneofibular ligament. The posterior talofibular ligament is rarely sprained (Fig. 14.11).

Fig. 14.11: Showing lateral ligament sprain (due to adduction injury)

Clinical Features

The patient complains of pain, swelling and tenderness over the affected ligament (Fig. 14.12). Anterior drawer test is positive and it is performed by stabilizing distal tibia with one hand, then grasps the posterior heel with the opposite hand and applies anterior force. If the displacement of talus is more than 8 mm anterior, it suggests laxity of the anterior talofibular ligament. Next the talar tilt test is performed, if the tilt is more than 5°, it suggests laxity of anterior talofibular and calcaneo-fibular ligaments.

Fig. 14.12: Clinical photograph showing ankle sprain

Grading of Ankle Sprains

Grade I No laxity, minimal pain and mild swelling.

Grade II Mild-to-moderate laxity, soft tissue swelling, anterior drawer and talar tilt is slightly positive.

Grade III Severe swelling and pain, the anterior drawer and talar tilt tests are highly positive.

Medial Ligament Sprain

This is due to pronation eversion injury. In mild sprains, only the superficial part of the deltoid ligament is torn but in severe forms the deep part of the deltoid ligament is also torn resulting in a lateral talar tilt. If this exceeds more than 2 mm, significant alteration in the weight-bearing mechanism takes place resulting in post-traumatic arthritis. For mild sprains, conservative treatment is sufficient and for severe sprains surgical reduction and repair are considered.

Treatment of Ankle Sprain

Grade I Sprain (RICE Regimen)
- Rest to the part.
- Ice therapy.
- Compression bandaging.
- Elevation of the limb.

In addition to the above, the following measures needs to be taken:
- Active toe exercises.
- NWB crutch walking.
- Drugs like pain killers, etc.

Fig. 14.13: Showing ankle strap

Grade II sprain (partial tear) Apart from the above measures. Grade II sprains are further managed as follows:

- *Strapping* This is given for three weeks. After 3 days patient is permitted partial weight-bearing with crutches. Alternatively knee brace can also be used (Fig. 14.13).
- *Cast bracing* Allows early mobilization of the ankle.
- *Long leg cast* is indicated in partial or complete rupture of the ligament (after surgical repair) and is given for 3-4 weeks.

After removal of the long leg cast the following physiotherapy measures are suggested following surgical repair:

- *To prevent adhesions* Deep friction massage
- *To prevent pain, spasm and swelling* Thermotherapy
- *For early mobilization* Early relaxed passive ankle movements
- Active and progressive resistive exercises are begun at the earliest
- Intrinsic muscles exercises of the foot
- Full weight-bearing after 6 weeks
- Ambulation and gait training
- Once gait is regained, patient is trained to stand on the toes, heel, spot jogging, running etc.
- By 8-12 weeks, patient should regain sports.

Grade III Treatment is essentially surgical and consists of exploration and primary ligament repair or reconstruction. The limb is then immobilized in a long leg POP cast for a period of 3-4 weeks. Later, mobilization is the same as for Grade II sprain. Physiotherapy measures are the same as above but performed more rigorously.

FRACTURES OF THE HINDFOOT

FRACTURE CALCANEUM

Calcaneus is the most often fractured tarsal bone. No ideal method of treatment has been described yet. Calcaneal fracture could be extra-articular or intra-articular.

Fig. 14.14: Showing heel compression test for diagnosing undisplaced or stress fracture of calcaneum

Mechanism of Injury

Twisting forces Cause many of the extra-articular fractures.

Fall from height Causes vast majority of intra-articular fractures. This is a common cause.

Clinical Features

Patient complains of pain and swelling of the heel, inability to bear weight on the heel. In undisplaced or stress fractures, patient complains of pain during the heel compression test (Fig. 14.14). In grossly displaced and communited fractures, the swelling is more and the breadth of the heel is increased.

Radiograph

Routine and special radiological views helps to make a correct diagnosis and plan the appropriate line of treatment (Fig. 14.15).

The two angles of importance are the Gissane angle and the Böhler's angle (Fig. 14.16) which will be disturbed in intra-articular fractures. These angles needs to be restored back following treatment.

Fig. 14.15: Plan X-ray of the calcaneum, lateral view showing fracture of the calcaneum

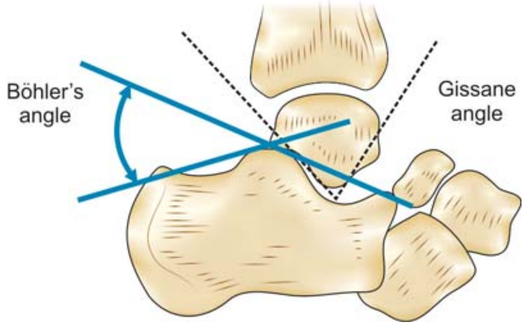


Fig. 14.16: Showing Gissane angle and Böhler's angle

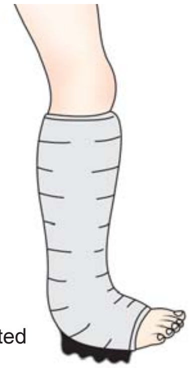


Fig. 14.17: Showing the calcaneal fracture treated with below knee POP cast

Treatment

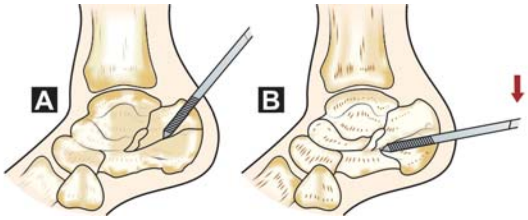
Extra-articular fractures:
- Fracture of anterior process:
  - — *Avulsion fracture* Short leg cast.
  - — *Compression fracture* Should be reduced and fixed with K-wire or screw.
- Fracture tuberosity:
  - — *Undisplaced fracture* Short leg cast.
  - — *Displaced fracture* Open reduction and internal fixation.
- Fracture medial calcaneal process:
  - — *Undisplaced fracture* Plaster cast.
  - — *Displaced* Open reduction with medial lateral compression and internal fixation.
- Fracture sustentaculum tali:
  - — *Undisplaced* Plaster cast.
  - — *Displaced* Open reduction and casting.
- Fracture of the body not involving the subtalar joint:
  - — Responds well to conservative treatment.

Intra-articular fractures Account for 60 percent of all tarsal injuries and 75 percent of all calcaneal fractures. Intra-articular fractures of the calcaneum could be either undisplaced, tongue shaped or communited varieties.

Treatment methods
- Undisplaced fractures can be treated by below knee POP cast (Fig. 14.17) and is called the calcaneal cast.
- Tongue-shaped depressed fracture needs to be elevated with an axial percutaneous pin and after restoration of the Böhler's angle a below knee POP cast is applied (Essex-Lopresti method—Fig. 14.18).
- Open reduction and internal fixation is sparingly done in calcaneal fractures.

Management

The goals of treatment for calcaneal fractures are as follows:



Figs 14.18A and B: Essex-Lopresti method of treating calcaneal fractures

Orthopedic goals To restore the length and width of calcaneum, calcaneal surface of the subtalar joint, and the Böhler's angle back to normal .

Rehabilitation goals To restore the movements of ankle, subtalar and foot joints. To restore the muscle strength of plantar flexors, dorsiflexors, invertors and evertors of the foot.

Functional goals To normalize the gait pattern.

Note Required time for bone healing—8 to 12 weeks.

Physiotherapy Management for Calcaneal Fractures Treated by Essex-Lopresti Method

The cast should allow full range of knee movements and should be upto the level of MTP joints. Active range of movements to the MTP, IP and knee joints is started during the first week. The limb is kept elevated to prevent edema. By the end of 8 weeks, active range of exercises is started to the ankle and subtalar joints after removal of the cast. From 8-12 weeks, active, active assistive and passive range of movements to the ankle and subtalar joints is commenced.

Weight-bearing The weight-bearing following calcaneal fractures should follow the protocol as shown below:
- Bed-rest for 2-5 days with leg elevated.
- In a short leg cast the patient may be allowed toe-touch weight-bearing.

- By 2-3 weeks partial weight-bearing is permitted and allowed to continue for further 3-weeks.
- Weight-bearing is done in the cast within 8 weeks, following surgery.
- Weight-bearing out of the cast after 8 weeks.
- Full weight-bearing after 12 weeks of surgery.

Functional activities The patient is taught to wear the pant with the affected leg first and remove it from the unaffected leg. The patient is taught non-weight-bearing crutch/walker standing and weight transfer from bed to chair and vice versa.

Physiotherapy Management for Calcaneal Fractures Treated Conservatively with Short Leg Cast

The physiotherapy proceeds on the same lines as discussed above except that if takes longer time for range of motion exercises and weight-bearing to be commenced.

Complications

- Nonunion is rare due to the cancellous nature of the bone.
- Malunion is more common.
- Heel pain: The source of heel pain could be from
  - Subtalar joint due to post-traumatic osteoarthritis.
  - Peroneal tendinitis due to stenosing tenovaginitis of the peroneal tendons.
  - Bone spurs due to malunion of fracture and disruption of fat pad of the heel.
  - Arthritis of calcaneocuboid joint is a major source of pain.
  - Nerve entrapment is rare. Medial or lateral plantar branches of posterior tibial nerve or sural nerve may be entrapped due to soft tissue scarring.

FRACTURE TALUS

Importance of talus:
- Takes part in weight transmission.
- Has a precarious blood supply.
- 3/5th of the bone is covered by articular cartilage.
- Sudden hyperextension of the forefoot causes fracture neck called "Aviators Astralagus".

Blood Supply of Talus

- Sixty percent is covered by articular surface, only limited surface is available for vascular perforation.
- No muscle originates or inserts into talus.
- All the three major arteries of the foot supply talus.
- There is important contribution from capsular and ligamentous vessels (Fig. 14.19).

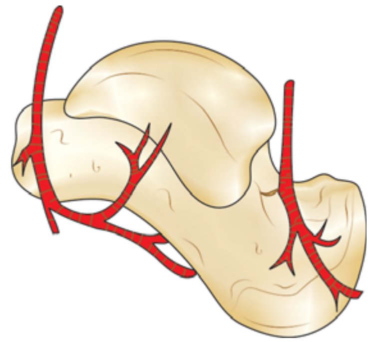


Fig. 14.19: Blood supply of talus

Due to the above factors, avascular necrosis of the talus following injuries is fairly common.

FRACTURE NECK TALUS

This is second in frequency to the chip and avulsion fracture of the talus.

Incidence is 30 percent.

Mechanism of Injury

The common mode of injury is hyperdorsiflexion of the foot on the leg. It may be associated with fracture of tarsal bones and fracture of the metatarsal bones.

Classification

It is classified into four types as shown in Table 14.2 and Figure 14.20.

TABLE 14.2: Types of fracture neck talus

Type I	Undisplaced vertical fracture neck of talus.
Type II	Displaced fracture with subluxation or dislocation of subtalar joint.
Type III	Displaced fracture neck with dislocation of the body of the talus from both ankle and subtalar joints.
Type IV	Displaced fracture neck with dislocation of the body of the talus from subtalar/ankle/talona vicular joints.

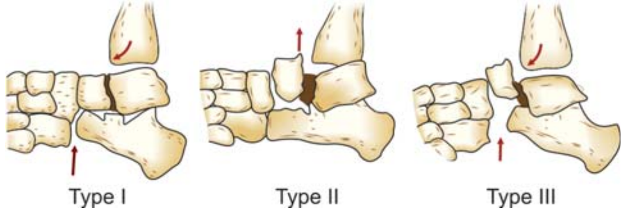


Fig. 14.20: Fracture neck of talus

Fig. 14.21: Plain X-ray of the ankle showing fracture of the talus

Clinical Features

Patient complains of pain, swelling, inability to bear weight and loss or restricted ankle and subtalar joint movements.

Radiology Routine and special radiological views helps to make a correct diagnosis of the talar fractures and helps to plan the appropriate line of treatment (Fig. 14.21).

Treatment

Type I This is best treated by below-knee plaster cast.

Type II In this, closed reduction is done by traction in plantar flexion and a plaster cast is put in equinus. If this fails, ORIF with lag screws is done.

Type III In these, approximately 25 percent are open fractures. Debridement is done first and closed reduction is attempted later. If unsuccessful, ORIF with K-wires or open reduction with lag screws is attempted.

Complications

Skin necrosis, infection, delayed union, nonunion, malunion, avascular necrosis; post-traumatic arthritis, etc. are some of the well-known complications of fracture talus.

Physiotherapy Management of Talus Fracture

The goals of treatment of fracture talus are as follows:

Orthopedic goals Due to the threat of avascular necrosis, a complete anatomic restoration in fracture talus assumes utmost significance. Stable fixations should be aimed for fractures of talar neck, body and head.

Rehabilitation goals To restore back the ankle and foot movements to normal or near to normal. To regain the strength of invertors, evertors of the foot, dorsiflexors and plantar flexors of the ankle.

Functional goals To normalize the gait pattern.

> *Note* Required time of bone healing—6 to 8 weeks.
> Required time of rehabilitation—12 to 16 weeks.

The protocol of physiotherapy management for talar fractures is as follows:

Physiotherapy Management after Conservative Treatment

Closed Reduction and POP casting is advocated for minimally displaced and undisplaced fractures need just immobilisation.

Active exercises are prescribed to the MTP and IP joints by the first week itself. Active knee joint movements are started from the 2nd week onwards. By 4-6 weeks along with the above exercises, small amount of subtalar and ankle joint movements within the cast are attempted. By 8-12 weeks the cast can be removed, and active range of motion exercise to the MTP, IP, knee, ankle and subtalar joints are advised. Isometric and isokinetic exercises to the joints mentioned above also helps.

Physiotherapy Management after Surgical Treatment for fractures treated by open reduction internal fixation, active range of motion exercises are started to the MTP, IP, and ankle joints by the first week itself. By the end of 2nd week, knee joint and subtalar joints are also included. By 8-12 weeks, active-assistive and passive range of motion exercises to the ankle and subtalar joints are prescribed.

Weight-bearing Non-weight-bearing is advised for all talar fractures and foot end elevation to control the foot edema. By the end of 2nd week, in rigidly fixed fractures, toe-touch weight-bearing as tolerated by the patient is advised using assistive devices. Partial weight-bearing by the end of 4-6 weeks in rigidly fixed fractures. Again in these fractures, full weight-bearing is allowed by 8-10 weeks.

For patients treated with cast, non-weight-bearing is advised for a prolonged period and partial weight-bearing is commenced only after 8-12 weeks.

Functional activities The patient is instructed to wear the pant with the normal leg and remove it from the affected leg. The patient is also taught non-weight-bearing pivot standing and transfer with assistive devices from bed to chair and

Fig. 14.22: Therapist teaching the method of alternate floor squatting by keeping the fractured limb forwards in talar fractures

vice versa. Ambulation with assistive devices is taught. After 8-12 weeks, the patient is functionally independent.

Additional Measures

A shortened tendo-Achilles is the bane of these fractures. This prevents the patient from his normal squatting. To counter this and enable the patient to squat again, two methods are recommended:

1. Vigorous dorsiflexion and plantar flexion exercises are prescribed to regain early dorsiflexion. This enables proper squatting.
2. An alternate method of floor squatting with the patient keeping the fractured leg forwards so that the pelvis can be lowered more on the normal side is taught (Fig. 14.22).

Quick Facts

Physiotherapy protocol for talar fractures

- The treatment of choice is open reduction and internal fixation to prevent AVN.
- For rigidly fixed fractures, early weight-bearing and active/subtalar joint mobilization is advocated.
- Prolonged periods of non-weight-bearing for non-rigid fixation.
- Modified functional activities for daily living.
- Alternate method of floor squatting is taught to the patients.

MIDFOOT FRACTURES

Midfoot consists of the navicular, three cuneiform and cuboid bones with their intervening joints. This region of the foot is fairly susceptible to injuries. Midfoot fractures are depicted in Flow chart 14.1.

Mechanism of Injury

There are three common causes of midfoot fractures.

Twisting of the forefoot This usually occurs in a RTA due to forced foot abduction (twisting injury).

Axial loading of a fixed foot This can happen in two ways:

1. Fall on an extremely dorsiflexed foot (here an axial compression is applied to the heel).

Flow chart 14.1: Showing different midfoot fractures

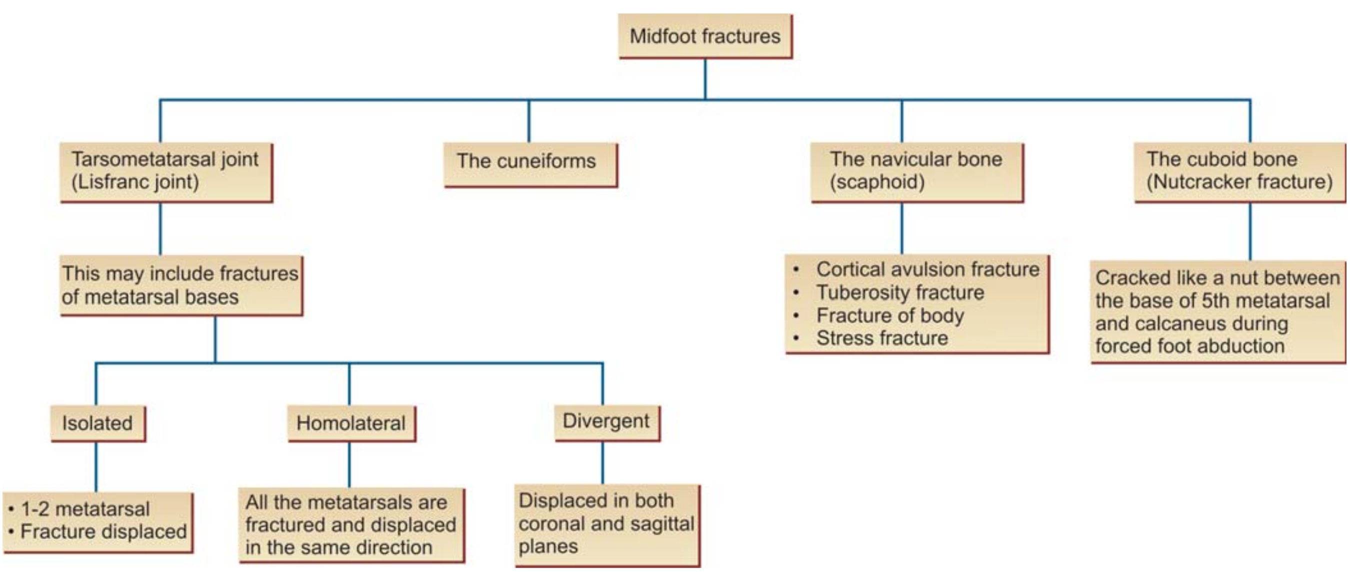


Fig. 14.23: Plain X-ray showing cuboid fracture

2. Fall on an extremely ankle equinus (here axial compression is from the body weight).

Direct crushing injuries As in industrial accidents.

Clinical Features

Patient complains of pain, swelling, limp and inability to bear weight over the affected foot.

Radiograph

Routine foot X-rays including the AP and lateral views helps to make a correct diagnosis (Fig. 14.23).

Treatment Goals

Orthopedic goal

- To restore the keystone of the midfoot (i.e. the first and second metatarsal articulation with the medial cuneiform) as it provides stability between the midfoot and forefoot during gait.
- To maintain the medial longitudinal arch of the foot by restoring the length and alignment of the cuneiforms, cuboid and navicular bones. The longitudinal and transverse arches should be maintained as they control the direct distribution of weight of the body or the foot during gait.
- To restore the Lisfranc joint complex.

Rehabilitation goals

- To restore the full range of movements to the foot and ankle or at least the functional range (*see* Table 14.1).
- To restore the motion at the 4th/5th metatarsal cuboid joints as greater degree of dorsiflexion, plantar/flexion, pronation and supination takes place here.
- To restore the normal muscle strength of invertors, evertors of the foot, dorsiflexors and plantar flexors of the ankle.

Functional goals

- To restore the normal gait pattern.
- To maintain the longitudinal and transverse aches of the foot.

> *Note*
> Required time of bone healing
> - *Lisfranc joints* 8-10 weeks
> - *Cuboid, cuneiform and scaphoid bones* 6-10 weeks
>
> Required time of rehabilitation
> - *Lisfranc joint* 8 weeks to 4 months
> - *Cuboid, cuneiform and scaphoid bones* 6 weeks to 4 months.

Methods of Treatment

Lisfranc's injuries (Fig. 14.24) Undisplaced fractures are treated by a short leg cast for 6 weeks. Displaced fracture is treated by open reduction and rigid internal fixation. For bony injuries, closed reduction and percutaneous pinning are very effective.

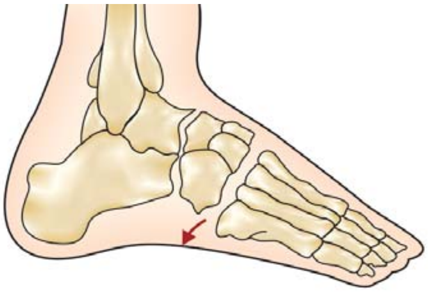


Fig. 14.24: Showing Lisfranc's injury (related to tarsometatarsal joints)

Navicular, cuboid and cuneiform fractures Dorsal lip fractures, tuberosity fractures and stress fractures of navicular bone, undisplaced fractures of the cuneiform and cuboid bones are treated by short leg cast. For intra-articular navicular bone fractures involving both talonavicular and naviculocuneiform joints, nonunion and stress fractures not responding to conservative treatment, require open reduction and rigid internal fixation.

A nutcracker fracture requires either external fixation or open reduction and rigid internal fixation.

Physiotherapy Management for Midfoot Fractures

During the first 2 weeks Active range of motion exercises to the toes and MTP joints. No strengthening exercises to the ankle and foot.

Partial weight-bearing for the avulsion and tuberosity fractures of the navicular bones, avulsion and undisplaced fractures of the cuboid bones. The remaining fractures are all non-weight-bearing.

By 2nd week, isometric exercises to the dorsiflexors, plantar flexors, invertors and evertors of the foot are started. Active ankle movements are begun.

After 2 weeks By 6-8 weeks, gentle active, active assistive and passive range of motion exercises to the ankle and subtalar joints are started. Isometric and isotonic exercises to ankle and subtalar joints are advised.

Partial weight-bearing may be allowed for Lisfranc injuries treated by either cast or closed reduction and percutaneous pinning, cortical avulsion, tuberosity or stress fractures of navicular bones, undisplaced and avulsion fractures of cuneiform and cuboid bones. Rest of the fractures is non-weight-bearing.

After 8-12 weeks Gentle resistive exercises to the dorsiflexors, plantar flexors, invertors, evertors, long flexors and extensors of the toes. Full weight-bearing may be permitted for Lisfranc fractures treated by cast or closed reduction and percutaneous pinning, navicular fractures with cortical avulsion, tuberosity and stress fracture, undisplaced and avulsion fractures of the cuneiform and cuboid bones. Partial weight-bearing for the other remaining injuries.

FRACTURES OF THE FOREFOOT

The forefoot complex consists of five metatarsals sesamoid bones and the bones of the five toes. The joints include metatarsophalangeal and interphalangeal joints. Forefoot plays a very important role both in gait and weight transmission. It is frequently injured in sports persons.

Fracture of the foot is classified as shown in Flow chart 14.2.

Mechanism of Injury

Mechanism of injury is usually due to direct trauma due to fall of heavy objects on the toes or the foot.

PHALANGEAL FRACTURES

- *Proximal phalanx of great toe* Direct trauma or twisting injury (avulsion fractures).
- *Phalanges of 2nd to 5th toes* Direct trauma.

Flow chart 14.2: Showing different fractures of the forefoot

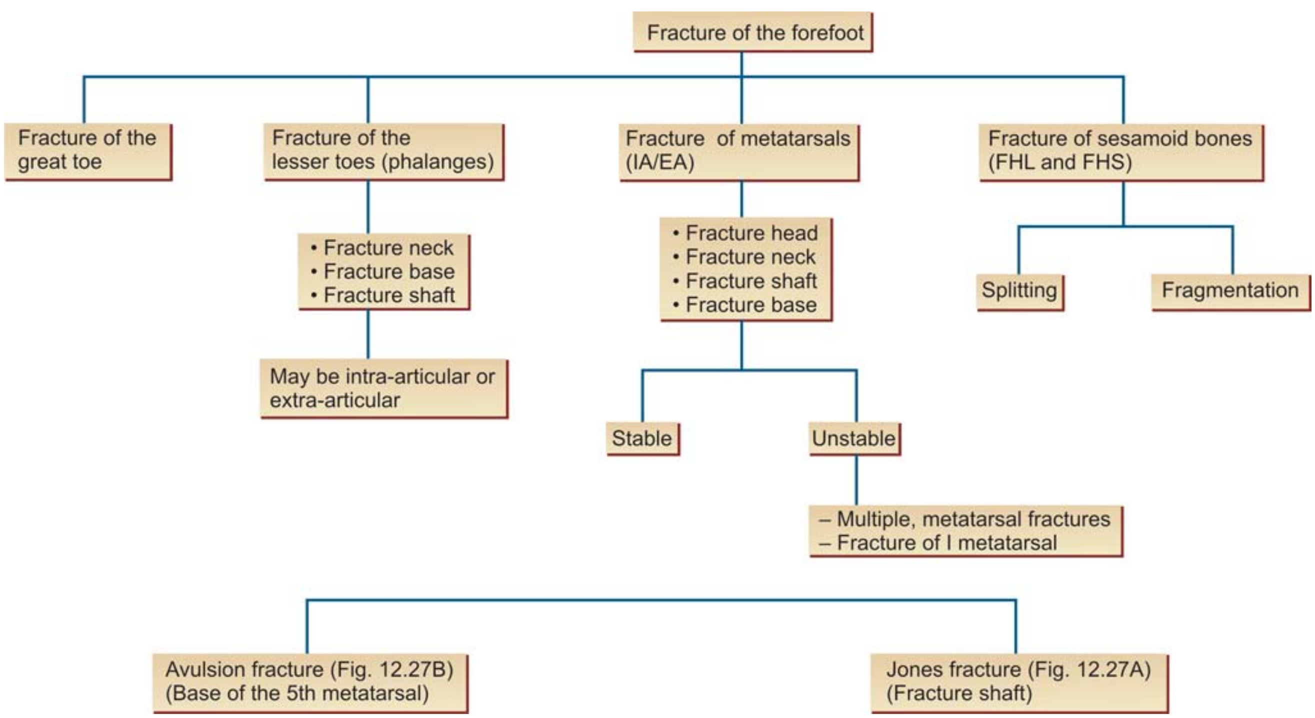


Fig. 14.25: Plain X-ray showing fracture proximal phalanx of great toe

Clinical Features

Patient complains of pain, swelling over the dorsum of the toe and restricted toe joint movements.

Radiograph

Plain X-ray with the AP and lateral views helps identify these fractures and plan the line of treatment (Fig. 14.25).

METATARSAL FRACTURES

- *Fractures of I to IV metatarsals* Direct trauma.
- *Fracture of II to V* Direct trauma, twisting injury.
- *Stress fractures (II to IV toes)* Repeated minor trauma. Common in policeman, nurses, soldiers, etc. and is called the March fracture (Fig. 14.26).
- *V-metatarsal-inversion* Injury on a plantar flexed ankle.

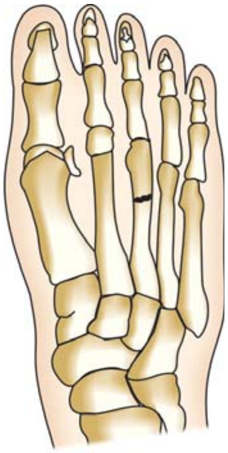
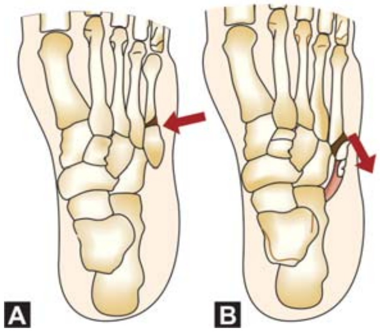


Fig. 14.26: Showing March fracture



Figs 14.27A and B: Showing: (A) Jones fracture, (B) Avulsion fracture of the styloid process of 5th metatarsal bone

Fig. 14.28: Clinical photograph of metatarsal fractures

JONES FRACTURE

This is fracture of the base of the shaft of V metatarsal bone and is confused with avulsion fracture of the tuberosity of the fifth metatarsal bone (Fig. 14.27A). It is due to twisting injury of the forefoot.

Clinical Features

Patient complains of pain, swelling over the dorsum of the forefoot and restricted foot movements (Fig. 14.28).

Radiograph

Plain X-ray of the forefoot, AP and oblique views helps to diagnose the metatarsal fractures (Fig. 14.29).

SESAMOID BONE FRACTURES

- It is due to the impact of the foot on a hard surface while the toes are dorsiflexed (Fig. 14.30).
- Stress fracture due to repeated trauma (as in dancers/ runners, etc.)

Treatment Goals in Forefoot Fractures

Orthopedic goals

- To restore the normal anatomy of the great toe, phalanx, metatarsal and sesamoid bones.

Fig. 14.29: Plain X-ray of the forefoot showing multiple metatarsal fractures

Fig. 14.30: Showing sesamoid bone fractures

- In phalanges 2 through 5 toes, perfect alignment is not very crucial

TABLE 14.3: Showing the healing time and rehabilitation time in forefoot fractures

Bones	*Required Healing Time (weeks)*	*Required rehabilitation time (in weeks)*
• Lesser phalanx fractures	4-6	2-6
• II, III, IV metatarsal fracture	4-6	4-6
• V metatarsal fracture	6-8	4-6
• Great toe phalanx	4-6	4-6
• First MT fracture	6-8	4-6
• Sesamoid fracture	4-8	8-12

- Metatarsals two through five needs to be restored as anatomically as possible.

Rehabilitation goals

- To restore the normal range of ankle and foot movements (*see* Table 14.1 and Flow chart 14.3)
- To restore the normal range of MTP and IP joints movements is classified in folloiwng Flow chart.
- To improve the muscle strength of long flexors and extensors of the toes, evertors and invertors of the foot.

Table 14.3 shows the required healing time and rehabilitation time in fractures of the metatarsals and phalanges.

Functional goals To restore the normal gait.

Note Residual effects

- Due to sesamoid bone fractures—weakness of flexor hallucis brevis muscle.
- Due to fracture of first MT bone—weakness of extensor hallucis longus and flexor hallucis longus.
- Due to fracture of the lesser 4 metatarsals—weakness of extensor digitorum longus.

Flow chart 14.3: Showing different types of forefoot movement

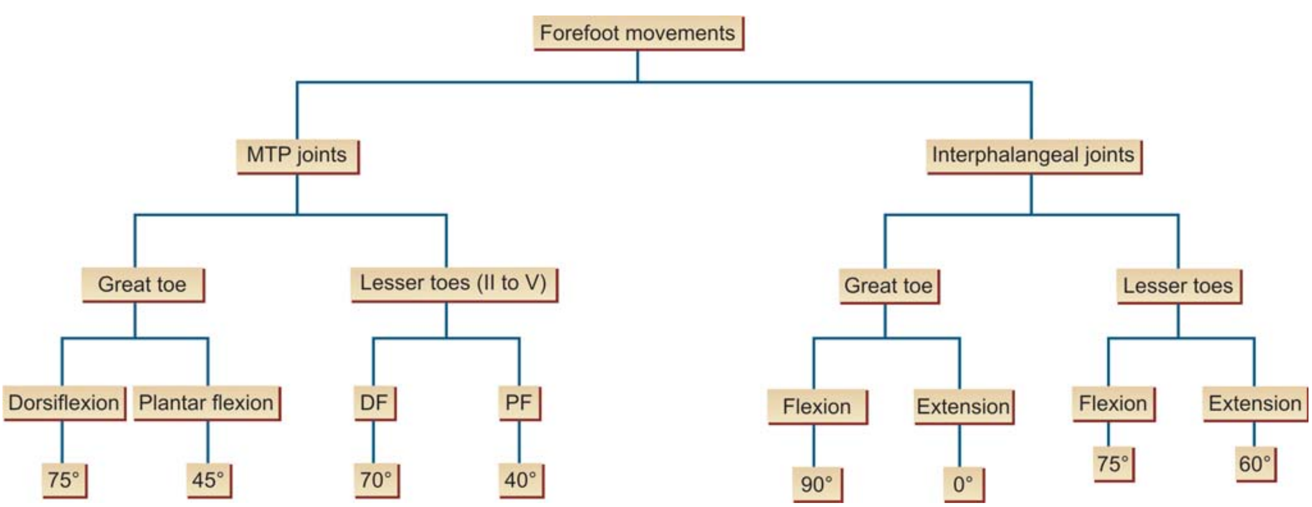


Fig. 14.31: Showing Buddy taping for undisplaced phalangeal fractures of toes

Methods of Treatment

Lesser phalanx fracture

- *Undisplaced fracture* Buddy taping/splints (Fig. 14.31)
- *Displaced fracture* Open reduction and internal fixation with K-wire.

II, III and IV metatarsal fractures

- *Undisplaced fracture or minimally displaced fracture* Closed reduction and Short leg walking cast.
- *Open displaced fracture* Open reduction and Internal fixation/External fixators.

V metatarsal fracture

- *Acute avulsion fracture* Short leg walking cast.
- *Displacement < 2 mm* Strapping and walking boot
- *Jones fracture* Non-weight-bearing short leg cast.
- *Stress fracture* Short leg cast.

For avulsion fracture > 2 mm displacement Open reduction and Internal fixation with lag screws.

Great toe phalanx fractures

- *Undisplaced fracture* Non-weight-bearing and short leg cast.
- *Displaced or intra-articular fractures* Closed reduction percutaneous pinning.
- *Open reduction and internal fixation* This is indicated where closed reduction fails.

First metatarsal fracture

- *Undisplaced fracture* Non-weight-bearing short leg cast.
- *Displaced or intra-articular fractures* Open reduction and internal fixation with DCP plates and screws.

Sesamoid bone fractures

- *Acute fractures* Soft padding, strapping the MTP joint in neutral or in slightly plantar flexed position. The foot is then placed in a short leg cast.
- *Sesamoidectomy* This is done if casting fails or if there is persisting pain.

Physiotherapy Management

During the first 2 weeks For stable phalangeal fractures, active range of motion exercises to the MTP joints. For fractures of first metatarsal, sesamoid and first phalanx, no range of motion, and no strengthening exercises. Non-weight-bearing for fractures of sesamoid, first phalanx, first and fifth metatarsals. Weight-bearing for the stable fractures of the other metatarsals and phalanges.

By the end of 2 weeks, active range of motion exercises to the II, III, IV, V metatarsals, interphalangeal and MTP joints.

After 2 weeks For stable phalangeal fractures, isotonic exercises to long flexors and extensors of the toes.

For metatarsal fractures, isometric and isotonic exercises to the ankle, plantar and dorsiflexors, evertors and invertors.

Partial weight-bearing for first phalanx, first and fifth metatarsals and sesamoid bones. By 6-8 weeks active, active assistive and passive ROM exercises to all phalangeal, metatarsal and ankle dorsiflexors, plantar flexors, invertors, evertors, long flexors and extensors of the toes. For stable fractures, full weight-bearing and for fractures of sesamoids, first and V metatarsals and first phalanx, partial to full weight bearing. After 8-12 weeks, progressive resistive exercises are started to the long flexors, extensors of the toes, dorsi and plantar flexors, invertors and evertors. Full weight-bearing is now allowed.

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3

Section

PELVIC AND SPINE FRACTURES

15. Fracture of the Pelvis
16. Injuries of the Spine
17. Peripheral Nerve Injury

15

Chapter

Fracture of the Pelvis

FRACTURE PELVIS

Pelvic fractures are difficult injuries and are usually occur due to high-velocity trauma following a road traffic accident (RTA) or due to fall from a height.

The relative incidences are as follows:

- RTA—80.7 percent.
- Fall—16.1 percent.
- Compression fracture—rest.

Stable Pelvic Fracture

These fractures do not involve the pelvic ring and they are minimally displaced.

Unstable Pelvic Fracture

They involve the pelvic ring and are widely displaced. Pelvic fractures pose a problem different from others. Here the emphasis is on recognition of potential complications associated with these fractures, the notable ones being injuries to the major vessels and nerves of the pelvis and major viscera like intestines, bladder and the urethra, severe intrapelvic hemorrhage from fracture of pelvic ring. Mortality from pelvic fracture varies from 10 to 50 per cent. Proper fracture management decreases the blood loss and controls the hemorrhage. A to F management as proposed by Mac Murthy in multiple trauma patients is important in management of the pelvic fractures (Table 15.1).

TABLE 15.1: Vital practice points in pelvic fractures

A to F management of Mac Murthy
A. Airway management
B. Blood and fluid replacement
C. Central nervous system management
D. Digestive system management
E. Excretory system management
F. Fracture management

Mechanism of Injury

There are four mechanisms by which pelvic ring fractures are produced:

1. Anteroposterior compression
2. Lateral compression
3. Vertical shear forces
4. Inferior forces (e.g. fall on buttocks).

The first two mechanisms are common in RTA and may cause stable or unstable fractures. Vertical shear forces are due to fall from a height and will cause grossly unstable fractures.

Fortunately most pelvic fractures are stable and respond to non-operative treatment. Unstable fractures need manipulative reduction and stabilization by external fixators and some times by internal fixation. A proper evaluation of the fracture by radiograph and CT scan helps to determine the best course of management.

Classification

Broadly speaking the pelvic fractures can be placed under two categories.

Fractures not Affecting the Integrity of the Pelvic Ring

Direct blow fractures which are commonly seen in iliac bone and avulsion fractures frequently encountered in the young come under this group. Avulsion fractures are commonly seen in anterosuperior and inferior iliac spines and ischial tuberosity (Fig. 15.1).

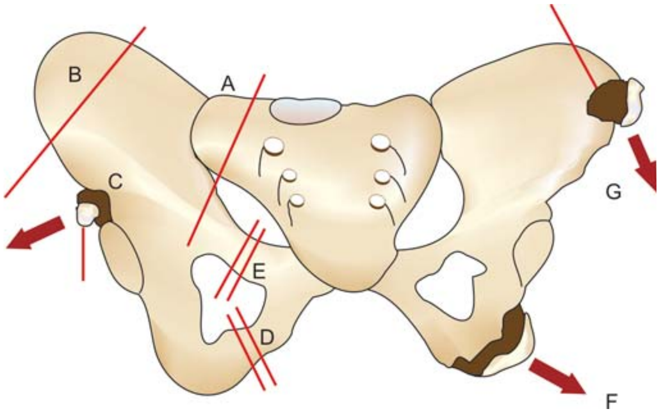
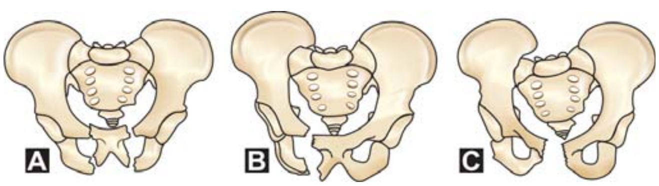


Fig. 15.1: Showing avulsion fractures and fractures of individual bones not affecting the pelvic ring: (A) Fracture of the sacrum, (B) Fracture of the iliac wing, (C) Avulsion fracture of anteroinferior iliac spine, (D) Inferior rami fracture, (E) Superior ramus fracture, (F) Avulsion fracture of ischial tuberosity, and (G) Avulsion fracture of anterosuperior iliac spine



Figs 15.2A to C: Showing the displaced pelvic fractures: (A) Dislocation of pubic symphysis and SI joint, (B) Fracture ipsilateral pubic rami with subluxation of SI joint, (C) Straddle fracture (double vertical fracture)

Fractures Affecting the Integrity of the Pelvic Ring

These are single or double break fractures in the pelvic ring and could be stable or unstable. A stable fracture is one which resists displacing forces. Obviously fractures which cannot resist usual forces are called unstable fractures and these pose a major therapeutic challenge (Figs 15.2A to C).

Clinical Features

Symptoms Patient gives a history of high-velocity trauma and usually presents in a state of hypovolaemic shock. Features of intra-abdominal injuries and genitourinary injuries are frequently present.

Clinical Signs

The patient may present with all signs of shock. Tenderness is present over the fracture site and one has to look for three important signs described by Milch (Table 15.2).

TABLE 15.2: Clinical points: Milch signs

- **Destot's sign** Large hematoma above inguinal ligament or scrotum.
- **Roux's sign** Distance from greater trochanter to pubic spine is - on affected side.
- **Earle's sign** On per rectal examination, the bony prominence or a large hematoma can be palpated.

Quick Facts

Look for the signs of shock in pelvic fracture
- Pale look
- Cold nose
- Sweating
- Tachycardia
- Hypotension
- Cold and clammy skin
- Unconsciousness

Clinical Tests

Compression test When a compressive force is applied through the two iliac bones patient complains of pain in pelvic fracture (Fig. 15.3).

Fig. 15.3: Showing compression test in pelvic fractures

Distraction test When distraction force is applied to the two iliac bones at the anterosuperior iliac spine, patient complains of pain (Fig. 15.4B).

Direct pressure test Direct pressure over the symphysis pubis elicits pain (Fig. 15.4A).

Following this, an examination for abdomen and pelvis injuries is carried out and next urethral catheterization or urethrogram is done.

INVESTIGATIONS

Radiography

Different radiographic views are recommended to study the fracture configuration, displacements, etc. (Fig. 15.5) in pelvic fractures:

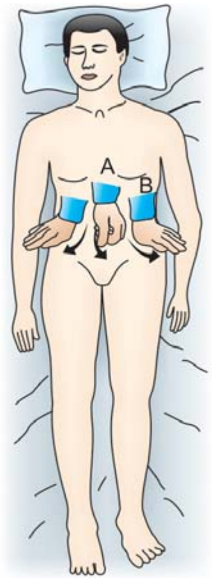


Fig. 15.4: Showing (A) Direct pressure test, (B) Distraction test

Fig. 15.5: Plain X-ray of pelvic fracture

- Plain AP view.
- Oblique view—45° oblique projections.
- Internal and external rotation view.
- Inlet view—40° caudad view.
- Outlet view—40° cephalad view.

CT Scan Further radiographic studies include CT scans and 3-dimensional imaging. This is the gold standard in the evaluation of pelvic fractures especially in acetabular fracture (Fig. 15.6).

Management

One should remember that pelvic fractures are usually due to high-velocity trauma and is associated with multiple fractures and multiple system injuries. Resuscitation and correction of

Fig. 15.6: Clinical photograph of CT scan of pelvic fracture

hypovolaemic shock takes precedence over the management of fracture per se. But once the general condition is stabilized attention should be given to treat the fracture which will prevent further blood loss and damage to visceral organs.

Treatment points

Three main pitfalls in the treatment of pelvic fracture

1. Treating only fracture overlooking visceral injuries.
2. Over treating a stable fracture.
3. Treating an unstable fracture.

Treatment Methods

Initial treatment is carried out as follows:

- Resuscitation and other general measures, to improve the general condition of the patient.
- Blood transfusion and other medical and surgical emergency measures are carried out.

Avulsion fractures Conservative treatments like bed-rest, traction; physiotherapy, etc. gives good results. They rarely need surgery.

Undisplaced fractures Respond to bed-rest, traction, pelvic slings (Fig. 15.7) non-steroidal anti-inflammatory drugs (NSAIDs), etc.

Displaced fractures Reduction by lateral compression methods as described by Watson Jones is very helpful. Retention is either by spica cast, canvas sling or external fixators.

Role of external and internal fixator's Fractures associated with multiple system injuries need to be stabilized either by

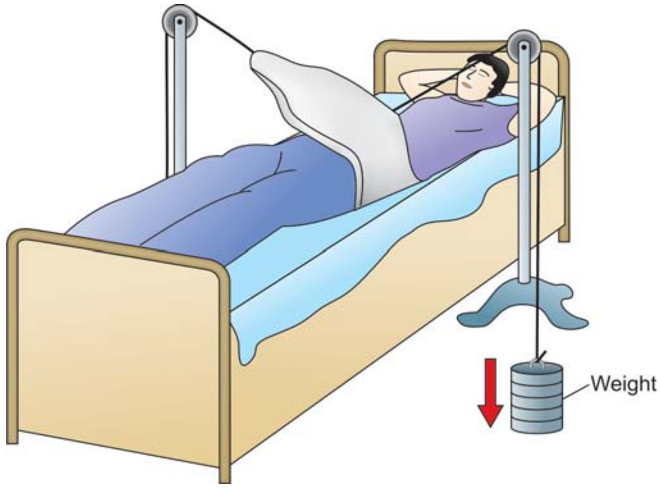


Fig. 15.7: Pelvic sling as a mainstay of conservative treatment in fracture pelvis

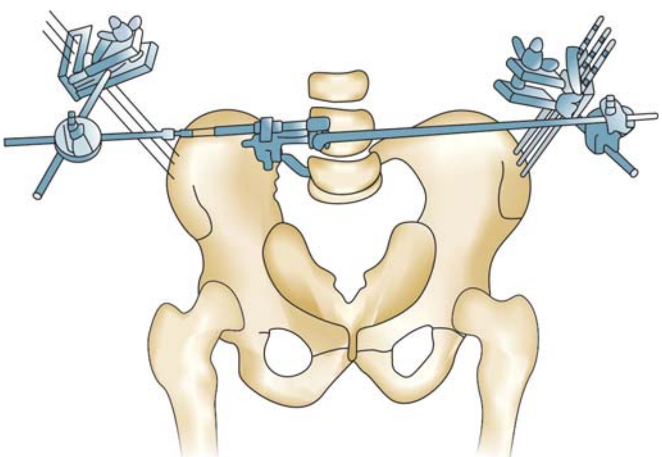


Fig. 15.8: Showing treatment by external fixation methods in pelvic fractures

external fixators (Fig. 15.8) or by open reduction and internal fixation (ORIF). These two methods have the following advantages:

- Gives firm stability.
- Helps early mobilization.
- Reduces period of bed-rest.
- Helps early control of osseous bleeding.

Physiotherapy Management for Pelvic Fractures

*Physiotherapy treatment for fractures not affecting the integrity of the pelvic rin*g No specific physiotherapy is required in these injuries as they are stable. However, isometric exercises to the glutei, quadriceps and hamstring muscles are advised along with active range of exercises to the ankle and toes during the period of immobilization.

Adjunctive measures like ice therapy, thermotherapy, massage, etc. helps to relieve pain and spasm. After 3-4 weeks gradual weight-bearing and ambulation with assistive devices may be permitted.

Physiotherapy management for fractures affecting the integrity of pelvic ring None of the treatment methods mentioned above can be implemented here as the injuries are unstable. Mobilization and muscle strengthening exercises are commenced slowly for only the lower limbs in the initial stages. Gradual weight bearing, walking and gait training is initiated in the parallel bars. Under appropriate guidance, patient is taught to roll on bed, get up and sit on bed. By 10-12 weeks patient may resume the normal activities.

For patients treated by surgery or external fixation, mobilization may be done early by 3 weeks.

Rest of the management is the same as mentioned above.

COCCYX FRACTURES

These are relatively rare injuries but causes considerable difficulty and embarrassment to the patients as it poses problems during sitting, traveling, etc.

Mechanism

Mechanism is usually direct and is due to slip and fall on the buttocks (Fig. 15.9).

Fig. 15.9: Showing mechanism of injury in coccyx fractures

TABLE 15.3: Key and Conwell's types: A comparative study of different types of pelvic fractures, their clinical features and treatment is presented here

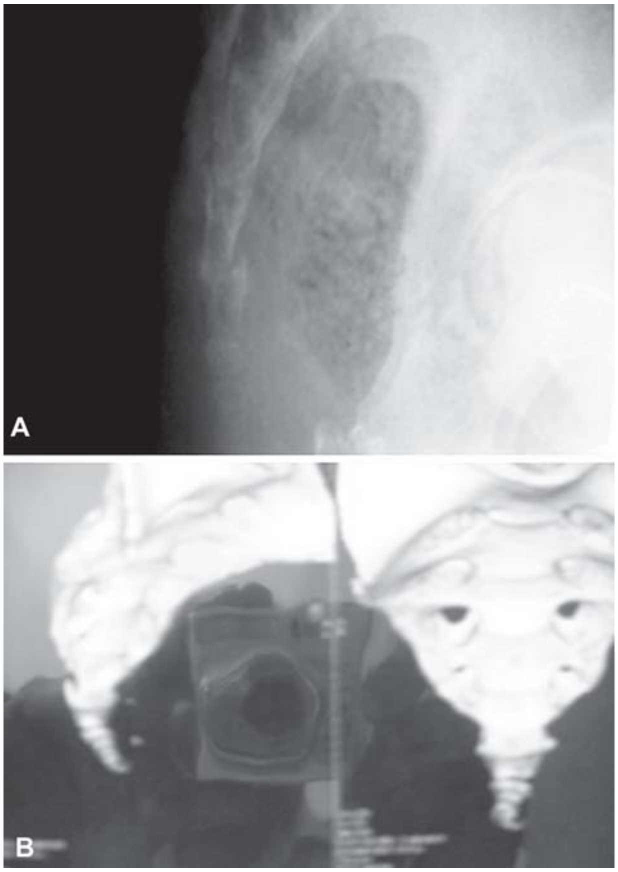
Sl No	*Type of pelvic fracture*	*Clinical features*	*Treatment*
Type I	• Avulsion of anterosuperior iliac spine	Pain on trying to flex and abduct the thigh	Bed-rest, hip spica, ORIF rarely done
	• Avulsion of anteroinferior iliac spine	Rare	Rest with hip flexed for 2 to 3 weeks
	• Avulsion of ischial tuberosity	Flexion of thigh with knee in flexion - pain	Conservative treatment
	• Single ramus fracture of pubis or ischium	Most common fracture seen in elderly, confused with fracture neck of femur	Bed-rest
	• Fracture body of ischium	Pain when hamstrings are put in tension	Bed-rest
	• Stress fracture pubis or ischium fracture	Can occur in last trimester of pregnancy	Bed-rest
	• Fracture iliac wing (6%)	Lateral compression force - pain Walking is painful	Strapping of pelvis
	• Fracture sacrum	Neurological deficits due to involvement of higher sacral roots	Undisplaced fracture; bed-rest In neurological lesions posterior sacral laminectomy is done
	• Fracture coccyx	Fall in sitting position	Bed-rest Cross-strapping of buttocks In severe disability, coccygectomy
Type II	• Fracture of two rami ipsilateral	Flexion, abduction and external rotation (FABER) test is positive. This fracture is common	Bed-rest; bucks traction **FABER—Flexion abduction and external rotation**
	• Fracture or subluxation near symphysis pubis	Tenderness over symphysis pubis + palpable gap + injury to genitourinary tract common.	Circumferential strapping
	• Fracture or subluxation near SI joint	FABER test is positive Straight leg raising test is painful	Symptomatic treatment and bed-rest, pelvic sling, belt
Type III	• Double vertical fracture **(Straddle fracture)**	Urethral injury—20% Abdominal injury—38%	Symptomatic treatment, bed-rest etc.
	• **Malgaigne's fracture** (ipsilateral Pubic rami fracture with ipsilateral SI joint dislocation)	Shortening, external rotation deformity, limb shortening, umbilicus displaced	Postural reduction + traction + pelvic slings
	• Severe multiple fracture of pelvis	Associated with severe visceral damage	In compound fracture external fixators preferred Open reduction and internal fixation if associated with multiple system injuries Rest in bed with sand bags, pelvic slings and traction
Type IV	Fracture acetabulum	Could be displaced or undisplaced, could be a rim fracture or central floor fracture	Skeletal traction through the greater trochanter

Clinical Features

Patient usually complains of pain in the buttocks and has considerable difficult to sit. The treatment is essentially conservative in nature with periods of bed rest and symptomatic treatment for pain and inflammation.

Investigations

Plain X-ray of the Pelvis, AP and lateral views, with dynamic postures are recommended (Fig. 15.10A). CT scan and MRI are better alternatives but expensive (Fig. 15.10B).



Figs 15.10A and B: (A) Plain X-ray of pelvis (lateral view), (B) CT scan showing coccyx fracture

Management

Conservative measures Pain killers like NSAID's, muscle relaxants help to relieve pain in acute cases. Physiotherapy has an important role in the treatment.

Injection therapy For those patients who are unresponsive to painkillers and in patients who develop Coccydynia injection therapy consisting of locally acting steroids like Inj Depomedrol or Inj Kenacort with local anesthetic Xylocaine gives good results.

Surgery Coccygectomy is indicated in patients who do not respond to the conservative treatment methods and who develop coccydynia that fails to respond to injection therapy.

Physiotherapy Management

Consists of the following steps:

- To relieve pain, thermotherapy like ultrasound and TENS helps.
- To relieve prolonged pressure on the buttocks, sitting on a ring cushion and sitting on alternate buttocks is advised.
- Isometric exercises to the glutei maximus muscle in sitting, lying and prone positions are advisable.
- *Sitz bath helps to relieve pain.

Note Coccyx injuries are difficult to tackle for the following reasons:
- Due to the position of coccyx which is deep and covered by thick muscles on either side.
- Due to the pressure from sitting. Hence long sitting posture needs to be controlled.

RIB FRACTURES

These are relatively rare injuries. The rib usually breaks at the angle which is a point of maximum convexity (Fig. 15.11).

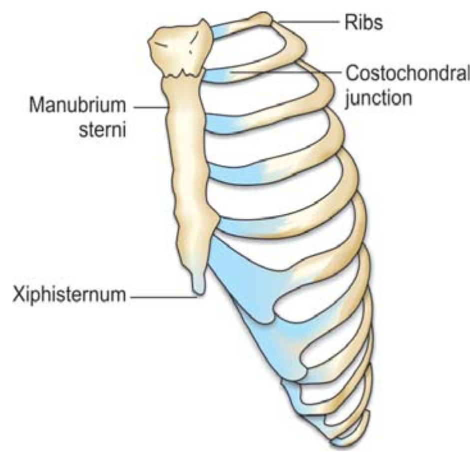


Fig. 15.11: Showing anatomical features of rib cage

Mechanism of Injury

Fracture ribs are usually due to direct trauma

Clinical Features

Patient complains of pain in the chest and has difficulty in breathing and lying on the affected side.

Radiograph

Plain X-ray of the chest helps to identify the rib fractures (Fig. 15.12).

Note Sitz bath—this consists of sitting in a shallow tub of warm water. Commonly advocated in Piles patients after surgery.

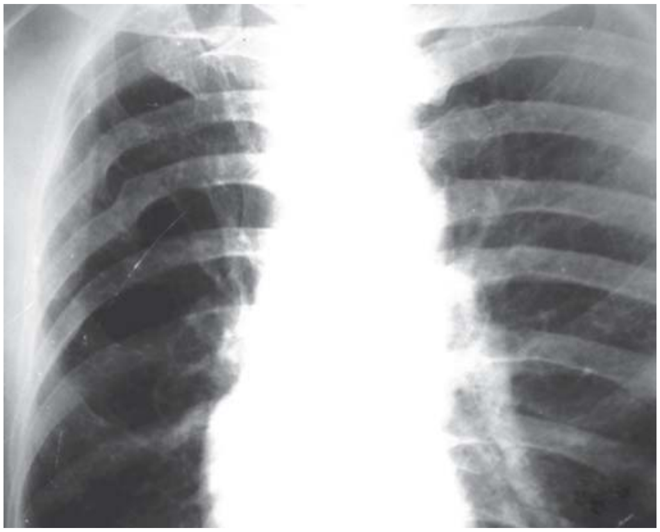


Fig. 15.12: Plain X-ray showing rib fracture

Management

Intercostals muscles provide natural immobilization to the fractured ribs and hence no aggressive management is required. Strapping (Fig. 15.13), ultrasound or TENS, etc. are effective in reducing the pain. Occasionally a local infiltration of hydrocortisone helps.

Fig. 15.13: Showing strapping method for treatment of fracture ribs

Complications

Very rarely the fracture fragments may pierce the pleura causing pneumothorax, hemothorax, etc. These are dangerous injuries and needs to be managed aggressively. Plain X-ray of the chest helps to make a diagnosis.

Physiotherapy Management

This essentially consists of deep breathing exercises which are progressively made more vigorous to improve the mobility of the thorax.

16

Chapter

Injuries of the Spine

ABOUT SPINE

Spine is a family of 33 bones running from the skull to the pelvis (Fig. 16.1). It has been assigned the twin responsibility of carrying the load of the body and head, thanks to the two-legged posture human beings enjoy and the still more important responsibility of protecting the vital spinal cord.

The neck bones are called *cervical vertebrae*, bones of upper back and in line with the chest are called *thoracic vertebrae* and the bones of the lower back are called *lumbar vertebrae*. Each vertebra rest on the vertebra above and below. At these points they articulate with each other through the *facet* joint which keeps all the vertebrae in their correct position and in alignment with each other. It has a spinal shock absorber called the *disc* which separates each vertebra from the next.

Each vertebra has an *anterior body* and a *posterior neural arch* (Figs 16.2 and 16.3). The body has a tough outer cortex and a cancellous middle portion. It is supported

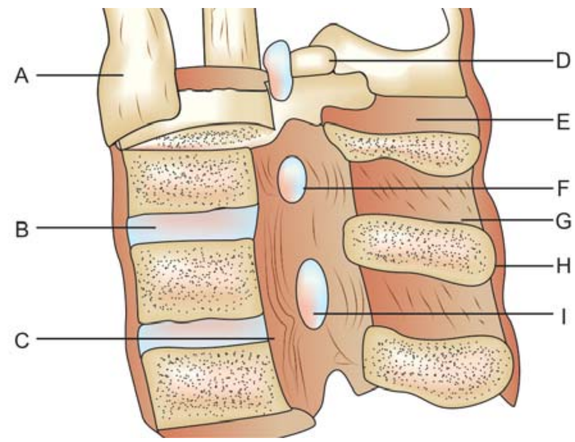


Fig. 16.2: Anatomy of spine: (A) anterolongitudinal ligament, (B) intervertebral disk, (C) posterior longitudinal ligament, (D) facet joint, (E) interspinous ligament, (F) ligamentum flavum, (G) spinous process, (H) supraspinous ligament, (I) intervertebral foramen

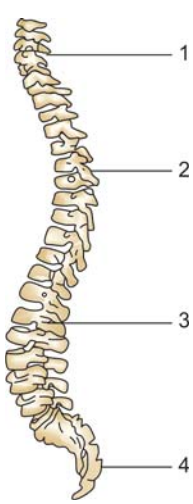


Fig. 16.1: Normal spinal curves: (1) cervical lordosis, (2) thoracic kyphosis, (3) lumbar lordosis, and (4) sacral kyphosis

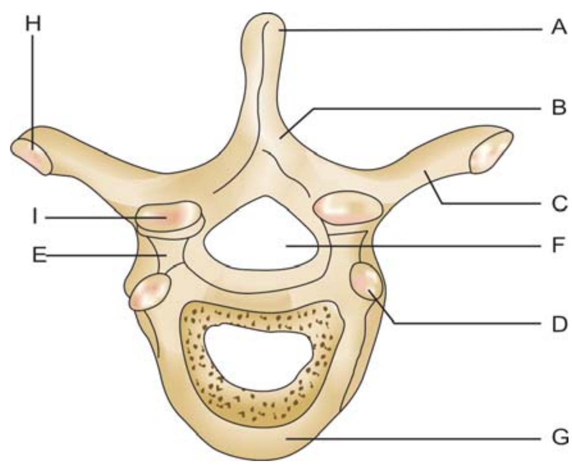


Fig. 16.3: Anatomy of a vertebra: (A) spinous process, (B) lamina, (C) transverse process, (D) superior articular facet, (E) pedicle, (F) spinal canal, (G) body, (H) transverse costal facet (I) inferior articular facet

in front and back by anterior longitudinal ligament and posterior longitudinal ligament respectively. The posterior neural arch consists of two pedicles, two transverse processes, a posterior spinous process and a pair of lamina which together form the spinal canal along with the posterior surface of the body. In this canal of mine lies the all important spinal cord.

While ligamentum flavum binds the laminae together, the interspinous ligament binds the spinous processes, and the supraspinous ligament binds the tip of the spinous process. All the structures mentioned so far help the spine in providing the much needed stability.

Quick Facts

- Spine is the principal load bearing structure of the head and torso.
- Each portion of the spine has specific functions:
  Cervical spine provides head with limited mobility and protects proximal part of spinal cord.
  Thoracic spine provides mobility to the upper torso and rib cage and protects the cord.
  Lumbar spine provides the lower torso, its mobility and protects the cord.
- Like the skull which protects the brain, spinal column protects the cord.
- Spine should be flexible yet strong.
- Spinal cord injury could result in death, quadriplegia or paraplegia.

INJURIES OF THE CERVICAL SPINE

Injuries of the cervical spine are dangerous and if associated with neurological damage the results can be devastating. Though diagnostic and treatment methods have vastly improved over years, still injuries of the cervical spine pose the greatest challenge to the skill and acumen of orthopedic and neurosurgeons.

Jefferson pointed two areas commonly involved in cervical spine injuries, C1-2 and C5-7. According to Meyer C2 and C5 are commonly involved. Neurological damage is seen in 40 percent of cases. In 10 percent of cases, radiographs are normal.

Causes

- *Fall from height* It is the most common cause in developing countries.
- *Diving injuries* Diving into water with insufficient depth or in an inebriated condition.

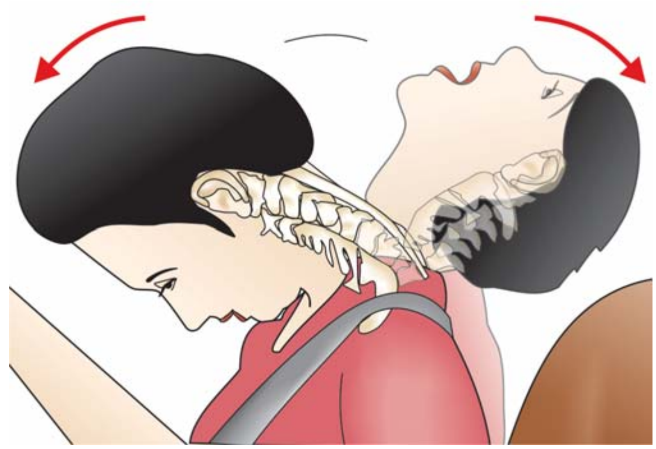
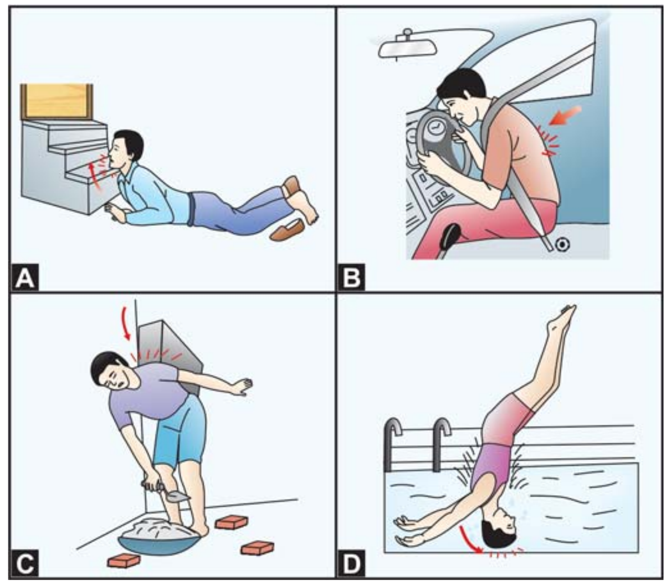


Fig. 16.4: Whiplash injury: Due to sudden deceleration, forceful hyperextension is followed by flexion of the neck



Figs 16.5A to D: Showing common mechanism of spine injuries: (A) Hyperextension injury, (B) Flexion extension injury, (C) Flexion rotation injury, (D) Flexion injury

- *Road traffic accidents (RTAs)* Common cause in developed countries, e.g. whiplash injury (Fig. 16.4).
- Gunshot injuries, etc. These injure the cervical spine and the cord directly.

Mechanism of Injury

Figures 16.5A to D show common mechanism of cervical spine injuries.

Pure flexion force For example, compression fracture of vertebral body, e.g. fall from height.

Flexion rotation force For example, fall on one side of the shoulder, disruption of facet capsule is seen.

Axial compression For example, fall of an object on the head results in load compression, e.g. explosive comminuted fracture of C5 body.

Extension force For example, avulsion fracture of superior margin of vertebral body, e.g. whiplash injury.

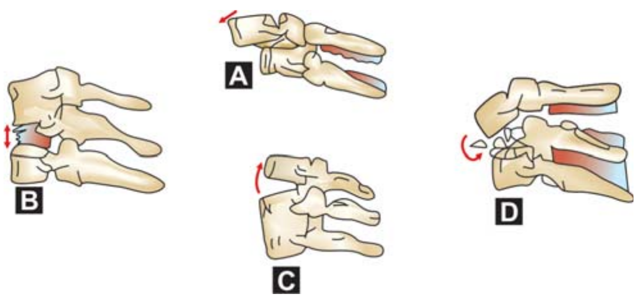
Lateral flexion For example, fracture pedicle, fracture transverse process and facet joints, etc.

Direct injuries For example, fracture spinous process and body. Due to assault, gunshot injury, etc.

Allen's Classification [6 Patterns (Figs 16.6A to D)]

Compressive flexion (5 stages) Ranges from blunting of anterosuperior vertebral margin to posterior displacement into the spinal canal. It is usually a stable fracture but may become unstable if compression is more than 50 percent.

Vertical compression (3 stages) Ranges from fracture of superior or inferior end plate with Centrum fracture of the vertebral body. Stable fracture if compression is less than 50 percent of the vertebral body.



Figs 16.6A to D: Cervical spine injuries: (A) Distraction injury, (B) Compression injury, (C) Hyperextension injury, (D) Compression and distraction injury

Distractive flexion (4 stages) Ranges from failure of posterior ligamentous complex to full-width vertebral body displacement. This is an unstable fracture.

Compression extension (5 stages) Ranges from unilateral vertebral arch fracture to bilateral vertebral arch fracture with full-vertebral body displacement anteriorly. It is unstable.

Distractive extension Ranges from failure of anterior ligament complex to posterior ligament complex. This is also an unstable fracture.

Lateral flexion Ranges from asymmetric compression and ipsilateral vertebral arch to fracture without displacement and with displacement. May become unstable.

> *Note* All unstable cervical spine fractures have a high incidence of neurological damage.

Clinical Features

Patient usually gives history of trauma following which there will be pain, swelling and inability to move the neck. There will be tenderness over the involved spinous process and there could be a palpable gap. There may be signs of neurological involvement. The injuries to the spinal cord at the cervical region can manifest in the following ways.

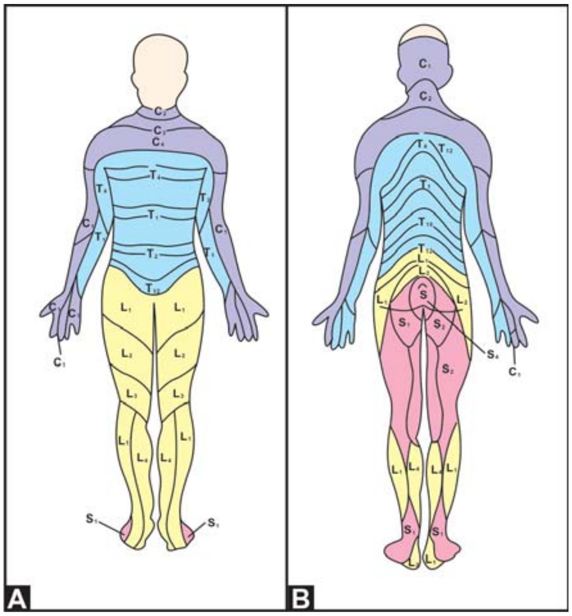
Concussion This is a state of spinal shock and there will be sensory loss, flaccid paralysis, visceral paralysis, reflexes are in abeyance and anal reflex is absent. By 8 hours concussion is known to regress and by 8-10 days there is complete recovery.

Nerve root involvement Individual nerve roots could be affected at their respective intervertebral foramen. All the features of peripheral nerve injury with LMN type of lesion are seen. The myotome and the dermatome should be assessed to know the root involvement (Figs 16.7 to 16.14 and Table 16.1).

TABLE 16.1: Showing cervical nerve root involvement

Roots	*Sensory system*	*Motor system*
C_2	Sensation decreased over back of the scalp	C_2-C_4 root involvement survival of patient is rare
C_3	↓ Sensation over anterior aspect of the neck	-do-
C_4	↓ Sensation over lateral aspect of neck and inferiorly over clavicles down to the rib space	-do-
C_5	↓ Sensation over the lateral deltoid	↓ voluntary activity of deltoid and biceps
C_6	↓ Sensation over the radial aspect of the forearm, thumb, index and middle finger	↓ ECRL, ECRB activity
C_7	↓ Sensation over the ulnar border of ring and small fingers	↓ triceps, finger extensors, pronator teres and FCR activity
C_8	↓ Sensation over ulnar border of hand and forearm	↓ FDS or Profundus activity
T_1	↓ Sensation over the medial aspect of the upper arm	
T_2	↓ Over the anterior chest wall above the nipple	Intrinsic function of the hand is intact

Note FCR—flexor carpi radialis, ECRL—extensor carpi radialis longus, ECRB—extensor carpi radialis brevis, FDS—flexor digitorum superficialis



Figs 16.7A and B: Dermatomal levels: (A) Anterior, and (B) Posterior

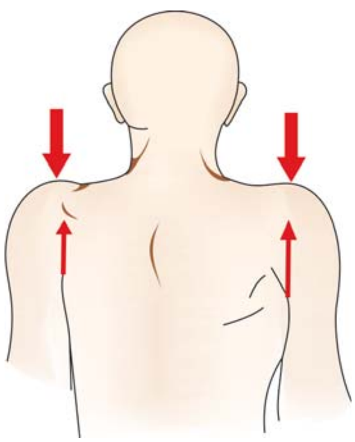


Fig. 16.8: Examination of C_3-C_4 (trapezius muscle)

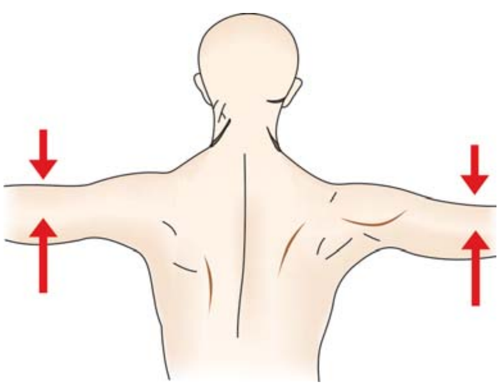


Fig. 16.9: Examination of C_5-C_6 roots (deltoid muscle)

Fig. 16.10: Examination of C_5-C_6 roots (biceps muscle)

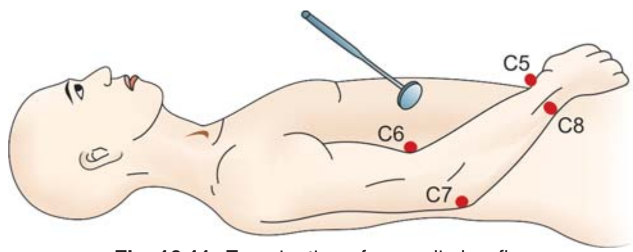


Fig. 16.11: Examination of upper limb reflexes

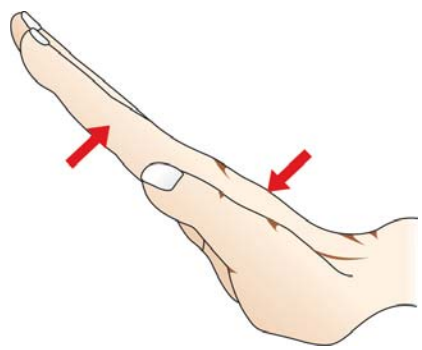


Fig. 16.12: Examination of C_7-C_8 (wrist extensors)

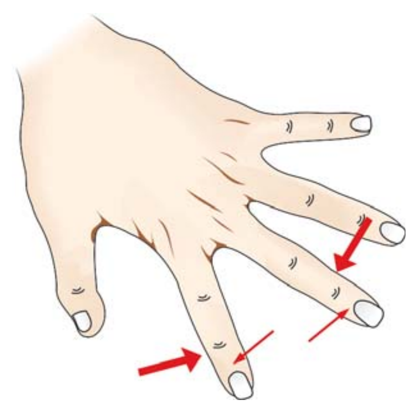


Fig. 16.13: Examination of C_8-T_1 (dorsal interosseous muscle)

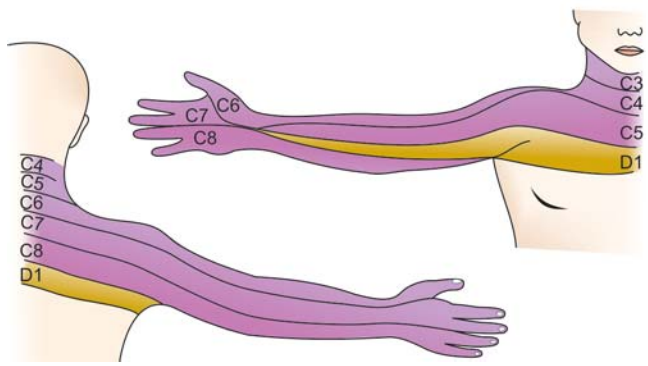


Fig. 16.14: Showing dermatomal pattern of cervical nerve roots

Cord involvement could be:

- *Complete* This leads to quadriplegia or quadriparesis.
- *Incomplete* Here the central cord, lateral cord, anterior or posterior cord could be involved (Flow chart 16.1).

Flow chart 16.1: Showing cervical spine injury

Root injury
- At the neural foramen nerve injury (flaccid paralysis) (Table 16.1)

Incomplete (sparing distal to the injury)

1. *Brown-Sequard syndrome* injury to lateral half of the spinal cord.
2. *Central cord syndrome*–most common. Results in gross quadriplegia, with sacral sparing.
3. *Anterior cord syndrome*–complete motor paralysis and sensory anaesthesia except deep pressure and proprioception.
4. *Posterior cord syndrome*–motor power, deep pressure, pain and proprioception lost.

Cord injury

Complete

Complete loss of sensation and motor power below the level of injury.

Vital Steps

- The lowermost functioning muscle is documented and a functional level is established.
- Next the sacrally innervated skin is examined. Perianal, anal, scrotal, labia, and plantar surface of the toes are examined.
- Perianal sensation may be the only sign to indicate an incomplete lesion.

Other Examinations

Rectal sensation Loss of sensation around the anus.

Rectal motor Sphincter contracts over the gloved finger.

Bulbocavernosus reflex Involves S1, S2 and S3 nerve roots. Squeeze the glans penis, anal sphincter contracts around the gloved finger.

Initially following the injury, the above reflexes are absent, indicating spinal shock. Usually it returns within 24 hours. If not a presumptive diagnosis and determination of a root or cord lesion is made.

A diagnosis of a complete or incomplete syndrome is documented.

Cord concussion

A state of “spinal shock”, i.e. temporary electrical dys-function

Features
- Sensory loss.
- Flaccid paralysis.
- Visceral paralysis.
- Reflexes are in abeyance.
- Anal reflex lost (anal wink lost).

Usually
- 8 hrs later concussion regresses.
- 7-10 days later complete recovery. If the reflexes, do not return within 24 hrs to 10 days a diagnosis of complete cord transaction is made.

Investigations

Radiography Lateral view is important. If an adequate lateral radiography reveals no fracture or dislocation, then a complete radiographic examination including anteroposterior, open mouth and oblique projections are performed (Fig. 16.15).

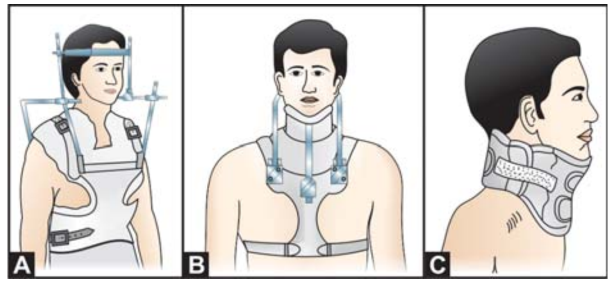
Myelography is of value in incomplete lesion who fails to show progressive improvement.

CT scan Makes an accurate diagnosis of hidden fracture. It is not helpful in assessing the soft tissue injury.

MRI evaluates Cord injuries better. MRI is found to be very reliable and helpful in assessing the bony, soft tissue damages and injury to the cord very accurately.

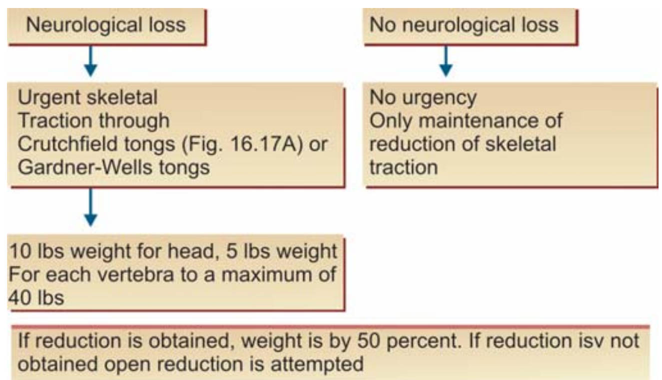
General laboratory investigations Like Hb percentage, blood group, bleeding time, clotting time, electrolyte states, etc. are done.

Fig. 16.15: Plain X-ray lateral view of the neck showing dislocation of cervical vertebrae



Figs16.16A to C: Methods of cervical immobilisation: (A) Halo-vest traction, (B) Four postcervical collar, (C) Cervical collar

Flow chart 16.2: Showing indications of skeletal traction in cervical spine injury



Treatment facts

Goals of treatment of cervical spine injury
- Realign the spine.
- Prevent further neurological damage.
- Aid neurological recovery.
- Obtain and maintain spinal stability.
- Aim at early functional recovery.

Treatment Methods

At the accident site Resuscitation and transport is important. *In a person lying still without using his neck after an RTA, a cervical spine injury is always suspected until proved otherwise.*

The patient is transported with utmost care over a stretcher to the hospital. All unnecessary neck movements should be totally avoided. If patient needs resuscitation it has to be carried out with a lot of care.

At the hospital

Nonoperative treatment Most cases can be treated non-operatively by halo vest, Minerva jacket, cervical collars, four post cervical collars, etc. (Figs 16.16A to C).

Indications
- Stable cervical spine with no neurological injury. A rigid cervical brace or halo for 8 to 12 weeks is usually sufficient.
- Stable compression fracture of vertebral bodies and undisplaced fracture of laminae, lateral masses or spinous process.
- Unilateral facet dislocations reduced in traction may be immobilized in a halo vest for 8 to 12 weeks.

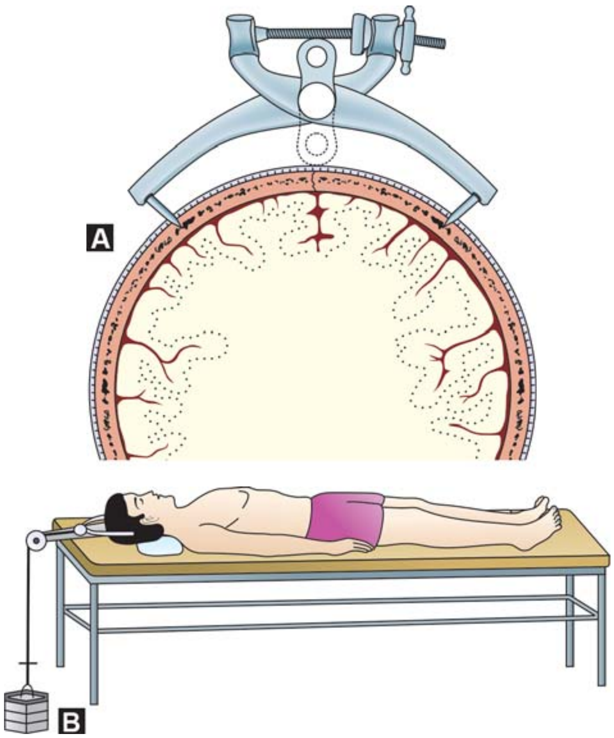
Skeletal traction Reduction with traction is done for unstable fractures. *Urgency of reduction is based on neurological loss* (Flow chart 16.2).

Traction is given for 3 to 6 weeks (Figs 16.17A and B) and once satisfactory reduction is achieved, patient is mobilized with a collar, corset or jacket

Surgical treatment

Indication Unstable injury with or without neurological damage require surgery.

Methods
- In most patients early open reduction and internal fixation (ORIF) is indicated to obtain stability. Cervical spine is stabilized through an anterior or posterior approach. Usually a posterior approach is used with triple wire stabilization and fusion with iliac bone grafting. This allows rapid mobilization of patient in cervical orthosis.
- Anterior decompression consists of removal of the disc and is recommended when disc prolapse is present.
- Posterior approach preferred for ligamentous instability.
- Anterior approach and corpectomy (removal of the crushed body) for burst fracture with cord compression.



Figs 16.17A and B: (A) Crutchfield tongs, (B) Showing skeletal traction applied through crutchfield tongs

- Combined anterior and posterior decompression for posterior instability and anterior compression of the neural elements.

Laminectomy has limited role in the treatment of cervical fracture.

Physiotherapy Management of Cervical Vertebral Fractures

The treatment objectives are aimed at achieving the following goals:

Orthopedic goals
- To restore the cervical spinal alignment.
- To prevent future spinal deformity.
- To prevent new neurological deficits, to improve and prevent further deterioration of existing neurological deficit.
- To provide spinal stability.

Rehabilitation goals To restore the normal or functional range of neck movements without creating neurological injury (Table 16.2).

To restore and maintain the strength of the cervical, Para cervical, upper limb, trapezium and lower limbs muscles.

Functional goals To restores the flexibility of cervical spine.

TABLE 16.2: Showing normal range of neck movements

Movements of neck	*Flexion*	*Extension*	*Lateral flexion*	*Rotation*
Normal	65°	65°	45°	75°

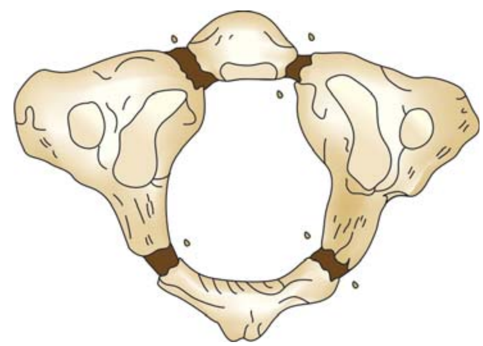


Fig. 16.18: Jefferson fracture

Note Cervical spine fracture
- Required time of bone healing—8-16 weeks
- Required rehabilitation time—3-6 months

Individual Cervical Fracture of Interest

Fracture of C1 this is popularly known as Jefferson's fracture (Fig. 16.18).

Clinical features: Here the patient usually presents with neck pain without neurological deficit.

Radiograph: This can be radiologically diagnosed by a plain X-ray of the neck with an open mouth odontoid view (Fig. 16.19).

Fig. 16.19: Plain X-ray showing fracture of C_1 (open mouth odontoid view)

Treatment

- *For stable fracture* Rigid cervicothoracic brace for three months.
- *For unstable fractures* Open reduction and posterior spinal fusion. Skeletal traction or halo cast for three months.

Physiotherapy Management of C1 Fracture (Jefferson Fracture)

During the First 2 Weeks

Range of motion Active ROM exercises are prescribed to the upper and lower limb muscles. No such exercises to the cervical spine.

Exercises Isometric exercises are prescribed to the abdominal, glutei and quadriceps muscles but nothing for the cervical spine.

Functional activities Patient is taught bed rolling with assistance, transfers, ambulation and weight-bearing with assistive devices. During this period the cervical spine should be immobilized with the help of orthoses.

After 2 Weeks

The same regime is followed up to 8 weeks while maintaining the spinal immobilization. However, full weight-bearing may be permitted.

By 8-12 weeks, gentle active range of movements to the cervical spine are begun and gentle passive movements to the neck by 12 weeks. Isometric strengthening exercises to the cervical spine is also commenced. Patient is encouraged to be independent in bed, wheel chair and ambulation.

> *Note* Because of the roomy spinal canal, Jefferson fracture seldom cause neurological damage.

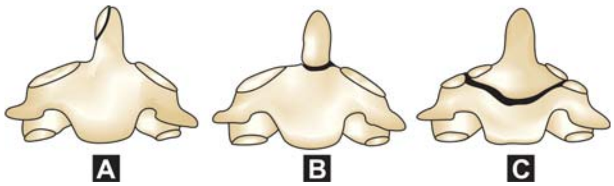
Rotary subluxation of C1 or C2 Here the patient presents with torticollis and neck pain and is diagnosed radiologically. Treatment is usually by reduction and skull traction.

Odontoid process fracture (Figs 16.20A to C) Anderson and D'olonzo's classification.

Type I Oblique fracture of the upper part of the odontoid process. It is uncommon and is treated by cervical cast.

Type II Junction of odontoid process and body. Common with a nonunion rate of 36 percent. Requires surgical wiring and fusion.

Type III fracture is through the upper part of the body of vertebra. Cancellous area hence fracture unites well with a halo cast.



Figs 16.20A to C: Odontoid process fracture: (A) type I, (B) type II, and (C) type III

Fig. 16.21: Plain X-ray showing the Hangman's fracture

Hangman's fracture It is a fracture through pedicle of C2 and is due to distraction extension force. There is no neurological deficit and patient needs rigid cervical support. The physiotherapy protocol for the Hangman fracture and odontoid process fracture is the same as for Jefferson fractures (Fig. 16.21).

CERVICAL SPINE INJURIES WITH NEUROLOGICAL PROBLEMS

Management of Quadriplegia If the patient has developed quadriparesis or quadriplegia due to unstable cervical spine injury transecting the cord, physiotherapy measures should be instituted to combat this dreaded problem.

Physiotherapy Measures during the Spinal Shock

This is mainly preventive in nature as it aims to prevent cardiorespiratory collapse and early complications.

If the patient has acute cardio respiratory compromise, emergency measures like resuscitation, tracheostomy and ventilator support are immediately instituted. Frequent monitoring of the vital capacity is done.

If the patient is less serious and has a stable cardio-respiratory function, the following measures are undertaken:

- Prophylactic antibiotics to prevent chest infection.
- Chest physiotherapy like assisted coughing, intermittent positive pressure breathing, and deep breathing exercises, etc.
- Postural drainage in the event of chest infection.

Measures to Combat Early Spinal Shock Complications

- Proper alignment of the fracture to maintain the correct neck position.
- An effort is made to detect and treat deep vein thrombosis and thrombophlebitis and thus minimize the chances of pulmonary embolism.
- Intermittent catheterization to prevent renal complications.
- Keeping the pressure points like the back, sacrum, trochanters, ischial tuberosity, occiput, elbows, posterior heel, malleoli, etc. dry and frequent changing of bed position to prevent pressure sores from developing.
- Keeping the limbs in functional positions with the aid of splints to prevent contractures and deformity.
- Avoiding overstretching of the muscles to prevent ectopic ossification.
- Keeping the limbs in elevated position to prevent and control limb edema.
- Frequent turning in bed, passive movements, resisted movements, early weight-bearing, etc. to prevent osteoporosis.
- Sitting or semi-reclining posture to prevent autonomic dysreflexia (wild fluctuation of blood pressure and temperature due to lesions above T10 level).
- Thermotherapy, TENS, and other measures to combat chronic pain.

Quick Facts

Immediate and late complications of spinal injuries

- Spinal shock
- Pulmonary embolism
- Pressure sores
- Renal complications
- Deformities
- Heterotrophic ossification
- Edema
- Paralytic ileus
- Osteoporosis
- Pain
- Autonomic dysreflexia

Physiotherapy Measures Postspinal Shock

After the spinal shock wears off a systematic and through neuromuscular examination is carried out to evaluate the residual effects. A knowledge of the segmental innervations helps to identify the site and level of the damage and consequent therapeutic measures to be followed to combat the residual effects (*see* Table 16.1).

Having determined the site, level of damage and the residual effects, the following measures are adopted:

- *Passive movements of the limbs* These are carried out in slow, rhythmic and relaxed manner. This helps improve circulation, reduces edema and spasticity, prevents deformities, etc.
- *Active movements* Active to active resistive exercises are prescribed for the muscle groups with intact innervation.
- To control edema, foot end elevation, use of splints and passive movements, etc. is adopted.
- Proper splinting of the joints in their respective functional positions helps to control spasticity and prevent contractures and deformities.
- Below the lesion, there is loss of perception of movements, the bodily and limb positions.
- Blood vessels in the viscera do not contract due to loss of vasomotor control. Breathing exercises, position alteration, etc. helps to compensate.
- *Self-care training* To develop independence in self care is the final goal of treating these patients. The functional independence depends on the degree and extent of spinal cord lesion. Training in mat activities like rolling, turning, sitting, lying, and trunk balance is taught. Wheelchair activities are also taught.

Standing and walking with assistance helps to improve circulation, reduce spasticity, prevent osteoporosis, improve postural sensibility and vasomotor control and gives a tremendous psychological boost.

THORACIC AND LUMBOSACRAL SPINE INJURIES

Thoracolumbar spine is generally regarded as extending from 10th thoracic vertebrae to 2nd lumbar vertebrae and is the transitional area between the kyphotic upper thoracic spines to the lordotic lumbar spine. The general anatomy of the vertebral column is more or less the same as in other areas of spine. The three-column concept of spine consists of the anterior, middle and posterior columns. Anterior column is the load bearing structure and the posterior column functions as motion limiters as well as load bearing structures.

One column injury is stable, two column injuries are unstable and the three column injury is invariably unstable.

Mercifully the thoracolumbar injuries spare the upper limbs and vital functions. Though a lesser challenge than cervical injury nevertheless it poses problems, no less risky than the former.

Mechanism of Injury

- Fall from a height. This is the common cause.
- RTAs: Seat belt injury (Chance fracture).
- Other causes like gunshot injuries, assault, etc.

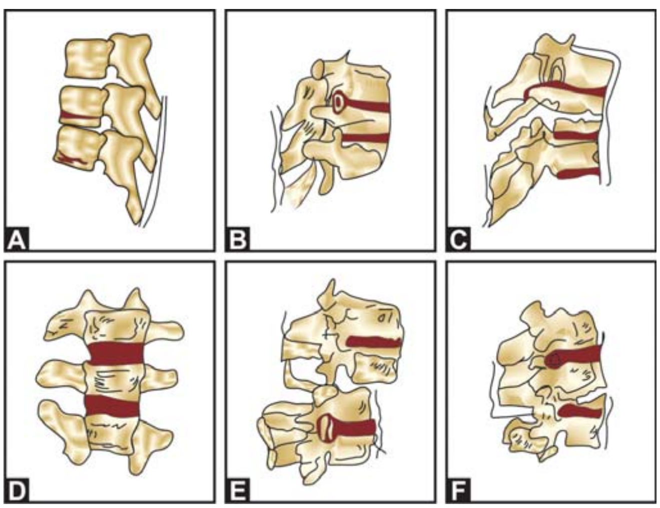
Mc Afee's Classification—Three Column Classification (Figs 16.22A to F)

Wedge compression Isolated failure of anterior column due to forward flexion. No neurological deficit.

Stable burst fractures Anterior and middle columns fail. No loss of integrity of posterior elements.

Unstable burst fractures Anterior and middle column fail in compression. Posterior column fail in compression, lateral flexion or rotation. Post-traumatic kyphosis and neural symptoms are present.

Chance fracture (Seat belt injury) Horizontal avulsion fracture of vertebral bodies caused by flexion about an axis anterior to the antero longitudinal ligament. Entire vertebrae are pulled apart by a strong tensile force (*see* Fig. 16.5B).



Figs 16.22A to F: Thoracolumbar fractures: (A) Flexion compression fracture, (B) Burst fracture, (C) Flexion distraction fractures (seat belt fractures), (D) Lateral compression fractures, and (E and F) Fracture dislocation

Flexion distraction injury Flexion axis is posterior to the anterior longitudinal ligament. Anterior column fails in compression. Middle and posterior column fail in tension. It is unstable because supraspinous, interspinous and ligamentum flavum fail.

Translational injuries Malalignment of neural canal which has been totally disrupted. All 3 columns fail in shear. At the affected level, one part of sacral canal has been displaced in the transverse plane.

Clinical Features

Patient gives history of trauma due to RTA or fall from height and complains of pain; posterior swelling, tenderness, palpable interspinous gap or a step may be felt. Neurological involvement may vary from paraplegia to individual nerve root involvement (*see* Figs 22.6 to 22.9). Spinal shock is present for 24 hrs during which all the reflexes are lost. Cauda equina paralysis is present if the lesion is below L1 (Fig. 16.23).

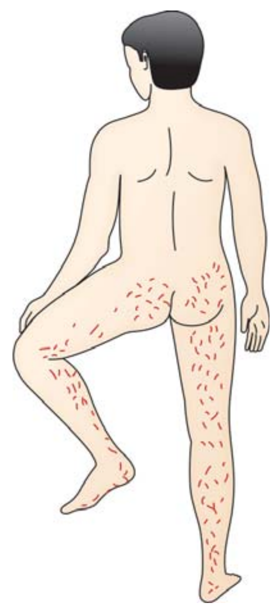


Fig. 16.23: Showing Cauda equina lesion

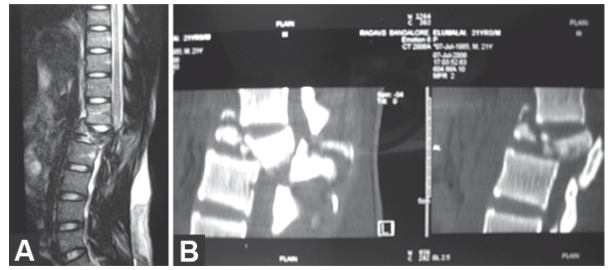
Investigations

Radiography of the affected spine (Fig. 16.24) This is the preliminary investigation and all 3 views (AP, lateral and oblique) are taken. Fracture of the vertebral body, pedicles, lumbar transverse process, spinous process, etc. is looked for. Disc space and neural canal narrowing is also looked for. With the advent of MRI and CT scan, the role of radiography appears to be diminishing in importance.

Fig. 16.24: Radiograph showing exaggerated lumbar lordosis due to L_1 fracture

Fig. 16.25: MRI showing flexion compression fracture of L_1 vertebra

CT scan and MRI Both CT scan and MRI (Fig. 16.25) have found to be more useful than radiographs in evaluation of spinal trauma. While CT scan helps in studying the bony elements, MRI helps in the study of both bone and soft tissue elements. The damage to the cord is detected fairly accurately and is now being considered as the "gold standard" in the investigation of spine injury (Figs 16.26A and B).



Figs 16.26A and B: (A) MRI and (B) CT scan images of the thoracolumbar fractures

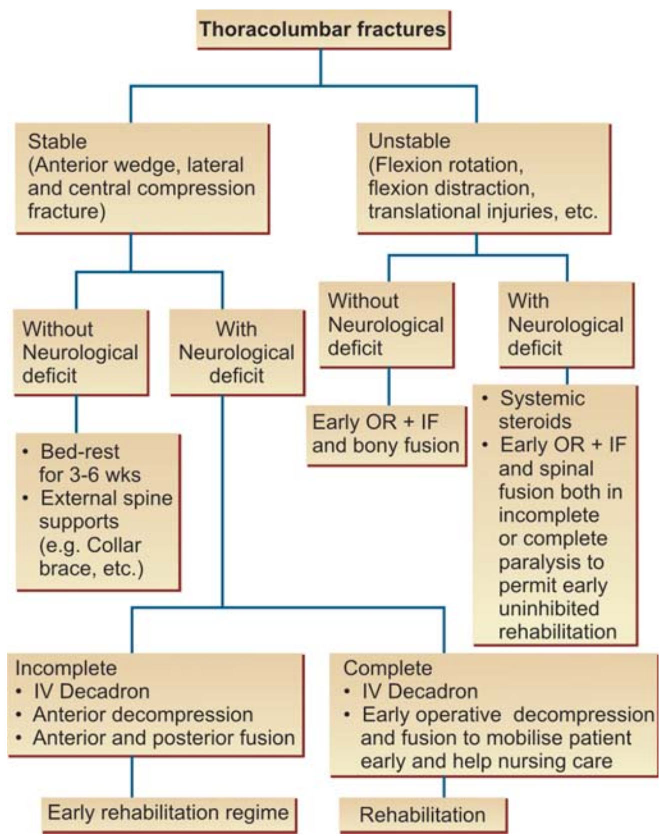
Management

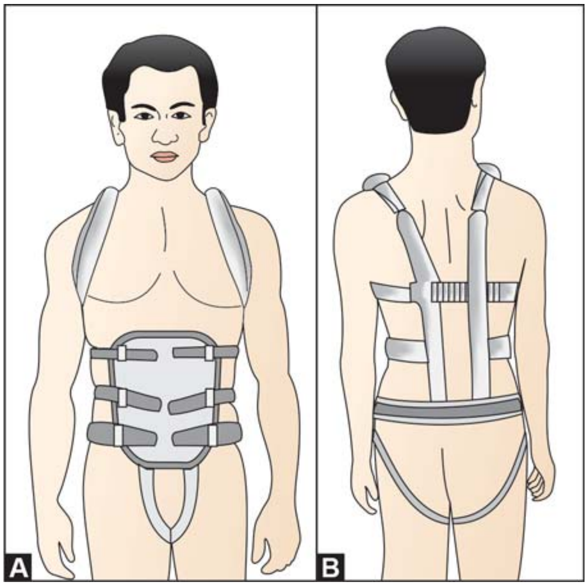
This is discussed under two heads.

Management at the site of accident This consists of careful handling of the patient suspected to have spine injury. Consider all patients with spine injury to have neurological damage and shift them to the hospital with utmost care and caution avoiding all unnecessary movements.

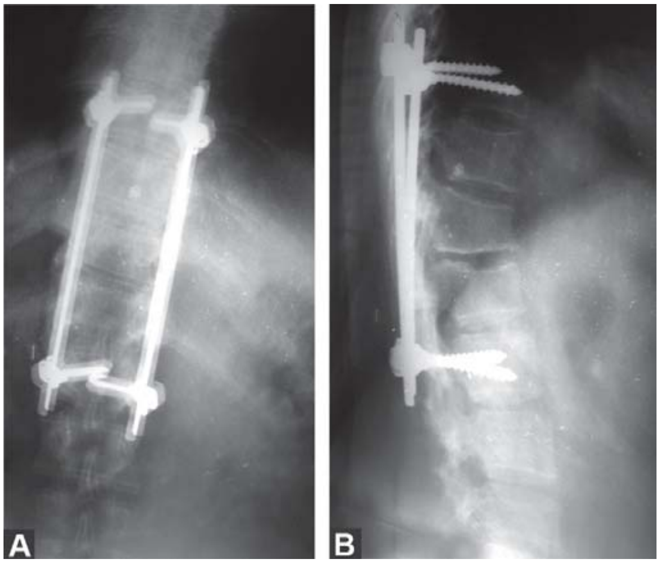
Definitive treatment at the hospital This varies depending upon the nature of injury (stable or unstable) and the presence or absence of neurological damage (Flow chart 16.3).

Flow chart 16.3: Showing treatment plan for thoracolumbar injuries





Figs 16.27A and B: Showing treatment of stable thoracolumbar fractures with brace



Figs 16.28A and B: Plain X-ray showing posterior fixation with Rods and screws

For stable fracture without neurological deficit Less than 30 percent anterior wedge, lateral, central compression fracture of the vertebral body is considered as stable fracture. In these injuries there is no fracture of the posterior cortex of the vertebral body, and there is no disruption of the neural arch.

Treatment This is essentially conservative and consists of bed rest, NSAIDs and external spine supports like brace, corsets, etc. (Figs 16.27A and B). If the vertebral body compression is less than 30 percent, only corset is used and if the compression is more than 30 percent but less than 50 percent a plaster jacket along with a corset is preferred.

For stable fracture with neural deficit It has to be first determined whether the neurological deficit is complete (loss of motor power, sensory loss and absent reflexes) or incomplete (only cord or only spinal nerve roots).

Treatment: If neurological damage is incomplete, IV steroids are given for 4 days. Anterior decompression and anterior interbody fusion is done in the first stage, followed by posterior segmental spinal stabilization by either pedicle screws, Hart shill rectangle frame, Luque instrumentation, etc. can be done one week later. Laminectomy has fewer roles as it makes the spine less stable.

Unstable fracture without neurological deficit *this* is best treated by early open reduction, internal fixation and fusion is done preferably within 12 to 24 hours. It is done with spinal cord monitoring. Internal fixation is either by VSP plates, Hart shill frame, Harrington instrumentation, etc. (Figs 16.28A and B).

Unstable fracture with neurological deficit Systemic Decadron 4 to 6 mg/every 6 hrs IV for 3 days is given. Early open reduction, internal fixation and fusion are done in incomplete neurological deficit cases. This is also desirable in complete neurological deficit to permit early uninhibited rehabilitation. Segmental spinal stabilization with Luque or Hart shill frame is recommended.

Physiotherapy Management of Thoracic and Thoracolumbar Fractures

The goals of management for thoracic, thoracolumbar and lumbar spine fractures are as follows:

Orthopedic goals

- To restore normal spinal anatomy.
- To provide spinal stability.
- To prevent new neurological deficits and to improve and prevent further deterioration of the existing ones.

Rehabilitation goals To restore the normal or functional range of movements of the spine (Table 16.3).

To restore the muscle strength of the Para spinal muscles, the latissmus dorsi, the trapezius and quadratus lumborum.

TABLE 16.3: Showing the normal and functional range of TL movements

Movements	*Flexion*	*Extension*	*Lateral bends*	*Rotation*
Normal range	60°	30-40°	$\pm$30°	20°

Functional goals To allow pain free sitting, standing and walking.

Note
- Required time of bone healing—8-16 weeks
- Required rehabilitation time—3-6 months

The physiotherapy management for thoracic thoracolumbar and lumbar spine fractures proceeds on the following lines:

During the first 2 weeks
- *ROM* Active range of movements is allowed to the upper and lower limbs. No range of motion is permitted to the thoracolumbar spine.
- *Exercises* Isometric strengthening exercises to the abdominal, glutei and quadriceps muscles but no exercises to the spinal muscles.
- *Mobilization activities* The patient should be mobilized on a chair at the earliest as soon as the pain level comes down.
  - — *Bed mobility* The patient is turned using the log-rolling method. He should either lie on the back or sides and not prone on the abdomen (Fig. 16.29A).
  - — *Sitting and transfer* To sit, the patient is instructed to turn to one side, pushes up on the elbow and shoulder and sits with assistance. From this position, the patient is brought to the standing position, weight-bearing on the lower extremities and transferred from bed to chair (Fig. 16.29B).
- *Functional activities* The patient is encouraged to dress in the sitting position initially. He needs assistance in the lower limb dressings.
  An elevated toilet seat is recommended.

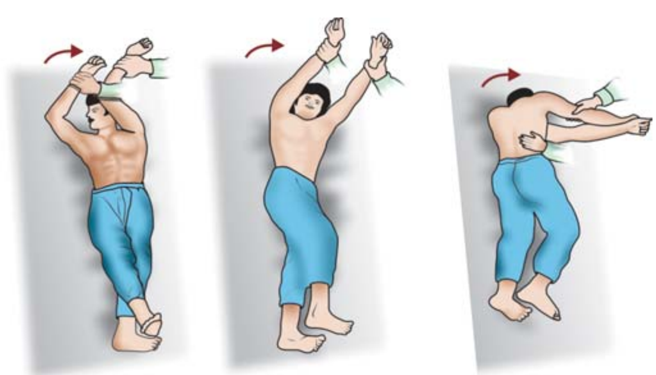


Fig. 16.29A: Method of turning a patient prone in paraplegia

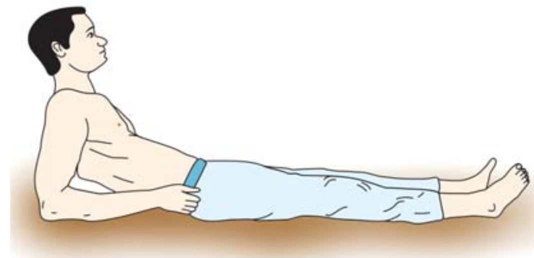


Fig. 16.29B: Method of sitting with the support of the elbows in a paraplegic patient

- *Gait and ambulation* The patient can bear weight and walk on the lower limbs using a walker or cane for support.

After 2 weeks By the end of 6 weeks, gentle extension exercises are prescribed for the back with stable compression fractures. Isotonic exercises with weights are recommended to the upper and lower extremities. No strengthening exercises for the Para spinal muscles.

By 8-12 weeks, active flexion, extension, lateral bending and rotation is allowed to the thoracolumbar spine. Trunk strengthening and Para spinal strengthening exercises are commenced. Full weight-bearing is allowed.

By 12-16 weeks, gentle passive movements and progressive resistive exercises to the back are started. Independent weight-bearing, transfer and ambulation are allowed.

SPINAL CORD INJURY

Spinal cord could be damaged due to injuries of spine extending from cervical vertebrae to the thoracolumbar junction. Below this the cord ends and the cauda equina begins.

Pathology

The pathology may vary from extradural hemorrhage to cord concussion, laceration to cord crushing. Lesion has longitudinal, sagittal and coronal dimensions. Amount of neural damage has no relationship to radiographic appearance (Fig. 16.30).

Clinical Classification of Neurological Damage

- Complete paralysis
- Sensory paralysis
- Motor paralysis useless
- Motor paralysis useful
- Recovery.

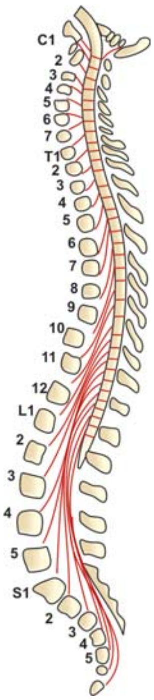


Fig. 16.30: Spinal cord ending at L_1 cauda equina starting at this point

Injury at the cervical level This has already been discussed and may vary from concussion, root injuries, incomplete and complete cord transection.

Injuries at the thoracic level This could result in paraplegia.

Injuries at the thoracolumbar region Due to injuries at the thoracolumbar junction, three things can occur:
- Complete cord division and nerves intact
- Complete cord division and partial nerve division
- Complete cord division and complete nerve division.

Injuries below L1 Causes cauda equina paralysis.

Clinical Assessment

General examination This consists of examination of the head, chest, pelvis and other systems for incidence of injuries and also recording the vital statistics.

Neurological examination Each muscle group and dermatome has to be checked (*see* Figs 16.7 to 16.14). In cases of cervical cord injury survival is impossible if the cord is injured above C4 level due to paralysis of the diaphragm and respiratory muscles. In injuries below C4 and above C7, the level of lesion can easily be detected by examining the respective myotome, dermatome and reflexes (*see* page 215). In cases of injury at the thoracolumbar junction a mixed picture of both cord and root lesion may emerge and there could be a UMN and LMN feature in the lower limbs. Below L1 it is the nerve roots which are damaged and it is easy to identify the injured nerve root by a careful examination of myotome, dermatome and reflexes of the lower limb (*see* page 361). Slightest voluntary movement and sensation below the level of cord lesion indicate cord continuity with better prognosis. If paralysis is complete even after 8 hrs and if there is symmetrical returning of reflexes and priapism in male, it indicates an unfavorable prognosis.

Return of reflex activity (e.g. anal reflex, bulbocavernosus reflex and plantar response) Return of reflex activity below the lesion indicates that the spinal shock has passed off and remaining paralysis and anesthesia may be due to injury to the long tracts of cauda equina.

Total sensory and motor paralysis After 8 hrs with return of reflex activity indicates that distal part of spinal cord has been separated from cerebral control. There will be total paraplegia and could lead to wasted and functionally useless lower limbs (Fig. 16.31).

Fig. 16.31: Clinical photograph showing paraplegic limbs

Investigations

This consists of plane radiograph of the affected part and all three views, anteroposterior, lateral and oblique are done. MRI and CT scan are also done and their role has already been described (*see* Figs 16.26A and B).

Treatment

- First aid as already discussed.
- Management of vertebral fracture and dislocations as discussed in individual injuries.
- Rehabilitation programmes in neurological injury following spinal fracture are as shown in Table 16.4.

TABLE 16.4: Rehabilitative measures for neurological injury

Level	*Disabilities*	*Measures*
$S_{2,4}$	only bowel and bladder injured	Bladder and bowel programme
L_4-S_1	Bladder, bowel and prolonged sitting impaired	Short leg braces
$L_{1,2,3}$	Bladder, bowel and Walking impaired	Walking with long leg brace
T_{7-12}	UMN bladder	Long leg brace and Wheelchair
T_2-T_6	Bowel, bladder, walking, Sitting impaired	Wheelchair is a must
C_7-T_1	Upto the level patient can Become independent in all Activities of daily living	Wheelchair is a must
C_5	Assistance to all activities Of daily living required	Electrical chair is required
Above C_5	Total dependence + impaired breathing	

Table shows the level of spinal injuries, their corresponding disabilities and the measures to be followed

Paralyzed bladder Bladder injuries could be either UMN type or LMN type (Table 16.5).

TABLE 16.5: Characteristic features of UMN and LMN bladder injuries

Bladder	*Automatic*	*Autonomous*
• *Type*	UMN	LMN
• *Level*	Above S_2	S_2 and below
• *Reflex centre of bladder*	Takes over	Lost
• *Controlled by*	Reflex centre	intrinsic plexus of bladder
• *Emptying by*	Involuntary	Voluntary
• *Residual urine*	Minimal	Large > 200-300 cc

Goal in either case is to attain an automatic reflex emptying of the bladder.

UMN type (automatic bladder) This is seen in injury above S2 due to complete transection of the cord. Here the bladder is distended and there is no real sensation of vesicle filling and the bladder is controlled by the reflex centers. There is automatic involuntary emptying and no residual urine is left.

LMN type (autonomous bladder) This occurs in injuries at or below S2. The bladder reflex centre is destroyed. It now depends on the intrinsic plexus in the musculature of the bladder wall (detrusor ganglion). Here emptying is to be done by manual pressure or by trained contraction of abdominal musculature. There is a large amount of residual urine in this condition.

Treatment In either condition mentioned above the treatment method aims at obtaining automatic reflex emptying. This is done as follows:

- Urinary retention catheter is placed in the bladder for 24 to 48 hrs.
- After 48 hrs, intermittent catheterization is started, to develop the automatic reflex emptying of the bladder. Periodic irrigation of the bladder with mild antiseptic.
- Persons with traumatic quadriplegia have an UMN bladder controlled by reflexes through conus medullaris.
- If intermittent catheterization is not available, bladder range of motion exercises are performed by clamping the catheter tube for 50 minutes and opening for 10 minutes every hour to allow the bladder to develop a reflex pattern of emptying.
- If reflex emptying with residual bladder urine volume of less than 100 cc does not occur within 6 to 9 months, urological procedures like external sphincterotomy or bladder neck resection is done to achieve a balanced bladder.
- Urinary diversion through ileal loops, etc. is not superior to reflex emptying of the bladder and hence is not recommended.

All possible attempts should be made to remove the catheter and have a catheter-free reflex emptying of the bladder.

Bedsores Happens due to constant pressure over the anesthetic skin over the body points (Fig. 16.32). They are difficult to treat.

Fig. 16.32: Clinical photograph showing the bed sores and catheterization for paralyzed bladder

Bedsore Management

Nursing goals Education of the patients and relatives is of prime importance and is the duty of a nurse. The following measures are recommended for bedsore management:

- Only sure method of preventing pressure ulcers is strict nursing care and gradual shifting of responsibility of the skin to the patient's family.
- Spinal beds, mattresses and pads are not reliable to prevent pressure sores.
- Sleeping in prone position with a pillow bridging the bony prominences is the most reliable method of preventing bedsores.
- Using water bed also helps prevent bed sores.
- Side lying method to prevent pressure over the back.

Nursing Facts

What should a nurse do to prevent bedsores?
- Turning the patient on the sides every 1-2 hrs
- Keeping the back dry by wiping
- Application of antiseptic powder to the back
- Regular sponge bath.

Bowel Program

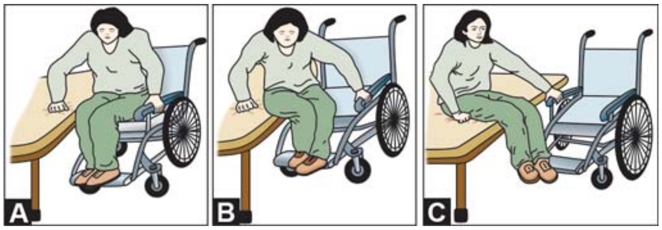
Reflex emptying of the bowel with suppository stimulation is the goal of bowel training Every 2nd or 3rd day bowel reflex is stimulated by insertion of glycerin or Dulcolax suppository with digital stimulation. Enemas should not be given as this destroys the bowel reflex. Stool softeners and mild laxatives may be necessary.

Sex rehabilitation in complete cord lesion, production of semen which is a hormonal activity is not affected but erection is lost. However, power of recreating is not lost as ejaculation can occur as it is a reflex function.

Beds A conventional hospital bed and pillow is preferred. Side to side rotating bed is used during the first week. Proper positioning of the patient with supportive pillows, frequent turning in the bed and care towards personal hygiene is very much needed (Fig. 16.33).

Family education The family members of the victim are trained to take care of the victim's bowel, back, bladder and bed. They are also encouraged to give all the necessary moral support which is so essentially required to rehabilitate the patient back to normalcy.

Fig. 16.33: Bed posture (side lying) to prevent formation of bedsores



Figs 16.34A to C: Method of self-transfer by a paraplegic patient from wheelchair to the bed (A, B, C) and from bed to wheelchair (C, B, A)

Physical therapy This consists of putting joints through all the range of movements by passive stretching and exercises. Parallel bar walking, walking with the help of walkers or crutches is encouraged. Wheelchair transfer activities from chair to bed and back (Figs 16.34A to C) are encouraged for injuries from C6 level onwards.

Physiotherapy for a Paraplegic Patient

During the phase of spinal shock the physiotherapy management is the same as discussed in spine injuries. The bladder and bowel management is also the same. However, certain other measures to be followed in paraplegic patients are as follows:
- Strengthening of specific group of muscles.
- Gait training and ambulation
- Additional measures.

Strengthening of specific group of muscles For adequate trunk balance the following muscles needs to be strengthened by adequate exercises, the latissimus dorsi, the trapezius and the abdominal muscles.

To enable the patient to use the crutches properly, special exercises to strengthen the shoulder muscles particularly the abductors, triceps, wrist dorsiflexors, finger flexors and quadratus lumborum muscles are indicated.

Gait training and ambulation This is preferably done in parallel bars. In this the patient is taught the correct method of balancing while standing from a wheelchair and transferring the weights properly. Gait training is also commenced within the parallel bar for patients with lesions below T6 level. Above this level walking may not be possible (Fig. 16.35).

Patient is taught within the parallel bars how to balance on a single leg placing the feet properly, moving the hands correctly, avoiding dragging of the feet, lifting the body, etc. in a continuous long and repeated practice sessions. This helps

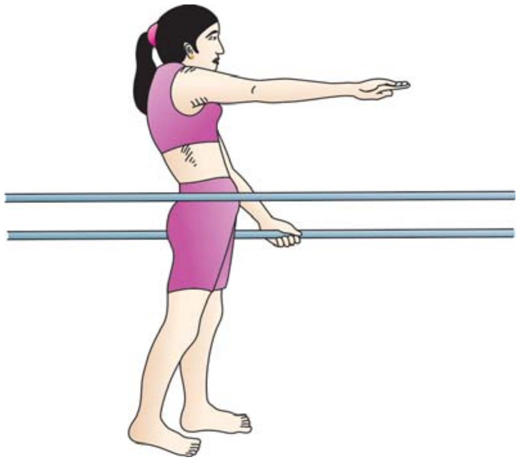


Fig. 16.35: A paraplegic patient learning to balance and walk within a parallel bar

a patient to achieve the necessary control for proper rhythm, timing and balance during walking.

Of the many gait patterns, the swing to gait is recommended more commonly as it is simple and safe. It is recommended for lesions above T10 and the patient need to use axillary crutches with bilateral above knee orthoses. After adequate practice, a swing through gait is adopted as it is readily acceptable to the patients. For patients with lesions below T12, a four point gait is recommended since it is more or less like a normal walk.

Additional measures This includes training the patients to use their appliance properly, frequent checks at pressure points, use of braces, etc. vocational rehabilitation, family education, occupational therapy, sex rehabilitation, etc. needs to be given equal importance during rehabilitation of a paraplegic patient (Fig. 16.36).

Occupational therapy If possible patient is allowed to return to his original work with minor adjustments if necessary. But however if the patient is unable to return to his original work, an alternative employment depending upon his present status of health is suggested.

Social therapy The attitude of the people towards these patients should not be one of sympathy, but of support and encouragement. The right attitude of the society towards these unfortunate victims will go a long way in rehabilitating them back to normal.

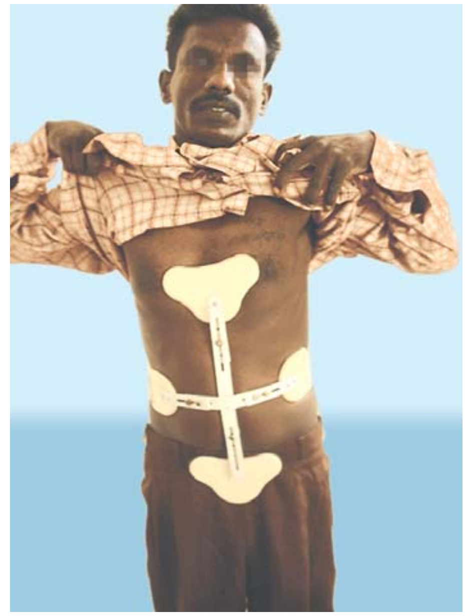


Fig. 16.36: Clinical photograph showing the close of anterior hypoextension brace

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17

Chapter

Peripheral Nerve Injury

ABOUT SPINAL NERVE

The dorsal and ventral nerve roots arising from the spinal cord join at the intervertebral foramen to form a spinal nerve. In the thoracic segments, these mixed spinal nerves retain their autonomy and supply one intercostals segment both dermatomal and myotomal. In virtually all other segments spinal nerves join with others to form a plexus. There are 31 pairs of spinal nerves consisting of 8 cervical, 12 thoracic, 5 lumbar, 5 sacral and 1 coccygeal.

A spinal nerve has got three components: motor, sensory and sympathetic. The sympathetic components of all 31 mixed spinal nerves leave along the 14 motor roots (12 thoracic and 2 lumbar roots). Each spinal nerve now divides into *anterior and posterior* rami. The anterior rami of the upper four cervical nerves forms the *cervical plexus* and the lower four cervical together with upper thoracic nerves form the *brachial plexus*. The anterior rami of the first three lumbar nerves and part of the fourth lumbar nerve form the *lumbar plexus*. The sacral anterior rami along with the anterior rami of the fifth lumbar and part of fourth lumbar form the *lumbosacral plexus*.

The posterior rami supplies the Para spinal muscles and the skin of the back. They are smaller than anterior ramie except for upper three cervical posterior rami. The spinal nerves are then distributed to the limb buds through several peripheral nerves. *So basically a peripheral nerve is also a mixed nerve like the spinal nerve* (Fig. 17.1).

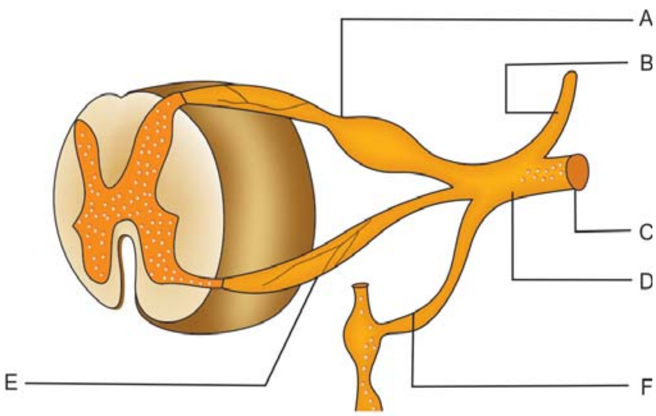


Fig. 17.1: Components of a spinal nerve: (A) dorsal root ganglion on the sensory root, (B) posterior rami, (C) anterior rami, (D) mixed spinal nerve, (E) grey ramus communicans from the sympathetic ganglion, and (F) motor root

Dermatome is an area of skin supplied by a single spinal root.

Myotome Represents a muscle unit supplied by a single spinal root.

CLASSIFICATION OF NERVE INJURIES

Seddon's (1943) Classification

Seddon identified three types of nerve injuries: the first one is a mere contusion, second is the transection of axons only, and third complete transection of the nerve. This classification is less accepted clinically (Table 17.1).

TABLE 17.1: Seddon's classification

Neuropraxia	*Axonotemesis*	*Neurotemesis*
• Minor contusion of the peripheral nerve • Axis cylinder is preserved • Temporary • Recovery is complete	• Axon breakdown • Endoneurium is intact • Spontaneous recovery is expected	• Complete anatomic section • No recovery

TABLE 17.2: Sunderland's classification of nerve injuries

Degrees	*I°*	*II°*	*III°*	*IV°*	*V°*
Axon	Contusion	Disrupted	Disrupted	Disrupted	Disrupted
Endoneurium	Intact	Intact	Disrupted	Disrupted	Disrupted
Perineurium	Intact	Intact	Intact	Few fibres preserved	Disrupted
Entire nerve	Intact	Intact	Intact	Intact	Disrupted
Myelin	Intact	Intact	Intact	Intact	Disrupted
Motor march: Recovery of the motor innervation in a progressive manner from proximal to distal	• No motor march* • No Tinel sign • Complete restoration of function	• Motor march present • Tinel sign present • Good recovery	• Motor march present • Tinel sign present • Incomplete recovery	• No Tinel sign or motor march • No recovery	• No recovery • Grade VI° is a mixture of above injuries from I° to V°

Sunderland's Classification

Accepted clinically Arranged in ascending order of severity from 1 to 5. Various degrees represent injury to myelin, axon, endoneurium, perineurium and entire trunk (Table 17.2).

Etiology

General causes Metabolic diseases, collagen diseases, malignancies, endogenous or exogenous toxins; thermal, chemical or mechanical trauma, etc. can cause injury to the peripheral nerves.

Local causes Forty percent of bone and joint injuries are associated with peripheral nerve lesions.

Types

Primary This is due to injury of a peripheral nerve resulting from the same trauma that has injured a bone or joint.

Secondary This is due to involvement of the nerve in infection, scar, callus, etc.

Incidence of peripheral nerve injuries
- Radial nerve is commonly injured.
- Ulnar nerve 30 percent.
- Median nerve 15 percent.
- Peroneal nerve.
- Lumbosacral plexus 3 percent.
- Tibial nerve.

Clinical Diagnosis

It is difficult to evaluate a nerve injury immediately after a severe trauma. However typical attitudes and simple screening test help clinch the diagnosis with reasonable accuracy.

Typical deformities
- Wrist drop → Radial nerve injury.
- Claw hand → ulnar nerve injury.
- Foot drop → Lateral popliteal nerve injury.
- Ape thumb → Median nerve injury.
- Winging of scapula → Thoracodorsal nerve injury.
- Pointing index → Median nerve injury.
- Policeman tip → Brachial plexus injury.

Simple Screening Tests

- In ulnar nerve injury, loss of pain at tip of the little finger.
- In median nerve injury, loss of pain on the tip of index finger.
- In radial nerve injury, inability to extend the thumb (Hitch-Hiker's sign)

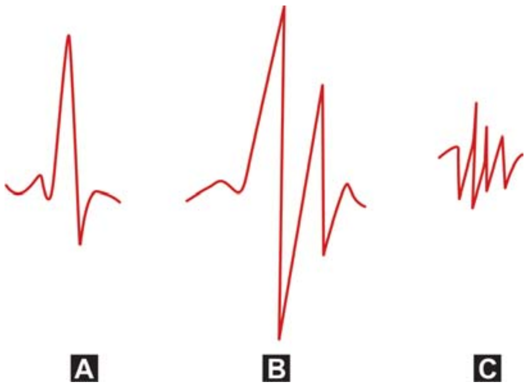
Diagnostic Tests

Electromyography (EMG)

Electromyography helps to record the electrical activity of a muscle at rest and during activity.

Intact muscle There is no electrical activity in an intact muscle at rest. During a weak contraction, the electrodes record a single action potential. In powerful muscle contractions these motor action potentials superimpose to give an interference pattern.

Injured or denervated muscle These muscles show denervation potentials which are spontaneous electrical activity at rest. These are primitive responses which are normally suppressed by the stronger nerve action potentials. These denervation potentials normally appear by 1 to 2 weeks after injury. If they have not appeared by 15 to 20 days after muscle denervation, it indicates a good prognostic sign.



Figs 17.2A to C: Pattern of electromyography curves: (A) Normal insertional activity, (B) Positive waves (5-14 days), and (C) Denervation fibrillation after 15-30 days

Quick Facts

EMG (Figs 17.2A to C)

- Normal insertional activity immediately after section.
- Positive waves seen after 5 to 14 days.
- Denervation fibrillation after 14 days.
- Spontaneous fibrillation after—15 to 30 days of interruption.

Uses and limitations of EMG Electromyography helps to detect the presence or absence of nerve injury if present whether it is complete or incomplete and whether any regeneration is taking place or not. EMG does not give the level of injury or the degree of injury accurately.

Strength duration curve A muscle usually responds to an electric stimulus. However, greater strength of current is required to excite a denervated muscle than normal muscle. Minimum current required to elicit a muscle contraction is called the "rheobase" and is expressed in milliamperes. The "chronaxie" is the duration of current required to excite a muscle with a current strength of double the rheobase. This is expressed in milliseconds.

To know the excitability of a muscle in relation to the current strength and its duration, the muscle is stimulated by decreasing the duration of the current from 300 milliseconds to 1 millisecond and a consequent increase in the strength of the current required is detected and plotted on a graph as the strength duration curve.

Utility of Strength Duration Curve (SDC)

Normal muscle A normal muscle responds to stimuli from duration of 300 millisecond to 1 second without any increase in the strength of the current. However, if it is less than 1 millisecond, increase in the strength of the current is required. This curve is called the *nerve curve*.

Completely denervated muscle Records a muscle curve and here either more strength or longer duration stimulation is required to produce a contraction.

Partially denervated muscle The curve here lies in between the two curves mentioned above. However there is an upward kink which denotes the superimposition of the two basic types of curves.

Limitations of EMG It merely indicates whether the muscle is innervated or not. It gives no specific indications as to the level of injury or degree of injury.

Nerve Conduction Studies

Stimulation of a peripheral nerve by an electrode placed on the skin overlying the nerve will readily evoke a response from the muscle innervated by that nerve. Immediately after section, stimulation distal to the point of injury will elicit an essentially normal response for 18 to 72 hrs after injury till Wallerian degeneration sets in. This failure of response after about 3 days excludes "neuropraxia." Slowed conduction at a specific point indicates "compression neuropathy".

Tinel's Sign

This is an important sign which helps in recording the rate of regeneration of the nerve clinically.

Procedure Gentle percussion is done along the course of injured nerve. Tingling sensation is experienced by the patient in the distribution of injured nerve rather than the area percussed, and the sensation should *persist* for several seconds following the stimulation. Positive Tinel sign indicates regenerating axonal sprouts have not obtained complete myelinisation. Response fades as myelinisation takes place. Distal progression of the response and the rate of the progression have been used by some to establish prognosis (rate of recovery should be 3 cm per month). Presence of this sign is encouraging. Even a few regenerating sensory fibers can result in positive Tinel's sign. *Thus, its presence cannot be taken as an absolute evidence of recovery*.

Sweat Test Starch Test

Presence of sweating within *autonomous zone suggests that complete interruption of the nerve has not occurred.

*Small area of complete anesthesia after section of a peripheral nerve or root

Skin Resistance Test

It is another method of evaluating autonomic interruption by using Richter's thermometer.

Electrical Stimulation

Faradic stimulation is of little value (because even normally innervated muscles may fail to respond).

Galvanic stimulation Recording of chronaxie and strength duration curve by galvanic stimulation is more helpful in evaluating nerve injuries.

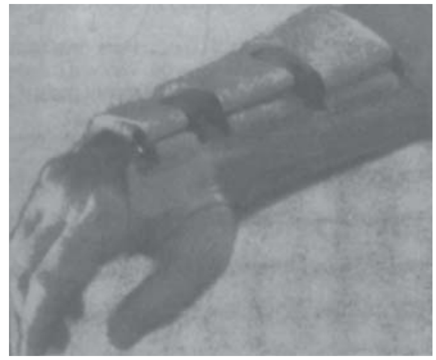


Fig. 17.3: Wrist cock-up splint (static type)

Management

General principles Resuscitation is carried out first, if the patient is in shock. General condition is improved by the emergency management measures. A thorough debridement of the wound is carried out, and if the wound is clean primary repair of the nerve is carried out by direct suturing of the perineurium or epineurium or epiperineurium of both the cut ends. If the wound is contaminated nerve is repaired after 3 to 6 weeks. In closed fractures with peripheral nerve injuries, conservative management is the treatment of choice. Careful assessment of the recovery is made and early surgical exploration is done if the recovery is not satisfactory.

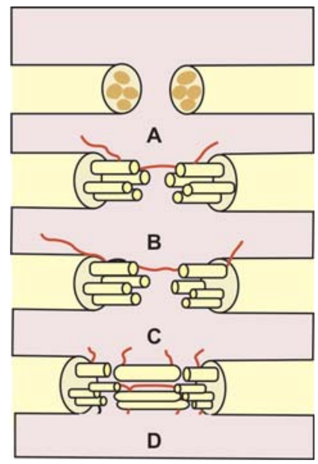
Conservative management This consists of the following essential steps:

- *Splinting of the limbs* Different splints are required to immobilize the limbs in various nerve injuries.
  - — *Upper limb*
    - i. Brachial plexus injury—aeroplane splint
    - ii. Axillary nerve injury—shoulder abduction splint
    - iii. Radial nerve injury—cock-up splint. (Fig. 17.3)
  - — *Lower limb: common peroneal nerve injury*—foot drop splint.
- *Passive movements* of all joints are done to prevent contractures.
- *Physiotherapy* Massage, exercises, stimulation, etc.
- *Care of the skin*, especially the anesthetic skin to prevent pressure sores from developing.

Operative management This consists of various types of nerve repair (Figs 17.4A to D), tendon transfers, arthrodesis, etc.

Types of nerve repair

- Primary repair is done within 6 to 8 hrs after injury and if the wound is clean cut.



Figs 17.4A to D: Types of nerve repair: (A) Epineural neurorrhaphy, (B) Perineural neurorrhaphy, (C) Epiperineural neurorrhaphy, and (D) Interfascicular nerve grafting

- Delayed primary repair is done between 7 to 18 days after injury and if the wound is contaminated.
- Secondary repair is carried out 18 days after injury, if the injury is seen late, failure of conservative treatment, incomplete injury, etc.

Techniques

- *Endoneurolysis* It is freeing of the nerve entrapped within the scar tissue either external scar (external neurolysis) or within nerve (internal neurolysis).
- *Partial neurorrhaphy* This is advisable if one-half of a large nerve is disrupted, e.g. sciatic nerve injury.
- *Neurorrhaphy and nerve grafting* If there is a gap after injury.
- *Methods of closing* The gaps between the nerve ends if the nerves cannot be approximated end to end:
  - — Mobilization of the nerves by sectioning its cutaneous branches and freeing it from the fibrous tissue around.

— Positioning of the extremities in functional position.
— Transposition of the nerves, e.g. ulnar nerve transposition.
— Bone resection.
— Nerve grafting by using sural nerve.
— Nerve crossing.

By these above methods the cut ends of the nerves can be brought together and sutured by any one of the techniques mentioned above.

- *Tendon transfers* are contemplated after 18 months of injury when there is no recovery after various nerve repair techniques or if the patient presents late.
- *Arthrodesis* is considered if no tendons are available for transfers and if there is no hope of recovery.

Quick Facts

- Peripheral nerve is a mixed nerve.
- Sunderland's classification is clinically accepted
- Forty percent of bone and joint injuries are associated with peripheral nerve lesions
- Radial nerve is the most common peripheral nerve to be injured
- Screening test helps in quick diagnosis
- In closed injuries conservative management is the treatment of choice
- In open injuries, primary nerve repair if the wound is clean and if the wound is contaminated delayed primary nerve repair or secondary repair is done

Methods of Nerve Suture

Figures 17.4A to D shows different methods of nerve repair.

- Epineural repair
- Epiperineural repair
- Perineural repair
- Fascicular repair

ULNAR NERVE INJURY

Ulnar nerve is the largest branch of the medial cord of the brachial plexus (root value C8T1). It supplies flexor carpi ulnaris and medial half of flexor digitorium profundus in the forearm. In the hand through its superficial branch it supplies palmaris brevis and digital branches to the volar side of the little finger and medial half of ring finger. The deep branch supplies the hypothenar, the dorsal and palmar interossei, two medial lumbricals and the adductor pollicis muscles of the hand.

General causes are as described in the general principles of peripheral nerve injury.

Local causes are more important and could be in the following areas:

Causes in the axilla
- Crutch pressure.
- Aneurysm of the axillary vessels.

Causes in the arm
- Fracture shaft of humerus.
- Gunshot and penetrating injuries.

Causes at the elbow
- Compression by the accessory muscle (anserina epitrochlearis).
- Fracture lateral epicondyle of humerus.
- Repeated occupational strains.
- Recurrent subluxation of the nerve.
- Compression by the osteophytes as in rheumatoid and osteoarthritis.
- Cubitus valgus deformity due to various causes results in repeated friction of the nerve giving rise to tardy (late) ulnar nerve palsy.

Causes in the forearm
- Fracture both bones forearm.
- Incised wounds, gunshot wounds and penetrating injuries of the forearm.

Causes at the wrist
- Compression by osteophytes.
- Fracture hook of the hamate.
- Compression by ganglion.
- Wrist injuries.

Causes in the hand
- Blunt trauma
- Penetrating injuries
- Occupational—people operating high-speed drills in rock mining, etc.
- Associated ulnar artery aneurysm.

Ulnar nerve injuries give rise to *claw hand* deformity either true type or ulnar claw hand.

Entrapment sites The ulnar nerve could be entrapped in any one of the following sites during its anatomical course:
- Supracondylar process medially.
- Arcade of Stuther's (near medial intermuscular septum).
- Between 2 heads of flexor carpi ulnaris.
- Guyon's canal.

CLAW HAND DEFORMITY

Definition

It is a deformity with hyperextension of the metacarpophalangeal joints and flexion of the interphalangeal joints of the fingers.

Types and Causes

Two varieties are described: one is a true claw hand involving both median and ulnar nerves and the second an ulnar claw hand or claw-like hand due to ulnar nerve injury (Table 17.3).

Problems of claw hand

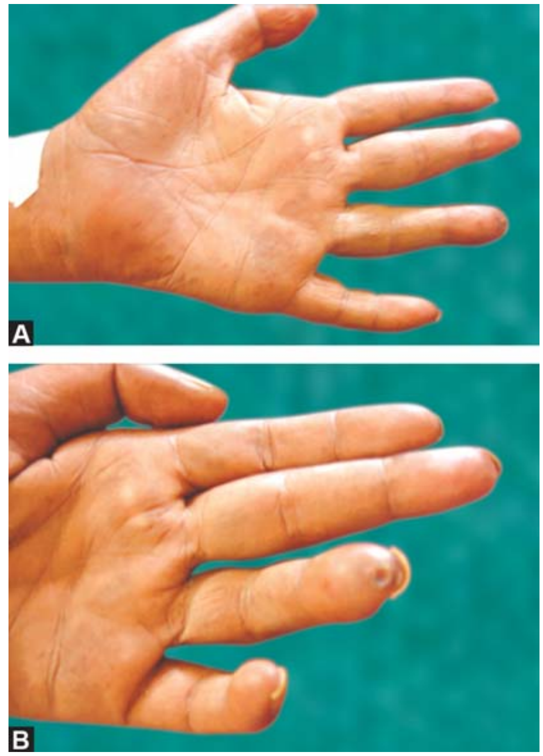
- Hyperextension of MP joints (not the only primary or most disabling deformity).
- Grasp decreased by 50 percent due to loss of power of flexion at MP joints.
- Pinch decreased due to loss of stabilizing effect from the intrinsic.
- Roll up maneuver lost.

Many surgical procedures are devised to block hyper-extension of MP joints as it is still considered as the primary deformity.

Note: MP—Metacarpophalangeal, IP—Interphalangeal.

TABLE 17.3: Types and causes of true claw hand and ulnar claw hand

True claw hand	**Ulnar claw hand**
(Both median and ulnar nerve involved) (Fig. 17.5A)	OR A claw-like hand (Fig. 17.5B)
↓	↓
Syringomyelia, amyotrophic lateral sclerosis, progressive muscular atrophy, VIC, leprosy, peripheral neuritis, anterior poliomyelitis, etc.	here only ulnar nerve is involved (causes already mentioned)



Figs 17.5A and B: Clinical photograph: (A) True claw hand, (B) Ulnar claw hand

TABLE 17.4: Levels of lesion of ulnar nerve injury

High Above the level of elbow entire nerve function is lost	
Low	
• *Below the elbow* at the junction of middle and lower third of forearm	*Spared*: Function of FDP and FCU *Lost*: Motor-HTM, Its, Lum, PB. • Sensory—dorsal aspect of hand (Medial border) and one and half fingers.
• *Proximal to Guyon's canal*	*Spared*: FDP, FCU and dorsal sensation. *Lost*: Same as above + loss of volar sensation.
• *Distal to Guyon's canal*	*Spared* FDP, FCU, HTM, PB, dorsal and volar sensations *Lost*: Interossei and lumbricals.

FCU—flexor carpi ulnaris, FDP—flexor digitorum profundus, HTM—hypothenar muscles, PB—palmaris brevis, Lum—lumbricals, Its—interossei.

Clinical Features

These include the classical deformity, loss of sensation along the ulnar nerve distribution and wasting of the hypothenar muscles, intrinsic muscles of the hand leading to hollow intermetacarpal spaces on the dorsum of the hand (Figs 17.6A to C) and causes ulnar claw hand.

A test for loss of sensation along the distribution (Fig. 17.7) of the ulnar nerve in the hand and fingers is carried out. However, the clinical features vary depending upon the level of lesion (Table 17.4).

Clinical Tests

For ulnar nerve injury

***Froment's sign* (Fig. 17.8)** This is a reliable clinical test for ulnar nerve injury. Three muscles (first palmar interossei,

*[*] **Jules Froment** (1878-1946) France. He was a Professor of Clinical Medicine.

Fig. 17.6A: (1) Ulnar clawing, (2) Total clawing, and (3) Wasting of intermetacarpal spaces

Fig. 17.6B: Claw hand deformity with thenar muscle wasting

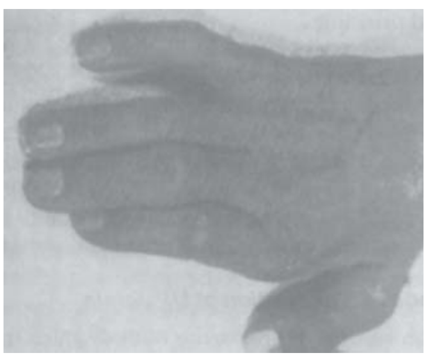


Fig. 17.6C: Wasting of intermetacarpal spaces

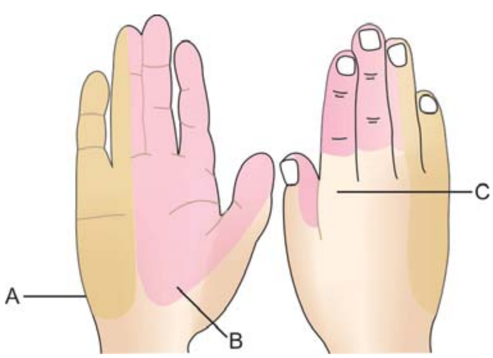
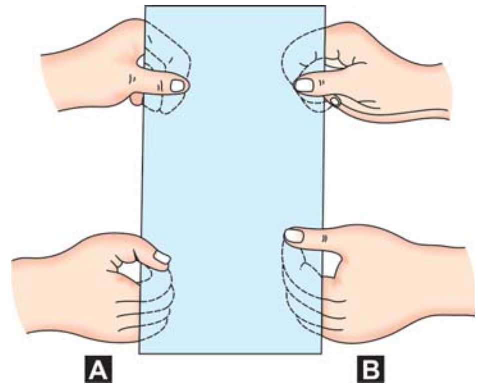


Fig. 17.7: Sensory distribution of the hand: (A) Ulnar nerve distribution, (B) Median nerve distribution, and (C) Radial nerve distribution



Figs 17.8A and B: Froment's sign: (A) Normal, and (B) Ulnar nerve injury

adductor pollicis and flexor pollicis longus) are required to hold a book between the thumb and other fingers. In ulnar nerve injury the first two muscles are paralyzed and now to hold the book, patient has to depend only on flexor pollicis longus which flexes the thumb prominently. This is the positive Froment's sign.

Card test (Fig. 17.9): Inability to hold a card or paper in between fingers due to loss of adduction by the palmar interossei.

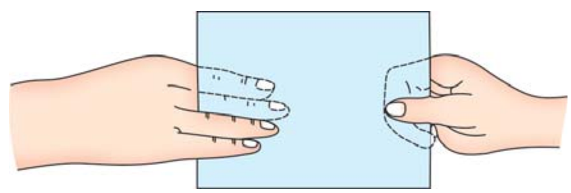


Fig. 17.9: Card test for ulnar

Egawa test (Fig. 17.10): With palm flat on the table the patient is asked to move the middle finger sideways. This is a test for the dorsal interossei of middle finger.

In total clawing median nerve is also injured. Following tests will help to detect the median nerve injury.

For median nerve injury

Note Median nerve supplies the following muscles:
- *In the forearm* Pronator teres, flexor carpi radialis, palmaris longus, flexor digitorum superficialis, flexor digitorum profundus, flexor pollicis longus and pronator quadratus.
- *In the hand* It supplies the abductor and flexor pollicis brevis, opponens pollicis brevis, lumbricals of the middle and index fingers.

Pen test (Fig. 17.11) Patient is unable to touch the pen due to the loss of action of abductor pollicis brevis.

Fig. 17.10: Egawa test

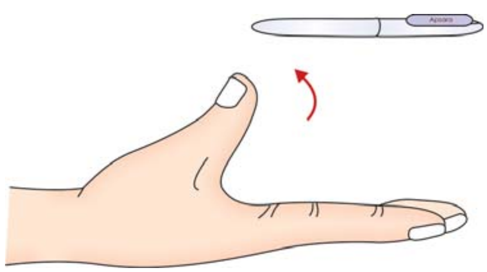


Fig. 17.11: Pen test

Pointing index or Oschner's clasp test (Fig. 17.12) When both the hands are clasped together, index and middle fingers, fail to flex due to the loss of action of long finger flexors of the index and middle fingers which are supplied by the median nerve.

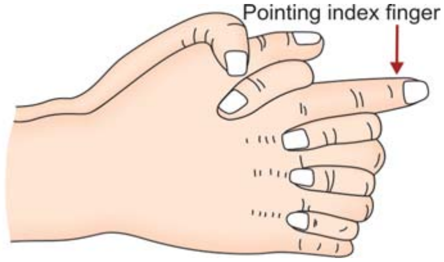


Fig. 17.12: Oschner's clasp test for median nerve

Benediction test (Fig. 17.13) For the same reason mentioned above patient is unable to flex the index and middle finger on lifting the hand (this is the position a clergyman uses to bless a couple during marriage. Hence, called benediction test).

Fig. 17.13: Benediction test

What is ulnar paradox?

The higher the lesion of the median and ulnar nerve injury, the less prominent is the deformity and vice versa. This is because in higher lesions the long finger flexors are paralyzed. The loss of finger flexion makes the deformity look less obvious.

Investigations

Plain radiograph of affected area and other investigations like EMG, SD curve, nerve conduction studies, Tinel sign, etc. are carried out.

Treatment of Ulnar Nerve Injury

In acute injuries The treatment is as discussed in the general principles.

For Claw Hand Deformity

Principles of treatment All the treatment measures aim at blocking the hyperextension at the metacarpophalangeal joint. Once this joint is stabilized the long extensors will bring about the extension of IP joints. The long finger flexors will help in flexion of the MP joints along with their action of finger and wrist flexion.

Methods of Stabilization of MP Joints

This can be done by the *active method* which involves tendon transfer or by *passive method* which involves arthrodesis, capsulodesis or tenodesis.

Active method This is by tendon transfers. A neighboring healthy tendon is brought to replace the action of the lost intrinsic. The choice of the tendon is dictated by the available normal tendons and the existing local situations. *Whichever the tendon chosen, it is passed through the lumbrical canal and is attached to the dorsal digital expansion which then brings about the action of the lost intrinsic.* Before resorting to tendon transfers, certain criteria are to be followed (Table 17.5).

TABLE 17.5: Criteria for tendon transfers

The donor tendon should fulfill the following criteria before it is selected for transfer:

- The tendon should have a muscle power grade 5 preferably. If not at least grade 4 because after the transfer it loses its muscle power by one grade.
- It should have its own nerve and blood supply.
- Transfer should be done from the synergistic group because rehabilitation will be easier. The tendon should be routed in a straight line and should be ensured to have sufficient padding to prevent wear and tear.
- Tendon should be sutured in moderate tension.
- Prior to tendon transfer, joint stiffness, contractures and malunion of bones should be corrected.
- Age of the patient should be minimum of 5 years.
- The disease should not progress.
- Any infection of bone and joints should be controlled.
- There should be good range of passive movements available at the joints.

RADIAL NERVE INJURY

Radial nerve is the continuation of the posterior cord of the brachial plexus with a root value of $C_{5\text{-}8}T_1$. It supplies all the three heads of triceps, anconeus, brachialis, brachoradialis, extensor carpi radialis longus brevis and supinator muscles. Through the posterior interosseous nerve, it supplies the remaining extensor muscles of the forearm and abductor pollicis longus muscle.

General Causes already discussed *(see* page 230).

Local

In the axilla

- Aneurysm of the axillary vessels
- Crutch palsy

In the shoulder

- Proximal humeral fractures
- Shoulder dislocation

In the spiral groove ***5'S***

- **S**haft fracture
- **S**aturday night palsy
- **S**yringe palsy
- **S**urgical positions (Trendelenburg)
- '**S**'march's (Esmarch) tourniquet palsy.

Between spiral groove and lateral epicondyle

- Fracture shaft humerus (Fig. 17.14)
- Supracondylar fracture humerus
- Lateral epicondyle fracture of the humerus
- Penetrating and gunshot injuries
- Cubitus valgus deformity.

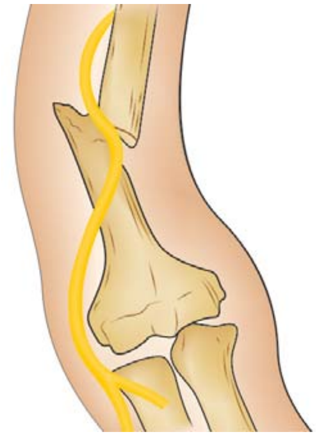


Fig. 17.14: Showing entrapment of radial nerve in between the fracture fragments of the humerus

At the elbow

- Posterior dislocation of the elbow
- Fracture head of radius
- Monteggia fractures

Causes in the forearm

- Fracture both bones forearm
- Penetrating and gunshot injuries

Radial nerve can be entrapped at the following sites:

- In the arm—fibrous arch of lateral head of triceps.
- In the forearm—arcade of Frohse.
- At the elbow—radial tunnel syndrome at origin of extensor carpi radialis brevis.

Clinical Features

If the lesion is high patient will present with wrist drop (Figs 17.15 and 17.16), thumb drop and finger drop. He will be unable to extend the elbow. If the lesion is low the elbow extension is spared but the wrist, thumb and the finger extensions are lost but *however the patient can extend the IP joints of the fingers because of the action of the intrinsic muscles of the hand (*Table 17.6). Sensation along the posterior surface of the arm and forearm is lost in high lesions and in low lesions the above sensations are spared, but there is loss of sensation over the first dorsal web space.

In acute injuries it is difficult to evaluate the injury to the radial nerve. In such situations, the Hitchhiker's sign (inability to extend the thumb) is used as the screening test.

Investigations

Radiograph of the injured part and all other investigations mentioned in the general principles are carried out.

TABLE 17.6: Levels of lesion in radial nerve injury

Level of injury	*Features*
High Above spiral groove	Total palsy
Low: Type I	
Between the spiral groove and the lateral epicondyle	*Spared:* Elbow extensor *Lost:* Motor • Wrist extensor • Thumb extensor • Finger extensors *Sensory:* Dorsum of first web space.
Low: Type II	
Below the elbow	*Spared* • Elbow extensor • Wrist extensor *Lost* : Motor • Thumb extensor • Finger extensor *Sensation* first web space

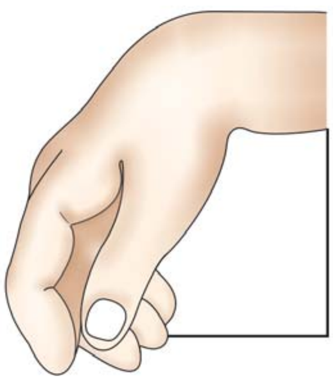
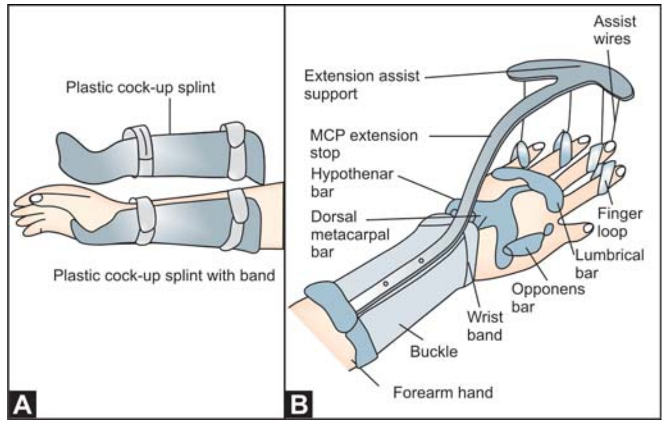


Fig. 17.15: Showing wrist drop

Fig. 17.16: Clinical photograph showing wrist drop



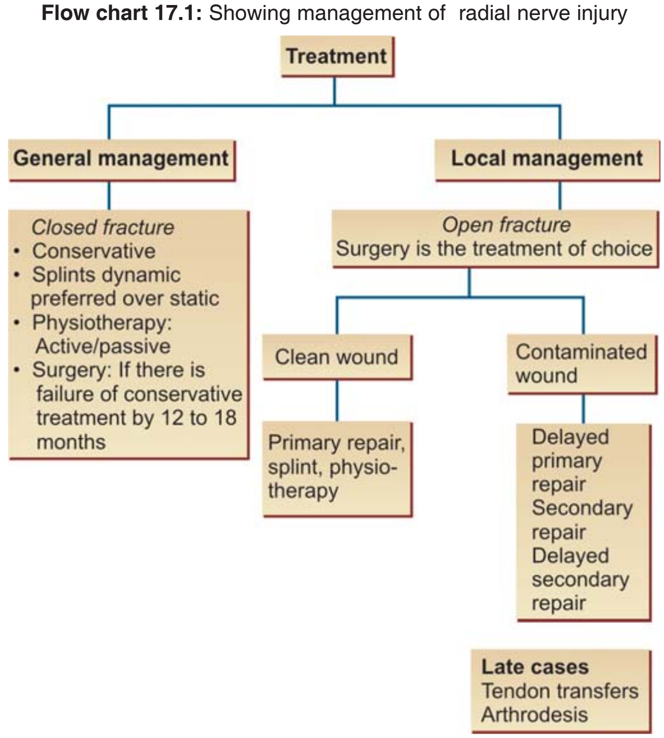
Figs 17.17A and B: Wrist drop splints: (A) Static or cock-up splint, (B) Dynamic splint

Treatment

Early cases As mentioned in the general principles for closed fractures conservative treatment is adopted. Patient is put on a cock-up splint or dynamic splints (Figs 17.17A and B). This is followed by active and passive physiotherapy. In failed conservative treatment operative treatment is considered after a period of 12 to 18 months.

In open fractures, surgery is the treatment of choice. If the wound is clean, primary nerve repair is done and if the wound is contaminated delayed primary or secondary nerve repair is resorted to (Flow chart 17.1).

Flow chart 17.1: Showing management of radial nerve injury



Treatment of Late Cases: (> 1 year)

Broad principles

Active treatment If neighboring tendons are intact and if all the criteria for tendon transfers mentioned earlier are met, then tendon transfer is the treatment of choice.

Passive method If no tendons are available for transfer then tenodesis or wrist arthrodesis in functional position is preferred. Choice of tendons in active treatment

From the wrist flexors Flexor carpi ulnaris can be spared. Flexor carpi radialis takes care of the wrist flexion. Palmaris longus is not a very strong wrist flexor and hence can be spared.

From the pronators Pronator teres can be spared as pronator quadratus takes care of pronation.

From the finger flexors, rarely a flexor digitorum superficialis can be chosen.

So the tendons chosen for transfer in radial nerve injuries are flexor carpi ulnaris, palmaris longus, pronator teres and rarely flexor digitorum superficialis.

Tendon Transfer Techniques

High lesion For elbow extension transfer of latissimus dorsi or pectoralis major to the triceps muscle can be done, if the patient needs active extension to use the crutches. Otherwise gravity alone helps in passive extension of the elbow and is sufficient if the patient does not prefer to use the crutches.

Low lesions

Type I
- For wrist extension → pronator teres transfer.
- For finger extension, flexor carpi ulnaris split into four slips and transferred dorsally into four fingers.
- For thumb extension and abduction → almaris longus transfer.

Type II Here wrist extension is spared and hence the plan is
- For finger extension → flexor carpi ulnaris transfer (split into 4 slips).
- For thumb extension → palmaris longus transfer
- For thumb abduction → pronator teres transfer.

Omer's technique consists of splitting flexor carpi ulnaris into five slips and transferring into all the five fingers instead of four.

Boye's technique uses flexor digitorum superficialis instead of flexor carpi ulnaris to bring about extension of four fingers.

FOOT DROP

Sciatic nerve is the thickest and largest nerve in the body with a root value of L4-5 S1-2-3. It supplies the biceps, semitendinosus, semimembranosus and adductor magnus muscles. Through its superficial branch it supplies proneus longus and brevis muscles and its deep branch supplies all the four muscles in the anterior compartment of the leg.

Causes of Foot Drop

General causes have been already mentioned, *the important one being leprosy as a cause of foot drop.*

Local causes are seen along the course of the nerve.

At the spine
- Spina bifida
- Tumors
- Disk prolapse, etc.

At the hip
- Posterior dislocation of the hip (Fig. 17.18)
- Fractures around the hip
- Fracture acetabulum.

At the gluteal region
Deep intramuscular injections.

At the thigh
- Fracture shaft femur
- Penetrating injury and gunshot injury.

At the knee (common causes)
- Forcible inversion of the knee
- Dislocation of knee
- Fracture lateral condyle of tibia
- Lateral meniscal cysts and tumors
- Dislocation of superior tibiofibular joint

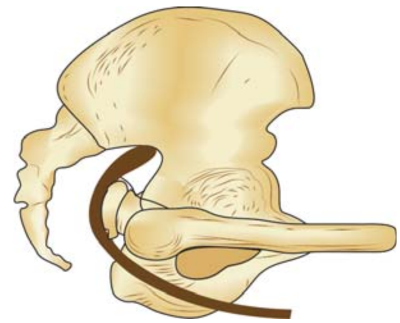


Fig. 17.18: Showing injury to sciatic nerve due to posterior dislocation of hip joint

TABLE 17.7: Levels of lesion in sciatic nerve injury

• **High lesion** (above knee)	Both tibial nerve and common peroneal nerve are paralysed.
• **Low lesion** (below knee)	*Spared:* Peroneus longus and brevis.
Type I Anterior tibial nerve injury	*Lost:* Tibialis anterior, extensor hallucis longus, extensor digitorum longus and peroneus tertius. *Sensation:* Over first web space is lost.
Type II Musculocutaneous nerve injury	*Spared:* All the above muscles innervated by anterior tibial nerve. *Lost:* Peroneus longus and brevis. *Sensation:* over outer leg and foot.

- Tight plaster casts around the knee
- Poor padding during traction
- Surgical damage during application of skeletal traction.
- *Direct injuries* like gunshot injuries, incised and penetrating injuries, etc.

Clinical Features

The resulting deformity following injury to the above nerves is *foot drop* (Figs 17.19A, B and 17.20). This could either be *complete* (in sciatic nerve or lateral popliteal nerve injury) or *incomplete* (injury to either superficial or deep peroneal nerve).

In high lesions it is a total foot-drop and in low lesions the foot-drop is usually incomplete. In low type I patient cannot dorsiflex and invert the foot but eversion is possible, front of the leg is wasted. In low type II, patient cannot evert but can dorsiflex and invert the foot. There is wasting of the outer half of the leg. In type I injury sensation over the dorsal web space is lost and in type II injury it is lost over outer leg and foot. The gait typical of foot-drop is a *high stepping gait* (Table 17.7).

Fig. 17.20: Clinical photograph showing foot drop

Investigations

- Plain X-ray
- EMG
- SD curve
- Tinel sign, etc.

Treatment of Early Foot-drop

Conservative treatment The lesions show a high incidence of recovery. Hence, conservative treatment with a view to encourage recovery (at least for 1 year) should be carried out.

Splintage of knee in 20° of flexion and ankle in 90° for night time. In day time, walking is allowed by using a “Foot-drop appliance”.

Foot-drop appliances are of two varieties:

- Dynamic—spring shoe (Fig. 17.21).
- Static—back stop shoe (Fig. 17.22).

Along with the splintage general treatment to correct the underlying etiology is undertaken. Steroids are also known to help.

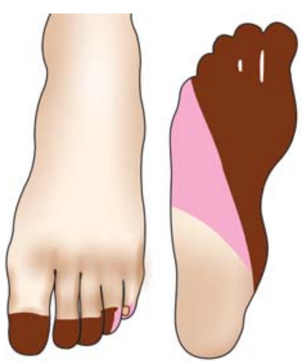


Fig. 17.19A: Showing nerve supply to the toes and sole of the foot

Fig. 17.19B: Foot drop

Fig. 17.21: Showing dynamic foot drop splint

Fig. 17.22: Foot-drop splint (static variety)

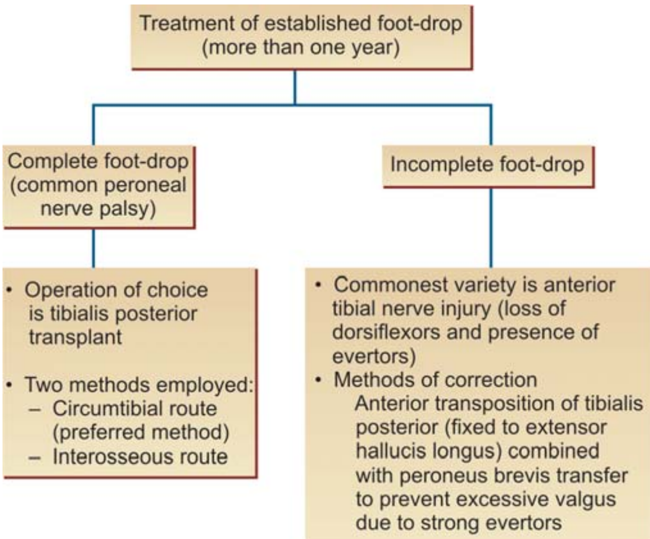
Surgery: This is indicated if the conservative treatment fails.

Common peroneal nerve stripping is done in leprosy. It is done in a thickened, tender nerve in a tuberculoid case with history of recent paralysis.

Choice of Surgery

- Tendon transfers—for mobile foot drop (Flow chart 17.2)
- Tendo-Achilles lengthening—in fixed equinus.
- Subtalar stabilizing procedure—for fixed varus.
- Triple arthrodesis—for fixed varus at the subtalar joint.

Flow chart 17.2: Showing treatment of foot drop



PHYSIOTHERAPY MANAGEMENT IN PERIPHERAL NERVE LESIONS

Physiotherapy management in peripheral nerve lesions follows the protocol as under:

Stage of Paralysis

This phase usually lasts for 2-3 weeks. Here the emphasis is to reduce pain and inflammation, splint the affected extremities in functional position exercise they joint to prevent contractures from developing.

- *Measures to reduce pain* TENS seems to score over other modalities in reducing pain during this stage.
- *Measures to control inflammation and edema*
  — Keep the affected limb elevated.
  — Active and passive exercises to the affected and unaffected joints.
- *Measures to prevent contractures* Splints tailor made to suit the situation plays a big role in helping prevent contractures due to muscle imbalance following paralysis. The affected extremities are splinted in their respective functional positions.

Caution When applied on an anesthetic area, repeated checks are needed to ensure pressure sores do not develop.

- *Exercises regimen* For the unaffected extremity, active and active-assistive range of movement exercises is indicated. For the affected joints, full range passive movements are prescribed.
- *Measures to prevent joint stiffness* Apart from the measures mentioned above, passive stretching of the affected joints by the patient himself goes a long way in preventing joint stiffness.

Quick Facts

Physiotherapy during the Stage of Paralysis.

- Measures to control pain.
- Measures to control edema.
- Measures to prevent contractures.
- Exercise regimen.
- Measures to control joint stiffness.

Postparalytic Stage

In this post paralytic stage after the first 3 weeks, apart from the previously mentioned measures, emphasis is now on re-education of the motor and sensory functions of the affected extremities.

- *Measures to re-educate the motor functions* Diagnosing the extent of nerve injury by appropriate electro diagnostic tests is of paramount importance to achieve success in motor re-education. The PNF techniques are found to be very effective in promoting early recovery.

  As the affected muscle regains its voluntary contractions, synergistic action returns earlier than the antagonistic actions.

Note Electrodiagnostic tests should be carried out at regular intervals to evaluate the response to the treatment. If no response is seen after 18 months to 2 years, surgery is indicated.

- *Measures to re-educate the sensory functions* The success of the motor re-education depends on the successful re-education of the sensory functions of the affected extremities.

In sensory re-education, both electrical stimulation and active efforts by the patients are of vital importance. In patients with total sensory loss, both are carried out simultaneously. However electrical stimulation is given to the intact skin sensation, just proximal to the affected area.

In patients with partial sensory loss and partial voluntary muscle contractions, visual and auditory feedbacks are used effectively to reinforce patients own active efforts to restore back the sensations.

- *Modifications in the splints* In this stage, the splints are modified from being static to dynamic, in such a way that they offer resistance to the contracting muscles and passively stretch the paralyzed muscles.

Note Check the skin for pressure sores when splints are applied on an anesthetic area.

- *Measures to prevent joint contractures and stiffness* As discussed previously, active and passive exercises and passive stretching of the joints by the patient helps to prevent stiffness.

Quick Facts

The post paralytic stage
- Motor re-education
- Sensory re-education
- Splint modifications
- Electrical stimulations
- Electro-diagnostic tests
- Measures to prevent joint contractures and stiffness

Delayed Stage

After a period of 18 months, the chances of improvement are drastically reduced. Such a situation warrants surgery either in the form of nerve repairs or tendon transfers.

Physiotherapy after nerve repair

During the first 3 weeks, measures to control pain and limb edema by elevation, etc. are followed. The unaffected joints could be put through vigorous active movements. Diapulse aids in faster healing and recovery (Flow chart 17.3).

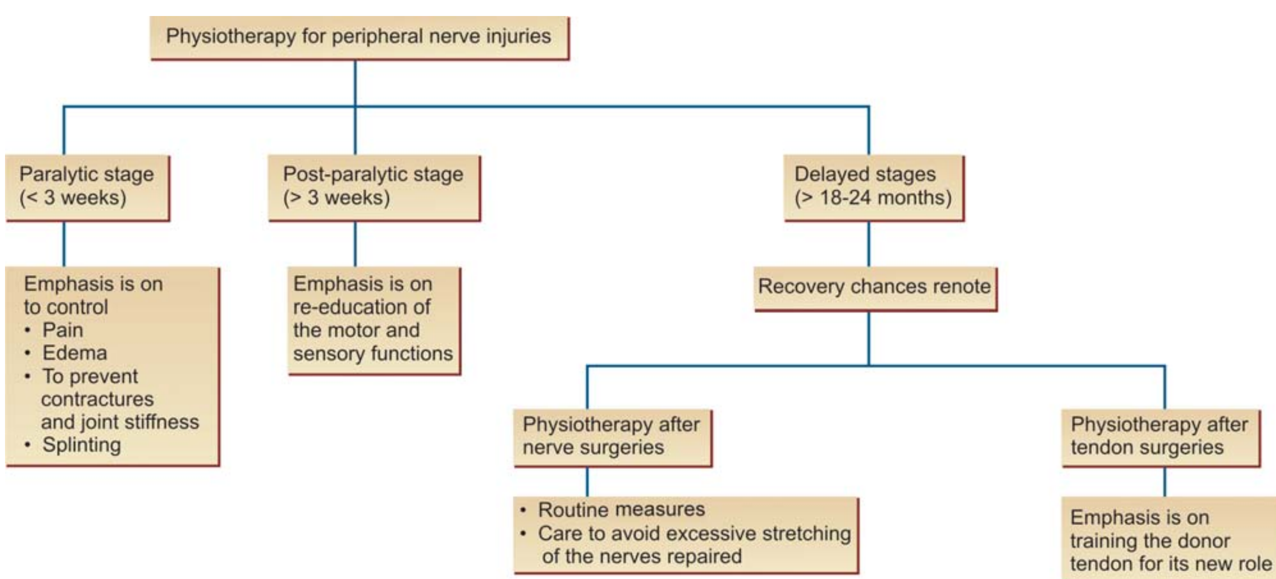
After 3 weeks, gentle active exercises could be commenced to the affected joints. Gentle relaxed passive and accessory passive movements to its full range, exercising due care and caution to prevent excessive stretch on the sutured nerve, is carried out.

After 8 weeks, the functional activities and the progressive resistive exercises are made more vigorous. The latter needs suitable alterations of the splint. Scar adhesions due to surgery could be prevented by deep frictional massage. A satisfactory return to function can be expected after 10-12 weeks.

Physiotherapy after tendon transfers Tendon transfers are contemplated when the expected recovery after nerve surgeries is not forthcoming. However, tendon transfers are subject to satisfactory meeting of all the necessary criteria's for such transfers (*see* Table 17.5).

Physiotherapy measures for the donor tendon To qualify as a donor apart from other criteria's the most important aspect for a tendon is to have grade V muscle power or at least grade 4, since after transfer, it loses its grade by one. So effort should

Flow chart 17.3: Showing physiotherapy for peripheral nerve injury



be made by vigorous isometric exercises and other measures to make the tendon donor fit.

Physiotherapy measures for the transferred tendon Here the emphasis is on retraining or re-education of the transferred tendon in assuming its new role. The most ideal way to do this is to train the patient to practice the expected movements in the normal contra lateral hand. After the transfer, the patient is put on the following physiotherapy protocol.

- Full range passive exercises.
- Active assisted and active movements.
- Progressive resistive exercises.
- Electrical stimulation by low faradic currents, and EMG biofeedback.
- Passive stretching of the part.
- Proper dynamic splints to assist the tendon in its new role.
- Additional measures like hydrotherapy, thermotherapy and deep ultrasound massage are very useful measures to prevent tendon adhesions and improve its stretch ability.

BRACHIAL PLEXUS INJURIES

Everything about brachial plexus (Fig. 17.23) is complex, its anatomy, mode of injury, the diagnosis, management and prognosis. It is a harrowing experience both for the patient and the surgeon. Among the more famous causes of brachial plexus injury is the birth injury in children and bike injury in adults.

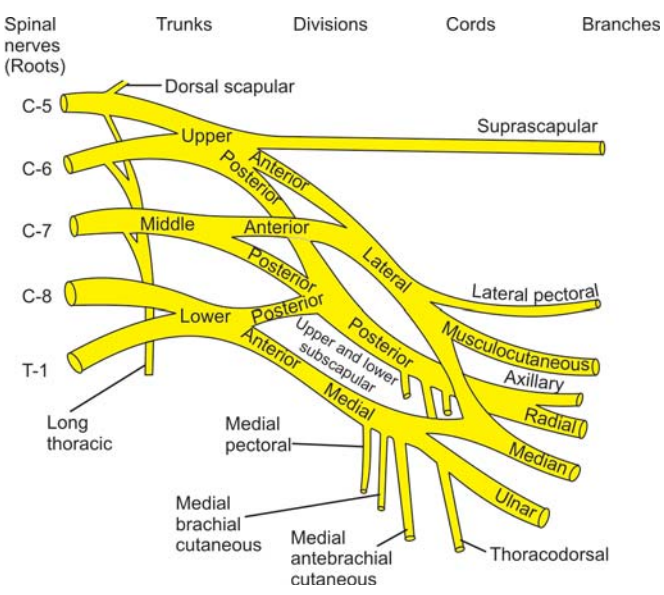


Fig. 17.23: Showing the normal anatomy of brachial plexus

Interesting facts

Remember **"B"** in
Brachial plexus injuries:
B—*Birth* injury due to faulty forceps application.
B—*Bike* injury-fall on the shoulder in young adults, usually from a speeding bike.
(A combination of depression of the shoulder and forced lateral flexion of the neck).
B—*Bad* prognosis most of the times.

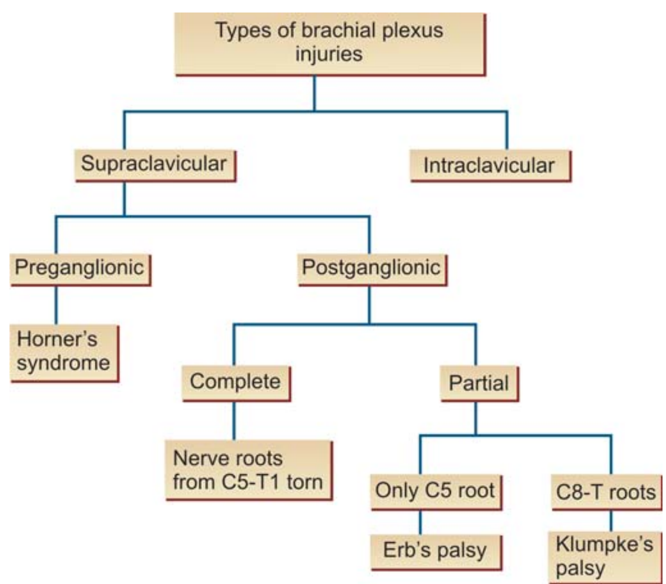
Types

Brachial plexus injuries could be:

Closed Here the injury could be due to birth trauma or bike trauma as mentioned above.

Open Rare injury could be due to penetrating or gunshot injuries (Flow chart 17.4).

Flow chart 17.4: Showing types of brachial plexus injuries



Note Other less important causes of brachial plexus Injuries:
- Traction injuries
- Tumor removal
- Abnormal pressures due to faculty postures
- Postirradiation scenario
- Surgical excision of cervical ribs
- Shoulder dislocations.

Supraclavicular Lesion

Pre-ganglionic lesions This is an unfortunate situation wherein the nerve roots are avulsed from the spinal cord. The cause could be either birth or bike trauma as mentioned earlier. The

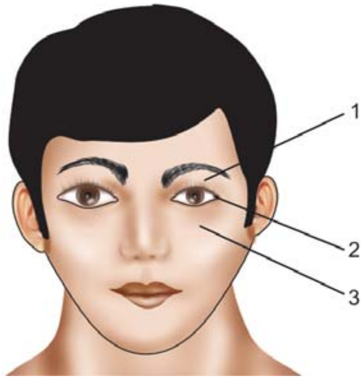


Fig. 17.24A: Showing features of Horner's syndrome: (1) drooping of the eyelid, (2) constricted pupil, (3) absence of sweating in the surrounding skin

characteristic feature of this lesion is the presence of Horner's syndrome (Fig. 17.24A).

Interesting facts

About Horner's syndrome
What constitutes a Horner's syndrome? (All P's)
- Ptosis of the eyelid.
- Pupils which are small and constricted.
- Protrusion of the eyeball which is slight.
- Pain even at rest.
- Positive sensory action potentials.
- Poor prognosis.

Postganglionic lesions Here there is no Horner's syndrome. The prognosis is slightly better than the preganglionic lesion. A positive Tinel sign may be elicited in this lesion.

Assessment of Brachial Plexus Injury

It is important to assess whether the brachial plexus injury is preganglionic or postganglionic.

In preganglionic lesions
- Horner's syndrome is present (Fig. 17.24A).
- Patient is unable to elevate the scapula (due to disruption in the nerve supply to the Rhomboids and L. scapulae) (Fig. 17.24B).

In postganglionic lesions
- No Horner's syndrome.
- Patient is able to elevate the scapula.
- Tinel's sign is present in the later stages.

(Tapping above the clavicle, produces tingling sensation in the anesthetic limb).

Fig. 17.24B: Clinical photograph showing flail upper limb

Investigations

These are less reliable than the clinical tests. However, X-ray to rule out neck fractures, CT scan to study the cross-section anatomy, MRI to study the soft tissue damages, myelogram (shows meningocoele in avulsion, bat hazardous) and electrical studies are some of the investigations which give useful information during a brachial plexus injury.

The electro diagnostic tests include EMG, nerve conduction study, SEP (somatosensory evoked potential), percutaneous electrical stimulation, etc. EMG is by far the most reliable and effective test which successfully identifies the roots involved.

Treatment

During the initial stages
- Splinting
  — *For complete paralysis* A flail arm splint (FAS) designed by Framton is advised.

Quick Facts

About FAS
- It immobilizes the shoulder in abduction.
- It prevents glenohumeral joint subluxation.
- It permits five different positions of the elbow.
- It provides a platform for the forearm on which split hook etc. can be applied.

- It can be operated through a cable to the shoulder strap attached to the opposite normal limb.
- It is cosmetically acceptable.

— *For incomplete lesions* here splints with necessary modifications as per the situations can be used.

- For pain control, TENS is best suited.
- To prevent contractures and deformities, a careful passive ROM exercises under suitable guidance is recommended.

During the later stages

- *Measures to strengthen the muscles* If there are movements, efforts are made to strengthen the muscles by repeated self-resistive exercises, PNF techniques, etc.
- *Re-education of the muscles* This is done by encouraging movements of the shoulder, percutaneous electrical stimulation, stimulating techniques like icing, brushing, etc.
- Modifying the splints and dynamising it helps.
- TENS to control pain
- After 2 years, reconstructive surgeries are planned for the residual paralysis and deformities.

Surgical Measures

Acute phases In preganglionic lesions wherein the roots have avulsed from the cord, surgical exploration serves no purpose. However suture or nerve grafting can be considered in postganglionic lesions.

Late stages (> 2 years) Reconstructive surgeries are planned after 2 years when the recovery can no longer take place. Surgeries are planned according to the residual paralysis.

- *For shoulder function* Trapezius transfer to the neck of the humerus to improve abduction is advised.
  Arthrodesis of the shoulder is done in functional position.
- *For elbow function* Steindler's flexorplasty (transfer of Latissmus dorsi or pectoralis major to biceps.
- *For wrist and finger extension* After the surgery, patient is put on a detailed regime for reeducating the transplanted muscle.

ERB'S PALSY

This is due to injury to the C5 nerve root and rarely the C6 nerve root is also injured. It occurs either very early in life due to birth trauma (obstetric palsy, due to faulty application of forceps) or in young adults due to bike trauma

The Effects of the Injury

At the shoulder Here there is paralysis of the deltoid, rhomboids, supra and infraspinatus and teres minor muscles. This results in the loss of shoulder abduction and external rotation.

Fig. 17.25: Showing policemen or waiter's tip deformity

At the elbow Biceps and brachialis muscles are paralyzed. This results in loss of flexion of the elbow joint.

At the forearm Supinator muscles are paralyzed resulting in loss of supination of the forearm. The combined effect of the injury is an arm hanging loosely by the side of the trunk. The shoulder is internally rotated, the elbow is in extension, the forearm is pronated and the wrist is in flexion. This characteristic posture is popularly known as *Policeman or Waiter's tip* (Fig. 17.25). Apart from this there may be sensory loss on the outer aspects of the arm and forearm both in the front and back.

Management

Splinting This is done by using an abduction or aeroplane splint. The shoulder is maintained in abduction and external rotation, elbow in 90° of flexion, forearm in supination and wrist in extension.

Measures to prevent contractures A full range of passive movements to the affected joints helps prevent the contractures. This is a home treatment programme and should be taught to the mother.

Electrical Stimulation of the affected muscles by using bilaterally symmetrical PNF stimulus helps to activate them.

Surgery This is rarely indicated as most of the cases recover spontaneously with the above treatment. Some of the recommended surgical measures are:

- Exploration and repair of the nerve roots.
- Tendon transfers to improve abduction and external rotation of the shoulder

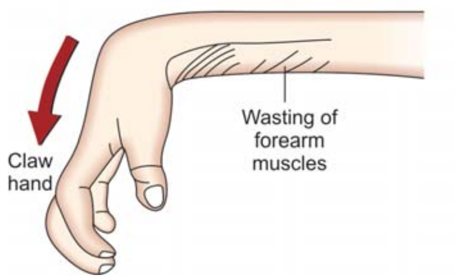


Fig. 17.26: Klumpke's paralysis

- Release of soft tissue contractures
- De-rotation osteotomy for the rotational deformity.

Klumpke's Paralysis

This is also due to either a birth trauma or a bike trauma. The C8 T1 nerve roots are involved and there will be paralysis of the wrist flexors, finger flexors and intrinsic muscles of the hand. This results in a claw hand deformity (Fig. 17.26). The clinical features and management are discussed in the section on ulnar and median nerve injuries.

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4

Section

REGIONAL DISORDERS

18. General Principles of the Treatment of Orthopedic Disorders
19. Regional Conditions
20. Hand Disorders

18

Chapter

General Principles of the Treatment of Orthopedic Disorders

There are three time-tested and time-honored treatment methods (i) masterly inactivity, (ii) conservative methods, and (iii) operative treatment methods of treating an orthopedic disorder.

MASTERLY INACTIVITY

It is interesting to observe that nearly 50 percent of the orthopedic disorders can be managed best by *not doing anything*. To allay the doubts, fears, myths, and misconceptions the patient has regarding his ailment and assuring him that nothing is seriously wrong with him is all that is required.

This is more of a 'mind' management than 'orthopedic' management and is more a 'human' care than 'health care'!

CONSERVATIVE METHODS

This is the next commonly advocated and recommended method of treatment.

Rest This implies not total rest but selective rest with avoidance of unnecessary activities and strain. This was first advocated by HO Thomas and of late due to improved methods of treatment and technology; emphasis is now on early restoration of activities and not passive rest.

Support This enables the diseased part to heal, provides rest, prevents deformities, relieves pain and also supports the patients psychologically, e.g. plaster splints for fractured limbs, lumbosacral belts and corsets for low backache, calipers in polio, cervical collars for neck pain, knee cap, ankle binder, etc.

Physiotherapy

Physiotherapy, if properly understood and skillfully executed by trained persons, gives excellent results in treating orthopedic disorders and in postoperative rehabilitation. For optimum results physiotherapy should be pursued systematically till its final logical conclusion and should not be abandoned in between. Physiotherapy has a great role to play and sometimes is the only treatment option in diseases like polio, cerebral palsy, hemiplegia, paraplegia, etc.

The following are the various physiotherapy options:

Active exercises Here the patient is made to actively contract his or her muscles and joints against resistance and weight. This helps to mobilize the joints, strengthen the muscles and to improve coordination or balance.

Passive exercises This can be given by the physiotherapist normally or by machines which can provide continuous passive movements of the joints. This is of immense help to maintain the mobility of all the joints when active movements are not possible due to paralysis or injury to the muscles. Thus the joints are kept supple and deformities are prevented.

Note Active muscle strengthening exercises could be either isometric (here muscle does not move and hence no change in length, e.g. pushing against a static object) or isotonic (here muscle actually moves, e.g. quadriceps exercises).

Electrical muscle stimulation Depending upon whether the nerve supply of the muscle is intact or not, two types of electrical stimulation is chosen:

- *Faradism* In this, the nerve supply of the muscle should be intact. In faradism an electronic stimulator delivers

shocks at shorter duration at a frequency of 1 mm at 50 Hg to the muscle through its intact motor nerve root, e.g. for regaining the strength of intrinsic muscles of the hand and foot, quadriceps muscle and to retain the tendons after tendon transfers.
- *Galvanism* Here the muscle is stimulated directly with shocks of longer durations (100-1000 mm at frequency of 5-15 Hg). When the muscle is denervated after a peripheral nerve injury, etc. this treatment modality helps.

Hydrotherapy This is particularly useful in patients suffering from rheumatoid arthritis. The warmth and buoyancy of water helps to relieve pain and muscle spasm.

Heat therapy By direct application of heat the local temperature underneath the tissues rises up to 10° inducing vasodilatation, reduced muscle spasm and decreased pain. There are two varieties of heat therapies.
- *Surface heat* This heats only the superficial tissues and consists of hot packs, infrared heat, paraffin wax bath, etc.
- *Deep heat* Apart from vasodilatation it stimulates the circulatory mechanism and helps in heating the deeper structures. It is also helpful in treating joint disorders, e.g. shortwave diathermy.

Manipulation This term denotes a deliberate attempt by the surgeon to passively move the joints bone or soft tissues. It is useful in three specific purposes:
- *Manipulation for correction of deformity* Closed reduction of fractures and dislocations and manipulation of a club-foot falls under this category. This is done under general anesthesia and after the correction; the part is immobilized in splints, etc. to retain the correction.
- *Manipulation for joint stiffness* This is useful in knee joints, it may be successful in shoulder and foot but responds poorly in cases of elbow and hand. The manipulation should be done gradually under general anesthesia and forcible or abrupt movements should be avoided.
- *For relief of chronic pain* Manipulation may help in chronic pain of tarsal, spine or sacroiliac joints.

Note Manipulation should not be done in acute painful conditions for fear of aggravating the problem.

Radiotherapy

It has a role in:
- *Inflammatory conditions* Like recalcitrant ankylosing spondylitis.
- *Neoplastic conditions* For example, Ewing's sarcoma and giant cell tumor recurrence.

Massage Delicate continuous and systematic massage if done regularly has a lot of beneficial effects like relief of pain, soothening, etc.

Drugs

Drugs though limited have an important role to play in orthopedic practice. The commonly used ones are:
- *Analgesics and anti-inflammatory agents* These help relieve pain and inflammation. Long-acting drugs are preferred in chronic disorders like rheumatoid arthritis, etc. while short-acting drugs are preferred in acute infections, trauma, etc.
- *Muscle relaxants* These are useful to relieve painful muscle spasms.
- *Sedatives and anxiolytics* These are used to induce sleep, alleviate anxiety and also to relieve muscle spasm.
- *Antibiotics* These are extremely useful in acute and chronic infections of bones and joints. Broad-spectrum, bactericidal agents are usually preferred.
- *Hormones* Growth hormones, stilboesterol for metastatic carcinomas, anabolic steroids and oestrogens for osteoporosis are some of the examples.
- *Specific drugs* Vitamin C for scurvy, vitamin D for rickets are some of the examples.
- *Cytotoxic drugs* These are used as chemotherapeutic agents for malignant tumors.

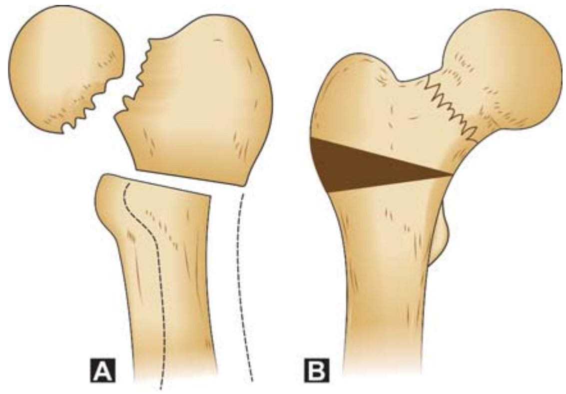
OPERATIVE METHODS

Operative treatment should be resorted to after great deliberations and when all other treatment options have been tried or thought of. Once undertaken, it should not worsen the condition of the patient.

A brief account of various orthopedic surgical techniques are presented here as follows:

OSTEOTOMY

This is a procedure of creating a surgical fracture (Table 18.1) to achieve the following objectives:
- To correct excessive angulations, bowing or rotation of a long bone.
- To compensate and correct the malalignment of a joint.
- To correct leg length inequality either by shortening or lengthening.
- To alter the line of weight bearing and increase the stability at the hip joint, e.g. abduction osteotomy.
- To relieve the pain in an arthritic hip, e.g. displacement osteotomy.



Figs 18.1A and B: Different types of osteotomies: (A) McMurray's displacement osteotomy, (B) Angulation osteotomy

TABLE 18.1: A quick glance at famous osteotomies

Upper limbs	*Done for*
• French osteotomy	Malunited supracondylar fracture humerus
• Fernandez and Campbell osteotomy	Malunited Colles' fracture
Lower limbs	
• Salter, Chiari, Pemberton	CDH
• McMurray's, Shanz (Figs 18.1A and B)	Fracture neck femur
• Pauwel's	OA Hip
• High tibial osteotomy (Fig. 18.2)	OA Knee
• Dwyer's osteotomy	Club foot
Spinal osteotomy	Ankylosing spondylitis

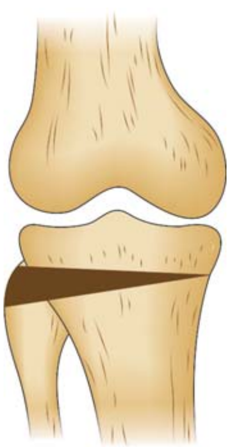


Fig. 18.2: Showing high tibial osteotomy done in OA knee

Physiotherapy Measures in Osteotomy

During Immobilization

The osteotomy site is protected by a long cast or is fixed internally. During the period of immobilization the following measures are suggested:

- Active exercises of the uninvolved joints.
- Isometric exercises to the immobilized muscles.
- NWB crutch walking.

During Mobilization

- Active exercises to the affected joints.
- Thermotherapy to reduce pain.
- Gradual mobilization of the affected joints.
- PRE to the affected muscles.
- Ambulation and weight bearing training are gradually commenced.

ARTHRODESIS

Arthrodesis is fusion of the joints by surgical methods. Because it limits the function of the joint, arthroplasty is more commonly used nowadays. However, it can be used in the following situations:

- Gross destruction of the joints as in rheumatoid arthritits, Charcot's joints or advanced osteoarthritis.
- Quiescent tubercular arthritis.
- Gross instability due to muscle paralysis as in polio.
- For permanent correction of a deformity.

Methods

There are three methods:

Intra-articular arthrodesis Here joint is opened, articular cartilage is denuded, cancellous bone grafts are packed, joint is kept in a functional position (Table 18.2) and either fixed internally or externally by plaster, etc.

Extra-articular arthrodesis This is indicated in infective condition of the hip, shoulder or spine. In this there is no risk of reactivating or spreading the infection as the joint itself is not opened but bone to bone fusion is obtained above or below the joint.

Combined arthrodesis This is a combination of the above two procedures.

Note Arthrodesis of a joint gives it stability but takes away its mobility.

Physiotherapy in Arthrodesis

- Thermotherapy to reduce pain and swelling.
- Elevation and compression bandage to prevent swelling.
- Active exercises to the unaffected joints.
- Mobilization strengthening exercises to the affected joints. Ambulation and gait training is also taught.

TABLE 18.2: Practical facts: Arthrodesis—each joint should be fixed in its functional position as mentioned below to enable the patient to still continue using it

Joints	*Functional positions*
Upper limbs	
• Shoulder	30° Abduction/30° flexion/40° Internal rotation
• *Elbow*	
— Eating hand (right)	90° of flexion
— Toilet hand (left)	70° of flexion
• Wrist	20° dorsiflexion
• Forearm	10° pronation
• MP joint	35° flexion
• IP joints	45° flexion
Lower limbs	
• Hip	15° flexion, no adduction or abduction or rotation
• Knee	20° flexion
• Ankle (men)	90° or neutral position
— Ankle (women)	15-20° of plantar flexion
• Metatarsophalangeal joints of big toe	Slight extension

ARTHROPLASTY

Arthroplasty is an operation to construct a new mobile joint. The following are the indications:

- Advanced osteoarthritis or rheumatoid arthritis of hip, knee, shoulder, elbow, hand and foot.
- Quiescent destructive tuberculous arthritis of hip and elbow.
- Fracture neck nonunion in patients of more than 60 years.
- Rarely to correct deformity, e.g. hallux valgus.

Types

There are three varieties of arthroplasties of hip namely:

1. Excision arthroplasty of hip (Fig. 18.3)
2. Hemireplacement arthroplasty (HRA) (Fig. 18.4)
3. Total replacement arthroplasty (Fig. 18.5)

Excision Arthroplasty of Hip

Here one or both the articular surfaces are excised; fibrous tissue fills up in the gap thus created and provides mobility. It is usually done in hip, elbow and metatarsophalangeal joint of the great toe.

Physiotherapy Measures following Excisional Arthroplasty (EA)

This procedure is commonly done in very advanced cases of tuberculosis of the hip with extensive destruction of the hip joint.

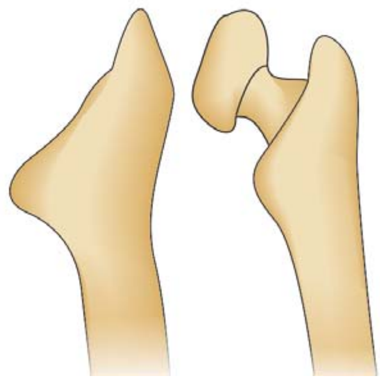


Fig. 18.3: Excision arthroplasty

Other indications are:

- Septic arthritis of the hip.
- Ankylosing spondylitis.
- Severe OA of the hip.
- Failed THR.
- Severe infection following HRA and THR.

In EA the head and neck of the femur is resected upto the level of the base of the trochanter and superior margin of the acetabulum.

Preoperative regime

- Isometric exercises are prescribed to the glutei, quadriceps and hamstrings to strengthen them.
- Vigorous active and resistive exercises to the entire joint to be resected.

Postoperative regime

During the first 15 days

- Patient is put on skeletal traction.
- Chest physiotherapy.
- Measures to prevent DVT and pulmonary embolism.
- Isometric exercises to the glutei quadriceps and hamstrings.
- Active exercises to the unaffected limb, ankle and upper limb. Gradually pro-gressed to resistive exer-cises.

Between 15 to 30 days

- Relaxed passive movements of the hip are started.
- Full range active and active resistive movements to the hip, knee and ankle are begun.
- Patient is encouraged to sit up with a back support. This flexes the hip upto 60°.

Between 30 to 45 days

- Continue isometric exercises to the glutei, quadri-ceps and hamstrings.
- Continue all the measures described above.

- Relaxed passive stretching of the hip during all its movements prevents fibrosis and contractures.
- The skeletal traction may be discontinued.

After 45 days

Measures to prevent contractures

- Intensive stretching of the hip joint muscles.
- Frequent prone lying.
- Isometrics to the glutei.

Measures to strengthen the muscles Isometric, active and active resistive exercises to the hip, knee and ankle muscles are indicated.

Measures for weight bearing and ambulation

- Weight bearing is begun in the parallel bars to encourage the patient to balance on the operated leg
- Partial weight-bearing is begun with two crutches by 8-10 weeks. Gradually progressed to a single crutch and later to a cane only.
- Full weight-bearing is allowed after 12 weeks.

Note

- Shortening of the limb should be corrected by appropriate measures.
- Cane may have to be used by the patient for rest of their lives especially for outdoor walking.
- Unnecessary stress on the affected limb should be avoided.
- Home exercises have to be regularly practiced
- Prone kneeling and cross leg squatting should be practiced gradually.
- Climbing the stair cases and walking on uneven and rough surfaces should be allowed after 14-16 weeks.

Hemireplacement Arthroplasty (HRA)

Either of the articulating surfaces is removed and replaced by prosthesis of similar shape and size, e.g. Austin Moore's prosthesis in nonunion of fracture neck of femur (Fig. 18.4).

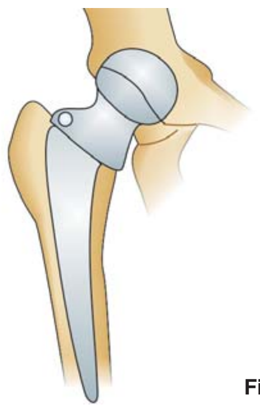


Fig. 18.4: Hemireplacement arthroplasty

Physiotherapy Management after Hemireplacement Arthroplasty of Hip (HRA)

The common indications for HRA are:

- Nonunion fracture neck of femur.
- Avascular necrosis of head of femur.
- Fracture neck of femur in the elderly.

Preoperative regime Same as in Excisional Arthroplasty.

Immediate postoperative treatment

- The patient is immobilized in the bed with the limb in abduction to prevent redislocation of the prosthesis.
- Skin traction is sometimes applied to the operated limb in patients who are not cooperative.

Precautions

- Avoid movements of flexion and adduction for 6-8 weeks.
- Skin traction may be required for about 10 days.
- Bedsores should be prevented by good nursing care.
- Partial weight bearing by 3 weeks.
- Full weight bearing by 6-8 weeks.

Measures to encourage walking and cross leg sitting

- Prone kneeling—this helps in the early initiation of hip and knee flexion and encourages weight bearing on the operated leg (Fig. 18.5A).
- Hip flexion is carried out by active self-assisted flexion of the hip in supine or sitting position with the back supported against the wall.
- Squatting exercises
  — Back supported cross leg sitting exercises (Fig. 18.5B)
  — Knee supported squatting against the wall (Fig. 18.5C).
- The patient should be able to carry out all the functional activities independently by 12 weeks.

Fig. 18.5A: Prone kneeling helps in early mobilization of the hip after arthroplasty of the hip

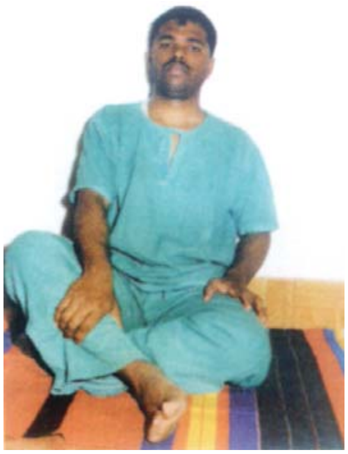


Fig. 18.5B: Clinical photograph showing back supported cross leg sitting exericse

Fig. 18.5C: Clinical photograph showing knee supported squatting against the wall exercise

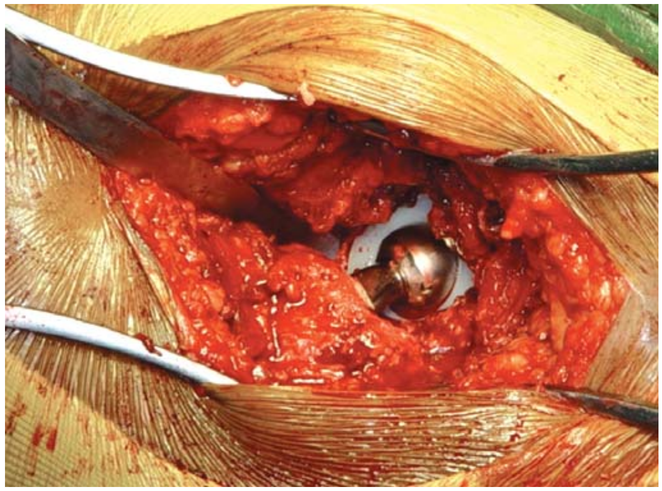


Fig. 18.7: Clinical photograph of total hip replacement

Fig. 18.6: Total hip replacement

Fig. 18.8: Plain X-ray showing total hip replacement (R)

Total Replacement Arthroplasty

Here both the articular surfaces are excised and replaced by prosthetic components, the larger joint is replaced by a metallic prosthesis, and the smaller joint by high-density polyethylene. Both the components are fixed by acrylic cement, e.g. total hip replacement for osteoarthritis or rheumatoid hip (Figs 18.6 to 18.8).

Physiotherapy Measures following Total Hip Replacement

Preoperative measures

- Chest physiotherapy and deep breathing exercises.
- Isometric exercises to the glutei, quadriceps and hamstring muscles of the affected limb.
- Active ROM exercises to the unaffected limb and both the upper limbs. This is progressed to resistive exercises later.
- To prepare the patient for proper limb positioning after surgery, to teach the method of transfer, etc.
- Psychological reassurance to the patient.
- The patient is taught to carry out the postoperative physiotherapy regimen on the normal limb.
- A proper evaluation of the patient before surgery has to be done by noting the pain, deformity, ROM at the hip and other joints, muscle power, ambulation and gait.

Postoperative measures

During the first 7 days

- Chest physiotherapy.
- Measures to prevent DVT and pulmonary embolism—Limb elevation, elastocrepe bandaging, active exercises of the ankle and toes, preventing hyperextension at the knee, etc.

- Measures to improve joint stability isometric exercises to the glutei, quadriceps, hamstrings, ankle dorsiflexors and plantar flexors should be done for both the limbs.
- Small range of relaxed passive movements by using continuous passive motion (CPM) equipment can be begun.

From 7-14 days

- The passive, active and active assisted movements are made more vigorous.
- Measures to improve mobility—Increase the range of CPM, suspension therapy and roller skates exercises.
- The patient should be taught how to turn in the bed and should be encouraged to sit with the knees hanging.
- The patient should be gradually trained to transfer himself from bed to wheelchair to parallel bars and back.

During 21 to 28 days

- Patient is encouraged to bear weight partially within the parallel bars. Crutch walking is permitted the next day and walking must be initiated with a reciprocal gait pattern.
- Vigorous strengthening exercises to the hips, knee and ankle muscles are continued.
- Knee standing and walking is taught to the patient.
- Single leg standing on the operated limb is encouraged.

Quick Facts

Total hip replacement VS uses of crutches
- Both the crutches—upto 6 weeks
- Single crutches—upto 8 weeks
- Walking stick—upto 6 months
  (As suggested by Beber and Covery)

After 1 month

- All the exercises are made more vigorous.
- Stair climbing is started. The patient should go up with the sound leg and come down with the operated leg first.
- Bicycle exercises and rotational exercises for the hip in supine positions are initiated.
- By 12 weeks the patient should be functionally independent.

Quick Facts

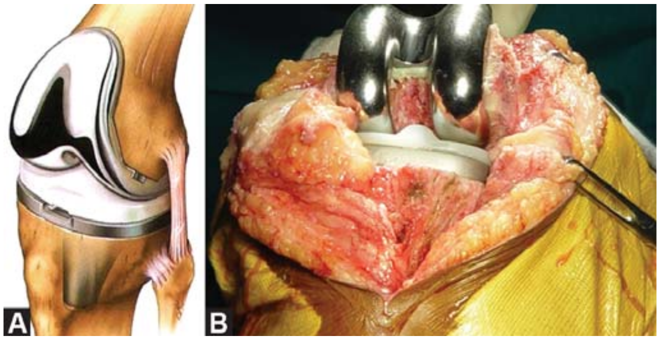
Activities of a patient with THR should not do:
- Squatting on the floor.
- Flexion of the hip beyond 90°.
- Cross leg sitting.
- Position of flexion, adduction and internal rotation.
- Knee crossing while sitting.
- Long sitting and bending forwards to touch the toes.

Total Knee Replacement (TKR)

Indications for TKR (Figs 18.9A and B):
- Severe osteoarthritis of the knee.
- Rheumatoid arthritis causing severe destruction.
- Severe pain and deformity due to any form of arthritis.

Quick Facts

Types of TKR
- **Unicompartmental** Either the medial or lateral compartment of the knee is replaced. Outdated method.
- **Bicompartmental** Here both the compartments of the knee are replaced. Not a very popular method.
- **Tricompartmental** Here along with both the compartments of the knee, the patello-femoral component is also replaced
  This is the most commonly preferred method.



Figs 18.9A and B: Clinical photograph of total knee replacement

Physiotherapy Measures in TKR

Preoperative measures

- *Evaluation* To evaluate a patient for TKR, the following points are noted: Pain, deformity, ROM, gait analysis, muscle strength, status of the other joints, etc.
- *Education* The patient is taught the postoperative physiotherapy regimen on the normal side, isometrics and other exercises are indicated for the affected and normal joints, reassurance, measures to counter DVT, edema, etc.

Postoperative measures

During the first 7 days

- Chest physiotherapy to prevent lung problems.
- The limb is kept elevated and positioned properly with a pillow beneath the heel preventing rotation.
- Rotation is avoided at all costs.
- Isometrics to the quadriceps:
  - — To begin with, it should be gentle and rhythmic.
  - — Sustained and slow contractions with reinforcement by dorsiflexion of the ankle.
  - — Progress this to speedy exercises.
- Isometrics of the glutei, hamstrings are also begun.
- SLR with support with isometric contraction of the quadriceps and ankle dorsiflexion is begun.
- By 4th or 5th day, patient is allowed to stand and ambulate with walkers.

Quick Facts

• For cemented prosthesis	Weight-bearing to tolerance (WTBTT) or partial Weight-bearing (PWB)
• For uncemented TKR	Toe down weight-bearing (TDWB)

- Self-assisted slow passive flexion of the knee or CPM with one cycle/minute is begun.
- The range of knee flexion should be less than 40° during the first 3 days.
- Active or active assist knee flexion can be commenced.

Between 7-14 days

- Isometrics are made move intensive.
- Active, active assist and passive ROM exercises for knee flexion are also made more vigorous. Knee flexion should be 90°.
- SLR is also made intense.
- Partial weight bearing and ambulation is begun on crutches.

Quick Facts

When to permit ambulation?
Ambulation is permitted when the patient is able to do three independent SLR test against gravity.

After 3 weeks

- Knee flexion should now reach 110-120°.
- Exercises over pedocycle or stationary bicycle are started.
- Partial weight-bearing with a crutch is progressed to full weight-bearing.
- Stair case walking is begun. Quadriceps drills are also begun.
- Hydrotherapy is beneficial.

After 45 days

- Patient should be encouraged to walk with a cane.
- Patient is taught to balance his weight evenly on both the knees.
- By 12 weeks, the cane should be discarded and the patient should be able to resume all the normal activities.

Total Ankle Arthroplasty

This is not as common as THR or TKR. Arthrodesis of the ankle is more popular than arthroplasty. However, in some cases of rheumatoid arthritis and hemophilia it is considered.

Note The commonly used ankle joint prosthesis consists of a metal plate over the dome of the talus and a high molecular weight polyethylene attached to the lower end of tibia.

Preoperative Assessment

- Improving the ROM of the ankle and subtalar joints.
- Improving the muscle strength of the ankle and foot muscles.
- Improving the gait pattern.
- Improving the joint stability.
- Detecting and improving muscle wasting.

Postoperative Management

- To control and reduce swelling, the limb is elevated and pressure bandage is applied.
- Active exercises to the hip, knee and toes of the operated limb are begun.
- By 5th day the pressure bandage may be discontinued and slow active dorsiflexion and plantar flexion of the ankle is permitted.
- Graduated active dorsiflexion and plantar flexion movements of the ankle and foot are permitted.
- Partial weight bearing on the affected limb is allowed by 2-3 weeks.
- Full weight bearing with the help of one stick is permitted next in the event of absence of pain.
- Gradually the patient is trained to walk on uneven surfaces and climb the staircases.
- Relaxed sustained passive stretching of the scar helps.
- Patient is discharged after 2-3 weeks and should be back to normal activities at the end of 8-10 weeks.

ARTHROPLASTY OF THE UPPER LIMBS

Shoulder Arthroplasty (SA) (Fig. 18.10)

Indications
- Grossly comminuted fractures of the shoulder joint.
- Severe OA.
- Advanced stages of rheumatoid arthritis.

In SA, the humeral head and the glenoid are replaced by prosthesis.

Types of Prosthesis

Neer's Here the glenoid is replaced by a shallow cup and humeral head by a ball. This is the most commonly used total shoulder prosthesis.

Liverpool Here the ball is on the glenoid side and the socket on the humeral side.

Fig. 18.10: Plain X-ray showing shoulder arthoplasty

Physiotherapy Management

Preoperatively the patient may have lax ligaments, weakness of the shoulder muscles and rotator cuff. Efforts are made to improve these problems by:
- Active and passive ROM exercises.
- Muscle strengthening exercises.

Postoperative Management

- After the surgery, the limb is immobilized in a sling for a period of 3 weeks under the clothes.
- A further 3 weeks immobilization is advised outside the dress.
- During this period active exercises of the normal limb and the wrist, hand finger movements of the operated limb are permitted.
- All movements of the shoulder joint except the lateral rotation are commenced by 3 weeks.
- Shoulder shrugging and pendulum exercises are commenced.
- With the patient supine, active and active-assisted movements of the shoulder and elbow are begun.
- Gradually exercises in the sitting position are permitted.
- By the end of 6 weeks, lateral rotation of the shoulder is permitted.
- Patient should regain the normal functional activities by the end of 3 months.

Elbow Arthroplasty

Three types of elbow arthroplasty are generally described:
- Excisional arthroplasty
- Interpositional arthroplasty
- Total elbow (implant) arthroplasty.

Indications
- Advanced stages of rheumatoid arthritis.
- Severe OA.
- Severe fractures and fracture dislocations of the elbow.
- Bilateral elbow ankylosis.
- Tumors.

Aim of the surgery
- To relieve pain.
- To provide mobility.
- To provide stability.

Contraindications
- Infection in the elbow joint.
- Shoulder ankylosis on the same side.

Postoperative Physiotherapy Measures

- Limb elevation to prevent edema.
- Pressure bandaging.
- Sling suspension.
- Active ROM exercises to the fingers and wrist of the operated limb.
- Active exercises to all the joints of the unaffected limb.
- After 5-15 days, elbow is gradually mobilized after the swelling has subsided as follows:

  Methods of gradual mobilization of the elbow:

  — *Prone position (Fig. 18.11)* In the prone position, with the elbow hanging over the edge of a table, the patient is instructed to carry active elbow flexion and extension exercises.

Fig. 18.11: Showing active elbow flexion and extension exercises in prone position

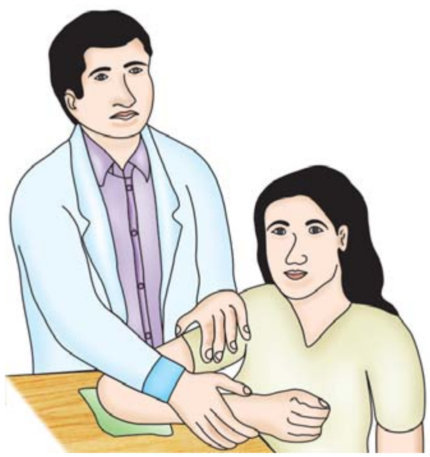


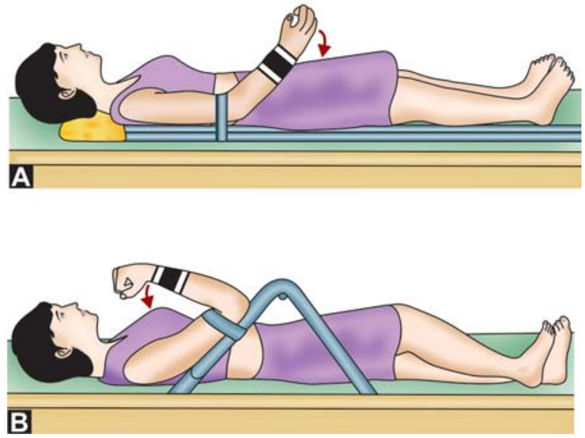
Fig. 18.12: Therapist assisting in the active elbow flexion and extension in gravity eliminated position

— *In gravity eliminated position (Fig. 18.12)* Here the patient keeps the arm at the edge of a table. The therapist fixes the arm to the table and then assists the patient to carry out active flexion and extension in a gravity eliminated position.

— *Pronation and supination* Mobilization is carried out in the same way as explained in earlier sections (*see* page 129).

— *Gravity and weight assisted mobilization (Figs 18.13A and B)* Using a knee ratchet, with the patient in supine position, patient is instructed to first actively flex (Fig. 18.13A) and then extend (Fig. 18.13B) against gravity. Adding of small weight while doing the above exercises, gradually stretches the muscles further.

- Active flexion exercises, active pronation-supination exercises and gentle passive exercises to the elbow are commenced.



Figs 18.13A and B: Active elbow flexion: (A) Extension, (B) Assisted by gravity and weight

- The elbow is splinted back after these exercises.
- The splint is continued for a period of 3-4 weeks.
- Graduated mobilization techniques are continued till the patient regains satisfactory functional activities and the patient has a stable painless joint.
- Patient is instructed not to lift or carry heavy weights with the operated limb.
- Graded strengthening exercises for the biceps and triceps are gradually begun.
- Patient is gradually encouraged to carry out the day to day functional activities with the affected hand.

Total Wrist Arthroplasty

Wrist arthroplasty is less popular when compared to hip, knee, etc. However, arthrodesis of the wrist gives better functional stability and is hence preferred.

Indications

- Severe wrist fractures and dislocations.
- Severe pain due to OA.
- Advanced rheumatoid arthritis.
- Total ankylosis of the wrist.

Aim

- To relieve pain.
- To provide a stable joint.
- To provide a mobile joint.

Postoperative Measures

- Arm is elevated to minimize swelling.
- Pressure bandaging.
- Arm is supported in a splint.

- To promote soft tissue healing a POP cast is applied with the wrist in neutral position for a period of 3-4 weeks.
- Active exercises are advised to the shoulder, elbow and fingers on the operated side.
- After 3-4 weeks, gradual active and active-assisted movements to the operated wrist are begun.
- Gentle passive relaxed wrist flexion and extension in gravity eliminated position are slowly begun.
- The patient should be functionally independent by 4-6 weeks.

Hand Arthroplasty

This could be either implant arthroplasty of Metacarpophalangeal joints (Silastic implants) or excisional arthroplasty.

Indications
- Severe and persistent pain in the MCP joints due to OA.
- Severe deformities due to RA.

Aims
- To improve mobility.
- To provide stability.
- To relieve pain.

Physiotherapy Management

- Hand elevation.
- Pressure bandaging.
- Active exercises of the shoulder, elbow, and wrist on the affected side are begun.

Hand physiotherapy Three different schools of thought are advocated.

Wym Parry (1981)
- Hand is immobilized in a plaster cast, till the dorsal expansion has healed.
- Flexion at MCP joint is restricted to 30°.
- Movements at the IP joints are permitted.
- After 3 weeks, patient is readmitted for daily intensive rehabilitation program.

Madden *et al* (1977) regime After five days of surgery, when the swelling has subsided, a dorsal splint with the wrist held in 15-20° extension is applied. To this splint is attached an outrigger with rubber bands and finger loops. Early passive movement and prolonged dynamic splinting is recommended.

Swansun regime (1982)
- On the 3rd or 5th postoperative day, protective movements of the fingers are begun as soon as the postoperative swelling of the hand is reduced.
- To prevent ulnar deviation and allow 70° flexion at the MCP joints a dynamic splint with rubber outrigger is indicated.
- This 70° flexion has to be maintained for a minimum period of 3 weeks.
- If the patient develops extensor lag, flexion contracture or ulnar deviation, this brace should be continued.

Other Measures

- Assistive devices to the affected hand are indicated to carry out the functional activities.
- To improve strengths, progressive ROM and strengthening exercises are advised.
- By 3 months of surgery, fully functional hand should be restored.

Bone Grafting Operations

Bone grafting is used in the following situations in orthopedic practice:
- To promote union in cases of nonunion or ununited fractures.
- In arthrodesis of joints for intra-articular or extraarticular fusion.
- To fill a defect or cavity in a bone.

Types

These are three types of bone grafts.

Autogenous Grafts or Autografts

These are bone grafts either cancellous (Fig. 18.14) or cortical obtained from different parts of patients own body. Cancellous bone grafts are obtained from the iliac crest and the cortical

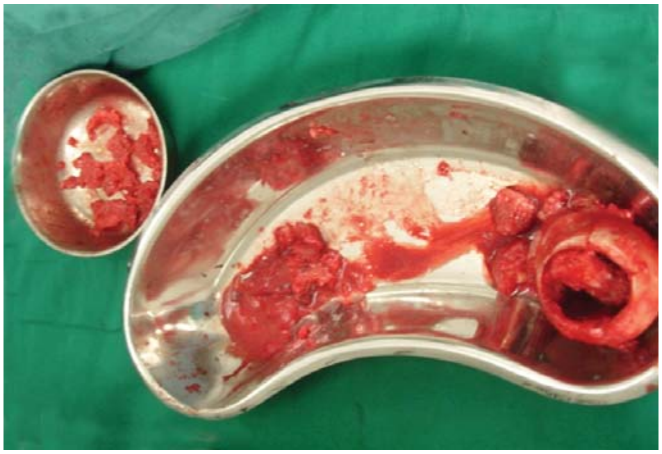


Fig. 18.14: Photograph showing specimen of cancellous bone graft

bone graft is obtained from the fibula. Due to improvement in micro vascular surgery it is now possible to obtain a graft with the muscle pedicle with its blood vessel intact and anastomosed to the recipient area, e.g. Meyer's muscle pedicle graft. The other method is to obtain a free vascularised graft where the bone graft is taken along with its blood supply, and the blood vessels are anastomosed to the vessels in the recipient area, e.g. fibula with its blood supply intact.

Allograft or Homograft or Homogenous Grafts

Here the bone graft is obtained from another person's body usually if the requirement is large as in filling up the gap after a tumor resection (e.g. osteoclastoma) and if graft is insufficient from his or her own body. Allograft is obtained from another person living or dead. The latter is called "cadaveric graft". These bone grafts are usually used fresh or may be stored under aseptic conditions until required. Cadaveric bone is sterilized either by boiling or by irradiation and stored at –70°C in a bone bank after decalcification and preservation with formalin.

Xenografting (Heterogenous or Heterograft)

Here the bone graft is obtained from animals mainly bovine. It is sparingly used.

Note Artificial bone this is made up of hydroxyapatite and is now being used in some centers.

Role of Bone Grafts

It provides a scaffold or a temporary bridge upon which a new bone is laid down. Thus, the bone cells of the graft die and are eventually replaced by a new living bone. Vascularised grafts get incorporated very rapidly.

TENDON SURGERIES

Tendon Transfers

In this operation the insertion of a healthy functioning muscle is moved to a new site, so that it has a different action. Other intact tendons will take care of the original function of the transferred tendon (for criteria of tendon transfers.

Indications

- Muscle paralysis as in polio or peripheral nerve injury.
- Muscle imbalance as in cerebral palsy.
- In rupture or cut tendon where direct suture is not possible.

Tendon Grafting

In this a length of free tendon is used to bridge a gap between the severed ends of the recipient tendon, e.g. reconstruction of flexor tendons severed in the fibrous digital sheaths of the hand.

Free tendon graft is usually obtained from the palmaris longus or from one of the toe extensors at the dorsum of the foot.

OTHER IMPORTANT SURGERIES

Equalization of Leg Length

In patients with unequal leg length as in polio, equalization of leg length can be obtained by

- Leg lengthening by llizarov technique.
- Leg shortening especially in femur or tibia. Not advocated as a routine procedure.
- Arrest of epiphyseal growth by stapling in children.

Excision of Tumors

This has been discussed in Chapter 31 on Bone Neoplasia (*see* page 480).

Amputations

With improvement in the treatment methods amputation is no longer done. However, it is reserved for cases that are badly damaged and there is no vascular supply and there is fear of gangrene (Fig. 18.15). This is described in the chapter on amputations.

Fig. 18.15: Clinical photograph of below elbow amputation

Now after having studied the general principles of treatment, let us now discuss individual regional conditions in greater detail.

19 Chapter

Regional Conditions

Regional orthopedics deals with a vast array of interesting orthopedic problems. Each region has its own peculiar problems depending on various factors like anatomical, physiological, occupational and others operating in that region. An effort is made in this section to highlight the various regional orthopedic problems. However, a detailed description of the regional disorders is avoided as it is outside the scope of this book. The student is requested to refer bigger books in orthopedics in case he or she desires a detailed study of the regional problems.

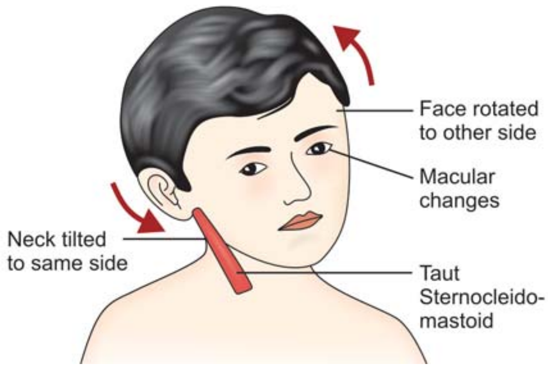


Fig. 19.1A: Wry neck

REGIONAL CONDITIONS OF THE NECK

TORTICOLLIS (WRY NECK)

Torticollis is defined as the rotational deformity of cervical spine that causes turning and tilting deformity of the head and neck (Figs 19.1A and B).

Fig. 19.1B: Showing clinical photograph of wry neck

Causes

- *Congenital (see* Chapter 21 on Gait for description).
- *Infective* Tuberculosis of cervical spine, acute respiratory tract infection, etc.
- *Traumatic* Sprain, dislocation and fracture of the cervical spine.
- *Myositis or fibromyositis* of sternocleidomastoid, exposure to cold causes myositis.
- *Spasmodic* painful, persistent or intermittent sternomastoid muscle contraction.
- *Unilateral muscle paralysis*, e.g. polio.
- *Neuritis* of spinal accessory nerve.
- *Ocular disturbances* Child turns head to one side to compensate for defective vision.

Among the acquired causes of torticollis, spasmodic muscle contraction of the sternocleidomastoid is the most common cause.

Clinical Features

Head of the patient is tilted towards the affected side while the chin points to the other side. Sternocleidomastoid muscle is prominently seen. In the later stages, the patient may develop facial asymmetry and macular disturbances in the eye.

Radiographs

Plain X-ray neck helps to rule out intrinsic causes that can contribute to neck pain.

Management

Conservative Initially conservative line of treatment is observed. This consists of nonsteroidal anti-inflammatory drugs (NSAIDs), muscle relaxants drugs, etc.

Physiotherapy measures Like ultrasound, heat, massage is advocated. In acute pain, patient is encouraged to wear a collar. Gradual neck strengthening exercises are advised once the acute symptoms subside. For more details on physiotherapy management in torticollis (*see* page 389).

Surgical Management is advised after the failure of conservative treatment. It consists of release of sternomastoid muscle from its clavicular attachment as in congenital torticollis and intradural section of both spinal accessory and three cervical roots in cases of torticollis due to spasmodic or neural causes.

THORACIC OUTLET SYNDROME

The space at the thoracic outlet or inlet when it is less than adequate, subjects the neurovascular structures seeking to gain entry into the upper limbs via this space, to undue pressure (Fig. 19.2). The blame for the neurovascular complaints should be placed at the doorstep of the decreased space and not at the structures producing the problems.

This syndrome results from the compression of neurovascular bundle comprising of subclavian artery and vein, axillary artery and vein and brachial plexus at the thoracic outlet. Thoracic outlet is a space between the first rib, clavicle and the scalene muscles. The above structures are liable to be compressed (Fig. 19.3) when this space gets narrowed either due to hypertrophy of the existing muscles or due to any other causes like congenital, trauma, etc.

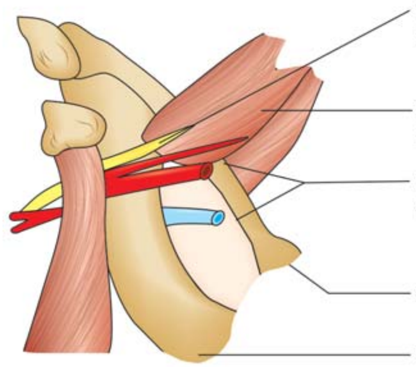


Fig. 19.2: Anatomy of the thoracic outlet

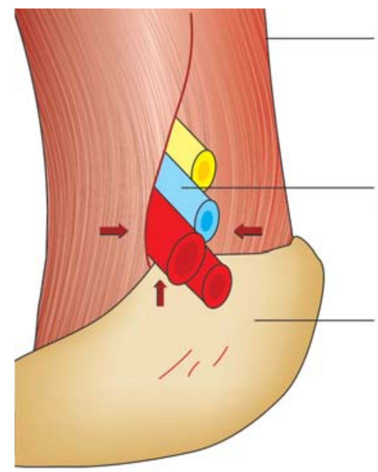


Fig. 19.3: Abnormal scalene muscle insertion causing compression of neurovascular structures

Sites of Compression

The sites of compression could be either supraclavicular, subclavicular or infraclavicular.

- *Supraclavicular* At the interscalene triangle between the anterior scalene muscles.
- *Subclavicular* Interval between the second thoracic rib, clavicle and subclavius.
- *Infraclavicular* Beneath an enclosure formed by the coracoid process, pectoralis minor, and costocoracoid membrane.
- *Rare causes* Scissor-like encirclement of axillary artery by the median nerve.

Contributing Factors

Dynamic factors Arm when in full abduction, pulls up the artery by 180° causing compression in the short retroclavicular space.

Static factors

- *Vigorous occupation* Increases the muscle bulk and thereby decreases the space.
- *Inactive occupation* Decreases the muscle bulk and thereby increases the space.
- *Congenital* Cervical rib decreases the interscalene space and thereby decreases the retroclavicular space.
- *Traumatic* Malunion or nonunion of fracture clavicle.
- *Arteriosclerosis.*
- *Anomalies of the first thoracic rib.*
- *Miscellaneous*
  - — Tumor arising from the upper lobe of the lung.
  - — Cervicothoracic scoliosis.
  - — Abnormal variations of the scalene muscles.

Clinical Features

Obviously this syndrome poses two major problems. The first one relates to the compression of the major vessels and secondly to the compression of the nerves. The first problem has a *definite clinical entity, w*hile the second one presents a *vague picture* and makes an accurate diagnosis difficult.

Vascular problems Here the compression could be arterial or venous. During the arterial compression, which is mild in the early stages patient complains of *numbness* of the whole arm with rapid fatigue during overhead exercises. If the compression is significant patient will complain of *cold, cyanosis, pallor and Raynaud's phenomenon.*

Venous compression leaves the limb *swollen and discolored* after exercises which disappears slowly with rest.

Neurogenic problems This involves C8 T1 segment (Klumpke's paralysis). Patients complain of *paraesthesia* along the medial aspect of the arm, hand, little and ring fingers. There is *weakness* of the hand also.

Complications

Subclavian artery compression → results in post-stenotic dilatation → stasis favors thrombosis → the thrombi break and migrate distally causing embolisation → this result in the distal artery blockade causing ischemia and gangrene of the upper limbs.

Investigations

X-ray neck To rule out intrinsic causes like cervical spondylosis, cervical rib, etc.

Nerve conduction studies Difficult to determine the nerve conduction velocity through the thoracic outlet, but its biggest value is to rule out problems like entrapment, e.g. ulnar nerve at elbow, wrist, etc.

Treatment

- *Conservative treatment* Consists of rest, pain killers, etc.
- *Surgical treatment.*

Indications: Gangrene and post-stenotic dilatation.

Methods

- *Removal of the first thoracic rib* This is the most effective treatment as it deals with both supraclavicular and infraclavicular etiological factors in this syndrome.
- *Removal of cervical rib* If this is the cause of compression.
- *Scalenotomy* is indicated in scalenus anticus syndrome.

Quick Facts

- Sites of compression—could be supra, sub, or infraclavicular.
- Clinical manifestation—could be neural, vascular or both.
- Diagnosis is usually by exclusion and the screening test helps.
- Excision of the first thoracic rib is the most effective surgical procedure.

Physiotherapy Measures

This proceeds on the same lines as described for the cervical rib.

CERVICAL RIB

*Cervical rib problem is akin to the story of the "Return of the *Prodigal Son". But unlike the chastened prodigal son, cervical rib returns to torment the unfortunate victim!*

Cervical rib is an accessory rib arising from the 7th cervical vertebra, rarely 6th and 5th cervical vertebra.

Incidence is 0.46 percent. Nearly 50 percent of these are unilateral.

Side It is more frequent on the right side.

Note *The story of 'Prodigal Son' is mentioned in the Bible.

Developmental Factors

In the embryo nerves larger than the ribs interfere with the development of the costal process. When brachial plexus is prefixed, well developed 4th cervical root and small 2nd thoracic root offer little resistance to the costal process at the 7th cervical root.

In postfixed brachial plexus, well-developed 1st thoracic root offers, resistance to costal process of 7th cervical root. Obviously cervical rib is more common in the prefixed variety.

Types

Four varieties are described:
- *Complete* The cervical rib reaches up to the first thoracic rib.
- *Bulbous end* In this the cervical rib has a bulbous end.
- *Tapering end* In this the cervical rib tapers.
- *Fibrous band* In this the rib is represented by a thick fibrous band.

Pathological Anatomy

The neurovascular structures, the brachial plexus and subclavian vessels are hung up by the cervical rib that is inserted into the scalene tubercle of the 1st rib space.

Pronounced drooping of the shoulder in women after middle age, trauma, unusual lifting operations, acute illness make the muscles weak, pulling the plexus and artery distally giving rise to symptoms.

Clinical Features

- *Cervical rib with local symptoms* Show presence of a lump and tenderness in the supraclavicular fossa (Fig. 19.4).

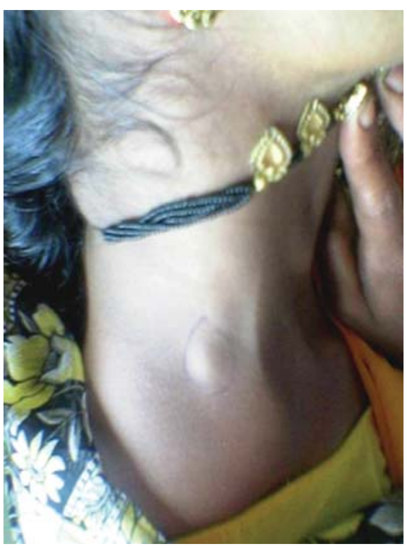


Fig. 19.4: Clinical photograph showing the presence of a bony lump on the right side of the neck indicating cervical rib

Fig. 19.5: Plain X-ray of the neck Showing the presence of cervical rib

- *Cervical rib with vascular symptoms* This gives rise to pain in the upper limbs, temperature and color changes, radial pulse is feeble or absent and a feeling of numbness is present.
- *Cervical rib with nerve pressure symptoms* The nerve pressure symptoms are due to the angulation of the first thoracic nerve root. The patient complains of par aesthesia along the medial aspect of the arm, hand and little fingers. There is weakness of the hand muscles also.

Radiograph

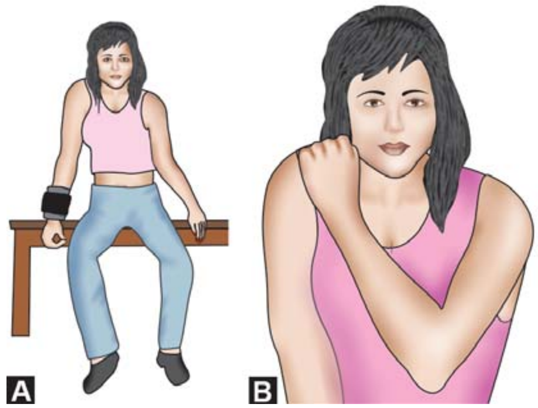
Plain X-ray (Fig. 19.5) of the neck, AP view helps to identify the cervical rib whether unilateral or bilateral. However the absence of the rib shadows does not rule out the possibility of a rib as fibrous bands are not visible on the X-ray.

Treatment

In mild cases, sling exercises often help. In more severe cases, scalenotomy (resection of scalenus anterior muscle) may be required and is successful in 70 percent of the cases. In troublesome cases removal of the cervical rib or the first rib surgically with its periosteum to prevent its regeneration is advocated.

Physiotherapy Treatment

The following physiotherapy measures are recommended in cervical rib:
- *Thermotherapy* For pain relief and relaxation.
- *Strengthening exercises* For all the shoulder joint muscles. Self resisted strengthening exercises for shoulder elevation and adduction muscles. PRE with weight belts for shoulder girdle muscles (Figs 19.6A and B).
- *Exercises* For the active arm especially the hand are advised.



Figs 19.6A and B: Shoulder shrugging exercises (A) PRE with weight-belts, (B) Self-resisted

CERVICAL DISK SYNDROMES

The cervical region consists of seven cervical vertebrae with their intervening disks. The disk is made up of central nucleus pulposus and annulus fibrosus at the periphery. The disk functions as an effective shock absorber and also gives the cervical spine more mobility. If the disk material herniates (Fig. 19.7) because of trauma or old age it gives rise to cervical disk syndrome.

More than 90 percent of the disk lesions in the cervical spine occur at the C5 and C6 levels as these are the most mobile segments.

Types

- *Soft disk lesions* It is common in young adults and is usually following trauma. In this there is only a nuclear herniation through the wide annulus fibrosus of the disk.
- *Hard disk lesions* This is more common than the first, seen in older age group, gradual in onset and is usually due to cervical spondylosis. Rarely large posterior osteophytes may cause pressure on the anterior portion of the spinal cord and produce mixed symptoms of the upper limb nerve root pain and lower extremity weakness (cervical spondylosis with myelopathy).

Fig. 19.7: Cervical disk herniation compressing the nerve root

Figs 19.8A and B: Clinical photograph showing the clinical presentation in cervical spondylosis

Clinical Features (Figs 19.8A and B)

Symptoms Patient complains of *pain* in the neck which is gradual or acute in onset. There is history of morning stiffness. Extension of the neck increases the pain. *Tingling and numbness* develops if the nerve root is compressed but it does not follow the dermatomal pattern. Patient may also complain of radiating pain along the neck, shoulder upper arm, forearm and hand (Fig. 19.9).

Signs Movements of the neck are decreased due to pain. Pain increases on hyperextension. There is localized tenderness over the spinous process. Trigger point tenderness at the scapular region is present. Pressure against the top of the head increases pain. If the nerve root is compressed by the disk herniation (*see* Fig. 19.7) sensory, motor and reflex changes occur and follow the dermatomal pattern (Table 19.1 and Fig. 19.10). *Rarely symptoms referable to the lower limbs develop due to*

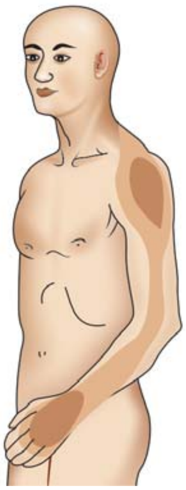


Fig. 19.9: Showing distribution of radiating pain in cervical spondylosis

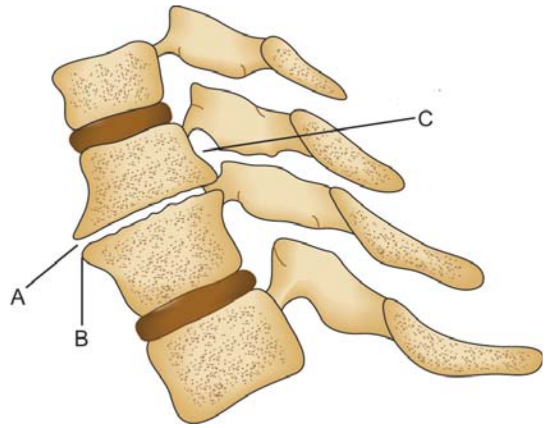


Fig. 19.11: Radiograph in cervical disk syndrome: (A) disk space narrowing, (B) osteophyte formation, and (C) narrowing of intervertebral foramina

TABLE 19.1: Dermatomal pattern

Root	*Motor*	*Reflex*	*Sensation*
C_5 (C_{4-5} lesion)	Deltoid↓	Biceps reflex↓	Numbness in the deltoid region
C6 (C_{5-6} lesion)	Wrist extension↓	Brachioradialis reflex↓	Dorsolateral aspect of the thumb and index finger
C7 (C_{5-6} lesion)	Wrist flexion↓	Triceps reflex↓	Index, middle and dorsum of the hand
C_8	Finger flexion↓	None	Ring, little finger, medial border of forearm

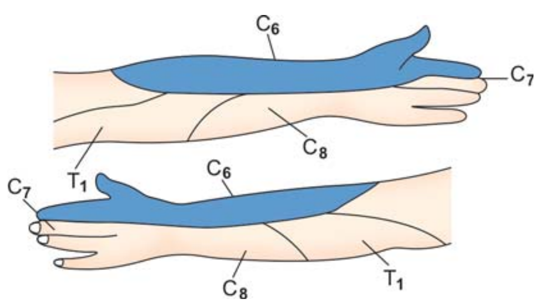


Fig. 19.10: Dermatomal pattern of upper limb

pressure of posterior osteophytes on the anterior portion of the cervical cord. This symptom complex appears as a combination of cervical roots and cord symptoms [LMN upper limbs + UMN lower limbs].

Investigations

X-ray (Fig. 19.11) Normal in soft lesions but in hard lesions it shows, narrowing of disk space, anterior and posterior osteophyte formation, and narrowing of intervertebral foramen (Fig. 19.12).

Fig. 19.12: Plain radiograph showing advanced stages of cervical spondylosis

Myelography It helps in localizing the lesion but is invasive.

MRI This is useful, as it is non-invasive, and helps localize the lesion, but its high cost is prohibitive.

CT scan It is more useful in evaluating traumatic conditions of the neck than degenerative conditions.

EMG, discography, thermography is occasionally used.

Treatment

Conservative treatment is the more accepted form of treatment in cervical disk syndrome. It consists of rest which is the cornerstone of the treatment as it allows soft parts to heal by reducing the inflammation. NSAIDs once a day are usually preferred. After the pain decreases, patient is encouraged to perform gradual graded isometric neck exercises.

Surgical treatment Less than 5 percent of the cases of cervical spondylosis require surgery and is usually indicated in cases of chronic pain, failed conservative treatment and neurological deficits due to root or cord compressions.

Quick Facts

Surgical treatment of cervical spondylosis
- Anterior cervical discectomy with interbody fusion for single or 2 level disk involvement.
- Corpectomy and strut graft for multiple level disk involvement.
- Laminectomy has a doubtful role.
- Surgery is required in less than 5 percent of cases.

The surgical procedure usually consists of removal of the cervical disk through an anterior approach and cervical interbody fusion by placing an autologous iliac bone graft. Excision of large osteophytes can also be done through this route. Excision of one or two cervical bodies (corpectomy) may be justified in multiple level disk pathology. Laminectomy usually does not produce the desired results.

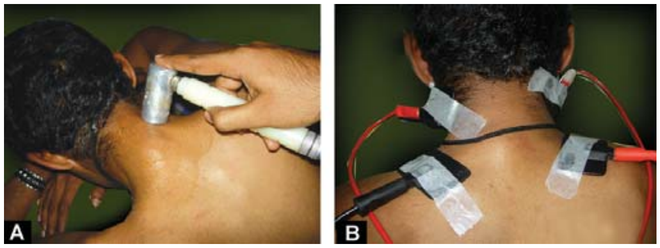
Preventive measures This can be done by good postural habits and using proper sized pillows of 7.5 to 10 cm thickness and should be placed under the neck rather than the head.

Physiotherapy treatment for cervical syndrome The physiotherapy treatment for cervical spine disorders encompasses a wide spectrum of measures; the important ones are as follows.

Measures to Reduce Cervical Pain, Spasm and Inflammation

The aim of these measures is to reduce pain and spasm in the neck and thus provide the all important relaxation of the neck muscles. The modalities are:

- *Thermotherapy* This is heat therapy and could be either superficial or deep.
  — *Superficial* These are IFT TENS, infrared rays and hydro collator packs (Fig. 19.13B).
  — *Deep* This is provided by the ultrasound (Fig. 19.13A) and the SWD, and the microwave.
- *Cryotherapy* This consists of ice packs and ice massage.



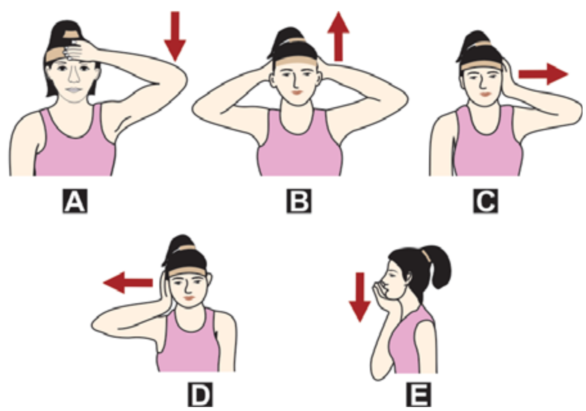
Figs 19.13A and B: Clinical photograph showing the technique of ultrasound massage and IFT for the treatment of neck pain

- *Massaging* by way of friction circular kneading, etc. to the local area of pain, considerably reduces the pain and induces relaxation.

Measures to Strengthen and Mobilize the Neck

Exercises play a pivotal role in strengthening the neck muscles and mobilizing the neck once the pain has subsided after employing the above methods.

- *Exercises to strengthen the neck muscles* Strong isometrics helps to achieve this when movement is contraindicated.
- *Exercises to improve the weak muscles* The weak muscles of the neck could be strengthened by active assisted exercises to the neck.
- *Exercises to strengthen the neck muscles* The active self-resisted isometric exercises help considerably to strengthen the neck muscles (Figs 19.14A to E).
- *Exercises for neck mobilization* The relaxed active and passive exercises for all the neck movements helps achieve this goal (Fig. 19.15).
- *Combination exercises* All the above exercises combine together in the PNF technique.



Figs 19.14A to E: Different self-resistive isometric neck exercises: (A) Neck flexion, (B) Neck extension, (C) Lateral flexion, (D) Neck rotation, (E) For neck flexion

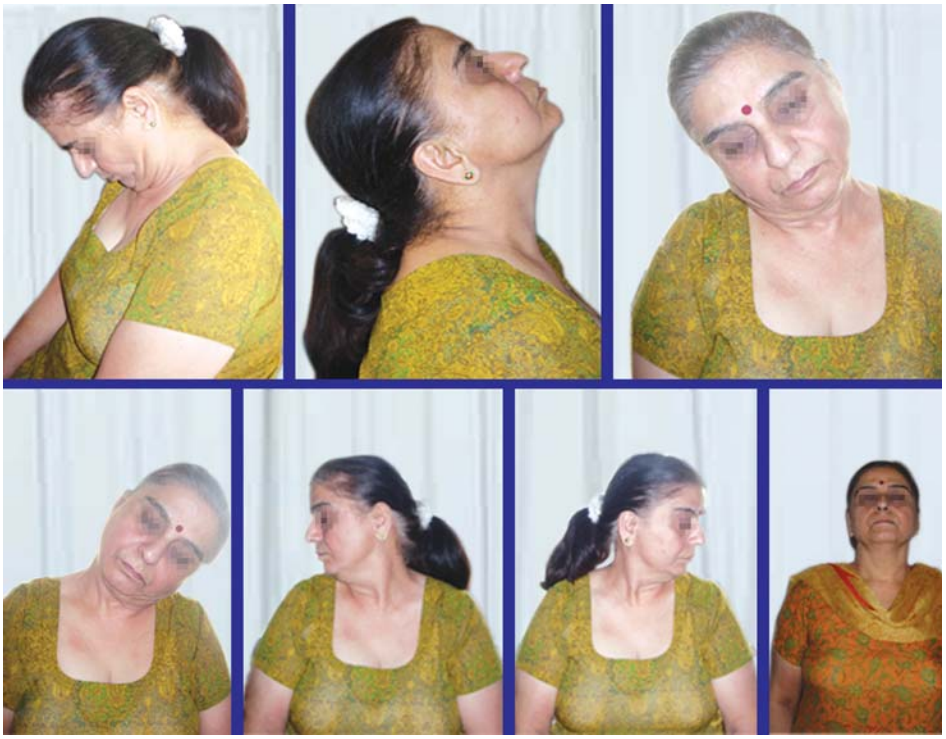


Fig. 19.15: Showing the neck mobilization for cervical spondylosis

Quick Facts

How do exercises help?

- Stretches the inelastic soft tissues and muscles.
- Breaks the contractures
- Improves blood supply
- Corrects the poor posture and provides a sense of
- Well-being.

Caution Exercises should not be overdone lest it causes pain to the patients.

Cervical Traction

Whether it is sprain, strain, fractures dislocations, infections, etc. in the neck, cervical traction has a role to play in each of these troublesome neck problems.

The various types of cervical traction and their significance are as follows.

1. *Continuous traction*

Indications

- To reduce fractures and dislocation of the cervical vertebrae.
- To reduce cervical disk prolapse.
- To relieve pressure on the compressed cord and nerve roots.

Methods It is given 24 hours a day with a weight of 5 to 15 lbs.

2. *Static traction*

Indications

- Minor disk prolapse.
- Neurological deficits either due to fractures or disk prolapse.

Method Here the traction is applied for 20-30 min with weights ranging from 10-30 lbs.

3. *Intermittent traction (Fig. 19.16)*

Indications

- To relieve pain and spasm.
- To prevent and break the adhesions in the joints of the neck.

Methods This is the most popular method of cervical traction. Due to alternating traction and relaxation, it produces an effect of massage and relaxation of the neck muscles, thereby reducing pain, spasm and inflammation.

4. *Polyaxial cervical traction* This provides a pull on a particular segment of cervical vertebrae.

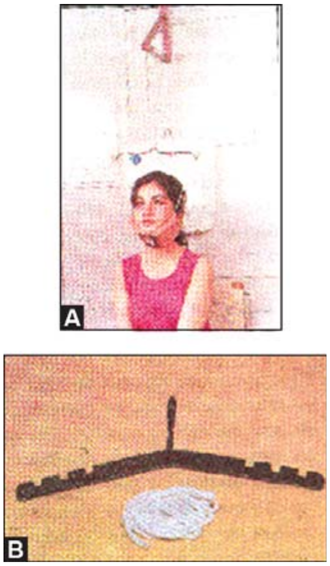
Fig. 19.16: Showing method of intermittent cervical traction

Importance of neck positions during traction

- *For upper cervical vertebrae* Traction is given in hyperextension.
- *For middle cervical vertebrae* Traction is given in neutral position of the neck.
- *For lower cervical vertebrae* Traction is given in flexion.

Importance of patient position during traction

- *Supine position* This is the ideal position of the patient during cervical traction (Fig. 19.16).
  Advantages
  — Relaxation is better.
  — Intervertebral separation is better.
  — Better stability and less muscle guarding.
- *Sitting position* Though this position is convenient it is not ideal (Figs 19.17A and B).



Figs 19.17A and B: Showing the technique of intermittent cervical traction in sitting position

Note The pull of the traction should be under the chin and not the occiput to prevent neck extension.

Interesting facts

- **How to determine the position of comfort for traction application?**
  Manual traction is applied to the neck in various positions like flexion, extension, rotation and lateral flexion. The position of 'greatest comfort' is chosen for applying traction.
- **How to determine the weight?**
  The rule of thumb for the weight to be chosen is 1/7th to 1/10th of the body weight.
- **When not to apply traction?**
  During marked ligament instability, malignancy, cord compression, rheumatoid arthritis, etc.

Role of Manipulation

It has a limited but definite role in reduction of the intra-articular displacement in a mild or moderate cervical spondylosis. Manipulation is usually carried out during strong traction and is maintained by a neck collar.

Cervical Collar

The use of cervical collar is on the decline (Fig. 19.18). But it is indicated in the following situations:

- Acute disk prolapse.
- Acute pain due to sprain, strain, fractures and dislocations.
- Temporarily immobilization during driving, walking, etc.

Role of a Collar

- It reduces pain and spasm of the neck muscles.
- It provides immobilization to the neck.

Fig. 19.18: Wearing a cervical collar is a popular method of treatment of cervical spondylosis

- It helps to do the isometric exercises.
- It helps to correct the deformity.
- It provides additional support, comfort and psychological well-being.

Note Firm collar for the day and soft collar for the weight.

Drawback of a Cervical Collar

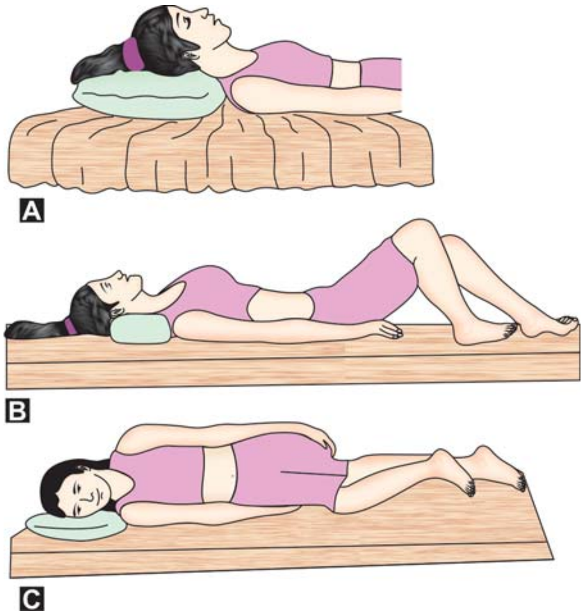
Neck immobilization due to a collar results in wasting of the muscles of the neck leading to the decreased support of the affected structures.

Additional Measures

- Maintenance of proper neck posture of straight neck with chin tucked in during sitting, walking, standing and working is of paramount importance.
- Proper sized pillows with correct height during sleeping should be used to maintain the neck position of neutral in relation to the shoulders (Figs 19.19A to C).

Concept of 'Butterfly Pillow' in Cervical Spondylosis

A soft thin pillow is tied loosely in the centre. The constricted central portion supports the head and neck. While the butterfly portion of the pillow supports the neck on either side while sleeping (Fig. 19.20).



Figs 19.19A to C: (A) Improper neck posture during lying down. Correct neck posture: (B) During supine position, (C) During side-lying

Fig. 19.20: Clinical photograph showing the use of cervical pillow

Quick Facts

Do you know the common causes of pain in the neck?
- Poor postural habits—common cause.
- Neck strain and sprain.
- Cervical disk syndromes.
- Cervical rib
- Thoracic outlet syndrome
- Torticolis
- Infection
- Ischemia
- Fractures and dislocations.

REGIONAL CONDITIONS OF THE SHOULDER

FROZEN SHOULDER

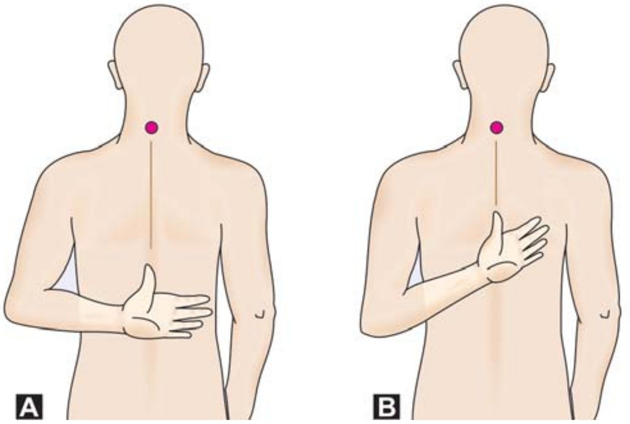
(Syn: Periarthritis, Adhesive Capsulitis)

Paradoxically shoulder joint privileged as the most mobile joint in the body has its nemesis because of this very advantage. Its mobility makes it very vulnerable to problems which ultimately "freeze" its movements. Unable to come to terms with the paucity of liberal movements hitherto enjoyed, the hapless patient resigns himself or herself to suffer the agony in silence!

It is defined as a clinical syndrome characterized by *painful restriction* (Figs 19.21A and B) *of both active and passive shoulder movements* due to causes within the shoulder joint or remote (other parts of the body).

History

Dupley first described it in 1872 and called it as *humeroscapular periarthritis.* In 1934 Codman coined the term *frozen shoulder*, and in 1945, Neviaser gave the name *adhesive capsulitis.*



Figs 19.21A and B: Showing degrees of internal rotations: (A) Forzen, (B) Normal

Fig. 19.22: Clinical photograph showing limitation of abduction of shoulder in frozen shoulder

Causes

The causes are mainly idiopathic and are due to fibrosis following chronic inflammation. This could be due to:

Primary Shoulder causes Problems directly related to shoulder joint which can give rise to frozen shoulder are tendinitis of rotator cuff, bicipital tendinitis, fractures and dislocations around the shoulder, etc.

Secondary Non-shoulder causes Problems not related to shoulder joint like diabetes, hyperthyroidism, hypertriglyceridemica, cardiovascular diseases with referred pain to the shoulder which keeps the joint immobile, reflex sympathetic dystrophy, frozen hand shoulder syndrome, a complication of Colles' fracture can all lead to frozen shoulder. The reason could be prolonged immobilization of the shoulder joint due to referred pain, etc.

Pathogenesis

- During abduction, and repeated overhead activities of the shoulder, long head of biceps and rotator cuff undergo repeated strain. This results in inflammation, fibrosis and consequent thickening of the shoulder capsule which results in loss of movements. *If the movements are continued, then the fibrosis gradually breaks, movements return but never come back to normal.*
- Prolonged activity causes small scapular and biceps muscles to waste faster, load on joint increases and degenerative changes sets in. Capsule is fibrosed and shoulder movements are decreased.

Clinical Features

There are three classical stages in frozen shoulder.

***Stage I** (stage of pain)* Patient complains of pain with insidious onset, decreased movements, external rotation greatest followed by loss of abduction (Fig. 19.22) and then forward flexion. *Internal rotation is least affected.* This stage lasts for 10 to 36 weeks. Pain due to frozen shoulder is predominantly nocturnal and usually will not radiate below the elbow unlike in cervical spondylosis (Fig. 19.23).

***Stage II** (stage of stiffness)* In this stage pain gradually decreases and the patient complains of progressive stiff shoulder in a capsular form. Slight movements are present.

***Stage III** (stage of recovery)* Patient will have no pain and movements will have recovered but will never be regained to normal. It lasts for 6 months to 2 years. ADL is severely affected.

Note Apprehension test indicates impending frozen shoulder (Fig. 19.24).

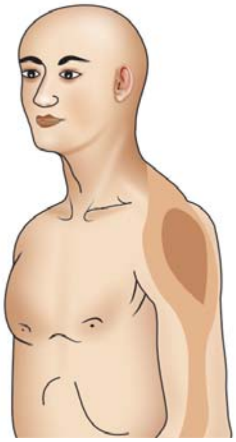


Fig. 19.23: Showing region of distribution of pain in frozen shoulder

Fig. 19.24: Pain during extreme passive abduction is an indicator of the future impending frozen shoulder

Fig. 19.25: Showing arthrography view of the frozen shoulder

Investigations

Plain X-ray of the shoulder is usually inconclusive but may show sclerosis (Golding's sign). Arthrographic evaluation of the shoulder shows contracted capsule and is the gold standard (Fig. 19.25).

Treatment

Stage I In this stage long-acting once a day NSAIDs are usually preferred as this condition usually runs a long course (10-36 weeks). Intra-articular steroids may help. Thermotherapy using TENS or alternative therapies like acupuncture helps in this stage.

Stages II and III A stiff shoulder is a stiff challenge to the physiotherapist and the patient alike since its thwarts the best of attempts to restore back the earlier free shoulder movements. A 'sustained approach' rather than an 'aggressive approach' is the 'mantra' in these patients.

The 'twin approach' needed to put the shoulder joint back on its rails is shoulder mobilization and strengthening of the muscles needed to bring about these movements. Needless to say, the former assumes greater importance than the latter.

SHOULDER MOBILIZATION TECHNIQUES

The real culprit for the shoulder stiffness is the thick and contracted capsule of the shoulder joint. Efforts are targeted at softening this capsule by passive mobilization. Maitland's mobilization and Manual techniques.

Role of the Physiotherapist

The following are the most effective options available to a physiotherapist in achieving his goal of a mobile shoulder joint.

Thermotherapy Before resorting to passive mobilization, the thick and contracted capsule can be relaxed and made more stretchable by deep heating using ultrasonic or other suitable modalities. The heating is carried out all round the shoulder with a special focus on the anterio-inferior border of the axilla where the basic defect is said to exist.

Passive mobilization technique after The initial thermotherapy, a physiotherapist is required to observe the following protocol for passive mobilization of the shoulder joint.

- *In the forward stoop position* In this position the physiotherapist stabilizes the shoulder joint with one hand and grasps the wrist with the other hand. A slow rhythmic circumduction movement is carried out up to the limit of pain (Fig. 19.26).

Fig. 19.26: Passive mobilization of the shoulder joint by the therapist in a forward stooping position

Fig. 19.27: Passive gliding of the shoulder joint with longitudinal traction

- *In the supine position* here the patient is supine and the shoulder is in a position of maximum abduction, neutral rotation with the elbow in 90° of flexion. The physiotherapist now grasps the arm with his hand and applying a longitudinal traction along the axis of the humerus, he carries out an anteroposterior glide and an abduction adduction glide in a slow rhythmic manner (Fig. 19.27).

  Both the above passive mobilization techniques are very effective in mobilizing the lethargic and stiff shoulder.

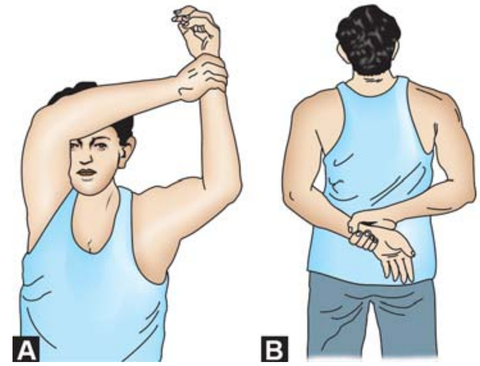
Patient Heal Thyself (Role of the Patient)

In the physiotherapy treatment for frozen shoulder this is the most important treatment method of the patient healing himself by a 'home-treatment' regimen. This method supercedes the role played by the physiotherapist as a sustained effort is needed by the patient to complete the good work initiated by the physiotherapist in his clinic.

The following measures are suggested to the patient to be carried out at home at frequent intervals:

Pendulum exercises: In a forward stooping position, with one hand resting on a table or chair, the patient gradually swings his arm like a pendulum and later carries out a circumduction movement (Fig. 19.28).

Fig. 19.28: Active rhythmic pendulum exercises for shoulder mobilization



Figs 19.29A and B: Self-assisted passive stretching of the shoulder in: (A) Flexion abduction and external rotation, (B) Extension, adduction and internal rotation

Shoulder elevation With the normal hand supporting the affected one, the shoulder is gradually lifted up in a position of flexion, abduction and external rotation (Fig. 19.29A).

Hand to back position here the patient carries the affected arm backwards with the shoulder in a position of extension, adduction and internal rotation with the elbow in 90° flexion (Fig. 19.29B).

Self stretch using The normal arm the patient is instructed to stretch the affected limb gradually and periodically.

Other measures

Apart from the above mentioned measures the following methods are also known to help combat the stiffening effects of the frozen shoulder.

- *Shoulder wheel exercises* to be done at the physiotherapy centre.
- *Pulley exercises* can be done by the patient himself at home alternatively can be done at the centre also.
- Well climbing exercises by the arm—can be practiced at home.
- Manipulation under GA is a hazardous procedure and lot of care has to be exercised. Breaking of adhesions to be done very gradually and not abruptly.

Preventive measures

Early detections to detect the onset of frozen shoulder in its infancy a simple test needs to be done.

- In the supine position the patients shoulder is passively adducted in elevation. If the patient complains of pain or stiffness in its terminal range, such a patient has an increased chance of developing periarthitis.
- The patient is made to lie on the side. If he complains of pain, he may be a candidate for future frozen shoulder.

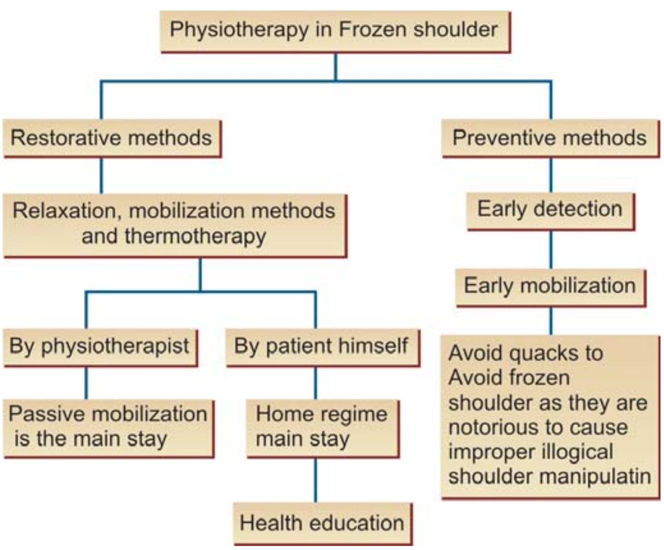
High-risk patients Certain patients like diabetics, fractures of clavicle, shoulder, humerus, Colles' fracture, etc. patients with ischemic heart disease, respiratory diseases, etc. have a higher incidence of developing frozen shoulder.

In all such high-risk patients, the shoulder joint needs to be mobilized early to prevent the future occurrence of frozen shoulder (Flow chart 19.1).

Quick Facts

High-risk candidates for frozen shoulder:
- Diabetics
- Fracture clavicle, humerus, radius, etc.
- IHD patients
- Patient with respiratory diseases
- Elderly people

Flow chart 19.1: Showing various physiotherapy measures in frozen shoulder



What is new?

Neil Asher technique and the hydrodilatation techniques are being considered and is described below:

Neil Asher Technique: The following are the salient features of this technique:
- Natural method uses body's own healing mechanism
- No drugs, no surgery, but hands on only
- Unlike other methods it does not force through the blockage
- It first reduces the pain by reducing the swelling around various shoulder tendons
- Next, it defrosts and increases the range of motion of the shoulder by stimulating unique sequence of reflexes
- 6-9 sessions in 10-12 weeks helps

Hydrodilatation Technique

Indications Duration of the problem is more than 3 months, no internal rotations, flexion is less than 60 degrees and patient cannot lie on the affected shoulder (night pain). Hydro dilatation is the gold standard here.

Procedure After giving local anesthesia, a mixture of a minimum of 40 ml of local anesthetic and cortisone is injected and the resistance of the giving away of the capsule can be felt. No repeat injection for 8 weeks.

ROTATOR CUFF LESIONS (RCL)

Fine adjustments of the humeral head within the glenoid are achieved by coordinated activity of four interrelated muscles arising from the scapula and are called *the rotator cuff.*

Note Incidence of rotator cuff tear, less than 70 years—30 percent; 71 to 80 years—60 percent; more than 89 years—70 percent.

Rotator cuff comprises supraspinatus, infraspinatus, subscapularis and teres minor.

In the movement of abduction, supraspinatus steadies the head from above, infraspinatus depresses the head, and subscapularis steadies the head in front paralleling the action of the infraspinatus. *This combined action allows the deltoid muscle to swing up the arm from a steady fulcrum irrespective of the position of the scapula.*

Rotator cuff lesion is a problem which is commonly associated with supraspinatus tendon. Other causes like bicipetal tendinits, etc. may give rise to rotator cuff problems but they are not that common.

Clinical Features

RCL is common in athletes and sportspersons. A patient with RCL complains of pain in the shoulder and difficulty in carrying out the shoulder movements especially abduction.

Investigations

X-ray, MRI, arthrography, and arthroscopy are some of the important diagnostic tools.

Treatment

This could be conservative or surgical arthroscopic repair depending upon the severity of tear in the RCL.

Physiotherapy in Rotator Cuff Lesions

During the Initial Acute Stage

- *Rest* in the sling.
- *Thermotherapy In* the form of TENS, ultrasound, SWD and cryotherapy to abate the initial pain and stiffness.
- *Exercises Active* ROM exercises to the hand, wrist, forearm and elbow.

During the Later Stages

Isometric exercises to the deltoid and other shoulder joint muscles.

Thermotherapy in the form of ultrasound, SWD, TENS, etc. helps.

Mobilization gradual active and passive mobilization of the shoulder as already discussed in frozen shoulder.

Exercises Gravity eliminated abduction, pendulum swing, flexion and extension exercises, progressive resistive abduction exercises are some of the effective exercises.

Once the pain has subsided, the following measures are advocated:

- *Isometric exercises* to the abductors, flexors and extensors of the shoulder joint muscles.
- *Passive exercises* With the patient in supine position, relaxed passive mobilization of the shoulder joint is carried out gently for all its movements especially abduction.
- *Active exercises* These are carried out as follows.

With gravity eliminated

- *For abduction* Here the patient is supine. Holding the arm of the patient in neutral rotation with the elbow flexed the patient is instructed to abduct the shoulder actively. The other hand stabilizes the shoulder from above. As the patient gradually abducts, the lever arm is lengthened by slowly extending the elbow (Fig. 19.30).

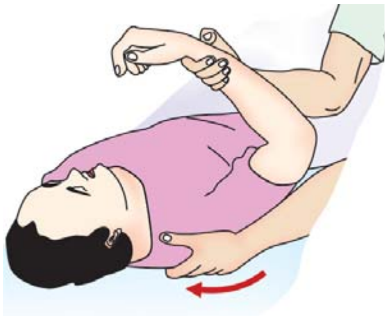


Fig. 19.30: Active assisted shoulder abduction with gravity eliminated

If the patient is unable to do this, assisted abduction is carried out by the physiotherapist totally supporting the weight of the arm.

- *For flexion* For this the patient is in side lying position. The patient is instructed to actively flex the shoulder joint. If he is unable to do it then assisted flexion is carried out by the physiotherapist stabilizing the shoulder with one hand and supporting the weight of the arm with the other.
- *For rotations* This is carried out in the sitting position.

Against gravity All the above movements are now carried out against gravity against resistance.

Exercises against resistance this is the final step. All the movements of the shoulder are now carried out against manual resistance or resistance offered with dumbbells with increasing weights.

Caution The persons suffering from rotator cuff lesions should exercise the following cautions:

- *Sling support to* prevent excessive stretch on the rotator cuff by prolonged hanging of the arm, supporting the arm either with the contra-lateral normal hand or a proper sling is advisable.
- Only gravity eliminated positions should be adopted by the patient for positioning their shoulder and thereby prevent excessive stretch on the affected muscles.

Preventive Measures

Rotator cuff lesions can be prevented to a great extent by the following simple measures:

- Proper conditioning of the shoulder girdle muscles by progressive resisted exercises.
- Avoiding certain sports which constantly cause friction to the shoulder.
- Avoiding sudden jerky movements and abrupt lifting of heavy weights.

THE SUBACROMIAL BURSITIS

The subacromial bursa is situated beneath the acromion process and gets inflamed during the afflictions of the neighboring structures of shoulder joint.

Clinical Features

The patient experiences pain during abduction and internal rotation of the shoulder.

Radiograph

Plain X-ray of the shoulder helps to detect any bony problems beneath the acromion that can lead to the development of bursitis.

Treatment

Conservative methods These include analgesics steroid injection, TENS, ultrasound, SWD, etc. Immobilization in sling also helps.

Gradual mobilization of the shoulder is done by relaxed passive movements and resistive exercises as mentioned earlier.

Surgical excision of the bursa is carried out in intractable cases.

SUBSCAPULARIS TENDINITIS

This is less common than suprapsinatus tendinitis.

Clinical Features

In this, patient will experience pain during the terminal stages of the active resisted internal rotation movement of the shoulder. Passive internal rotation will be painless and so is adduction, unless there is associated damage of pectoralis major, latissimus dorsi and teres major.

Radiograph

Plain x-ray of the shoulder helps to detect any bony problems that can lead to the development of tenditinitis**.**

Treatment

- Relaxed full range passive arc of internal rotation should be advised to these patients.
- Self-assisted and later on resisted internal rotation exercises to strengthen the subscapularis muscle are advocated (Fig. 19.31).

Fig. 19.31: Self-assisted and resisted internal rotation exercises

BICIPITAL TENDINITIS

This is an uncommon injury seen occasionally in elderly males. Rupture usually takes place due to repeated friction in a degenerated tendon.

Clinical Features

The patient complains of pain in the inter-tubercular groove. During lifting or pulling weight patient complains a sense of giving way. Resisted elbow flexion causes pain and so does resisted supination. A bulge may also be seen in the anterior aspect of the upper arm.

Diagnostic test Pain during the terminal range of resisted elbow flexion or forearm supination clinches the diagnosis.

Treatment

During the acute painful stage, *analgesics*, sling for 2 to 3 days, thermo or cryotherapy will be of immense help to relieve pain and spasm.

INFRASPINATUS TENDINITIS

The salient features of this relatively rare injury are as follows:

- *Strain* In this the patient experiences pain only during resisted external rotation and the other movements are painless.
- *Superficial rupture* Here the patient exhibits the painful arc.
- *In complete rupture* Loss of 30° of external rotation, painless weakness and painful arc are the important findings.
- *Distal rupture* here the full passive elevation will be painful.

Clinical Test

If the patient experiences pain during the terminal stages of active external rotation, of the shoulder joint a diagnosis of infraspinatus tendinitis can be made with certainty.

Radiograph

Plain X-ray of shoulder region helps to detect the problem.

Treatment

In the initial painful stages, rest analgesics, sling and cryotherapy helps.

Physiotherapy Measures

The following physiotherapy measures are found to be helpful in this condition:

Thermotherapy, injection therapy during the acute stages helps to reduce pain and spasm.

Exercises

- Initially, gravity eliminated full range passive external rotation is advocated.

Fig. 19.32: Self-assisted and resisted external rotation exercise

- Later on self-resisted external rotation movement of the shoulder in the sitting position is advised (Fig. 19.32).
- Finally, progressive resisted external rotation movements are carried out.

SUPRASPINATUS TENDINITIS

Supraspinatus tendon is the most commonly injured or affected structure in the rotator cuff that could lead to the development of pain due to impingement in the shoulder and the other causes that lead to the development of this condition is enumerated in the box (Fig. 19.33).

Causes of impingement syndrome

- Complete or partial rupture of rotator cuff
- Supraspinatus tendinitis
- Calcific deposits
- Subacromial bursitis
- Sub deltoid bursitis
- Periarthritis
- Bicipital tenosynovitis
- Fracture greater trochanter

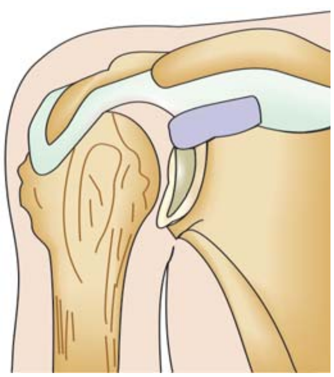


Fig. 19.33: Showing tear of supraspinatus

Fig. 19.34: Showing anterior impingement syndrome

IMPINGEMENT SYNDROME

Among the various causes mentioned above supraspinatus tendinitis is the one that is commonly encountered and this gives rise to the *impingement syndrome*. Impingement occurs beneath the coraco-acromial arch. The most vulnerable structures for impingement between the undersurface of the acromion and the head of the humerus are the greater tuberosity, the overlying supraspinatus tendon and the long head of biceps. The major site of compression is slightly anterior to the angle of the acromion. Hence the proper term is *anterior impingement syndrome* or painful arc syndrome (Fig. 19.34).

Clinical Features

All patients with supraspinatus syndrome have similar clinical features like pain, swelling, limitation of shoulder movements, muscle atrophy (supraspinatus and infraspinatus), and tenderness over the greater tuberosity, etc. The following grades are described in anterior impingement syndrome.

Grade I This is common in young adults and athletes in the age group of 18 to 30 years. Due to overstress and repeated overhead activity, impingement occurs and supraspinatus is inflamed. **The painful arc** appears here (Fig. 19.35).

Note The painful arc syndrome is seen in:
- Subacromial bursitis.
- Supraspinatus tendinitis.
- Incomplete tear or calcified deposit is seen in the supra-spinatus muscle.
- Incomplete fracture of the greater tuberosity of the humerus.

Grade II This is seen in age group of 40 to 45 years and may be due to supraspinatus tendinitis or subacromial bursitis. The cause could be either overuse or degeneration and osteophyte formation.

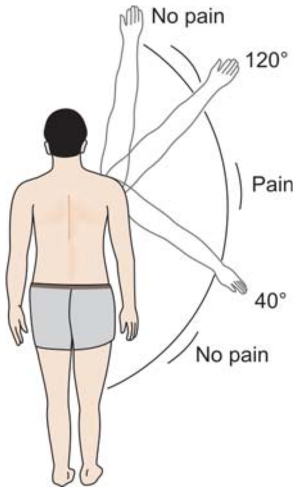


Fig. 19.35: Pain occurs in the impingement syndrome between 40 to 120° of shoulder abduction, as it is in this position that the supraspinatus tendon is impinged against the undersurface of the acromion and head of the humerus. Rest of the movements are painless (Painful Arc Syndrome)

Grade III It is seen in patients over 45 years of age and may be due to occupational overuse, fall, and sudden increase in activity, atrophic degenerative changes in the cuff and rarely due to acute tear of the rotator cuff.

Investigations

Plain X-ray of the shoulder is not very helpful. MRI, arthrography etc are more reliable.

Management

Conservative treatment It consists of, NSAIDs, local infiltration of hydrocortisone, subacromial steroid injections, exercises both active and passive, temporary immobilization, massage, etc. *Ninety percent will recover with these measures.*

Physiotherapy Measures

- *Thermotherapy* Ultrasound, SWD and TENS are very effective in reducing pain and spasm.
- *Passive mobilization* Relaxed full range passive mobilization is of great help.
- *Gradually resisted exercises* Help a great deal to strengthen the abductor mechanism.

Surgical treatment

Indications Failure of conservative treatment for three months, if the patients are young and active, and if there is increasing loss of shoulder function, surgery is indicated.

Methods

Depending upon the etiological factors the following surgical techniques are described: excision of adhesions and manipulation of shoulder, excision of calcium deposits, repair of incomplete tear, acromioplasty, acromimectomy for more disabling pain with normal range of movements, direct suture for complete rupture of rotator cuff, rotation and transposition of flap, free graft, etc.

Physiotherapy after Surgery

- Immobilization is advocated for 3 weeks. Active elbow, hand, wrist movements are encouraged after the initial phase.
- Strong isometric deltoid exercises after 10 days.
- Rest of the measures is the same as for the conservative methods.

REGIONAL CONDITIONS OF ELBOW, WRIST AND HAND

TENNIS ELBOW

I am sure every one is fascinated by tennis. We may not get a place under the sun with Steffi Graff, Monica Seles, Boris Becker and others but certainly we may get an appointment with an orthopedic surgeon for a problem common in them, that too without playing tennis! Yes, the obvious reference is towards *tennis elbow* (Fig. 19.36).

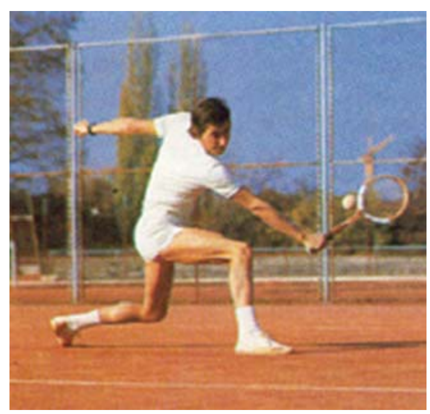


Fig. 19.36: Tennis players are more prove for tennis elbow

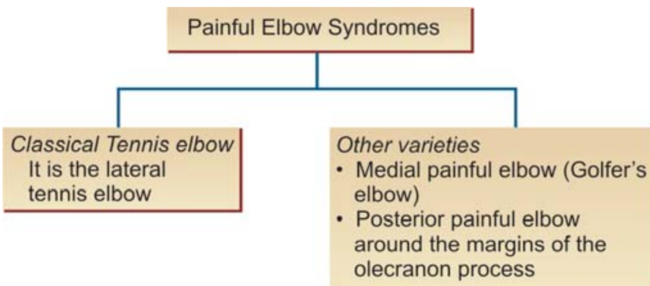
History

IT was first described from the *Writer's cramps* by Range in 1873. It was Madris who called it as “tennis elbow” shortly thereafter.

Definition

Painful elbow syndromes encompass lateral, medial and posterior elbow symptoms. The one commonly encountered is the lateral tennis elbow which is known as the ***classical tennis elbow*** (Flow chart 19.2) and is the *pain and tenderness on the lateral side of the elbow*, some well defined and some vague that results from repetitive stress.

Flow chart 19.2: Showing sites of elbow pain



Vital points

Location of pain in tennis elbow
- Lateral epicondyle (75%)
- Lateral muscle mass (17%)
- Medial epicondyle (10%)
- Posterior (8%)

LATERAL EPICONDYLITIS OR TENNIS ELBOW

It is a lesion affecting the tendinous origin of common wrist extensors from the lateral epicondyle (Fig. 19.37).

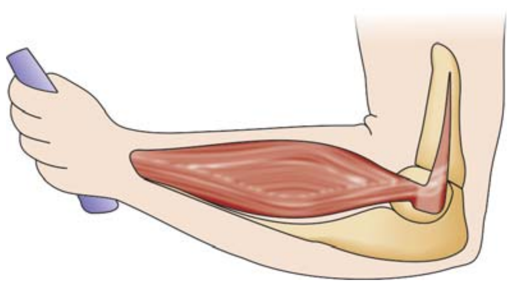


Fig. 19.37: Repetitive stress at common extensor origin in tennis players

Causes

- *Epicondylitis* This is due to single or multiple tears in the common extensor origin, periosteitis, angiofibroblastic proliferation of extensor carpi radialis brevis (ECRB), etc.
- *Inflammation of adventitious bursa* Between the common extensor origin and radio humeral joint.
- *Calcified deposits* Within the common extensor tendon.
- *Painful annular ligament* is due to hypertrophy of synovial fringe between the radial head and the capitulum's.
- *Pain of neurological origin*, for example, cervical spine affection, radial nerve entrapment, etc.

Tennis elbow

Tennis elbow is seen in:
- All levels of tennis players.
- In world class players "SERVE" appears to be the cause.
- In less than world class players "backhand stroke".
- Seen in other sports also.
- May be occupational, etc.
- Activities other than tennis which lead to tennis elbow:
  - — Tightening a screw
  - — Using a wrench
  - — Wringing washed clothes
  - — Vigorous hand shake

Causes in tennis players More than one-third tennis players all over the world are affected with this problem over 35 years of age.

- Novice
- Playing several games per week (Fig. 19.37)
- > 35 years of age
- Equal sex incidence
- Backhand stroke (38%)
- Serve (25%)
- Forehand stroke (23%)
- Backhand volley (7%)
- Overhead smash (4%)
- Forehand volley (3%)

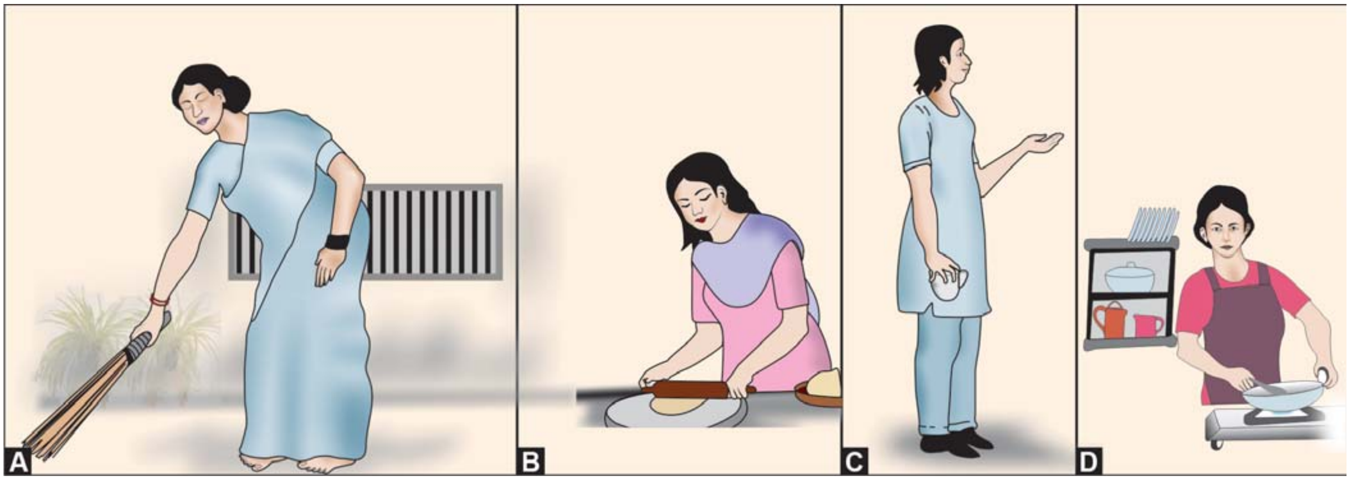
Household activities causing tennis elbow Different types of Indian household women suffering from tennis elbow (Figs 19.38A to D).

Contributing factors

- Little playing experience.
- Consistent missing of "*sweet spot*" while hitting.
- Poor stroke techniques: use of arm instead of body.
- Poor power or flexibility.
- Heavy stiff racket, large handle size, too tight racket stringing.
- Heavy duty wet balls.
- Playing surface—balls bounce quicker off the cement court.

Pathophysiology and Related Symptoms

Stage I There is acute inflammation but no angioblastic invasion. *Patient complains of pain during activity.*



Figs 19.38A to D: Showing household activities in Indian women which causes tennis elbow

Stage II This is the stage of chronic inflammation. There is some angioblastic invasion. *Patient complains of pain both during activity and at rest.*

Stage III Chronic inflammation with extensive angioblastic invasion. *Patient complains pain at rest, night pains, and pain during daily activities.*

Clinical Tests

- Local tenderness on the outside of the elbow at the common extensor origin with aching pain in the back of the forearm (Fig. 19.39).

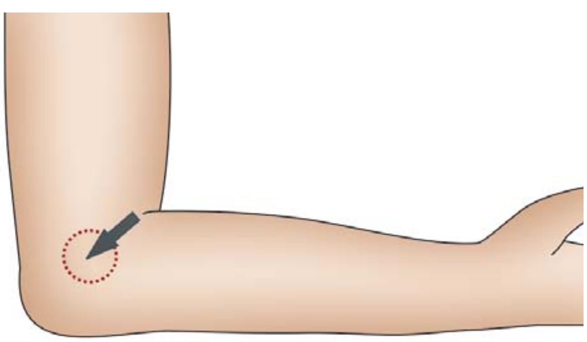


Fig. 19.39: Arrow showing site of tenderness in tennis elbow

- Painful resisted extension of the wrist with elbow in full extension elicits pain at the lateral elbow (Fig. 19.40—Cozen's test).
- Elbow held in extension, passive wrist flexion and pronation produces pain.

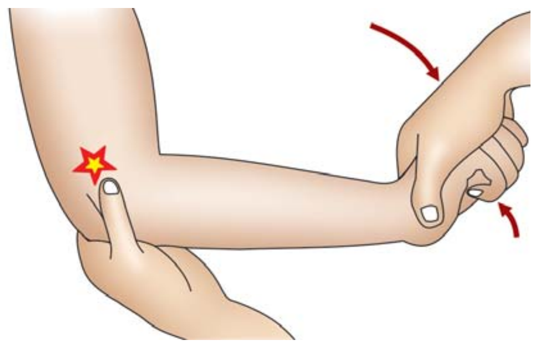


Fig. 19.40: Showing Cozen's test

Treatment

Conservative management It consists of rest and pain killers. In tennis players exercises, light racket, smaller grip, elbow strap, etc. are helpful (Fig. 19.41). Injection of local anesthetic and steroid are useful in 40 percent of cases (Fig. 19.42).

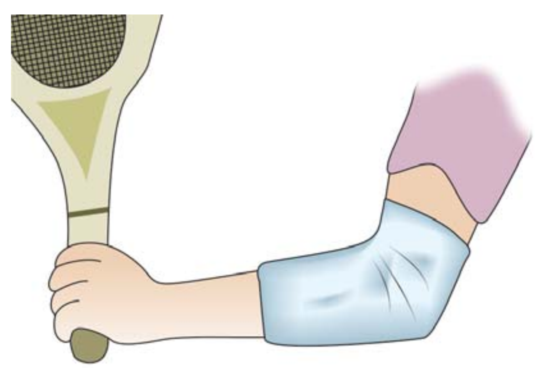


Fig. 19.41: Showing the elbow supports to be used in tennis elbow

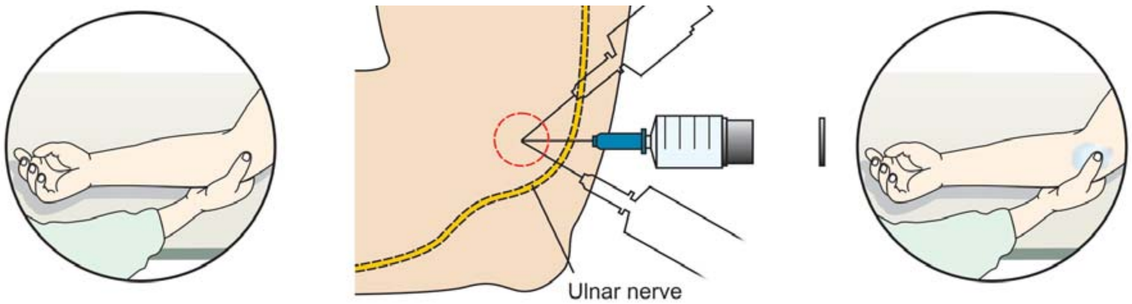


Fig. 19.42: Figure showing site of steroid infection in tennis elbow

Physiotherapy Management for Tennis Elbow

The following measures are used to counter the pain:

During the Acute Phase

- *Rest* An above elbow POP splint with elbow in 90° flexion and supination and the wrist in slight dorsiflexion is recommended.
- *Thermotherapy* Heat modalities like, ultrasound and SWD help a great deal in reducing pain.
- *Cryotherapy* Ice cold packs on the tender area for a period of 15-20 mts are very effective in reducing the pain.
- *Electrical stimulation* If this is done for 15-20 mts with the arm elevated, it reduces pain and inflammation.
- *Massaging* gentle massaging for the first 10 days followed by friction massages for the next 15 days greatly helps.
- *Exercises* Active exercises for the shoulder, elbow, wrist and hand are indicated. Isometrics also helps.
- Progressive resistive exercises for wrist extension, lateral deviation, forearm supination and finger flexion using the normal contra lateral hand distinctly improves the condition (Dumbbells of 0.5 to 2 kg are used).
- *Manipulation* This is practiced in certain situations and is not commonly done.
- *Injection treatment* Local infiltration of hydrocortisone is an effective method in certain resistant cases.

Postacute Phase

- Patient is instructed to avoid repeated wrist extension and supination movements.
- Strengthening exercises to the extensor carpi radialis longus and brevis muscle, supinator muscle and common extensor group of muscles after adequate period of rest and support during the acute phase.
- Exercises:
  — *Passive exercises* In the supine position, relaxed passive movements of the elbow flexion and forearm supination are carried out in its complete range.
  — *Resistive exercises* When a painless range of movements are achieved by the passive exercises, progressive resistive exercises are advised.
  — *Strengthening exercises* Strong isometric exercises to the triceps, active ROM, exercises to the wrist and fingers are also advised.

Surgical Management

Indications
- Severe pain for 6 weeks at least.
- Marked and localized tenderness over lateral epicondyle.
- Failure to respond to restricted activity or immobilization for at least 2 weeks.

Surgical Methods

- Percutaneous release of epicondylar muscles.
- Bosworth technique of excision of the proximal portion of the annular ligament, release of the origin of the extensor muscles, excision of the bursa and excision of synovial fringes.
- Arthroscopic release of the common extensor muscles origin from the lateral epicondyle is the surgical method of choice due to its minimal exposure and effectiveness.

Physiotherapy after Surgery

- Measures to control pain as mentioned earlier.
- Active ROM exercises to the shoulder
- Passive ROM exercises to shoulder, elbow, forearm and wrist.
- Progressive RE as mentioned earlier.
- Thermotherapy helps to reduce pain.

Quick Facts

Significant relief of symptoms in tennis elbow	
• Changing tennis strokes	92 percent
• Stretching exercises	84 percent
• Use of splints	83 percent
• NSAIDs/steroid	85 percent
• Physiotherapy	50-75 percent
• Rest more than 1 month	72 percent

GOLFER'S ELBOW

(Syn: Epitrochleitis, Medial tennis elbow)

Definition

It is a tendinopathy of the insertion of the epitrochlear muscles (flexors of the fingers of the hand and pronators).

Clinical Features

Epitrochleitis is very similar to lateral epicondylitis (tennis elbow) but occurs on the medial side of the elbow, where the pronator teres and the flexors of the wrist and fingers originate. Tensing of these muscles by resisted wrist and finger flexion in pronation will provoke the pain (Figs 19.43 and 19.44). Tenderness is often less and well localized than in tennis elbow.

Treatment

It is the same as for the tennis elbow but the treatment is even less satisfactory.

Fig. 19.43: Golf players are more prone for golfers elbow

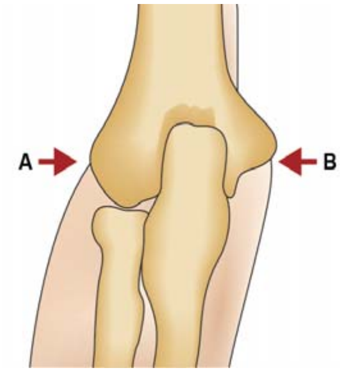


Fig. 19.44: Showing sites of pain in: (A) Tennis elbow, (B) Golfer's elbow

Physiotherapy treatment Proceeds on the same lines as for the tennis elbow.

DE QUERVAIN'S DISEASE AND TRIGGER FINGER

Both are stenosing tenovaginitis, in which the sheath of a flexor tendon thickens, apparently spontaneously, so as to entrap the tendon (Figs 19.45 to 19.47).

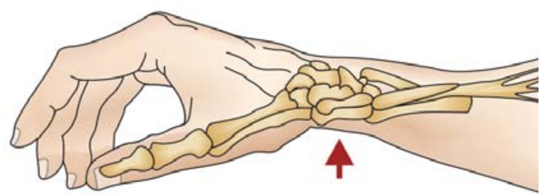


Fig. 19.45: De Quervain's disease: Arrow showing the site of tenovaginitis of the common sheath of abductor pollicis longus and extensor pollicis brevis

Fig. 19.46: Clinical photograph of De Quervain's disease

Fig. 19.47: Clinical photograph of trigger finger

Fig. 19.48: Showing the point of tenderness by sudden forceful ulnar deviation of the flexed hand. This is called Finkelstein's test

Etiology

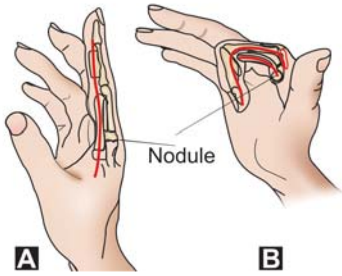
Exact cause is not known. *De Quervain's disease is commonly seen in women and may be due to repeated overuse of the wrist. Trigger finger is common in conditions like rheumatoid arthritis.

Clinical Features

Pain and limitation of the movements of the involved tendons are the presenting features.

De Quervain's (Fig. 19.45) In this, the common sheaths of abductor pollicis longus and extensor pollicis brevis tendons at the wrist are involved. Tenderness can be elicited by sudden ulnar deviation of the flexed hand (Finkelstein's test—Fig. 19.48).

Trigger finger (Figs 19.49) Occurs at the retinaculae of the flexor tendons of the fingers and the thumb (Fig. 19.50) in the palm. In the palm the flexor muscles are sufficiently strong to continue forcing the tendon through the diminished gap in the flexor retinaculum. The flexor tendon as a consequence gradually develops a constriction under the retinaculum and a bulge distal nodule (Fig. 19.49) to it. Finally, the flexor muscles



Figs 19.49A and B: Trigger finger

*__Fritz, De Quervain__ (1868-1940) Switzerland. Described the condition in 1940.

Fig. 19.50: Trigger thumb

may force the bulge through the retinaculum but the extensor muscles may be insufficiently powerful to extend the finger hereafter. The finger now snaps as it passes through the constriction and finally locks in a position of flexion from which attempts to passively extend the fingers are painful.

These are common in women. Congenital trigger fingers are seen in 25 percent of cases and may present as late as 2 years of age.

Treatment

Treatment of both the conditions is almost similar and consists of rest, NSAIDs, local infiltration of hydrocortisone, etc.

Surgery Division of the appropriate retinaculum if the above measures fail.

Physiotherapy Measures for De Quervain's

- Cryotherapy during the acute stages.
- Thermotherapy, TENS, ultrasound, SWD is also very effective.
- Splinting of the wrist in functional positions.
- Appropriate active and passive exercises to the wrist and fingers are advocated.

Physiotherapy Treatment for Trigger Finger

- Thermotherapy to relieve pain and spasm.
- Paraffin wax bath treatment for relieving the locking.
- Friction massage to the fingers.
- Hand exercises to mobilize the fingers.

GANGLIA

Definition

It is defined as a localized, tense, painless, cystic, swelling, containing clear gelatinous fluid (Fig. 19.51).

Fig. 19.51: Clinical photograph showing a wrist ganglion

Origin The clear gelatinous fluid may be due to leakage or subsequent fibrous encapsulation of synovial fluid through the capsule of a joint or a tendon sheath.

Sites It is commonly seen over dorsum of the wrist, flexor aspects of the fingers and dorsum of the foot.

Quick Facts

Ganglion
- Dorsal wrist ganglia accounts for 60 to 70 percent of all hand ganglia. It arises from scapholunate ligament.
- Volar ganglion—18 to 20 percent.
- Ganglion at the flexor tendon.
- Finger flexor sheath at 'A' pulley—10 to 12 percent.

Predisposing factors Chronic repetitive stress and sometimes injury.

Treatment

It may resolve spontaneously or excision under local anesthesia if it is causing symptoms likes pain, restriction of movements, etc.

Physiotherapy Measures

Active exercises to the wrist and finger helps in faster and effective recovering of lost function of wrist and hands.

DUPUYTREN'S CONTRACTURE

*Dupuytren's contracture is defined as proliferative fibroplasias of the subcutaneous palmar tissue, forming nodules of cords along its ulnar border. These fibroplasias results in finger contractures, thinning of subcutaneous fat, adhesions of skin to the lesion, pitting of skin, and knuckle pads on the dorsum of proximal interphalangeal (PIP) joints.

The following lesions may be associated with Dupuytren's, lesions in medial plantar fascia in 5 percent and plastic induration of penis (3%).

Causes

Exact cause is not known but it may be due to:
- Heredity
- Trauma of chronic repetitive in nature.
- Occupational seen in people employed in rock drilling due to the vibrations of the machine.
- Males—10 times more common in males.
- Whites are affected more than Black.
- Frequent and severe in epileptics and alcoholics (42%).
- Onset is usually less than 40 years of age.

Usually begins with ring finger at the distal palmar crease and later involves little finger. Flexion of MCP and PIP joints occur (Fig. 19.52). Discomfort is rare, itching or occasional pain over the nodules may be present.

Fig. 19.52: Showing contractures of MCP and PIP joints of ring and little finger in Dupuytren's contracture

Pathogenesis

Nodules and cords develop due to fibroplasias and hypertrophy of the already existing fibers of palmar fascia on its ulnar border.

Clinical Features

Patient presents with the deformity and difficulty in carrying out the hand functions (Fig. 19.53).

Treatment

Observation Consists of no treatment, with observation being done at every three months interval.

*****Baron Guillaume Dupuytren** of France (1817). His other contributions: (1) Described neurological manifestation of spine bifida occulta, (2) Subungual exostosis (3) Callus and its formation. (4) Upward and outward dislocation of foot.

Fig. 19.53: Clinical photograph showing Dupuytren's contracture

Radiotherapy is given only during the early fibroblastic phase.

Surgery It is the best known treatment and is delayed until actual contractures develop.

Procedures chosen It depend upon the degree of contractures, age, occupation, status of the palmar skin, presence or absence of arthritis of the finger joints, etc. More severe the involvement, more extensive is the surgery.

Prognosis: Poor prognostic facts

- *Hereditary* In patients with family history the lesion progresses fast. Hence heredity is a poor prognostic factor.
- *Sex* In women it begins late and progresses slowly.
- *Alcoholics or epileptics* Severe, rapid and recurs.
- *Bilateral*.
- *Behavior of the disease in the past.*

Surgical Methods

Subcutaneous fasciotomy This is preferred in elderly, arthritis patients and if the general condition is poor. Results are good when lesion is mature than diffuse. It may be used as a preliminary step to fasciectomy. This procedure has a 72 percent recurrence rate.

Partial selective fasciectomy This is indicated only when the ulnar two fingers are involved. This is a commonly done procedure, morbidity is less and is associated with less complications. Recurrence rate is 50 percent, needs another surgery in 15 percent of the cases.

Complete fasciectomy This is rarely done and is associated with haematoma, joint stiffness, delayed healing and recurrence.

Fasciectomy with skin grafting This is done in young people with epilepsy, alcoholism, and in cases of recurrence after excision.

Amputation may be considered if flexion contractures of PIP joints are very severe.

Resection and arthrodesis is indicated for severe contractures of the PIP joint. This is better than amputation as it prevents amputation neuroma.

Physiotherapy Measures

- *Thermotherapy* Paraffin wax baths, ultrasound, SWD etc. helps to relieve pain and spasm.
- *Exercises* Gentle relaxed passive exercises, active assisted and active movements of the fingers and wrist are indicated.

CARPAL TUNNEL SYNDROME

Carpal tunnel (Fig. 19.54) syndrome was first described by *Sir James Paget in 1854, but the term was coined by Moerisch.

Fig. 19.54: Median nerve coursing through the carpal tunnel

Anatomy

The carpal tunnel is bounded by bones on three sides and a ligament on one side. The floor is an osseous arch formed by the carpal bones and the roof is formed by the transverse carpal ligament.

Contents

Tendons of flexor digitorum superficialis and profundus in a common sheath, tendon of flexor pollicis longus in an independent sheath and the median nerve.

*__Sir James Paget,__ London (1914-1899). His other contributions (a) Paget's disease (b) Apophysitis of tibial tubercle.

Synovitis of the above tendons can generate pressure on the nerve.

Causes

General

- Inflammatory—e.g. rheumatoid arthritis.
- Endocrine—hypothyroidism, diabetes mellitus, menopause, pregnancy, etc. are some of the important endocrine causes.
- Metabolic cause—gout.

Local These cause crowding of the space. Malunited Colles' fracture, ganglion in the carpal region, osteoarthritis of the carpal bones, and wrist contusion, haematoma, etc. are some of the important local causes.

Mnemonic *PRAGMTIC* for causes of Carpal Tunnel syndrome [(*P*—Pregnancy, *R*—Rheumatoid arthritis, *A*—Arthritis degenerative, *G*—Growth hormone abnormalities (acromegaly), *M*—Metabolic (gout, diabetes myxoedema, etc.), *T*—Tumors, *I*—Idiopathic, *C*—Connective tissue disorders (e.g. amyloidosis)].

Clinical Features

- *Stage I* In this stage, pain is usually the presenting complaint and the patient complains of characteristic discomfort in the hand but there is no precise localization to the median nerve. There may be history of morning stiffness in the hand.
- *Stage II* In this stage, symptoms of tingling and numbness, pain, paraesthesia, etc. are localized to areas supplied by the median nerve.
- *Stage III* Here the patient complains of clumsiness in the hand and impairment of digital function, etc.
- *Stage IV* In this stage sensory loss in the median nerve distribution area can be elicited and there is obvious wasting of the thenar eminence.

Clinical Tests

These are provocative tests and act as important screening methods and as an adjunct to the electrophysiologic testing.

Wrist flexion (Phalen's test) The patient is asked to actively place the wrist in complete but unforced flexion. If tingling and numbness are produced in the median nerve distribution of the hand within 60 secs, the test is positive. It is the most sensitive provocative test (Fig. 19.55). It has a specificity of 80 percent.

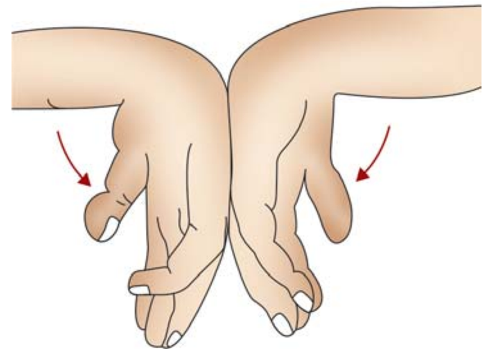


Fig. 19.55: Phalen's test

Tourniquet test A pneumatic blood pressure cuff is applied proximal to the elbow and inflated higher than the patient's systolic blood pressure. The test is positive if there is paraesthesia or numbness in the region of median nerve distribution of the hand. It is less reliable and is specific in 65 percent of cases only.

Median nerve percussion test (Fig. 19.56) The examiner gently taps the median nerve at the wrist. The test is positive if there is tingling sensation. Seen only in 45 percent of cases.

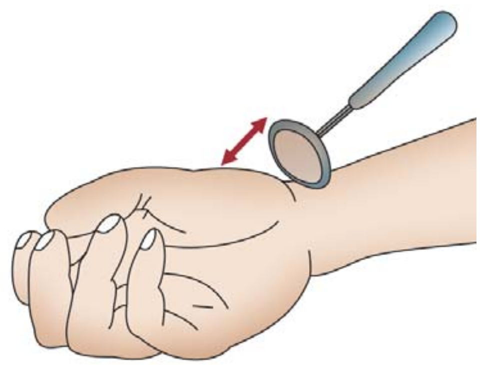


Fig. 19.56: Median nerve percussion test

Median nerve compression test (Fig. 19.57) Direct pressure is exerted equally over both wrists by the examiner. The first phase of the test is the time taken for symptoms to appear (15 sec to 2 min). The second phase is the time taken for the symptoms to disappear after release of pressure.

Other Tests

Two-point discrimination test This test is positive in about one-third cases.

Electrodiagnostic tests are not totally infallible with 10 percent individuals having normal values.

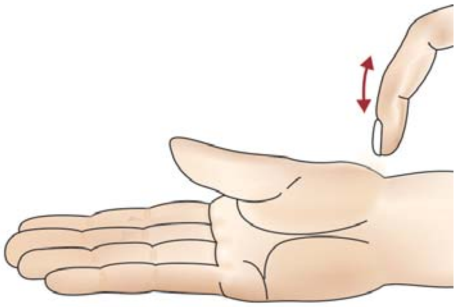


Fig. 19.57: Median nerve compression test

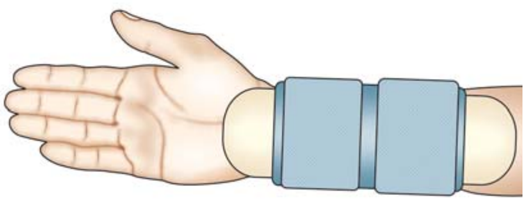


Fig. 19.58: Carpal tunnel splint

Treatment

Non-operative methods In the initial stages non-steroidal anti-inflammatory drugs (NSAIDs) are given. If it is unsuccessful steroids like prednisolone for 8 days starting with 40 mg for 2 days and tapering by 10 mg every 2 days are tried. Use of carpal tunnel splint is also advocated (Fig. 19.58).

Physiotherapy measures

- *Thermotherapy* Using ultrasound, SWD helps to relieve pain.
- *Exercises* Gentle relaxed passive movements, active assisted and active movements of the wrist and fingers area indicated. Treatment of the underlying disease is of utmost importance.
- *Splints* Carpal tunnel splint helps.

Injection treatment This is indicated in patients with intermittent symptoms, duration of complaints less than one year and if there is no sensory deficits, no marked thenar wasting, etc.

In the injection therapy, a single infusion of cortisone with splinting for 3 weeks is tried.

Surgery This consists of division of flexor retinaculum and transverse carpal ligament and is indicated in failed nonoperative treatment, thenar atrophy, sensory loss, etc.

COMPOUND PALMAR GANGLION

This is a condition which affects the flexor tendons of the fingers mainly the ulnar bursa (Fig. 19.59). It is usually due to tuberculosis though rheumatoid arthritis may also be a cause. The term *compound* is derived from a swelling one above and below the flexor retinaculum.

Here the endothelial lining of the sheath is substituted by granulation tissue containing miliary tubercles. The presence of *melon seed* bodies is a hallmark of this condition. Effusion may be seen and in the late stages the tendons may rupture.

Quick Facts

About Melon seed bodies

- Hallmark of compound palmar ganglion.
- Resemble grains of boiled sago.
- Give rise to soft, coarse crepitations.
- Made up of fibrin, cellular debris and occasional TB bacilli.

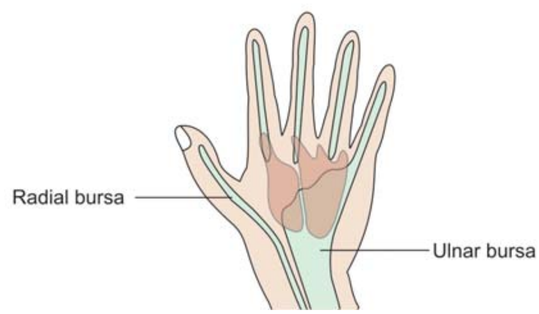


Fig. 19.59: Showing ulnar bursa site of compound palmar ganglion

Clinical Features

Those affected with this condition are usually less than 40 years and pain is not a feature. An hour glass swelling with cross-fluctuation may be noticed. There may be features of median nerve compression but there is definite evidence of wasting of the hand and forearm muscles.

Treatment

If it is due to tuberculosis, antitubercular treatment, splinting of the forearm and exercises in the late stages. Complete excision forms the treatment in rheumatoid.

Physiotherapy Measures

This is the same as described for the carpal tunnel syndrome.

KIENBOCK'S DISEASE

Features

- It is a painful disorder of the wrist
- Cause is not known
- X-ray show osteonecrosis of the lunate bone
- Seen commonly in dominant hand
- Seen between the ages 15-40 years
- In CT occult fractures of the lunate could be seen
- If not treated, it results in fragmentation of the lunate, collapse and shortening of the carpus
- X-rays become positive usually after 18 months after the presentation of the disease
- MRI is helpful in detecting early
- Natural course of the disease is unpredictable
- Lichtman has classified the disease into four stages.

Treatment

- *Stage I* Conservative management by casting of the wrist for 4 months.
- *Stages I to III* May require joint leveling procedures like ulnar lengthening and radial shortening.

Other recommended procedures are:
- Wedge osteotomy
- Vascularized grafts
- Excision of the lunate
- Prosthetic lunate replacement
- Intercarpal fusion
- Proximal carpal row resection if secondary osteoarthritis develops.

OLECRANON BURSITIS (STUDENT'S ELBOW)

This is a chronic inflammation of the olecranon bursa. It may be the result of repetitive minor injuries or irritation, micro-crystalline deposition. Infection occurs due to chronic friction as in students who tend to keep their elbows repeatedly over the table, bench etc. over long periods during writing, reading, etc.

Clinical Features

It usually manifests as a swelling over the tip of the Olecranon, due to inflammation the patient may develop. It can be easily detected by inspection or palpation (Figs 19.60 and 19.61)).

Investigations

Aspiration and culture of the bursal fluid is necessary to exclude the possibility of an infectious etiology.

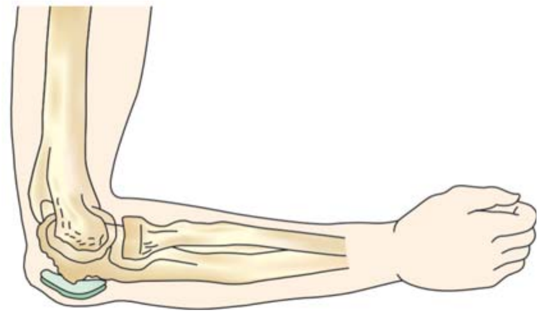


Fig. 19.60: Olecranon bursitis

Fig. 19.61: Clinical photograph showing olecranon bursitis

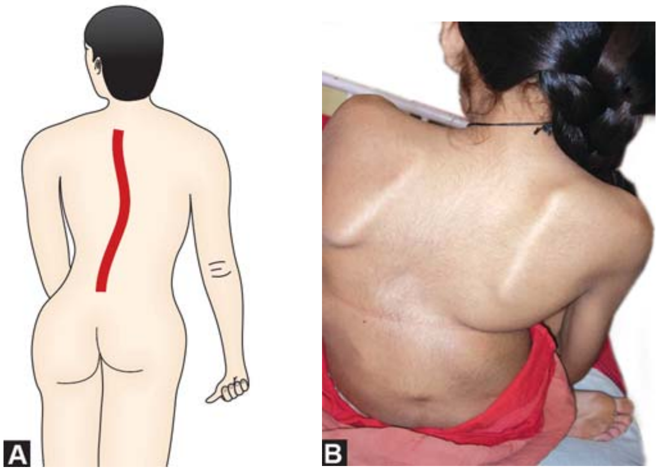
Treatment

Treatment is essentially conservative and consists of NSAIDs, local steroids, etc. Surgical excision is done in chronic cases. Microcrystalline-induced bursitis has a good prognosis and the symptoms usually resolve after a few days, whether treated or not. But bursitis due to repeated minor irritation is more difficult to treat.

REGIONAL CONDITIONS OF SPINE

SCOLIOSIS

By definition scoliosis is the lateral curvature of the spine in the upright position (Figs 19.62A and B). The lateral curvature is usually accompanied by some rotational deformity. Only man boasts of an erect posture. Nature has designed four physiological curves in the so-called erect spine, cervical and lumbar lordosis, dorsal curve in the thoracic spine and the sacral region. Thus when the spine develops a lateral curve it is abnormal. It throws the well-adjusted spinal mechanism out of gear and poses the following problems:
- A cosmetically unacceptable deformity.
- Deranges the load and force transmission mechanism through the spine.
- Jeopardizes the functions of vital organs like lungs, heart by overcrowding the ribs.



Figs 19.62A and B: Scoliosis is a lateral curvature of the spine (best examined from the back)

- Managing it is cumbersome and unrewarding experience most of the times.

Note Lateral curvature in excess of 10° is scoliosis.

Thus, a scoliotic curve makes the spine 'crooked' and a 'crooked spine is a wicked spine', if one considers the above problems it poses.

Varieties

Structural scoliosis *In structural scoliosis the curves are fixed and nonflexible and fail to correct with side bending.* Lateral bending of spine is asymmetric or involved vertebrae are fixed in a rotated position or both.

Nonstructural scoliosis In nonstructural scoliosis the curves are flexible and readily correctible with side bending. It is frequently seen as a compensatory mechanism to a leg length discrepancy, fixed flexion deformity of the hip (compensatory scoliosis), local inflammation or irritation due to acute lumbar disk disease and prolapsed disk (sciatic scoliosis) or due to poor postural habits (postural scoliosis).

Quick Facts

Nonstructural scoliosis types:
- Compensating scoliosis
- Postural scoliosis—most common
- Sciatic scoliosis

Note
- Postural scoliosis is the most common variety of nonstructural scoliosis.
- Idiopathic scoliosis is the most common variety of structural scoliosis.

Structural scoliosis may occur from a variety of causes. Idiopathic scoliosis accounts for 90 percent of all scoliosis and appears to represent a hereditary disorder but the exact mechanism of its production is unknown. Broadly speaking there are two types of scoliosis:

1. Idiopathic (unknown cause)
2. Known cause. The important among these are:
   a. *Congenital scoliosis* This is due to defect in segmentation which is usually due to a lateral bar or due to a defect in the formation including hemi vertebrae or double hemi vertebrae. These curves usually progress very fast and require surgical fusion on both the convex and concave sides of the curve.
   b. *Paralytic scoliosis* This is due to muscle imbalance on either side of the trunk, the most common cause being anterior poliomyelitis. Cerebral palsies, muscular dystrophies, etc. are the other common causes.

   Some of the other causes are mentioned at the end of the chapter.

Idiopathic scoliosis *(unknown cause)* This is the most common (75-90%) and three varieties are recognized—infantile, juvenile and adolescent (Table 19.2).

TABLE 19.2: Types of idiopathic scoliosis

Infantile	Juvenile	Adolescent
• > 70-90% • < 3 years • Curve is progressive Or resolving	• 15% • 4-10 years • Thoracic curve usually to the right	• 2-3% • 10-16 years F: M = 3.6:1
Treatment	**Treatment**	**Treatment**
• Curves < 20° Observation • > 20° Bracing • If severe Surgical fusion	• < 20° observation • > 20% Milwaukee brace • If > 60° surgical correction and fusion	• Surgical correction

Clinical Features

Though idiopathic scoliosis can occur at any age it usually appears clinically between 10 and 13 years *(Hence, school screening is important. About 3 percent of children show positive forward bending test. This is done yearly).* It is more common in females. The disease is usually asymptomatic and is usually accidentally discovered. The diagnosis is usually made on routine physical examination.

For the examination, the patient should be undressed to the waist or wear a bathing suit and a routine should be followed. The shoulders and iliac crest are inspected to determine whether they are at the same level. The scapulae, rib cage and flanks are then observed for symmetry. The spinous processes are palpated to determine their alignment. Rib hump or abnormal Para spinal muscular prominence indicates spinal rotation. The patient is then made to bend forward to see for the disappearance of the curve.

Note Rib hump is measured by using a rib gauge in the thoracic level. The measurement is taken in the forward bending position and prone position and the readings are then plotted on to a graph.

Importance of the Arm Span

In a normal child the arm sprain is equivalent to total body height within an error of 1 cm.

In a scoliotic child, the measurement of arm span helps to assess the height of the child if there were to be no scoliosis.

Radiographic evaluation of the spine is the only available method to determine the severity of the curve. It is repeated at intervals to determine the progression of the curve.

Scoliotic Facts

- *Structural curve* This is a laterally curved spine that lacks normal flexibility.
- *Primary curve* This is the earliest curve to appear.
- *Compensatory curve or secondary curve* This is the curve which develops above or below the primary curve in an effort to balance the spine.
- *Major curve* This is the largest structural curve
- *Minor curve* This is the smallest curve.
- *Apical vertebra* This is the most deviated vertebra from the vertical axis of the patient.
- *End vertebrae*
  - — The uppermost vertebra whose superior surface tilts maximally towards the concavity of the curve.
  - — The lowermost vertebra whose inferior surface tilts maximally towards the concavity of the curve.

Quick Facts

Curve Patterns in Idiopathic Scoliosis	
Curve	*Apical Vertebra*
• Cervical	C1-C6
• Cervicodorsal	C7-T1
• Thoracic	T2-T11
• Thoracolumbar	T12-L1
• Lumbar	L2-L4
• Lumbosacral	L5-S1

Note Ninety percent of adolescent scoliosis is convex to the right.

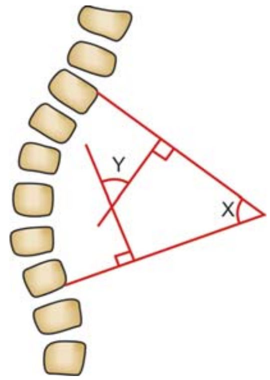


Fig. 19.63: Cobb's method of measuring severity of a scoliosis curve (Y = angle)

Radiograph

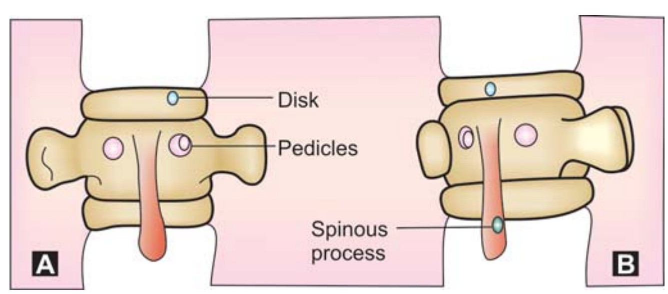
In radiography of the spine the following views are taken:

PA view of the spine, standard lateral radiography of the spine, right and left bending films of the spine and the stagnara derotation view which is an oblique view of the spine. The radiological parameters of importance are:

Cobb's method to measure severity of the curve (Fig. 19.63) The upper and lower vertebrae are identified. The upper end vertebra is the highest one whose superior border converges towards the concavity of the curve and the lower end vertebra is the one whose inferior border converges towards the concavity. Intersecting perpendicular line from the superior surface of the superior end vertebrae and from the inferior surface of the inferior end vertebrae is drawn.

The angle of deviation of these perpendiculars from a straight line is the 'angle of the curve'.

Nash and Moe's method to measure vertebral rotation In the PA view (Figs 19.64A and B) the positions of the spinous process and the pedicles are noted. Normally the spinous process lies in the centre. The apical vertebrae are graded for rotation on a scale from 0-4, depending upon the pedicle shadows and the position of spinous process. The spinous processes are identified and classified according to the amount of rotation.



Figs 19.64A and B: (A) Normal PA view of the spine showing the normal positions of the pedicles and spinous processes, (B) The pedicles and spinous processes shadows are altered and indicate vertebral rotation in scoliosis (Nash and Moe's method)

Reisser's sign This is a classification of the ossification of the iliac epiphysis which usually starts from the anterior superior iliac spine and progresses posteriorly towards the posterior iliac spine. Reisser's Stage 4 corresponds with cessation of spine growth and Stage 5 correlates with cessation of height increase. *The importance of this sign is, the completion of growth can be radiologically assessed which indicates no possibility of the curve progression.*

Rib angle of Mehta The rib vertebral angle is constructed by the intersection of a line perpendicular to the apical vertebral end plate with a line drawn from the midneck to the midhead of the corresponding rib. The rib vertebral angle difference (RVAD) is the difference between rib vertebral angle of the convex and concave side of the apical vertebra. If the initial RVAD is less than 20°, progression is unlikely and if initial RVAD is more than 20°, the curves tend to progress (Fig. 19.65).

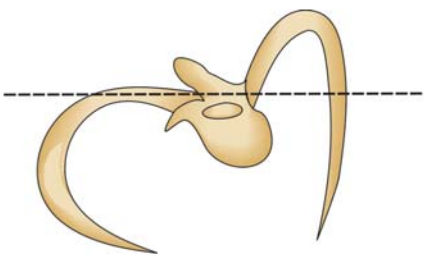


Fig. 19.65: Showing rib distortion due to vertebral rotation

Original structural curves are distinguished from secondary curves by the following criteria:
- Vertebrae in structural scoliosis are displaced to the convexity of the curve, but in secondary curve they are displaced to the concavity of the secondary curve.
- When there are three curves *middle* one is structural.
- When there are four curves *two middle* ones are structural.
- The greater curve or the one towards which the *trunk is shifted is the structural curve.*
- The curve that is flexible and corrective is the non-structural curve.

Quick Facts

Radiological parameters in scoliosis:
- *Cobb's angle* Indicates severity of the curve
- *Nash and Moe* Indicates the severity of vertebral rotation
- *Rib angle of Mehta* Indicates curve progression
- *Reisser's sign* Indicates the spinal maturity and the likely cessation of scoliotic curve.

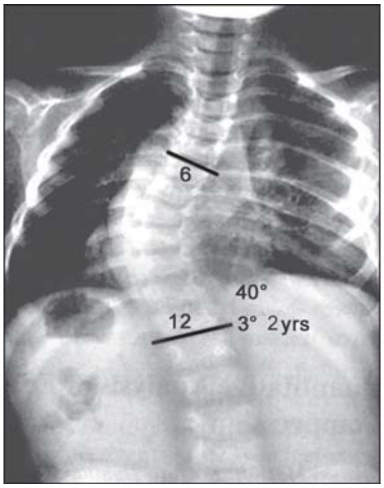


Fig. 19.66: Plain X-ray showing paralytic scoliosis

Compensation

If head is to be balanced above the pelvis when the patient is erect, it is done so by any curve or curves that develops in the opposite direction. *The formation of curves in the opposite direction is called compensation.* The angle of secondary curves should be equal to that of the primary curve. If it exceeds it is called over compensation (Fig. 19.66).

Treatment

The most important aspect in the treatment of scoliosis is early detection of the curve. A curve that is obvious in standing position has already approached 30 to 40°. Detecting a curve before it reaches 20° is of utmost importance because curves over 20° tend to progress. Frequent re-examinations are essential. The treatment depends on the age of the patient and the severity of the curve.

Quick Facts

Remember 4 O's in Scoliosis treatment
- Observation—for curves < 20°
- Orthosis—for curves between 20°-40°
- Operation—for curves > 40°
- Other measures—like exercises, electrical stimulation, etc.

Non-surgical treatment Observation is the primary treatment of all curves less than 20°. *At present radiography is the only definite documentation of curve size and progression.*

Generally accepted guidelines
- Curves of less than 20° in skeletally immature persons are examined every 6 months.

- Curves less than 20° in skeletally mature persons require no further evaluation.
- Curves more than 20° in skeletally immature patients should be examined every 3 to 4 months. Orthotic treatment for curves more than 25°.
- Curves more than 30 to 40°in skeletally mature persons do not require treatment. But they are examined radiographically for progression every 2 to 3 years.

Orthotic treatment This is effective in skeletally immature persons. For mild or moderate curves, *Milwaukee Brace, Boston Brace, Reisser's turn buckle cast, localizer cast etc. are used and the 20° level is considered still for bracing.

Other non-operative measures Exercises and electrical stimulation have been unsuccessfully tried in adolescent variety.

Physiotherapy Management in Scoliosis

Physiotherapy management in scoliosis is indicated for patients with curves less than 40°. These are mainly postural scoliosis and are managed on the following lines:

Screening Methods

Patients are instructed to come for screening regularly (see nonsurgical treatment).

Posture Correction

Special emphasis is placed on correction of faulty posture by active and passive methods:

Active methods By a trial and error method of altering the position of leg or trunk levels, the positions at which the curves get corrected are identified. The patient is then instructed to adopt that position and try to attain the correction.

Passive methods

- *Unequal traction* The best way to provide this is to instruct the patient to hang from a suspension with one hand.
- Unequal traction can also be provided by a suspension apparatus with equally good results.
- *Axial traction* With the patient in supine position traction is given along the direction of the leg and pelvis by one physiotherapist while counter traction is given by another physiotherapist in the opposite direction along the chin and occiput. This helps to obtain the correction.
- *Proper education* is imparted to the patient to hold the correction so obtained by active efforts to achieve the desirable results.

***Milwaukee Brace.** Was developed in 1945 for more efficient and comfortable passive correction of the scoliosis.

Exercises

- Deep breathing exercises are recommended.
- Balancing exercises by instructing the patient to walk with a book on the head.
- Active ROM exercises to the spine.
- Strengthening exercises to the abdominal and spinal muscles.
- Passive stretching of the muscles on the concave side of the curves is highly effective.

Health Education

Patient needs to be educated about the advantages of maintaining proper posture and frequent follow-ups to inspect the curves periodically. The advantages of the exercises also need to be impressed upon.

Orthotic Treatment

Orthotic treatment with Milwaukee or Boston Brace (Fig. 19.67) is recommended for patients with structural scoliosis for curves less than 40°. Mere exercises fail to achieve and maintain the correction. However, active exercises within the brace prevent deterioration and maintain the correction obtained. The brace has a stretching effect on the spine and by putting a pad over the rib hump on the convex side of the curve, correction for the major curve can be obtained.

Rest of the measures is the same as mentioned above.

Fig. 19.67: Showing orthotic treatment of structural scoliosis with Boston's Brace

Note
- The brace should be worm both during day and night.
- The brace has to be adjusted repeatedly as the child grows.
- The brace has to be worm till skeletal maturity and weaned gradually.
- Exercises have to be continued within the brace. Each exercises due for 10 times at 5 seconds hold.

Management of Structural Scoliosis with Curves > 40°

For structural scoliosis with curves > 40°, surgery is the treatment of choice. Traction helps to stretch the contracted structures prior to surgery. Methods of the traction could be either non-skeletal or skeletal.

Non-skeletal Traction

- *Combination of intermittent and continuous traction a* combination of intermittent and continuous traction helps to stretch the contracted spinal structures and this provides relaxation.
- *Superimposition of continuous and intermittent traction* This is the cotrel traction and is twice as effective as the one mentioned above.
- Here a continuous traction of 2 kg is applied to the neck and through a system of Pulley's intermittent traction is provided by the patient himself by arm or leg stretch.
- *Traction by gravitational methods* Here weight of the body pulled by the gravitational force provides traction. Patient is suspended in a frame after securing firmly through a pelvic corset. Counter traction is provided by applying a weight of 1/4th of the body weight to the head. By varying the angle of suspension from 30°, 60° and 90° the force of the traction can also be increased accordingly.
- This method is found to be twice as effective as the cotrel traction.

Skeletal Traction

This is provided by the halo pelvic or halo femoral traction (Fig. 19.68).

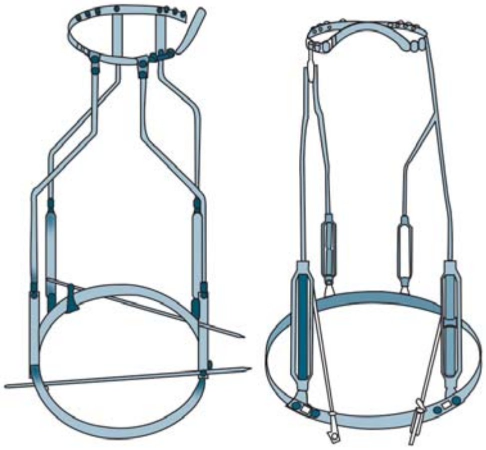


Fig. 19.68: Showing halopelvic distraction apparatus used for skeletal traction in correction of structural scoliatic curves

Quick Facts

Scoliosis vs. traction
- Intermittent traction—effective
- Cotrel traction—twice as effective as intermittent
- Gravitational traction—twice as effective as cotrel

These tractions stretch the spine and relax the contracted soft tissues.

Quick Facts

Other measures prior to surgery for scoliosis
- Detailed neurological examinations and muscle charting
- Postural corrections.
- Chest physiotherapy to improve the breathing capacity.
- Measurement of the rib hump.
- Gait analysis and isometrics to glutei and isotonic to knee and ankle.
- Various traction options.

Surgical treatment is indicated for high degree thoracic curve which is inflexible and is associated with secondary changes in the ribs. Casts are not effective in thoracic spine. Spinal surgery is also indicated when the curve is over 60° and aims at obtaining achieving the correction of the curve and maintain the correction so obtained by spinal instrumentation (anterior or posterior) and by spinal fusion (Fig. 19.69 and Flow chart 19.3).

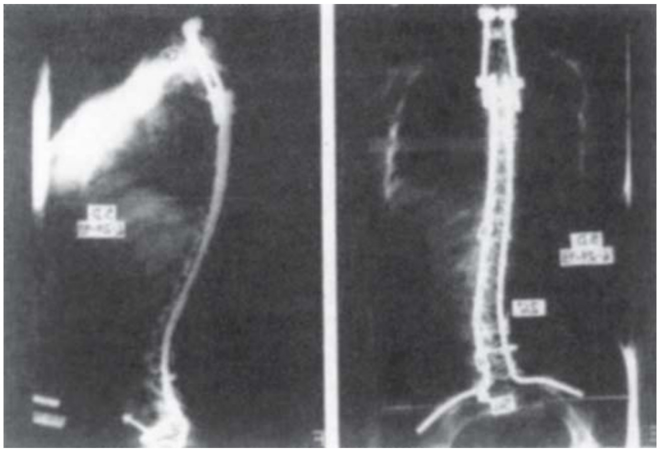


Fig. 19.69: Spinal instrumentation in scoliotic correction

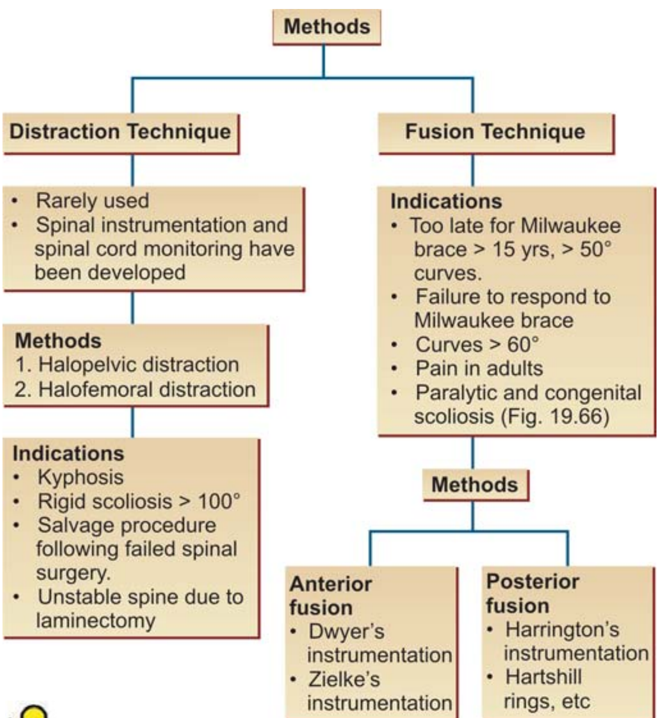
Quick Facts

Indications for surgery in scoliosis
- Curves > 60°
- Cord compression
- Pain
- Respiratory problem
- Cosmetic reasons.

Surgical Methods

Skeletal traction and open surgical correction and fusion one of the recommended types of surgical correction in scoliosis.

Flow chart 19.3: Showing different surgical methods of treating scoliosis



Quick Facts

- Scoliosis is lateral curvature of the spine.
- Idiopathic variety accounts for 90% of cases.
- Female preponderance.
- X-ray is the only definite documentation of curve size and progression.
- The most important aspect of treatment is early detection.
- Curves < 20° need observation.
- Curves > 20° require treatment.
- Curves between 20 to 40° can be treated by Milwaukee brace which has to be worn 23 hr per day for a period of at least two years.
- Curves > 40° need surgical correction and fusion.

Facts about curve progression

- Curves < 20° will improve spontaneously in over 50 percent of cases.
- No accurate method to predict the outcome of curves.
- 20 percent curves <30° will progress.
- Progression is more common in young children.
- Bigger the curve at detection, higher is the chance of curves progression.
- Curve in females and double curves are more likely to progress.

Physiotherapy Measures during the Postoperative Phase

During the First 4 Days

- Vigorous chest physiotherapy to improve the much reduced vital capacity of the patient.
- To prevent pressure on the back, patient is turned to the sides every 2 hours.
- Active ROM exercises upto the pain limit for the shoulder and ankle joint muscles. Passive movements to the lower limbs to relieve pain and stiffness.
- By the end of 4th day, full range active and passive movements to the hip and knee joints are carried out.

After 4 Days

With assisted guidance patient is taught to sit, roll and stand.

- *Getting out of bed* The method taught to the patient is 'reverse climb down technique.' Patient is log rolled to the prone position, prone kneeling, getting down slowly from the foot end of the bed. Climbing up the bed is done in the reverse manner.
- *Sitting* While sitting on the chair, patient is provided back rest for the lumbar region.
- For sitting on the bed, patient is instructed to roll over the side, sit at the edge of the bed with the legs hanging. Initially sitting time should not exceed 15 minutes.
- *Standing* Initially patient needs support while standing as he has difficulty in maintaining the balance. Unsupported sitting should precede standing.
- *Walking* is initiated in the parallel bars once the patient is able to maintain the balance while standing. In the later stages, patient may be provided cane or elbow crutches for ambulation.

Additional Physiotherapy Measures

- For one level anterior fusion
  - — Corset or POP jacket for 3 months.
  - — Isometrics to the back muscles.
  - — After 3 months back exercises are begun.

- For two level anterior fusions
  - — Corset or POP jacket for 3 months.
  - — Isometrics to the back muscles.
  - — After 3 months, back exercises are begun.
- Posterior fusion
  - — Corset or POP jacket is advised for 6 months
  - — Hip spica if L5-S1 joints are fused.
- Combined anterior and posterior fusion
  - — Log rolling and later table tilt activity
  - — POP jacket or corset for 6 months.
- If anterior and posterior fusion is done with a gap of 2 weeks, hydrotherapy is suitable as there is considerable muscle weakness.

Rest of the measures is the same as mentioned earlier.

Scoliosis of known cause Congenital/Paralytic, etc.

Neuromuscular scoliosis

- *Neuropathic cause's* Spinal cord injury, poliomyelitis, progressive neurological disorders, syringomyelia, myelomeningocele and cerebral palsy are some of the neuropathic causes.
- *Muscular* AMC and Muscular dystrophy are some of the important muscular causes.
- *Neurofibromatosis*
- *Miscellaneous* Multiple epiphyseal dysplasias, osteogenesis imperfecta, etc.

SPONDYLOLISTHESIS

(Spondylos—spine; Olisthein—to slip)

It is the story of a "slipping" spine causing "gripping" problems both to the patient and the clinician. That animals never suffer spondylolisthesis is proof enough to declare that this condition is a curse of erect posture which only man prides to possess.

Definition

It is defined as slow anterior displacement of a vertebra at the lower lumbar spine, generally accepted as, the lowermost vertebra L5 slipping forward on the first sacral segment S1 (Figs 19.70A and B).

Essential lesion is the interruption in the concavity of the pars interarticularis.

Spondylolysis In this the defect in the pars exists but without the forward slipping. This could be due to a fracture, stress fracture or nonunion.

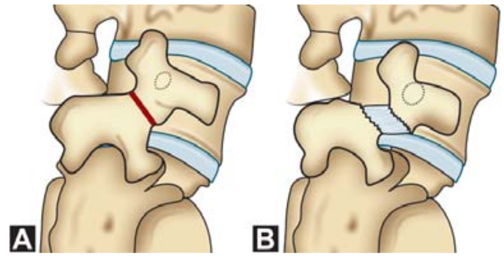


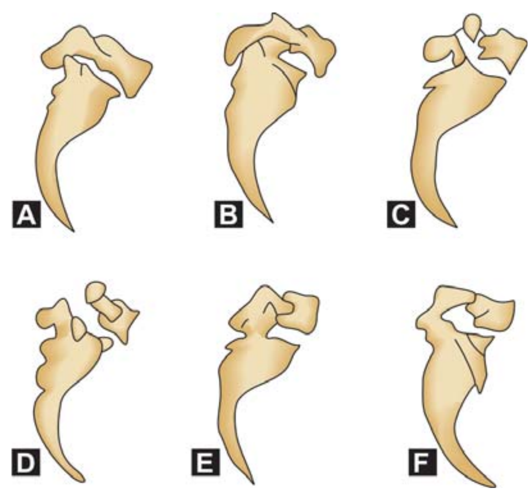
Fig. 19.70A: (A) Fracture or discontinuity in the pars (spondylolysis), (B) Spondylolisthesis

Fig. 19.70B: Radiograph showing spondylolisthesis

Classification (Wiltse, Mac Nab and Newman)

Five varieties are described (Figs 19.71A to F).

Dysplastic Congenital abnormalities of the upper sacrum or the arch of L_5. These permit the olisthesis to occur.



Figs 19.71A to F: Showing varieties of spondylolisthesis: (A) Normal, (B) Congenital, (C) Isthmic, (D) Traumatic, (E) Degenerative, and (F) Pathological

Isthmic (true) The lesion is in the pars and is the most common variety. Common in children. Rarely seen before 8 years. At adolescent growth spurt, sudden increase in activity, gymnastics, carrying heavy bags, etc. may lead to a fatigue or stress fracture of the pars which may give rise to the slip.

Types

- Lytic fatigue fracture of the pars in children.
- Elongated but intact pars.
- Acute fracture of the pars due to trauma.

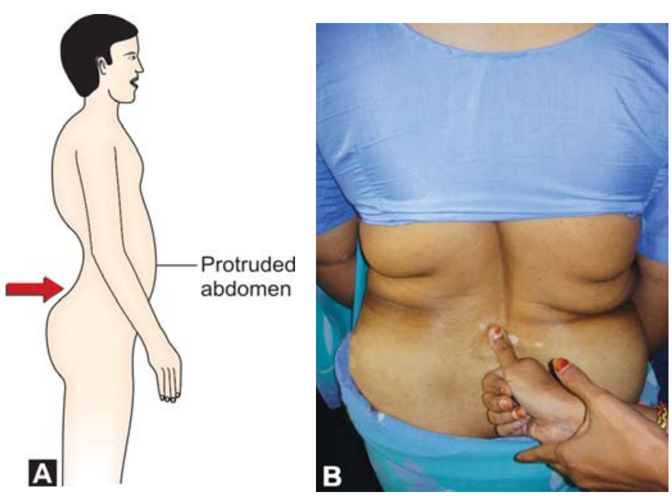
Degenerative This is due to long-standing intersegmental instability. Here pars are intact but the facet joints degenerate and allow the forward slip.

Traumatic This is due to fracture in other areas of the bony hook rather than the pars.

Pathological There is a generalized or localized bony disease in this variety.

Clinical Features

The clinical features of different varieties of spondylolisthesis are shown in Table 19.3. However, increased lumbar lordosis and a positive step sign are unmistakable features of spondylolisthesis (Figs 19.72A and B).



Figs 19.72A and B: (A) Showing increased lumbar lordosis in spondylolisthesis, (B) Showing step sign in spondylolisthesis

Investigations

Radiograph of the spine is the investigation of choice. Anteroposterior and lateral films are helpful. But oblique view

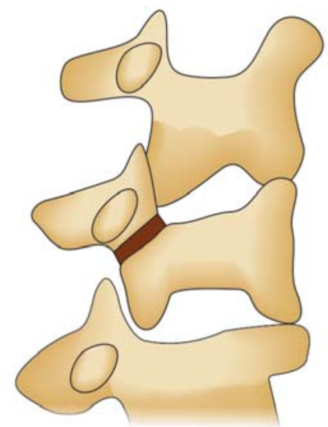


Fig. 19.73: Showing fracture of the pars. In true spondylosis familiarly known as "Scottish terrier sign"

of the lumbar spine demonstrates the defect in the pars very accurately as a "Scottie dog" sign. The Scottie dog's neck, which represents the pars defect, is broken in the isthmic variety (Fig. 19.73). The edges of the defect are smooth and rounded and suggest a pseudarthrosis rather than acute fracture. The percentage of ship is calculated by Meyerding's grading method (Fig. 19.75 and Table 19.4).

Treatment

Conservative treatment Clinically spondylolisthesis is divided into three groups, asymptomatic, mild to moderate and severe varieties, based on the severity of symptoms. Table 19.5 shows the different methods of conservative treatment to be employed in the above three clinical varieties of spondylolisthesis.

Physiotherapy Treatment

- Bracing: The brace recommended is antilordotic total contact, thoraco-lumbar-sacral moulded brace. It has to be worn continuously for a period of 2 years.
- Thermotherapy especially SWD and ultrasound.
- Correct postural habits are taught.
- Exercises to correct the deformity.
  - — Mobility exercises of the spine.
  - — By active posterior pelvic tilt, exaggerated lumbar lordosis is obliterated.
  - — Strong abdominal isometric exercises.
  - — Forward bending exercise of the trunk at lumbar spine in chair sitting position with strong abdominal contractions.
- Prone lying and repeated stretching of the hamstring muscles.

TABLE 19.3: Clinical features of different spondylolisthesis

	True Spondylolisthesis (Isthmic)	*Congenital*	*Degenerative*
Clinical Features	• Asymptomatic or low backpain. H/o Trauma present in 50 per cent • Common history of injury in adults and children.	• Pain-low backache, buttocks, feet, toes, thighs and legs	• Known as pseudo-spondylolisthesis • Intermittent symptoms and is common in the elderly patients Five times more common in women and affects 4 to 10 percent of the population
Deformity	• ↑ Lumbar lordosis • Palpable step at L_5-S_1 (Fig. 19.74) • Torso is short • Transvere furrow at L_5 • Sacrum is more vertical • Buttocks flat and hamstring tightness • L_5 spinous process prominently felt. Scoliosis in 13 percent	• Scoliosis, pelvic waddle present • Buttocks are flat • Stiffness of spine present • Cannot bend beyond the lower thigh	• Pain in the back, buttock or thigh
Neurology	• L_5 nerve root is involved but rare	• L_5 or S_1 nerve root is involved	• L_5 rare • Neurologic claudication may be present. • L_{3-4} common
Obstetrics	• Narrowing occurs at the outlet		
X-ray	• Lateral view is characteristic • Oblique view—shows **Scottish terrier's sign**	• Development of sacral neural arch, superior sacral articular process is defective. .• Sacral root is not well developed.	• Hyperdactility at L_{4-5} • No motion at L_5-S_1 • Displacement is < 30 percent
Myelography	• Partial or complete block at L_5		• Hour glass configuration

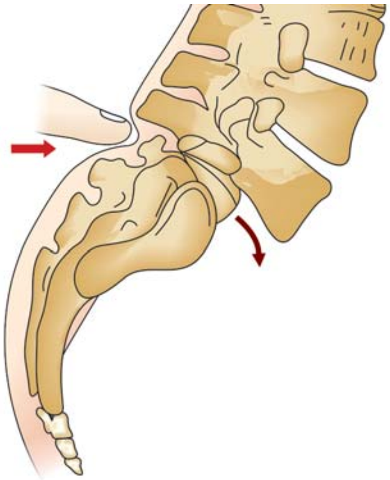


Fig. 19.74: Clinically a step can be palpated at the back in spondylolisthesis and is called a "Step sign"

Table 19.4: Meyerding's grading* (forward displacement)

Grade	*Percentage*
G1	25 percent
G2	25-50 percent
G3	50-70 percent
G4	> 75 percent

*Percentage of slip calculated by the upper vertebral displacement over the lower vertebral body on a lateral X-ray.

Surgical Management

Indications

- Failure of conservative therapy.
- Signs of root compression.
- Progressive slipping.
- Slip of more than 30 percent even when painless.
- Persistent pain in the back, thigh or persistent sciatica.

Methods of Surgery

- *Posterolateral fusion* This is the best method of fusing the slipped vertebra because it preserves the supporting soft tissues and has a high rate of fusion.
- *Posterior fusion* In this method postoperative and additional slip is frequent till the fusion is solid. This also

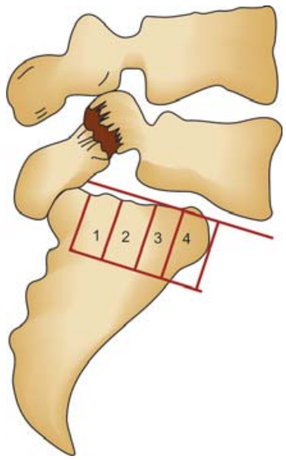


Fig. 19.75: Meyerding's classification of spondylolisthesis. The amount of slippage is graded 1-4

Fig. 19.76: Posterior spinal stabilization by Steffee plate and screws

TABLE 19.5: Different methods of conservative treatment		
Asymptomatic	*Mild to Moderate*	*Severe*
• Correction of poor posture • Elimination of stressful occupation • To avoid certain special sports activities	• Alleviation of anxiety • Analgesics and muscle relaxants • Deep heat • Exercises	• Rest • NSAIDs • Gradual exercises

has a high rate of pseudarthrosis and has to be done with intertransverse fusion.

- *Laminectomy* This mainly helps to relieve the neurological deficits and has to be followed by posterolateral fusion.
- *Laminectomy and intertransverse fusion.*
- *Anterior interbody fusion.*

This is indicated for subtotal spondylolisthesis and is a risky and difficult procedure with doubtful efficacy. Fusion is achieved in spondylolisthesis by putting autologous cancellous bone graft and stabilization is obtained by Hart shill rectangle frame or Steffee plate and screws (Fig. 19.76).

Physiotherapy Measures Following Surgery for Spondylolisthesis

First 2 weeks This is the phase of immobilization. During this period deep breathing exercises are indicated. Glutei isometrics are begun. Hip flexion exercises should not be done beyond 60° active and active assisted knee, ankle and foot movements are begun.

After 2 weeks Patient is mobilized in a plaster jacket after 2 weeks. The jacket needs to be worn till the fusion is complete (4-6 months). Patient should be educated to carry out the functional activities. Isometric abdominal and glutei muscles are recommended.

Spine is gradually mobilized as described earlier after the removal of plaster jacket. By 8 months patient should be fully independent.

KYPHOSIS

Definition

IT is defined as increase in normal posterior convexity of the thoracic spine and is referred to as 'hyper kyphosis' (Fig. 19.77).

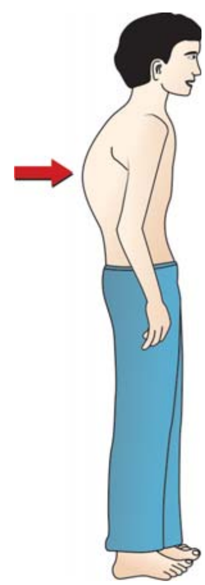


Fig. 19.77: Thoracic kyphosis arrow showing gibbus

Causes

- *Localized injury or disease* Like fracture, Pott's disease, secondary in the spine, etc.
- *Generalized bone diseases* Like ankylosing spondylitis, Osteomalacia, Paget's disease, acromegaly, etc. are some of the examples.
- *Defective growth or habit*

Children Stooping posture while reading.

Adolescents Vertebral epiphysitis (Scheurmann's) seen in boys of 14-17 years of age.

Adults People employed in bending occupation, e.g. porter, cobbler, etc.

Old men Senile atrophy.

Types

Knuckle Here there is prominence of single spinous process, indicating collapse of single vertebra, (e.g. TB spine/Kummel's disease, etc.).

Angular Here 2-3 vertebral bodies are collapsed, e.g. late stage of TB, Secondary carcinoma, etc. (Hunch back deformity)

Round Here several vertebrae are involved and hence it gives a rounded appearance, e.g. in children (Fig. 19.78) Scheurmann's disease. In old age—senile kyphosis, ankylosing spondylitis, etc.

Fig. 19.78: Clinical photograph of kyphosis in a child

Methods of Examination

Inspection Look from the sides and note if the thoracic curvature is regular. Now determine if the kyphosis is mobile or fixed.

Tests for mobility

For example, Postural kyphosis is mobile.
1. When patient bends forward, deformity increases.
2. When patient braces the shoulder back, deformity decreases.
   If the above two tests are negative, kyphosis is fixed.

What is gibbus?

Acute kyphosis is called gibbus and it is due to single or two level vertebral involvements.

Stages in Kyphosis

Depending upon the severity, kyphosis, is graded as first, second and third degrees. The pathological changes due to kyphosis are as follows:

- Anteriorly
  - — The prevertebral muscles are shortened.
  - — Chest expansion is reduced.
  - — Alteration in respiratory functions.
  - — Anterior longitudinal ligament is shortened.
  - — Anterior wedging of the vertebra in late stages.
- Posteriorly
  - — The longitudinal back muscles, rhomboids, etc. are elongated and stretched.
  - — The posterior longitudinal ligaments are stretched.
  - — Kyphotic deformity is prominently seen.

Quick Facts

Remember the important kyphotic facts
- Kyphosis in children—Scheurmann's disease
- Kyphosis in older—TB Spine children and young adults
- Kyphosis in middle age—Ankylosing Spondylitis
- Kyphosis in Old age—Senile Osteoporosis

Radiograph

Plain X-ray of spine AP and lateral view helps in diagnosis.

Physiotherapy Management

The following measures are recommended:
- Maintenance of proper posture of head and neck.
- By bracing the shoulders back and holding it for sometime, the shortened anterior structures are stretched.
- Resistive exercises are indicated to the back muscles.
- Deep diaphragmatic breathing is encouraged.
- Controlled pelvic tilt and rocking are helpful.
- In the advanced third stage, a Milwaukee brace with a posterior pad is applied.

- With the brace on, the patient is instructed to push against the posterior pads thereby stretching the shoulder and the gibbus deformity.
- Respiratory exercises and mobility exercises of the spine are helpful in reducing the deformity.

Surgical Management

Through an anterior approach the spinal cord is decompressed and stabilization with either bone graft or metallic implants is done anteriorly. After the decompression, spinal fusion is done by either bone graft or metallic implants.

Postsurgical Physiotherapy Measures

Plaster jacket is worn for about 6 months. Rest of the measures is the same as described above.

LUMBAR CANAL STENOSIS (LCS)

Canal stenosis is common in lumbar vertebrae. One or more roots of the cauda equina may be affected due to the constriction in spinal canal before it exits through the foramen.

This condition was first described by Portal in 1803.

Definition

Lumbar canal stenosis is a cauda equina compression in which the lateral or anteroposterior diameter of the spinal canal is narrow with or without a change in the cross-sectional area.

Classification

- Generalised/localised varieties.
- Segmental (local area of each vertebral spinal segment are affected).
  - Central
  - Lateral recesses
  - Foraminal
  - Far out
- Anatomical area
  - Cervical (seen)
  - Thoracic (rare)
  - Lumbar (most common)
- Pathological (Arnold's classification)
  - Congenital—e.g. achondroplasia
  - Acquired—degenerative, iatrogenic, and spondylitic
- Other causes
  - Paget's disease
  - Fluorosis
  - Kyphosis
  - Scoliosis
  - Fracture spine
  - DISH (diffuse idiopathic skeletal hyperostosis) syndrome.
- Iatrogenic causes, e.g. hypertrophy of posterior bone graft, incomplete treatment of stenotic condition, etc.

Clinical Features

Lumbar canal stenosis is common in males below 40 years. Usually the symptoms are fewer in number but the patient may complain of low backache.

Cauda equina claudication is the common symptom. Here the patient complains of pain in the buttocks and legs after walking, which decreases on sitting, rest and forward bending. Patient may complain of hypoesthesia and paraesthesia. Usually the patient finds no problem in walking uphill or riding a bicycle. Nerve root entrapment in the lateral recess causes claudication and sciatica. Difference between ischemic claudication and cauda equina claudication (neurogenic claudication) is mentioned in Table 19.6.

TABLE 19.6: Differential diagnosis of claudication

Cauda equina claudication	*Ischemic claudication*
• Pain in the buttocks and lower Extremities after walking.	• Pain in the legs appears on walking
• Relieved by sitting forward for 20 minutes	• Appears and disappears fast
• Hypoaesthesia, paraesthesia Precipitated by walking, walking Uphill, cycling etc.	• No neurological deficit
	• absent pulses
• Pulses are felt	• Trophic changes in foot and toes
• No trophic changes.	

Stoop test It is positive in lumbar canal stenosis. Ask the patient to walk briskly → pain develops → continues to walk → patient assumes a stooped posture → symptoms disappear. The pain decreases by forward bending because the canal length increases by 2.2 mm.

Investigations

Radiographs of the lumbar spine consisting of AP lateral and oblique views are recommended. The following points are looked for:

- Reduced interpedicle distance.
- AP or midsagittal diameter of the affected vertebra (Normal—15 mm), absolute midsagittal diameter of the canal is decreased.
- Measurement of the lateral sagittal diameter.
- Hypertrophy and sclerosis of the facet joints.
- Reduced interlaminar space and short, stout spinous process.
- Associated features like presence of listhesis, prolapsed disk, osteophytes, etc.

Radiographs of pelvis are also done.

Myelographic findings Consist of waist-like narrowing of the dural sac at the level of facet joints and indentation of the dural tube due to disk prolapse, etc.

MRI and CT scan Helps to diagnose lateral recess stenosis, facet hypertrophy, midsagittal distance, etc.

Treatment Methods

Conservative Method

This has got a limited role in the management of LCS. NSAIDs, bed rest, etc. helps to reduce pain.

Surgical Methods

Most of the surgical methods described for lumbar canal stenosis aim at decompressing the constricted lumbar canal. Laminectomy is useful in central canal stenosis. Discectomy and osteotomy of inferior articular process helps to remove the hypertrophic elements.

For lateral canal stenosis laminotomy, disk excision, partial medial facetectomy and foraminotomy help. Spinal fusion to stabilize the lumbar spine is usually not required as instability is less commonly seen in lumbar canal stenosis.

It should be noted that neurogenic claudication responds poorly to the conservative treatment but responds well to surgical decompression.

Physiotherapy Treatment

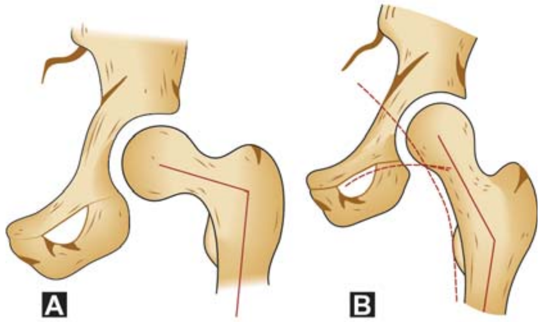
- Strong isometric exercises are indicated for the abdomen to improve their strength, endurance and tone.
- Lumbar traction to relieve spasm.
- Lumbar corset provides necessary back support.
- Gentle passive manipulation of the back helps.
- Proper back ergonomics.
- Flexion attitudes are greatly encouraged.
- Patient is instrumented to avoid extension exercises and practice flexion exercises.

REGIONAL CONDITIONS OF THE HIP

COXA VARA (FIGS 19.79A AND B)

Definition

It is an abnormality of the proximal end of femur, which is characterized by decreased neck shaft angle (Normal angle is 125-132°). Normal coxa vara is due to differential growth pattern of capital femoral and greater trochanteric epiphysis.



Figs 19.79A and B: Showing (A), Coxa valga, (B) Coxa vara

Classification

Congenital
- Congenital coxa vara
- Congenital short femur with coxa vara
- Congenital bowed femur with coxa vara.

Acquired (according to the site of disturbance)
- *Capital coxa vara* this is seen in Perthes disease, chondro osteodystrophy, cretinism, septic arthritis, of hip, etc.
- *Epiphyseal coxa vara* Slipped capital femoral epiphysis.
- *Cervical coxa vara* this is seen in malunited trochanteric fracture, pathological hip conditions like
  - Children—Rickets, bony dystrophies, etc.
  - Adults—Osteomyelitis, osteoporosis, Paget's disease, fibrous dysplasia, etc.

Part of generalized skeletal dysplasias This is seen in mucopolysaccharidosis, multiple epiphyseal dysplasias, achondroplasia, cleidocranial dysostosis, etc.

Disadvantages of coxa vara
- Normal apposition between joint surfaces is lost.
- Trochanter is displaced upwards, impinges on the side of pelvis.
- Marked shortening of the limb.
- Waddling gait.

Clinical Features

Small stature, limp, waddling gait, upward shift of greater trochanter, decreased rotation and abduction of hip, pain, stiffness and flexion contractures are some of the important clinical features of coxa vara.

Radiograph

Radiographic features are neck shaft angle is less than 90°, length of the neck is decreased, head is unusually translucent, and triangular fragment of bone is seen occupying lower part of the head close to the neck.

Treatment

It consists of corrective osteotomy at the intertrochanteric level. Usually a lateral wedge osteotomy is preferred. Macewen and Shand's corrective osteotomy corrects both coxa vara and retroversion of the femoral neck.

Physiotherapy Measures after surgery

The following measures are suggested:
- Sutures are removed after two weeks.
- As soon as the pain permits, a non-weight-bearing crutch walking is permitted.
- Full weight-bearing may be allowed after 8-12 weeks.

LEGG-CALVE-PERTHES DISEASE
(Syn: Osteochondritis Deformans Juvenilis and Coxa Plana)

**Legg-Calve-Perthes disease is a complex pediatric hip disorder and has some controversial aspects. Although its precise etiology remains unknown, the pathogenesis and pathology are fairly well understood. The prognosis for a child with this disease has improved considerably than in the past.*

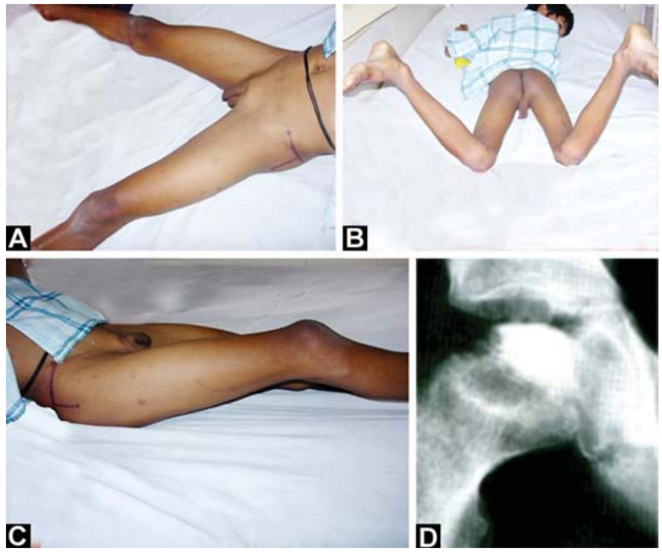
Definition

It is *a disorder affecting the capital femoral epiphysis*. It is the most common form of osteochondroses, characterized by avascular necrosis (AVN) and disordered enchondral ossification of the primary and secondary centers of ossification. It is associated with potential long-term morbidity.

Clinical Features

It is usually common in boys between 4 to 8 years (mean age 7 years) but can also occur in less than 2 years and more than 12 years. *If the child is older than 12 years it is not true Perthes disease but rather adolescent avascular necrosis.*

Symptoms
- Painless limp (classical presentation).
- Mild pain in the hip or anterior thigh or knee.
- History of trauma may be present or absent.
- Onset of pain may be acute or insidious.



Figs 19.80A to D: Clinical photograph showing: (A) Limitation of abduction in Perthes' disease, (B) Limitation of internal rotation, (C) FFD of hip, (D) Plain X-ray showing destruction of head of femur

Signs
- Antalgic gait.
- Muscle spasm (detected by the roll test).
- Proximal thigh atrophy (by 2-3 cm).
- Limitation of abduction (Fig. 19.80A) and internal rotation (Fig. 19.80B).
- Short stature.
- Mild fixed flexion deformity of hip < 15° (Fig. 19.80C).

Classification

**Catterall in 1971 proposed a four group classification system for Perthes disease based on the radiographic appearance of the femoral head. *This classification has been extremely useful in retrospective analysis of the results of treatment and has a very limited prognostic value.*

The presence of an intact and viable lateral margin of capital femoral epiphysis indicates good prognosis and its absence suggests poor prognosis.

Radiographic Assessment

Radiographic assessment is necessary to determine the progress of the disease, sphericity of the femoral head, epiphyseal extrusion or collapse, and response to the treatment. Plain radiographs are usually adequate but rarely arthrography, MRI may be required (Fig. 19.80D).

***George Clemens Perthes** (1869-1927), a German Orthopaedic Surgeon described it independently. Legg, Arthur Thornton, Massachusetts (1910) and Jacques Calve (1910) of France also described it and called it as coxa plana.

****Anthony Catterall** (1971), described the natural history and monograph of this disease.

Management

Perthes disease is a local, self-healing disorder of the femoral head. Prevention of the femoral-head deformity and secondary degenerative osteoarthritis is the only justification for treatment.

Goals of Treatment

- *Elimination of hip irritability* can be done by 1 to 2 weeks period of bed rest, sling, suspension, traction, etc.
- *Restoration and maintenance of hip motion* this can be done by physical therapy active and passive. Abduction exercises may be helpful.
- *Prevention of the extrusion and collapse* by bed rest, abduction splints, etc.

Treatment Plan of Perthes' Disease

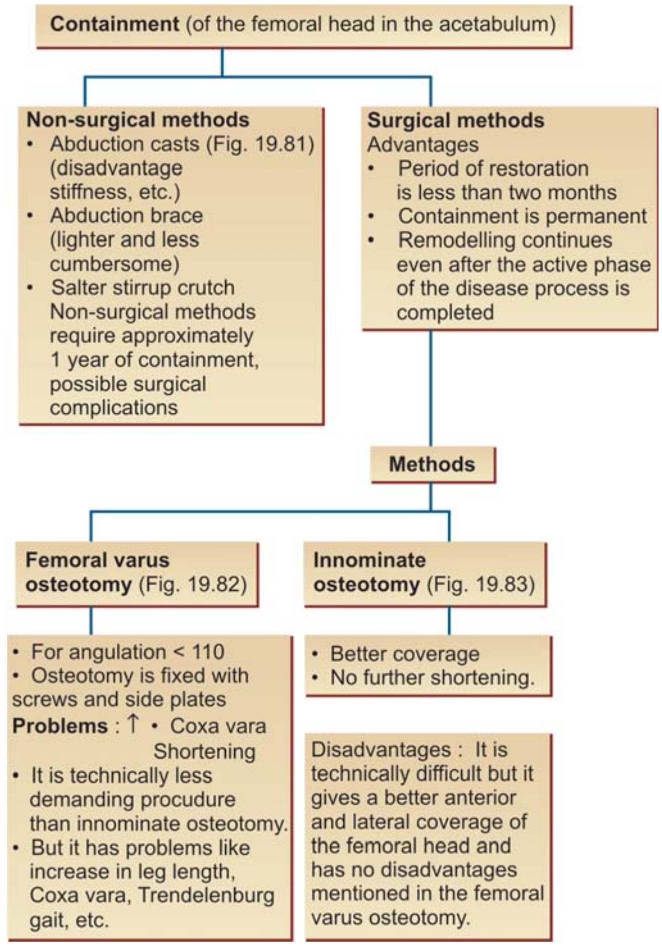
- This aims to attain a spherical femoral head to prevent femoral head deformity and can be done by containment methods which may be non-surgical or surgical (Flow chart 19.4). The following are the four currently accepted forms of management:
  - — *Observation* is indicated for children less than 6 years, and for more than 6 years in Catterall I and II.
  - — *Intermittent symptomatic treatment* consists of observation, bed rest and abduction exercises.
  - — *Definitive early treatment* Non-surgical or surgical containment of the femoral head (see chart) early in the course of the disease is indicated when the
    1. Age at onset is more than 6 years or older.
    2. Catterall III and IV grades.
    3. Lateral extrusion of the capital femoral epiphysis.

Prerequisites are good to full range of hip motion, no residual irritability, and the femoral head must also appear round or almost round.

Physiotherapy Management

- Measures to control pain, inflammation and muscle spasm.
  - — Cryotherapy—in the later stages.
  - — Thermotherapy—in the initial stages.
- Measures to strengthen the muscles.
  - — Active isometric exercises to the glutei muscles, quadriceps and hamstrings.
  - — Active, active assisted, resistive exercises to the flexors, extensors and abductors of the hip, quadriceps and hamstrings, dorsiflexors, plantar flexors and intrinsic muscles of the foot.
- Measures to improve movements
  - — Passive ROM exercises to the hip to improve the restricted movements of hip like extension, abduction and internal rotation.

Flow chart 19.4: Showing different types of containment methods in Perthes' disease



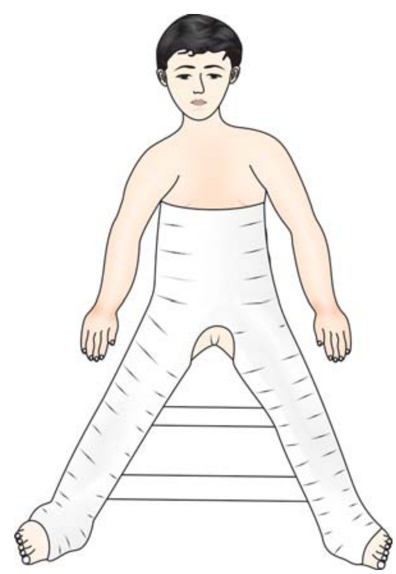


Fig. 19.81: Abduction cast is a non-surgical method of containment in Perthes' disease

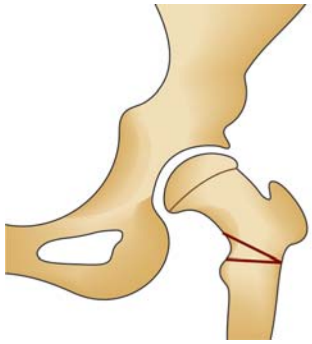


Fig. 19.82: Femoral varus osteotomy

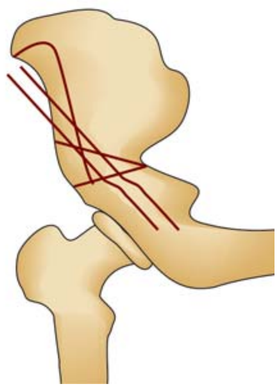


Fig. 19.83: Innominate osteotomy

— Active assisted and active ROM exercises to the hip, knee and ankle joints.

Quick Facts

Other important advantages of passive exercises:
- Improves nourishment to joint cartilages
- Maintains the soft tissues in fractures normal state
- Helps in molding of the joint surfaces
- Prevents soft tissue contractures.

- *Measures to prevent contractures* A patient with Perthes' disease tends to develop flexion contracture of the hip. This can be prevented by:
  - — Repeated prone lying positions.
  - — Repeated slow passive stretching of the hip joint
  - — Gentle stretching of the hip joint.
- Measures for ambulation
  - — *Non-weight-bearing walking* Patient is taught non-weight-bearing standing and walking initially in a parallel bar. Later he is permitted to use a walker and then axillary crutches for walking.

Quick Facts

Other important measures during ambulation:
- Relaxed passive and active movements
- It patient complains of pain during walking, ambulation is stopped and the brace is reapplied.
- Pool exercises are useful.
- Proper shoe raise is to be given it the limb is short.
- The assistive devices should be gradually weaned.
- ROM exercises with active and passive to be continued.
- Resistive exercises should be continued regularly.
- Patient should be educated to refrain from faulty postural habits and joint positions.

— Walking by bearing weight

i. Initially the patient is allowed weight-bearing walking with the help of specially designed braces and splints like the Scottish rice brace or Petric cast. These devices help in the containment of the femoral head within the acetabulation during weight-bearing by maintaining a position of flexion, abduction and internal rotation.

ii. After removal of the brace or splint, patient is encouraged by proper assistance and support both at home by the parents and at the clinic by the therapist to stand bear-weight and walk independently.

Physiotherapy measures following surgery The physiotherapy measures are more or less the same as for the conservative treatment, except that during the period of immobilization following surgery in a hip spica, isometrics for the hip and knee muscles inside the plaster cast and resistive toe movements for the affected side and full range resistive movements to the hip, knee and ankle joints and isometrics to the hip abductor and extensors to the normal limb is given. Continuous passive movements to the hip after removal of the plaster cast are recommended.

Late Surgical Management for Deformity

For a significant femoral head deformity which prevents reduction into the acetabulum or remodeling after treatment with standard containment methods, an alternative must be considered and may consist of one of the following techniques—muscle release and abduction casts, partial excision of the femoral head or cheilectomy, proximal femoral valgus osteotomy and greater trochanter advancement.

SLIPPED CAPITAL FEMORAL EPIPHYSIS

(Syn: Epiphyseal coxa vara; Adolescent coxa vara)

Slipped capital femoral epiphysis occurs during adolescent rapid growth period when epiphyseal plate is weak and the capital epiphysis is displaced down and back. It was first described by **Muller** in 1889.

Etiology

Predisposing factors

- *Age* It is common in 10-17 years of age.
- *Sex* Males: Females is 5:2 ratios.
- *Body type* Female—slender long built, and male—obesity type.
- *Location* Left hip is involved in 58 percent of the cases.
- *Trauma* Trivial or none at all.

Clinical Types of SCFE

- *Acute (11%)* Sudden onset and the symptoms are less than 2 weeks duration
- *Chronic (60%)* Symptoms are present for more than 2 weeks. X-ray shows callus and remodeling
- *Acute on chronic (23%)* Symptoms are present for 1 month and there is a recent sudden increase in pain following trivial injury.
- *Preslip (6%)* X-ray shows irregular wide epiphysis.

Stages and Clinical Features

This is shown in Table 19.7.

TABLE 19.7: Stages in SCFE and their clinical features

Pre-slipping stage	*Chronic slipping stage*	*Stage of fixed deformity*
• Discomfort in The groin • Stiffness/limp • No objective Finding • Medial rotation of the hip is decreased	• Pain ↑ • Antalgic gait • All movements ↓ particularly. Abduction and internal rotation • Varus + Adduction + External rotation Deformity is present • Shortening is present • Extension and External rotation ↑ • Waddling gait is Present • Trendelenburg's Gait is positive	• No pain • No spasm • Limb shortening • External rotation • Adduction deformity

Fig. 19.84: Plain X-ray of SCFE

Radiograph

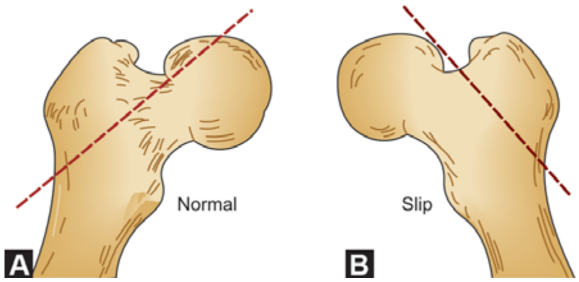
Early changes

- Marginal blurring of the proximal metaphysis.
- Lower margin of metaphysis is included within the acetabulum normally but excluded in the early epiphyseal slip (Fig. 19.84).
- *Trethovan's sign (Figs 19.85A and B)* Line drawn along the superior margin of the neck, transects the epiphysis normally, but will be above it in slip.
- Depth of epiphysis is reduced.
- There is a step between the metaphysis and epiphysis.

Late changes

- Trethovan's sign is present.
- Head is atrophic.
- Neck shaft angle is less than 90°.
- New bone formation is seen at the anterior superior part of the neck.
- Joint space is usually clear.
- Shenton's line is broken.

CT scan This is very useful in assessing the degree of slips and other changes in the hip.



Figs 19.85A and B: Showing Trethovan's sign

Classification of Slipping

- *Mild slipping: (51%)* Neck is displaced less than one-third of the diameter of the head or the head-shaft angle deviates from the normal by less than 30°.
- *Moderate slipping: (22%)* Neck is displaced more than one-third to one-half of the diameter of the head or the head shaft angle deviates from the normal between 30 to 60°.
- *Severe slipping: (17%)* Neck is displaced more than one-half diameter of the head or head shaft angle is more than 60° from normal.

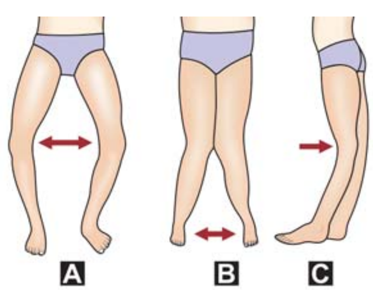
Principles of treatment are as follows:
- If the epiphysis has begun to displace, there is no safety till the epiphyseal line is fused.
- When there is minor displacement, epiphysis is fused at once by pinning in displaced position.
- Acute major slip: Emergency reduction is done under (GA) or reduction is obtained by traction and fixed with pins.
- Irreducible displacement: This is treated by open reduction and cervical osteotomy.
- Old fixed displacement: This is treated by a corrective osteotomy at intertrochanteric or subtrochanteric level.

Complications

Avascular necrosis (13%) of the femoral head and chondrolysis are the usual complications. Secondary osteoarthritis may be seen at later stages.
- Thermotherapy to control pain and relieve spasm.
- Hip is gradually mobilized in a graded manner.
- Strengthening exercises to the abdomen, glutei, hamstrings and quadriceps are started
- Till independent ambulation is achieved patient should be allowed to transfer weights in stages.

REGIONAL DISORDERS OF THE KNEE

Deformities (Figs 19.86A to C) around the knee joint could be in two planes. In the coronal plane we may encounter *genu valgum* and *genu varum* deformities and in the sagittal plane *antevertum* and *recurvatum* deformities.



Figs 19.86A to C: Principal knee deformities: (A) Genu varum, (B) Genu valgum, (C) Genu recurvatum

Strange it may seem but a normal knee is a crooked knee. Nature identifies a 6° physiological outward deviation of the knee (valgum) as normal and not a straight knee! Only when the crookedness of the knee increases (genu valgum) or decreases (genu varum) or when it bends backwards (recurvatum) that it is considered abnormal and is a cause of worry. A person affected by any one of these conditions is brought on his “knees” and is forced to seek remedial measures to be up on his “knees” normally again!

GENU VALGUM (Knock Knee)

Definition

It is an outward deviation of the longitudinal axes of both tibia and femur. Apex of the curve or angulation of the knee is medial (Figs 19.87 and 19.88).

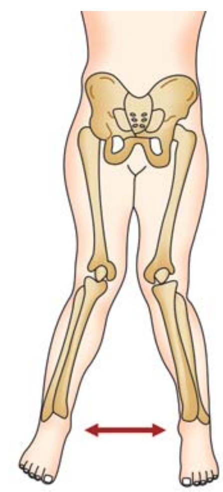


Fig. 19.87: Genu valgum or knock knee deformity

Incidence

Seventy-five percent children have genu valgum up to 4 years of age. This is called physiological genu valgum which usually disappears by 7 years.

Types

It is broadly classified into physiological and pathological, the latter could be unilateral or bilateral (Table 19.8).

Clinical Features

Genu valgum complex The primary deformity in a genu valgum is *a medial angulation of the knee.* In response to this,

Fig. 19.88: Clinical photograph of genu valgum

secondary deformities develop in the femur, tibia and foot. Primary and secondary deformities together form the genu valgum complex (Flow chart 19.5).

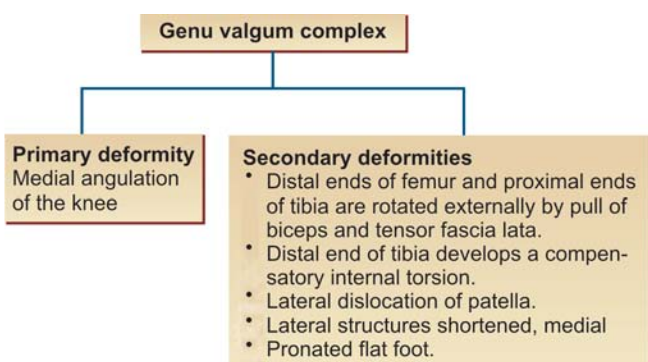
Quick Facts

Idiopathic genu valgum

The following are its features:

- Commonest variety
- Invariably bilateral
- Deformity is the only complaint
- Occurs at the age of 2 to 3 years, and
- Recovers by the age of 6 years

Flow chart 19.5: Showing various deformities in genu valgum



Assessment of Genu Valgum Deformity

Clinical Assessment

Intermalleolar gap The severity of the deformity is measured by noting the intermalleolar distance.

Method In the spine position the patella is brought to vertical by rotating both the legs and made to touch lightly at the knee.

TABLE 19.8: Causes of genu valgum

Unilateral	*Bilateral*
• Trauma • Osteomyelitis • Tumors	• *Physiological* (disappears by 4 yrs) • *Pathological* • Congenital disorders • Idiopathic (most common) • Developmental disorders (e.g., epiphyseal dysplasia) • Endocrine disorders (e.g. thyroid disorders) • Metabolic disorders (e.g. rickets) • Paralytic disorders • Traumatic disorders • Infective disorders • Degenerative disorders • Inflammatory disorders (e.g. rheumatoid arthritis)

Then holding both the knees in position, the distance between the two malleoli is measured. The acceptable normal limit is 8 to 10 cm. In genu valgum deformity it will be more than 10 cm.

Plumb line tests Normally, a line drawn from anterior superior iliac spine (ASIS) to middle of the patella, if extended down strikes the medial malleolus. In genu valgum, the medial malleolus will be outside this line.

Knee flexion test This is to detect the cause of genu valgum whether it lies in the femur or tibia. If the deformity disappears with flexion of the knee, the cause lies in the lower end of femur and if it persists on flexion, the cause lies in the upper end of the tibia.

Radiological Assessment

Clinical assessment of genu valgum is less accurate in adults and an assessment by radiology is preferred. X-ray of the entire lower limb is taken with the patient weight bearing. The angle formed between the femoral and tibial shafts is measured on the radiographs and allowing for a normal angle of 6°, genu valgum is calculated.

Treatment

Different treatment options of genu valgum is given in Table 19.9.

Mild cases This requires the following physiotherapy measures. Child is seen at intervals of 3 months and the progress is recorded. These cases usually require no treatment, and raising the inner side of the heels by 4 to 5 mm may possibly relieve strain on the ankles. The knock knee braces may be useful. If by the age of 4 years, intermalleolar distance is 10 cm or more, operation may become necessary and unless deformity is increasing rapidly, operation is best postponed till the child is 10 years old.

TABLE 19.9: Treatment of genu valgum

Mild (< 8 cm IM distance at 4 years)	*Severe* (> 10 cm IM at 10 years)
• **No treatment** • Frequent follow-up every 6 months • Raise medial heel by 4-5 mm • Knock knee brace (outer Iron bar, inner strap)	**Surgery** *Indications* • Unilateral genu valgum • Intermalleolar distance > 10 cm at 10 years
Epiphysis arrest • Done before skeletal maturity • Lateral epiphysis should be intact as seen in X-ray • Staple the medial epiphysis to arrest the growth	**Osteotomy** • Done after skeletal maturity • Medial closed wedge osteotomy if limb is longer or normal • Lateral open wedge osteotomy if limb is short

Note: IM = Intermalleolar

Severe cases

- If lateral portion of epiphyseal plate is intact as seen in the radiographs, it contributes to the longitudinal growth at a reduced rate. This situation is suitable for stapling of the medial epiphysis which arrests the growth on the medial side and allows the growth on the lateral side and thus helps to correct the deformity.
- After skeletal maturity, an osteotomy must be performed at the site of maximum deformity of tibia or femur. If limb is long *medial close wedge osteotomy* is done. If limb is short *lateral open wedge osteotomy* is done. *Knock knee deformity more than 10 cm at the age of 10 years is an indication for surgery.*

Postsurgery Physiotherapy Measures

- Thermotherapy to control pain and relieve spasm.
- Knee is gradually mobilized in a graded manner.
- Strengthening exercises to the glutei, hamstrings and quadriceps are started
- Till independent ambulation is achieved patient should be allowed to transfer weights in stages.

Treatment facts of Genu Valgum

- < 4 years—No treatment
- 4 -10 years—Heel raise, knock knee brace
- 10-14 years—Epiphyseal stapling
- 14-16 years—Wait till skeletal maturity as it is too late for stapling and too early for osteotomy, as it may recur
- > 16 years—Osteotomy

Quick Facts

Genu valgum

- Medial angulations of the knee
- 75 percent is physiological upto 4 years of age
- Idiopathic is the most common type
- Deformity is the only complaint

GENU VARUM (BOW LEGS)

Definition

It is defined as *lateral angulations of the knee. The longitudinal axis of femur and tibia deviates medially*.

The deformity involves tibia alone or the femur or tibia and fibula (Figs 19.89 and 19.90) both.

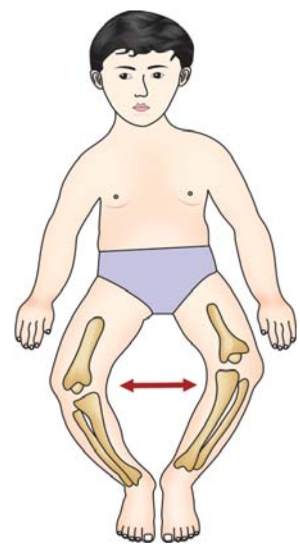


Fig. 19.89: Showing genu varum with increased intercondylar distance. Genu varum is said to exist if there is approximately 3 cm gap between the medial femoral condyles when the malleoli are together

Types and Causes

Unilateral

- Due to growth abnormalities of upper tibial epiphysis.
- Infections like osteomyelitis, etc.
- Trauma near the growth epiphysis of femur and tibia.
- Tumors affecting the lower end of femur and upper end of tibia.

Bilateral This could be either

- Physiological (gets corrected by 4 years).

Fig. 19.90: Clinical photograph of genu varum

- Pathological—the causes are:
  - — Congenital causes
  - — Postural abnormalities
  - — Developmental disorders
  - — Metabolic disorders (rickets rare)
  - — Endocrine disorders
  - — Degenerative disorders (e.g. osteoarthritis of knee)—this is a common cause
  - — Occupational disorders (e.g. in jockeys)
  - — Idiopathic
  - — Paget's disease
  - — 'Blounts' disease (tibia vara).

Clinical Measurements of the deformity

Child

- Patient is examined supine with knee extended, patella facing the ceiling and the medial malleoli touching each other. If the separation of knee exceeds more than 3 cm or if it is unilateral, it should be investigated.
- A line is drawn from anterior superior iliac spine through centre of patella to medial malleolus. Normally all the structures are in the same line but in genu varum medial malleolus is medial to this line.

Adults The angle of genu varum is calculated on a standing radiograph of the whole limb.

Clinical Features

Genu varum complex The primary deformity in genu varum is *lateral angulations of the knee*. In response to this secondary deformities develop in the tibia and the foot. This together is known as genu varum complex (Table 19.10).

TABLE 19.10: The primary and secondary deformities in genu varum

Primary deformity	*Secondary deformity*
Lateral angulation of the knee	**Associated abnormalities** • An internal torsion of distal tibia • In toeing of both the feet • Patella face outward while walking • Tight medial and lax lateral structures of the knee

Note **What is apparent Genu varum?**
Due to anteversion of femoral neck, there is medial rotation of the femur and the child looks bow-legged. But with the patella facing forwards the "varus deformity" disappears.

Treatment

- Treatment should be conservative till 4 years of age. Knee-ankle-foot orthoses with the medial bar and the lateral strap is used.
- Correction of early deformity is done by dynamic bracing or splints. After 4 years, significant deformity should be corrected by surgery. Lateral epiphyseal stapling when the child is within the growth period and supracondylar medial open or lateral closed wedge osteotomy is done after skeletal maturity.

Physiotherapy Measures

With appropriate modifications, the physiotherapy measures are more or less the same as discussed in genu valgum.

GENU RECURVATUM

Genu recurvatum is defined as *backward bending of the knee*. Up to 5° of genu recurvatum is sometimes seen in women with lax ligaments and is usually generalized.

Causes

- *Congenital* discussed in congenital disorders
- *Quadriceps contracture* is the most common cause in acquired genu recurvatum and is discussed below.
- *Neurological disorders* Polio, cerebral palsy, etc.
- *Malunited fractures* around the knee.

Quadriceps contracture There are two varieties:
- Congenital variety.
- Post injection contractures of infancy and childhood.
- *Quadriceps contracture* in early childhood has an age of onset between 1 and 7 years.

Features

- Limitation of knee flexion from mild to severe.
- Effusion and other evidence of knee abnormality are absent.
- Sometimes a dense band that becomes tense during flexion of the knee could be palpated in the proximal part of the patella.
- Patella is always located more proximally and some times laterally.
- ***Other features*** include, it is usually bilateral, common in identical twins, more common in females, and extremely resistant to conservative treatment.

Post-injection contractures in infancy First described in 1962 by Miki.

Features

- Repeated injections and infusions to the thigh soon after birth.
- Dimples present in the skin at the sites of injections.
- Common in twins and prematurity (because they often make injections necessary and in infants anterior thigh is commonly preferred site).

  The muscles usually involved are:
  - Vastus lateralis
  - Rectus femoris
  - Vastus intermedius: *Vastus medialis is not involved because injections are not given to this muscle.*

Treatment

Surgery is the treatment of choice and is usually indicated in established contractures as conservative treatment is not beneficial. Early recognition and prevention through passive exercises while child is receiving injections is the best preventive measure.

Surgery is indicated early in habitual dislocation of the patella and in established contractures to prevent late changes in the femoral condyles and patella.

Methods

Thompson's quadriceps plasty (V-Y plasty) is the commonly done procedure.

Kullman and Leonart's surgery This procedure consists of proximal release of rectus femoris in an isolated contracture of rectus femoris.

Physiotherapy Measures Following Quadricepsplasty

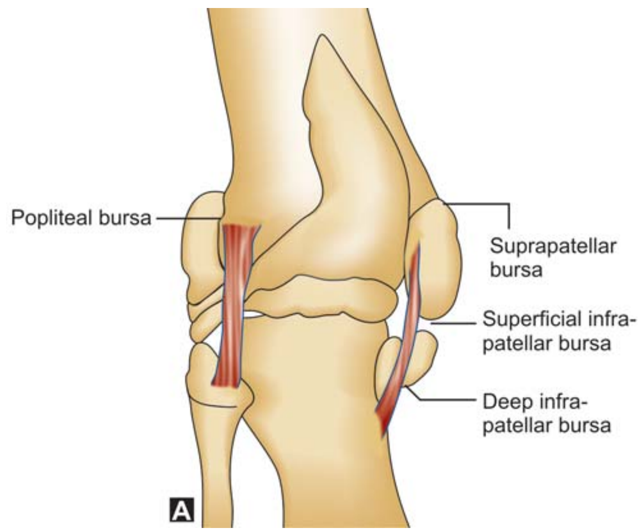
Aim The aim is to maintain the range of movements obtained from surgery by early mobilization of the knee.

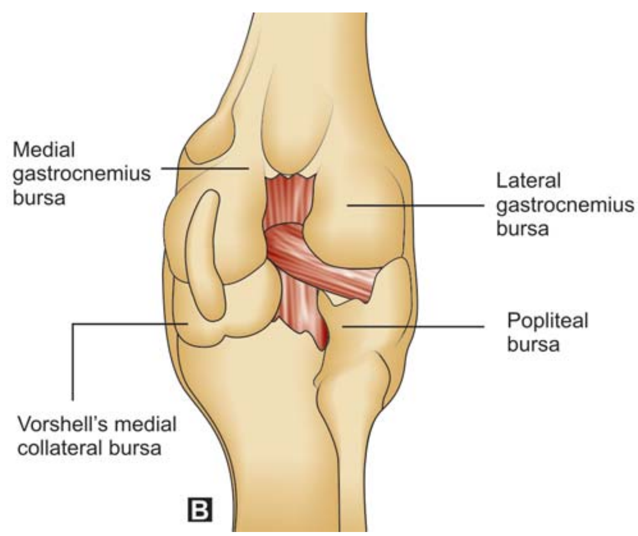
Methods

- Sutures are removed after 2 weeks.
- Thermotherapy in the form of TENS, SWD and Ultrasound helps to relieve pain.
- Isometric quadriceps exercises both speed and slow are extremely effective.
- Range of movements is further improved by continuous passive motion (CPM) immediately after surgery and later by vigorous knee exercises.

BURSAE AROUND THE KNEE

Knee is a complex joint in the body sub serving complex functions. To do so it requires a host of ligaments, muscles, menisci, etc. To serve the knee efficiently and longer these structures





Figs 19.91A and B: Bursae around the knee

need to be cushioned properly from the bony surfaces. As long as the knee is being used normally, no problems are encountered. Violation of the physiological actions by way of over and abnormal use frustrates and irritates these cushions which are nothing but bursae around the knee giving rise to various interesting clinical problems.

Bursae are sacs lined with membrane similar to synovium. They are located over the joints and bony prominences and may or may not communicate with the joint. They reduce the friction and protect the delicate structures from pressures. When subjected to repeated pressure they give rise to bursitis. There are two types of bursa, one that is normally present and second, *adventitious bursa* which develops due to trauma, friction, pressure, etc. Adventitious bursa differs from true bursa by the lack of true endothelial or synovial lining.

The problems related to bursa around the knee (Figs 19.91A and B) are as follows:

Anterior

- *Suprapatellar* this always communicates with the knee joint.
- *Prepatellar bursitis* (housemaid's knee) is seen in the lower half of patella and upper half of ligamentum patella.
- *Infrapatellar* bursitis is seen in the lower half of ligamentum patella (Clergyman's, Parson's, or Carpet layer's knee).

Lateral Cyst of the lateral meniscus is the common lesion seen on the lateral side of the knee.

Medial

- Cyst of the medial meniscus.
- Bursa anserina—this is present between the tibial collateral ligament and tendons of the semimembranosus, gracilis and semitendinosus tendons.

Posteriorly

- Semimembranosus bursitis
- Baker's cyst.
- Lymphangiectasia
- Aneurysm of popliteal artery
- Neuromyxofibroma.

Popliteal Cyst (Baker's Cyst) this was first described by Adam in the year 1840 and later by *Baker in 1877 (Fig. 19.92A).

*__William Morrant Baker__ (1838-1896) of England. Described Baker's cyst in 1877.

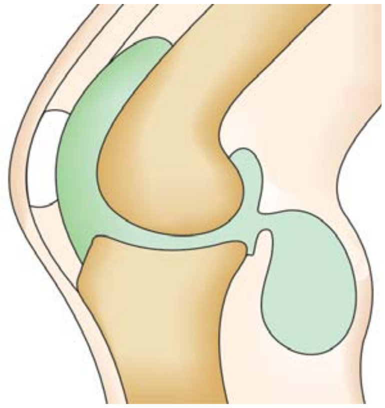


Fig. 19.92A: Baker's cyst arises from the herniation of the synovial membrane through the capsule

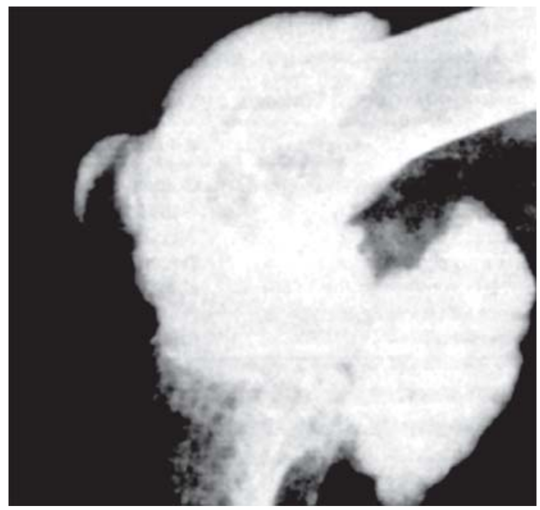


Fig. 19.92B: Arthrography showing ruptured popliteal cyst

What is Baker's cyst? (Fig. 19.92A)

The exact origin is not known, but it is a distended bursa arising from any one of the structures below:

- Between hamstrings and collateral ligaments.
- Between hamstrings and tibial condyles.
- Each head of gastrocnemius.

Commonly symptoms are seen in bursa of the medial head of gastrocnemius and semimembranosus bursa.

How is it produced?

- In 30% of cases, herniation of synovial membrane takes place through the posterior part of the capsule of the knee joint.

- Escape of fluid through the normal communication of bursa with the knee (either semimembranosus or medial gastrocnemius) is the other mode.
- Indeterminate site in about 10 percent of cases.

What is a giant cyst?

It is a huge popliteal cyst commonly seen in rheumatoid arthritis.

Treatment
- 1-2 days of non-surgical treatment.
- Later, arthrography and cyst is excised (Fig. 19.92B).
- Synovectomy is done later to prevent recurrence.

Clinical Features

These are similar to internal derangement of the knee, like pain, stiffness, swelling, giving way, etc. (Fig. 19.93).

In adults, intra-articular pathology is seen in 50 percent, of these 50 percent are caused by a lesion in the posterior one-third of medial meniscus and the remaining from some other pathology of the knee (Table 19.11).

TABLE 19.11: Differences between Baker's cysts

Children	*Adults*
• No communication with the joint	• Communication is present
• Intra-articular pathology are rare	• Commonly seen in 50 percent of cases?
• No recurrence even with complete removal of the cyst	• Recurrence is common
• Postoperative immobilization is not required	• Postoperative immobile-lisation is required

Duck waddle test is useful to detect pathology in the posterior part of the medial meniscus.

Investigations

- Plain X-ray of the knee joint
- Arthrography of the knee joint (Fig. 19.92B).

Treatment

The treatment of choice is excision of the bursa and closure of the capsular orifice by:
- Scarification of the edges and suturing.
- To close the gap by a graft from tendinous part of the gastrocnemius, etc.

  One-third to one-half of patients with Baker's cyst is children. It is rare after seventh year of life. Hence delay in excision is followed by gradual disappearance of the cyst.

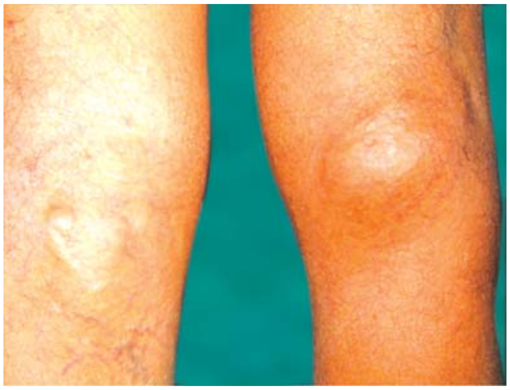


Fig. 19.93: Clinical photograph of Baker's cyst

Role of Physiotherapy after Surgery

- Thermotherapy to reduce pain and stiffness.
- Isometric exercises to the quadriceps.
- Active ROM exercises to the knee.
- PRE to the knee joint muscles.

Note Avoid excessive compression or stretching of the knee.

RECURRENT DISLOCATION OF PATELLA (RDP)

It is a condition in which there is recurrent dislocation of the patella usually to the lateral side. This is usually preceded by an episode of acute traumatic dislocation of the patella and probably has not healed properly after the initial trauma. It has to be differentiated from another entity called habitual dislocation of patella in which the patella dislocates with each flexion and extension movements of the knee.

The following are the predisposing factors responsible for recurrent dislocation of patella:
- Patella Alta or high riding patella.
- Genu valgum.
- Hypoplastic lateral condyle of femur.
- Tight lateral structures of the knee joint.
- Lax medial patellar retinaculum.
- Femoral anteversion.
- External femoral torsion.
- Genu recurvatum.
- Abnormal insertion of vastus medialis.
- Patellar tendon laterally inserted.
- External tibial rotation.
- Hypoplastic patella.
- Atrophy of vastus medialis.
- Hypertrophy of vastus lateralis.
- Generalized joint relaxation.

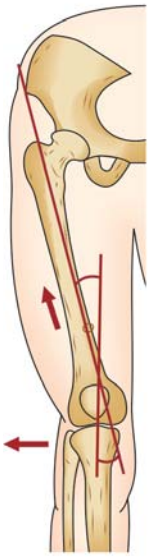


Fig. 19.94: Showing the 'Q'-angle

Clinical Features

Patient gives history of diffuse pain in the knee joint which gets worsened by going up and down the stairs or hills. He or she complains of a feeling of insecurity in the knee and may feel the joint is about to give way or the patella is about to go out! On examination, in addition to the predisposing factors mentioned above, there may be mild swelling and crepitus in the joint. The apprehension test is positive. In this test the patient's knee is held flexed at 30° and an attempt is made to push the patella laterally. In a positive test the patient complains of pain and resists the attempt. Next the Q-angle (Fig. 19.94) is determined. If the Q-angle is more than 10°, medial transplantation of the patellar tendon is recommended.

Radiograph

The following radiographic views are necessary: AP view, lateral view, infrapatellar view and the intercondylar notch view or the tunnel view. In the lateral view the *Blumensaat's line* (Fig. 19.95) is drawn which represents the bony roof of the intercondylar notch. Normally the lower pole of patella just touches that line. If the patella is above this line, a diagnosis of high riding patella is made.

Note Blumensaat's line is a line which passes through the superior margin of the intercondylar notch.

Again in the lateral view the ratio between the length of the patella and the length of the patellar tendon is determined. If it is more than 1, it suggests patella Alta. This is also known as *Insaal's line*.

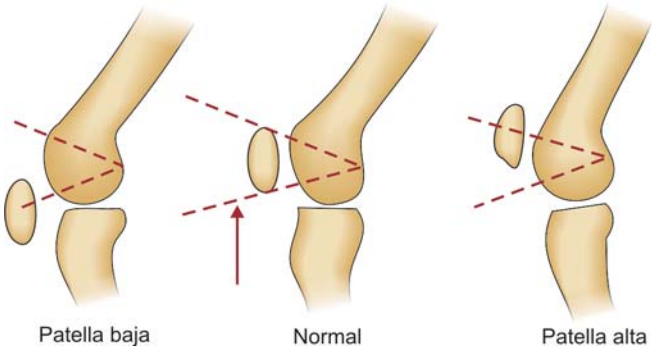


Fig. 19.95: Blumensaat's line

Treatment

A non-surgical or conservative measure This consists of quadriceps exercises, supportive elastocrepe bandages, NSAIDs, etc. and is found to be successful in only 50 percent of the cases.

Surgical methods These are successful in the remaining cases and can be conveniently grouped under four methods (Table 19.12):

- Proximal realignment of structures like the capsule of the knee, quadriceps, etc. (e.g. Campbell's operation).
- Distal realignment of structures like patellar tendon, tibial tuberosity, etc. (e.g. Roux-Goldthwait's operation).
- Both proximal and distal realignment of structures around the knee.
- Patellectomy and realignment of extensor mechanism, e.g. West and Soto Hall.

TABLE 19.12: A brief account of the surgical procedures in recurrent dislocation of patella

Surgery	*What is done?*
• *Campbell's*	Proximal to the knee, the capsule is stripped and carried from medial to the lateral side.
• *Roux-Goldthwait's procedure*	Here lateral structures of the knee are released and the patellar tendon is split and the lateral half is transferred medially.
• *Galeazzi's procedure*	Here the semitendinosus tendon is tenodesed to patella.
• *Houser's procedure*	Here the tibial tuberosity is shifted down and medial.
• *Elmsllie-Trillat procedure*	Here release of lateral knee structures, plication of medial structures and medial transfer of tibial tuberosity is done.
• *Hughston's procedure*	it is a combination of the above procedures.
• *West and Soto Hall procedure*	This includes patellectomy and is done as a last resort.

Physiotherapy following Surgery in RDP

During the first 4 weeks This is the phase of immobilization during which the following measures are followed:
- Active exercises to the hip, ankle and toes.
- Ambulation by non-weight-bearing crutch walking from the second day itself.
- Assisted SLR to strengthen the quadriceps.
- Indirect isometrics are slowly begun.

After 4 weeks This is the phase of mobilization and includes the following regime:
- Thermotherapy to reduce pain.
- Assisted SLR to strengthen the quadriceps.
- Gentle isometrics to the quadriceps.
- Hydrotherapy.
- Gentle passive exercises using a CPM are begun.
- Active knee swinging is encouraged. Self-assisted knee swinging (using the sound leg) is also begun.
- Isotonic, isokinetic exercises to the knee are gradually progressed to resistive exercises.
- Self-resistive hamstring exercises helps.
- Till the patient regains full active extension and 70-90° of flexion, knee orthosis is advised.
- After 10-12 weeks, patient may be allowed squatting, jogging running climbing, etc.

CHONDROMALACIA PATELLA

It is defined as a blistering, cystic change of the patellar cartilage and it usually affects the medial facet of the patella. This condition is commonly associated with vastus medialis tendinitis. It is caused by the combination of several factors which ultimately push the patella out of its groove on the femur.

Factors

The following factors may give rise to chondromalacia patellae. Weakness of the vastus medialis muscle, high 'Q'-angle which causes vastus imbalance and over action of the lateral vasti, malalignment produced by foot pathomechanics leading to abnormal excessive pronation and internal rotation of the tibia. Aberrations of the anatomy can also lead to malfunction, such as irregular shaped facets on the patella or an abnormally high vastus medialis insertion.

Clinical Features

Patient complains of generalized deep pain in the knee. The knee may be swollen with a chronic effusion of synovial fluid

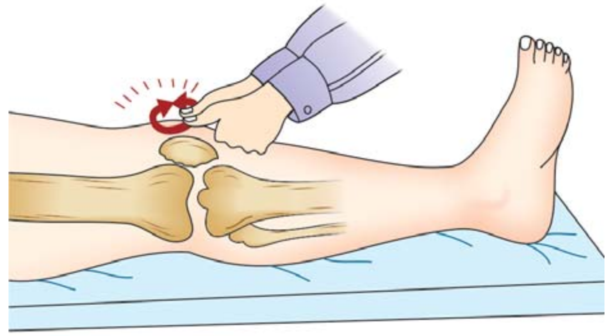


Fig. 19.96: Showing method of performing a grinding test in chondromalacia patella

and there will be a positive patellofemoral grinding test when the condition is severe. The patella will appear out of alignment and there may well be a high 'Q'-angle (Fig. 19.96). The vastus medialis will be weak, radiographs will occasionally show spurring and the patient will be unable to do squats.

Investigations

Radiographs of the knee shows irregular retro patellar surface. Arthroscopy is an extremely useful diagnostic technique.

Differential Diagnosis

Chronic synovitis of the knee, sprain of the retinacula, etc.

Treatment

Conservative methods This is indicated in mild cases and consists of:
- A POP cylinder cast application.
- Strong isometric exercises to the quadriceps.
- Drugs like painkillers, muscle relaxants, anti-inflammatory drugs, etc.
- Corticosteroid injection into the joint, if the symptoms fail to respond to the above line of treatment.

Surgery If conservative methods, fail to bring the desired results, surgery is indicated. The methods include:
- *Arthroscopy* In mild cases, arthroscopic shaving of the undersurface of the patella followed by joint lavage gives excellent results.
- *Patellectomy* In intractable cases of pain, if the fragmentation is more than 1.3 cm, in severe destruction of the articular cartilage and subchondral bone, patellectomy is indicated.
- *Lateral retinacular* Release also gives good results in well indicated cases.

Physiotherapy Measures

- Thermotherapy helps to reduce pain.
- Isometrics to hip, quadriceps, etc.
- Assisted SLR to strengthen the quadriceps.
- ROM exercises both active and passive for the knee.
- Gradual PRE to the knee joint muscles.
- Shoe raise on the normal leg during ambulation.
- Preventive measures to be employed to prevent excessive hyperextension of the knee while ambulation.

After surgery, an above knee cast is applied. After the soft tissue healing the above physiotherapy measures are followed.

INFANTILE QUADRICEPS CONTRACTURE

Quadriceps contracture could develop due to congenital or acquired causes. It is the latter that is more common. Now let us explore the causes:

- *Congenital*
  - Arthrogryposis Multiplex Congenita
  - Congenital Genur Recurvatum
  - Spina Bifida
- *Acquired*
  - *Infants:* Repeated injections into the quadriceps
  - Fracture of the femur with quadriceps adherent to the callus
  - Prolonged immobilization of the knee in a plaster cast following a injury to the lower limb
  - Injections and chronic osteomyelitis of the femur
  - Injury to the quadriceps muscles.

Postinjection Quadriceps Contractures

This is the most common variety of acquired quadriceps contracture.

Important Past Clinical History

- These is usually always a history of severe infections in infancy like severe bronchopneumonia, septicemia, acute gastroenteritis, CHD, neonatal jaundice, etc. Thus, a careful evaluation of the past history is of extreme importance.
- For the above infections there is history of repeated intramuscular injections into the thigh.
- Over the formative years, the child slowly loses its ability to flex the knees.

Incriminating Infamous Injections

Tetanus toxoid (Most common in Japan), Antibiotics, Vitamin K, Ascorbic Acid

Predisposing factors The following factors contribute to the development of postinjection quadriceps contractures:

- Low socioeconomic conditions
- Poor nutrition
- Prolonged recumbency

Sites of contractures

- Vastus intermedius (due to the poor blood supply among the quadriceps groups)
- Vastus laterlais
- Tendinous band along the anteromedial border of the vastus lateralis
- Rectus femoris especially in Japan where injection are given in front of the thigh.

Clinical Features

- History of repeated intramuscular injection into the thigh
- History of previous some diseases in the infancy
- At birth both the knees appear normal
- Gradual limitation of the flexion, both active and passive, is then noticed by the parents
- In Asian countries, parents first become concerned when their child fails to squat
- A child walks with a straight knee gait.

Clinical Signs

Examination of the child should be carried out from the front, back and sides.

From the front

- Wasting of the front of the thigh
- Absence of skin creases over the knee
- Small patella
- High riding patella
- Forward inclination of the pelvis
- Injection scars are visible in the mid-thigh. These become prominent on flexion of the knee
- White patches and dimpling of the skin are due to subcutaneous atrophy
- Genu recurvatum may be seen with growth and subluxation could result
- Habitual dislocation is usually seen
- In a dislocated position of the patella, knee flexion is full.

From the sides

- Exaggerated lumbar lordosis
- Prominent abdomen
- Forward inclination of the pelvis

Clinical Tests

Thomas test: It is frequently positive.

Radiographic Findings

The knee is normal in early stages.

Treatment

Conservative methods: Physiotherapy and stretching has very little in the management of established quadriceps contracture and in mentioned here only for completion.

Surgery: This is the treatment of choice. Surgical lengthening of the quadriceps can be done either proximally or distally.

Surgical methods
Proximal release This is indicated during the early stages of contractures when there are no significant changes seen in the joint, Sengupta recommends proximal release.
- This helps to eliminate extensor lag and prevent hemarthrosis of the knee
- Here the affected muscle is in the upper lateral part of the thigh involving mostly the vastus lateralis and intermedius muscles.

Postoperative protocol
- The knee is maintained in full knee flexion for 4 weeks in a plaster slab.
- Quadriceps exercises are then begun.
- After 3-4 weeks, child is allowed to walk.
- After 12-14 weeks, it can be allowed to get up from the squatting position.
- Knee stretching exercises should be continued throughout the growth period.

Distal release: Thompson's quadriceps plasty This is the most commonly done procedure in India. The steps of the procedure are as follows:
- Anterolateral incision in the distal third of the thigh and the knee.
- Vasti is exposed and separated from the recti and also on the either side of the patella and partially excised.
- Remaining adhesions are slowly released by gradually bending the knee.
- If the rectus muscle is contracted-Y plasty is done.

Postoperative rehabilitation
- The leg is kept in plaster cast in a flexion of 70-90° for 2-4 weeks
- Later active and passive range of movements exercises are begun
- Knee stretching exercises are carried out for a prolonged period.

REGIONAL DISORDERS OF THE FOOT

ARCHES OF THE FOOT

The tarsal and metatarsal bones of the foot are bound by ligaments and arranged in the form of two arches, longitudinal and transverse. Integrity of these arches are maintained by
- Shape of the bones.
- Tension of the ligaments and plantar aponeurosis.
- Muscular action of both short and long muscles through bracing action of their tendons.

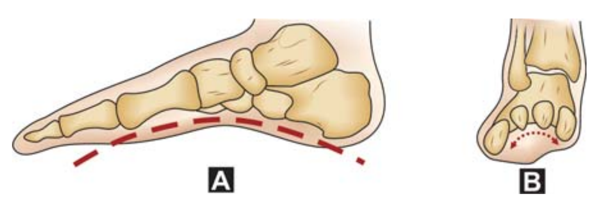
Longitudinal Arch

Longitudinal arch is of greater height and has a wider span along the medial side of the foot than the lateral (Fig. 19.97A). It has got two pillars, anterior and posterior. The posterior pillar is short and solid and is formed by calcaneus alone. Rest of the tarsal bones and metatarsal form the anterior pillar. The anterior pillar has got two columns, medial and lateral. Head of the talus forms the key stone of the summit and is situated between the deep socket formed by anterior end of calcaneum and navicular and is supported by the plantar calcaneo-navicular ligament called the spring ligament.

All other ligaments on the plantar surface of the bones of the foot play a part in maintaining the arches of the foot. They are assisted by extensive insertion of tibialis posterior and peroneus longus and especially by the plantar aponeurosis which joins the two ends of the arch and acts as a "tie beam."

Transverse Arches of the Foot

Transverse arches of the foot lie along the line of tarsometatarsal articulations (Fig. 19.97B). Inferior surfaces of the cuneiforms and metatarsal are narrow transversely and are held tightly together by plantar and interosseous ligaments and by tendons of peroneus longus. This arrangement gives the plantar surface in this region a much smaller transverse radius of curvature than the dorsal surface, thus, forming a well-defined transverse arch.



Figs 19.97A and B: Showing the longitudinal arch of the foot (A) and transverse arch (B)

Two conditions of clinical importance discussed in this chapter relates one to exaggerated longitudinal arch called the ***pes cavus*** and the other to loss of medial longitudinal arch called the ***pes planus.***

PES CAVUS

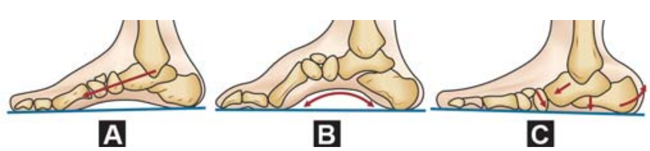
Pes cavus is a deformity characterized by an excessively high longitudinal arch that results from an equinus position of the forefoot in relation to the hindfoot (Table 19.13 and Figs 19.98A to C).

TABLE 19.13: Showing degrees of pes cavus, their corresponding deformities and treatment

Degree	*Deformities*	*Treatment*
• **First**	• Foot is normal • Deformity appears when foot is relaxed. • Flexible and corrected by pushing I MT bone manually up	• Daily manipulations • Exercises • Anterior arch bar • Night splint
• **Second**	• Equinus and pronation of I MT is fixed • Clawing of large toe • Early contractures of the plantar fascia	• Stiendler's operation • Jones transfer • EHL is transferred to the neck of I MT • Arthrodesis in adults
• **Third**	• All five metatarsals are in equinus • Calcaneus begins to invert • No bony deformities	• Extensor shift operation • Dwyer's osteotomy in children
• **Fourth**	• All the components of deformities become pronounced and resist passive correction • Some midtarsal movements are preserved	• Japa's 'V'-shaped osteotomy • Anterior tarsal wedge osteotomy
• **Fifth**	• Extreme degree of cavus foot • All components are fixed • Toes are dislocated dorsally • Plantar fascia is markedly contracted	• Bone wedge corrections of hindfoot and midfoot and triple arthrodesis

MT—Metatarsal, EHL—extensor hallucis longus

Note In this condition finger can be slipped under the navicular bone and it penetrates a distance of greater than 2 cm from the vertical edge of the foot.



Figs 19.98A to C: Showing (A) Normal foot, (B) Pes cavus, (C) Pes planus

Theories of Pathogenesis

- Weakness of intrinsic muscles of the foot.
- Over activity of the intrinsic.
- Muscle imbalance
  — Weak anterior tibial muscle and normal peroneus muscle.
  — Weakness of the calf muscles.

Pathologic anatomy This consists of dropping of the foot, contractures of the plantar fascia, varus of the heel, and clawing of the toes.

Classification

Pes cavus is classified as idiopathic, secondary due to diseases or trauma (Table 19.14).

TABLE 19.14: Classification of pes cavus

Idiopathic	*Secondary*	*Trauma*	*Others*
• Commonest type (80%) • Develops after 3 years of age • Male: Female 1: 1 • May be seen in spina bifida	• Spinocerebellar hereditary degeneration • Freidreich's ataxia • Poliomyelitis • Diseases of conus medullaris • Spina bifida • Cerebral palsy • Progressive peroneal palsy	• Direct trauma to the foot or the leg. • Compart-mental syndromes	• Myopathies • CTEV • Plantar fibromatosis

Clinical Features

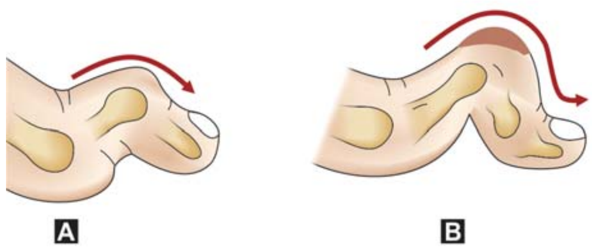
This consists of high medial longitudinal arch (Fig. 19.99), first metatarsal drop and pronation, tight plantar fascia, cock-up deformities of all the toes at the MTP joints, varus heel, and clawing (Figs 19.100A and B) of the toes (late feature).

Radiograph

AP view Talocalcaneal angle is decreased.

Lateral view Angle between 2 lines, one through the first metatarsal and another through the talus or calcaneus is decreased.

Fig. 19.99: Clinical photograph of pes cavus



Figs 19.100A and B: Showing (A) Claw toe, (B) hammer toe

Treatment

Correction of the primary deformity which is equinus and pronation of the foot is done first. Secondary deformities like contracted plantar fascia, clawed toes and varus of the heels are corrected next.

Early stages Require conservative line of treatment.

Late stages Surgery is required and it consists of soft tissue release in children and bony surgeries in adults. See the Table 19.8 for degree of pes cavus, their corresponding deformities and treatment.

Physiotherapy Measures

The following measures are suggested:

During the period of immobilization in a POP cast
- Active movements of the unaffected joints of hip, knee and ankle are encouraged.
- To strengthen the intrinsic muscles of the foot, strong toe flexion exercises are begun.

During the period of mobilization
- Foot is mobilized gradually.
- Intrinsic foot muscle exercises are begun
- Walking and standing on the outer border of the foot is encouraged.

PES PLANUS

Pes planus (flatfoot) refers to loss of medial-longitudinal arch of the foot (Fig. 19.98C). This condition is opposite to that of pes cavus described above (Fig. 19.101B).

Associated abnormalities
- Heel valgus.
- Mild subluxation of the subtalar joint.
- Eversion of the calcaneus at the subtalar joint.
- Lateral angulations at the metatarsal joint.
- Supination of the forefoot.
- Shortened tendo calcaneus.

Types

Pes planus could be congenital or aquired (Table 19.15).

TABLE 19.15: Types of pes planus

Congenital	*Acquired*
Causes	*Causes and varieties*
• Calcaneovalgus foot	• *Traumatic flatfoot* (fracture calcaneus; traumatic Pott's fracture)
• Vertical talus deformity	• *Relaxed or static* flatfoot (commonest)
• Talocalcaneal bar	• *Rigid flatfoot,* fibrous or bony ankylosis from any cause
• Congenital ligament laxity	• *Spasmodic flatfoot* due to spasmodic contraction of the peroneal muscles

Predisposing Factors

- General muscle hypotonia of the foot.
- Excessive fatigue of the foot muscles due to prolonged standing.
- Unsuitable footwear.

Clinical Features

Medial arch is obliterated, navicular bone is prominent, and fingers cannot be inserted under the arch and sole of the foot. Area of weight-bearing increases and may cause increased callosity. Pes planus could be flexible, rigid or static (Fig. 19.102A).

Flexible type On non-weight bearing, normal appearing arch develops.

Rigid type Could be semi-rigid or fixed. During non-weight bearing normal acceptable medial arch does not develop.

Static type This is the most common type; the reasons could be faulty postural activity of the muscles, equinus and varus deformity of the foot.

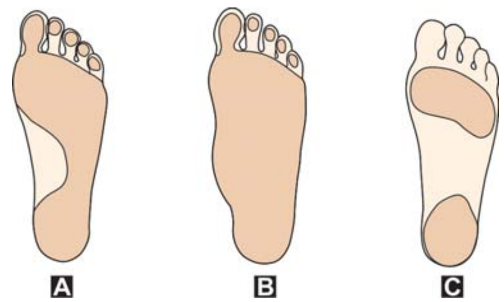
Peroneal or spasmodic flat-foot this is Common in young adolescents, patient complains of acute onset of pain, tightness, spasm of peroneal muscles, and eversion of foot. It is commonly associated with calcaneo-navicular bar. It can also be associated with conditions like tuberculosis, rheumatoid arthritis, which causes spasm due to reflex muscle reaction. For podoscopic appearance of different foot deformities (Figs 19.101A to C).

Radiograph

Plain X-ray of the foot especially the lateral view helps to determine the flat foot (Fig. 19.102B).

Treatment Plan

Fifteen to twenty percent of adults have flexible pes planus which are asymptomatic.



Figs 19.101A to C: Podoscopic front in: (A) Normal foot, (B) Flat foot, (C) Pes cavus

Figs 19.102A and B: Showing clinical photograph of the flatfeet (A) and plain X-ray lateral view (B)

Up to 3 years Orthopedic shoes with Thomas heels, medial heel wedges and navicular pads are recommended in this group.

Between 3-9 years of age

Asymptomatic cases need parent education.

Symptomatic cases require

— Orthopedic shoes for mild cases.

— Custom prosthesis for severe cases.

10-14 years age group

- *Asymptomatic* cases require no treatment.
- *Symptomatic* cases require molded orthoses worn in a sturdy shoe.

Surgical Correction

Principles of surgical correction

- This is done to relieve the disabling pain and not for cosmesis alone after exhausting every means of conservative management.
- Patient should accept loss of inversion and eversion of foot.
- Subtalar joint should be included for arthrodesis in the painful flatfoot.

Techniques

- Miller's flat foot procedure.
- Modified Hoke-Miller's flat-foot procedure.
- Durban's flat-foot plasty.
- Triple arthrodesis.
- In congenital variety displacement osteotomy of calcaneum.

Except for the calcaneal osteotomy all these procedures require arthrodesis of at least one metatarsal joint.

Physiotherapy Measures in Flatfoot

The following measures are suggested:

During the period of immobilization in a POP cast

- Active movements of the unaffected joints of hip, knee and ankle are encouraged.
- To strengthen the intrinsic muscles of the foot, strong toe flexion exercises are begun.

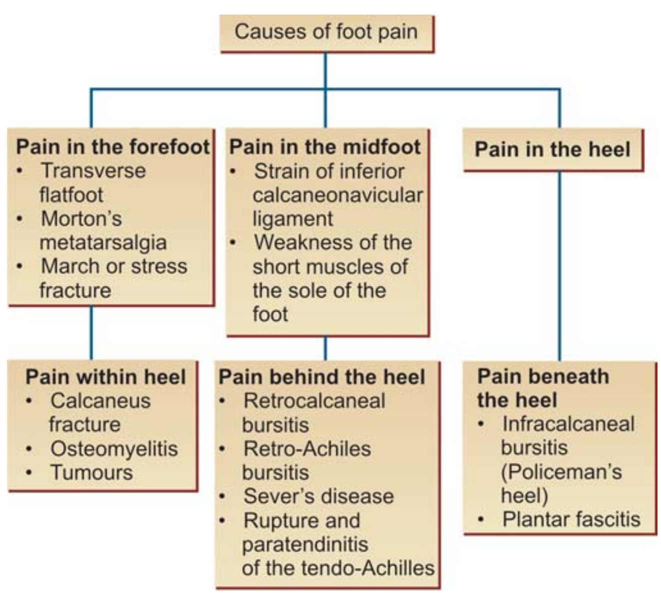
During the period of mobilization

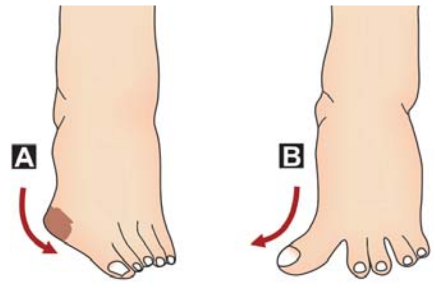
- Foot is mobilized gradually.
- Intrinsic foot muscle exercises in the form of toe curling; foot cupping, etc. are begun and performed in warm water.
- Walking and standing on the outer border of the foot is encouraged.

FOOT PAIN

Foot is one of the most common musculoskeletal problems and it could be due to problems in the forefoot, midfoot or hindfoot (Flow chart 19.6).

Flow chart 19.6: Showing causes of foot pain





Figs 19.103A and B: Prominent great toe deformities: (A) Hallux valgus, (B) Hallux varus

HALLUX VALGUS

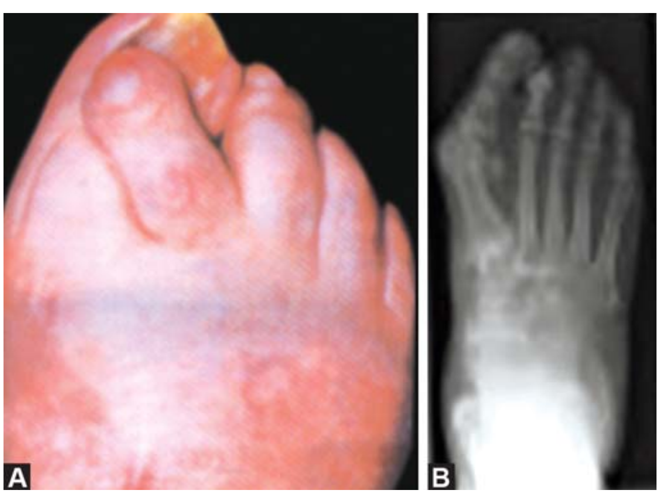
It is a deviation of the great toe at the metatarsophalangeal joint away from the midline (Figs 19.103A and B).

Causes

These are some of the important causes of hallux valgus:
- Wearing of tight socks and footwear
- Diseases like gout, rheumatoid arthritis, etc.
- More commonly seen in women (Male: Female = 1:10).
- Congenital.

Clinical Features

Deformity is the main complaint (Fig. 19.40A). However due to long standing deformity patient complains of pain in the great toe and also there could be ulceration on the medial side of the MTP joint of the great toe due to friction and pressure from the foot wears. However, there could be secondary changes due to the primary deformity and is enumerated below:
- Varus of the first metatarsal bone.
- Adduction of the phalanges.



Figs 19.104A and B: (A) Clinical photograph of hallux valgus, (B) Plain X-ray showing hallux valgus

- A protective adventitious bursa may develop over the medial aspect of the joint (called the Bunion)
- Hypertrophy of the medial end of the first metatarsal head.
- OA changes in the first MTP joint.
- New bone formation at the end of the I MTP joint
- Extensor hallucis tendon may be displaced laterally
- The bunion may get ulcerated and infected due to friction from tight footwear.

Radiograph

Plain X-ray of the fore-foot especially the AP view helps to determine the angle and extent of hallux valgus (Fig. 19.104B).

Treatment

Mild cases The following physiotherapy measures and footwear correction suffices in mild cases:
- Relaxed passive stretching of the abductors of great toe.
- Active exercises to the foot intrinsic muscles.
- Proper weight-bearing methods.
- Footwear with straight inner border with a wedge between the I and II toe helps.
- Faradic foot bath is recommended.

Severe cases In severe cases surgery is the treatment of choice and includes
- *Keller's operation* Excision of the head of the first metatarsal and proximal portion of the proximal phalanx.
- *Mayo's operation* here only head of the I metatarsal bone is excised.
- *Arthroplasty* Excision of the I MTP joint with Bunion.
- *Arthrodesis* of the I MTP joint is also done.

Physiotherapy Measures after Surgery

This is the same as mentioned above except that it is done more vigorously and patient needs training in weight bearing, gait and transfers.

HALLUX RIGIDUS

In this condition there is pain and stiffness in the MTP joint of the great toe.

Causes

- Repeated injuries to the great toe.
- Improper footwear.
- Familial and common in females.

There may be erosion of the articular cartilage and formation of exostosis.

Clinical Features

Consists of pain, swelling, tenderness over the first MTP joint of the great toe.

Radiograph

Plain X-ray of the forefoot - AP and lateral views helps to determine the severity of the condition.

Treatment

Mild cases
- Conservative measures like pain killers, etc.
- Thermotherapy helps to reduce pain and spasm.
- Footwear modifications like metatarsal bars, soft soles, etc.
- POP cast may be required in some cases.

Severe cases This may be treated by:
- Arthroplasty of the I MTP joint
- Arthrodesis of the I MTP joint.

Physiotherapy Measures following Surgery

This is the same as mentioned for hallux valgus.

METATARSALGIA

It is defined as a pain beneath the metatarsal heads or shafts. It may be due to trauma, inflammation and static causes (Fig. 19.105).

Types

- *Static metatarsalgia* Found with developmental anomalies like metatarsus primus varus, hallux valgus, metatarsus hypermobilis, obesity and debilitating illness.
- *Relaxation metatarsalgia* Interosseous muscle flex the MTP joints → extend the toes → draw the metatarsals together. Failure of these muscles causes splaying of the foot. The extra-weight borne by the metatarsal heads throws a strain on the transverse ligament of the metatarsal heads and pain results.
- *Compression metatarsalgia* is due to crowded footwear and this causes neuritis.

Fig. 19.105: Showing areas of pain in metatarsalgia

Clinical Features

In relaxation metatarsalgia (commonest variety), patient complains of pain beneath the metatarsal heads, compression of the foot increases the pain. Splay foot, atrophy of the interosseous muscles and clawing of the toes are the other features.

Radiograph

Plain X-ray of the fore foot especially the AP view is recommended as a routine and helps to rule out organic lesions and deformities.

Treatment

Treatment consists of intrinsic muscle exercises, well designed shoes, pad and strapping changed at intervals of one week, support of inner sole with pad and oblique osteotomy of the metatarsal necks for metatarsalgia associated with metatarsal head prolapse.

MORTON'S METATARSALGIA

In 1876, *Morton described a condition of pinching of the lateral plantar nerve in the fourth web space between the mobile fourth and fifth metatarsal heads of the foot (Figs 19.106 and 19.107).

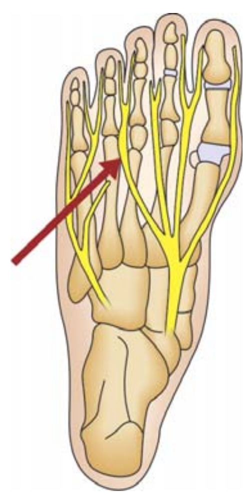


Fig. 19.106: Morton's neuroma

Clinical Features

Patient complains of pain in the region of the third and fourth metatarsal heads. By walking pain increases and decreases by rest.

*George Thomas Morton (1835-1903) of Philadelphia, USA

Fig. 19.107: Clinical photograph of Morton's neuroma

Mulder's click When neuroma is squeezed between the metatarsal heads a click is felt. This is common in women and is usually unilateral.

Radiograph

Plain X-ray of the fore foot especially the AP view is recommended as a routine and helps to rule out any bony problems.

Treatment

Nonoperative treatment This consists of shoes with metatarsal bars, local infiltration of hydrocortisone, wide toe box use is unpredictable, etc. are some of the common nonoperative methods of treatment.

Surgical treatment is mainly excision of the neuroma in the third web space and this has an 83 percent success rate.

Physiotherapy Measures in Morton's Metatarsalgia

- *Measures to relieve pain* This can be done by appropriate thermotherapy.
- *Measures to strengthen the intrinsic muscles of the foot* This can be done by the following methods:
  - — Toe curling exercises in warm water.
  - — Foot cupping exercises.
  - — Gripping a piece of cloth with the foot.
- *Measures for walking* This consist of the following methods:
  - — Walking on the outer border of the foot.
  - — Curling the toes and actively holding it while walking on the outer border of the foot helps considerably.
- *Supportive measures*
  - — Providing metatarsal bars in the sole of the footwear to relieve pressure over the metatarsal heads (Figs 19.108A and B).
  - — Avoiding high heeled footwear and using soft cushions within the shoes helps.

Figs 19.108A and B: Showing incorporation of metatarsal bars, under the sole of the footwear

PAINFUL HEEL

Heel pain is the 2nd most common foot complaint next only to the toe nail pain. The following are some of the common causes of pain in the heel (Fig. 19.109):

- Traumatic disturbances.
- Developmental and pathological disturbances
- Epiphysitis of the calcaneum.

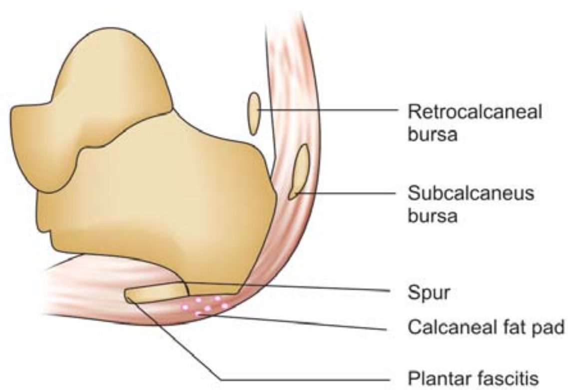


Fig. 19.109: Showing causes of heel pain

TRAUMATIC DISTURBANCES

Trauma to the back of the heel, around insertion of the tendocalcaneus, and plantar aspect of the heel.

Trauma around the region of tendo-Achilles Tenosynovitis of tendo-Achilles, formation and initiation of enlarged bursa and partial tendon tears. In all the above cases, pain increases on movements and decreases by rest.

Hagelands Disease or Winter Heel

In this condition, tenosynovitis leads to fibrous deposits which press on the back of the tendoAchilles of the heel on wearing a boot and cause pain.

Bursal Enlargements

Normal bursa is present between the tendon and the calcaneus.

Adventitious bursa is subcutaneous and forms over the most prominent part of the posterior surface of the bone.

BURSITIS

It is inflammation of the adventitious bursa due to repeated friction from an ill fitting footwear or may be due to trauma and rarely infection.

Clinical Features

Pain in the heel is the main complaint and it accounts for nearly 39 percent of the cases of pain in the heel. A tender hard lump usually forms over this and is called the "*knobby heels*". It is seen in children and adolescents in whom it is liable to develop due to friction by an ill-fitting boot.

Radiograph

Plain X-ray of the heel especially the lateral view is recommended and it helps to detect the calcaneal and the retrocalcaneal spurs.

Treatment

Conservative treatment consists of beating out the lateral half of the counter of the shoe at the back of the heel.

Surgery is the treatment of choice and consists of removal of the prominent posterosuperior angle of the calcaneum and any exostoses. In younger children excision of a large wedge shape of bone is found to be useful.

Partial tears of tendo-Achilles Here pain is due to fibrous tissue or periostitis. Treatment consists of rest, and below-knee cast in full equinus for first 3 weeks and later for 2 weeks in neutral position.

NON-TRAUMATIC HEEL CONDITIONS

Plantar fascitis Repeated sustained stress of weight-bearing during walking, running, climbing, etc. over a number of year's causes in micro trauma to the plantar fascia which results in inflammation and pain.

Clinical Features

Patient complains of pain in the sole or heel during weight-bearing and is relieved once it is discontinued. On examination, there will be tenderness over the medial side of the calcaneum (Fig. 19.110). It is characterized by pain at the insertion of plantar fascia (Fig. 19.111) and is also seen in gout, RA, inflammatory

Fig. 19.110: Showing the method of eliciting tenderness in plantar fascitis

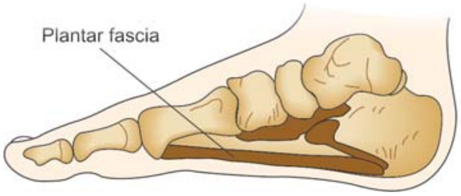


Fig. 19.111: Showing the plantar fascia

conditions, overweight, flat feet, fat pad atrophy etc. Probably the number one cause is lack of flexibility in the calf muscles.

Radiograph

Plain X-ray of the hind foot especially the lateral view is recommended and this helps to detect the presence of calcaneal spurs.

Treatment

Conservative treatment Consists of NSAIDs, injecting local steroids and footwear correction and wearing heel cushions like MCR foot wear, etc.

Surgery If the conservative treatment fails, surgical release of the plantar fascia through a proximal medial longitudinal arch incision is contemplated.

Physiotherapy Measures

Physiotherapy plays a very important role in the management of these conditions and involves the following measures:

- Stretching of the calf muscles
- Ice therapy after the activity
- Taping
- Rest to the feet

- Arch support and heel pads
- Losing weight

CALCANEAL SPURS

It is a spike of bone at the anterior edge of the calcaneal tuberosity (usually medial) and is called calcaneal enthesiopathy.

Incidence

- 8 to 21% of the population has calcaneal spurs.
- 30-70% of the patients with heel pain have heel spurs

Causes

Though the exact cause is still now known however the following reasons could lead to the development of calcaneal spurs**:**

- Repeated attacks of plantar fascitis.
- Repeated trauma.
- Constant pulls of the shortened plantar fascia.
- Ill-fitting footwear (Figs 19.112A and B).
- Fibromatosis of the plantar fascia.

Figs 19.112A and B: Showing (A) Correct footwear, (B) Improper footwear which distorts the normal arches of the foot

Clinical Features

Patient complains of pain over ball of the heel (Fig. 19.113), tenderness on plantar aspect of the heel (Fig. 19.114), slight swelling at the attachment of plantar fascia. It is due to fibrositis or traumatic detachment of plantar fascia and does not give rise to symptoms perse and the pain when present is due to the causative condition and not the spur.

Fig. 19.113: Showing the calcaneal and retrocalcaneal spurs

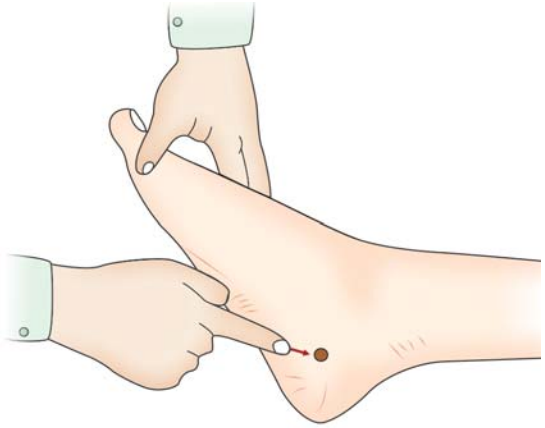


Fig. 19.114: Showing the point of tenderness in plantar fascitis and calcaneal spur

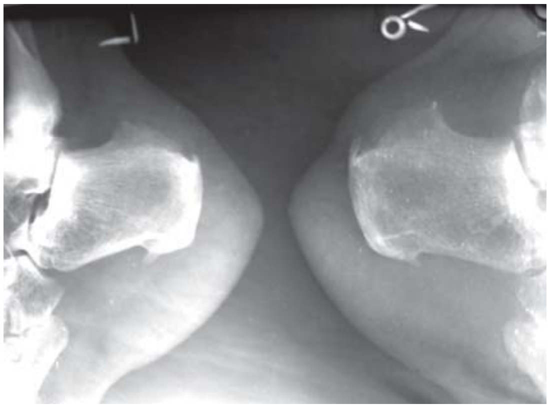


Fig. 19.115: Radiograph showing the presence of calcaneal spurs on both sides in the lateral view

Radiograph

Plain X-ray of the foot especially lateral view of the heel helps in identifying the bony growth from the calcaneal tuberosity (Fig. 19.115).

Interesting facts about heel spur syndrome

- It is called “Toothache in the heel”.
- Every year 1% of the population seek help.
- Heel spur also called Medial Sub-calcaneal Exostosis
- Coin Test: If a small coin or firm pressure or a soft pad applied beneath the heel for 2 minutes, relieves pain, then it is diagnostic.
- Too much time on the feet is the cause.
- Hence, the best treatment is to spend less time on the feet.

Fig. 19.116: UC-BL shoe inserts to relieve heel stress in plantar fascitis and calcaneal spur

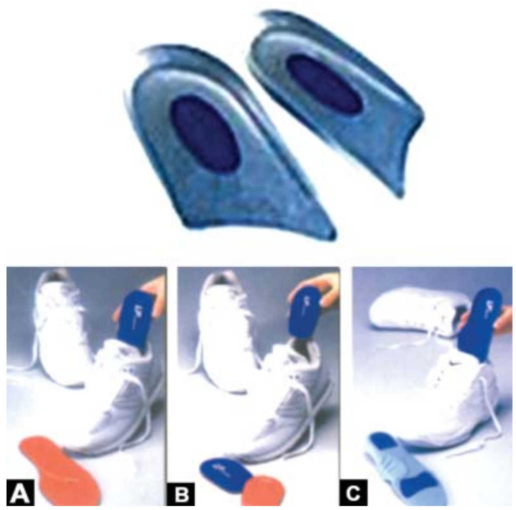
Treatment

Conservative methods include treating the causative factor, rest, NSAIDs, local infiltration of hydrocortisone and microcellular rubber used for the sole of the footwear.

Physiotherapy Management

The following physiotherapy measures are suggested:

- *Measures to relieve stress on the plantar fascia*
  — After prolonged sitting or while getting up in the morning from bed, patient is instructed to bear weight on the toes instead of the heel.
  — During walking an appropriate wedge in the heel (e.g. UC-BL shoe insert) (Fig. 19.116) to increase the angle between the hind foot and forefoot is inserted. This relaxes the plantar fascia and relieves stress on it. This is very effective in reducing the pain.
  — Alternatively an elongated soft heel-pad (Figs 19.117A to C) or well padded medial arch could also be used.



Figs 19.117A to C: Showing various types of heel cushions

- *Measures to strength the intrinsic muscles of the foot:*
  — As soon as the patient gets up in the morning he is instructed to immerse his foot in warm water and curl his toes and hold it for sometime. This method is very effective in reducing the morning pain and exercising the intrinsic muscles of the foot.
  — This exercises of sustained toe curling and holding it for some time in an effort to exercise the intrinsic muscles of the foot can also be practiced by the patient within the shoes for several times everyday while standing, sitting, etc.
  — Faradic stimulation of the foot.
- *Measures to maintain the longitudinal arch of the foot*
  — By inserting proper 'shoe inserts' as already mentioned.
  — Walking on the outer border of the foot with the toes curled up either bare foot or within the shoes during walking, standing, sitting, etc. is also very effective.
  — For patients suffering from pain due to calcaneal spur, a sarbo-rubber heel pad is used. Foot as back as possible the foot is planted over knee a plinth and moves forward over it and maintains the flexion for some time.
- *Measures to strengthen the leg and the calf muscle.*
  — *Straight leg raising exercises* these exercises help to regain the strength and endurance of the lower limb muscles. Initially the patient lifts the leg without the heel touching the bed and holds it for sometime. Gradually weight upto a maximum of 10-15 lb is put and the exercises are carried out.
  — For knee flexors, bicycle peddling after adjusting the seat height to avoid excessive tension on the knee, progressing from half circle to full is practiced.
  — Prone lying knee flexion also helps.
  — *Isokinetic exercises these* exercises help to restore back the quadriceps and hamstrings muscles to its normal strength.

Gradually, the ROM exercises are made more vigorous. Prone kneeling, squatting, climbing and getting down staircases, cross-leg sitting, spot running; jogging and aerobic exercises are practiced.

Surgery is indicated when no relief is seen with conservative treatment methods mentioned above.

Methods

- Osteotomy of the calcaneus.
- Decompressing operation with multiple drill holes in the calcaneus.
- Excision of the medial inferior tuberosity of the calcaneum.

Traumatic subtalar joint arthritis develops due to calcaneal fracture. Some other causes are TB, syphilis, gonococcal arthritis, etc.

EPIPHYSITIS OF THE CALCANEUM

***Sever's disease** this is commonly seen in the age group of 9 to 13 years. It is common in boys and is due to inflammation of bursa beneath the tendo-Achilles tendon.

Clinical Features

It is usually asymptomatic but there could be pain behind the heel due to the development of infection or fracture of the epiphysis following trauma to the heel.

Radiograph

Plain X-ray of the Hind foot especially the lateral view is recommended and it helps to detect the epiphysitis (Fig. 19.118).

Fig. 19.118: Showing calcaneal epiphysitis over the lateral view of the plain x-ray of the heel

Treatment of *Rest* and footwear correction usually helps to relieve pain.

Fibromatosis of the plantar fascia In this condition nodules formation are seen which becomes painful with pressure and weight-bearing. It is similar to Dupuytren's contracture, and is seen commonly in patients with anti-epileptic drugs.

Physiotherapy Management for all these above heel problems more or less remains the same as for the calcaneal spur and plantar fasciitis.

***James Warren Sever,** Boston, USA (1878-1964). Described this condition in 1912.

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20

Chapter

Hand Disorders

Hand is a very important organ of the body. Disorders affecting the hand could lead to loss of hand function in various forms and degrees. Thumb itself accounts for over 40 percent function of the hand. It is imperative that the problems affecting the hand should be diagnosed and managed correctly.

ANATOMY OF THE HAND

An attempt is made here to present a brief anatomy of the hand. The hand consists of five digits, i.e. four fingers and one thumb. Each digit has a corpometacarpal joint and a metacarpophalangeal joint. The fingers have two IP joints while the thumb has only one. 19 bones and 19 joints make up the hand. The other structures of the hand are as following.

Skin

There are extensive innervations on the volar surface of the hand. This is essential for the function of the hand. Dorsum of the hand has loose skin and is less sensitive than the palmar aspect.

The Muscles and the Nerves

There are two sets of muscles bringing about the hand functions.

1. *The extrinsic muscles* These originate in the forearm and act on the hand. This comprises the superficial and deep forearm flexors and extensors.
2. *The intrinsic muscles* These muscles arise in the hand and act on the digits. It consists of:
   - *The hypothenar muscles* Abductor digit minimi, flexor digiti minimi, opponens digiti minimi.
   - *The thenar muscles* Abduction pollicis brevis, flexor pollicis brevis, adductor pollicis, opponens pollicis.
   - The lumbricals are four in number.
   - The interossei: 3 palmar and 4 dorsal interossei muscle.

The hypothenar, interossei, adductor pollicis and medial two lumbricals are supplied by deep branch of the ulnar nerve and the remaining muscles by the median nerve.

The Joints and Ligaments of the Hand

This consists of the metacarpophalangeal, proximal, middle and distal interphalangeal joints supported by ligaments (Table 20.1).

After a brief anatomy of the hand let us now study some of the important hand functions.

Hand Function

The important functions of the hand are:

- Power grip
- Precision grip.

Table 20.2 shows the functions brought about by various hand muscles.

Power grip This is achieved by flexion of all the fingers and rotation with ulnar deviation towards the thenar eminence. The wrist is slightly extended and ulnar deviated. The thumb assumes the sideways position.

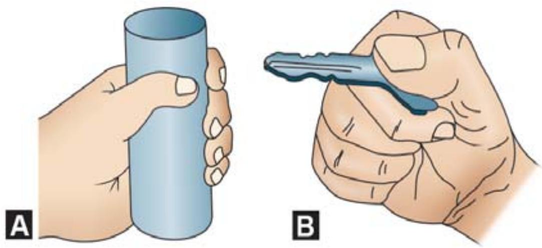
All this enables the hand to make a powerful grip to hold the objects (Fig. 20.1A).

Precision grips in these four types are described:

1. Flexion, extension at MP joints and slight flexion at IP joints.
2. *Key grip* here the thumb is adducted, flexed and opposed to the radial side of index finger (Fig. 20.1B).
3. *Opposition* Here the thumb is adducted, flexed and opposed. The little and ring fingers are rotated inwards and

TABLE 20.1: Showing joints and ligaments of the hand

The joints	*Types*	*Movements*
• PIP/DIP	Bicondylar joints 6-13° obliquity	Flexion/extension. This helps in opposition with the thumb
• MP joints	Condylar joints	Flexion/extension Radial/ulnar deviation
• Carpometacarpal joints		
— Index, middle, ring	Plane joint	Flexion/extension
— Little finger	Semisaddle joint	Flexion/extension Rotation (for opposition)
— Thumb	Sellar joint	Flexion/extension/adduction, abduction and rotation
Ligaments		
• Stability to the hand is provided by		Ligaments of radiocarpals, Intercarpal,Carpometacarpal, Metacarpophalangeal joints
• Support and stability		Capsular and extracapsular ligaments
• Grasping and prehensile activities		Transverse intermetacarpal ligament



Figs 20.1A and B: Showing different types of hand grips: (A) Power grip, (B) Key grip (precision grip)

in radial deviation while the middle and index fingers are rotated inwards and deviated medially.

4. *Pinch* Same as opposition. Here there is strong flexion of the IP joint of the thumb with the concerned finger (Fig. 20.2).

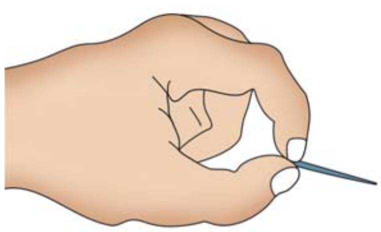


Fig. 20.2: Showing pinch grip

Note Lesions of the ulnar nerve affect the power grip. Lesions of the median nerve affect the hand precision.

Sensory Supply

The hand is richly supplied by sensory fibers from the median and ulnar nerves.

An attempt is made here to present a brief description of some of the important hand disorders.

TABLE 20.2: Showing the action and role of hand muscles

Hand muscles	*Functions*
• FDP	Active during flexion of the fingers
• FDS	Flexion and grip
• Interossei	• MCP joint flexion, deviation and rotation • Extension of IP joints Help both in power and precision grips
• Lumbricals	Flexion of MCP joint Extension of PIP joints These flex the MCP joints only when the IP joints are held in extension
• EDL	Helps primarily in pincer grip. Mainly extends the MCP joints

CONGENITAL ANOMALIES OF THE HAND

Some of the important congenital anomalies of the hand are:

Polydactyly It is a duplication of one or more digits and may require amputation for cosmetic purposes (Fig. 20.3).

Fig. 20.3: Clinical photograph of polylactyly

Syndactyly This is fusion of digits and usually occurs between the middle and ring fingers and is three times more common in males. The fusion may be only in the skin or all the structures. In the latter case surgery is done early at 18 months age and in the less severe former case surgery is done after 5 years.

Macrodactyly This is a rare congenital anomaly and is characterized by enlargement of all structures especially of the nerves of a single or more digits. It is often associated with neurofibroma, lymphoangioma, arteriovenous malformation, etc.

Congenital trigger digits Thumb is more commonly involved. It is frequently bilateral and is due to flexion contracture of the distal joint of the thumb. More than 30 percent of these cases resolve after first year and the remaining may require surgical release after 2 years of age.

Streeter's dysplasia This is a syndrome of congenital constrictions which may affect any part of the body. In the hand it may range from simple constriction to congenital amputation. To prevent distal circulatory compromise it frequently requires surgical release by Z-plasty.

Camptodactyly This is a flexion contracture of the proximal interphalangeal joint especially of the little finger. It may rarely be seen in other fingers too. Severe deformity in older patients requires tendon lengthening procedures. Clinicodactyly is angulation of the finger in radioulnar direction. Mild clinodactyly is seen in normal children while the severe ones are associated with mental retardation.

Cleft hand (also called Lobster claw hand) This is frequently bilateral and is associated with cleft foot, cleft lip, cleft palate, etc. There are two varieties in the first line a deep palmar cleft separates the two central metacarpals and in the second type the central rays are absent. Both the varieties require surgical excision and Z-plasty.

Mirror hand (reduplication of ulna) Here the ulna and carpus are reduplicated and there may be seven or eight fingers with no thumb. Pollicization of a finger solves the problem of the absent thumb.

Congenital radioulnar synostosis (*see* page 392)

Madelung's deformity (*see* page 393)

Congenital absence of radius or ulna Congenital absence of radius is more common than that of ulna. The radius may be completely absent or in parts. The forearm is short, wrist is highly unstable and the hand is deviated radially. It requires complex and difficult surgical corrections.

This deformity of radius absence is also called radial club hand and the absence of ulna is called the ulnar club hand (1:4).

Kirner's deformity This is a spontaneous injuring of the terminal phalanx of the fifth digit. It is a rare disorder and is more often seen in females.

INJURIES OF THE HAND

This can be best discussed under the following heads:
- Fractures and dislocations.
- Tendon injuries.
- Soft tissue injuries of the hand.
- Crush injuries of the hand.

FRACTURES AND DISLOCATIONS OF THE HAND BONES

General Principles

This includes injuries to the phalanges, metacarpals and carpal bones. The following principles should be followed in treating hand fractures:
- All stable fractures need closed reduction and splinting.
- K-wire is the commonly used internal fixation device.
- While using the K-wire, injury to the tendons, ligaments and extension into the joints should be avoided.
- Rotational malalignment of the fingers (Fig. 20.4) should be avoided and this can be done by evaluating the rotation by looking at the alignment of the fingers when the fingers are flexed at metacarpophalangeal and interphalangeal joints. The fingers should point towards the scaphoid bone.

Fig. 20.4: Showing assessment of rotational malalignment of fingers

- The safe position for hand immobilization is 70° flexion at MCP joint, 15-20° flexion at PIP joint, and 5-10° flexions at DIP joint. This is called the intrinsic plus position or the James position (Fig. 20.5).

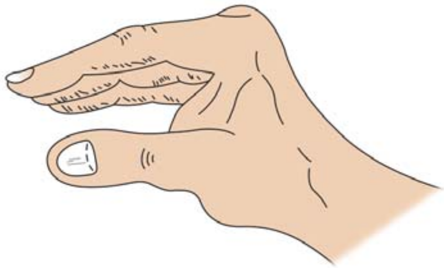


Fig. 20.5: Functional position of the hand (James position)

Management of Hand Injuries

Conservative Most of the hand injuries can be managed conservatively. These include undisplaced fractures and soft tissue injuries. The important conservative methods are buddy taping (Fig. 20.6), POP slab or cast and use of hand splints to immobilize the fingers (Flow chart 20.1).

Fig. 20.6: Clinical photograph showing Buddy-taping

Surgery This is done specific indications:

Indications for open reduction in hand injuries are:

- Intra-articular fractures with a small fragment.
- Severely displaced fractures.
- Highly unstable fractures.
- Multiple fractures.
- Soft tissue (e.g. tendon) interposition.

After open reduction, internal fixation is usually done by K-wires (Fig. 20.7). Intraosseous tension band circlage wiring, intramedullary fixation, small AO plate and screws are the other but less commonly used fixation methods.

Role of Hand Splints

Splints play a very important role in the management of hand injuries. A brief description of various hand splints is given in Flow chart 20.1.

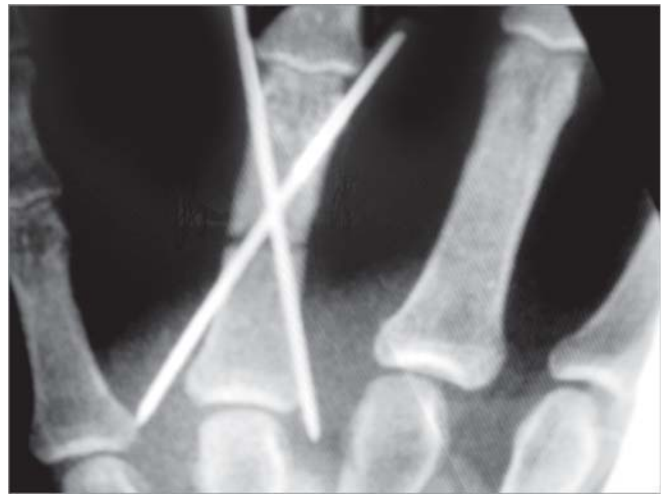


Fig. 20.7: Plain X-ray showing K-wire fixation in phalanges

Flow chart 20.1: Showing different types of hind splints

- **Hand splints**
  - **Static splints**
    - Types
      - Anti-swan neck splint
      - Anti-Boutainnaire splint
      - Safe position splint
      - Functional position splint
      - Cock-up splint (Fig. 20.9)
      - Opponens splint (Fig. 20.8)
  - **Dynamic splints**
    - Types
      - Dynamic wrist flexion extension splint (Fig. 20.10)
      - MP joint flexion extension spint (Fig. 20.11)
      - PIP joint flexion-extension splint (Fig. 20.12)
      - Buddy system splint
      - Dynamic thumb splint
    - **Low profile**
      - Outrigger not attached to rubber band
    - **Hight profile**
      - Outrigger attached to rubber band

Functions of a Splint

Table 20.3 show different types of splints and their functions.

Static Splints

- This provides rest and support to the acutely inflamed joints of the fingers.
- It helps to maintain the joint in correct positions.
- It supports the lax joints.
- It prevents contractures and consequent deformities.
- It provides stability to a proximal joint to facilitate action on a distal joint (e.g. cock-up splint).

TABLE 20.3: Types of static and dynamic splints

Type of splints	*Description*	*Role*
I. **Static splints (Figs 20.8 and 20.9)**		
• Anti-Swan neck	Made up of plastic material	Prevents hyperextension at the PIP joint
• Antiboutainnaire	Same as above	Reverse of (1) above.
• Safe position (James)	• Wrist in 30° extension • MP joints in 90° flexion • PIP/DIP—neutral • Thumb in abduction and opposition	Prevents flexion contractures especially after burns
• Opponens	Maintains the thumb web space	Holds the thumb in maximum opposition
• Wrist cock-up	Simple splint	Holds the wrist in 25-30° of extension
• Functional position splint	Same as 3 above	Except MP and IP joints are in 40-45° of flexion
II. Dynamic splints (Figs 20.10 to 20.12)		
• Wrist flexion extension	• It allows flexion and extension at the wrist and can maintain it in a desired range • By adjusting the outrigger it can be made low or high profile	• Flexor/extensor tendon repair • Wrist arthroplasty
• MP joint flexion extension	• Can be made assistive or resistive	• MCP joint arthroplasty • Soft tissue injury • Extensor tendon repair • PIP joint arthroplasty
• PIP joint flexion extension	• Immolise the proximal phalanx • By adjusting the outrigger rubber band, it provides controlled resistance and dynamic assistance to the middle phalanx	• Flexor or extensor tendon repair • After PIP joint arthroplasty
• Finger trapper or Buddy system splint	Here active face of one digit is used to mobilize the adjacent finger	• Soft tissue injury • Joint pathology • Fracture of the phalanx • Anxious patients
• Dynamic thumb	Maintains the webspace of the thumb	To mobilize the MCP/IP joints of the thumb

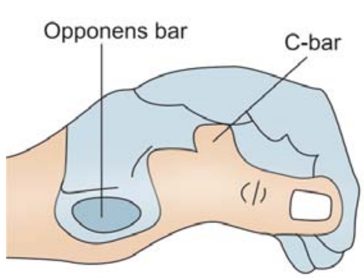


Fig. 20.8: Opponens splints

Dynamic Splints

The functions of the dynamic splint are as follows:

- *Stretching* Through a sling and rubber band it offers low stretching effect to the scar tissues.
- *Controlled resistance* It offers controlled resistance to the tendons facilitating easy glide.
- *Mobility* By providing continuous low load stretching, it helps in the mobilization of the stiff joints.

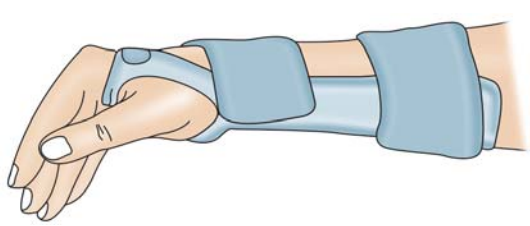


Fig. 20.9: Coock-up splint

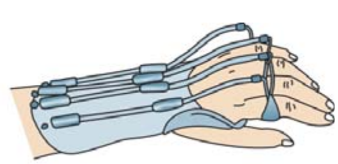


Fig. 20.10: Dynamic wrist splint

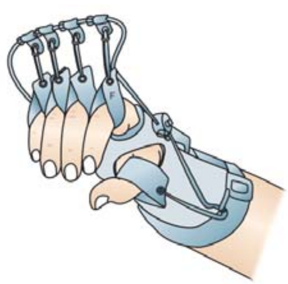


Fig. 20.11: MP joint flexion extension splint

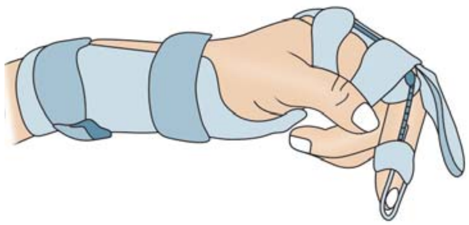


Fig. 20.12: PIP joint flexion extension splint

- *Protection* It protects the weak muscles from being pulled by the normal opposing muscles.
- *Re-education* it provides re-education to the weak or paralyzed muscles.

Quick Facts

What are the materials used for making hand splints

- Plaster of Paris
  - Do not require heating.
  - Used commonly as a static splint.
  - Can be made dynamic by attaching an outrigger.
- Plastics
  - Low temperature.
    - i. Very commonly used.
    - ii. Orthoplast, aquaplast, polytorm—types.
    - iii. It is easy to fabricate, light and cosmetically acceptable.
  - High temperature
    Molding is needed to fabricate them.

  For strapping the splints—Velcro materials are ideal.

METACARPAL BONE FRACTURES

Metacarpals are short bones and are divided into base, shaft, neck and head. Fractures could involve any of these areas. These fractures are discussed as under:

Metacarpal bone fractures involving the carpometa-carpal joints In the thumb it is called Bennett's fracture and Rolando's fracture.

In the remaining four medial metacarpals, these fractures need closed reduction in early stages and open reduction in late stages with K-wire fixation.

The displaced intra-articular fracture of the base of the fifth metacarpal bone is similar to Bennett's fracture of the thumb with the extensor carpi ulnaris tendon acting as the displacing force. If not properly reduced, malunion results leading to weakness of grip and painful joints.

Metacarpal shaft or neck fracture The common causes for these injuries are direct hit on the dorsum of the hand as in assault, boxing, fall, road traffic accident (RTA), etc. These fractures should be accurately reduced with no rotational malalignment and immobilized with either plaster (common) or percutaneous or open K-wire fixation (less common). Fracture of the fifth metacarpal neck is known as *Boxer's fracture* (Figs 20.13A and B).

Metacarpal head fractures These are also known as *'fight bite'* fractures as they occur when the patient strikes an opponent's teeth in a fist fight. They are frequently intra-articular and need open reduction and internal fixation with K-wire.

Fig. 20.13A: Metacarpal shaft fracture

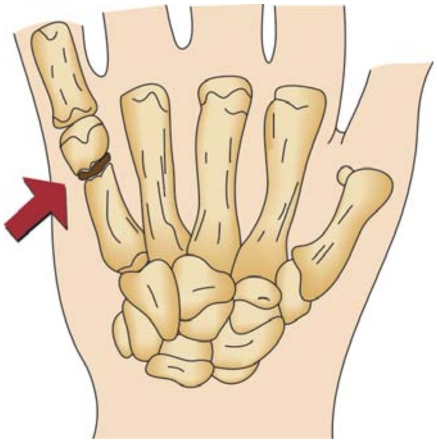


Fig. 20.13B: Showing fracture neck of V metacarpal bone (Boxer's fracture)

Figs 20.14A and B: (A) Plain X-ray showing phalangeal fracture with fracture dislocation (B) Plain X-ray showing K-wire fixation in phalangeal fracture

FRACTURE OF THE PHALANGES

Fracture of proximal or middle phalanx These are due to direct blow on the dorsum of fingers (Figs 20.14A and B). The fracture is angulated towards the palm. Rotational malalignment should be strictly avoided. These are best managed by conservative methods while highly unstable oblique fracture require open reduction and K-wire fixation. Severely comminuted fractures are aligned best by external fixators.

Fracture of distal phalanx These fractures are usually caused by crushing injuries; they are frequently comminuted and require only splinting. K-wire fixation may be required for open injuries.

Fracture dislocations of proximal IP joint This usually results in an unstable volar displacement of the middle phalanx. If the displacement is more than 50 percent, ORIF with K-wire is done.

Dislocation of metacarpophalangeal joints These are due to hyperextension injuries and could be simple or complex with the dislocation being dorsal. Simple dislocations can be treated conservatively while complex ones require open reduction.

Complications

The important complications of finger bone fractures are nonunion, malunion tendon adhesions, joint stiffness, infection, etc.

Metacarpals and phalangeal fractures and their physiotherapy treatment has been discussed in Chapter 10 (Injuries of the Forearm, Wrist and Hand).

TENDON INJURIES

Either flexor or extensor tendons of the hand can be injured when the patient sustains hand injuries by a sharp cutting object. Flexor tendons are more commonly injured than the extensors (Fig. 20.15). These tendon injuries are more often missed by the clinician who treats it, if he or/she does not explore the hand or the wrist wounds and look for the possibility of tendons being severed. Old healed scars over the hand or wrist with loss of function of the injured tendon confirms the diagnosis.

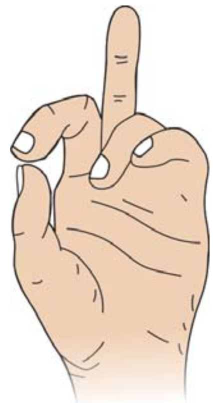


Fig. 20.15: If the flexor tendon is injured, the finger does not flex but remains straight

FLEXOR TENDON INJURIES

Both flexor digitorum superficialis (FDS) and flexor digitorum profundus (FDP) could be injured single or together. Flexion of the proximal interphalangeal joint of the fingers is brought about mainly by FDS and since FDP crosses this joint, it also aids FDS but FDP is solely responsible for the flexion of distal interphalangeal joint (Fig. 20.16).

Tests to Diagnose Flexor Tendon Injuries

Flexor digitorum profunds (FDP) (Fig. 20.17) Instruct the patient to actively flex the DIP joint while you stabilize the PIP joint. If he or she can flex it, there is no injury to FDP tendon.

Fig. 20.16: Clinical photograph of flexor tendon injury

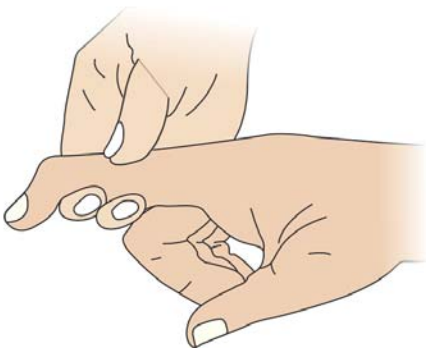


Fig. 20.17: Clinical method of testing FDP

Flexor digitorum superficialis (FDS) (Fig. 20.18) Hold the two adjacent fingers in complete extension. This anchors the FDP tendon in the extended position and prevents it from flexing the PIP joint, now ask the patient to flex the fingers if he or she can do it then FDS is intact.

Fig. 20.18: Clinical test to FDS injury

Both FDS and FDP stabilize The metacarpophalangeal joint and instruct the patient to flex the finger. If he or she cannot flex either the DIP or the PIP joints both the tendons are cut.

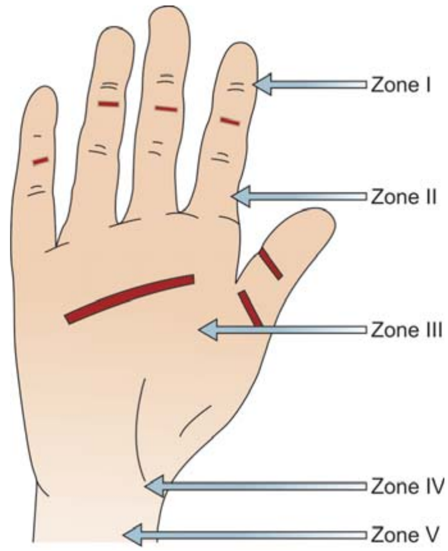


Fig. 20.19: The flexor zones of the hand

Flexor pollicis longus Stabilize the MP joint of the thumb and instruct the patient to actively flex the IP joint, if he or she can do it FPL is intact.

Flexor Zones of the Hand

It is extremely important to know the zones of injury with regard to flexor tendon injuries of the hand and wrist. There are five zones (Fig. 20.19):

- Zone I — This extends from the tip of the finger to the middle of the middle phalanx.
- Zone II — This extends from the middle of the middle phalanx to the distal palmar crease.
- Zone III — This overlies the palm.
- Zone IV — Overlies the transverse carpal ligament of the wrist on the carpal tunnel.
- Zone V — Extends from the wrist crease to the level of the musculocutaneous junction of the flexor tendons.

Importance of the Zones

Bunnel has labeled Zone II as *no-man's* land and is a critical area of pulleys. These pulleys help in the tendon movements. Primary repairs at this level invariably fail due to the adhesions in the area of pulleys.

- Zone I — Here the injuries to the profundus tendon are not very common and tendodesis of the DIP joint usually suffices.
- Zone II — In this zone, for reasons already mentioned, tendon grafting is preferred over tendon suturing.

Zone III In this zone (also called the lumbrical zone); the severed tendons can be repaired primarily.

Zone IV Primary suturing of the flexor tendons gives good results for injuries in this zone.

Zone V In this zone, primary suturing of the cut flexor tendons poses no problems.

Methods of Treatment

Primary repair This is indicated in fresh, clean-cut wounds. Here the tendons are primarily sutured end to end, end to side or by various special suturing techniques.

Secondary repair This may be necessary in severe hand injury, contamination, skin loss, etc. Here after the initial debridement tendons are secondarily repaired after 2 to 3 weeks.

Tendon transfers This can be thought of if the patient comes to the treatment late or the previous measures have not been successful. In this a normal functioning tendon is used to replace the damaged tendon and for this to happen all the necessary criteria for tendon transfers should be fulfilled.

Tendon grafting In the event of loss of tendons due to crush injury, tendon grafting can be considered. Donor tendons for grafting in order of preference are the palmaris longus, the plantaris, the long extensors of the toes, etc.

A single or two stage grafting is preferred in old tendon injuries.

Single stage Here the tendon graft is sutured to the proximal and distal cut ends of the tendon in a single sitting.

Two stages This procedure is preferred in situations where the fibrosis is dense or in contractures.

In the first stage, a silastic smooth rod is placed in the tendon and the pulleys are reconstructed. A fibrous sheath develops over this rod and acts as a tendon sheath. After 3-4 months, a free tendon graft is placed in the sheath after pulling out the rod.

Postoperatively the hand is immobilized in Jones position with a dorsal POP slab.

Physiotherapy Measures for Flexors Tendon Injuries

During the First 3 Days (Phase of Inflammation and Pain)

During this phase the fingers are immobilized and the physiotherapy treatment is aimed at the following:

- *Measures to reduce pain and inflammation* TENS, shortwave diathermy, ultrasound, etc. are used.
- *Measures to reduce edema* Hand elevation, retrograde massaging, active exercises to the adjacent fingers, cryotherapy, compressive dressing, etc. help.
- *Measures to improve circulation* Active vigorous movements to the adjacent fingers help considerably to improve the circulation.
- *Measures to control infections* Proper wound care is extremely vital to prevent infection which is most undesirable for proper healing.

Note
- This is the inflammatory phase of wound healing and lasts upto 4 days.
- Excess inflammation leads to joint stiffness.
- Infection must be prevented at all costs as it may lead to fibrosis, adhesions and eventual loss of hand function.
- The fingers should be immobilized in functional position during the above four measures.

From 4 to 15 Days (Phase of Fibroplasias)

During this phase, the formation of scan from fibroblasts takes place as follows:

$$[\text{Fibroblasts} \xrightarrow[\text{O}_2,\ \text{Vit C}]{\text{Zn, Fe, Cu}} \text{Tropo Collagen} \rightarrow \text{Collagen} \rightarrow \text{Scar}]$$

In this phase measures aim at imparting tensile strength to the scar by movement procedures which are not haphazard but "controlled".

The Apparatus

- This is a flexion assist POP dorsal splint or a dynamic splint made up of thermoplastic material (Fig. 20.20A).
- The splint extends from the proximal forearm to beyond the fingertips.

Fig. 20.20A: Flexion assist dynamic splint

- The wrist is kept in 30-45° of flexion and the MP joints in 0-20° of flexion. This position ensures less pressure on the repaired tendon.
- To keep the finger of the repaired tendon in flexion, a rubber band is used to connect the nylon loop to the wrist.
- This rubber band also permits resistive extension of the fingers.
- This splint should be worn for 24 hours.

Note Modified splint of earley.
He spared the other fingers by providing dorsal extension to only the affected finger. This enabled the other fingers to have free movement.

The Exercises

Step one Passive flexion and extension of the fingers (Fig. 20.20B).

Fig. 20.20B: Showing full range of simultaneous passive flexion of all the finger joints using the normal hand

Flexion In order to prevent overstretching of the repaired tendon, flexion of the PIP and DIP joints is done after flexing the MP joints.

Extension The MP joints are maintained in flexion, when PIP and DIP joints are simultaneously extended.

Note The above procedures are done twice a day.

Step two Resistive extensions to the repaired tendon. Within the dorsal splint, against the resistance provided by a rubber band, active finger extension is encouraged.

Note This resistive extension serves the following purpose.
- It provides reciprocal relaxation to the finger flexors.
- It provides graduated tension to the repaired tendon.

Step three Active flexion to the repaired fingers is now started in a graduated manner.

Note This controlled application of stress or tension improves the tensile strength of the scar, besides helping in the regeneration of the nerves.

Quick Facts

How does this control mobilization help?
- The intracellular healing is encouraged.
- Greater degree of synovial diffusion.
- The cellularity at the repair site is increased.
- The tensile strength is improved.
- The vessel density and arrangement around the tendon increases.
- The nerve regenerations also takes place (Bora—1980).
- The gliding of the repaired tendon is improved.
- The joint contractures are prevented.
  All the above features help in the restoration of the optional hand function.

After 15 Days (Remodeling Phase)

The remodeling phase begins after 3 weeks and progresses beyond 2 to 4 weeks. During this phase the realignment of the collagen fibers of the scar takes place.

Quick Facts

What happens during the remodeling phase?
- First, the collagen fibers align themselves parallely to between the co-apted. This helps in improving the tensile strength of the scar.
- Second, the collagen fibers along the longitudinal surface of the tendon 'disorganize randomly. This prevents adhesion formation and this facilitates 'tendon sliding'.
- Thirdly, the collagen fibers mature by cross linking between its own fibers and with other fibers.

During this phase, efforts are made:
- To further improve the tensile strength of the scar.
- To improve the strength and endurance of the repaired tendon.
- To improve the range of movements.
- To restore the function of the hand completely.
- The regimen below helps attain these objectives:

By week 4

Active extension of the IP joints should be restored completely and the assisted exercises should be stopped.

By week 6

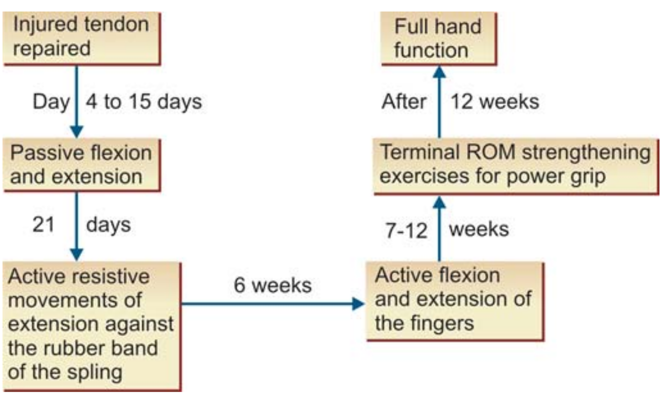
Active flexion and extension of the fingers are encouraged while the rubber band traction is discontinued.

A full range simultaneous, passive flexion of the DIP, PIP and MC joints by using the normal hand is encouraged (Fig. 20.20B). Graded resistance to the flexion is offered and once the normal flexion is restored, the finger is maintained at the position of maximal flexion for some time. The patient can be allowed to carry on with the light activities.

By 7 to 12 Weeks

All the exercises are made more vigorous. The use of splints is discontinued. To prevent scar adhesions, deep frictional massage is introduced. To encourage active isolated flexion of the PIP and DIP joints, isolated blocking exercises are introduced. Full function of the hand and the repaired tendon is permitted after 12 weeks (Flow chart 20.2).

Flow chart 20.2: The 'cycle' of controlled mobilization of the hand



EXTENSOR TENDON INJURIES

Extensor tendons of the hand are less commonly injured than the flexor tendons and are commonly seen in injuries to the dorsum of the hand, compound fractures of fingers and hand (Fig. 20.21).

A simple diagnostic test of inability of the patient to extend the finger following injury to a digit clinches the diagnosis of a cut extensor tendon.

Fig. 20.21: Clinical photograph of extensor tendon injuries

Test

Instruct the patient to extend the metacarpophalangeal joint. If the long extensors are severed he or she will not be able to do so. But however he or she can extend the IP joints due to the action of the intrinsic muscles of the hand.

Treatment

The extensor surface of the hand is also divided into eight zones (Table 20.4). But unlike in the flexor tendons, extensor tendons can be primarily repaired at almost any level if the injury is clean-cut. In contaminated or crushed injuries, secondary repair after 2 to 3 weeks can be done with good results.

TABLE 20.4: Level of extensor injuries and their treatment

Zones	*Region*	*Treatment*
I	DIP joint	this leads to mallet finger deformity and is managed as such.
II	Middle phalanx	
III	PIP joint	This leads to Boutainnaire deformity.
IV	Proximal phalanx	Repair of the central slip is done.
V	MP joint	• For fresh injuries (< 3 weeks). Direct repair for those injuries • > 3 weeks, tendon transfer, tendon grafts to neighboring tendon are done
VI	Dorsum hand	
VII	Wrist joint	
VIII	Forearm	

Physiotherapy Management

Simple Injuries

- Immobilization of the finger with the volar slab.
- The wrist and the fingers are placed in extension.
- Gradual progressive mobilization.
- Full activity by 8 weeks.

Complicated Extensor Tendon Injuries

- Here along with the tendon, surrounding soft tissues, bone, etc. are also damaged.
- The treatment of choice is early controlled mobilization.

The Apparatus

- It is a dynamic forearm splint with a volar block to prevent flexion beyond a certain range.
- A dynamic extension sling holds the fingers in neutral position.
- Through this dynamic extension sling, a controlled stress is applied in a graduated manner.

The Exercises

- From the 3rd or 4th postoperative day, patient is instructed to flex the fingers, till it touches the volar splint and then allowed to relax so that the fingers are brought back to the zero position by the extensor outrigger. This is done for 10-20 times every hour.
- Gentle passive ROM for the IP joints are carried out next with the wrist and MP joints in extension.
- By 3 weeks, retaining the dynamic extension apparatus, volar block is discarded.
- The resistive flexion with controlled extension is continued.
- By 6 weeks, the dynamic extension apparatus is discontinued.
- Active finger flexion and extension are made more vigorous.
- Functional activities including power grips are gradually encouraged
- By 12 weeks, full hand functions should be permitted.

Note Immobilization should be continued for longer periods (4-8 weeks) in Swan neck and Boutainnaire injuries.

INTERESTING FINGER INJURIES

Jersey finger It is due to avulsion of flexor digitorum profundus from its insertion on distal phalanx. This is the opposite of 'Mallet finger' and the patient is unable to flex the distal interphalangeal joint. It is seen in football and rugby players (Fig. 20.22).

Mallet finger This injury has been discussed on page 138.

Boutonnière injury This is due to the rupture of central extensor slip which results in dorsal displacement of lateral bands and finger is flexed at the PIP joint (Table 20.5) (*see* page 139).

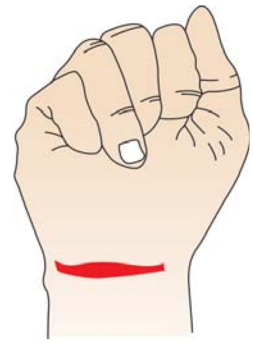


Fig. 20.22: Showing jersey finger

Quick Facts

Tendon injuries

- Flexor tendons are more commonly injured than the extensors.
- Primary flexor tendon injury repair is unsuccessful in Zone II.
- It is likely that tendon injuries can be missed during the initial evaluation and treatment of hand injuries.
- Primary repair is done in clean-cut injuries while secondary repair is done in contaminated wounds.
- Extensor tendons can be successfully sutured in any zone.

TABLE 20.5: Common complications and their preventive measures

Common complications	*Preventive measures*
• Extensor lag	• The fingers should be kept at neutral position • Mobilize the MCP joints
• Extension contractures	• Preserve the collateral ligament stability • Controlled movements
• Edema	• Controlled finger flexion • Limb elevation • Retrograde massage, etc.
• Swanneck or Boutonnière deformities	Immobilize for a longer period (4-8 weeks)

Note The process of repair in extensor tendon is extrasynovial, and hence delayed while in the flexor tendons it is intrasynovial and hence rapid.

SOFT TISSUE INJURIES OF THE HAND

Subungual hematoma This is due to blunt injury of the fingertips. If it is painful, decompression can be done by puncturing it with a 16-gauge needle.

Nail bed lacerations Before repairing the wound, distal phalangeal fractures should be reduced if any and the original nail if available should be reinserted back.

Fingertip avulsions If the soft tissue defect is more than 1 cm; it should be closed by split or full thickness grafting.

Frostbite injury In this condition extreme cold causes vasoconstriction which may result in thrombosis of the digital vessels. The treatment consists of rapid rewarming in a water bath at 40 to 45°C.

CRUSH INJURIES OF THE HAND AND AMPUTATIONS

Crush injuries of the hand are very serious injuries seen in industrial accidents, RTAs, fire-cracker injuries, machine tool injuries, etc. (Fig. 20.23). Amputation of the fingers or hand is not readily advocated and the following considerations are taken into account before making this painful decision:

- Is the part injured suffering from absolute or irreversible loss of blood supply? If so, this is the only absolute indication for primary amputation.
- Are the other fingers normal? If not, delay the amputation of the affected finger.
- If the finger is left unamputated, will the ultimate function of the hand be good?
- What is the status of the five tissue areas namely the skin, tendon, nerve, bone and joint. If three or more than three of these five areas require special procedures like grafting, etc. give a serious thought about the possibility of amputation.
- Is the victim a child? If so exercise caution.
- If both the flexor tendons and digital nerves are damaged and if the patient is an adult consider amputation.

Fig. 20.23: Clinical photograph of crush injury of finger

- If the thumb is badly injured, do everything to salvage the thumb.

Thus, in badly crushed hand injuries it is advisable to avoid radical amputations and to be as conservative as possible in excising the vital parts of the all important hand.

Principles of Amputation of Fingers

After thorough debridement and removal of all the foreign bodies, amputation is planned keeping the following principles in mind:

- The volar skin flap should be long enough to cover the stump and join the dorsal flap.
- The digital nerves should be resected at least 6 mm proximal to its end and allowed to retract back.
- The digital arteries should be cauterized.
- The flexor and extensor tendons should be pulled distally, cut and allowed to retract.
- If the amputation is through the joint, the flares of the bony condyles are excised.
- No much consideration should be given to the dog ears.
- Tourniquet should be released before closing the wound and all the bleeders should be cauterized.
- Small interrupted sutures are used to close the flaps.

Treatment Protocol in Crush Injuries

Whatever treatment protocol is followed it should aim to fulfill the following objectives:

- It should promote primary healing.
- The injured parts should be salvaged.
- It should aim to prevent infection.

The recommended protocol is as follows:

First aid These measures include covering the wound with a sterile dressing, hand elevation and judicious application of a tourniquet if required.

First examination Here status of the skin is assessed in sterile conditions without probing the deeper structures. After the skin, tests are conducted to assess the damages to bones, tendons and nerves. Each of these structures should be considered as damaged until proved otherwise. Radiograph of the hand and general measures like IV fluids, antibiotics, etc. is then done.

Second examination This is the most important step and is done in a major operation theatre under general anesthesia or a regional block. After a thorough debridement all the structures are very carefully inspected again. Skin is examined for viability, bones, nerves, tendons; vessels are inspected for crushing, loss, viability, etc. All the nonviable structures are excised and loose small pieces of bones are removed.

If the wound is clean all the structures are primarily repaired and the bone is fixed either by K-wire or Joshi's external fixators. If the wound is contaminated, secondary repair of the tendons, nerves, etc. are planned after 2 to 3 weeks. If the wound is badly crushed and nonviable, then primary amputation is considered as discussed above.

Postoperative Considerations

After the surgical procedures mentioned above the hand is splinted in functional positions—Fig. 20.5 (as discussed earlier) and is kept elevated. Active and passive physiotherapy, wax bath and other rehabilitative measures are planned and appliances given if necessary.

INFECTIONS OF THE HAND

The effects of hand infection can be as devastating as major trauma. Trivial injuries like a scratch, a prick, small punctured wounds, etc. cause hand infections. *Staph. aureus* (80%), *Streptococcus pyogenes* and gram negative bacilli are the famous trio who inflict the infective unmitigated disaster in the hand. The squeal of these infections is edema, abscess, necrosis, fibrosis and lastly contractions leading to a grotesque, debilitating hand. The presence of an abscess seems to send a message to the surgeons, *Drain me or I'll drain myself!* Hence, an abscess caused should be drained; the surgeon only has to decide the proper time and incisions. Early use of potent antibiotics has considerably downed the threat of serious hand infections.

As elsewhere before us dwelve into the discussions on individual hand infections, it helps considerably to know the principles of treatment:

- Hands should be kept elevated to facilitate gravity to drain and thereby prevent edema and swelling of the hand.
- Following treatment hand needs to be placed in functional positions (Fig. 20.5) for optimum results.
- Early and appropriate use of IV antibiotics prevents pus formation (within 24-48 hrs).
- If pus is formed let it out through proper incisions at the appropriate time.
- Local anesthetic may help the spread of infection and adds more fluid to the already existing swelling. Hence general anesthesia or regional block is preferred.
- Tourniquet is indicated but exsanguinations are not preferred as it helps spread the infection (alternatively elevation of hand for three minutes is ideal).

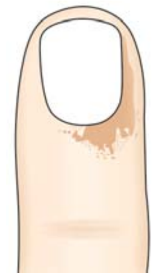


Fig. 20.24: Paronychia

- Do not forget the all important hand aftercare which has a direct bearing on the final outcome of the hand function. With the principles of treatment as a backdrop let us now consider the important hand infections in order of importance.

PARONYCHIA

Paronychia (Fig. 20.24) is an infection of the eponychium and could be acute or chronic. Acute paronychia has the distinction of being the most common infection of the hand. *Staph. Aureus* is the culprit and it usually is due to a hangnail, unsterile manicure instruments and reckless nail pairing. The infection normally begins at one corner, tracks down to the opposite end via the eponychium or nail (40%).

Clinical Features

Agonizing pain, marked tenderness and a conspicuous red looking swelling are the hallmarks of acute paronychia.

Treatment

Conservative measures and early antibiotic therapy is the mainstay of initial treatment. However, if abscess has formed and if the pus is at one end, incise it, if under one nail corner, remove that corner and if it has shifted to the opposite end excise proximal one-third of the nail. If encountered with a floating nail, write its obituary by taking it out totally as it is dead and gone!

> *Note* Chronic paronychia which is regarded as a complication of acute paronychia is usually not so! It is usually seen in syringomyelia or in people who do not wear rubber gloves during washing!

DISTAL PULP SPACE INFECTION (Syn: Felon)

Next to acute paronychia this is the most common hand infection. It usually follows a pin prick. The index finger and thumb are the common unfortunate victims.

Fig. 20.25: Multiple fibrous septa in distal pulp space

Fig. 20.26: Surgical incision for draining felon

Fig. 20.27: Middle volar space infection

Surgical anatomy Multiple fibrous septae travel from skin to bone partitioning the fat filled distal pulp space into tiny compartments (Fig. 20.25). One such septum also cordons of the space at the distal finger flexor crease. The terminal branches of the digital artery after giving a branch to the basal epiphyseal plate runs through this compartment. The evil effects of this arrangement could lead to the following undesirable consequences:

- Since it is a tight compartment any swelling increases the pressure causing excruciating pain.
- If superficial, penetrates the skin causing skin necrosis and if deep penetrates the periosteum causing osteomyelitis.
- Thrombosis of the digital arteries leads to osteomyelitis.
- In rare events it may cause flexor tenosynovitis or infective arthritis of DIP joint.

Clinical Features

Patient initially complains of dull pain more so in the dependent position and swelling. Loss of sleep due to nocturnal pain is a usual feature after about 2 days. Pressure over the involved part increases pain. Abscess may develop in the later stages if left unattended.

Treatment

Treatment consists of antibiotics in the initial stages and if the pain lasts for more than 12 hours, incision helps (Fig. 20.26). If the abscess is pointing volarwards, a longitudinal midline incision is taken and if the abscess is deep a longitudinal incision at the side cutting through the partitions is preferred. If osteomyelitis develops in the distal phalanx, sequestrectomy is done if the sequestrum is well formed and separated.

MIDDLE AND PROXIMALVOLAR SPACE INFECTION

These also follow pin pricks and may be confused with tenosynovitis of the flexor tendons (Fig. 20.27). Spread to the adjacent web space is fairly common. Clinical features and treatment are almost similar.

INFECTION OF THE WEB SPACES

What are these web spaces?

These are three triangular areas filled with loose fat between the ends of the fingers. Infection reaches these areas either through a skin crack or a blister or through the lumbrical canal courtesy an abscess in the proximal volar space.

Clinical Features

The patient first presents with severe constitutional symptoms and edema of the back of the hand. Once the infection localizes the following signs become evident:

- The base of the affected finger is swollen.
- In severe cases, the adjacent finger is separated.
- Skin over the affected space shows purplish discoloration.
- A fan-shaped blush extends from the web to the dorsum.
- Maximum tenderness is found in the web and base of the finger.

Treatment

Conservative treatment with antibiotics helps in the initial stages. In the later stages incision and drainage becomes very essential. Though the swelling is more towards the dorsum, the dangerous part of the abscess remains nearer the palm. If not incised it may spread into the middle palmar space via the lumbrical canal. Two incisions may be required for drainage, one on the dorsal surface between the metacarpal heads and the other on the palm distal to the distal palmar crease. The web should be left unincised.

Deep Palmar Abscess

This is rare and accounts for only 1 percent of all hand infections (Fig. 20.28).

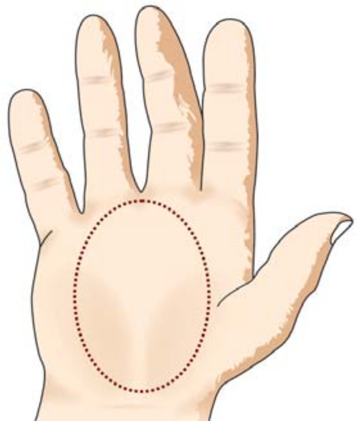


Fig. 20.28: Deep palmar abscess

Surgical Anatomy

This is a space lined by fascia and in between the flexor tendons above and metacarpal bones below. Its medial border is formed by the fascia of the hypothenar muscles and its lateral border by the fascia of the adductor and other thenar muscles. A fascia divides this space into middle palmar space and a thenar space.

Clinical Features

The patient usually presents with a severe systemic reaction. There is a local pain, tenderness, loss of active movements of the middle and ring fingers and there is generalized gross swelling of the hands and fingers which resemble an inflated rubber glove (also called Frog hand). Similar symptoms are seen in a thenar abscess but the thumb web is more swollen, index finger is held flexed and active movements of both the index and thumb is lost. With the increasing swelling, the concavity of the palm becomes flat and later convex before it bursts open.

Diagnostic Test

In a deep palmar abscess, passive stretching of the metacarpophalangeal joint is painful while that of interphalangeal joint is painless. In tenosynovitis of the flexor tendons the passive stretching of both the MP and the IP joints are painful.

Treatment

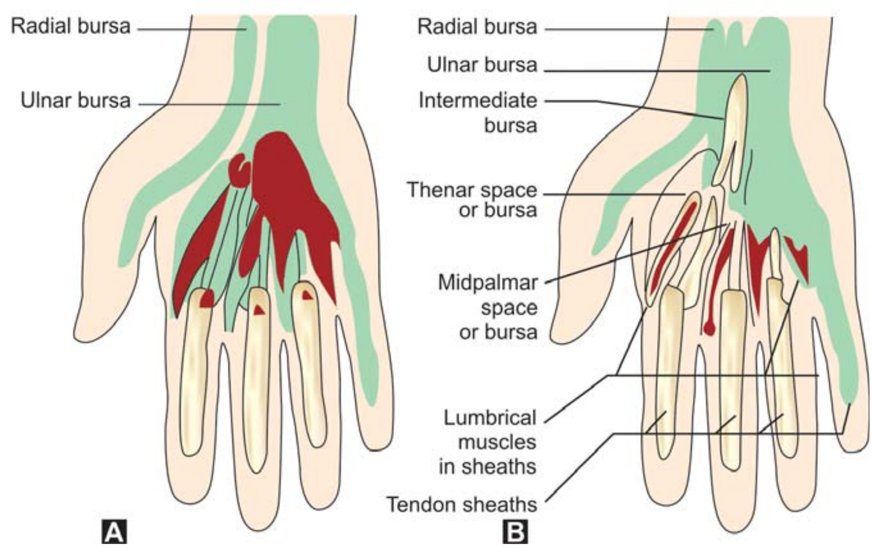
After the initial conservative treatment, the abscess in the middle palmar space is drained by a central transverse incision at the level of the distal palmar crease in line with the middle finger extending ulnarwards towards the hypothenar eminence. Abscess in the thenar space is drained by a curved incision in the thumb web parallel to the border of the first dorsal interosseous muscle.

TENOSYNOVITIS

These are serious infections and are due to infection of the fibrous sheaths and synovial lining of the flexor tendons of the hand.

Surgical Anatomy

The fibrous and synovial sheaths of the flexor tendons of the hand are arranged in two groups: the radial and ulnar bursae (Figs 20.29A and B). The radial bursa is the smaller of the



Figs 20.29A and B: Radial and ulnar bursae of the hand

two and it lines the flexor tendon of the thumb and extends 1-2 cm above the wrist upto the distal end of the tendon. The ulnar bursa encloses the synovial sheaths of the index, middle, ring and little fingers. Distally those for the index, middle and ring fingers it extends upto the level of transverse palmar cause and for the little finger it extends throughout the length of the tendons. The ulnar bursa encloses tendons of flexor digitorum superficialis and profundus of the above fingers. These two bursae may communicate with each other.

Etiology

The causative organisms are almost always due to *Staph. Aureus* or *Streptococcus pyogenes.* Penetrating injuries of the tendon sheaths, extension of the infection from its terminal pulp space, etc. are some of the common modes of infection. The consequences of tenosynovitis are disastrous, as it may lead to adhesions, rupture if infection is severe and loss of gliding movements.

Clinical Features

Patient complains of pain, swelling, and the affected finger is motionless. Active or passive extension of the fingers is very painful. The classical local signs include the swelling of the finger through its entire length, flexion of the finger with marked pain on extension, and tenderness over the sheath.

In tenosynovitis of the little finger (Fig. 20.30) tenderness can be elicited at a point in between the two palmar creases. This is called the 'Kanavel's sign' (Fig. 20.31).

Treatment

Early treatment with antibiotics is started. In the early stages of pus formation abscess is drained by a transverse incision at the distal palmar crease and the proximal edge of the sheath is opened. Then the sheath is opened distally through a midcarpal incision over the middle phalanx. If the infection has progressed far, then a full midlateral incision may be required. Sloughed tendons require excision.

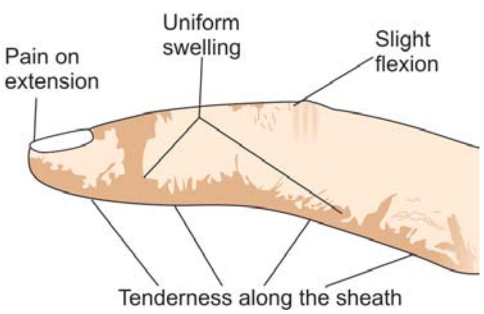


Fig. 20.30: Tenosynovitis of a finger showing its four typical features

Fig. 20.31: Kanavel's sign

Physiotherapy Measures following Hand Infections

- *Thermotherapy* Short wave diathermy, ultrasound to the entire hand helps achieve the following objectives.
  — Increases and improves blood circulation.
  — Increases the normal reaction of the tissues.
  — Prevents further spread of infection.
- *Mobilization* Early controlled mobilization of the hand is beneficial and helps achieve the following objectives:
  — Prevents edema.
  — Prevents joint contractures and soft tissues contractures.
  — Improves local circulation.
  — Prevents scar adhesions.
- *Hand passive stretching regime* Sustained passive stretching of the hand helps overcome the residual soft tissue tightness.

ARTHRITIC HAND

The following arthritic conditions affect the hand.

Rheumatoid arthritis the rheumatoid hand is discussed in Chapter 29 (Rheumatic Diseases).

Osteoarthritis The distal interphalangeal joints are more commonly affected than the proximal interphalangeal joints. Heberden's nodes are seen in DIP joints. Carpometacarpal joint of the thumb may also be affected. Cartilage destruction, spur formation and limited motion are the common sequelae.

Lupus erythematosus This involves the skin over the nose as well as tendons and joints. Periarticular soft tissue and tendons are affected very severely; joints get grossly deformed at the metacarpophalangeal joints.

Psoriasis Psoriatic arthritis has an incidence of about 7 percent and the deformities are similar to rheumatoid arthritis.

Reiter's syndrome This is described as a triad of conjunctivitis, urethritis and synovitis. Synovitis is asymmetrical and heel pain, back pain and nail deformities are seen. More common in young males it attacks the lower limbs more than the upper limbs. More than 90 percent resolve on its own.

Gout It usually presents as a single, painful, red joint in an adult male. The joint is swollen, hot and tender and is usually confused to a cellulitis or abscess and drained. This is a disease due to massive deposits of monosodium urate crystals around the joints.

PARALYTIC HAND

This is mainly due to peripheral nerve involvement of the upper limbs. Discussed at great length in the Chapter on Peripheral Nerve Injuries.

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5

Section

GAIT AND LOW BACKACHE

21. Gait
22. Low Backache

21

Chapter

Gait

What is Gait?

It is a term used to describe the style of walking. Through evolution, man has changed from a quadruped gait to a biped gait. The gait in the animals is more stable, since it walks on all the four limbs and the centre of gravity is in between the fore limbs and hind limbs. And the 'speed' is also more in animal gait, since the trunk musculature helps the limbs in locomotion. This stability and speed is compromised in human gait because of the two legged gait. The centre of gravity keeps changing and is above the base. The gait in each person is different and has a characteristic pattern which helps in the identification of that person.

Study of human gait is a fascinating subject. Even a subtle variation in the gait has a story to tell and only a discerning and knowledgeable eye will be able to detect the cause for such a change.

GAIT CYCLE

Definition

It can be defined as all the activities that occur from heel contact of one foot to the next heel contact of the same foot (alternatively, it can be from toe off of one foot to the next toe off of the same foot).

Phases

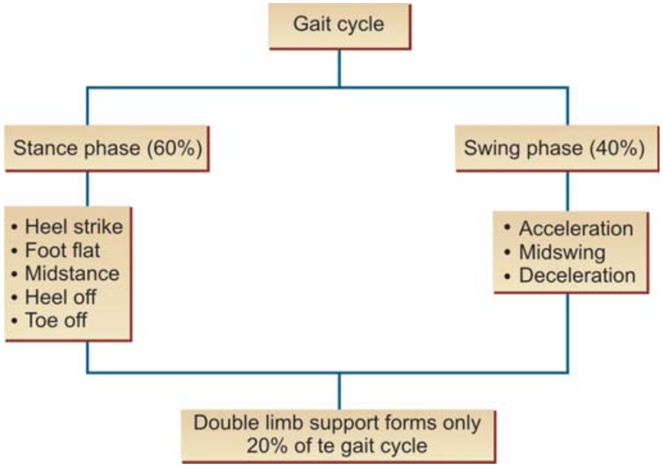
Phases of the gait cycle are shown in Flow chart 21.1 and Figs 21.1A and B and consist of two phases:

1. The stance phase
2. The swing phase.

Stance phase This comprises 60 percent of the normal adult gait cycle. It begins with the initial heel contact and ends with the toes coming off the ground.

Swing phase This forms 40 percent of the gait cycle in adults. It begins when the concerned foot lifts off the ground and ends when the same foot comes in contact with the ground.

Flow chart 21.1: Showing phases of gait cycle



Terminology of the Gait Cycle

Two gait terminologies are described:

1. Traditional terms.
2. Rancho Los Amigos (RLA) terms.

Quick Facts

Traditional terms vs. RLA terms	
Traditional	*RLA*
• Heel strike	Initial contact
• Foot flat	Loading response
• Midstance	Midstance
• Heel off	Terminal stance
• Toe off	Preswing
• Acceleration	Initial swing
• Midswing	Midswing
• Deceleration	Terminal swing

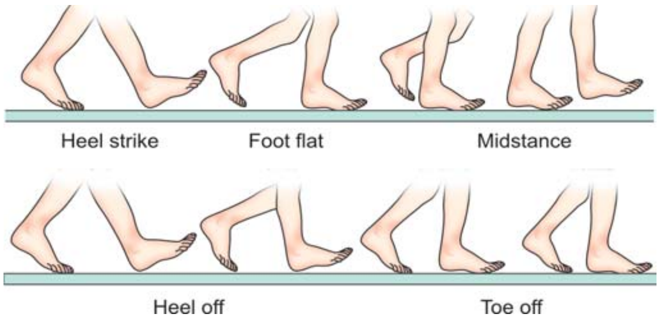


Fig. 21.1A: Stance phase of gait cycle

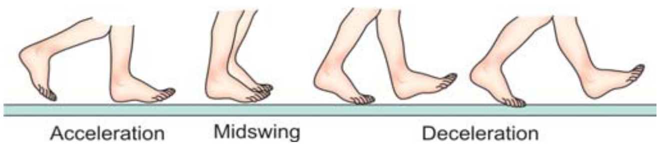


Fig. 21.1B: Swing phase of gait cycle

Stance Phase

This consists of the first five phases (Fig. 21.1A).

- Heel strike—here, the heel strikes the ground.
- Foot flat—here, the foot is flat on the ground.
- Midstance.
- Heel off—here, the heel is off the ground.
- Toe off—here, the toes are off the ground.

Swing Phase (Fig. 21.1B)

This consists of three phases (Fig. 21.1B)

- Acceleration—here the leg is in front of the body.
- Midswing—here the leg continues to swing forward.
- Deceleration—here the swing slows down and the heel is ready for the strike.

In a normal gait, each leg alternatively goes through a stance phase and a swing phase. Thus, the body is carried forward in normal walking by these rhythmic cycles.

Quick Facts

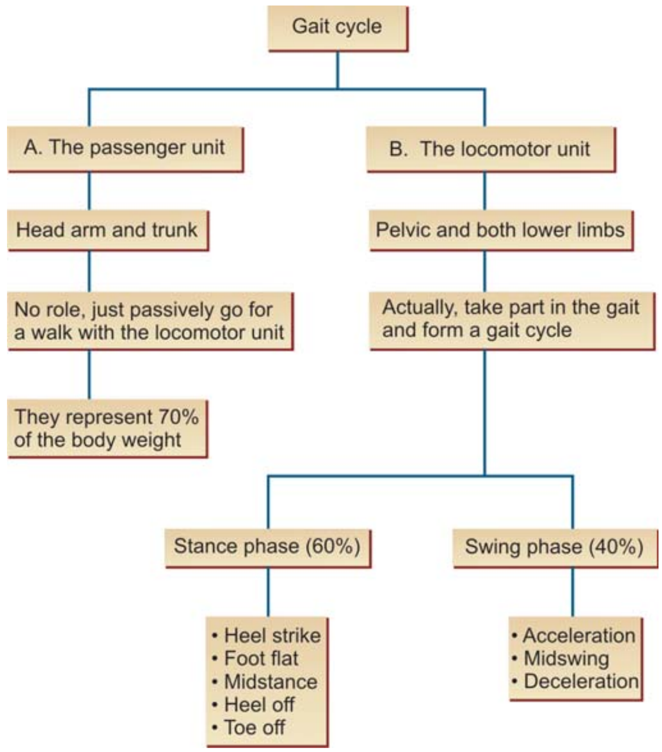
What is the percentage of each phase in the gait cycle?

Stance phase (60%)	
• Heel strike	0-2%
• Foot flat	0-10%
• Midstance	10-30%
• Heel off	30-50%
• Toe off	50-60%
Swing phase (40%)	
• Acceleration	60-73%
• Midswing	73-85%
• Deceleration	85-100%

HUMAN GAIT

The human gait cycle consist of two units namely passenger and locomotor units (Flow chart 21.2 and Fig. 21.2).

Flow chart 21.2: Showing units of human gait cycle



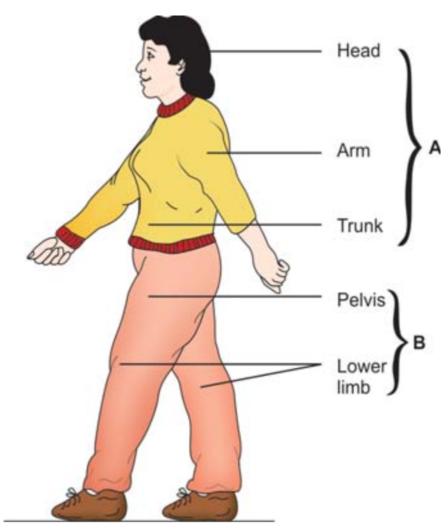


Fig. 21.2: The two important units of human gait: (A) The passenger unit, (B) The locomotor unit

Note

- *The swing stance ratio is 0.66.*
- *Double limb support* Here both the limbs are on the ground for a brief period of time. This constitutes 20 percent of the gait cycle.

Quick Facts

Interesting 'gait' facts

- *The passenger unit* (This represents 70 percent of the body weight). According to Perry 1992. It is the head, neck, arms and trunk.
  According to Elthman (1954) It is head, arms and trunk (denoted by the acronym—HAT).
  This is so called, because they do not directly contribute to the act of walking but 'go along for the ride,'
- *The locomotor unit* This is the functioning system which is comprised of the pelvis and both the lower limbs.

Note The locomotor unit consists of 19 joints:
- Lumbosacral
- Both hips
- Both knees
- Both ankles
- Both subtalars
- Both MTP joints

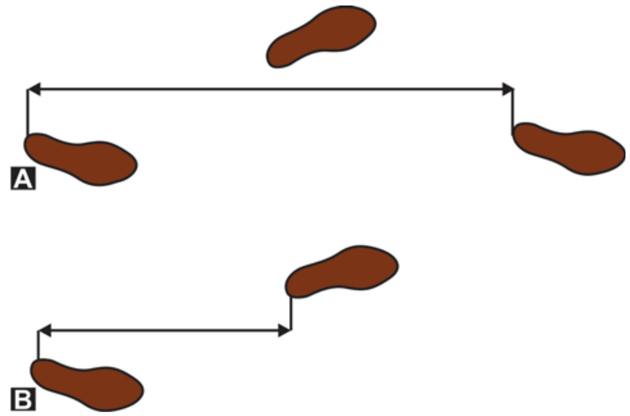
Quick Facts

Vital facts

- **Single limb support** Here only one foot is in contact with the ground. Forms 80% of the gait cycle.
- **Double limb support** Both limbs are on the ground. Forms the remaining 20% of the gait cycle.
- **Stride length** It is the distance the 'body' has travelled in one gait cycle (Fig. 21.3A).
  — *Men* 4.8 feet
  — *Women* 4.2 feet. Overall average is 4.6 feet.
- **Step length** It is the distance one foot has travelled during a gait cycle (Fig. 21.3B).
  — *Men* 2.4 ft feet
  — *Women* 2.1 feet, both (average)—2.3 feet.
- **Cadence** Number of steps taken in a specified time.
  — *Men 111* steps/min, Women: 117 steps/min.
  — *Both* 113 steps/min (average).
- **Walking velocity** The speed of walking on a smooth snail surface.
  — *Men* 276 ft/min
  — *Women* 250 ft/min
  — *Both* 262 ft/min (average).

FORCES RESPONSIBLE FOR GAIT

The function of the locomotors unit is to move the passenger unit forward. This is possible by contraction of the muscles and the external forces like the gravitational and ground reaction forces.



Figs 21.3A and B: Showing measurements of (A) Stride length, (B) Step length

The Gravitational Forces

The body uses the gravitational force as a propulsive force in moving the body forwards. The body is technically falling in a controlled fashion from one stance limb to the other. The centre of gravity (COG) keeps the balance of the body. However, the COG does not keep constant and keeps changing during the gait cycle. The following are the various displacements of the COG.

Vertical Displacement

During a gait cycle, a total of 2 inches (one inch up and one inch down), vertical displacements take place. The COG is highest during the midstance, and lowest during the double limb support. The features which prevent COG from going too high are lateral, anterior to the pelvis, ankle plantar flexion and knee flexion. And the features which prevent COG from falling low are terminal stance heel raise, initial heel contact with knee extended and horizontal pelvic rotation.

Quick Facts

What is COG?

It is an imaginary point in a body around which all of the forces act. In a human body standing in the anatomical position, the COG falls just anterior to the 2nd sacral vertebra.

Lateral Displacement

The lateral displacement of COG is 2 inch total (one inch up and one inch down). During midstance the COG is most

TABLE 21.1: Kinetics and kinematics of gait (stance phase)

Joints	*HS*	*FF*	*MST*	*Heel off*	*Toes off*
HIP					
• Motion	Flexion 30-25°	Flexion 30-25°	Extension	Extension	Flexion
• GRFV	Anterior	Anterior	Ant → Post	Posterior	Posterior → 0°
• Movement	Flexion	Flexion	Fl → 0°	Extension	Extension
• Muscles acting	Gluteus Maximus Hamstrings Adductor Magnus	Gluteus Maximus	No action	Adductors	Flexors
KNEE					
• Motion	Flexion 5°	Flexion	Extension	Extension/flexion	Flexion
• GRFV	Anterior	Posterior	Posterior → anterior	Anterior → posterior	Posteior → 0
• Movement	Extension	Flexion	Flexion/extension	Extension/flexion	Flexion →
• Muscle groups	Quadriceps Hamstrings Popliteus	Quadriceps	Quadriceps ↓ 0°	Gastro-Popliteus	Gastro-popliteus
ANKLE					
• Motion	PF 0°	PF	DF	DF → PF	PF
• GRFV	Posterior	Posterior	Anterior	Anterior	Anterior
• Movement	PF	PF	DF	DF	DF → 0°
• Muscle groups	Dorsiflexion	Dorsiflexion	PF	PF	PF

Note DF—dorsiflexion, PF—plantar flexion

laterally displaced. The features which control the lateral displacements of the COG are pelvic rotations, medial femoral angulations, etc.

In addition to the two displacements mentioned above, there is a 5° horizontal dip of the pelvis and COG towards the weight bearing side and a horizontal rotation of the pelvis around its vertical axis which helps in the forward movement of one leg while the other is firmly on the ground.

Note The various displacements of the COG mentioned above along with the selective contraction of the various muscles helps in conserving the energy during gait.

Ground Reaction Force Vector (GRFV)

This is the sum of three forces namely the vertical force, the horizontal force (lateral force) and the anterior posterior force acting on the body. This is equal and opposite to the amount of momentum generated by the foot and the body during the stance phase.

Quick Facts

What is centre of pressure (COP)?

It is a point on a body's supporting surface (Walker's plantar surface of the feet) around which all of the forces act during gait.

Note

- *Kinetics* This comprises a study of the forces that produce or change the movements (the gravitational force and the ground forces).
- *Kinematics* It is a study of the angular movements and the changes brought about by the action of various muscle groups.

Kinetics and Kinematics of Gait

Stance phase The following table gives an insight into the kinetics and kinematics of gait (Table 21.1) during the stance phase.

Thus during

- *Heel strike* The hip is in flexion of 25-30°, the knee is in 50° flexion and the ankle is at 0° plantar flexion. The GRFV is anterior to the hip and knee joints, posterior to the ankle joints.
- *Foot flat* The hip is still in 25-30° flexion, the knee in flexion and the ankle in plantar flexion. However, the GRFV is anterior to the hip but posterior to the knee and ankle joints.
- *Midstance* The hip is in extension the knee is also in extension and the ankle is in dorsiflexion. The GRFV is passing anterior to posterior in the hip region, posterior to anterior in the knee region and anterior to the ankle joint.

TABLE 21.2: Kinetics and kinematics during swing phase

Joints	*Acceleration*	*Midswing*	*Deceleration*
HIP			
• Movements	Flexion	Flexion	Flexion, with extension at the end
• Muscle acting	Flexors	Ad longus Gracilis	Extensors
KNEE			
• Movements	Flexion	Extension	Ext → Flexion
• Muscles acting	Hamstrings, Sartorius, Gracilis	Hamstrings	Hamstrings, Quadriceps propliteus
ANKLE			
• Movements	Dorsiflexion	Dorsiflexion	Dorsiflexion
• Muscles acting	Dorsiflexors	Dorsiflexors	Dorsiflexors

- *Heel off during* heel off the hip is in extension, the knee is passing slowly from extension to flexion and the ankle from dorsiflexion to plantar flexion.
- The GRFV passes posterior to the hip, anterior to posterior in the knee and anterior at the ankle joints.
- *Toe off during* toe off, the hip is in flexion, the knee is also in flexion and the ankle joint is in plantar flexion. The GRFV is posterior to hip and knee and anterior in the ankle joints.

Swing phase Table 21.2 shows different swing phases.
- During acceleration phase, the hip joint is in flexion, the knee joint is also in flexion and the ankle joint is in dorsiflexion.
- During midswing, the hip is in flexion, the knee is in extension and the ankle joint is in dorsiflexion.
- During deceleration phase, the hip joint progresses from flexion to extension, the knee joint from extension to flexion and the ankle joint continues to be in dorsiflexion.

Quick Facts

Name the factors that help in shock absorption during gait.

The following joint movements help to absorb the shock of impact each time weight is shifted from one limb to the other:
- Ankle plantar flexion
- Subtalar pronation
- Knee flexion
- Hip flexion
- Hip abduction.

Gait evaluation techniques are depicted in Table 21.3.

TABLE 21.3: Gait evaluation techniques

Methods	*Description*
• Observational method	it is a careful eye observation by the physiotherapist. Described by Weber in 1836
• Photographic method	It is an interpretation of the TV, Video and Movie film analysis of the gait. Described by Marey (1855), Fisher (1898) and Muray (1964)
• Method of force study	It is a study based on the data of floor reaction of forces described by Schwartz (1934), Paul, Morrison (1964), etc.
• EMG methods	It is a study of gait using the EMG methods. Described by Eberhart and Inman (1947)
• Electrogoniometric method	it is a study of the joint functions during gait by strapping an electro-goniometer. Described by Johnstom and Smidt (1971)
• Method of energy, cost and requirement	It is a study of the data on energy requirement and expenditure during normal and pathological gait. Described by McDonald (1961)
• Method of spatial and temporal measurements	It is a study based on the temporal and spatial characteristics. Described by Cerny (1983)
• Combination methods	It is a combination of various methods described above
• Multichannel functional electrical stimulation (MFES) method	It is a study of multichannel, electrical stimulation to the hip flexors and extensors, knee flexors and extensors, ankle plantar and dorsiflexors. Described by Malezi *et al* 1984

Practical Method of Gait Evaluation

All the methods mentioned so for are complicated and time consuming. A simple, practical and yet affective methods of gait analysis is a combination of:

- Observational method.
- A quantitative analysis of temporal and spatial characteristics.

Gait Analysis by the Observational Methods

- Described by Brunnstrum in 1964.
- A naked eye systematic observation and recording of the changes in the three main joints during gait namely the hip joint, the knee joint and the ankle joints.
- Each joint at a time is studied in detail from the front, back and sides.
- Several repetitions are studied and recorded at both the phases and sub phases of the gait cycle.
- Trunk and pelvic movements are also noted.
- In this procedure, the patient is required to walk at his normal speed.

It there is any deficiency detected during the above method it should be correlated with the clinical examination of the patient in standing position.

Quantitative Gait Evaluation

This is fairly a simple method of gait evaluation which uses the temporal and distance data during gait.

The parameters employed in this study are:

- Stride length (Fig. 21.3A)
- Step length (Fig. 21.3B)
- Step width
- Velocity
- Cadence (*see* page 351).

Requirements

- A 16 mt or 50 ft long walkway which is divided into 3 segments.
- A middle 6-metre segment with 5-metre segments on either side.
- Two felt tip markers taped to the back of the shoes of the patient which just touches the floor and puts a mark on the floor at every step. Another pen is fixed on front of the shoes to put a mark at the toe-off stage.

Joining the lines of the heel and toe markers helps in identifying the angle of the foot in relation to the midline.

Procedure

- Patient is instructed to walk at his normal speed.
- Time taken to cover the 6-metre area is recorded by the therapist with a stop watch. With this the velocity and cadence is calculated.
- By joining and measuring the contact pen marks within the 6-metre walkway, the stride length, the step length and width and foot angles are calculated.

A study of this temporal and spatial readings help to describe the individual gait and is compared with the normal standard values of the various para-meters to arrive at the diagnosis of gait abnormality if any.

Quick Facts

Advantages of this combined approach:

- Cheap
- Adequate
- Simple
- Effective and reliable
- Does not require costly instruments, etc.

PATHOLOGICAL GAIT

To diagnose a pathological gait, a sound knowledge of the normal ambulation, locomotion, etc. is a must.

Instead of labeling the abnormal gaits as antalgic, circumduction, etc. which is wholly inadequate, it is better if by careful analysis, a gait in question is described, how it differs from the normal ambulation. Important pathological gaits are given in Table 21.4.

GAIT TRAINING

Training a patient to resume his normal gait requires patience and skill from a therapist and involves the following steps:

- *Evaluation* A pre-gait training evaluation consists of assessing the ROM of the concerned joints, the muscle strength, the sensory status of the limb, the condition of static and dynamic balance, the age, occupation of the patient, his physical and mental well-being, family cooperation and his cardio-respiratory status.
- *Detecting and treating* Any obstructing factors, like contractures, adhesions, deformities, etc.
- *Gait training* This consists of the following phases:

During the Non-ambulatory Phase

In this phase, either the patient is not weight bearing or is partial weight-bearing. During NWB emphasis is on conditioning of

TABLE 21.4: Various types of pathological gaits

Abnormalities	*Characteristics*
Hip	
• Lateral trunk bending	Here the patient leans towards the affected side on bearing weight on that side
• Hip pain	Patient leans towards the affected side
• Hip abductor weakness	Here the pelvis drops on the unaffected side when patient bears weight on the affected leg (Trendelenberg or glutes medius, dip gait)
• Hip/knee flexion contracture	Swing phase is shortened, the trunk bends backwards with circumduction, trunk dips sideward and the hip is elevated on the affected side
• Hip extensor weakness (Gluteus maximus gait)	Backward thrust of the trunk, Affected hip is protruded, lumbar lordosis is increased.
• Hip hiking (seen in hip flexor weakness, extensor spasticity, dorsiflexor weakness, etc.)	By the action of quadratus lumborum and lateral abdominalis, patient elevates the pelvis on the affected side and advances the affected limb by increased pendulum action.
• Circumduction	To clear the ground, the limb goes around a laterally curved path. Seen in spastic limb.
• Internal rotation of the hip	Seen in biceps femoris weakness, fixed inversion of the heel, spastic cerebral palsy, etc.
• External rotation of the hip	Seen in hamstring weakness, fixed eversion of the heel, weakness of tibialis anterior, posterior and plantar flexors muscles.
Knee	
• Quadriceps paralysis	In this condition the patient cannot stabilizes the knee in early stance phase and the knee bends backwards.
• Knee instability	In this condition the knee flexes abruptly after midstance causing the patient to buckle.
• Hyper extended knee	Here the knee bends backwards during the stance phase. The trunk is bent forwards, pushing back with forceful contractions of the gluteus maximus helps to overcome this problem
• Arthritic knee	A patient with rheumatoid and OA knee walk with a limp which increases with speed. The knee is flexed and there is lateral trunk bending
Foot	
• High step	Here patient walks with a high stepping gait to clear the ground as in the case of foot drop.
• Push off	Weight is borne mainly on the heel and the entire foot leaves the flour simultaneously instead of the roll from heel to toes. Seen in tendo-Achilles rupture.
• Pes calcaneus	Here the patient uses the entire sole for push off. Seen in hammer toes, Metatarsalgia, etc.
Trunk	
• Lordosis	During weight-bearing on the affected side, the lumbar curvature is increased and the upper trunk is displaced posteriorly. Seen in hip extensor, abdominal muscle weakness or both.
• Anterior trunk bending	Here the patient bends the trunk forwards while walking. Seen in quadriceps weakness combined with weakness of gluteus, maximus, gastroc-nemius or both.
• Posterior trunk	Here the patient extends the upper trunk bending backwards while walking. Seen in hip extension and weakness of both the hips.
CNS	
• Rhythmic disturbances	In this condition the patient takes a quick short steps with the affected limb and corresponding long slow step with the normal leg, e.g. Parkinsonism, ataxia, etc.
• Cerebellar gait (drunken or reeling gait)	Here the gait is wide-based unsteady and irregular, seen in Cerebellar dysfunction.
• Gait in sensory ataxia	The leg is wide based, lifts the legs high and stamps the foot firmly on the ground. Seen in Freiedreich's ataxia, etc.
• Hemiplegic gait	Circumduction gait (see page 330)
• Paraplegia gait	In spastic paraplegia, there may be crossing of the legs in front, e.g. Scissors gait
• Festinant gait (Parkinsonism)	Short steps, trunk bent forwards, arms flexed leg stiff and flexed at hip and knee.
• Hysterical gait	The patient does not lift the leg, but drags it like a useless member of the body. May be monoplegic or paraplegic.

the leg for further gait training and during partial weight-bearing. Shadow walking should be instituted at the earliest and patient should be trained strictly keeping the requirements of the normal gait uppermost on the mind. Patient needs assistive devices for walking, but that has to be critically evaluated.

During the Ambulatory Phase

In this phase, the goal is to achieve a normal pattern of gait which is safe, easy and effortless. The steps recommended are:

- Do not initiate ambulation in a hurry, it may prove counter productive. Wait for the appropriate time.
- Prolonged sessions of balancing on the affected leg helps.
- Unnecessary long sessions of gait training may not fetch the desired results. Hence, moderation is emphasized.
- Provide appropriate support by proper orthotic and prosthetic devices, if required, before commencing the training.
- Help the patient to practice walking over the footmarks marked on the floor in front of a postural mirror.
- Encourage reciprocal arm swinging which provides opposite reaction forces.
- PNF techniques of resistive gait help considerably.

Once the patient gains enough confidence and expertise for normal walking, he should be encouraged to practice vigorously other forms of walking like turning, side walks, back walks, climbing the stair cases, squatting and getting up from the floor, walking on uneven and rough surfaces, etc.

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22

Chapter

Low Backache

BACKACHE

Low backache is a very common problem and has a ubiquitous distribution. Among the galaxy of causative factors, both spinal and extra spinal, the most common cause of low backache seems to be the lumbar disk disease. Bad posture plays a very significant role in the genesis of this disease. So much is the contribution of bad posture towards this problem that one can categorically conclude that low backache is all about disk degeneration predisposed by poor posture. A thorough know-how of the posture, disk disease and back care will enable the student to understand and treat this malady both in his or her patients and household. Other causes of low backache are merely mentioned and the students are suggested to refer suitable chapters for details.

Epidemiology of Backache

Backache which was known as an ancient curse is now known as a modern international epidemic. Eighty percent of the population is affected by this symptom at sometime in life. Impairments of back and spine are ranked as the most frequent cause of limitation of activity in people younger than 45 years. In 2 percent of the population backache is the presenting complaint in general practitioner's clinic. In 78 percent men and 89 percent women specific cause was not known. It was believed that bad posture was responsible for most of these cases. The cost to the society and the patient for treatment, compensation, etc. is very high.

Posture

Posture is defined as the positional relationship of the different regions of the body to each other. It is divided into:

- Standing
- Sitting, and
- Recumbent positions.

  The features of normal posture are as follows:
  - Moderate lordosis of cervical and lumbar spines.
  - Kyphosis of the thoracic and sacrococcygeal sections.
  - Forward pelvic inclination of 30°.
  - Neutral rotation of femur.
  - Plumb line dropped from the mastoid process passes through the middle of the shoulder and hip, just anterior to the knee and lateral malleolus of the ankle.

Pathological Physiology

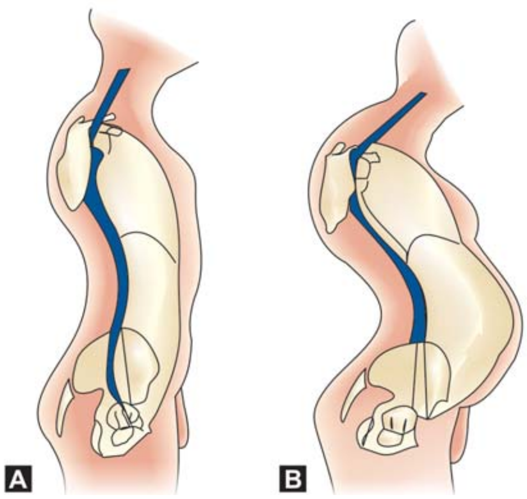
In the course of evolution from quadruped to orthograde animal, the relatively straight spine develops forward and backward curves as it yields to the forces of gravity. Para spinal and glutei muscles maintain the erect posture. There is a continuous minimal muscular contraction called the postural tone.

When the spine becomes displaced and unbalanced, a greater number of muscle fibers are called into play at more frequent intervals to keep the spine straight. Thus fatigue develops earlier. This fatigue causes muscle insufficiency as a result of which the spine sags putting the strain on the ligaments and posterior articulating facets. Changes occur at the facet joints and the lumbosacral junction.

Posture (Figs 22.1A and B) of the hip joint is the key to that of the whole body because it determines the pelvic inclination, the pelvis being the foundation for the spine and rotation of the legs. Normal angle is 28 to 31°.

Functional Anatomy

In the upright position spine has a stabilizing function. The body weight is transmitted through the shoulder girdle to the thorax and abdominal cavity, the hydraulic action of which enables the weight to be carried towards the pelvis. Bad posture with lax



Figs 22.1A and B: Posture: (A) Normal posture, and (B) Bad posture due to protruding belly

abdominal muscles impairs the function of the hydraulic system overloading several segments of the spine. In all upright position other than that of the physiological vertical axes, the strain on the structures like disks and ligaments is quite high. Furthermore stabilization of the muscles is less good during movements, especially if performed abruptly or associated with lifting of a weight. Thus it can be concluded that postural defects, overloading and abrupt unbalanced movements are frequently responsible for backache.

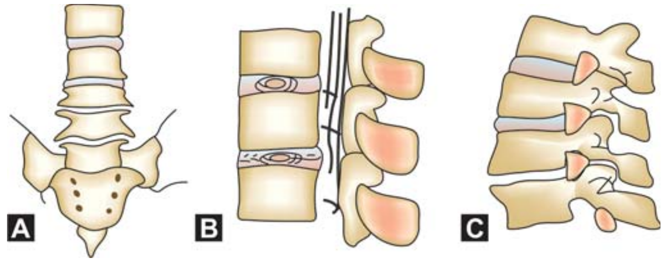
Remember

- Posture is an entity seen only in human beings, thanks to the two legged posture.
- Backache is a very common malady next only to headache and affects nearly 80 percent of the population.
- Most common cause of backache is bad posture which increases the strain on the disks and ligaments causing faster disk degeneration.
- Any abrupt, unbalanced and unwarranted movements upset the stabilizing function of the back muscles increasing load on the disks.
- Hence bad posture, overloading and abrupt unbalanced movements are the causes of disk rupture or prolapse.

Structures Involved in Backache

Figures 22.2A to C shows structures involved in backache.

- *Vertebral bodies* Micro crush fractures, and spondylosis.
- *Intervertebral disks* Disk degeneration and prolapse.



Figs 22.2 A to C: Structures involved in low backache:(A) osteophytes seen in lumbar spondylosis, (B) compression on PLL and nerves due to disc protrusion, and (C) disc disease and facet joint arthritis

- *Posterior intervertebral joints* Degenerative lesions, synovitis, sprain, etc.
- *Ligaments and small intervertebral muscles* Elongation, excessive use, reflex contractures.
- *Posterior longitudinal ligament* Elongation and irritation by diskal protrusion.
- *Nerves* Irritation or compression of the spinal nerve roots by disk herniation or irritation of the sensory nerves of the various paravertebral structures.

Remember

Factors keeping the spine healthy

- Genetics
- Muscle strength and balance
- Flexibility
- Posture
- Body weight
- Adaptation to stresses

Common Low Backache (Mechanical Backache)

These account for 80 percent of low backaches and are due to mechanical causes life back muscle strain, ligaments sprain and disk problems (lumbar disc disease). The muscle strain and sprains are due to sudden unaccustomed activities and improper postures.

However disk disease is more common and is dealt at length.

LUMBAR DISK DISEASE AND LOW BACKACHE

General Disk and Spine Anatomy

Development of spine starts from the third week of intrauterine life and continues till third decade of life. There are 23 disks throughout the spine, absent only in atlantoaxial articulation. It is thinnest in the thoracic region and thickest in the lumbar. Each disk is interposed between the bodies of a pair of vertebrae. Body of each vertebra is covered by a thin end plate of a bone which is perforated by numerous tiny holes. This in turn is covered by a hyaline cartilage which may be considered as the outermost portion of the disk.

Anteriorly and laterally the bodies and the disks are bounded firmly by the anterior longitudinal ligament and posteriorly by the posterior longitudinal ligament which is weak. The intervertebral disks in adults are avascular; the cells within it are sustained by diffusion of nutrients into the disk through the pores in the bodies. Movements and weight-bearing help in diffusion. Degeneration of the disk may be prompted by changes in the permeability of the cartilage end plate.

The disk consists of two parts; centrally it is nucleus pulposus which is made up of collagen fibrils, fibrocytes, chondrocytes, gelatinous matrix, water and salt. Peripherally it has annulus fibrosus which is a fibro cartilaginous tissue. It is thick anteriorly and thin posteriorly more so in the posterolateral aspect. Hence posterolateral disk prolapse is more common. The fibers of annulus are joined by diagonal fibers also known as Sharpe's fibers.

Neural fibers in the outer rings of the annulus contain branches of the Sinuvertebral nerve dorsally and ventrally branches from the sympathetic chain.

With age, water content of the disk decreases, fibrous tissue and cartilage cells increase, and the nucleus becomes granular and friable.

Disk Physiology

Disk apart from giving the spine its mobility, functions as a shock absorber. Following loss of disk, the vertebral body reacts to abnormal pressure forces by hypertrophic bone formation at the surface revealed as sclerosis and osteophyte formation. Schmorl node is the disk material which has escaped into the body through the pores and is walled off by the fibrous tissue.

Remember

About disk:
- It gives spine the mobility.
- It acts as shock absorber.
- It is fibro cartilaginous.
- It increases the height of the spine by 25 percent.
- Centrally it has a nucleus pulposus and peripherally annulus fibrosus.
- It is avascular.
- Annulus fibers are weak posteriorly; hence postero-lateral disk prolapse is more common.
- With age, water content of the disk falls.

Natural History of Lumbar Disk Disease

All spines degenerate with advancing age and so does the intervertebral disks. Degenerative process is divided into three stages:

1. *Stage of dysfunction*
   - Seen between 15 to 45 years of age.
   - Circumferential and radial tears are seen in the disk annulus.
   - Localized synovitis of the facet joints is seen.
2. *Stage of instability*
   - Seen between 35-70 years of age.
   - There is an internal disruption of the disk.
   - Progressive disk resorption takes place.
   - Degeneration of facet joints with lax capsules, sub-luxation and joint erosions are seen.
3. *Stage of stabilization*
   - Seen over 60 years of age.
   - Progressive development of hypertrophic bone about the disk and facet joints leading to segmental stiffening or frank ankylosis is seen.

Disk herniation (Fig. 22.3) is considered as a complication of disk degeneration in Stages I and II. Spinal stenosis is a complication in late instability and early stabilization stages. Disk can herniate either into the body as Schmorl's node or posteriorly towards the canal compressing the nerve roots.

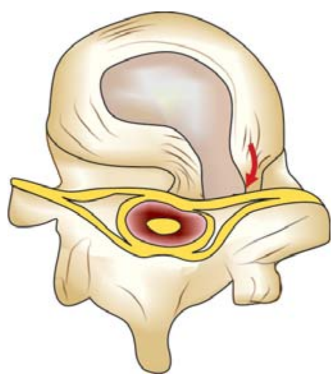


Fig. 22.3: Showing posterolateral disk herniation

Classification of Prolapsed Intervertebral Disk

Figure 22.4 shows the classification of prolapsed disk.

Disk bulging or protrusion This refers to some eccentric accumulation of nucleus with slight deformity of the annulus.

Prolapsed disk is the one in which eccentric nucleus produces a definite deformity as it works through the fibers of the annulus.

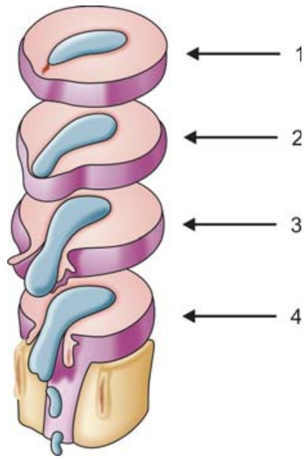


Fig. 22.4: Showing types of prolapse disk: (1) Bulge disk, (2) Prolapse disk, (3) Extruded disk, and (4) Sequestrated disk

Extruded disk Here the disk comes out into the canal and impinges on the adjacent nerve root.

Sequestrated disk Here the nuclear material has separated from the disk itself and potentially migrates.

Etiology of Disk Herniation

The etiology consists of risk factors and the definitive causes resulting in disk herniation.

Risk factors
- Jobs requiring heavy and repetitive weightlifting (Fig. 22.5).

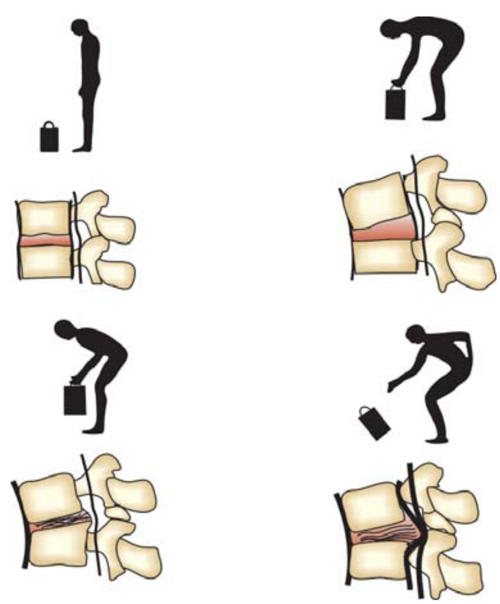


Fig. 22.5: Showing common mode of disk prolapse due to sudden and improper weightlifting

- Use of machine tools.
- Operation of motor vehicles.
- Cigarette smokers and tobacco consumers.
- Anxiety and depression.
- Stressful occupation as in doctors, police, etc.
- Women with greater number of pregnancies.
- Obesity and other cardiovascular risk factors.
- Monotonous work, working overtime, etc.
- Improper postural habits.

Definitive Causes

- Degenerative changes make the disk susceptible to trauma. Any trauma which suddenly increases the pressure will result in rupture of the posterior fibers of the annulus, e.g. weight lifting, fall on the buttocks, direct trauma to the back, twisting movements and occupation involving flexion and lifting motions.
- Disk may also rupture during pregnancy, labor and after prolonged bed rest due to disk softening.
- Disk rupture without any cause is due to degenerative process.

Remember

About disk disease:
- It is due to ageing process.
- It passes through three stages.
- There are four types of prolapse disk.
- Disk prolapse is a complication of Stage I and II.
- Herniation can take place into the body or posteriorly into spinal canal.

Clinical Features

Clinical features can be discussed under three headings:

Low backache Back pain is common in the second decade, disk disease and disk herniation in the third or fourth decade. The usual history of lumbar disk herniation is of repetitive low back pain, radiating to the buttocks and decreased by rest. Pain is increased by flexion, sitting, straining, sneezing, coughing, etc. Pain is decreased by rest and in Semi-Fowler's position.

Radiculopathy This refers to pain in the distribution of the sciatic nerve and is invariably due to disk herniation. This is called as sciatica. The radicular pain from the nerve root compression due to herniated disk is evidenced by leg pain equal to or more than the back pain. Pain usually begins in the lower back radiating to the sacroiliac regions, buttocks and thigh. The radicular pain usually extends below the knee.

TABLE 22.1: Different levels of nerve root compression and their presentation

Disk prolapse between	*Pain*	*Radiation*	*Sensory loss*	*Motor loss*	*Reflexes loss*	**SLRT*
L_3 and L_4 L_4 nerve root is involved	Lumbar region	Along the anteromedial aspect of the thigh	Medial shin	Quadriceps	Knee jerk	Normal
L_4 L_5 L_5 root involved 95% disk prolapse occur here	Lumbar region, groin, sacroiliac region	Lateral thigh, leg, dorsum of the foot and hallux	Hallux area	Extensor hallucis muscle	Medial hamstrings	Reduced
L_4 and S_1 S_1 root is involved	Same as above	Buttocks, posterior thigh, leg and lateral foot	Lateral foot	Gastrocnemius	Ankle jerk	Reduced

Easy way to remember
L_4 root involvement—remember '4' heads of quadriceps. Hence knee jerk lost (Fig. 22.7)
L_5 root involvement—remember '5' toes—Great toe and lateral 4 toes lose extension (Fig. 22.8)
S_1 root involvement—remember of 'S' of tendo-Achille. Hence ankle jerk lost (Fig. 22.9)

*SLRT—Straight leg raising test

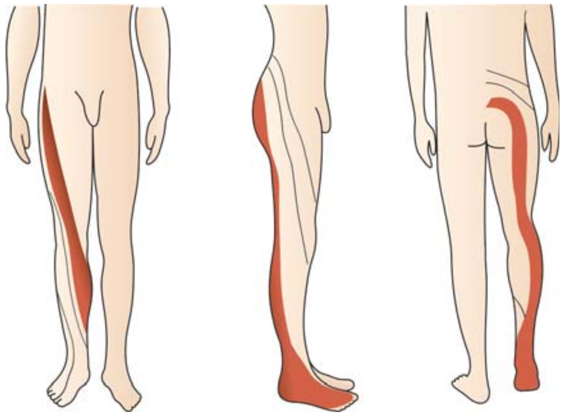


Fig. 22.6: Dermatomal pattern from above downwards belong to L_4 L_5 S_1 nerve roots respectively

Nerve root compression About 95 percent of the disk prolapse takes place through the L_{4-5} region compressing the L_5 nerve root (Fig. 22.6). The other nerve roots commonly involved are L_4 and S1 due to disk prolapse between L_{3-4} and L_5-S_1 respectively. Table 22.1 shows the various clinical manifestations following nerve root compression.

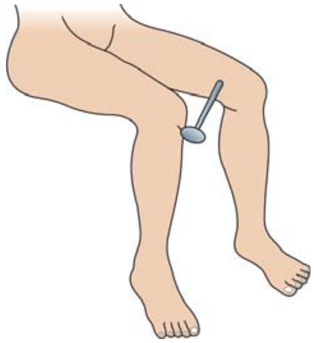


Fig. 22.7: Involvement of L_4 myotome

Fig. 22.8: Involvement of L_5 myotome, Patient is unable to extend the toes

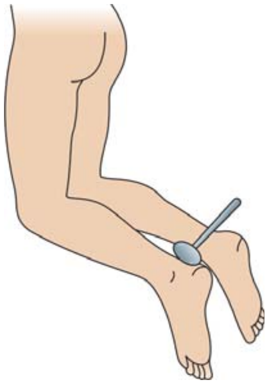


Fig. 22.9: S_1 myotomal involvement loss of ankle jerk

Remember

One question test: Radicular pain

Between the knee and the ankle, where is the pain?

- Front → L_4
- Side → L_5
- Back → S_1

Examination of the Back

Figures 22.10 to 22.18 shows different clinical examination methods in low backache.

- Inspection Note any postural defects like scoliosis, lordosis or kyphosis.
- Palpation consists of:
  - — Tenderness Look for the following points:
    - i. Localized tender infiltrates of the skin and subcutaneous tissue. Palpable tender induration of small intervertebral muscles. Tenderness at the level of posterior articulation of the involved segment and pain on percussion of affected intervertebral space.
    - ii. Movements all the movements of the spine are tested (Table 22.2).
- Evaluation of neurological system the dermatome and the myotomal distribution are carefully analyzed (*see* Table 22.1) to detect the level of lesion.
- Clinical tests these tests are based on stretching of the sciatic nerve over the prolapsed disk:
  - — Forward bending to touch the toes.
  - — Sitting and alternatively extending one leg and then the other.
  - — Slump test sitting bent forward and extending one leg and then the other.
  - — Straight leg raising test (SLRT) Patient is in supine position. The examiner raises the leg of the patient straight one after the other. Upto 30° nerve is not put under stretch. Between 30-70° nerve comes into contact with the prolapsed disk and the patient complains of pain. Beyond 70° if patient complains of pain it is usually not due to disk prolapse but could be due to sacroiliac joint involvement (Fig. 22.19).

Modifications of SLRT

Lasegue test Here the hip is flexed, knee is flexed and the leg is slowly straightened.

Buckling sign Perform an SLRT till the patient complains of pain. Now ask the patient to flex the knee. Pain decreases due to relief of tension on the nerve.

Sicard's test After doing a SLRT, dorsiflex the great toe. This puts further tension on the sciatic nerve and the patient complains of pain.

Fajerstazan's test After doing an SLRT dorsiflex the foot. This tenses the sciatic nerve and the patient complains of pain.

  - — Well leg raising test here the patient is asked to perform SLRT of the normal limb. If the patient complains of pain on the affected side, then it is highly suggestive of disk prolapse and this is a pathognomonic test which has more relevance than the conventional SLRT.
  - — Bilateral straight leg raising test Here patient is asked to raise both the legs simultaneously. This is a test for the sacroiliac joint rather than the spine. During the first 70° stress is on the SI joint, over 70° stress is on the lumbar spine.
  - — Femoral nerve stretch test (reverse SLRT) (Fig. 22.17). Here the patient is in prone position and is asked to lift the leg straight. This puts a stretch on the femoral nerve. If the patient complains of pain it indicates a high level disk prolapse ($L_{1\text{-}2\text{-}3}$).

Remember

About SLRT
- SLRT exerts tension on the sciatic nerve as it passes over the prolapsed disk.
- In disk prolapse SLRT is positive usually between 30° and 70°.
- Many modifications of SLRT either exert more tension (Fazerstazan's test) or relieve tension on the sciatic nerve. (Buckling sign).
- Contra lateral well leg raising test is more path gnomonic of disk prolapse than SLRT.
- Bilateral leg raising test has more relevance for SI joint pathology than back.
- Reverse leg raising test or femoral nerve stretch test is for detecting high lesion like L1 root involvement.

Clinical facts

Diagnosis of the disk disease is a suspect if
- Leg pain is minimal and back pain is predominant.
- If pain is bizarre or continuous.
- If the forward bending of the spine is normal.
- If the lumbar spine deviates to the opposite side.
- If tenderness is elicited over the midline.

Note Remember the hallmark of disk disease is repetitive low backache and buttock pain which is relieved by rest.

Remember

Diagnostic clues to detect high level disk lesion involving L_1 and L_2 nerve roots:
- Pain in the groin or testicles.
- Cauda equina lesion.
- Positive femoral stretch test.
- Atrophy of the involved limb.
- 95% of the disk ruptures usually occur at L_4 L_5.

TABLE 22.2: Clinical examination of the back

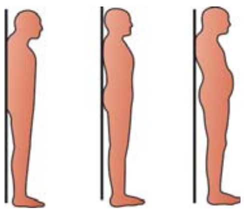


Fig. 22.10

Inspection With the patient in standing position look for postural abnormalities.
The figure from left to right depict thoracic hyperkyphosis, normal spine and exaggerated lumbar lordosis (Fig. 22.10).

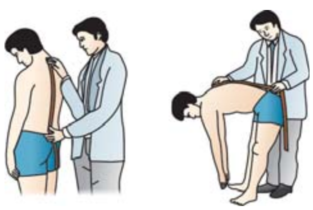


Fig. 22.11A Fig. 22.11B

Movements of the spine

1. **To test flexion**
   Instruct the patient to bend forwards as much as possible at the waist.
   Normal flexion is 80° or fingertips 3 to 4 inches from the floor (Figs 22.11A and B).

Fig. 22.12

2. **Lateral flexion**
   Instruct the patient to bend to the left and to the right as far as possible.
   Normal range is 35° on each side (Fig. 22.12).

Fig. 22.13

3. **Extension**
   Instruct the patient to bend at the waist as far backward as possible. Normal range is 20 to 30° (Fig. 22.13).

Fig. 22.14

4. **Rotation** Instruct the patient to rotate from the waist to the left and to the right as far as possible.
   Normal range is 45° per side (Fig. 22.14).
   Note: In all the movements of the spine the neutral position is 0°.

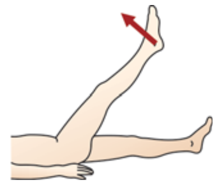


Fig. 22.15

SLRT With the patient in the supine position raise his or her leg to the point of pain or 90° whichever comes first.
Inference: localised pain indicates a disk lesion, while radiating pain indicates sciatic radiculopathy. Dull posterior thigh pain indicates tight hamstrings.
If the test is positive for sciatic radiculopathy do Lasegue test, buckle sign, etc. (Fig. 22.15)

Fig. 22.16

Site of pain and sciatic radiculopathy in disk prolapse (Fig. 22.16).

Fig. 22.17

Femoral nerve stretch test
Patient is instructed to lift the leg straight in prone position. Presence of pain in the anterior aspect of thigh indicates high level disk lesion (Fig. 22.17).

It is important to note that paraesthesiae and motor signs are seen in 96 percent of cases of disk prolapse. Sensory signs are seen in 80 percent. They are distributed along the involved nerve roots as explained earlier.

Investigations of Low Backache

Radiography of the back is not very reliable as normal findings are observed in 7 to 46 percent of the cases. Disk space is reduced in old cases but in acute cases it is maintained. Oblique view is recommended to rule out spondylolysis (Figs 22.20A and B).

Myelography consists of injecting radiopaque dye (Myodil was used earlier now it is the water soluble Iopamiro 300 which is being used) into the spinal canal and taking radiographs of the back. It is helpful in detecting the intraspinal lesions, spinal stenosis and cases of previously operated (Fig. 22.21) backs. It is also indicated when the diagnosis is in doubt. It is an invasive procedure and is no longer performed. It is now replaced by noninvasive procedures like CT scan and MRI (Figs 22.22 to 22.24B).

Figs 22.18A to E: Examination in IVDP: (A) Scoliotic posture in IVDP, (B) Reduced forward lumbar spine flexion, (C) Reduced lumbar extension, (D) Loss of lumbar lordosis, (E) ShLR test positive

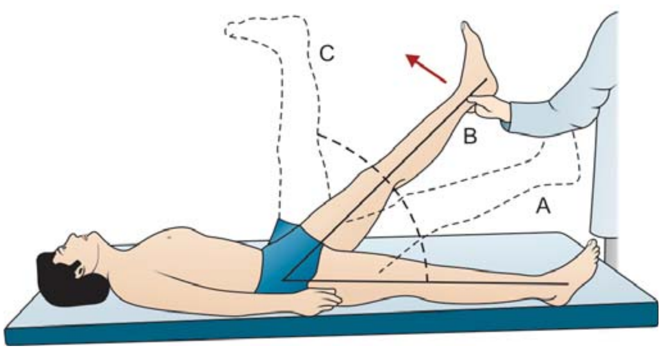
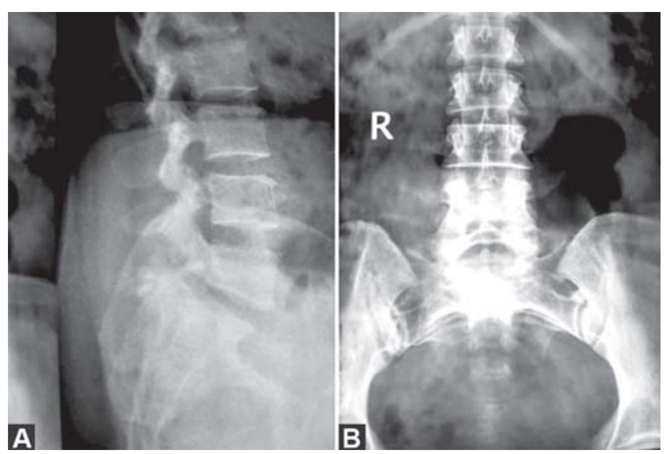


Fig. 22.19: Interpretation of SLR test (passive): (A) Up to 30°, sciatic nerve not under stretch, (B) Between 30-70°, nerve is stretched by prolapsed disc, hence positive, (C) Pain between 70-90°, is not due to disk prolapse but due to S1 joint arthritis



Figs 22.20A and B: Plain X-ray showing lumbar disk prolapse

L_4 and L_5 Disk Prolapse

CT scan it is a very useful noninvasive, painless outpatient procedure. It gives a cross-sectional study of the pathology. It however fails to detect intraspinal lesion, arachnoiditis and scar from disk herniation (Fig. 22.22). It helps to detect the foraminal stenosis and the lateral disk prolapse.

Fig. 22.21: Myelographic study of the lumbar spine

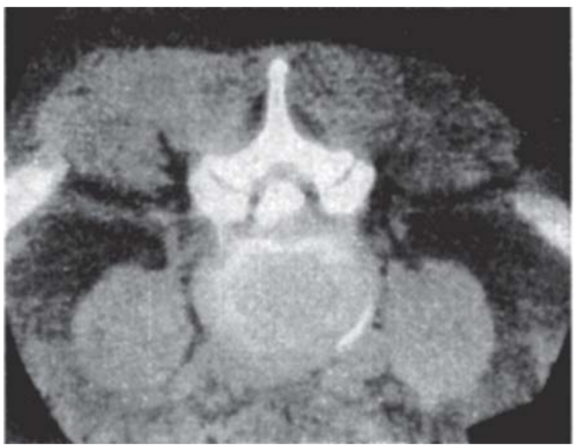
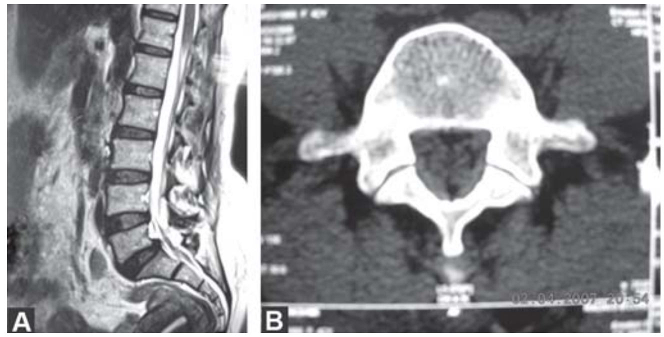


Fig. 22.22: CT scan cross section showing posterolateral disk herniation

Fig. 22.23: Showing MRI of lumbar spine with L_4 disk prolapse compressing the spinal cord



Figs 22.24A and B: MRI showing lateral and cross-sectional views of L_5 disk prolapse

MRI This is also an extremely useful, painless, noninvasive outpatient procedure. It helps to detect the intraspinal lesion, helps to examine the entire spine and identifies degenerative disk (Figs 22.22 to 22.24). However, it is expensive and hence prohibitive.

Discography After identifying the disk correctly, through a needle, a radiopaque dye is injected into the space. This reproduces the pain experienced by the patient previously and is relieved by injecting Xylocaine. This confirms the diagnosis. It is a painful procedure and can introduce infection into the disk. Hence it is less practiced.

Other tests of diagnostic importance are bone scans, EMG, routine laboratory studies, injection studies, etc.

Differential Diagnosis

There are many causes for backache. The most common ones being back muscle, strain, ligament sprain and lumbar disk disease due to abnormal posture and ageing process. The differential diagnosis is as follows:

Extrinsic causes (unrelated to spine) Diseases of the
- Urogenital system
- Gastrointestinal system
- Vascular system
- Endocrine system
- Nervous system
- Musculoskeletal system, etc.

Intrinsic causes (related to spine)
Important causes
- Unstable spondylolisthesis
- Osteoporosis and compression of the vertebrae
- Marked loss of disk height at multiple levels
- Severe scoliosis

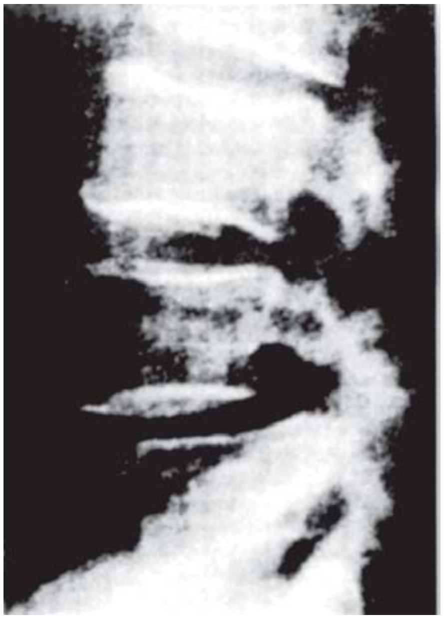


Fig. 22.25: Radiograph of LS spine showing lumbar spondylosis

Unimportant causes
- Lumbar spondylosis (Fig. 22.25)
- Mild discopathy
- Arthroses of the facet joints
- Disk calcification
- Spina bifida
- Schmorl's nodes
- Mild to moderate scoliosis.

Predominant cause of backache as already suggested is lumbar disk disease. Common diseases that mimic lumbar disk disease include ankylosing spondylitis, multiple myeloma, vascular insufficiency, arthritis of the hip joint, osteoporosis with stress fractures, extradural tumors, peripheral neuropathy, herpes zoster, etc.

Treatment of Common Low Backache

Principles

The principles of treating common low backache are explained by three R's.
- Relieve pain in acute cases.
- Restore normal movements in chronic cases.
- Recurrence is to be prevented.

The following are the treatment modalities in low backache.

Treatment Modalities in Low Backache

Conservative therapy Absolute bed rest is the best treatment for low backache. Non-steroidal anti-inflammatory drugs (NSAIDs), muscle relaxants, antidepressants are recommended. Bucks extension skin traction and pelvic traction help to relieve pain. As the pain decreases, isometric abdominal and lower extremity exercises are begun. Walking within limits of comfort is also encouraged. Sitting and riding in a car is discouraged. Back education and importance of proper posture is taught. Choice of exercises is based on the increase or decrease of pain by extension or flexion. If pain decreases by extension, extension exercises are recommended. On the other hand if the pain decreases by flexion, flexion exercises are recommended. Improvements in symptoms with extension are indication of a good prognosis with conservative care. Lower extremity exercises increases the strength and relieves the stress on the back, but they may increase the lower extremity arthritis. Thus the true benefit of such treatment may be in the promotion of good posture and body mechanics than strength.

Back braces or belts are recommended in acute stages. They are discarded as soon as symptoms decrease otherwise muscles become weak and hasten the degeneration.

See the pictorial display of proper postural habits and back exercises recommended for prevention of low backache (Table 22.3).

Thus, a patient suffering from low back pain needs a multi-prolonged approach to successfully combat the causative factor and relieve the patient from pain. The various treatment options are now discussed in detail:

1. Bed Rest

The intradiscal pressure are the lowest when the patient is supine, it increases three times during standing and eleven times during sitting. This is the rationale for suggesting bed-rest for patients suffering from acute low back pain.

Types
- Semifowler's positions in this position, both the hip and knee of the patients are flexed. This is a very comfortable position, as it relieves stress on the back.
- Supine lying with pillows beneath the knees also helps in relieving the pain.
- Side lying with hip and knee flexed (fetal position) also is found to be effective.

Caution Prone lying is hazardous and is avoided at all costs.

TABLE 22.3: Proper postural habits (Figs 22.26 to 22.33)

Fig. 22.26: *Lifting objects*—Bend at your knees and not at your waist. Hold the object you are lifting close to your body, not higher than your chest. It is easier to push rather than pull heavy objects, e.g. furniture, and keep the knees bent while pushing

Fig. 22.27: *Walking*—Walk well-with your head high, chin tucked in, toes pointing straight in front. Wear comfortable footwear. Take steps of a natural, comfortable length. Swing the arms naturally

Fig. 22.28: *Standing*—Keep one foot in front and knees slightly bent while standing upright. If you have to stand for a long time, try keeping one foot higher than the other, on a low stool. Change your position often.

Fig. 22.29: *Sitting*—Ensure your back is firmly touching the back of the chair. Keep the knees slightly higher than the hips, e.g. by using something to prop up your feet. Sit close to your desk or table to avoid bending forward. Do not sit for too long. And when driving, move the front seat close to the steering wheel and both hands should be kept on the wheel.

Fig. 22.30: *Turning and reaching out*— Do not twist your waist. Rather, turn by moving your feet. Keep the phone and such like objects within easy reach; don't strain to reach them. Stand on a stool to reach high objects.

Fig. 22.31: *Sleeping*—If you sleep on your side, keep knees and lower body bent a little. On your back, put a pillow under your knees. Try not to sleep on your stomach—but if you must, put a pillow under your waist not under your head. Use a firm mattress—neither soft/ squashy nor very hard.

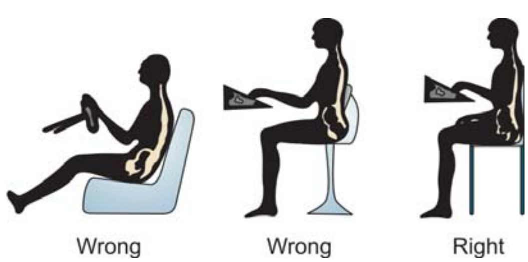


Fig. 22.32: Sitting and driving habits—right and wrong

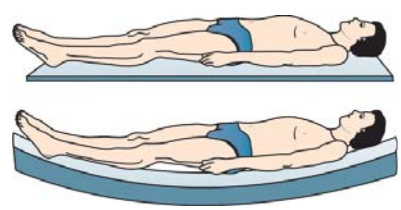


Fig. 22.33: Choice of a suitable bed. The mattress must be pliant so as to adapt itself to the shape of the body whereas the underlying frame must be rigid in order to provide support for the body. Use a firm mattress, neither soft nor hard.

Vital facts

Bed rest vs. backache
- Period of bed rest should not exceed > 2 weeks.
- Bed rest, not very ideal for patients with chronic low backache. Ambulation is preferred in these patients.
- Bed rest on a firm mattress gives better pain relief.
- Too long a bed rest is detrimental and may lead to medical complications like bedsores, renal stones, respiratory complications, muscle atrophy, etc. especially in geriatric patients.
- Bed-rest combined with thermotherapy, etc. is still more effective.

2. Physical Agents

When combined with other therapies like exercises, these agents are known to give effective results.

Cryotherapy

This is indicated during acute low back pain, as it is known to reduce pain, swelling and muscle spasm. It is also known to reduce the local metabolic activity and delay the nerve condition.

Cold packs This is used initially, during the first 24-48 hrs and is found to be very effective.

Ice massage Ice is applied along the course of the muscle fibers in a stoking direction. This cools the skin to a higher degree than cold packs.

Note Cold relieves pain and spasm for a longer duration than heat.

Thermotherapy

Heat causes vasodilatation thereby reducing the muscle ischemia. This decreases the pain and relieves the muscle spasm. It is also known to act through counter irritation.

Superficial heat This is given through the hydro collator packs, infrared rays, heating pads and whirlpools.

The heat generated by these penetrates only upto the level of subcutaneous tissues.

Infrared rays The amount of heat given depends upon the size of the bulb and the distance from the skin. The duration of therapy is usually 30 minutes.

Hydrocollator packs This is wrapped in two towels and placed on the patient's back for 30 minutes.

Whirlpool Not easy to use in patients with backache.

Note For all superficial heating, the safe exposure is upto 30 minutes at 45°C.

Deep heat The two common mode of deep heat therapy are the ultrasound and the shortwave diathermy. These two heat the structures below the subcutaneous tissue.

Shortwave diathermy This is known to heat deeper structures like muscle, ligaments and bones.

There are two modes. One is continuous (preferred in chronic low backache) and the other is pulsed mode (preferred during acute pain).

Though effective, other deep heating modalities like ultrasound are preferred over SWD.

Ultrasound This penetrates deeper than SWD. Though it is used for both acute and chronic pains, its use in acute conditions is not recommended as it is known to cause vasodilatation.

Usage Treatment for about 20 minutes at 3 times a week for 3-4 weeks. Other advantages of ultrasound are it helps to drive medicines like Xylocaine, analgesic cream and hydrocortisone deeper into the tissues and it also increases the stretch ability of the joint capsules and ligaments.

Quick Facts

New trends in heating
- Microwave diathermy
- Interferential therapy
- Diapulse
- Laser beams
- Helium neon laser beams
- Mega pulse

TENS This is effective in relieving both acute and chronic pains.

Mode 2-4 Hz at 50 MA pulse rate at 2 pulses/sec between 30-60 minutes pulse width.

3. Role of Traction in Low Back Pain

Traction as a form of treatment for low backache is followed since ages. Undoubtedly it is one of the most popular methods of conservative management of LBA.

How does traction help in relieving pain?
- It stretches the spinal muscles and ligaments and thereby reduces the intradiscal pressure.
- It distracts the vertebral body and the facet joints.
- It widens the intervertebral foramen, and relieves pressure on the nerve roots.
- It straightens the spinal curve.
- It compels the patient to be on bed and thereby ensures that the patient gets bed-rest for better relief of pain.
- Boosts the patient's psychology.

Different Types of Spinal Traction

Continuous traction in these light weights is applied for several hours a day. This method has its own drawback that it is difficult for the patient to tolerate the weight for a very long time.

Sustained traction this requires a steady amount of weight and is applied for a period 30 minutes. Patient is able to tolerate heavy weights for a short period of time.

Quick Facts

Indications for Spinal traction

- Disk protrusion
- Lumbar spondylosis
- Spondylolisthesis
- Failed back
- Sciatic scoliosis, etc.

Intermittent traction this is the most popular method of traction. Here through a mechanical device, weight is applied and released for short periods of time. It is very effective as it produces a massaging effect over the spine and this provides relaxation. It is tolerated very well by the patients (Fig. 22.34A).

Manual traction Here the physiotherapist applies the traction force manually. Not a very popular method, since patient is unable to anticipate the amount of traction force.

Positional traction this is useful to stretch one side of the spine.

Autotraction Here patient himself generates traction by pulling on a cord attached to a pelvic waist. Not a very popular choice for tractions.

Fig. 22.34A: Showing method of intermittent lumbar traction

Fig. 22.34B: Showing method of 90-90 traction

Gravity traction Here patient is suspended vertically or lies in an inverted position. Here the force of gravity is used to stretch the spinal structures. Not very popular.

90-90 traction here the patient is supine and his knee and hips are bent at 90° with the support of a chair of correct height (Fig. 22.34B).

Quick Facts

Traction vs. weight

The question is how much traction force is required for effective tractions:

- A force equal to 50% at body weight is required to distract the spine.
- Weights > 50 percent will cause sliding of the patient in the bed.
- Weights < 50 percent will not overcome the direction.

Direction of the force the pull must be from underneath the pelvis, as it reduces the posterior till of the pelvis and thereby decreases the lumbar lordosis.

Quick Facts

Contraindications for tractions

- Infective diseases of the spine
- Malignancy
- Severe osteoporosis
- Acute strains and sprains
- Massive disk prolapse
- Pain daring rest
- Cardiac and respiratory problems.

Note
- The scientific proof for the efficacy of traction is not established.
- Traction mainly helps by providing bed-rest for patients with disk diseases.

Corsets and braces More than 99 percent of orthopedists use corsets and braces during the treatment of LBA. How does it act? (Fig. 22.35).
- They increase the intra-abdominal pressure; the force is diverted against the diaphragm and thoracic spine. This reduces the load on lumbar spine.
- Some of the load will be transmitted to the oblique and transverse abdominal muscles.
- It provides a sense of security to the back.
- Though it is known to decrease the spinal movements, in reality it is supposed to increase the movements of the lumbar spine.
- It provides natural splintage to the back.
- It corrects the faulty posture.

Advantages of brace/corset
- It helps the patient to recover the mobility of the spine faster.
- Acts as an additional support when patients return to heavy labor.
- Excessively obese patients with weak abdominals are helped by bracing.
- Elderly patients who cannot tolerate exercises.
- Very useful role in patients with scoliosis.
- Provides a sense of security.

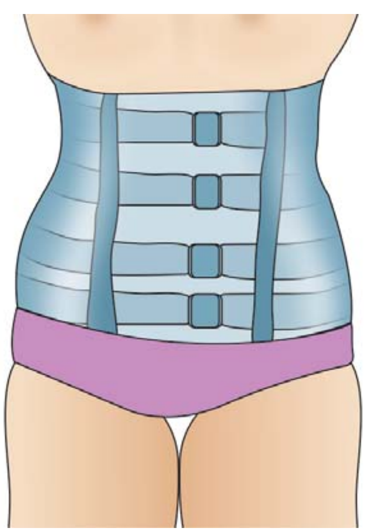


Fig. 22.35: Showing lumbar sacral belt application in LBA

Quick Facts

Indication for braces
- Acute disk disease
- Spondylolisthesis
- Post-spinal surgery
- When patients return to their work during travel

Disadvantage of braces By immobilizing the spine, it leads to muscle atrophy leading to weakness in the spinal musculature.

Quick Facts

Choice? Corset vs. braces

Not much choice but however
- Corset is sturdier and thus has less surface content and is, therefore, cooler.
- If a patient has pain relief in supine or bending forward position, such a patient will benefit from a rigid brace.

Spinal manipulations it is a skill technique to be done by a trained person in a gentle manner. Manual force is used to bring about the passive movements either within or beyond the active range of motion.

Mobilization is a less aggressive method than manipulation. It starts where the active ROM ends.

Principle of Manipulation

Manipulation is based on the principle that vertebral malalignment is the cause for low backache and it sets right this malalignment.

The Benefits of Manipulation
- It sets right the vertebral malposition.
- Relieves muscle spasm.
- Reduction of prolapsed disk by tightening the posterior longitudinal ligament and freeing the adhesions around the prolapsed disk.
- Stimulates large alpha fibers and blocks nociceptive inputs of pain fibers.

Indications
- For acute and chronic low back pain without complications.
- Sciatica without neurological deficits.
- Facet syndrome

- Sequestrated disk
- SI joint strain
- Psoas syndrome
- Spondylolisthesis
- Spinal stenosis
- Chronic low backache

Contraindications
- Malignancy
- Infections of spine
- Fractures
- Severe osteoporosis
- Ruptured ligaments
- Acute conditions
- Pregnancy

Techniques
- *Stretch technique* Useful in joints whose capsule is contracted.
- *Thrust technique* Useful in joint which exhibits hard stop in one direction.
- *Oscillation technique* Employed in recently injured joint.
- *Rotation and side body technique* Useful in fact joint locking or restorations.

Massage

Massage helps by stimulating the tissues and thus relaxes the contracted muscles (Fig. 22.36).

Mechanism of Action

- Relaxation of contracted muscles.
- Increases the blood circulation to the area.

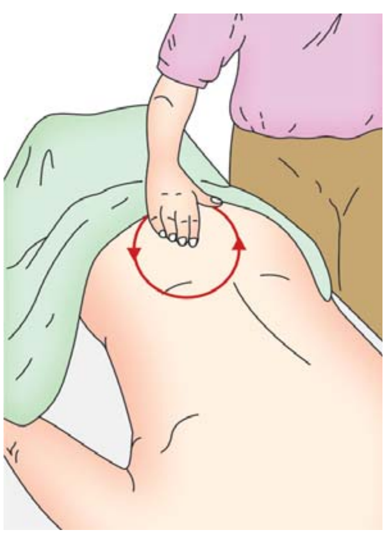


Fig. 22.36: Showing technique of back massage

- Counter irritation and release of endorphins.
- Psychological boost to the patient.

Exercises for Low Backache

The exercises for LBA could be flexion exercises, extension exercises, rotational exercises and aerobic exercises. Though exercises are beneficial there is a great deal of confusion and controversies regarding the indication and type of the exercises. Exercises should not be 'generalized' but should be 'individualized' depending upon the patients. This is the best way to derive maximum advantages from the exercises. Why should exercises be prescribed for LBA?

Reasons
- It reduces pain.
- To strengthen the weak muscles.
- To stretch the contracted muscles, ligaments and capsules.
- To reduce the mechanical stress on spinal structures.
- To improve the spinal mobility.
- To improve the posture.
- To stabilize the hyper mobile segments.

Quick Facts

How does exercise benefit LBA patients?
- The strength of muscles, bones and ligaments are increased.
- Nutrition to joints and disks are improved.
- Neuro-motor control and co-ordination are improved.
- The level of endorphin is increased in blood and CSF fluid.
- They relieve depression and anxiety.
- They increase alpha wave activity and produce central and peripheral relaxation and decrease the muscle tension.

Choice of Exercises

A correct choice whether flexion or extension exercises has to be made depending upon the specific indications as mentioned Table 22.4.

Flexion Exercises

Flexion exercises are advocated to achieve the following goals:
- To open the intervertebral foraminae.
- To unlock the facet joints.
- To stretch the hip flexors.

TABLE 22.4: Choice of exercises flexion or extension

Indications exercises	*Flexion exercises*	*Extension*
Pain relief on	• Sitting • Forward bending • Lumbar Lordosis • Fixed lumbar lordosis with bending	• Lying • Walking • Repeated back bending • Decreased lumbar lordosis
Pain increased on	• Walking • Standing • Sustained forward bending • Repeated back-ward bending • Extreme range of backward bending	• Sitting • Driving • Arising from chain • Stooping • Bending • Forward bending • Repeated forward bending
Pain unchanged on	Stooping	—

- To mobilize the posterior fixation of the lumbosacral articulation.
- To strengthen the abdominal muscles.
- To stretch the back extensors.
- To increase the intra-abdominal pressure by contracting the internal and external oblique abdominal muscles.

Indications of flexion exercises. See below.

Types of Flexion Exercises

Flexion Exercises for LBA

Figures 22.37A to J shows different types of flexion exercises for low backache.

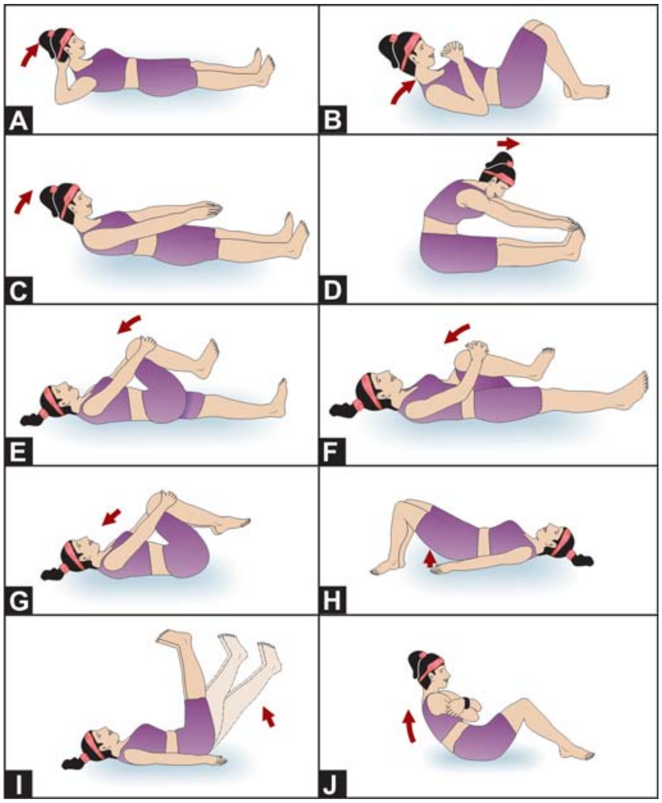
Contraindications for Flexion Exercises

- Acute disk prolapse.
- Immediately after prolonged rest with hyper hydrated disks which cause rupture.
- Postural LBA due to flexion.
- Lateral trunk shift or list.

Extension Exercises

These exercises aim to achieve the following goals:

- They maintain the normal lumbar lordosis.
- They improve the strength of the extensor muscles of back and the hip.
- In patients with posterior or posterolateral disk prolapse it relieves the pressure on the disks.

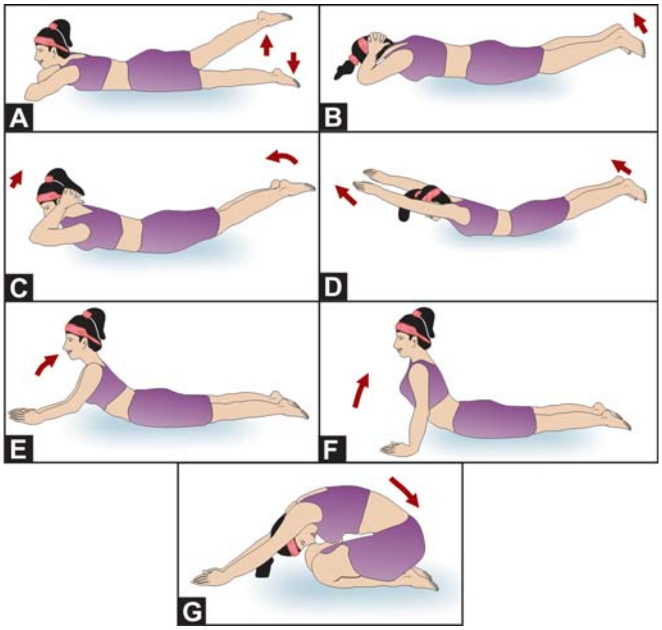


Figs 22.37A to J: Showing flexion exercises: I. Anterior abdominal wall strengthening exercises (upper abdominal muscles). Exercises from A to D. (A) in supine position, with knee extended, head supported at the back by both the hands, raise the head and neck and count 10. (B) Raise the head and neck, with both the knees bent and the hands in front of the chest. (C) Repeat the above exercise keeping both the hands straight. (D) Continuing exercise C, touch the toes with both the hands. II. Erector spinae stretching exercises (E, F, and G) E, F: In the supine position pulls the right thigh (E) and later the left thigh (F) over the abdomen and hold for 10-15 seconds. (G) Here both the knees are pulled up towards the chest. Hold for 15 seconds. III. Exercises for strengthening of lower abdominal muscles. (H) Patient is supine, feet flat, arms by the sides. Both the hips are raised from the ground and held for 10-15 seconds. (I) Patient is supine. Bilateral straight leg raising exercises at 30°, 60° and 90° are performed for 15 seconds each. (J) With the arms tucked in front of the chest, knees bent and feet flat, the patient raises the head, neck and chest forwards. Exercises both upper and lower abdominal muscles

- They improve the mobility of the spine.

Types of Extension Exercises

- Extension to neutral: Here the patient, positions themselves at the edge of the table on their stomachs, without extending the lumbar spine, lift the back from forward flexed position of 40-45°. This causes eccentric contractions of the extensors.



Figs 22.38A to G: (A) Patient is prone, both the arms are folded under the chin, keeping the knees straight, lift the legs alternatively and count ten, (B) Some position, hands tucked behind the head, the both the legs are lifted straight for a count of ten, (C) Patient is in the same position as in B, but lifts the head, neck and legs simultaneously, (D) Some exercises, is repeated but keeping both the arms straight and lifting up, (E, F) Prone lumbar extension eercise. Here the patient is prone. Both the hands are placed at the level of the shoulders. Gradually the upper body is pushed off the ground by straightening the arms. The hip should be placed firmly on the ground during this exercise. (G) Patient is positioned on the hands and knees with the chin tucked in and the back is arched. Instruct the patient to slowly sit back on the heels lefting both the shoulders drop towards the floor

- Hyperextension exercises: Here lying prone the patient extends from neutral (0°) position to 15 to 30° of hyper-extension.

  This is the most effective exercise to strength the back extensors.

Contraindications
- Acute disk prolapse
- Multiple back operations.
- Spinal stenosis
- Spondylolisthesis.

For different methods of doing the extension exercises for LBA (Figs 22.38A to G).

Rotational Exercises

Figure 22.39 shows rotational exercise for low backache.
- These exercises provide overall relaxation of the spinal muscles.

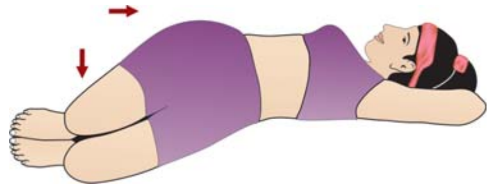


Fig. 22.39: Showing the rotational exercises and exercises for stretching the side muscles for LBA

- The external and internal oblique abdominal muscles help in the development of intra-abdominal pressure and help in the maintenance of anterior and posterior trunk balance. They also provide anterior stability to the spine.

Exercises for Stretching the Side Muscles

Figure 22.39 shows exercises for stretching the backside muscles.

Patient lies on the back, keeping the back flat and feet together, the knees are rotated on either side for a count of ten.

Other Forms of Exercises

- *Mobility exercises* By self-assisted pelvic rotation and chest roll, overall mobility of the spine induces relaxation of the muscles and joints.
  - Pelvic rotation Patient is supine, hip flexed, and knee flexed and the foot is placed on the table. The patient carries out complete rotation of the pelvis on either side (Fig. 22.39).
  - Chest roll on either side in sitting or supine position is carried out.

    These exercises relax the spine before passive mobilization and manipulation.
- *Stretching exercises* These could be generalized or specific and helps in stretching the contracted muscles and ligaments (*see* also Section on Yoga at the end of this chapter). Once a choice of the exercise is made, the techniques to be chosen are either isometric, isotonic or isokinetic varieties.
- *Aerobics* These exercises like walking, jogging, swimming, cycling, dancing, etc. are slowly incorporated and are found to be very effective.

Quick Facts

How to check the correctness of the exercise chosen?
- Centralization of the pain of the back.
- Absence of pain.
- Absence of diskomfort.
- Gradual improvement by 10-15 days.

These indicate the correctness of the choice of the exercise.

Quick Facts

What are the exercises to be avoided?
- Back bending in stranding
- Forward binding and touching the toes with knees straight.
- Bilateral straight leg rising.
- Lifting the arms and legs simultaneously in prone position.

Note Strengthening exercises to the back muscles are not really needed since they are antigravity muscles and are sufficiently stronger.
- Each exercise is done one to five times twice daily.
- The number of repetitions should be kept increasing to reach a minimum of ten repetitions twice daily.
- Exercises are to be done slowly and smoothly.

McKenzie's Approach to LBA Treatment

McKenzie's methodology of treatment is based on two principles:
- Prolonged flexion posture opens up the intervertebral space posteriorly and drives the disk material back compressing the spinal cord.
  On the other hand the physiological "lumbar lordosis" drives the disk material anteriorly. Hence, he emphasizes maintaining the physiologic lumbar lordosis.
- Among all the four spine movements, he identifies that movement, which reduces pain or causes centralization. This forms the basis of his therapy.

Steps

Step 1 Patient is instructed to correct the posture maintaining the lumbar lordosis in all situations.

Step 2 Extension exercises are carried out to restore the normal lumbar lordosis.

Step 3 After 2-3 weeks flexion exercises are incorporated to improve flexibility.

McKenzie's Exercises

- Extension exercises
  — Prone lying for brief periods for relaxation.
  — Prone lying in extension with forearm and elbow support (Fig. 22.40A).

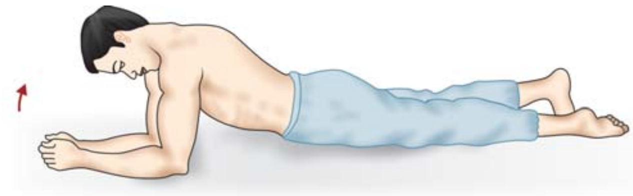


Fig. 22.40A: McKenzie's exercises for low backache

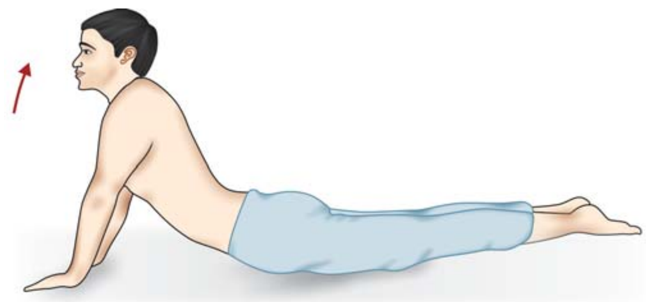


Fig. 22.40B: Prone lying exercise on the hand support

  — Prone lying in extension on hand support (Fig. 22.40B).
  — Extension as much as possible in standing position.
- If the pain is on one side shift the pelvis away from the painful side and repeat the above exercises.
- Flexion exercises (started after 2-3 weeks)
  — Patient bends the knee over the chest and counts ten. Then bends the other knee and finally bends both the knees over the chest (*see* Figs 22.37E to G).
  — Patient sits with both the legs apart. Bends forwards to slowly touch the knees and then the toes (*see* Figs 22.37C and D).

Treatment of Some Specific Low Back Pain

Idiopathic LBA

Early stages
- Bed rest.
- Drugs-analgesics, muscle relaxants.
- Treatment by physical agents.
- Mild traction.

Later stages
- Passive movements in a relaxed rhythmic manner.
- Relaxation techniques (by physical agents, mobility exercises, etc.).
- Specific exercise programme depending upon patient's problem.
- Early mobilization.

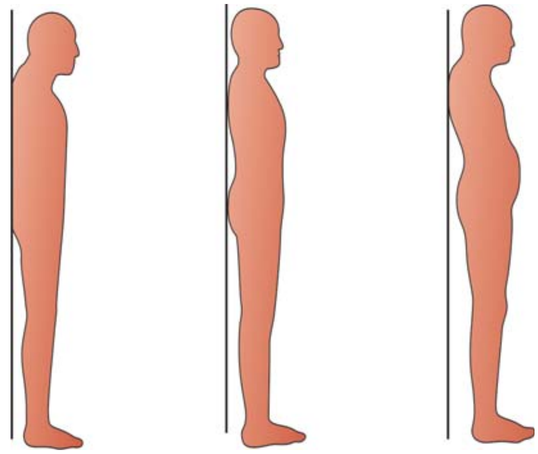


Fig. 22.41: Showing normal and abnormal human postures

LBA due to Faulty Postural Habits

Faulty postural habits lead to pelvic tilts on one side which causes muscular tightness and eventual fixed deformities (Fig. 22.41). Pelvic tilt could be:

- Anterior this is due to weak abdominal muscles, tight low back muscles, tight hip flexors, fascia facing lata and weak hamstrings. This causes increased lumbar lordosis.
- Posterior this is due to tightness of the low back muscles. This causes flat back.
- Lateral this is due to scoliosis or limb length discrepancy.

Specific Exercises for Backache due to Muscle Imbalance

- For weak abdominal muscles
  - — *Upper abdominal* In the supine position, with the hip and knees bent, patient is instructed to raise the head and shoulders above both unilateral and the table and hold in this position.
  - — *Lower abdominals* For lower abdominals both unilateral and bilateral straight leg raising exercises are indicated.
- For tight low back muscles Patient sits against the wall with both the knees straight. Slowly by bending forwards tries to reach for the toes.
- For hamstring tightness Self-resistive knee flexion exercises are indicated.
- For posterior tilt Hyperextension exercises for the back.
- For lateral pelvic tilt:
  - — On the raised side of the pelvis exercises to strengthen the weak gluteal muscles.
  - — On the dropped side, exercises to stretch the tight abductors.
  - — Shoe raise on the dropped side.
- For tight fascia lata to stretch the left tight fascia lata, the patient is on the sides on the right side. Stabilizing the pelvis on the right side with the limb in neutral position of abduction and adduction, the hip is slowly extended backwards to relax the tight fascia lata.
- The tight tendo-Achilles is also stretched by gradually dorsiflexing the foot.

Treatment of Chronic LBA

- Bed-rest is not very important.
- Correction of psychosomatic problems helps.
- Back strengthening exercises which are mentioned above.
- Strong isometrics to the back muscles.
- Mobility and active exercises.
- Aerobic exercises.
- Specific exercises depending upon situations.

Treatment of Acute Disc Lesion

- Bed-rest for 2 days
- Physical agents like cold, heat, etc.
- Drugs like NSAIDs, muscle relaxants, etc.
- Lumbar spinal support with the help of braces or corsets.

Late stages

- Intermittent lumbar traction.
- Gentle extension exercises.
- Later, flexion exercises.
- Stretching exercises for low back muscles.
- Active flexion and extension exercises.
- Aerobic exercises.
- Ergonomics.
- Surgical management if there is evidence of neurological problems.

Epidural Steroids

Epidural steroids are a symptomatic method of treatment, and consist of injecting a long-acting steroid and a local anesthetic. Its effect lasts for three weeks and is useful for sub acute and chronic cases. It also reduces dependence on narcotics in chronic cases.

Surgery

In backaches due to mechanical reasons surgery is seldom required. However, in 5% of the cases with the below mentioned indications, surgery may be required.

Absolute indications

- Failed conservative management.
- Marked progressive weakness of muscles.

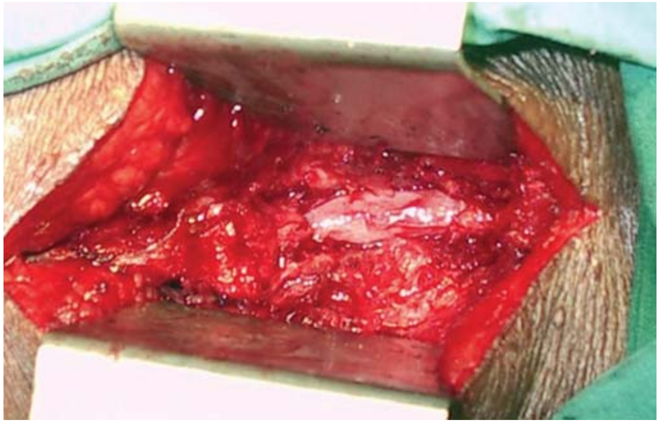


Fig. 22.42: Operative photograph of open disectomy

- Progressive neurological deficit.
- Cauda equina paralysis.

Relative indications
- Recurrent episodes of incapacitating sciatica.
- Pain unrelieved by complete rest from activity.

Principles of surgery The principle of surgery is to see that the pressure on the nerve root is relieved by removing the prolapsed disk. Dissection of muscles and bone removal should be kept at a minimum to prevent weakening of the spine.

Surgical Methods

Laminectomy and disk excision Earlier this was the surgery of choice but now it is no longer resorted to as it makes the spine unstable (Fig. 22.42).

Hemilaminectomy Here part of the lamina is removed. It is considered by many as extended fenestration approach. If fenestration technique is properly done hemilaminectomy is not necessary (Fig. 22.43).

The fenestration surgery Here the spine is approached unilaterally and the spine on the opposite side is not exposed.

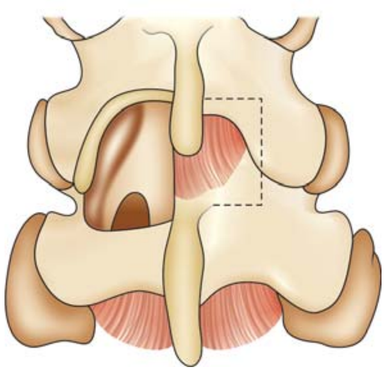
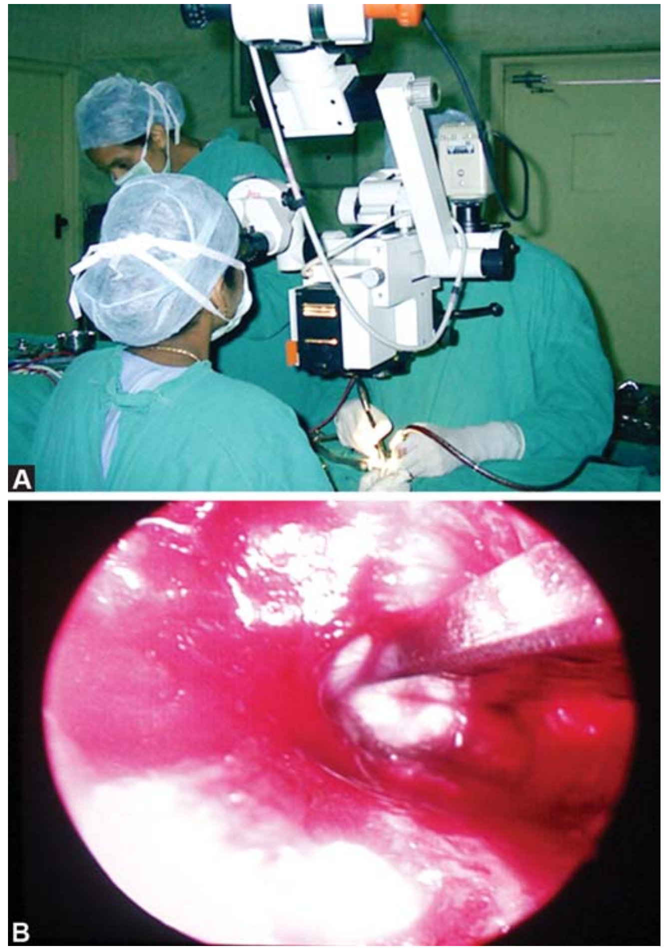


Fig. 22.43: Showing hemilaminectomy technique for decompressing the spinal cord



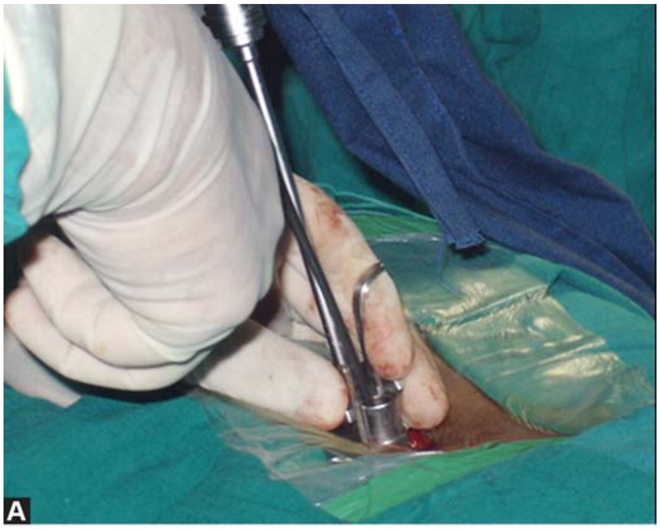
Figs 22.44A and B: Clinical photograph showing microscopic lumbar disectomy

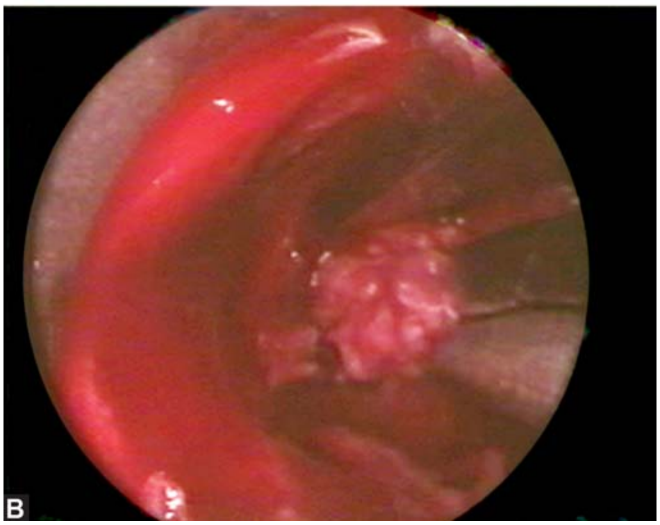
Here only the contiguous margin of upper and lower laminae is removed and medial facetectomy is done. The disk is now excised. This procedure requires that the affected disk is correctly located by MRI and radiographic studies.

Microscopic lumbar diskectomy (Figs 22.44A and B) Using an operating microscope the disk can be excised through a very small incision (< 3.5 cm) with minimum damage to the structures and minimal blood loss. It is a technically demanding procedure and gives excellent results if done in properly indicated cases like a single level posterolateral disk prolapse. The patient can be discharged home within two days and he or she can return back to his or her normal work faster. In short it can be described as a less invasive, less painful, more specific procedure giving maximum comforts to the patient. Dr PS Ramani calls it as "come today, go tomorrow" surgery!

Endoscopic lumbar discectomy (ELD) is also choice of treatment which is becoming more popular nowadays (Figs 22.45A and B).

The result of ELD is same as microscopic discectomy.





Figs 22.45A and B: Clinical photograph showing endoscopic lumbar disectomy

Physiotherapy Management after Spinal Surgery

Principles

- Mobilization should be done as early as possible to prevent complications due to prolonged bed-rest.
- Avoid strenuous exercises.
- Normal lumbar lordosis to be maintained in all postures.
- Ergonomic advice.

Physiotherapy after Fenestration Technique

Immediate

- Chest physiotherapy.
- Upper limb movements.
- Glutei and quadriceps isometrics.
- Hip and knee flexion by heel drag.
- Vigorous ankle and toe movements.

2nd-3rd postoperative days

Turning the whole body as one unit from supine and side lying position.

After One Week

- Isometric abdominal exercises.
- Assisted spinal extension exercises.
- Supported sitting.
- Gradual ambulation, flexion and trunk rotation.

After 3 Week

- Graded spinal extension exercises.
- Graded spinal flexion, rotation and side flexion exercises.
- Ambulation with correct posture and gait.
- Proper ergonomics.

Physiotherapy after Laminectomy

It is same as above with some modifications:

- Back aching in supine by the end of first week.
- Strong abdominal isometric exercises.
- Spine extension exercises by 2-3 weeks.
- Ambulation by 4 weeks.

Physiotherapy after Spinal Fusion

- Gradual turning in bed by 3 weeks.
- Gradual exercises for spine flexors and extensors.
- Assisted sitting by 4 weeks.
- Ambulation by 6 weeks.
- Spinal movements by 8 weeks.
- Spinal corset discarded by 12 weeks.
- Spine mobilization and strengthening exercises are made more vigorous.
- Daily activities and light sports resumed by 12 weeks.
- Proper back ergonomics.

Chemonucleolysis

Indications are the same as for surgery. It is limited to lumbar spine. Drug used is chymopapain. Not a very popular method of treatment for low backache.

BACK ERGONOMICS

This is an extremely important aspect of backache management as it helps in preventing recurrence. This consists of:

- Proper postural habits.
- Proper work environment.
- Back exercises.
- Modifications in activities of daily living.

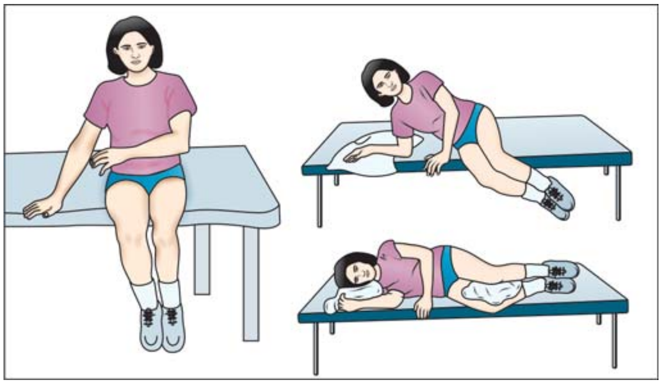
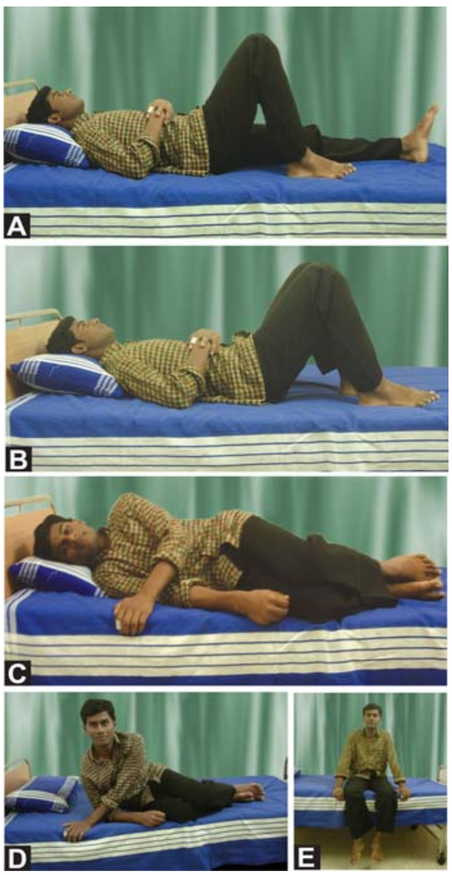


Fig. 22.46: Showing the proper method of retiring to bed



Figs 22.47A to E: Showing the step-by-step correct technique of getting up from bed: (A) Bend one knee first, (B) Now bend the other knee, (C) Turn to the sides, (D) Pushing the bed with the hands get up, (E) Sit on the edge of the bed for few seconds

Proper Postural Habits

Correct posture has to be maintained during sitting, walking, etc.

- Correct sitting—*see* Fig. 22.29 and 22.47.
- Correct standing—*see* Fig. 22.30.
- Correct sleeping—*see* Fig. 22.33.

FIg. 22.48: Adopting a correct sitting posture in an ergonomically designed chair keeps backache away

- Correct way of turning—*see* Fig. 22.32.
- Correct way of lifting—*see* Fig. 22.28.
- Correct driving habits—*see* Fig. 22.34.
- Correct choice for bed—*see* Fig. 22.35.
- Correct method of retiring to bed—Fig. 22.46.
- Correct method of getting up from bed—Fig. 22.47.

Proper Work Environment

Use of Proper Chairs

Our backs were designed to walk on all the four limbs and were not designed to sit. During evolution man adapted the two legged stance and spends nearly 60 percent of the lifetime sitting. The pressure on the spine is least on supine, 3 times more on standing and 11 times more during sitting. Thus, sitting is the most stressful on the back (Fig. 22.48).

Most of the jobs involving sitting. It is imperative that one adopts a proper posture and proper chair while sitting.

- *Choice of a proper chair* A proper chair should preserve the 'S curve' of the spine which is physiologic. Most of the chairs used in the office make the person assume a 'C' curve rather than the physiologic 'S curve'. This places enormous stress on the back and leads to backache.
- *Maintaining a proper posture in the chair maintaining a proper* Posture in the chair is extremely important and it is done as follows:
  - — The neck should be slightly forward and upper back is straight.
  - — Shoulders must be relaxed and the arms should hang naturally.
  - — The back must be in full contact with the back rest of the chair.

— The angle behind the knee should be > 90°.
— Elbows and arms should rest comfortably on the arms of the chair.
— Thighs must be parallel to the floor and the feet must be flat resting on the floor.

For proper chair and correct posture in a chair *see* Figure 22.48.

- *Avoid sitting on the stools*, crouching forwards on the table and sitting with the legs on the top of the table.
- *Health break* Taking a 'health break' while at work in the office at regular intervals is much more important than taking coffee breaks.

Ways of Taking 'Health Breaks'

- Taking a short quick brisk walk in the office at the end of one hour.
- Exercising the back and neck swiftly at the end of one hour.
- A stepper can be used to take a brisk walk.
- This will help the spine to relax from time to time, reducing the incidence of backache considerably in office goers.
- Abrupt twisting, improper weight lifting, prolonged standing, etc. should be avoided while at work.

Exercises

This has already been discussed at length in the previous sections.

Modifications in Activities of Daily Living

- *Carrying luggage* While traveling the luggage to be carried while traveling should be light. Carrying two suitcases of approximately equal weights, instead of one, will put equal pressure on both the shoulders (Figs 22.49A and B).
  It is advisable to use suitcases with built in rollers.
- *Kitchen standing habits* Housewives working in the kitchen, should stand erect and place one of their legs on a footstool. The legs should be alternated on the footstool when standing for a long time (Fig. 22.50).
- *Mattresses* The mattresses should be firm to support the physiological curves of the back. If too soft the back will sag and if very hard will cause more pressure. It is better to keep a small pillow beneath the knees or sleep on the sides with the knees bent?
- *Proper driving habits* While driving a car observe the following (Fig. 22.51):
  — Sit close to the steering as is comfortable.
  — Place a small pillow beneath the lumbar curve to preserve the normal lordosis.

Figs 22.49A and B: Showing improper luggage carrying technique (A) and proper luggage carrying technique (B)

Fig. 22.50: Showing correct postural habits while working in kitchen

Fig. 22.51: Showing correct posture during driving

— Use the rear view mirrors frequently and do not turn back to see the vehicles.
— Keep the knees bent.
— Avoid stress in life by proper planning and meditation.

Ways to Prevent Recurrence

This is the most important aspect of the management of backache. Like in all other diseases, so in backache prevention is better than cure. Backache can be prevented to a large extent by observing the following measures:

- Adopting proper posture and creating awareness that it is in the erect position that the back can withstand strain the best.
- Back education Stress on the back is less when it is properly used during sitting, walking, etc. These proper habits have to be cultivated with practice.
- Back exercises These aim to strengthen the abdominal, pelvic, back and thigh muscles. Strong healthy muscles reduces load on the discs and other structures.
- To avoid all sports including the aerobic ones. Swimming and walking are encouraged.

TO PREVENT RECURRENCE

Remember

Do's and Don'ts

Do's

- Forward bent attitude.
- Body weight borne on the heels.
- Proper weight lifting as shown earlier.
- Sit with buttocks tucked under.
- While driving push the seat forwards to raise the knees and decrease the lordosis.
- Flex the knees and hip when lying on the side.
- Turn to the side and then get up.

Don'ts

- Sleep in the prone position.
- Rise from a sitting position suddenly.
- Bend over a washbasin.
- Wear high heels as pelvis is thrust forward and the spine bends backward.
- Use too high a chair.
- Use soft mattress which increases the lumbosacral extension. A firm mattress encourages lumbar spine to be straight.

Remember

B's in backache

- Bad posture
- Bed rest
- Belts
- Back education
- Back exercises
- Bed choice

APPROACH TO A PATIENT WITH LOW BACKACHE

Low backache is an extremely common malady afflicting the human race across the globe cutting the geographical boundaries race, culture, etc. Eighty to ninety percent of the human population will suffer from some form of backache, mild or severe in their lifetime. It is of interest to know the historical background regarding low back pain.

A quick historical review

- Backache and leg pain are known since beginning of history.
- Primitive culture called it a work of a demon.
- Greeks recognized the symptoms as disease.
- In 18th century, Cotumis, attributed pain to the sciatic nerve.
- In 1881, Lasegue test described a test to distinguish hip disease from sciatica (first described by Frost).
- Virchow Kocher, etc. described acute traumatic ruptures of the disk that resulted in death.
- Goldthwait in 1911 first attributed back pain to posterior displacement of disk.
- Dandy in 1929 first reported removal of a disk tumor from patients suffering from sciatica.
- Myelography was first described in 1922.
- Barr (1932) finally attributed the source of sciatica to the herniated lumbar disk.
- Barr (1934) suggested surgical treatment for disk excision.
- Layman Smith (1963) suggested enzymatic dissolution of disk.
- Kirkaldy-Willis suggested ageing as the primary theory in disk disease.
- Nuchenson 1964, White and Punjabi 1982 described biomechanics of spine.
- Schnack 1983 described clinical anatomy.

Causes of Backache

A variety of conditions related and unrelated to spine cause backache (see the box). The common causes of backache are:

Unaccustomed activities A sedentary person suddenly adopting an active form of life, etc.

Poor posture Improper posture during sitting (Fig. 22.52), walking, standing, working places enormous load on the back and results in backache. This is by far the most common cause of low backache.

Quick Facts

Causes of low backache

Common causes (80%)

- Back muscle strain and ligament sprain
- Prolapsed lumbar intervertebral disk
- Obesity
- Poor posture
- Facet joint arthritis
- Unaccustomed activities
- Occupational causes

Uncommon causes (20%)

- Congenital causes (4 'S')
  - — Scoliosis
  - — Spondylolisthesis
  - — Spina bifida
  - — Spondylolysis
- Infective conditions
  - — Osteomyelitis
  - — Tuberculosis
  - — Brucellosis, etc.
- Traumatic causes
  - — Vertebral body injuries, posterior arch fractures
  - — Muscle sprain/strain
  - — Prolapsed disk
- Inflammatory causes
  - — Rheumatoid arthritis
  - — Ankylosing spondylitis and other SSA's
- Neoplasms
  - — Benign-Osteoid osteoma
  - — Malignant-Secondaries, multiple myeloma, etc.
- Metabolic causes
  - — Osteoporosis
  - — Osteomalacia
- Degenerative conditions
  - — Osteoarthritis
  - — Lumbar spondylosis
- Referred pain from
  - — Gynecological diseases
  - — Genitourinary diseases
  - — Gastrointestinal conditions, etc.

Fig. 22.52: Showing improper postural habits we normally adopt in our lives leading to LBA

Occupational backache Certain occupation places enormous stress on the back, e.g. garbage collectors, porters, etc.

Obesity Protruding abdomen places enormous strain on the back (*see* Figs 22.1A and B).

Muscle strain In 80 percent of the cases, backache is due to sprain of the back muscles during activity, sports, trauma, etc.

Prolapsed lumbar intervertebral disk This is the second most common cause for low back pain after muscle sprain. It is usually due to improper weight lifting (*see* Fig. 22.5). Discussed at great length in the previous section.

The facet joint osteoarthritis Due to old age, repeated bending and twisting activities lead to arthritis of facet joints.

Spinal stenosis Spinal stenosis due to degenerative process is another common cause.

Presenting Complaints

Age Backache is more common in middle-aged and elderly people (usually degenerative). In young adults it is due to trauma and in children it is usually due to organic lesions.

Sex Osteoporosis, rheumatoid arthritis, etc. are more common in females. Ankylosing spondylitis, trauma, secondary, etc. are more common in males.

Occupation People with sedentary jobs and heavy manual laborers are frequently prone for backache.

Pain

Over 90 percent of the patients complain of pain in the back. The following points should be enquired:

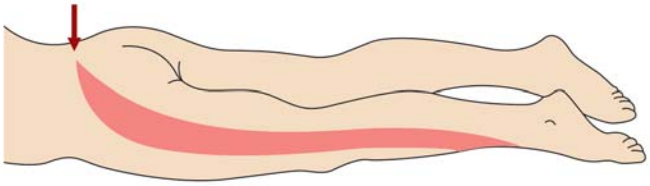


Fig. 22.53: Showing the pain distribution in sciatica

Nature of pain Is it sudden (trauma) or gradual (spondylosis)? Was it preceded by weight lifting, sudden bending, etc? Is there remissions and exacerbations (disk disease) or is it continuous (tumors)? Is there history of night cries (e.g. TB spine)? Is it relieved by rest? Does it radiate to the lower limbs? Etc.

Site Is the pain in the middle of the spine or Para vertebral muscles? Is it in the dorsolumbar spine (trauma or tumor) or in the lumbar spine (disk disease)?

Sciatic pain Here pain radiates along the course of the sciatic nerve (see causes for sciatica). Common cause is disk prolapse (Fig. 22.53).

Sciatica and its causes Sciatica is defined as a radiating pain along the course of the sciatic nerve and is felt in the back, buttocks, posterior of the thigh, legs and the foot. It is commonly due to disk prolapse. The other causes are:

- Spondylolisthesis.
- Sacroiliac joint arthritis.
- Affliction of the nerve root by herpex simplex virus can cause radicular pain.
- Tuberculoma causing cord compression.
- Lymphomas and pelvic malignancy.
- Incurled thickened ligamentum flavum.
- Cysts of the sacral nerve root.
- Intraspinal neurofibromas and other tumors.
- Hemorrhage in the ependymoma can cause sudden and gross neurological deficit, mimicking acute disk prolapse.
- Diabetic neuropathy, etc.

Neurogenic Claudication

This is a feature of spinal stenosis (*see* page 300).

Neurological Symptoms

These consist of paraesthesia, muscle weakness, disturbance of sphincters, cauda equina syndrome, etc.

Facet Syndromes

Here patient complains of chronic backache, early morning stiffness, difficulty in getting out of bed, standing, sitting or climbing.

Remember

Consider serious causes of backache if any one of the following situations is encountered:

- Pain in patients less than 10 years of age.
- First time backache in patients greater than 60 years.
- Unexplained weight loss.
- Chronic cough.
- Night pains.
- Intermenstrual bleeding.
- Altered bowel function.
- Altered bladder control.
- Visual disturbances and balance problems.

Other Complaints

There may be history of stiffness, pain in other joints (e.g. rheumatoid arthritis), constitutional symptoms (e.g. tuberculosis, malignancy, etc.), genitourinary complaints etc.

Physical Signs

Stance and gait Does the patient stand with a normal stance or has deformities like scoliosis, kyphosis, lordosis or pelvic tilt. Is the gait normal or altered?

Spasm This is seen in acute painful conditions of the spine. The patient complains of pain in the Para vertebral muscles and painful restriction of all the spine movements.

Movements There may be restriction of the spine movements due to the organic lesions affecting the back.

Swelling Swelling due to cold abscesses may be present.

Tenderness It may be present over the spinous process, in between the spinous processes, over muscles, ligaments, facet joints, etc.

Neurological Examination

This consists of examinations of the various dermatomes for sensations, myotomes for muscle power and reflexes (*see* page 362).

SLRT and tension signs This is to know the effects of disk prolapse on the sciatic nerve (the tests are described on (*see* page 362).

Other Examinations

Other examinations include examinations of the adjacent joints, peripheral pulses, abdominal, rectal or pervaginal examinations.

Investigations

Blood tests these are useful in detecting metabolic, hormonal, infective and malignant conditions.

Radiology Routine plain radiographs of the lumbar spine are advised. Both anterioposterior and lateral views are usually required. Oblique views are helpful in detecting the fracture of pars. Though X-rays are not very helpful in detecting the disk prolapse, it is of value in diagnosing metabolic, degenerative, inflammatory, malignant conditions affecting the spine.

Myelography This procedure is not routinely used any more because of its complications. However, it has a role in demonstrating blocks due to disk prolapse.

CT scan It is a noninvasive procedure and helps to identify the bone and soft tissue problems with greater accuracy.

MRI scan This is the gold standard in the investigations of the spine. It is noninvasive and is better than CT scan in diagnosing the bone and soft tissue problems around the spine. However, its high cost is prohibitive and is available only in major cities and centers.

Treatment

The underlying cause has to be detected and managed accordingly. The treatment for backache consists of drugs like NSAIDs, muscle relaxants, physiotherapy, traction, use of belts and corsets. Proper postural habits, back exercises and back education go a long way in preventing the backache. Surgery is done for specific indications (*see* page 375). Discussed in detail in the previous sections.

Treatment plan of backache: Summary	
• Conservative	• Absolute bed-rest • Traction • NSAIDs • Belts
• Epidural steroids	• For sub acute and chronic cases • Long-acting steroids + Local anesthetics • Reduces dependence on narcotics • Effect lasts for 3 weeks
• Surgery	• Done in proper indications • Open or microscopic lumbar discectomy
• Chemonucleolysis	• Same indications as for surgery • Limited only to lumbar spine • Drug used is chymopapain
• Physiotherapy	• Active and passive physiotherapy • Flexion or extension exercises
• Recurrence Prevention	• Back education • Proper postural habits • Back exercises • Avoid all sports

OTHER IMPORTANT CAUSES OF BACKACHE

- Spinal stenos is This is discussed at length is the Chapter on Regional Disorders of Spine (*see* page 300).
- Spondylolisthesis (*see* page 295)
- Tuberculosis of spine (*see* page 429)
- Spine injuries (*see* page 212)
- Lumbar spondylosis (*see* page 506)
- Osteomalacia (*see* page 415)
- Osteoporosis (*see* page 416)
- Ankylosing spondylitis (*see* page 456)
- SI joint arthritis (*see* page 454)
- Scoliosis (*see* page 288)

YOGA AND PHYSIOTHERAPY

Yoga is believed to have originated and existed in ancient India since the Rig Vedic age. It is the greatest gift to the World from the Indians. The word Yoga has its root in the Sanskrit word 'yuj' which means to merge, join or unite. It is the union of soul with the eternal truth, a state of unalloyed bliss arising from the conquest of duties. Yoga is a philosophy, a way of life, wherein art and science meet. Yoga frees one from life's sorrows and from the diseases and fluctuations of the mind.

Yoga aims at achieving a wholesome health in the form of physical, mental, psychological, and spiritual well being of a person. According to Patanjali, yoga helps to attain a complete control of the mind which in turn helps to attain mastery over our body through its various asanas and pranayams. The former helps to develop the muscles and joints and the neuromuscular co-ordination, the latter helps to control the breathing faculties. Patanjali, the father of yogic sciences, has described eight branches of yoga namely Yama, Niyama, Asana, Pranayama, Pratyahara, Dharana, Dhyana and Samadhi. Of these eight elements, asanas and pranayanas are the two important things which help to develop or acquire physical control. The other elements help in the development of moral and spiritual control. The scope of this book, does not allow us to go into the details of yoga. However, an effort is made here to know the importance of asanas and their role in physiotherapy.

Asanas in yoga are slow, rhythmic and gentle movements of the various bones, muscles and joints. They help to attain the physical conditioning of the body so essential to acquire good health. These asanas have three fundamental steps. In the initial step, through a gradual rhythmic movement a particular posture of an asana is first adopted. In the second step, this posture is held for a brief period. In the third and the final step, the body is gradually returned back to the starting position through a gradual, rhythmic reversal method. These three steps are the basic units of any asana in yoga. At no time a patient should experience pain or discomfort while doing an asana.

While asanas help to develop the physical control, pranayamas help to acquire a good respiratory control which tunes up the mind, heart and lungs. Together asanas and pranayamas help an individual to develop a physical, mental and spiritual well being.

Physiotherapy vs Yoga

By now I hope it has become amply clear that there is a lot of physiotherapy in yoga and yoga in physiotherapy. As discussed earlier physiotherapy is a branch of medicine which helps to prevent or treat a disease with the help of physical modalities like heat, cold, water, current, wax bath, exercises, etc. Among the various modalities of physiotherapy, exercise form the basis of physiotherapy around which other modalities revolves in treating a disease. Thus exercises form the basis of both yoga and physiotherapy and this is where the similarity arises. But however unlike the three steps of the asanas in yoga, exercises in physiotherapy are different. The exercises in physiotherapy could be active or passive, active assisted or even resistive. Whatever may be the difference, both yoga and physiotherapy play a very important role in the prevention of a disease and if a disease has already occurred, they help in prevention of further complications and promote faster recovery from ill health. Thus they play a very crucial role in the preventive and curative aspects of disease. They also play a very important role in preventing the recurrence of a problem. Apart from improving the flexibility of muscles and joints, muscles strength, neuromuscular coordination and control, they help in the conditioning of heart, lungs, brain and other important organs of the body. The end result is a complete sense of well-being.

The Role of Yoga and Physiotherapy in the Treatment of Low Backache (LBA)

The role of exercises in the treatment and prevention of LBA has already been dealt in previous sections. It is however, interesting to note that some of the exercises so described closely resemble or are similar to some of the well known asanas in Yoga. An attempt is made here to present some of these:

- Flexion exercise No. 22.37 (E and F) is similar to EKAPADAPAWANA MUKTASANA and exercise 22.37G is similar to PAWANA MUKTASANA in Yoga. These exercises help to stretch the lower back muscles and the thigh muscles.
- Exercise No. 22.37 (I) is similar to ARDHAKATI SARVANGASANA in Yoga. This helps to strengthen the lower anterior abdominal wall muscles.
- Exercise No. 22.37 (D): This exercise is similar to PASCHIMOTHASANA in Yoga and helps to stretch the spinal and Hamstring muscles.
- Exercise No. 22.38 (A): This exercise is similar to EKAPADASHALABHASANA in yoga.
  Exercise No. 22.38 (B): This exercise is similar to DWIPADASHALABHASANA in Yoga. Both these two exercises help to develop the back, buttocks, and thigh and leg muscles.
- Exercise No. 22.38 (C): This exercise is similar to the MAKARASANA in Yoga. They help to develop the back extensor muscles.
- Exercise No. 22.38 (D): This exercise is similar to the DIWASTHA SHALABHASANA in Yoga. This helps to develop the back muscles, hip and leg muscles.
- Exercise No. 22.38 (F): This exercise is similar to BHUJANGASANA in Yoga. This helps to develop the spinal extensor muscles.
- Exercise No. 22.38 (E): This exercise is similar to ARDHAKTIBHUJASANA in Yoga. This is known to develop the spinal muscles.
- Exercise No. 22.38 (G): This exercise is similar to SHASHANKASANA. It helps to stretch the back muscles.
- Exercise No. 22.39: This is similar to JATARASANA in Yoga, which stretches the side muscles of the chest and abdomen.

Thus, it is obvious that there is considerable overlap between some of the asanas in yoga and the physiotherapy exercises. Both complement each other in enabling the patient to enjoy a good, wholesome health.

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6

Section

GENERAL ORTHOPEDIC DISORDERS

23. Congenital Disorders
24. Developmental Disorders
25. Metabolic Bone Disorders
26. Osteomyelitis
27. Skeletal Tuberculosis
28. Disorders of Joints
29. Rheumatic Diseases
30. Neuromuscular Disorders
31. Bone Neoplasia
32. Osteoarthritis

Chapter 23

Congenital Disorders

CONGENITAL DISORDERS OF THE NECK AND UPPER LIMB

CONGENITAL TORTICOLLIS (WRY NECK)

Congenital torticollis is a condition where the sternocleido-mastoid muscle of the neck undergoes contractures pulling it to the same side and turning the face to the opposite side (Fig. 23.1).

Fig. 23.1: Wry neck

Exact cause of this condition is unknown but hypothetically it may be due to fibromatosis within the sternomastoid muscle.

Features

- Tumor palpable at birth or during the first two weeks of life.
- Common on the right side.
- May include the muscle diffusely but more often it is localized near the clavicular attachment of the muscle.
- It attains maximum size within 1 to 2 months; usually it disappears within a year.
- If it fails to disappear, then the muscle becomes permanently fibrotic and contracted and causes torticollis.

Etiology

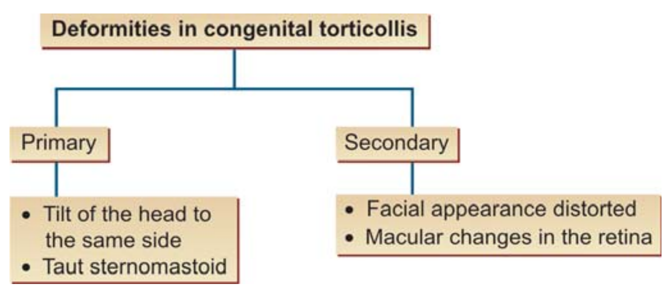
- Middle part of the sternomastoid is supplied by an end artery, which is a branch of the superior thyroid artery that gets blocked due to trauma, etc.
- Birth trauma—Breech delivery, improper application of forceps, etc. may cause injury to the sternomastoid muscle.

The above two reasons can result in sternocleidomastoid muscle ischemia, necrosis and fibrosis later on.

Clinical Features

Deformity is the only complaint initially. Later facial changes and macular problems in the retina may develop (Flow chart 23.1 and Fig. 23.2).

Flow chart 23.1: Showing deformities in congenital torticollis



Treatment

Principles

- During infancy, conservative treatment consists of stretching of the sternomastoid by manipulation and physiotherapy. Excision is unjustified in infancy.

Fig. 23.2: Clinical photograph of wry neck

- Surgery is delayed till fibroma is well formed. The muscle may be released at one or both ends and the muscle may be excised as a whole.
- If the muscle is still contracted at the age of 1 year it should be released.
- If wry neck is persistent for 1 year it will not resolve spontaneously and needs to be interfered operatively.
- Exercise programme is successful:
  — When restriction of motion is less than 30°.
  — When there is no facial asymmetry.
- Nonoperative treatment after 1 year is rarely successful.
- Any permanent torticollis becomes worse during growth. Head is inclined towards the affected side, face is turned towards the opposite side, ipsilateral shoulder is elevated and the frontoccipital diameter is increased.

Physiotherapy Treatment

The physiotherapy treatment in infancy for mild deformities proceeds on the following lines:

Measures aimed at passive correction This actually is the mainstay of treatment in early cases of torticollis in infancy.

Step 1 Assess the extent of deformity and the existing ROM.

Step 2 To relax the muscles, suitable thermotherapy and gentle massage is carried out.

Step 3 All the movements of the neck are carried out passively by bringing the head of the child beyond the edge of the table in a supine position. With an assistant stabilizing both the elbows and with a pillow placed beneath the chest, all the movements of the neck are carried out in a gentle relaxed manner passively.

Step 4 After the above steps, a gentle sustained passive stretch is carried out in the opposite direction of the affected muscle and held for some time in that direction.

Step 5 After doing the above steps, the passive correction is maintained by supporting the neck with appropriate pillows or supports.

Active measures This is a little difficult since the child is still in its infancy and cannot carry out the oral commands. By using a bright colored object which makes noise, the attention of the child can be drawn and its head is made to move in the arc of correction. Cumbersome but is found to be effective.

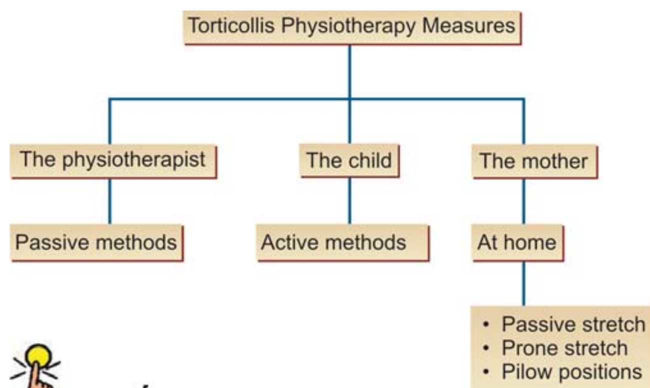
Home treatment regimen Since the above mentioned methods need repeated manipulations, the mother of the child is taught to carry them out at home at frequent intervals.

Other than the methods already explained two additional measures which the mother needs to carry out are as follows:

- In the prone position, with the head of the child turned towards the affected side, the child is encouraged to look back over the shoulder in the opposite direction.
- During sleep, the head of the child is positioned by pillow support in the opposite side of the deformity. This simultaneously relaxes and maintains the neck in corrected position.

Above physiotherapy measures employed in the treatment of torticollis are shown in Flow chart 23.2.

Flow chart 23.2: Showing physiotherapy measures in torticollis



Quick Facts

Congenital torticollis vs. physiotherapy
- Active methods: Child encouraged by toys
- Home treatment methods by the mother
- Passive stretch by the therapist

Surgical Methods

The most commonly employed surgical method is subcutaneous tenotomy of the clavicular attachment of the sternomastoid muscle.

For older children or after failed operation, bipolar release of the muscle from both sides, Ferkel's modified bipolar release or Z-plasty of the muscle is tried.

Physiotherapy after Surgery

- *Measures to control pain* This is done by thermo-therapy, hydrotherapy, etc.
- *Exercises* Active ROM exercises to the sternocleido-mastoid muscle are encouraged.
- *Supportive devices* Like cervical collar should be used till adequate correction is achieved.
- *Additional measures* Like self correction adopting a changed proper posture at work, etc.

CONGENITAL ELEVATION OF SCAPULA

*SPRENGEL'S DEFORMITY

In this condition scapula fails to descend down from its initial high position in the embryo. It is a tale of a disobedient scapula!

Here the scapula lies more superiorly. It is hypoplastic and improperly shaped (Figs 23.3 and 23.4). It is associated with other congenital anomalies like cervical rib, etc.

Etiology

This may be due to imperfect descent of the shoulder girdle by third month or a band of muscle from the skull to the scapula which has failed to grow.

Clinical Features

The scapula is high by 2 to 10 cm, the deformity is obvious, there is no functional impairment, all the shoulder girdle movements are normal, torticollis may be present in 10 percent of the cases, crania bifida and spina bifida may also be present.

Cavendish's Grading

Group 1—Very mild
Group 2—mild, shoulder slightly unaligned
Group 3—Moderate, shoulder high.
Group 4—Severe, with superior angle of scapula near the occiput.

Radiograph

Plain X-ray of the scapula helps to determine the level and extent of the disability.

*Otto Sprengel (1852-1915), a German orthopedic surgeon described it in 1891.

Fig. 23.3: Showing congenital elevation of scapula (Sprengel's shoulder)

Fig. 23.4: Clinical photograph of Sprengel's deformity

Treatment

For cases with mild deformity no treatment is required. For severe cases surgery is done after 3 years and this consists of release of muscles from the scapula or transfer of origin of the trapezius muscle.

Physiotherapy Measures

Measures to control pain Usual methods like ultrasonic, TENS, etc. are helpful.

Measures for mobilization Gentle relaxed passive movements of the shoulder girdle muscles. Early mobility of the shoulder is aimed at.

Measures to strengthen the muscles The muscles around the shoulder girdle are strengthened by suitable isometric and isotonic shoulder exercises.

CLEIDOCRANIAL DYSOSTOSIS

For some mysterious reasons clavicle chooses to remain absent either partially or wholly. It is a rare condition.

Salient Features

- Aplasia of clavicles.
- Exaggerated development of transverse diameter of cranium.
- Delay in closure of clavicles.
- Heredity.
- Equal sex incidence.

Types

- Where ends of the bones are normal, but a pseudarthritic gap is present in between.
- Where there is a partial defect of one end, usually the acromial end.
- Where the whole clavicle is absent.

Deformities of the clavicle are accompanied by variations in the following muscles: trapezius may be absent, pectoralis major may be maldeveloped, and other congenital malformations may be associated.

Etiology

The exact cause is unknown but the development of membranous bones may be affected during the first week of embryonic life due to various unknown factors.

Clinical Features

The patient is brought to the surgeon due to accidentally discovered trouble with the shoulder (Fig. 23.5A). Features of un-united fracture of the clavicle may be present. It may also present as complete absence of the clavicle. Tips of shoulder can be approximated to each other.

Radiograph

Plain X-ray of the clavicle shows the absence of clavicle on both the sides (Fig. 23.5B).

Treatment

Usually, it does not require any treatment but if pain is present due to pressure of one or both ends, then removal of the part is indicated. As a rule there is no disability or discomfort and abnormal mobility is not usually a hindrance.

Physiotherapy Measures

The measures are the same as described for Sprengel's shoulder.

Figs 23.5A and B: (A) Clinical photograph of cleidocranial dysostosis, (B) Plain X-ray showing abscence of clavicle (cleidocranial dysostosis) on both sides

ELBOW REGION

CONGENITAL RADIOULNAR SYNOSTOSIS

I call this an unholy alliance of radius and ulna, for; their union causes unmitigated hardship to the sufferer.

Salient Features

- Involves proximal ends of radius and ulna.
- Bones fix the forearm in pronation.
- Bilateral.
- Familial tendency.

Classification

This is classified as Type I and Type II as shown in Table 23.1.

TABLE 23.1: Classification of congenital radioulnar synostosis

Type I	*Type II*
• Medullary canals of the radius and ulna are joined together • Proximal ends of radius is Malformed and fused to ulna for a distance of several cms • Radius is longer and Larger than ulna and the Shaft arches anteriorly	• Radius is normal • Proximal end is dislocated either anteriorly or posteriorly • Fusion to ulna is not as extensive as in Type I • Unilateral • Other deformities like syndactyly, etc. are present

Radiograph

Plain X-ray of the forearm helps to make an accurate diagnosis (Fig. 23.6).

Reasons for difficulty in treatment

- Fascial tissues are short.
- Interosseous membrane is narrow.
- Supinator muscle is abnormal or absent.

Treatment

Treatment is limited to osteotomy, to place the forearm in mid-prone position for better function. Attempts to overcome the synostosis and give rotatory function to the forearm are doomed to failure because of the lack of properly functioning muscles. Fortunately, most patients are not disabled enough to justify an extensive operation.

Fig. 23.6: Radiograph showing congenital radioulnar synostosis

Madelung's Deformity

It is an abnormality of the *palmar ulnar part of the distal radial epiphysis* in which progressive ulnar and volar tilt develops at the distal radial articular surface, resulting in dorsal subluxation of the distal ulna.

First described by Malgaigne in 1855 and later by *Madelung in 1878. Though congenital, it is not obvious until late childhood and adolescence. It is a rare condition, incidence being only 1.7 percent.

Causes

The causes could be autosomal dominant, dysplasic (diaphysial aclasis), genetic or idiopathic.

Acquired deformities distinguished by lack of appropriate physical findings, unilateral, less severe carpal deformities, and history of repetitive injury or stress.

Clinical Features

Madelung's deformity consists of:

- Volar subluxation of hand.
- Prominence of distal ulna.
- Volar and ulnar angulation of distal radius (Fig. 23.7).

Other Features

This condition is commonly bilateral, girls are more affected. There is a positive family history, the deformity manifests in late childhood and adolescents with restricted wrist motion and minimal pain. As growth occurs, deformity worsens and the forearm is short.

Radiographic abnormalities are seen in radius, ulna and carpal bones. Radius is curved with its convexity dorsal and radial. Distal radial epiphysis is triangular in shape because of the failure of the growth in the ulnar and volar aspects of the epiphysis. Early closure of these aspects of epiphysis is frequent. Ulna is subluxated dorsally, its head is enlarged and the overall length of ulna is decreased. Carpus appears to have subluxated ulnarward and palmarwards into the distal radioulnar joint. Carpus appears wedge shaped with its apex proximal (Fig. 23.8).

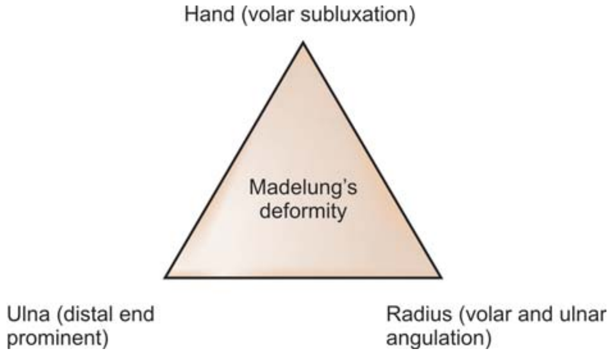


Fig. 23.7: Madelung's deformity

Fig. 23.8: Radial clubhand

Treatment

Children with Madelung's deformity have minimal pain and excellent function. Hence conservative treatment is given initially. Surgery is considered for severe deformity or

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*__Otto Madelung__ of Bonn. First described by *Malgaigne* in 1855 and later by *Madelung* in 1878.

persistent pain. In skeletally immature patients, distal radial osteotomy with ulnar shortening is (Milch resection) preferred. In skeletally mature patients, osteotomy and Darrach's procedure are done.

Deformity may recur after either procedure or range of motion of forearm usually does not improve after surgery.

CONGENITAL DISORDERS OF LOWER LIMB

DEVELOPMENTAL DYSPLASIA OF HIP (DDH)

Earlier Known as Congenital Dislocation of Hip (CDH)

Definition

Developmental dysplasia of hip is defined as partial or complete displacement of the femoral head from the acetabular cavity since birth.

Risk factors (4 F's)
- **F**emales
- **F**irst born
- **F**amilial
- **F**aulty intrauterine position (e.g. breech)

Theories of Etiology

- *Genetic theory* Dysplastic trait is found in families.
- *Hormonal theory* Hormone induced joint laxity.
- *Mechanical theory* Faulty intrauterine positions particularly in the first born.
- Primary acetabular dysplasia.

Remember

The incidences in DDH
- 1 per 1000 live birth.
- Left hip affected in 67% of cases.
- Family history present in 20%.
- Incidence of breech 30 to 50%.
- 1:3 cases are bilateral.
- Female preponderance.

Pathology

The following pathological changes are observed in DDH (Fig. 23.9) and the severity varies according to the stages of the disease.

Bone

Acetabulum There could be a primary acetabular dysplasia and the acetabulum is shallow. There could be a gap or groove at

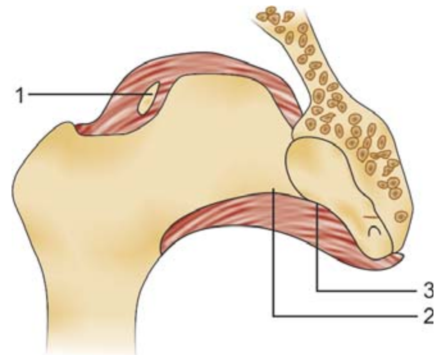


Fig. 23.9: Pathology in DDH: (1) Elongated capsule, (2) stretched ligamentum teres (3) fibrofatty tissue within the acetabulum

posterosuperior aspect. The triangular outer surface of ilium and acetabulum are in the same line. Above the acetabulum there is a depression containing the head of the femur.

Head of femur The dislocated head of femur at first appears normal, ossification is delayed, later head is flat on its posterior and medial aspect. Femoral head when present in the ilium is buffer or conical shaped.

Neck of femur There could be shortening and ante version.

Pelvis The pelvis is usually tilted forwards, it is small and atrophied. There is lordosis and it may be more vertical than normal.

Capsule *The* capsule could show *hour glass constriction*, one containing head and the other containing the acetabulum. Constriction is produced by iliopsoas and the ligamentum teres passes through this constriction and it is hypertrophied.

Muscles

Pelvifemoral group Adductors, sartorius, gracilis, rectus femoris, hamstrings, and tensor fascia lata muscles are shortened and they prevent reduction of the head.

Pelvitrochanteric group (obturators, quadratus femoris, Iliopsoas) These are elongated and the psoas forms an obstacle to reduction.

Gluteal muscles Show little organic change but power is diminished.

Remember

Conditions due to packaging problems (i.e. decreased intrauterine space)
- DDH
- Torticollis
- Metatarsus adductus
- Increased type III collagen

Stages of DDH

Figure 23.10 shows different stages of DDH.

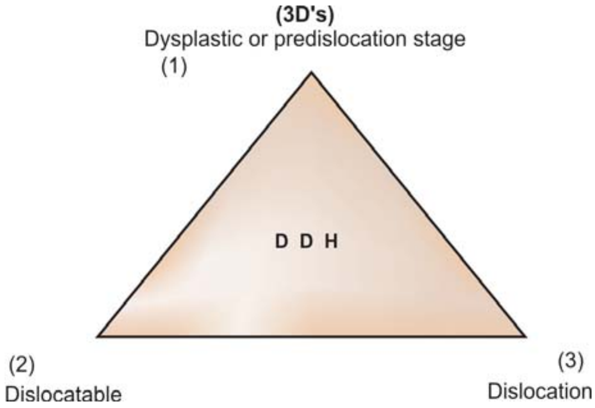


Fig. 23.10: Stages of developmental dysplasia of hip: (1) dysplastic stage, (2) dislocatable or subluxation stage, and (3) dislocation stage

Radiographic and Treatment Methods

Figures 23.11 to 23.17 shows radiographic features and treatment methods in DDH.

Fig. 23.11: Radiograph showing neglected DDH

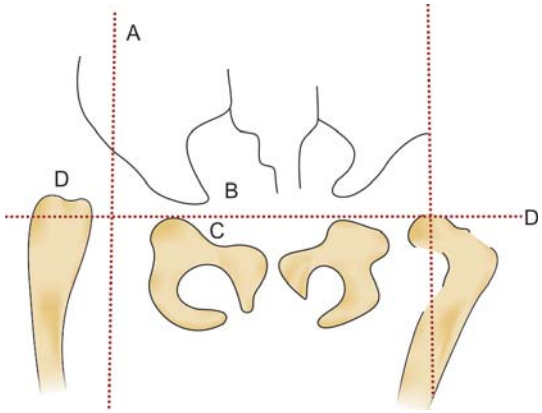


Fig. 23.12: X-ray pelvis in DDH: (A) Perkin's line, (B) Hilgenreiner's line, (C) normal location of head, and (D) location of head in DDH

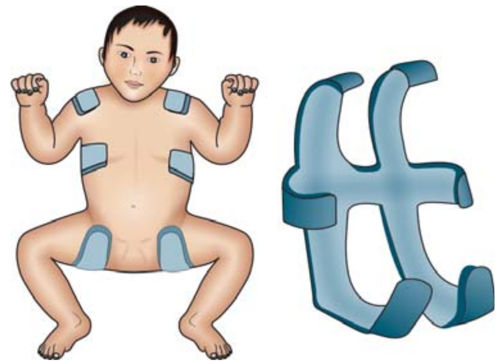


Fig. 23.13: Pavlik harness in DDH

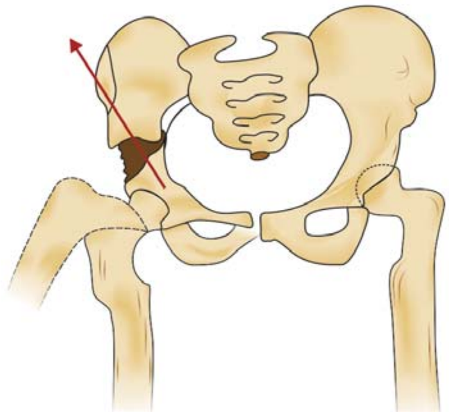


Fig. 23.14: Salter's osteotomy

Fig. 23.15: Acetabular shelf operation

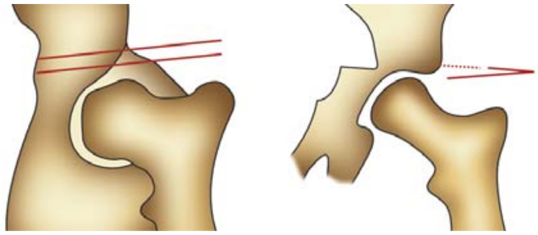


Fig. 23.16: Chiari's osteotomy

Fig. 23.17: DDH treated with plaster cast in frog leg position

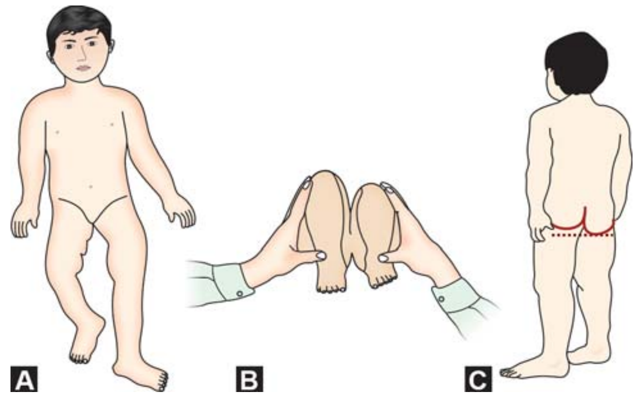


Fig. 23.18: Showing important clinical tests in DDH: (A) Asymmetrical thigh holds, (B) Galeazzi test (level of the knees), (C) Asymmetrical gluteal folds

Clinical Features

The clinical features vary in infants, children and adults.

In infants First a thorough clinical examination is carried out to detect the presence of any other congenital anomalies. If the hip is dislocated, all features of dislocation are present. The glutei and thigh folds are not symmetrical. The perineum is widened and abduction of the hip is decreased by 50 percent while the internal rotation movement is increased. Radiographic examination in infants is of little value, but Von Rosen's line is helpful in making an early radiological diagnosis in this age group.

Children and adolescents Here the patient shows a waddling or sailor's gait. There is an increased lumbar lordosis. The deformity frequently encountered in unilateral cases is shortening. In bilateral cases both the lower limbs are short, perineum is wide, and buttocks are broad and flat. Femoral artery is prominently felt. Abduction and lateral rotation movements of the hip are decreased. Telescopy and Trendelenburg tests are positive. Clinical tests of importance in infants are not of relevance in this age group (Figs 23.18A to C).

In adults DDH in adults shows all the features seen in adolescents. In addition patient will have features of secondary osteoarthritis of the hip namely pain, stiffness, limp, crepitus, restricted movements, etc.

Radiograph of the Pelvis

This is an important investigative tool in DDH. The assessment of DDH is based on various radiological parameters (*see* Figs 23.11 and 23.12).

Treatment

The aim of treatment in DDH is to achieve and maintain an early concentric reduction to prevent future degenerative joint disease. The methods to obtain reduction of the head into the acetabulum vary according to the age groups.

In infants Reduction can be obtained and maintained by Pavlik harness which was first described by Arnold Pavlik in Czechoslovakia in the year 1958, von Rosen splints and other splints. Pavlik harness is the most important appliance useful in this age group. *This is the only harness that promotes spontaneous reduction of a dislocated hip and maintains the reduction, whereas other appliances only maintain the reduction. Hence, Pavlik harness is called as "dynamic flexion abduction orthosis*". This is useful in children less than 6 months of age. Apart from the reduction and the immobilization, it allows active movements in all directions except extension and adduction. Nappies can be changed easily. The success rate of this harness is 85 to 95 percent. However, as the age advances, soft tissue contractures develop along with secondary changes in the acetabulum, which bring down the success rate of Pavlik harness (Fig. 23.18). Complications include osteonecrosis and failure of reduction.

Between 6 and 18 months As mentioned earlier Pavlik harness has no role in the treatment of DDH in this age group. Here the treatment of choice is gentle closed reduction and hip spica application (Fig. 23.17). Open reduction is done if this method proves unsuccessful.

Between 18 and 36 months In this age group open reduction is the treatment of choice as closed reduction is often not successful. Open reduction is to be followed with either pelvic or femoral osteotomy to provide concentric reduction of the femoral head within the acetabulum (Figs 23.14 to 23.16).

3-8 years Here open reduction is followed either by femoral shortening or pelvic osteotomies.

8-18 years In this age group open reduction is followed by femoral shortening or pelvic osteotomies. If osteoarthritis of the hip develops, total hip replacement is the surgery of choice. Arthrodesis of hip is rarely done.

Physiotherapy Measures

Measures during Immobilization

- *Exercises* Isometric exercises to the glutei and quadriceps muscles are indicated during this phase.
- *Movements* Active ROM exercises to the hip and knee are encouraged even as the patient is wearing the pavlik harness.

Measures during Mobilization

- *Movements* Active ROM exercises are prescribed for the hip, knee and ankle joints. Gentle relaxed passive movements are also carried out. Special emphasis is placed on the passive relaxed adduction as this is the movement which is greatly affected due to the limb being immobilized in abduction for a long period.
- *Strengthening exercises* these are given to the glutei and quadriceps muscles. Isometrics, isotonic and progressive resistive exercises are planned.
- *Ambulation* Gradual weight bearing and walking is encouraged with the help of assistive devices.

Initially, a wide base walk may be required to maintain the balance. The patient may be allowed to walk independently after regaining sufficient range of movement and muscle strength.

CONGENITAL TALIPES EQUINOVARUS (CTEV)

FOOT

One may pride in having flat foot, agile foot, nimble foot, but look at the tale of woes a clubfoot presents to the unfortunate victim affected with this malady!

Interesting features of CTEV

Talipes It is a Latin word derived from Talus = ankle, pes = foot

Original meaning A deformity that causes the patient to walk on the ankle.

Present day meaning is any variety of clubfoot.

Clubfoot It is so called because severe untreated talipes equinovarus has a club-like appearance. It is also known as Giles-Smith syndrome.

TABLE 23.2: Difference between CTEV and ATEV

CTEV	*ATEV*
• Present since birth	• Not present since birth
• May be associated with spina bifida	• May be due to polio, cerebral palsy, etc.
• Bilateral	• Usually unilateral
• Skin, subcutaneous tissue, muscles are normal.	• Trophic changes in the skin, muscles are flaccid (LMN lesion) or spastic (UMN lesion).
• Transverse crease is seen across the sole on the medial side.	• No transverse crease.
• Bones are normal in thickness.	• Bones are thinner than Normal.

This is the most common congenital foot disorder. Incidence is 1.2/1000 live births. Males are more commonly affected than females.

Table 23.2 shows how congenital TEV is different from acquired TEV.

Types of CTEV (Etiology)

Table 23.3 shows etiology of CTEV.

Idiopathic CTEV This is the most common type of CTEV one encounters in clinical practice. There is no apparent cause and various theories are proposed.

TABLE 23.3: Etiology of CTEV

• **Osseous type**	Club-foot is associated with absence of tibia and fibula.
• **Muscular type**	Arthrogryposis multiplex congenita or multiple congenital contractures.
• **Neuropathic type**	Due to spina bifida, etc.
• **Idiopathic type**	No apparent cause, commonest variety.

Clinical Features

Congenital talipes equino varus is a grotesque looking deformity of the foot (Figs 23.19 and 23.20). In idiopathic variety deformity is the only complaint. The diagnosis is fairly simple and straightforward. *Five classical primary deformities are seen and in response to this, secondary deformities develop. These primary and secondary deformities together form the club-foot complex* (Flow chart 23.3). A detailed examination of the foot is necessary to detect the full spectrum of deformities in CTEV.

With advancing age, the cosmetically unsightly club-foot starts posing functional problems like altered gait (stumbling gait), callosities, and degeneration and arthritic changes in the ankle and foot joints. Correction is a must to restore normalcy.

In other varieties of CTEV, clinical features peculiar to the etiological factors can be elicited.

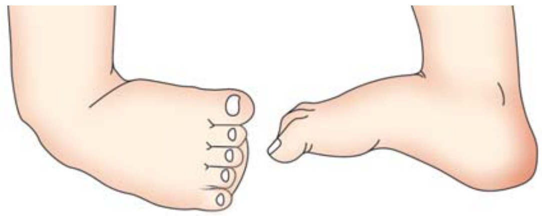
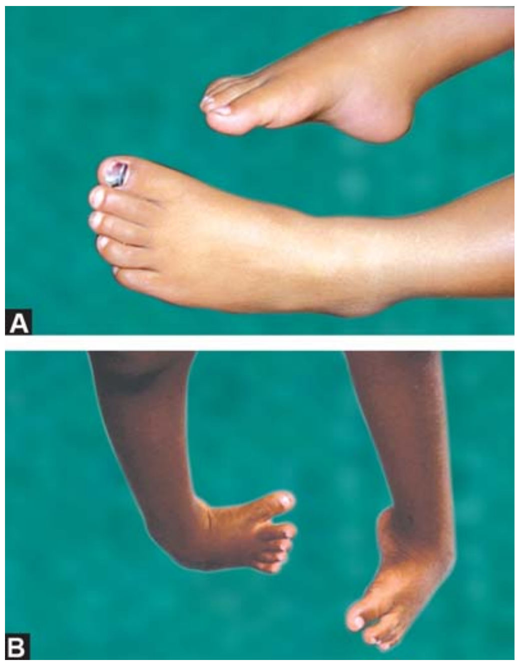


Fig. 23.19: Bilateral CTEV



Figs 23.20A and B: Clinical photograph of CTEV: (A) Unilateral CTEV, (B) Bilateral CTEV

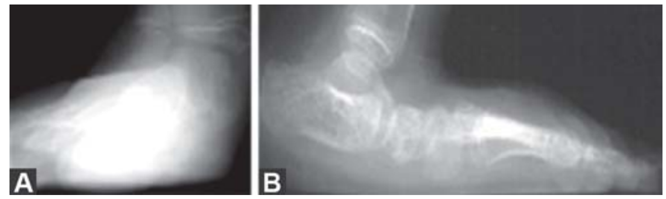
Flow chart 23.3: Showing deformities in clubfoot

Clubfoot complex

Primary deformities
- Equinus
- Varus
- Cavus
- Forefoot adduction
- Internal tibial torsion

Late changes
- Degeneation of joints
- Fusion of joints

Secondary deformities
- Foot size is decreased to 50%
- Medial border is concave, lateral border is convex
- Forefoot is plantarflexed upon hindfoot
- Skin is stretched over the dorsum of the foot
- Callosities are present over the dorsum of the foot
- Stumbling gait
- Hypotrophic anterior tibial artery
- Atrophy of muscles in anterior or posterior compartments of the leg



Figs 23.21A and B: Radiograph showing AP and lateral views of the affected foot

Radiograph

Plain X-ray of the affected foot its AP and lateral views helps to assess various angles to assess the extent of the deformity (Figs 23.21A and B).

Management

Broadly speaking CTEV can be managed by three methods.
- Conservative management.
- Surgical management.
- Management by external fixators.

Conservative management It is the treatment of choice in infants less than 6 months of age. The recom-mended regime is as follows (after Kite and Lovell) (Flow chart 23.4 'Modus operandi for CTEV').

First 6 weeks of life Weekly serial manipulation of the deformities and above knee casting for the first 6 weeks of life. Later, it is done every fortnightly till correction is achieved. Manipulation by mother is not usually sufficient. Success rate of serial manipulation and casting ranges from 15 to 80 percent. If correction is achieved in first 6 months of age, Phelps Brace is used during day time and Dennis Browne splint during the night time from 6 to 18 months to prevent recurrence. After 18 months, below knee walking calipers are given up to 4 years of age. From 4 years to skeletal maturity regular follow-up is advised.

Manipulation and Physiotherapy Measures in CTEV

The following methods are employed:

Manipulation actively by the mother For children less than 2 months of age, the mother of the child is trained to carryout the passive manipulation of the foot everyday (Fig. 23.22).

Kite's Method Till recent times this was the most popular method of non-operative treatment of club foot initiated soon after the diagnosis is made in a newborn child. The method and order of correction by the orthopedic surgeon is as follows:
- *Forefoot adduction* An attempt is made to correct this deformity first by stabilizing the heel with one hand and the other hand thumb is placed on the talus, and using the

Flow chart 23.4: Showing the plan of treatment in clubfoot

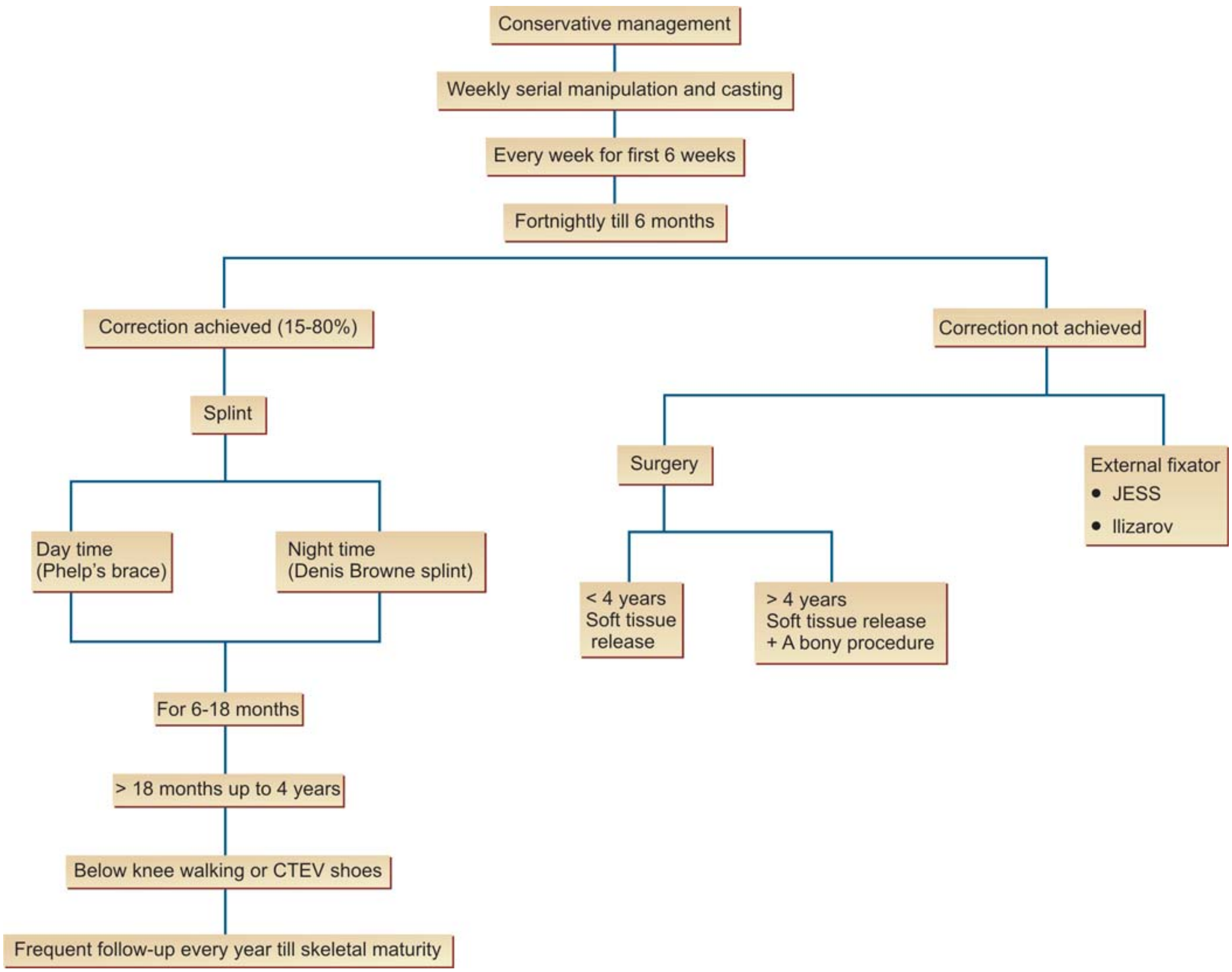


Fig. 23.22: Showing a mother manipulating her child's CTEV foot

talus as the fulcrum, the forefoot is slowly abducted and everted.

- *Inversion* This is corrected next by the method mentioned above and by exerting pressure over the undersurface of the 4th and 5th metatarsal heads.
- *Equinus* This is the last to be corrected. The hand is placed beneath the foot and is raised into dorsiflexion.

Manipulation and retention for children over 2 months of age, mere manipulation will not be sufficient. After carrying out the manipulation by the above mentioned methods, retention of the correction achieved is obtained by strapping in mild cases, splinting with Denis Browne splint or by applying on above knee POP casts. They are changed and re-applied every fortnightly for 6 months.

Remember

Order of correction of deformity

The mnemonic ADVERB helps to remember the order of correction.

AD—Forefoot adduction is corrected first.

V—Correction of heel varus next.

E—Lastly correction of hind foot equinus.

RB—This order is followed to prevent **Rocker Bottom Foot** which develops if foot is dorsiflexed through hind foot rather than midfoot.

If no correction is obtained after serial POP casting after 6 months, surgery or external fixator application is indicated.

Surgical management

*Indications (**5 R's**)*

- **R**esponse not obtained to conservative treatment after 6 months.
- **R**igid clubfoot (means *forefoot deformities are corrected but hindfoot deformities remain uncorrected after conservative treatment).*
- **R**elapsed clubfoot (means deformities are corrected initially, but relapse later, either partial or total).
- **R**ecurrent clubfoot (it is type of relapse, the cause being muscle imbalance which was overlooked initially).
- **R**esistant clubfoot (totally resistant to correction).

Ponsetti's Method This has now replaced the once popular Kite's method of non-operative treatment described above. This method is more successful and consists of non-operative or minimal operative technique. On an average 5 casts are changed over a 4 week period and after the end of serial casting about 80% of the infants require percutaneous tenotomy of the Achilles tendon. After correction is obtained, the correction is maintained for several weeks by a 23 hours abduction brace and later is replaced by a 12 hour brace upto the age of 4 years. This method is known to be more successful with more than 95% success rate.

Surgical Methods

Soft tissue procedures are advocated for children less than 4 years. Bony procedures are added later on. For mild CTEV with no severe internal rotation deformity of calcaneus, a one stage posteromedial release of TURCO is preferred.

For severe deformities with severe internal rotation of calcaneum—a one stage modified McKay procedure of both posteromedial and posterolateral release is preferred.

Bony procedures These are added to the soft tissue procedures after 4 years of age. Dwyer's lateral closed wedge osteotomy

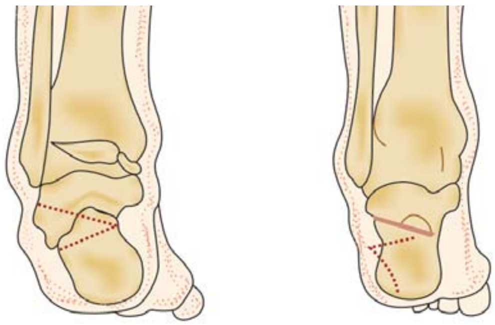


Fig. 23.23: Dwyer's lateral closed wedge osteotomy

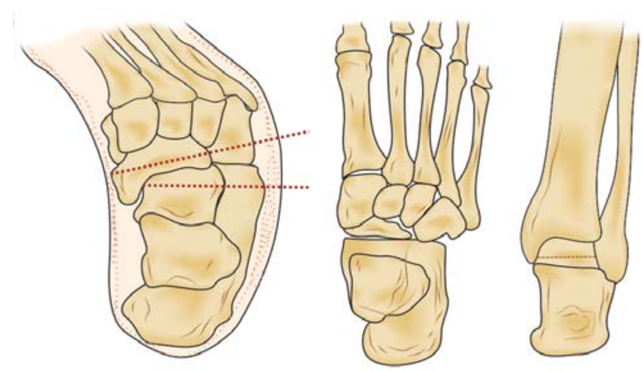


Fig. 23.24: Triple arthrodesis in CTEV

(Fig. 23.23) helps correct the varus deformity, Evan's and Davis operations also helps to correct varus in slightly older child. Triple arthodesis is recommended after skeletal maturity.

***Surgeries for uncorrected club-foot* in** older children and adolescents.

Triple arthrodesis (Fig. 23.24) Indicated for children more than 10 years. It is functionally and cosmetically, superior. Lateral closed wedge osteotomy through subtalar and midtarsal joints is done to fuse all the three joints of the foot namely the subtalar, talonavicular and calcaneculoid joints.

Talectomy It is a salvage procedure and is indicated for severe uncorrected club foot. It is also indicated in those cases previously corrected and unsuccessful. For uncorrectable CTEV by any other procedure, talectomy is useful as a salvage procedure.

Treatment by external fixators This is a recent concept in the management of CTEV and is reserved for difficult cases. There are two types of external fixator frames; one is designed by Ilizarov a Russian orthopedic surgeon. The second one is designed by an Indian orthopedic surgeon Dr. BB Joshi. This frame is known as Joshi's external stabilization system popularly called as JESS (Fig. 23.25).

Fig. 23.25: Showing Dr BB Joshi's JESS

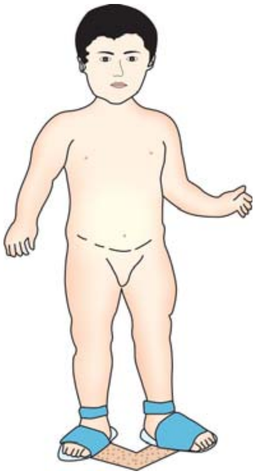


Fig. 23.26: Showing a Denis Browne splint

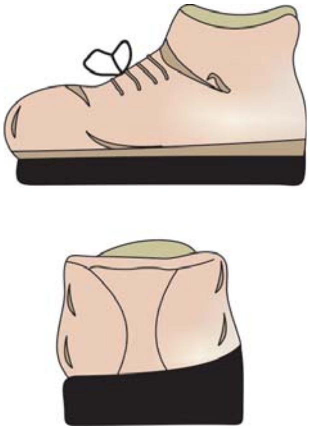


Fig. 23.27: Showing CTEV shoes

When done in properly indicated cases, external fixator produces excellent results. It is a semi invasive, bloodless surgery and can be done without a tourniquet. Though technically very demanding it avoids all the complications of surgery and a postoperative scar. It is known to correct all the components of the deformities both bony and soft tissues. The rate of relapse or recurrence is comparatively less and even if it does occur, the options of surgery are always open.

RETENTION OF CTEV CORRECTION

Whatever may be the methods of correction of CTEV whether conservative, surgical or by external fixators, retentions of the corrected deformities should be done by one of the following methods to prevent relapse:

- Denis Browne splint—used usually during the day time (Fig. 23.26).
- Phelps's brace—used mainly in the night
- Below knee walking calipers.
- CTEV shoes—these are mainly used when the child starts walking and upto 5 years of age (Fig. 23.27).

Quick Facts

Do you know how does a CTEV shoe differ from an ordinary shoe?

1. It has a straight inner border which helps prevent forefoot adduction
2. It has an outer shoe raise and this helps prevent foot-inversion
3. There is no heel and this helps prevent equinus.

CONGENITAL ABSENCE OF RADIUS

RADIAL CLUB-HAND

Failure of the formation of the parts along the preaxial or radial borders of the upper extremity, deficient or absent thenar muscles, short or absent thumb, short or absent radius. After birth, the deformity is corrected passively and splinted with a short arm plastic splint. Surgical correction, i.e. centralization of hands is usually done at 3 to 6 months. Pollicisation is done at 9 to 12 months. See box below for some of the salient features of this condition.

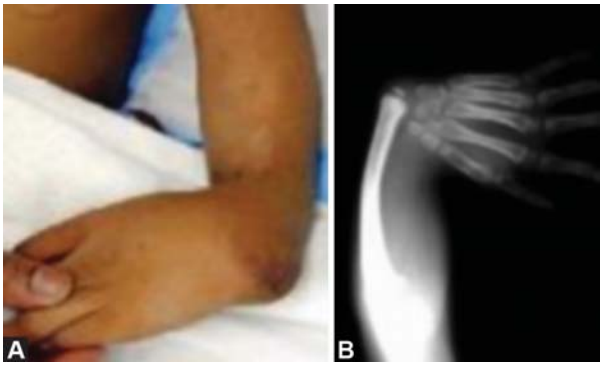
Quick Facts

- One in one lakh birth.
- Incidence—4.7%.
- Bilateral in 50% of cases.
- Sexes—equal.
- Right side more common.
- Complete absence more common than partial absence.
- Cause unknown/thalidomide/ genetic.

CONGENITAL ABSENCE OF FIBULA

Fibula is partially or completely absent more often than any other long bones of the body.

Treatment consists of lengthening of the affected tibia and epiphyseal arrest of opposite limb is done and if there is presence of tight band in place of absent fibula it should be excised. Wiltse's osteotomy is done for skeletally mature patients to correct the valgus deformity (Figs 23.28A and B).



Figs 23.28A and B: (A) Clinical photograph showing congenital absence of fibula, (B) Plain X-ray showing congenital absence of fibula

CONGENITAL ABSENCE OF TIBIA

This condition is less common than fibula. Deformity may be unilateral or bilateral. Tibia could be aplastic or dysplastic. Leg is short, bowed, and the foot is rigid in varus and the first metatarsal is short. Treatment consists of transfer of fibula,tibiofibular fusion,calcaneofibular fusion,disarticulation of ankle and modified Boyd's amputation depending on the type and severity of involvement.

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24 Chapter

Developmental Disorders

ACHONDROPLASIA

Achondroplastic is melancholic at heart, as he weeps at his stature but gives the greatest gift to mankind that is laughter, as he dispels the gloom on the weary faces of the people, by his clowning antics at the circus!

Introduction

It is a defect in the enchondral ossification of the bone, with the membranous ossification being normal. This is the most common type of dwarfism one encounters in clinical practice The limbs are short and the head is big, because, along with the growth of the limbs, growth of the base of the skull is affected but the membranous bones of the vault escape.

Achondroplasia Dwarfism

Achondroplasia dwarfism is a type of autosomal dominant genetic disorder that is a common cause of dwarfism with an average adult height of 131 cm (4 feet, 3-1/2 inches) for males and 123 cm (4 feet, 1/2 inches) for females.

Incidence

It is rare and is approximately 1 per one lakh population.

Causes

Dwarfism due to achondroplasia is a result of autosomal dominant mutation in the fibroblast growth factor receptor gene 3 (FGFR3), which causes an abnormality of cartilage formation and this has normally a negative regulatory effect on bone growth. In achondroplasia, the mutated form of the receptor is constitutively active and this leads to severely shortened bones.

Clinical Features

The patient is a short limbed dwarf (Figs 24.1 and 24.2). The fingers are short and stumpy and do not reach below the upper one-third of the thigh as he stands. Patient can kiss his toes with the knees straight. Head is large, nose is flattened but the length of the trunk may be normal and occasionally may show kyphoscoliosis or lordosis. Cervical lordosis and increased lumbar lordosis develop in the later stages of the disease. The intelligence and sexual developments are normal.

Radiograph

Plain X-ray findings show the skull is broad with a narrow foramen magnum. The vertebral bodies are short and flat with

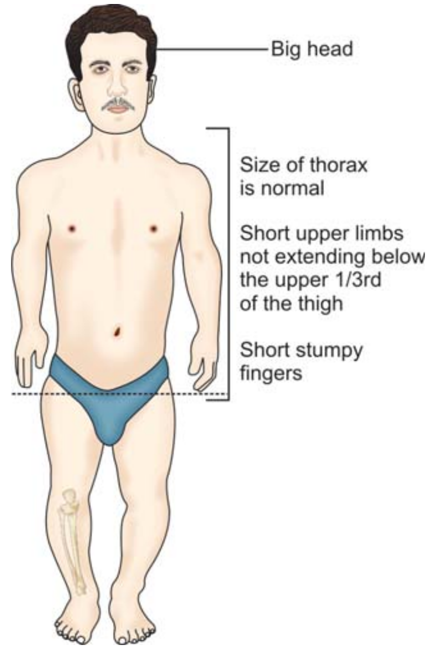

Fig. 24.1: Showing features of achondroplasia

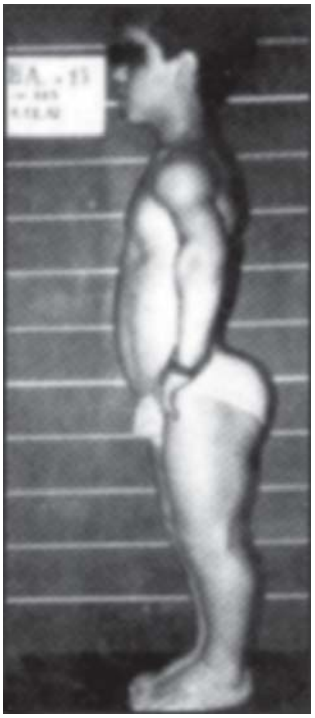

Fig. 24.2: Clinical photograph of achondroplasia

a narrow spinal canal. Ilium is quadrilateral in shape and there is coxa vara. The fibula is overgrown and the metacarpals and phalanges are short and stumpy and has a trident configuration (Fig. 24.3). Ribs are short and has cupped anterior ends. The joints are often double jointed.

Ultrasound The diagnosis can be made by fetal ultrasound by progressive discordance between the femur length and biparietal diameter by age. The trident hand configuration can be seen if the fingers are fully extended.

Fig. 24.3: Radiograph showing achondroplasia features

Quick Facts

Do you know the common causes of dwarfism?
- Achondroplasia
- Cretinism
- Diaphyseal aclasia
- Hunter, Hurler and Morquio's disease
- Malnutrition, etc.

Treatment

There is no treatment for Achondroplasia at present with the role of human growth hormone being redundant. However, the limited treatment methods consist of limb lengthening procedures to increase the height (Ilizarov's technique). But an achondroplastic is usually reluctant to undergo correction of his height for the following reasons:
- His height helps him gain employment as a clown in circus, movies and theaters.
- He is entitled for benefits offered to a handicapped person by the government and other agencies.
- Limb lengthening procedures are expensive and time consuming.

Remember

About achondroplasia
- Failure of endochondral ossification
- Commonest type of dwarf
- Normal intelligence
- Usually employed as a clown
- Limb lengthening procedures help

OSTEOGENESIS IMPERFECTA

To be a blue eyed boy is great but to virtually have blue eyes is a misery. Read on the story of osteogenesis imperfecta to find out why?

Definition

It is a hereditary condition characterized by *fragility of bones, deafness, blue sclera, laxity of joints and a tendency to improve with age.*

It is a disease of the mesodermal tissues with deposition of normal collagen in bone, skin, sclera and dentine.

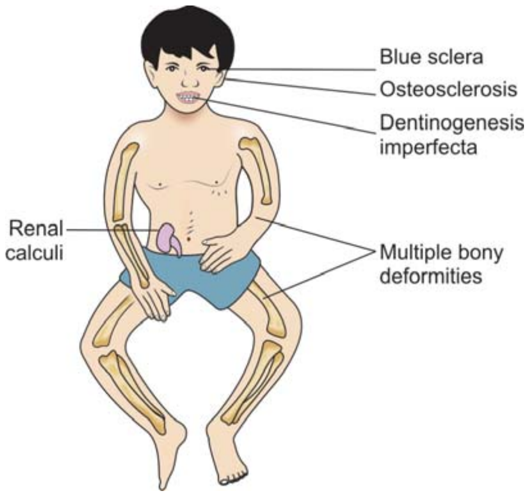

Fig. 24.4: Osteogenesis imperfecta

Etiology

The etiological factors could be heredity, Mendelian recessive—in prenatal cases, and Mendelian dominant—in postnatal cases.

Clinical Features

Patient presents with blue sclera (Fig. 24.5B), dentinogenesis imperfecta and generalized osteoporosis (Figs 24.4 and 24.5A). Blue sclera is seen only in 92 percent of cases, while the other two features are seen in almost all cases. Osteoporosis gives rise to bowing and multiple fractures. Fractures are usually due to trivial trauma but surprisingly heal well. Other features include: deafness due to otosclerosis, laxity of joints, dwarfism, broad skull, poorly calcified decidual teeth but permanent teeth are normal and the blood chemistry is normal.

Figs 24.5A and B: (A) Showing blue sclera (B) Clinical photograph of osteogenesis imperfecta

Remember

The mnemonic **BLOOD** in osteogenesis imperfecta
BL—Blue sclera
O—Osteosclerosis
O—Osteoporosis
D—Dentinogenesis imperfecta

Quick Facts

Do you know the 4 O's responsible for easy fracture?
- **O**steoporosis
- **O**steopetrosis
- **O**steomalacia
- **O**steogenesis imperfecta

Remember

3F's in osteogenesis imperfecta
- **F**ragile bones
- **F**ractures—multiple and frequent
- **F**etal variety is fatal

Laboratory Investigations

There is no specific laboratory test for this disease. Prenatal determination of the probability of osteogenesis imperfecta on the fetus can be achieved by amniocentesis and estimation of *inorganic pyrophosphate*. This compound is elevated 3 to 4 times the normal value.

Radiograph

Plain X-ray of the affected limbs shows multiple pathological fractures united in malposition and this helps to make a diagnosis (Fig. 24.6).

Fig. 24.6: Radiograph showing the multiple fractures and their malunion in osteogenesis imperfecta

Treatment

Principles

Protect The child with suitable orthosis till the tendency of the fracture lessens as age advances.

Administer Vitamins, estrogens and androgens.

Operate In infantile type as the tendency to fracture is much higher and hence the treatment of choice is multiple osteotomies with intramedullary nailing.

MUCOPOLYSACCHARIDE DISORDERS

The bone has two components—organic and inorganic. The organic component which forms 70 percent of the bone is formed mainly by type-I collagen (90-95%) and the remaining 5 to 10 percent is formed by the mucopolysaccharides which are protein polysaccharides. The principal mucopolysaccharide is chondroitin IV sulphate. Its role is not clear, but it appears to inhibit mineralization of bone by strongly complexing with calcium ions.

In certain diseases increased urinary excretion of polysaccharides results in loss of polysaccharides from bone and cartilage causing specific skeletal deformities. These are the inborn errors of mucopolysaccharide metabolism.

Morquio-Brailsford Disease

The following features are seen, normal development till five years, dwarfism is present, kyphosis is present, manubriosternal angle is more than 96° *(pathgnomonic)*, vertebra are too flat with a narrow tongue of bone projecting forwards *(platyspondyly)*, hips are grossly distorted, genu valgum and varum are severe, marked ligamentous laxity, skull and mentality are normal. Keratin sulphate is found in urine.

Hurler's (Gargoylism) Disease

The features are coarse skin; wide set eyes with corneal opacity, bloated lips and eyelids, mental retardation, limb deformities are same as in Morquio's. There is no platyspondyly. *Dermatin sulphate and heparin sulphate are found in urine. Cardio-pulmonary complications are common unlike in Morquio's.* These patients rarely survive into adults.

Hunter's Disease

Hunter's disease differs slightly from Hurler's; it is less severe and shows X-linked inheritance. All patients are males.

Hereditary Multiple Exostosis (Diaphyseal-Aclasia)

Diaphyseal-aclasia is autosomal dominant and there is a failure of bone remodeling, excess of metaphysis is not resorbed, but forms irregular cartilage capped exostosis.

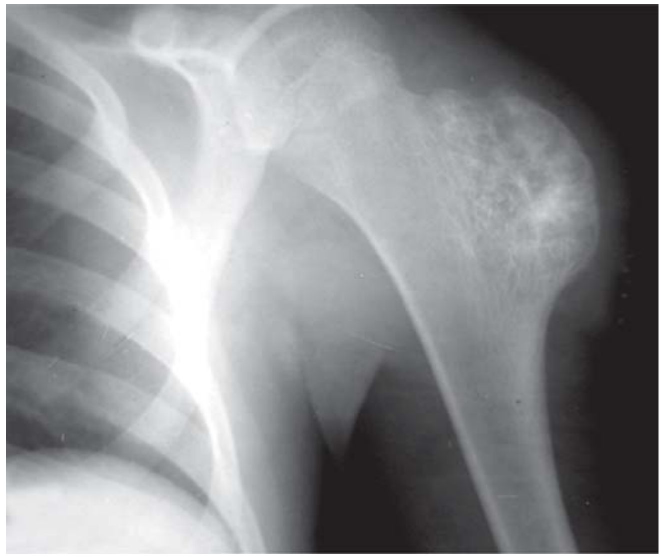

Fig. 24.7: Plain X-ray showing exostosis arising from the upper end of humerus

Clinical Features

Skull and spine are normal but the patient is slightly short stature and may present with multiple bony lumps in the following areas: Upper humerus, lower end of radius and ulna, around knee, around ankle and flat bones.

No lumps grow from the epiphysis and rarely an exostosis does migrate as far as middle third of the shaft of long bones. *Deformities* could be bowing of radius, genu valgum, ankle valgum, etc.

Radiograph

Plain X-ray of the affected part shows the presence of bony outgrowths from the metaphysis (Fig. 24.7).

Dyschondroplasia (Ollier's Disease)

This disease is not familial and the ossification of cartilages at growth plate is defective, with islands of unossified cartilage. It is typically unilateral and the affected limb is short and bent. There is valgus and varus at the knee and ankle. Relative shortening of the ulna with the radius curved and sometimes dislocated is often seen. Malignant change occurs in 1 percent of cases. Fingers and toes contain multiple enchondromas.

MaffuCci's Disease

Dyschondroplasia and multiple hemangiomas are seen in Maffucci's disease. Radiology shows translucent islands or columns of cartilage are seen in the metaphysis. In addition there are development of dense irregular spots shaft is curved but normal, and metaphysis is mottled or streaky.

OSTEOPETROSIS

(Syn: Marble bone disease, Albers-Schönberg disease)

Here the bone looks excessively dense and structure less on the X-ray. Bone has a marble appearance but breaks easily as it is very brittle.

Note Marble bone disease is due to functional deficiency of osteoclasts leading to failure of bone resorption.

Etiology

Etiology is unknown, consanguinity has a role to play and it is inherited as simple Mendelian recessive or dominant.

Clinical Features

The disease starts during gestation and is progressive till growth stops. The intensity varies; in mild type formation of dense bones occurs slowly, intermittently and incompletely. Malignant type occurs in consanguineous marriages. Bone is dense and brittle. Fractures are frequent and heal slowly. Anemia, optic atrophy, facial palsy, deafness, hydrocephalus are other features.

Radiograph

Here the bone looks dense and there is loss of bony structure and architexture. Pathological fractures could be seen (Fig. 24.8).

Fig. 24.8: Radiograph showing pathological fracture neck of femur in osteopetrosis

Complications

Could be due to insufficient formation of bone marrow, and due to encroachment on cranial foramina which causes optic atrophy, deafness and facial palsy.

EPIPHYSEAL DYSPLASIAS

Epiphyseal dysplasia multiplexa is the rarest in this group and is familial. Face, skull and spine are normal. X-ray features show that Epiphysis appears late and close early, ill formed, irregular and mottled, shape altered, deformity and stiffness results, and secondary osteoarthritis is common.

Epiphyseal dysplasia punctata is a variation of epiphyseal dysplasia multiplexa. It is more severe and is obvious at birth.

Conradi's disease The components are epiphyseal dysplasia, mental retardation, cataract, congenital heart disease and dwarfism. Mottling disappears with growth.

Epiphyseal dysplasia hemimelia Affects epiphysis of ankle, knee and only one limb is involved. One-half of the epiphysis either medial or lateral is involved. Child presents because of limp or stiffness.

METAPHYSEAL DYSPLASIAS

Metaphyseal dysplasia (Pyle's disease) It is an autosomal recessive and there is failure of remodeling of the metaphysis. Erlenmeyer flask deformities of distal femur and proximal tibia may develop. It may also be associated with genu valgum.

Craniometaphyseal dysplasia It is an autosomal dominant and is confused with Pyle's disease. There is metaphyseal widening, thickening of skull and mandible.

Metaphyseal chondrodysplasia It is autosomal dominant, the metaphysis is irregular and cystic. Varus deformities of the hips and knees may be seen.

DIAPHYSEAL DYSPLASIA

Progressive diaphyseal dysplasia (Canuati's or Engelmann's disease) This disease shows fusiform widening and sclerosis of shafts of long bones and skull. Femur, tibia, forearm bones are symmetrically affected. Cortical thickening is superficial, bone ends are normal, painful limbs, and waddling gait, weakness, etc. are other associated findings.

Craniodiaphyseal dysplasia Show expansion of long bone shafts and is associated with gross thickening of skull and face.

FIBROUS DYSPLASIA

Fibrous dysplasia is a rare disease with fibrous replacement of bones. It may be *monostotic (involves a single bone) or polyostotic (involves multiple bones)*. The former is more common and accounts for 70-80% of this condition.

Etiology

It is unknown, begins in childhood, progresses beyond puberty and has equal incidence in both sexes.

Clinical Features

Clinical features in early childhood are mild and asymptomatic. Onset is seen in less than 10 years of age. Patient may present with limp, pain, and fractures. Females have abnormal vaginal bleeding. Bending deformity and shortening of the bones are common features and lengthening is rare. *Shepherd's crook deformity (Fig. 24.9) is quite characteristic*. There is asymmetry of head and face and local irregular brown patches if seen are associated with polyostotic types. Sexual precocity is typical in females.

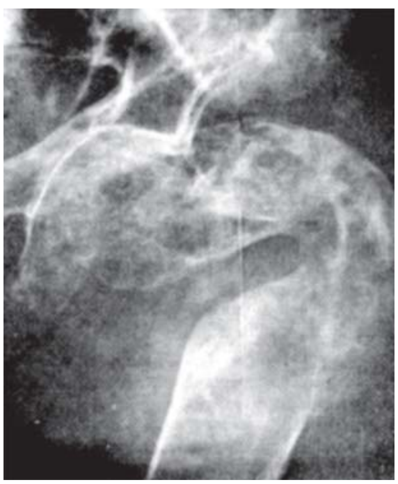

Fig. 24.9: Shepherd crook deformity in fibrous dysplasia

ALBRIGHT'S SYNDROME

It is a severe form of unilateral polyostotic fibrous dysplasia with sexual precocity in females.

Laboratory Investigations

Serum calcium, phosphorus, alkaline phosphatase are normal. In severe cases alkaline phosphatase may increase.

Radiograph

Localized lesions are cystic, multilocular, and show ground glass appearance, pathological fracture may occur. Shepherd's crook deformity and Harrison's grooves following rib fractures, intrapelvic protrusion of acetabulum, and hyperostosis at the base of the skull, are the other important features.

Remember

4 S's in fibrous dysplasia
- **S**hepherd crook deformity
- **S**exual precocity in females
- **S**erum investigations are normal
- **S**urgery is the treatment of choice

Treatment

Surgery is the treatment of choice in fibrous dysplasia and consists of different surgical methods for different problems (Table 24.1).

TABLE 24.1: Problems vs preferred surgical methods in fibrous dysplasia

Problems	*Preferred surgery*
• Long bones fractures	Open reduction + Internal fixation + Bone grafting
• Cyst	Curettage + Bone grafting
• Coxa vara	Subtrochanteric osteotomy + Internal fixation + Bone grafting
• Limb length discrepancy	• Epiphyseal arrest before skeletal maturity • Ilizarov treatment
• Limb severely shortened and deformed	Amputation

NAIL-PATELLA SYNDROME (ONYCHO-OSTEODYSPLASIA)

The features are, autosomal dominant gene, nails are hypo plastic, patella is unduly small or absent, radial head may subluxate laterally, bony excrescences develop on the lateral aspect of the ilium and there could be congenital nephropathy.

MARFAN'S SYNDROME*

It is autosomal dominant and there is a defect in elastin collagen. Ocular lens dislocation and aortic aneurysm are seen. The patient is tall with disproportionate legs. Chest deformities, scoliosis, long digits, generalized joint laxity, high arched palate and hernias may be seen.

Note Marfan's syndrome was described by Marfan, a French pediatrician in 1896. *Abraham Lincoln was affected with Marfan's syndrome.*

*__Bernard Marfan__ (1896) French Pediatrician

HOMOCYSTINURIA

It is autosomal recessive and the patient is prone to lens dislocation. Osteoporosis, widening of epiphysis and metaphysis, mental defect, stickiness of platelets are other associated features.

Acrocephalosyndactyly (Apert's Syndrome)

It is autosomal dominant. Head has a peculiar shape with high broad forehead (tower-shaped). Flat occiput, bulging eyes, prominent jaws, and associated syndactyly of fingers and toes are other findings.

Carpenter Syndrome

Carpenter syndrome is Apert's syndrome with polydactyly.

Cleidocranial Dysplasia

See Chapter 23 on "Congenital Disorders."

CONGENITAL NEUROFIBROMATOSIS

This disease targets the skeletal system with impunity. It is autosomal dominant and development of neurofibromas within ectodermal and mesodermal tissues takes place.

Von Recklinghausen's Disease

Clinical Features

This consists of skin lesions—*pigmented cafe-au-lait spots*, multiple neurofibromas which are derived from endoneurium and perineurium, etc.

Locations of the neurofibromas

- *Subcutaneous* Tender painful palpable nodules.
- *Subperiosteal* Periosteal reaction or a bone cyst.
- *Endosteal* Bone cysts, pseudarthrosis, etc.
- *Intraspinal* Dumbbell shaped tumor, paraplegia never occurs.

Skeletal changes Incidence is about 30 to 50 percent.

Long bones Show reduced growth rate, periosteal cysts, cortical cysts, osteoporosis, rarely increased density and multiple bone cysts, and congenital pseudarthrosis.

Spine Scoliosis is the most common skeletal lesion and there could be kyphosis or kyphoscoliosis. This disease is consistently associated with "cafe-au-lait spots" and elephantiasis due to diffuse hypertrophy of all soft tissues.

Less common lesions are head lesions, macrocranium, optic glioma, bilateral acoustic neuroma, cervical kyphosis, and vascular lesions.

Diagnostic criterion
Any two of the following • Positive family history • Positive biopsy finding • Minimum six "cafe-au-lait spots" • Multiple subcutaneous neurofibromas • Iris nodules called Lysch nodules

Radiograph

Plain X-ray shows psuedoarthrosis changes in the long bones (Figs 24.10A and B), kyphoscoliosis, lateral scalloping, pencil pointing of vertebral margins, and adjacent twisted *ribbon ribs* (characteristic).

Figs 24.10A and B: Plain X-ray showing pseudoarthrosis changes in long bones

Treatment

Complete excision is the only treatment and elephantiasis needs repeated resection. Scoliosis needs early correction and fusion. Painful spinal tumors require laminectomy and removal. Kyphosis needs anterior correction and spinal fusion. Antero-lateral bowing of tibia should be protected against pathological fracture till skeletal maturity is reached. Surgical intervention is necessary if fracture occurs.

PAGET'S DISEASE (OSTEITIS DEFORMANS)

Paget's disease is seen after 40 years of age and is more common in males. There is impairment in the bone resorption and bone formation due to defective osteoclastic functions. As a result of this bone gets thickened and bent more, so the tibia. Bone is soft in the initial stages and dense later.

Etiology

This is unknown and there could be a family history or association of viral antigen.

Clinical Features

In 70% of the cases, this disease is asymptomatic. The affected bones are thickened and bent. Patient complains of continuous dull bone pain and deformities.

Quick Facts

The distribution of bones affected in Paget's disease
- Pelvis (72%)

Spine
- Lumbar (58%)
- Thoracic (45%)
- Cervical (14%)
- Skull (42%)

Long bones
- Femur (55%)
- Tibia (35%)
- Humerus (31%)

Look for the following clinical signs
- Kyphosis
- Limb shortening or bowing
- Frontal forehead bossing
- Skull enlargement
- Loose teeth

Investigations

Both serum and bone specific alkaline phosphatase is increased in this condition.

Radiograph

Radiograph of the affected bone shows multiple lytic areas with intervening new bone formation leading to sclerosis (Fig. 24.11). This is due to the initial increased osteoclastic activity, followed by osteolytic and osteoblastic activity and finally by the deposition of dense bone due to osteoblastic activity.

Fig. 24.11: Radiograph of the spine showing the features of Paget's disease

Treatment

Treatment is essentially conservative and the drugs of choice are calcitonin or diphosphonate.

General management General Measures include the following:
- Adequate pain control
- Calcium supplementation 1500 mg qd
- Vitamin D 400 IU per day
- Low impact exercise
- Straining the affected bone should be avoided

Specific management This essentially consists of measures to suppress the bone resorption activity by the Osteoclasts.

Indications

In those patients who are symptomatic and in whom alkaline phosphatase is > 125 to 150% of normal the following drugs are recommended:
- First line agents: Bisphosphonates
- Alendronate (Fosamax) 40 mg qd for 6 months
- Pamidronate (Aredia) intravenous
- Alternative agents (not as potent as Bisphosphonates)
- Calcitonin 100 U SC or IM qd for 6 to 18 months.

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25

Chapter

Metabolic Bone Disorders

RICKETS

It is a metabolic disease of childhood in which, the osteoid, the organic matrix of bone, fails to mineralize due to interference with calcification mechanism. It is usually common between six months and two years.

Causes

Four main causes:

1. *Vitamin D deficiency:*
   - Reduced dietary intake
   - Reduced amount of sunlight
   - Pigmented skin
2. *Malabsorption due to:*
   - Celiac disease
   - Hepatic osteodystrophy
3. *Renal disease:*
   - Glomerular failure
   - Renal osteodystrophy
4. *Antiepileptic drugs* favor formation of hepatic enzyme which prevents conversion of calciferol.

Quick Facts

TYPES OF RICKETS

- **Fetal rickets** is commonly seen in osteomalacic mothers.
- **Infantile rickets (nutritional rickets) this** is rare before 6 months and is the most common form of rickets, seen between 6 months to 3 years of life.
- **Late rickets or rachitic tarda this** is late onset rickets, familial and it is vitamin D resistant rickets.

NUTRITIONAL RICKETS

This is the most common type of rickets and is due to deficiency of vitamin D. It is seen in children.

Clinical Features

Symptoms Patient complains of bone pain during rest, and excessive perspiration in upper half of the body (Fig. 25.1). He or she loathes using the limb and the weakness of proximal muscles of the lower limbs produces waddling gait. There is evidence of catarrh of mucous membranes (recurrent diarrhea, constipation, bronchitis). Irritability of CNS

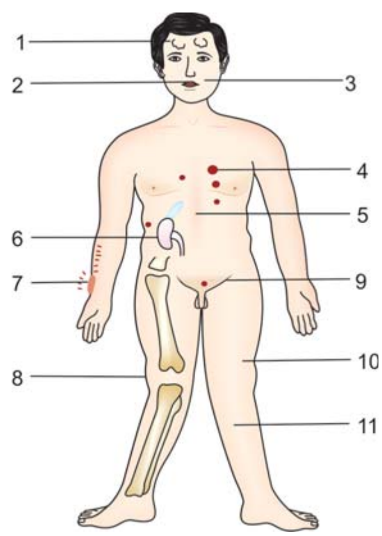


Fig. 25.1: Showing features as seen in nutritional rickets: (1) Frontal bossing, (2) Dentition changes, (3) Chovstek's sign, (4) Chest changes, (5) Malabsorption, (6) Aminoaciduria, (7) Expanded wrist, (8) Genu valgum, (9) Pelvic obliquity, (10) Myopathy, (11) Skin changes

produces convulsions, laryngismus, spasmophilia, Chovstek's sign, opisthotonos, etc.

Deformities of Rickets (from Head to Toe)

Skull
- Broadened forehead
- Skull squared (caput quadratum)
- Frontal and parietal bossing—seen after the age of 6 months.
- Craniotabes is a ping-pong sensation on compressing the membranous bones of the skull.

Chest
- Pigeon chest due to prominent sternum (Fig. 25.3A).
- Narrow chest.
- Rickety rosary (enlargement of costochondral junction) (Fig. 25.3C).
- Harrison's sulci due to diaphragmatic pull on the soft ribs.

Bones
- *Enlargement of the metaphyseal segments* of long bones like radius, tibia, costochondral junction, etc. seen in children between 6 and 9 months of age (Figs 25.2A and 25.3B).
- *Vertebral columns* show exaggerated curvature.
- *Pelvis* is trefoil shaped.
- *Coxa vara.*
- *Femur* is bent anteriorly and laterally.
- *Knock knee (genu valgum)* (Fig. 25.2A)
- *Bowed tibia.*

Other Features

Other features encountered in rickets are wizened look, delayed dentition, prominent abdomen, separation of recti, pale and flabby skin, incomplete fractures, etc.

Radiologic findings include widening of the physes, irregular (frayed) metaphyseal margins, splaying and cupping of the metaphyses, bowing of extremities, and osteopenia. Widening and lengthening of the growth plate is the earliest radiologic finding of rickets. Prominence of the rib ends and costal cartilage produces the characteristic rackety rosary. Defective osteoid mineralization is evident as diffuse osteopenia in the shafts of the long bones. Genu valgum or varus scoliosis, slipped capital femoral epiphysis, a triradiate configuration of the pelvis, and basilar invagination could also be seen. In advanced cases, insufficiency fractures (Looser zones) are seen as bilaterally symmetric linear lucencies perpendicular to the cortex (Figs 25.2B and 25.4).

Figs 25.2A and B: Showing clinical presentation and radiographic changes in rickets

Figs 25.3A to C: Showing clinical presentation in rickets: (A) Pectus excavatum, (B) Widened wrist, (C) Rickety rosary

Laboratory Investigations Calcium levels and Serum phosphorus may be low. Serum alkaline phosphatase may be high and there could be metabolic acidosis

Bone biopsy is rarely performed but if done will confirm rickets.

Other tests and procedures include the following: PTH ,Urine calcium, Calcium (ionized) and ALP (alkaline phosphatase) isoenzyme.

Quick Facts

How do renal rickets differ from nutritional rickets?
- Less osteoid formation and increased osteoclastic resorption of bone.
- Osteosclerosis is seen at the base of the skull.
- Slipped capital femoral epiphysis is more common.
- Delay in skeletal maturation.

Treatment

Medical treatment in the initial stages aims to bring about quick healing. A single oral dose of 6 lac IU of vitamin D is given. A second same dose may be required after 3 to 4 weeks of treatment if no sclerotic (healing sign) change is seen on the

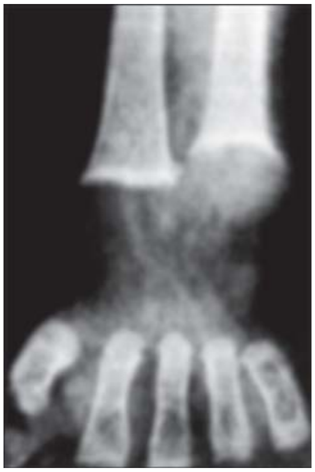


Fig. 25.4: Typical X-ray of the wrist showing thickening and irregularity of the epiphysis plate and cupping of the metaphysis

radiograph at the metaphyseal side of the growth plate. A maintenance dose of 4000 IU of vitamin D may be required if the child responds to the above treatment regimen.

Physiotherapy Measures

Prevention of deformity can be done by absolute and strict bed-rest, rickets splints etc.

Treatment of established deformity:

- *Correction by splints (Mermaid splint)* This is mainly useful when the disease is active and the deformity is slight. It is very effective in children and in preventing deformities concerning the lower limbs. But it is slow and requires continual supervision.
- *Correction by osteotomy* is indicated when deformity is near the joint and when the growth stops.

Differential Diagnosis

Acute poliomyelitis, congenital syphilis, septic arthritis, infantile scurvy, etc.

RENAL OSTEODYSTROPHY

Renal osteodystrophy was, first described by Lucas in 1883. In this condition, bone is diseased due to glomerular failure and renal tubular disease.

Three forms are described:

- Renal dwarfism
- Renal pseudo rickets
- Renal osteitis fibrosa cystica.

Why is renal rickets low-grade rickets?

Absorption of vitamin D and Ca from GIT is unimpaired. Hence osteoid tissue is being formed. So weight bearing deformities are not as pronounced as in rickets.

True florid phase of rickets is never seen. Shortness of stature is because enchondral ossification is affected at the growth plate.

Causes

At birth Congenital polycystic kidney and congenital hydronephrosis, etc.

Later Chronic glomerulonephritis, chronic interstitial nephritis, chronic pyelonephritis, and nephritis due to heavy metal poisoning, etc.

Clinical Features

In renal rickets (Table 25.1) the clinical features could either be due to renal lesion *per se*, tubular defects or due to the growth disturbances and the resultant bony changes. Symptoms

TABLE 25.1: Features of renal rickets

Those due to renal lesion	*Due to disturbance of growth*	*Bone changes*
• Thirst • Polydipsia • Polyuria • Urine – Low specific gravity – Output 1200-3700 ml/d – Albumin and Casts ++ • CVS symptoms of renal origin • Kidney failure: Headache, GIT disturbances and drowsiness • Death due to uremia	• Stunted growth • Body weight small • No malnutrition • Patient surviving beyond puberty shows infantilism and dwarfism • Mental development is normal up to puberty, thereafter mental sluggishness • Secondary sexual characters do not appear	• Genu valgum is the most common manifestation (Fig. 25.5). Age of onset is 11 to 14 years • Enlargement of epiphysis • Costochondral rosary • Bow legs, Harrison's sulci, etc. • May be associated with parathyroid hyperplasia.

Fig. 25.5: Showing genu valgum deformity in an older child in renal rickets

are present from early days of life. Child is normal for first few years before the symptoms start appearing. It is considered fewer than three groups.

Investigations

Plain X-rays reveal enlargement of the epiphysis, genu valgum, etc. Laboratory investigations are as described for nutritional rickets.

Treatment

Treat the underlying renal disease (e.g. removal of post urethral valve, etc.). Surgical intervention is done before puberty. Treatment is of little help in congenital polycystic kidney and renal hypoplasia. Good results are seen in hyperchloraemic renal acidosis and nephro-calcinosis. Organic acid with sodium citrate helps absorption of calcium from the intestines. Vitamin D in the form of OHD or 1, 25 $(OH)_2$ is to be given in high doses (1 lakh IU). In active stages, weight bearing is prevented and use of splints is recommended. Avascular necrosis of femoral head may appear due to treatment with steroids. Haemodialysis or kidney transplant may help.

> *Note* Chronic renal failure causes rickets due to increased PTH level, acidosis and hypocalcemia.

VITAMIN D RESISTANT RICKETS

It develops due to failure of phosphate re-absorption from the kidney. The disease is familial and there is excessive fecal loss of calcium and defect in the formation of 1, 25 (OH) 2D by the kidney.

Clinical Features

Children tend to survive into adulthood exhibiting features of osteomalacia. There is a prominent occipital protuberance and features of dolicocephaly (anteroposterior diameter increases but transverse diameter decreases). Patient has short stature and nose is saddle shaped.

Tackle Deformity

Tackle deformity is the hallmark of this disease (bow leg on one side and knock knee on the other) (Figs 25.6 and 25.7). There is marked ligamentous instability.

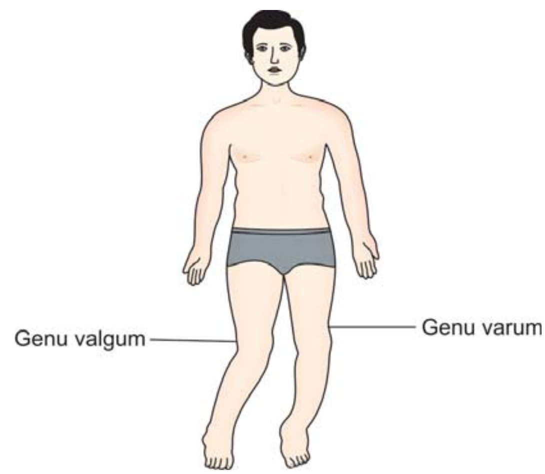


Fig. 25.6: Tackle deformity typical of vitamin D resistant rickets

Fig. 25.7: Clinical photograph showing windswept deformity

Remember

The term vitamin D resistant rickets refers to any condition that requires more than 1 lakh IU of vitamin D to produce healing.

Treatment

The aim of the treatment is to give doses of vitamin D (0.5-1.0 lakh IU/ d) and to maintain Sulkowitch test at 1+ or 2+.

Prognosis

Complete cure of skeletal dystrophy may occur if the individual survives more than 16 to 17 years. Occurrence of bone deformity is a grave omen; average duration of life is less than 2 years if kidney is untreated.

Quick Facts

A quick look at the late deformities seen with vitamin D-resistant rickets
- Genu varum/valgum
- Coxa vara
- Anterior bowing of femur
- Anterolateral bowing of tibia
- Protrusio acetabuli
- Kyphoscoliosis

OSTEOMALACIA

It is the adult counterpart of rickets and is characterized by failure of mineralization and an excess of osteoid due to an interference with calcification mechanism. *The osteoid is increased at the cost of mineralized bone.*

Etiology

- Decreased vitamin D absorption from the intestine.
- Derangement of vitamin D and phosphorus metabolism (hereditary or acquired).

Pathogenesis

It could be due to the following reasons:

Decreased vitamin D metabolism **decreased** vitamin D could be due to dietary malabsorption or disturbed metabolism.

Remember

Role of Vitamin D on
- *Gut* Increase in calcium absorption.
- *Bone* Increase in bone formation and mineralization.
- *Kidney* Decrease in phosphate reabsorption and increase in calcium reabsorption.

Inorganic phosphate decreased Hypophosphataemia impairs function of osteoblasts and thereby affects collagen synthesis and mineralization. It could be due to renal disease, decreased PTH, or increased antacid (non-absorbable).

Chronic acidosis due to renal disease adversely affects the calcium metabolism in the following ways:
- Bone mineral calcium is used up to buffer excess H+ ions.
- Acidosis decreases calcium absorption
- Causes hypophosphataemia and vitamin D resistance.

Clinical Features

Patient complains of generalized skeletal pain and muscle weakness. There may be acute pain due to fracture. Other symptoms related to causative factors like dietary, renal and GIT may be seen. The following deformities are encountered, scoliosis, kyphosis, coxa vara, protrusio acetabuli, thighs and legs are bent, pelvis is trefoil, etc.

Radiograph

Plain X-ray of the bones show decreased bone density and the presence of Looser's zones is characteristic (Fig. 25.8).

Fig. 25.8: Radiograph of the pelvis showing Looser's zones

Treatment

The following conservative regimen is recommended. Calcium is given at 0.5 to 3 gm/day, vitamin D 10,000 IU/day, and high protein diet. The gastrointestinal tract errors are also corrected simultaneously.

HYPERPARATHYROIDISM

Primary Hyperparathyroidism (Osteitis Fibrosa Cystica, Von Recklinghausen's Disease)

In the beginning of the chapter the role of parathormone has been highlighted. The net result is it increases serum calcium and decreases serum phosphorus through its action on kidney, bone and intestines.

Clinical Features

This disease equally affects both sexes. It is common in middle-aged women. Patient complains of severe pain and tenderness over the back and lower limbs, generalized muscle weakness and hypotonia. Pathological fractures and delayed union may be seen. Deformities of limbs and spine are common features. Hyperphosphaturia, polyuria, polydipsia, renal calculi are some of the urinary complications.

Radiograph

Radiographs show skeletal changes as diffuse bone resorption due to increased osteoclastic activity (Fig. 25.9), multiple deformities (because bone is soft due to replacement with fibrous tissue), pathological fractures (Figs 25.10A and B), marrow fibrosis, brown tumor due to cavities filled with blood, multiple bone cysts, etc. Fracture healing is normal.

Fig. 25.9: Extensive subperiosteal resorption of bone in hyperparathyroidism

Figs 25.10A and B: Radiograph of the hand showing features of hyperparathyroidism

Treatment

Medical treatment consists of providing large doses of calcium, phosphorus and vitamin D. Treatment of choice is parathyroidectomy. For hyperplasia, three glands and a portion of the fourth are removed. Preoperative calcium is avoided.

Orthopedic management consists of support by splints and corrective osteotomies for bony deformities.

Secondary Hyperparathyroidism

Normal kidneys eliminate phosphorus easily. When kidney is diseased, phosphorus is not excreted. Increased levels of phosphorus in serum results in increased calcium and phosphorus levels in the serum and the excess is deposited in the tissues. This is the pathogenesis in secondary hyperparathyroidism and is seen in certain diseases of the kidney.

Eventual result is renal rickets in a child and renal osteomalacia in adults. This is high phosphorus rickets compared to normal or low phosphorus rickets in vitamin D deficiency.

OSTEOPOROSIS

It is a generic term referring to a state of decreased mass per unit volume of a normally mineralized bone due to loss of bone proteins. Most common cause is involutional bone loss in perimenopausal age group.

Remember

About osteoporosis

It is the most common skeletal disorder in the world, next only to arthritis. In osteoporosis there is a long latent period before clinical symptoms develop. Most prevalent complications are fractures of vertebral bodies, ribs, proximal femur, humerus, distal radius with minimal trauma.

Classification

Osteoporosis is classified as Type I and Type II. Table 25.2 shows the features of these two varieties of osteoporosis.

TABLE 25.2: Classification of osteoporosis

Epidemiological factor	*Type I (Postmenopausal)*	*Type II (Age related)*
Age	55-75 years	70 years (Female) 50 years (Male)
Sex (Female : Male)	6:1	2:1
Bone metabolism		
• Pathogenesis	↑ Osteoclast activity	- Osteoblastic activity
• Net bone loss	Mainly trabecular.	Cortical and trabecular
• Rate of bone loss	Rapid/short duration	Slow/long duration
• Bone density	2 SD below normal	Low or normal
Clinical signs		
Sites	Pain and stress fracture of Vertebra (rush) Distal forearm	Pain and stress fracture of Vertebra (multiple wedge) (Fig. 25.11) Proximal hip and tibia.
Other sites	Hip (intracapsular) Tooth loss	Hip (extracapsular) Dorsal kyphosis
Laboratory values		
• Serum calcium	N	N
• Serum phosphorus	N	N
• Alk phosphatase	N	N
• Urine calcium	↑	N
• PTH function	↓	↑
• Renal conversion of 25 (OH)$_2$ D to 1,25 (OH)D	Secondary ↓ due to ↓ PTH	Primary ↓ due to ↓ responsiveness
• GIT Calcium absorption	↓	
Prevention		
• **High-risk patients**	Estrogen, calcitonin and calcium supplementation; adequate vitamin D is given; Adequate weight bearing activity; minimisation of associated risk factors are recommended.	Calcium supplementation, Adequate vitamin D, Adequate weight bearing activity, and minimization of risk factors.

Causes

- *Disuse*
  — Prolonged bed rest or inactivity
  — Prolonged casting or splinting
  — Paralysis, space travel, etc.
- *Diet*
  — Calcium, protein, vitamin C low in the diet
  — Chronic alcoholism
  — Anorexia nervosa.
- *Drugs* Whose prolonged use causes osteoporosis are heparin, methotrexate, ethanol, glucocorticoids, etc.
- *Idiopathic* Variety is seen in adolescent and middle aged male population.
- *Genetic* Role is seen in osteogenesis imperfecta.
- *Chronic illness* Like rheumatoid arthritis, cirrhosis, sarcoidosis, renal tubular acidosis, etc.
- *Neoplasms* Like bone marrow tumors (myeloma, lymphoma, leukemia).

Fig. 25.11: Radiograph showing compression fracture of spine in osteoporosis

- *Endocrine abnormalities* Hyperparathyroidism, increased levels of glucocorticoids, oestrogens, etc.

Remember

> **In osteoporosis**
> - Decreased density is due to deficiency of protein matrix in which calcium is laid down.
> - Here rate of bone resorption is greater than bone formation.
> - Most commonly it is due to ageing process.
> - But the most common cause is involutional bone loss in perimenopausal women.

Clinical Features

Figure 25.12 shows features of osteoporosis.

Early symptoms Patient complains of acute pain in middle or low thoracic or high lumbar region (Fig. 25.13A). Sudden movement, sitting, sneezing, cough, etc. increases pain. It is relieved by rest.

Most common symptom of osteoporosis is back pain secondary to vertebral compression. However in some cases, fractures of axial skeleton may be seen with trivial trauma. Due to osteoporosis there is progressive loss of height (Fig. 25.13B). Round type of gibbus due to compression of thoracic vertebrae is commonly seen (Fig. 25.14). Wrist fractures, fracture neck of femur, vertebral fractures, and rib fractures are some of the commonly encountered fractures in osteoporosis. Unfortunately they all occur due to trivial trauma.

Investigations include laboratory tests that are usually normal, plain x-rays of the affected bones show decreased bone density but however the gold standard is the densitometry studies that show the extent of osteoporosis.

Fig. 25.13A: Backache is the most common presentation in osteoporosis

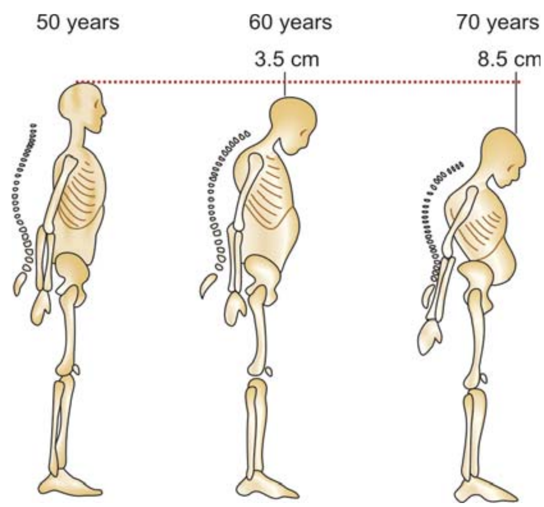


Fig. 25.13B: Showing progressive loss of height due to osteoporosis

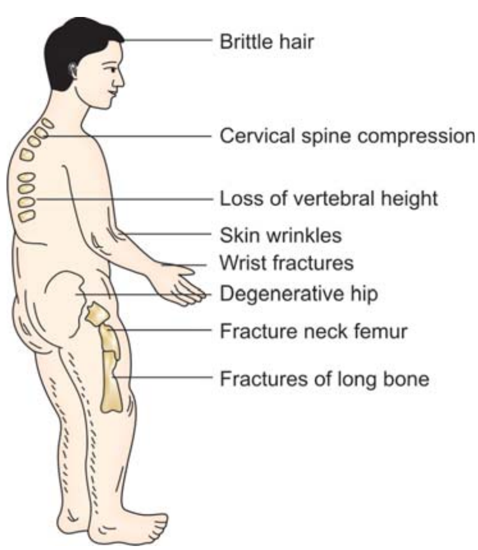


Fig. 25.12: Features of osteoporosis

Fig. 25.14: Radiograph of the spine showing senile kyphosis

Management of Osteoporosis

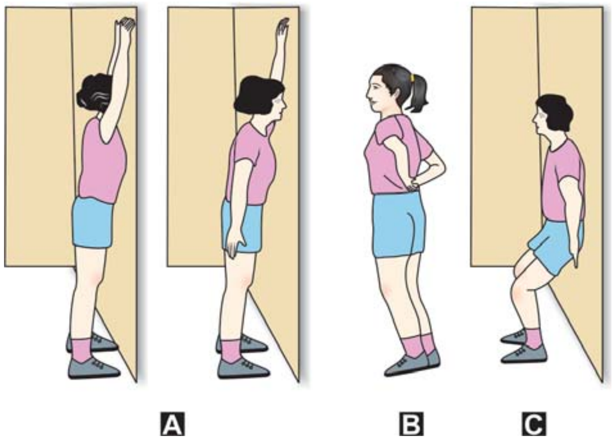
The best way to manage osteoporosis is to prevent it. But once there is impending threat of the disease or if there is fractures then the following multiple measures are recommended to manage this condition:

Drug therapy The following treatment regimen is recommended:

- High protein and calcium rich diet.
- Rest, analgesics and anti-inflammatory.
- Muscle relaxants
- Biphosphonates Alendronate sodium (5 mg/kg) is the most commonly used biphosphonate drug. It is indicated in patients who refuse or not suitable for estrogen replacement therapy.
- Estrogen supplementation (HRT) is the single most effective measure to prevent type I. It preserves positive calcium balance by bone remodeling.
- Calcitonin has been recently used for prevention of postmenopausal osteoporosis. It inhibits bone loss by bone resorption.
- Adequate vitamin D intake and calcium intake.
- Fluorides are beneficial in the treatment, but not in prevention as it stabilize the bone mineral and stimulate osteoblasts to form the new matrix.

Physiotherapy measures:

- *Posture exercises* Wall arch, back bending and wall sliding postural exercises helps to improve posture and overcome hunched back (Figs 25.15A to C).
- *Regular exercises* Like walking (Fig. 25.16).
- *Spinal orthosis* when patient is erect and mobile.
- *Supports* like belt, collar, etc.



Figs 25.15A to C: Showing various posture correction exercises in osteoporosis patient: (A) Wall arching, (B) Back bending, (C) Wall sliding exercises

Fig. 25.16: Regular exercises like walking is of great help in elderly patients suffering from osteoporosis

Recent trends

- *Coherence therapy* This is a recent therapy with oral phosphate and calcitonin.
- Low doses of anabolic steroids are being tried.
- New pure antiresorptive agents (aminopropylidene diphosphonate).
- Transdermal cyclic estrogen.
- Endogenous skeletal growth factors.

Metabolic disorders at a glance

Rickets	• Organic bone matrix fails to get mineralized. • *Nutritional rickets is the most common variety* • Characteristic rachitic features • Genu valgum is the most common deformity
Osteomalacia	• Adult counterpart of rickets • Here excess osteoid is not mineralized • *Looser's line is the hallmark of this disease*
Renal rickets	• A low-grade rickets • Defect could be in PCT or DCT • Growth is stunted and dwarfism is a feature • *Genu valgum is the most common deformity and manifests late at 11 to 14 years* • Treating underlying renal disease is important
Vitamin D resistant rickets	• Defined as any rickets requiring more than 1 lac IU of vitamin D • It is due to failure of phosphate reabsorption from kidney • There is defect in the formation of 1, 25 dihydroxyl vitamin D by kidney • *Tackle deformity is the hallmark*
Hyperparathyroidism	• Excess PTH stimulates action of osteoclasts • Bone resorbed resulting in multiple cavities

Osteoporosis	• Brown tumor is characteristic • *Pin head stippling and absence of lamina dura is the hallmark* • Commonest skeletal disorder in the world next to arthritis • It is age related and postmenopausal • Pathological fractures are very common • *The disease is due to loss of bone proteins*

SCURVY

It is a nutritional disorder caused by deficiency of vitamin C and is characterized clinically by a generalized hemorrhagic tendency. The severe form of disease is rare and mild varieties are more common. Deficiency targets the cells of skeletal system more often.

History

- More than half the crew of Vasco da Gama died from scurvy on his first trip (1497-99) around the Cape of Good Hope.
- In 1747, the Scottish naval surgeon James Lind treated scurvy-ridden sailors with lemons and oranges and obtained dramatic cures.
- In 1795, the British navy began to distribute regular rations of lime juice during long sea voyages and this was successful in preventing scurvy. It was probably the first disease to be definitely associated with a dietary deficiency.

Etiology

- Most frequent between 5 and 10 months in artificially fed infants.
- Vitamin C-deficient diet.
- When seen with rickets it is called Barton's disease.

Clinical Features

The affected child is restless, pale and febrile. The affected limb is swollen, tender, and painful, muscles are in spasm and the child loathes using the limb. This voluntary immobilization of the extremities is called *pseudoparalysis*. The gums display a bluish, spongy swelling especially around the uppercentral incisor teeth. Brittle and loose teeth, ecchymosis beneath the skin, haematemesis, haematuria, anemia, weight loss, anorexia, etc. are the other features. Sometimes even death supervenes. Mild forms of scurvy are more common. In adults pain and tenderness over the bone and fracture with mild trauma is suggestive.

Figs 25.17A and B: Clinical presentations and radiographic changes in scurvy

Radiograph

The lower femur, the upper tibia and the upper humerus are favored sites for epiphyseal fracture separation. Costochondral separation is typical (Figs 25.17A and B).

Treatment

Treatment is essentially conservative and consists of supplementing Vitamin C in the diet and also encouraging the child to take foods rich in other vitamins. The painful joints and the fractures need to be immobilized with plaster splints.

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26

Chapter

Osteomyelitis

DEFINITION

Osteomyelitis is defined as a suppurative process of the bone caused by pyogenic organisms or simply a pyogenic infection of the cancellous portion of the bone.

CLASSIFICATION

Three types are described based on duration of symptoms, route of spread of infection and host response (Table 26.1).

Hematogenous spread with primary infection being elsewhere like tonsillitis, ASOM, pyoderma, etc. is the common mode of spread. Spread from neighboring infective sites like septic arthritis and direct inoculation of infecting organisms by way of penetrating wounds, punctured wounds, trauma, etc. come second.

TABLE 26.1: Classification of osteomyelitis

Duration	*Route of spread Waldogel's*	*Host response*
• Acute (< 2 weeks) • Sub acute (2-3 weeks) • Chronic (> 3 weeks) • Residual	• Hematogenous (most common) • Direct • Contiguity	• Pyogenic • Non-pyogenic

ACUTE OSTEOMYELITIS

Etiology

The etiological factors causing osteomyelitis can be best understood if discussed under the following heads (Fig. 26.1).

Agent Factors

The following myriad of incriminating organisms is responsible for its causation:

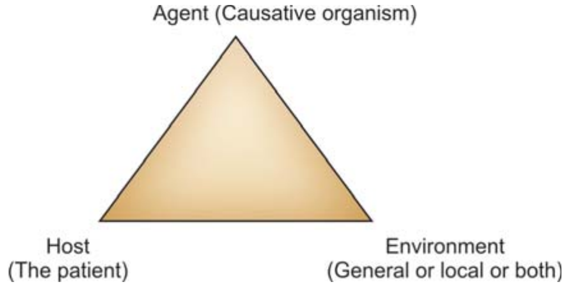


Fig. 26.1: Etiological factors causing osteomyelitis

- *S-series organisms* ('S' denotes severe osteomyelitis and those organisms causing it start with the letter "S")
  - — *Staphylococcus aureus (60-85%)*
    This is the most common organism causing acute osteomyelitis.
  - — *Streptococcus haemolyticus (8-10%)*
  - — *Salmonella* osteomyelitis is relatively rare and presents an interesting picture as most of its features start with "S".
    - i. Several bones involved
    - ii. Symmetrical involvement of bones
    - iii. Severe osteomyelitis
    - iv. Spine may be involved
    - v. Sickle cell anemia present
    - vi. Stool culture may be positive.
- *P-series organisms* (their mode of entry is through punctured wounds)
  - — Pseudomonas
  - — Pneumococcus.
- *C-series* ('C' denotes compound fractures)
  - — *Clostridium welchii*
  - — Coliforms *(E. coli).*

- *B-series*
  Brucella bacillus.
- *H-series*
  Haemophilus influenzae (7 months to 4 years). This is known to cause osteomyelitis in the age group of 7 months to 4 years.
- *T-series*
  — *Treponema pallidum* (Syphilitic osteomyelitis)
  — Tubercle bacillus (*Mycobacterium*)
- *Fungal osteomyelitis (ABC)*
  — Actinomycosis
  — Blastomycosis
  — Cryptococcosis and coccidiodomycosis

  These usually cause chronic osteomyelitis.

Host Factors

Age

In children the incidence is 88 percent (because more prone for injury and to fall).
In adults Twelve percent.
Hence, it is predominantly a disease of childhood.

Sex Male preponderance (? more playful).

Economic status Low socioeconomic groups are more susceptible.

Environmental Factors

General factors All the above mentioned general factors bring down the resistance of the patient thereby making them susceptible for infection.

Local factors are extremely important in localizing the infection to the metaphysis.

Hairpin bend of the metaphyseal vessels (Fig. 26.2) This slows down the circulation for a moment which is sufficient for the organisms to escape out.

Metaphyseal hemorrhage Results from the bleeding due to microscopic trauma. The blood clot so accumulated acts as an excellent culture media for the escaped organisms to grow.

Defective phagocytosis WBCs here are busy removing the debris of the decalcification due to growth process. So their function of eliminating the offending organism is slightly impaired.

Rapid growth at the metaphysis Makes the cells more susceptible to the action of bacterial toxins as the cells are immature.

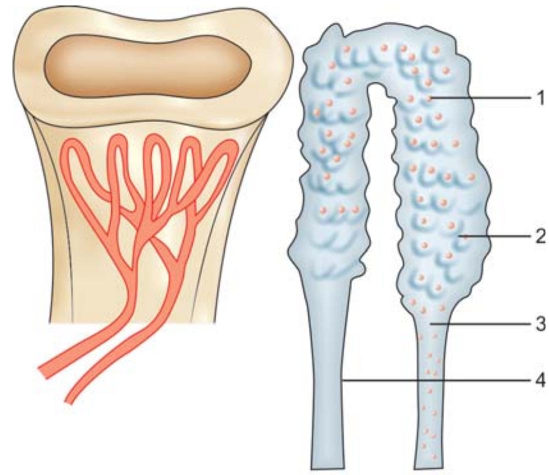


Fig. 26.2: Showing microanatomy of the hair pin bend vessels: (1) thrombosed vessel, (2) bacterial colonies, (3) artery, and (4) vein

Vasospasm Though protective as it arrests further bleeding from the traumatized vessels it also causes anoxia and failure of antibiotics and other defense cells from reaching the area.

Anoxia due to vasospasm it helps the bacteria grow.

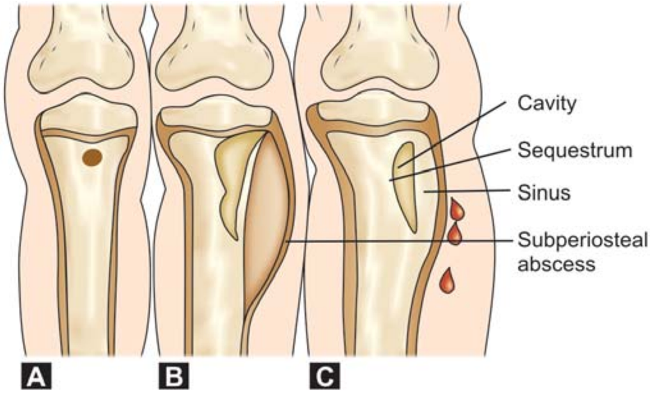
Thus, acute osteomyelitis develops as a result of the combination of agent, host and environment factors (Table 26.2).

TABLE 26.2: General and local risk factors in acute osteomyelitis

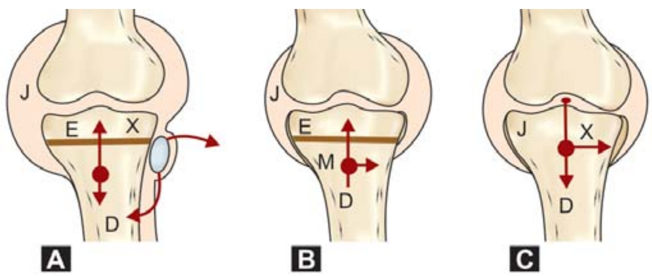
General factors	*Local factors*
• Anemia • Debility • Infection • Poor nutrition • Poor immune status	(Responsible for localization of infection at metaphysis especially in children) • Hair pin bend vessels • Metaphyseal hemorrhage • Defective phagocytosis • Rapid growth at metaphysis • Necrotic tissue acts as a culture media • Anoxia • Vasospasm

Pathophysiology

The infection results in the formation of abscess at the region of metaphysis. The pus so formed finds its way out through the *area of least resistance*. In children less than 2 years (Figs 26.3A to C), periosteum is loosely attached to the cortex and hence forms a potentially weak point. The sub-periosteal abscess so developed will either spread through the soft tissues or drain to the outside by forming a sinus breaking the skin or it will percolate down towards the diaphysis between the periosteum and the cortex and enter the shaft through the widened haversian pores due to anoxia. Spread to the joint is limited by the growth plate. Between 2 and 16 years periosteum is firmly attached to the cortex and with



Figs 26.3A to C: Showing pathological events in acute osteomyelitis in < years: (A) Beginning of the infection in the metaphysis, (B) Formation of a subperiosteal abscess, (C) Formation of a discharging sinus and sequestrum



Figs 26.4A to C: (A) Spread of pus from the metaphysis in children of less than 2 years. Subperiosteal (common), joint involvement rare but still joint can be involved in two ways: (i) If the capsule encloses the metaphyseal region, (ii) Through the common blood supply from the nutrient vessel which gives rise to metaphyseal and epiphyseal vessels; (B) Spread in children between 2-16 years. In this age group diaphyseal spread is common; and (C) Spread in patients > 16 years. In this age joint involvement may be direct because the growth plate has disappeared J—joint, E—epiphysis, M—metaphysis, D—diaphysis, and X—no spread

the growth plate still present the pus has to spread towards the diaphysis at a slow pace. Above 16 years the growth plate has disappeared, the periosteum is firmly adherent, and the pus spreads towards the diaphysis very slowly (Figs 26.4A to C, and 26.5 and Table 26.3).

Clinical Features

Acute osteomyelitis is a clinical catastrophe (Table 26.4). It presents in the following manner:

Fever This is the most common presenting symptom. The child usually has very high fever and is associated with profuse sweating, chills and rigors. Sometimes the presentation is so acute that the child may be in shock and unconscious.

TABLE 26.3: Spread in acute osteomyelitis

< 2 years (Fig. 26.3)	*2-16 years*	*> 16 years*
• Subperiosteal (common) • Diaphysis (rare) • Joint space (rare)	• Subperiosteal (rare) • Diaphysis (common but slow)	• Diaphysis (common but very slow) • Joint space involved • Extraperiosteal (rare)

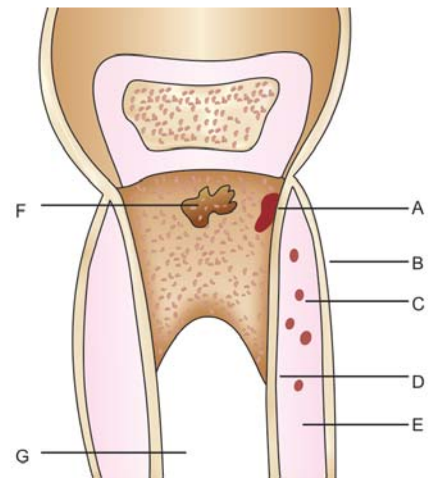


Fig. 26.5: Showing entire spectrum of pathological changes in osteomyelitis: (A) sequestrum, (B) periosteum, (C) pus, (D) cortex, (E) involucrum, (F) bone abscess, and (G) medullary cavity

TABLE 26.4: Clinical facts

	General	*Local*
Symptoms	• Fever (95%) • Sweating • Chills and rigors • Patient is usually in shock	• Local swelling (80%) • Limitation of movement (50%)
Signs	• Increased temperature • Increased pulse rate • Anemia (?) • Signs of dehydration and shock	• Tenderness (80%) • Local erythema (50%) • Raised temperature (50%) • Fluctuation present (20%) • Effusion (10%) • Decreased movements (50%)

Swelling This usually follows the fever and may affect the ends of long bones. The swelling may be acutely painful and the skin may appear red.

Limitation of movement The child may not move the joint near the affected bone due to pain and swelling. In fact, the child may lie still without moving the joint and this is sometimes called a state of pseudoparalysis.

Clinical Signs

General features of anemia, dehydration, pyrexia, pulse rate, shock and toxicity may be present.

Local features The local swelling may show increased temperature may be tender to touch, and the skin is stretched. Movements of the neighboring joints are decreased and there may be effusion in them too.

Management

Acute osteomyelitis is an orthopedic emergency which needs admission into a hospital. The management can be discussed as general and local.

General and physiotherapy management Conservative management is the main stay of treatment and consists of physiotherapy measures like rest, splint, elevation of the part, warm and moist packs to the affected part (Fig. 26.6).

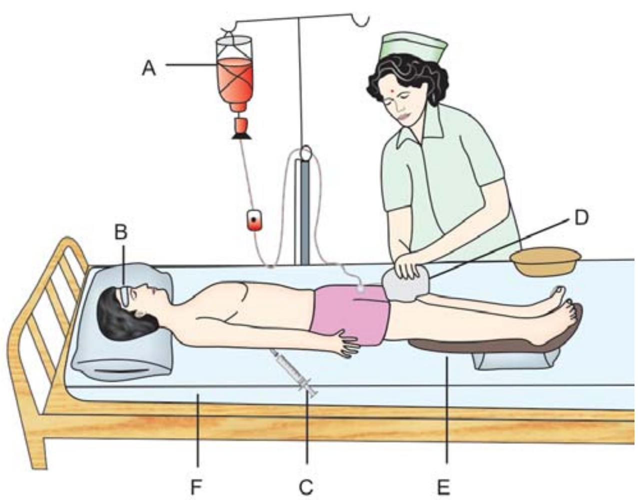


Fig. 26.6: Showing principles of treatment in acute osteomyelitis: (A) IV fluids and blood transfusion, (B) tepid sponging, (C) intravenous antibiotics, (D) cryotherapy, (E) splints and elevation of the affected part, (F) rest in bed and hospitalization

The mnemonic *RESTS* sums up the conservative line of treatment:

*R*est in bed; protect affected part with splints to alleviate pain and spasm.
*E*levation of the part, warm and moist packs to reduce the swelling.
*S*ystemic treatment Blood transfusions, intravenous fluids to correct shock and hypovolaemia.
*T*reatment With antibiotics discussed below helps to reduce toxicity.
*S*urgery Properly indicated and timed to prevent complications.

Principles of antibiotic therapy This is the main stay of treatment in acute osteomyelitis. Lack of understanding of the correct principles of antibiotic therapy in acute osteomyelitis leaves a sequel in the form of chronic osteomyelitis. This underlines the importance of correct antibiotic therapy (all **A's**).

A*ppropriate drug* Usually, the drug chosen is a broad-spectrum bactericidal agent.

A*ppropriate route* Intravenous for the first 2 weeks and oral for the next 4 weeks.

A*ppropriate dose* of the drug depending on the body weight of the patient.

A*ppropriate time to stop* When the disease is eradicated, controlled or resistance or side effects to the drugs develops.

A*ppropriate adjunctive measures* A combination of ampicillin and cloxacillin are found to be very effective though penicillin G is still the drug of first choice in our country. Fusidic acid is preferred in the western countries.

Current trends in antibiotic therapy This consists of a short course of intravenous antibiotics for a period of 2 weeks. Followed by oral antibiotics for further 4 weeks. Proper monitoring of the serum antibiotic level is very much essential to obtain good results.

Local management The focus here is on well-timed surgery if any one of the following indications is present.

Nade's indications for surgery:
- Abscess formation.
- Severely ill and moribund child.
- Failure to respond to intravenous antibiotics for more than 48 hrs.

Surgical Methods

Depending upon the situation any one of the following surgical methods could be employed:
- *Aspiration* It helps in decompression and the material so obtained may be used to identify the organism and also check for antibiotic sensitivity.
- *Incision and drainage* Helps to drain the subcutaneous abscess.
- *Multiple drill holes* If the abscess is subperiosteal this technique helps to drain the pus by making multiple holes in the cortex.

- *Small bone window* If the multiple drill holes do not drain the pus, a small window of bone is removed from the cortex and the pus is evacuated.

Characteristic points in acute osteomyelitis

- Disease is common in children.
- *Staphylococcus aureus* is the common organism.
- Metaphysis is involved.
- Fever is the common presenting symptom.
- Bone scan helps in early diagnosis.
- Conservative management is the main stay of treatment. And ninety percent resolve.

Note Acute osteomyelitis in epiphysis is taken to be caused by *Staphylococcus aureus* unless proved otherwise.

CHRONIC OSTEOMYELITIS

Any osteomyelitis lasting for more than three weeks is termed as chronic. Chronic osteomyelitis can arise from any one of the following ways:

- Sequel of acute osteomyelitis (5-10%)
- Following compound fractures
- Following surgery on bones and joints
- Chronic from the beginning (e.g. tuberculosis, syphilis, Brodie's abscess)
- Anaerobic organisms (sclerosing osteomyelitis of Garre)
- Fungal osteomyelitis.

Quick Facts

Salient features in chronic osteomyelitis

- Systemic symptoms would have disappeared.
- One or more foci in the bone containing pus, sequestra or draining sinuses, etc.
- Acute exacerbation is due to trauma, lowered resistance, etc.

Clinical Features

Symptoms are very few. Fever, pain, swelling are seen in acute exacerbation of chronic osteomyelitis.

Signs (Fig. 26.7)
Irregular thickening of bone develops due to unequal pace of destruction of bone and new bone formation. This is a characteristic feature of chronic osteomyelitis.

Sinuses are usually multiple and are fixed to the underlying bone. The presence of sinuses indicates unabsorbed sequestra, unobliterated cavities and presence of anaerobic organisms. They are immobile and adherent to the bone.

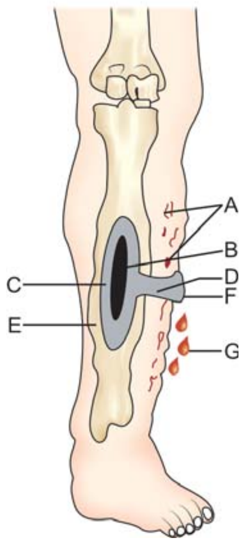


Fig. 26.7: Showing features in chronic osteomyelitis: (A) Multiple scars and sinuses, (B) sequestrum, (C) cavity, (D) sinus tract, (E) Irregular thickening of bone, (F) Sprouting granulation tissue, (G) discharge of bony spicules and pus

Note History of discharge of tiny bony spicules through the sinus, clinches the diagnosis of chronic osteomyelitis with certainty.

Scars and muscle contractures develop due to the spread of infection from the bones to the muscles and the consequent fibrosis (Fig. 26.8A).

Shortening or lengthening of the bones may occur due to the affection or stimulation of the growing epiphysis respectively.

Deformities and decreased movements develop due to scars and contractures.

Investigations

- Plain X-ray shows sclerosis, cavity, sequestra, pathological fracture, etc. (Fig. 26.8B)
- Laboratory include Hb%, TC, DC, ESR, CRP, pus for culture and sensitivity, sinogram, etc.

Figs 26.8A and B: Clinical photograph and plain x-ray of chronic osteomyelitis of radius and ulna

Pathological fractures may occur either due to chronic osteomyelitis which weakens the bone or due to extensive debridement during surgery which leaves a thin layer of bone.

Note
Sequestra It is a dead bone within a living bone and is defined as an infected granulation tissue. The inflammatory foci are surrounded by sclerotic bone supplied with blood and covered by periosteum, scarred muscle and subcutaneous tissues.

Quick Facts

Sequestra		
Disease		Type of sequestra
TB osteomyelitis	→	Sandy/feathery
Actinomycosis	→	Black
Pin tract infection	→	Ring
Chronic osteomyelitis in children	→	Diaphyseal

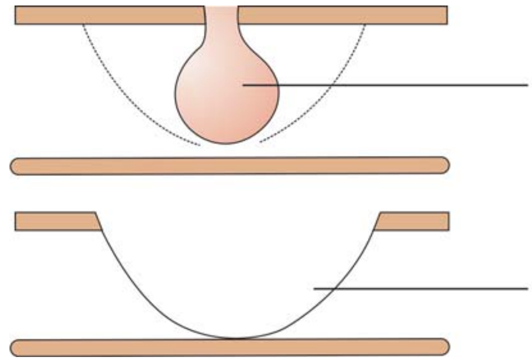


Fig. 26.9A: Sequestrectomy and saucerization

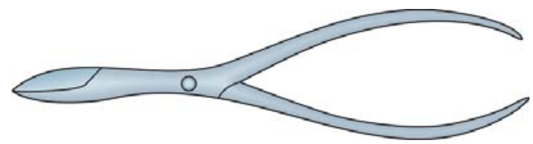


Fig. 26.9B: Sequestrum forceps (19 cm) straight/angular

Management of Chronic Osteomyelitis

Goal Eradication of the infection by achieving a viable and vascular environment. This can be done by radical debridement by way of sequestrectomy and resection of scarred and infected bone and soft tissue. Appropriate antibiotic is also required. Finally reconstruction of both the bone and soft tissue defects may be needed.

Principles of treatment As is evident from the goal, surgery is the treatment of choice.

- *Surgery* is to be undertaken only when fever and infection has subsided, living bone can be distinguished from the dead bone and when involucrum appears sufficient to maintain length and contour of the bone after excision of any large sequestra.
- *Secondary infection* is almost always present. When surgery is indicated culture is done and antibiotics started at least 4 days before surgery and is continued for 2 weeks.
- When acute exacerbation fails to respond to conservative treatment, incision and drainage have to be done.

Surgery Methods

Sequestrectomy and saucerization (Figs 26.9A and B) Sequestrum is identified on the X-ray as it is denser and lies free in the cavity. It takes 2 to 3 months before it is isolated, separated and easily seen on the X-ray and only then sequestrectomy is planned. All the sinus tracts are injected with methylene blue 24 hours before surgery. By making multiple drill holes the cortex is removed in a rectangular fashion. Sequestrectmy is done next. The cavity is curetted till fresh bleeding occurs and the deep shape of the cavity is converted into a shallow cavity.

Note Sequestrectomy usually leaves a deep cavity beneath which are potentially a dead space favoring collection of pus and other debris. To prevent this from happening the deep cavity is made shallow for effective drainage of the collected materials.

After sequestrectomy there is a huge gap in the bone and there are four basic methods of immediate biological management of dead space so left:

- Local closure if the space left is very small.
- Myoplasty for slightly larger space, surrounding muscles can be packed into the cavity.
- Cancellous bone grafts for a space less than 2.5 cm.
- Free vascularised bone graft for larger areas.

Residual Osteomyelitis

In residual osteomyelitis there is complete absence of signs and symptoms. There are no draining sinuses. There is soft tissue scarring, skin is fixed to the bone and the underlying bone is sclerotic.

TUBERCULAR OSTEOMYELITIS

This is discussed in Chapter 27 on **Tuberculosis of Bones and Joints.**

Physiotherapy Measures in Osteomyelitis

During Acute Osteomyelitis

The following measures are suggested:
- Proper splinting of the affected joints in functional positions.
- Limb elevation to control edema
- Cryotherapy by ice packs or ice water packs in the initial stages followed by thermotherapy in the later stages. These measures help to reduce the pain and spasm.
- The unaffected joints are put through active vigorous exercises.
- After complete cessation of pain, mild isometrics exercises are prescribed for the affected joints.
- Routine physiotherapy measures to mobilize the joints and strengthen the muscles like active, active assisted, passive and resistive exercises are commenced after the active disease is completely arrested.
- Ambulation and weight transfers are slowly commenced initially with the help of assistive devices.

Measures for Chronic Osteomyelitis

Here the disease has run its course and left back various sequel like limb length discrepancies, deformities, scarring, etc. Efforts are made to combat these problems.
- Limb length discrepancies—Corrected by shoe raise and other methods.
- Deformities—corrected by various orthotic devices in the initial stages. In the later stages surgical measures like soft tissue release, corrective osteotomies and Ilizarov corrections are done.
- For scars, contractures, etc. Sustained passive stretching of the scarred and contracted tissues.
- Assistive devices are used for ambulation, weight transfers, etc.
- Deep ultrasonic massage for adherent scars.
- Strengthening isometric and isokinetic exercises for the muscles.
- Range of motion exercises like active and passive ones for the affected and unaffected joints.

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Chapter 27

Skeletal Tuberculosis

HISTORY

- Hippocrates [460 BC-370 BC] was the first to suggest the relationship between pulmonary disease and spinal deformity.
- Percival Pott [1714-1788] described the "gibbus" deformity and its sequelae. He did not describe the disease or its tuberculous nature.
- Laennec [1781-1826] described the basic microscopic lesion, the tubercle.
- Drugs Streptomycin was first used in 1947, PAS in 1949 and INH in 1952.

Skeletal tuberculosis is always secondary, the primary foci being either in the lungs, lymph nodes or gastrointestinal tract. The incidence of bone and joint tuberculosis is 2 to 3 percent. Fifty percent of these cases are found in the vertebral column. The other major areas affected in order of predilection are hip, knee, foot, elbow, hand, shoulder, and others.

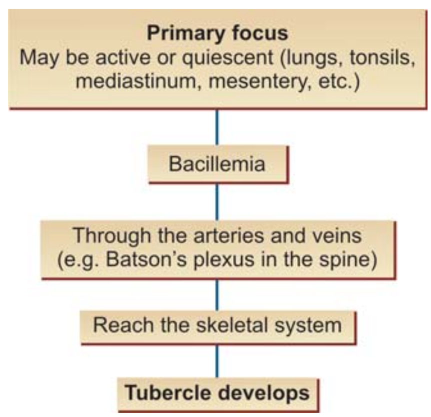
Skeletal tuberculosis occurs mostly in the first three decades of life but no age is immune.

Etiology

- TB bacillus
  - — Human (more common)
  - — Bovine (rare)
- Route always secondary, may spread to the bone through:
  - — Blood, e.g. through Batson's plexus in tuberculosis of spine
  - — Lymphatic spread
  - — Direct
- Precipitating factors
  - — General factors like anemia, debility, etc. help precipitate the infection.
  - — Local factors like trauma, etc. localize the problem to the bone.
- Local trauma causes vascular stasis and intraosseus hemorrhage.

Flow chart 27.1 shows the development of osteoarticular tubercular lesion.

Flow chart 27.1: Shows the development of tubercle



Clinical Features

Clinical features shows insidious, single joint lesion and presence of adjunct of constitutional symptoms and these are best summed up by the diagnostic triad (Fig. 27.1).

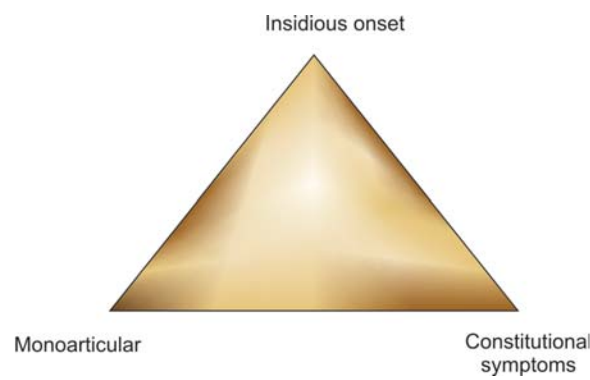


Fig. 27.1: Diagnostic triad of skeletal tuberculosis

Monoarticular The patient usually complains of pain in one joint which is dull aching and chronic in nature. He or she may give history of night cries which is due to the rubbing of inflamed articular surfaces against each other due to the release of muscular spasm at rest. The joint movements are decreased in all directions, initially due to muscle spasm and later due to arthritis. The wasting of the limb muscles is gross and is out of proportion. Regional lymph nodes may be enlarged.

Constitutional symptoms This is present in approximately 20 percent of the cases. It consists of low-grade fever, lassitude in the afternoon, loss of appetite and weight, night sweats, anemia, tachycardia and evening rise of temperature.

Principles of Treatment

- *General treatment* This includes rich protein diet, haematinics, adequate exposure to sunshine, etc. The general treatment aims at building up the general resistance of the patient.
- *Chemotherapy* is the mainstay of treatment. INH, streptomycin, rifampicin, ethambutol and pyrazinamide are some of the commonly used drugs in the treatment of tuberculosis. These drugs are used as a 6 months, 9 months, 12 months or 18 months regime in combinations depending upon the severity at the disease.
- *Local treatment* Aims to prevent, correct, or decrease the deformities. If the disease is osseous, aim at ankylosis in functional position by immobilization. If the disease is synovial aim at mobility by traction.
- *Operative treatment* Consists of partial capsulectomy, synovectomy, osteotomy, curettage, arthrodesis, etc. depending on the stage of tuberculosis.
- *Treatment of tubercular abscess* Conservative treatment is recommended in most of the cases. Aspiration is done if the abscess is tense.

Quick Facts

Skeletal tuberculosis (general)

- Incidence is 2 to 3 percent
- Usually monoarticular
- Always secondary
- Spine is affected commonly
- Only 20 percent show constitutional symptoms
- Cold abscess is a feature
- Chemotherapy is the mainstay of treatment

TUBERCULOSIS OF SPINE
(Known after Sir Percival Pott)

This is the most common form of skeletal tuberculosis constituting about 50 percent of all cases.

As is evident from the Table 27.1, spinal tuberculosis commonly affects the lower thoracic and lumbar vertebra accounting for nearly 80 percent of the cases.

Within the spine, in 98% of the cases the intervertebral space is involved. Due to various vertebral reactions, a tubercle is formed here. The tubercle later gives rise to the formation of a cold abscess which tracks down along lines of least resistance to reach various sites of the body as cold abscess.

TABLE 27.1: Regional distribution of TB spine

Region	*Percentage*
• Cervical	12 percent
• Cervicodorsal	5 percent
• Dorsal	42 percent
• Dorsolumbar	12 percent
• Lumbar	26 percent
• Lumbosacral	3 percent

Clinical Features

Tuberculosis of spine is usually insidious in onset although sometimes it may present acutely. The constitutional symptoms almost always antedate local spinal involvement. Weakness, anorexia, night sweats and cries, evening or afternoon rise of temperature, loss of appetite and weight are some of those.

Patient may complain of back pain which is localized over the site of vertebral involvement or is referred depending on the specific nerve root irritation. Thus, if cervical roots are involved pain radiates to the arm, if dorsal roots are involved patient complains of girdle pain, if lumbar nerve roots are involved patient complains of radiating pain to the groin, and if sacral roots are involved patient complains of sciatica.

Back stiffness is another common earliest complaint given by the patient. Patient is unable to bend and pick up the objects on the ground. Patient may give history of night cries. If the patient complains of stiffness, weakness, awkwardness of lower extremities, it heralds the onset of paraplegia.

Physical Findings

The patient has a very protective attitude and has a very cautious and careful gait. The muscle spasm straightens out the spine. The spinous process of the involved vertebra is tender to percuss and when an attempt is made to rotate the

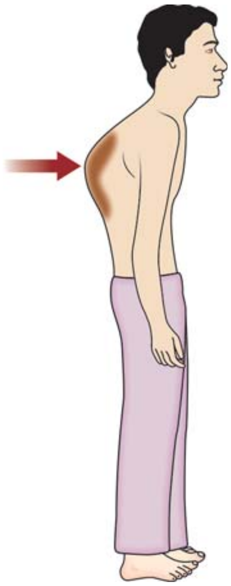


Fig. 27.2: Kyphotic deformity in tuberculosis of spine

vertebra, back movements are decreased in all directions especially forward flexion. There is pronounced wasting of the back muscles. The clinical attitude of the patient varies according to the region involved (Table 27.2). Cold abscess may be seen as Para vertebral swelling or in areas already described. Patient may develop or present with neurological complications like spastic or flaccid paraplegia. Of the various deformities (Fig. 27.2) of spine due to tuberculosis, kyphotic deformity is the most common and is seen in over 95 percent of the cases (Fig. 27.3).

General examination reveals signs of anemia, debility, involvement of lungs, lymph nodes, etc.

Quick Facts

Spine irregularities in skeletal TB

- Kyphosis (95%)
- Scoliosis (5%)
- Lordosis
- Boarding
- Paravertebral thickening

Other features

- Muscle spasm
- Wasting of all spinal muscles
- Spastic or flaccid paraplegia (20%)
- Cold abscess (20%)
- Sinuses (13%)
- Complications of skeletal TB

TABLE 27.2: Typical attitudes in skeletal TB

Theory of spine		*Attitudes*
• Upper cervical	→	Wry neck
• Lower cervical	→	Military position
• Lower thoracic	→	Alderman's gait
• Upper lumbar	→	Prominent abdomen
• Lower lumbar	→	Increased lordosis

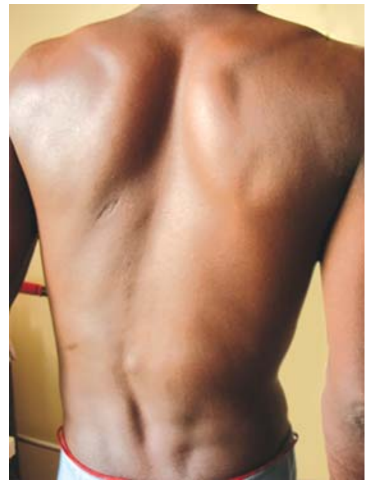
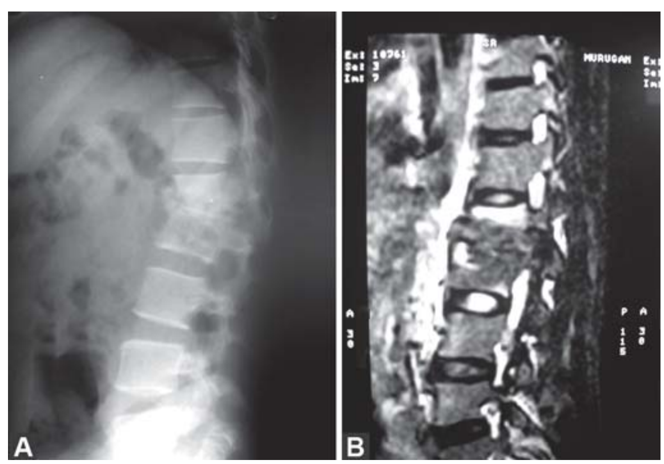


Fig. 27.3: Clinical photograph showing the knuckle gibbus in TB spine

Investigations

This consists of the mandatory laboratory tests which show raised ESR and anemia, X-rays of the spine which show osteoporosis, loss of intervertebral space, Paravertebral shadows, etc. MRI and CT scan are the other important diagnostic tools (Figs 27.4A and B).



Figs 27.4A and B: Plain X-ray (A) and MRI (B) of the spine showing the features in TB spine

Treatment

Definitive diagnosis by biopsy and culture is a must before starting the treatment, because of the toxicity of the chemotherapeutic regime and length of the treatment required.

Nonoperative and operative methods evaluated by the Medical Research Council working party are as follows:
- Radical surgery performed under chemotherapeutic coverage gives better results with regard to deformity correction, development of paralysis and resolution.
- Chemotherapy with long-term bed-rest with or without cast is ineffective.
- When facilities for radical surgery are not available ambulatory chemotherapy is the treatment of choice. Chemotherapy controls 90 percent of tuberculosis spine.

Physiotherapy Measures in Conservative Management TB Spine

Earlier Stages

- Maintenance of proper posture.
- Active exercises to the neck upper and lower limbs.
- Chest physiotherapy to improve the vital capacity of the lungs.
- Measures to prevent bedsores.

Later Stages

- Isometric exercises to the spinal flexors, extensors and rotators.
- Costal, diaphragmatic and apical breathing exercises.
- Spinal exercises in extension, later on to hyperextension, and progressed to flexion and rotation exercises are begun.
- Ambulation permitted with a spinal brace.

Surgery in TB Spine

Indications for Surgery

- Neurological symptoms.
- Kyphosis with several vertebral involvement, severe kyphosis, progressive kyphosis, etc.
- Resistance to chemotherapy.
- Recurrence of disease.
- Cord compression.
- Progressive impairment of pulmonary function.
- Spinal instability.

Surgical procedures The following surgical procedures are described.

Aspiration This technique is useful to aspirate the contents of a cold abscess through a thick bored needle. The needle should be inserted below the abscess so as to enable the gravity to help drain the contents.

Minimal debridement This consists of evaluating the cold abscess through costotransversectomy or decompression. Here the contents are evacuated, the walls thoroughly curetted and bone grafting is done if necessary. Recently, evacuation and debridement of a thoracic cold abscess through a thoracoscope has been successfully tried.

Radical debridement This is done through the anterior approach and is invariably followed by spinal fusion with a strut graft involving rib or fibula after a thorough debridement. This procedure has to be done before abscess or neurological complications develop. Fusion could be anterior or posterior but in the former normal anterior compressive forces are brought into play resulting in a high rate of successful bony fusion. Progression of disease and pseudarthrosis are common in posterior fusion. The only indication for posterior fusion is to add support for the disease at cervicothoracic or dorsolumbar regions.

Objectives of surgery Surgery helps to excise the infected tissue, decompress the intraspinal neural elements, reduce the spinal instability and provide stability by spine fusion techniques.

Complications of Tuberculosis Spine

- Paraplegia
- Cold abscess
- Sinuses
- Secondary infection
- Amyloid disease
- Fatality

Middle Path Regime in TB

Tuli and Kumar advocated triple drug therapy without surgery. In their series operative treatment was reserved for patients
- Not responding favorably to drug therapy after 6 months of treatment.
- Recrudescence of the disease.
- Patient with neural complications.

Operative treatment is combined with six to twelve months of bed rest, followed by eighteen to twenty-four months of spinal bracing.

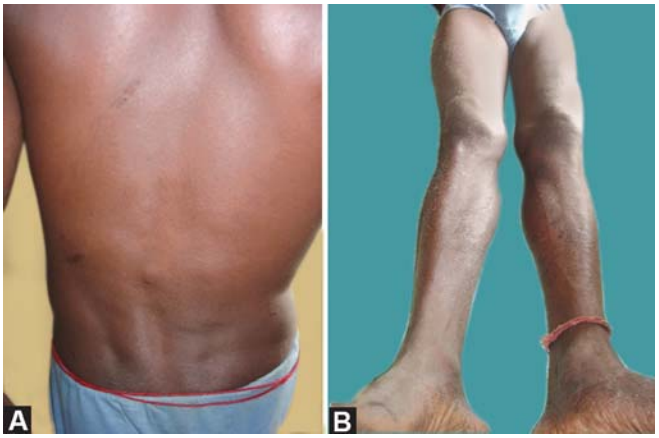
Physiotherapy Measures in Surgical Management

Preoperative Phase
- Chest physiotherapy.
- Proper postural habits.
- Mobility and back strengthening exercises.
- Techniques of sitting, standing, walking, etc. are taught.
- Education regarding proper back ergonomics.

Postoperative Phase
- Measures to prevent bedsores.
- Chest physiotherapy.
- Measures to prevent deep vein thrombosis.
- Simple resistive exercises to the neck, upper and lower limbs are started.
- Patient is gradually mobilized with a spinal corset.
- Log rolling, standing and walking is encouraged.
- Strengthening exercises to the back muscles and the abdominal muscles are gradually initiated.
- Back ergonomics is strictly taught.
- Spinal corset is gradually weaned off.

TB SPINE WITH PARAPLEGIA

The incidence of this complication is 10 to 30 percent and it is most often associated with tuberculosis of the dorsal spine (Figs 27.5A and B).



Figs 27.5A and B: Clinical photographs showing TB spine and paraplegia

Classification

Seddon's Classification

- Early onset paraplegia is associated with the active disease. It is seen within two years of onset of the disease.
- Late onset paraplegia is associated with healed disease. It is seen after two years after the onset of disease.

Clinical Features

Rarely paraplegia may be the presenting symptom (Figs 27.5A and B). Late onset paraplegia may be associated with clumsiness, twitching, increased reflexes, clonus, positive Babinski sign, etc. Motor functions are usually affected first. The paralysis usually follows the following stages in order of severity–muscle weakness, spasticity, in coordination, paraplegia in extension, flexor spasms, paraplegia in flexion (severe form), and flaccid paraplegia lastly.

Treatment of Pott's Paraplegia

The following measures are adopted in the treatment of Pott's paraplegia.

Conservative treatment Chemotherapy is the mainstay of this method and has already been described.

Physiotherapy and occupational therapy Helps in the treatment of the paralyzed lower limbs. Immobilization of the spine to provide rest and thereby promote healing is done by traction (in cervical region) plaster cast or brace (in dorsal region), etc. Management of bedsores, bladder and bowel management is done as already discussed in the management of spinal injury. This is the same as discussed in traumatic paraplegia.

Surgical treatment The incidence of surgery has considerably decreased as chemotherapy is found to be successful in treating Pott's paraplegia. Only 5 percent of the cases require surgery in uncomplicated cases and 60 percent of the cases with neurological deficits require surgery.

Main indications for surgery
- Failed conservative treatment: If the patient does not respond to conservative treatment even after 3 to 6 months.
- In doubtful diagnosis.
- Fusion for mechanical instability by some grafts, implants, etc. either by the anterior or posterior approach.
- Recurrence of the disease after treatment.
- In rapid onset paraplegia.
- In disease secondary to cervical disease and cauda equina paralysis.

Other indications
- Recurrent paraplegia.
- Painful paraplegia-due to root compression, etc.
- Posterior spinal disease-involving the posterior elements of the vertebra.
- Spinal tumor syndrome resulting in cord compression.
- Rapid onset paraplegia due to thrombosis, trauma, etc.
- Severe paraplegia.
- Secondary to cervical disease and cauda equina paralysis.

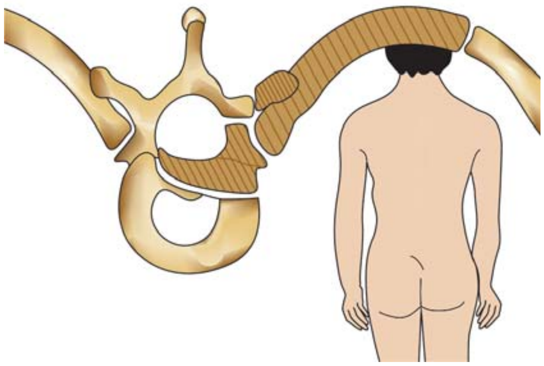


Fig. 27.6: Structures removed in costotransversectomy

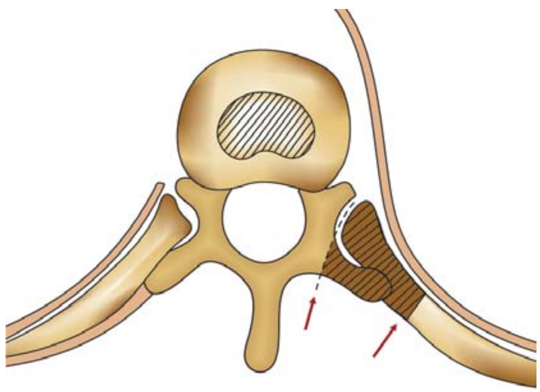


Fig. 27.7: Structures removed in ALD

Surgical Techniques

Costotransversectomy This is indicated for a tense Para vertebral abscess. As the name suggests excision of the transverse process of the affected vertebra and about an inch of the adjacent rib to facilitate the drainage of abscess is done (Fig. 27.6). If pus is yielded under pressure one has to wait up to six weeks for improvement. If no improvement occurs anterolateral decompression is done.

Anterolateral decompression (ALD) The structures removed in this procedure is posterior part of the rib, transverse process, pedicle and part of the vertebral body anterior to the cord (Fig. 27.7). This is the surgery of choice for Pott's paraplegia. It helps to effectively remove the solid and liquid debris. ALD is done through an extra pleural mediastinal approach (Fig. 27.8). Bone graft may be inserted if needed.

Anterior decompression This is technically more demanding. Here the affected vertebra is approached through a transpleural or transperitoneal route, diseased tissue is curetted and a bone graft is inserted.

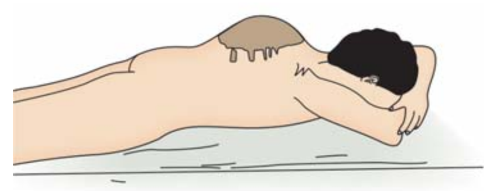


Fig. 27.8: Approach for ALD and costotransversectomy

Laminectomy In Pott's paraplegia, anterior part of the cord is predominantly affected and laminectomy does not decompress this part of the cord. Moreover it makes the spine unstable as it removes the healthy areas of the vertebrae. Hence this procedure is not commonly recommended.

If arthrodesis of the spine is required after the above procedures, anterior arthrodesis is normally preferred. Posterior spinal arthrodesis has limited value and is usually done to stabilize the craniovertebral region. Paralysis secondary to cervical disease is treated by either laminectomy and posterior arthrodesis or radical debridement and anterior arthrodesis. Severe cauda equina paralysis requires lumbar transversectomy.

Physiotherapy Measures after Surgery in Pott's Paraplegia

This is the same as mentioned in page 225.

TUBERCULOSIS OF THE HIP JOINT

Tuberculosis of hip joint is ranked next to spinal tuberculosis (10:7) and it constitutes 15 percent of all osteoarticular tuberculosis. It is always secondary. The initial focus of infection could be either in the: (i) Acetabular roof, (ii) Epiphysis, (iii) Metaphyseal region, (iv) Greater trochanter, (v) Synovial membrane (rare), and (vi) Trochanteric bursae (Fig. 27.9).

Stages

TB hip runs through three stages—stage of synovitis, stage of early arthritis and stage of advanced arthritis.

Clinical Features

Tuberculosis of hip is common in the first three decades of life. Patient usually presents with painful limp and is the most common earliest symptom. He or she has an antalgic gait with a short stance phase. Pain is maximum towards the end of the day and there is a history of night cries. There is marked wasting of the thigh and gluteal muscles. There may be presence of scars and sinuses. About 8 percent of the patients may develop cold abscess in the regions shown in the figure above and 10 percent may show pathological subluxation. Tenderness can be elicited by direct pressure in the femoral triangle or by bitrochanteric compression.

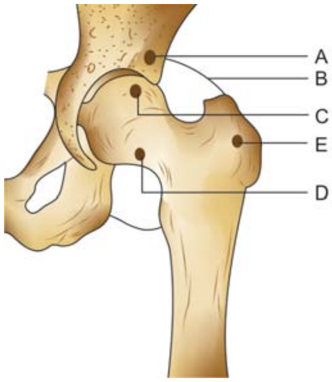


Fig. 27.9: Sites of common tubercular infection of the hip, A-acetabular roof, B-synovium, C-epiphysis, D-metaphysis, and E-greater trochanter

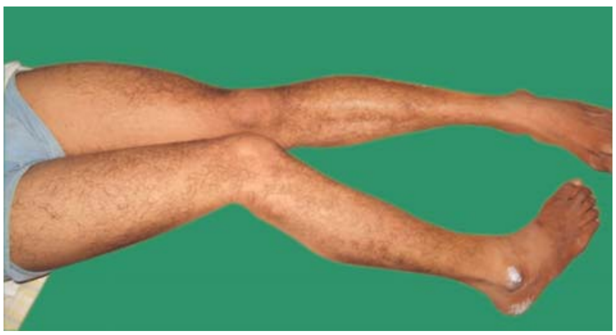


Fig. 27.10: Clinical photograph of flexed flexion deformity in TB hip

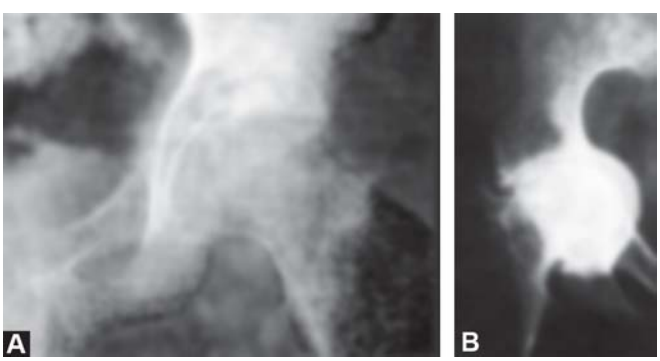
The affected hip then assumes a position of flexion and the degree of FFD is calculated by the angle formed between the thigh and the bed (Fig. 27.10).

Radiograph

Plain X-ray of the hip shows marked osteoporosis around the hip joint in early stages and gross destruction in the later stages (Figs 27.11A and B).

Treatment

This consists of conservative and surgical treatment. Whatever may be the method of treatment, chemotherapy is the mainstay. Flow chart 27.2 depicts the broad principles of treatment in TB hip.



Figs 27.11A and B: Plain X-ray of hip showing (A) Early stage of TB hip and (B) Protrusio in advanced arthritis

Flow chart 27.2: Showing treatment plan in TB hip, early stages (TB hip)

SYNOVITIS AND EARLY ARTHRITIS
Triple drug therapy and traction

Favourable clinical response

Continue same treatment

Hip mobilization

Ambulation after 4 to 6 months

Non-weight bearing first 12 weeks

Partial weight bearing for next 12 weeks

Discard crutches after unprotected weight bearing after 18 to 24 months

ADVANCED ARTHRITIS (Treatment Plan)
(Articular cartilage involved)

- Traction
- Chemotherapy

Once gross ankylosis is accepted

If in proper position → POP cast for 6 to 9 months → Partial weight-bearing after 6 months calipers ad crutches for nearly 2 years

If in bad position → Corrective osteotomy and/ or arthrodesis → Partial weight-bearing after 6 months calipers and crutches for nearly 2 years

Conservative treatment This is indicated in the stage of synovitis and early arthritis and consists of chemotherapy, bed rest, traction, physiotherapy, etc.

Surgical Treatment in Tuberculosis of Hip

Synovectomy and arthrotomy This is done in synovitis stage when the disease is not responding favorably to conservative treatment. Partial synovectomy and joint drainage and lavage are done.

Synovectomy and joint debridement This is preferred in early arthritis. The joint is exposed through the posterior approach, thorough debridement of the joint is done by evacuation and the walls are curetted and washed.

Osteotomy This is an upper femoral corrective osteotomy and is indicated in sound ankylosis in bad position in flexion adduction contractures. This helps to correct the deformity and change the line of weight-bearing.

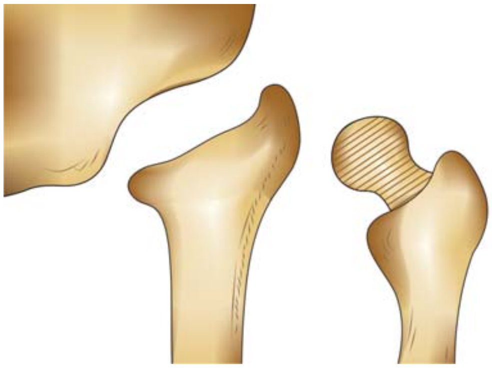


Fig. 27.12: Showing structures removed in Girdle stone arthroplasty

Displacement osteotomy is done in fibrous ankylosis with gross deformity.

Arthrodesis This is indicated in adults with painful fibrous ankylosis with active or healed disease. This procedure converts a painful hip to painless stable hip. The procedure could either be intra-articular or extra-articular or both.

Arthroplasty Stiff hip is a gross disability and is particularly not acceptable by Indian patients because they cannot use the Indian toilet. Here girdle stone excision arthroplasty (Fig. 27.12) is preferred and it can be done in active or healed disease after the growth stops. This gives a mobile painless hip joint apart from controlling the infection and correcting the deformity. However it leaves the hip unstable.

Total hip replacement is rarely done in tuberculosis hip. It is suggested after 10 years after the last evidence of active infection.

Amniotic arthroplasty has been tried in tuberculosis hip. But the results are far from satisfactory.

Physiotherapy Measures in TB Hip

During the conservative treatment and in the earlier stages the limbs are kept in functional position by using splints, skin traction etc. Cold therapy in the acute stages and thermotherapy in the later stages helps to overcome stiffness, pain etc. Physiotherapy measures after surgical procedures like osteotomy, THR, excision arthroplasty and arthrodesis have been discussed in relevant earlier sections.

Treatment facts: Tuberculosis hip

- Chemotherapy.
- Traction-Skin or Thomas splint immobilization.
- If disease is synovial, aim at mobility.
- If articular cartilage is involved, aim at arthrodesis in functional position.

TUBERCULOSIS OF KNEE

This is the third common site for skeletal tuberculosis. Incidence is 10 percent. It is also always secondary and may start in any one of the following sites in the knee joint.

Remember

Five classical deformities in TB knee

- Flexion
- Posterior subluxation
- Lateral subluxation
- Lateral rotation
- Abduction of tibia

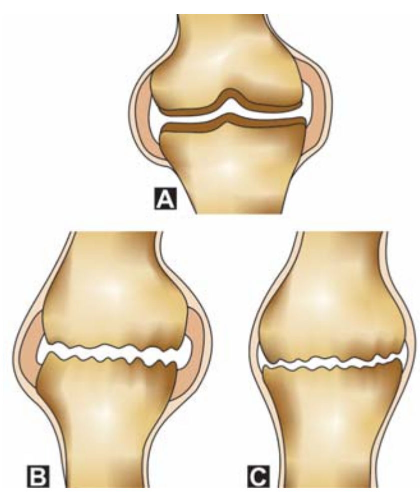
The above deformities are due to spasm and contractures of the hamstring muscles.

Stages

This is the same as TB hip (Figs 27.13A to C).

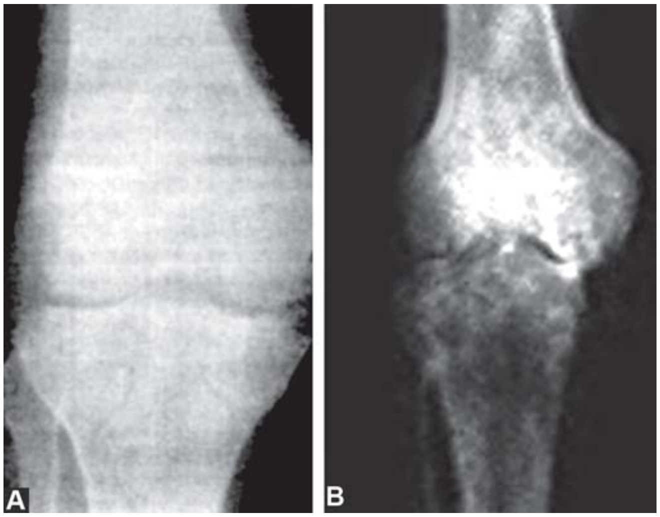
Clinical Features

The disease is insidious in onset, showing systemic and local features of tuberculosis. The joint shows effusion and evidence of synovial hypertrophy. The swelling is white in color. There is tenderness along the joint line and synovial reflections. During the synovial stage the movements are reduced and painful. In the arthritis stage; the joint movements are grossly restricted with painful spasm. There is gross quadriceps atrophy and lymphadenopathy. In the growing child, transient limb lengthening may be seen due to juxta-epiphyseal hyperemia. Triple deformity is the hallmark of TB knee and consists of flexion, posterior displacement and lateral rotation (Fig. 27.14).



Figs 27.13A to C: Stages of TB knee: (A) Synovitis, (B) Early arthritis, and (C) Advanced arthritis and fibrous ankylosis

Fig. 27.14: Clinical photograph showing TB of knee



Figs 27.15A and B: (A) X-ray showing changes in tuberculosis of the knee joint (B) Plain X-ray showing osteoporosis and joint destruction in TB knee

Radiograph

Plain X-ray of the knee shows marked osteoporosis around the knee joint in early stages and gross destruction in the later stages (Figs 27.15A and B).

Treatment

Nonoperative treatment This is indicated in children and in the stage of synovitis. It consists of chemotherapy, traction, and joint aspiration.

Surgical treatment

- In the synovial stage if the disease is not responding favorably, arthrotomy and partial synovectomy are done.
- In the stage of early arthritis synovectomy, joint debridement and curettage of the juxta-articular foci are carried out.
- In advanced arthritis, arthrodesis is the treatment of choice and the indications being, advanced tuberculosis, triple deformity, gross instability and painful ankylosis after earlier synovectomy.

Supracondylar osteotomy is preferred in varus or valgus deformity. Arthroplasty is also being tried without much success.

Role of supracondylar osteotomy This is indicated in the following situations, where the disease has healed with painless range of movements in an unacceptable position and in valgus or varus deformity.

Physiotherapy Measures in TB knee

During the conservative treatment and in the earlier stages the limbs are kept in functional position by using splints, skin traction, etc. Skin traction helps to prevent triple deformity, corrects the deformities and helps to keep the joint surfaces distracted. Cold therapy in the acute stages and thermotherapy in the later stages helps to overcome stiffness, pain, etc.

TUBERCULOSIS OF SHOULDER

This is quite uncommon and accounts for only 2 percent of the cases. It is more common in adults. Incidence of concomitant pulmonary tuberculosis is high. The tuberculosis of the shoulder could start in any one of the following sites:

- Synovium
- Glenoid
- Head of humerus.

Clinical Features

Tuberculosis of the shoulder rarely presents at the stage of synovitis (Fig. 27.16). Abduction and external rotation movements of the shoulder are grossly decreased. There is wasting of the deltoid and supraspinatus muscles. Common

Fig. 27.16: Clinical photograph of TB shoulder

variety is dry type and is called as caries sicca since there is no effusion into the joint.

Cold abscess formed could present at:

- Supraspinous fossa
- Deltoid
- Biceps.

Late stages In the late stages destruction of the upper end of humerus and glenoid cavity are seen. Fibrous ankylosis is the end result.

Radiograph

Plain X-ray of the shoulder shows marked osteoporosis around the shoulder in early stages and gross destruction in the later stages (Fig. 27.17).

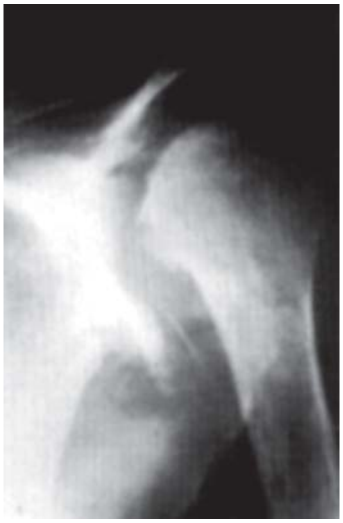


Fig. 27.17: Plain X-ray of TB of shoulder showing osteoporotic changes

Treatment

Treatment is essentially as in other forms of tuberculosis. Chemotherapy is the mainstay of treatment. The shoulder is immobilized in 'Saluting position' (70 to 90° in abduction and 30° in flexion) to encourage ankylosis in functional position. The shoulder is put in abduction frame after 3 months. As a rule, sufficient compensatory movements develop at the scapulothoracic joint. Generally a sound fibrous ankylosis develops and since this is a non-weight bearing joint a sound fibrous joint is acceptable.

Indications for arthrodesis are painful ankylosis, uncontrolled disease, recurrence, etc.

Physiotherapy Measures in TB Shoulder

In the earlier stages the shoulder is kept in a functional position by using shoulder and aeroplane splints. Cold therapy in the acute stages and thermotherapy in the later stages helps to overcome stiffness, pain, etc.

TUBERCULOSIS OF ANKLE

This is very uncommon, and the incidence is only 5 percent. Sites of involvement could be:

- Synovium
- Distal end of tibia
- Malleoli
- Talus
- Rarely calcaneum

Clinical Features

Pain in the region of the ankle, limp, swelling over and front of the joint, malleoli and tendo-Achilles. Ankle joint is held in plantar flexion. In the late cases, there is pathological anterior dislocation of the ankle joint. Ankle movements are decreased. There is gross wasting of calf muscles and evidence of sinus formation.

Radiograph

Radiographs in the early stages show marked osteoporosis of the ankle bones and in late stages there is destruction of the ankle joint (Fig. 27.18).

Treatment

Aim Here the aim is to achieve painless ankylosis in neutral position of the ankle. This is achieved by observing the following principles. Chemotherapy as is already discussed immobilization in below knee plaster cast in neutral position;

Fig. 27.18: Radiograph in the early stage showing marked osteoporosis of the ankle

crutch walking for first 8 to 12 weeks with plaster on and after 6 months below knee caliper is worn for 2 years.

Surgery

Indications

- When the conservative treatment fails.
- When the diagnosis is in doubt.

Methods

- Synovectomy and joint debridement during the stages of synovitis and early arthritis.
- Arthrodesis for advanced and persistent disease.

Physiotherapy Measures in TB Ankle

In the earlier stages the ankle is kept in a neutral position by using below knee splints. Cold therapy in the acute stages and thermotherapy in the later stages helps to overcome stiffness, pain, etc.

TUBERCULAR OSTEOMYELITIS

Here the onset of tuberculosis foci is within the bone. Because of deficient anastomosis of the osseous arteries in the childhood, thrombosis caused by tubercular pathology may lead to sequestration of a major part of the diaphysis.

Tubercular Osteomyelitis Without Joint Involvement

This can occur in any of the long tubular bones and the incidence is 2 to 3 percent and 7 percent occurring at multiple sites. The patient complains of pain in the affected bone. Swelling is warm and tender. There may be cold abscess or sinus formation or ulcer may be present. Enlargement of the regional lymph nodes are seen.

Spina Ventosa Type

In these cavities contain soft feathery sequestra. Subperiosteal new bone formation is present. If it is complicated by sinus or secondary infection, intense reactive sclerosis, sequestra and pathological fractures are seen.

Tuberculosis of long tubular bones The incidence is 3 percent and occurs in metaphysiodiaphyseal junction. It may also start as a diaphysial lesion.

Disseminated skeletal tuberculosis This is very rare with 7 percent incidence only. It may be due to hematogenous spread

Fig. 27.19: Clinical photograph of the foot in tubercular dactylitis of the metatarsals

or may be due to repeated impregnations at different sites. Rarely may it present as multiple cystic lesions called as osteitis tuberculosa multiplex cystioides.

Treatment Chemotherapy is the mainstay of treatment and radiographs are taken once in 6 months.

Tuberculosis of short tubular bones (Fig. 27.19) This involves metacarpals and metatarsals. In phalanges it is uncommon after the age of 5 years. This is called tubercular dactylitis (Fig. 27.20). Hand is more frequently involved than foot. Due to lavish blood flow through a large nutrient artery entering almost in the middle of the bone:

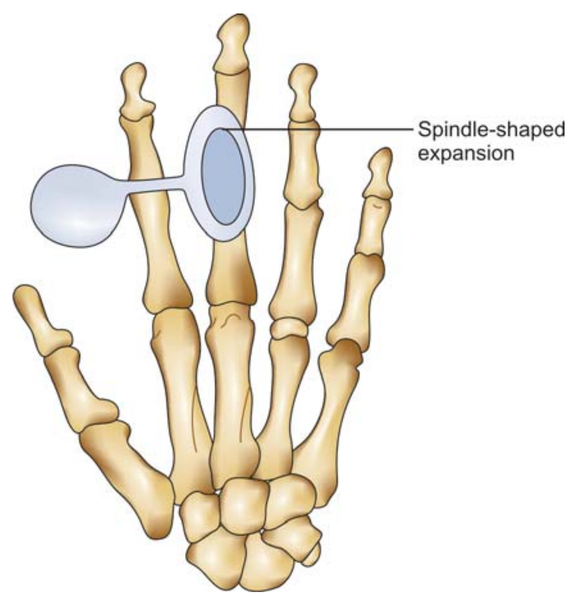


Fig. 27.20: Showing changes in tubercular dactylitis

- The first inoculum of infection is lodged in the centre of marrow cavity, which leads to a spindle shaped expansion of bone called spina ventosa.
- There is subperiosteal new bone formation. Abscesses and sinus formation are also seen.
- Secondary infection causes further thickening of the bones.

Radiograph

Plain X-ray shows lytic lesions in the middle of the bone, subperiosteal new bone formation is present, soft cork-like sequestra and spina ventosa honeycomb type (Fig. 27.21).

Fig. 27.21: Radiograph showing destruction in tubercular dactylitis

Treatment

Chemotherapy is the mainstay of treatment and has been already discussed.

Summary of Physiotherapy Management in Skeletal TB

During the Acute Stage

- Rest to the affected part.
- Proper splinting in functional positions to prevent deformities.
- No ROM, active or passive, for the affected points. However, the unaffected joints can be exercised.
- Routine measures like hydrotherapy, thermotherapy to control pain, edema and inflammation
- Nonweight-bearing.

During the Quiescent Stage

- Full range of active and passive ROM to the affected joints.
- Progressive resistive exercises.
- Isometric and isotonic strengthening exercises to the affected muscles.
- Assistive devices for ambulation weight transfer, etc.
- Orthotic devices for correction of deformities, etc.

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28

Chapter

Disorders of Joints

ARTHRITIS

Arthritis is a nonspecific term denoting acute or chronic inflammation of the joint. Clinically arthritis falls into the following groups:

- *Osteoarthritis*
  - Primary
  - Secondary
- *Rheumatoid arthritis*
  - Adult
  - Juvenile
- *Infective arthritis*
  - Acute
  - Chronic
- *Metabolic arthritis*
  - Gout
  - Pseudo gout
- *Nonspecific monoarthritis*
- Neuropathic joint disorders, e.g. Charcot's
- Special forms:
  - Hemophilic arthritis
  - Psoriatic arthritis
  - Psychogenic arthritis.

Nearly, ten percent of the population suffers from one form of the arthritis or the other.

INFECTIVE ARTHRITIS

PYOGENIC INFECTION OF JOINT OR SEPTIC ARTHRITIS

Definition

Septic arthritis is defined as a bacterial infection of the joint which causes an intense inflammatory reaction with migration of polymorphonuclear leucocytes and subsequent release of proteolytic enzymes. This could lead to destruction of the articular cartilage and later the joint.

Causative organisms The most common offending organisms are *Staphylococcus aureus* (50%), *Streptococcus* (20%), *Pneumococcus* (10%), Gonococcus, *E. coli*, etc. *H. Influenzae* is very common in children less than 2 years. *Blood culture is positive only in 60 percent of cases.*

Predisposing factors The following act as predisposing factors—trauma, diabetes, steroid therapy, malignancy, etc.

Sites of involvement of the joint

In adults

- Knee (53%)
- Hip (20%)
- Elbow (17%)
- Shoulder (10%)

In children

- Knee (39%)
- Hip (32%)

Remember

Ninety percent of cases of septic arthritis are monoarticular and ten percent are polyarticular.

Clinical Features

Septic arthritis usually presents as monoarticular affection in 90 percent and polyarticular in 10 percent of cases and fever is seen in only 50 percent of the cases. Limp is a common complaint. The severity of clinical manifestation depends upon the severity of disease (Fig. 28.1).

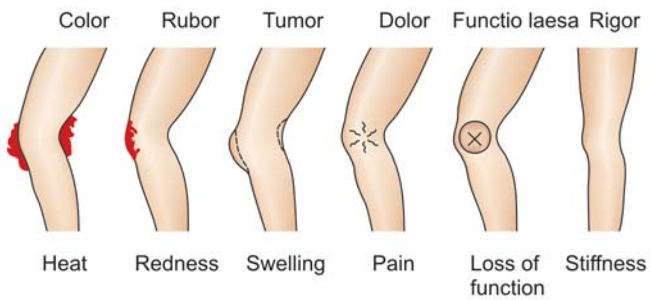


Fig. 28.1: Showing the cardinal signs of inflammation

TABLE 28.1: Types of infective arthritis

Serous	*Serofibrinous*	*Purulent*
• Pain is less	• Tenderness +ve	• Patient is very ill
• Movements of the joint ↓	• Fever +ve	• Pain +ve
• Local temperature ↑	• Night pains +ve	• Wasting +ve
• Flexion deformity		• Temperature ↑

Types of infective arthritis as depicted in Table 28.1.

Other features of infective arthritis are pain, swelling, local raise of temperature, redness, loss of joint movements and stiffness due to muscle spasm (Fig. 28.2).

Investigations

Laboratory investigations may show raised polymorphonuclear cells and raised ESR. Synovial fluid analysis may show increased cells, proteins and sugar. Plain X-ray of the affected joint shows gross swelling of the affected joints in the early stages and gross destruction or bony ankylosis in the later stages (Fig. 28.3).

Note Nearly one-third of patients affected with bacterial arthritis suffer loss of joint function.

Fig. 28.2: Showing clinical photograph of septic arthritis of the knee

Fig. 28.3: Plain X-ray showing features of infective arthritis

Treatment

- *Arthrotomy or joint drainage* The joint is aspirated first, if pus is present, open arthrotomy is indicated. The pus is cultured and is subjected to Gram staining. Appropriate antibiotics are then chosen and are given intravenously before surgical drainage. Antibiotics are used for a minimum period of 2 to 4 weeks.
- *Immobilization* of the joints by using plaster of Paris splints in functional position reduces pain.
- *Radical treatment* is reserved for all except, for very early cases, which do not respond rapidly within 24 hours to antibiotics and immobilization.
- If cartilage is destroyed, aim for ankylosis in functional position by plaster casts.

Complications

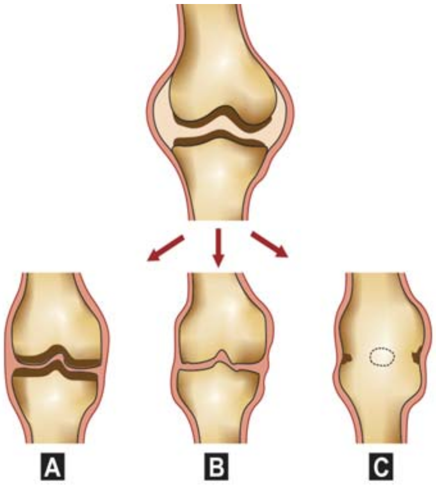
- Joint destruction (Fig. 28.4A).
- Pathological dislocation.
- Osteoarthritis in later years.
- Ankylosis—fibrous or bony (Figs 28.4B and C).
- Acute osteomyelitis.
- Amyloidosis very rarely develops.
- Septicemia, pyaemia, etc.

Remember

Tom Smith arthritis is a septic arthritis of the hip joint seen in infants.

Physiotherapy Management in Infective Arthritis

During the active stage
- Rest to the part.
- Limb elevation to control edema.



Figs 28.4A to C: Showing sequelae in infective arthritis: (A) No residual effect leaving back a normal joint, (B) Features suggestive of fibrous ankylosis, (C) Bony ankylosis

- Proper splinting for rest and to prevent deformities.
- Appropriate thermotherapy and cryotherapy to control pain.
- No ROM exercises and strengthening exercises.
- No weight-bearing is permitted.
- TENS and interferential therapy helps.

During the inactive stages (Quiescent stage)
- Full range active and passive ROM to the affected joints.
- Progressive resistive exercises to the affected muscles.
- Isometric and isotonic strengthening exercises to the involved muscles.
- Assistive devices for ambulation, weight transfers, etc.
- Orthotic devices for correction of deformities, etc.

GONOCOCCAL ARTHRITIS

The incidence of gonococcal arthritis is less than one percent and it familiarly known as a three weeks infection. The male is to female ratio is 5:1 and the age of predilection is between 20 and 30 years. It usually results due to lack of treatment for gonorrhea. Forty percent of the cases are monoarticular, knee being the most common.

Clinical Features

Gonococcal arthritis is usually sudden in onset. Patient presents with chills, fever, pain and swelling of the joint. On examination there is raised temperature and tenderness. There may be history of urethral discharge. The disease may become chronic due to inadequate and improper treatment.

Treatment

The treatment methods consist of local measures like splints, chemotherapy by intravenous penicillin G, and rest to the part, aspiration with a thick bored needle and arthrotomy to clear the joint debris.

Physiotherapy Measures

This is same as for infective arthritis.

SYPHILIS OF JOINTS

The incidence of syphilis of the joints is definitely on the decline due to the early use of antibiotics. Syphilitic arthritis is caused by *Treponema pallidum.* Antisyphilitic treatment is done but it is often not successful.

Physiotherapy Measures

This is same as for infective arthritis.

NEUROPATHIC JOINTS (*CHARCOT'S)

This causes extensive destruction of the joint as it is painless. The following are some of the important causes of neuropathic joints.
- Syringomyelia (25%)
- Tabes dorsalis (4-10%)
- Syphilis
- Rheumatoid arthritis
- Intra-articular steroids
- Traumatic division of sciatic nerve
- Chronic liver disease
- Prolonged administration of drugs like indo-methacin, etc.

Sites Knee, ankle, hip, elbow, shoulder, wrist and intervertebral joints in that order. It is rare before 40 years.

Clinical Features

In this condition, premonitory signs are rare, onset is usually sudden and unexpected. Gross swelling and lax joint are commonly seen. In the later stages of the disease the following features are seen, lax joints, *striking absence of pain*, joint becomes flail and there is a diffuse erythema around the joints (Fig. 28.5).

Radiograph

Plain X-ray of the affected joint shows gross destruction of the affected joints (Fig. 28.6).

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*__Jean Martin Charcot__ (1825-1893) of Paris. He first distinguished between gout and rheumatoid arthritis and Charcot's joints.

Fig. 28.5: Showing clinical photograph of a neuropathic knee

Fig. 28.6: Plain X-ray showing gross destruction of the joint in neuropathic ankle

Treatment

The treatment of choice is Charnley's compression arthrodesis but efficient bracing still has a major role to play (Figs 28.7A and B).

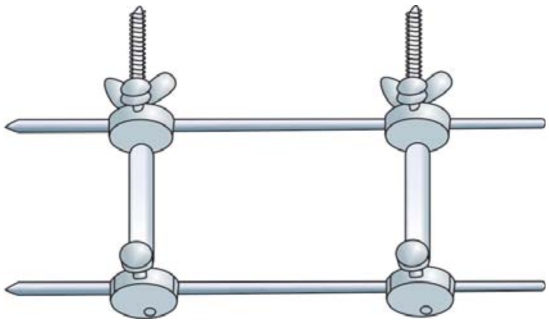


Fig. 28.7A: Charnley's compression clamp with 2 pins

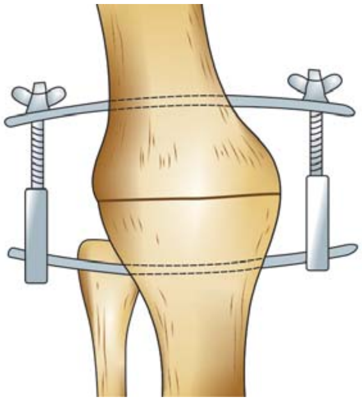


Fig. 28.7B: Showing Charnley's compression arthrodesis

Physiotherapy Measures in Charcot's Joint

- To avoid trophic changes proper footwear is advised.
- To stabilize the unstable joints braces are advised.
- To prevent contractures, passive stretching of the joints is indicated.
- Active ROM exercises to mobilize the joints.

HEMOPHILIC ARTHRITIS (BLEEDER'S JOINTS)

It is a hereditary coagulative disorder characterized by hemorrhages, which is spontaneous and is due to trivial trauma. It is X-linked, carried by female, manifest in male, and the cause being *prolonged clotting time but normal bleeding time.*

Incidence is 3 to 4 per one lakh population.

Table 28.2 shows different types of hemophilic arthritis.

TABLE 28.2: Types of hemophilic arthritis

Hemophilia A	80% cases due to ↓ factor VIII
Hemophilia B	15% due to ↓ factor IX (Christmas disease)
Hemophilia C	Both male and female affected autosomal dominant
von Willebrand's disease	Both platelets and factor VIII are deficient

Severity of factor VIII deficiency and the clinical effects is shown in Table 28.3.

TABLE 28.3: Severity of factors deficiency and their clinical effects

Severity	*Clinical effect*
< 1%	Severe bleeding
< 5%	Gross bleeding with minor trauma
< 5-25%	Severe bleeding after trauma or surgery
< 25-50%	Bleeding after excessive trauma or injury

Fig. 28.8: Showing clinical photograph in hemophilic knee

Pathology

The defective blood interacts with the synovial fluid and causes irritation to the synovial membrane. Due to the proliferation of the macrophages, there is synovial hyperplasia and pannus formation which ultimately causes destruction of the articular cartilage of the joint.

Clinical Features

Bleeding is spontaneous and is usually due to trivial trauma. Acute haemarthrosis occurs within hours. The joint is warm, tender and flexion attitude develops (Fig. 28.8). Acute phase lasts for few weeks. With each attack joint movement decreases, fixed flexion deformity occurs, degenerative arthritis sets in and results in fibrous ankylosis. There is gross muscle atrophy.

Investigations

Laboratory tests The classical feature of this disease is, bleeding time is normal but the clotting time is prolonged.

Plain X-ray of the affected joints show the radiological changes as depicted in Table 28.4 and Figure 28.9A.

MRI of the knee helps to see the soft tissue changes along with the bony changes (Figs 28.9B and C).

TABLE 28.4: Radiologic changes in hemophilic arthritis

Early stage	*Intermediate stage*	*End stage*
• Distended synovium • No para-articular skeletal • Abnormality	• Persistent boggy swelling • Osteoporosis of the epiphysis • Joint interval is normal • Subchondral cysts are present • Squaring of the patella • Intercondylar notch of femur and trochlear notch of ulna widened	• Joint disorganized • Subchondral cysts are large • Fibrous ankylosis is present

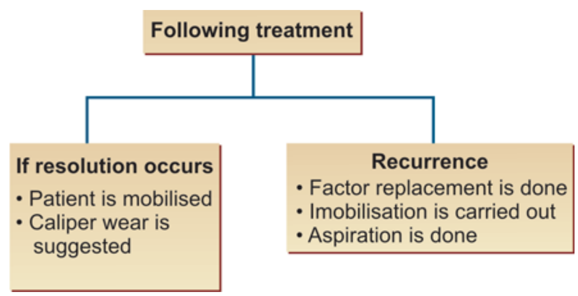
Treatment

This varies according to the stages of the disease.

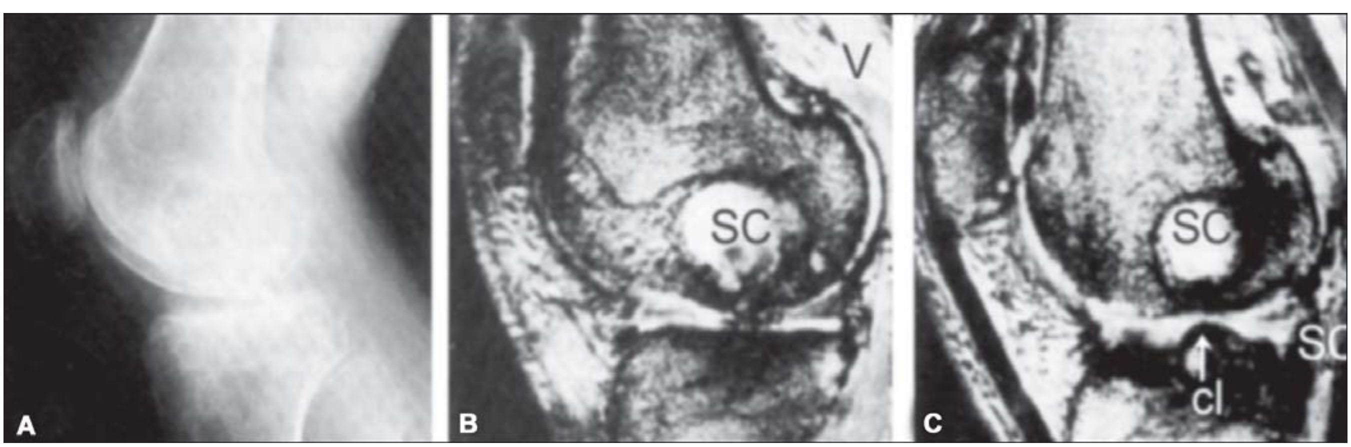
Acute stage For injuries of less than four hours, the patient is treated on OPD basis. Factor VIII is replaced and is discharged home on the same day.

For injuries more than four hours, factor VIII is replaced; joint is aspirated with a thick bored needle and immobilized with splints (Flow chart 28.1).

Flow chart 28.1: Showing the action plan after treatment



Late cases Treated as in patient, trial aspiration is done, prolonged immobilization, factor VIII is replaced and later mobilization, caliper and splints are recommended.



Figs 28.9A to C: Showing radiological changes and MRI features in hemophilic knee

Chronic haemarthropathy

- *For recent contractures plaster* Immobilization, dynamic traction and physiotherapy.
- *For posterior subluxation of tibia* Dynamic traction.
- *For painful unstable joints* Orthotic splintage.

Surgery is indicated for painful, stiff joints, stiff contractures, and recurrent bleeding into the joint.

Surgical methods These include synovectomy, internal fixations for fracture nonunion. Supracondylar osteotomy for severe flexion contractures of knee, arthrodesis for severely disorganized joints, total hip replacement for pain in the hip. in advanced stages and tendo-Achilles lengthening for tendo-Achilles contractures, etc.

Physiotherapy Management in Hemophilic Arthritis

Goals of Treatment

- To reduce pain.
- To prevent further bleeding into the joints.
- To increase the muscle strength.
- To prevent deformities.
- To shorten the period of immobilization.

Management during the Acute Phase

- The limb is splinted in POP slab and replacement therapy is given.
- By the end of 2nd or 3rd week, gentle isometrics to the quadriceps and hamstrings are begun.
- Resistive exercises to the normal limbs are given.
- By the end of 4th week isometric exercises are made more vigorous.
- Weight-bearing at the earliest is permitted with the help of assistive devices.

Later Stages

- *Thermotherapy* TENS is found to be very effective in relieving pain. Ultrasound and interferential currents are also used.
- *Pulsed short wave diathermy* This is found to be useful in both muscle and joint bleeds. It alleviates pain and also helps to resolve the joint bleeding.
- Efforts should be made to prevent deformities by splinting the affected joints in functional positions.
- Strengthening exercises and progressive resistive exercises are carried out to strengthen the joints.
- Ambulation and weightbearing with appropriate assistive devices are encouraged.

29

Chapter

Rheumatic Diseases

There is a tendency among the students and most of the clinicians to label all cases of polyarthralgia as rheumatoid arthritis. Though there is no dispute about the fact that the most common cause of polyarthritis is rheumatoid, yet not all cases of polyarthritis is rheumatoid. There are a plethora of conditions with this presentation. Rheumatoid and its variants are infamous in creating diagnostic dilemmas. Difficult to diagnose and difficult to treat, it is indeed a problem which presents a nightmarish experience both to the doctor and the patient.

We are all familiar with the saying regarding rheumatic fever, "it licks the joint but bites the heart”. Contrarily it can be said of rheumatoid arthritis, “It bites the joints, licks all other systems of the body and barks at the treating physicians”!

A chronic scourge which writes the obituary of the joints especially those of hands and feet, rheumatoid arthritis is a problem which needs to be understood in toto to successfully combat it and keep it subdued and improve the quality of those unfortunate victims afflicted by this malady.

The rheumatic diseases embrace an amazing array of heredietry and acquired disorders with a wide variety of clinical features. As per the present understanding rheumatic disorders can be classified under three broad headings.

Diffuse systemic

- Rheumatoid arthritis
- Seronegative spondyloarthritis
- Systemic lupus erythematosus (SLE)
- Polymyositis
- Scleroderma.

Localized articular

- Osteoarthritis
- Crystal induced arthritis
- Traumatic arthritis.

Nonarticular

- Fibromyalgia
- Low back pain
- Tenosynovitis.

RHEUMATOID ARTHRITIS

Definition

Rheumatoid arthritis (Described in detail for the first time at the end of 18th century) is the most common inflammatory disease of the joints. It is a systemic disease of young and middle-aged adults characterized by proliferative and destructive changes in synovial membrane, periarticular structures, skeletal muscles and perineural sheaths. Eventually joints are destroyed, fibrosed or ankylosed. It is a widespread vasculitis of the small arterioles.

Incidence is three percent.

Sex Eighty percent affected are women. Male: Female ratio is 1:3.

Age No age is exempt, mean age is 40 years.

Etiology

The exact cause is unknown but malfunction of the cellular and humoral arms of the immune system are cited as the probable cause.

Current hypothesis An initiating antigen triggers an aberrant response, which becomes self-perpetuating long after the offending antigen has been cleared.

Antigenic agents Which probably act as predisposing factors are viruses: rubella, Epstein-Barr, etc. genetic (common in

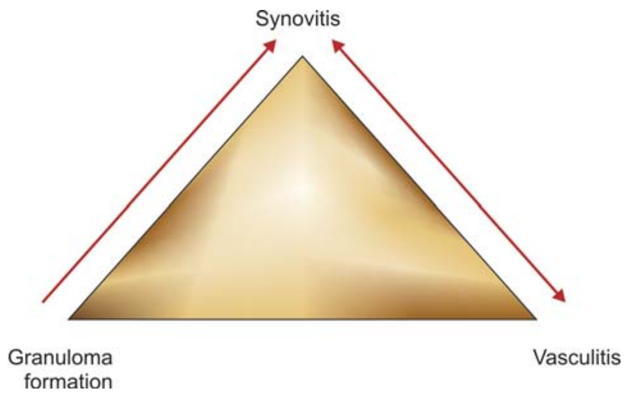


Fig. 29.1A: Rheumatoid arthritis = Synovitis + Vasculitis + Granuloma

people with HLA DR4 60%), psychological stress, allergic factors, endocrine factors and metabolic factors.

Pathogenic Spectrum (Fig. 29.1A)

Against unknown exciting antigenic agents rheumatoid factors are elaborated. Rheumatoid factors are synthesized in rheumatoid synovial tissue and are mainly IgM in 70 to 90 percent of cases. In the remainder 10 to 30 percent it could be IgG, IgA or IgE. This rheumatoid factor along with IgG triggers off a compliment cascade. The WBCs engulf this immune complex and elaborate lysosomes. Neutrophils release procollagenase which is converted into an active collagenase by the synovial fluid. This splits the collagen of the articular cartilage. The neutral proteases complete the degradation of the collagen fibrils.

Pathology

As explained earlier due to the synthesis of auto-antibodies, against unknown antigenic agents in the synovium, primary synovitis sets in. This primary synovitis gives rise to pannus, which in turn forms the villus. This villus migrates towards the joint causing its destruction and ankylosis, fibrous in the early stages followed by bony ankylosis in the late stages.

Clinical Features

Rheumatoid arthritis usually presents in three forms:

Classical presentation In this group patient is usually a woman in her mid 30s. Pain, swelling, stiffness of the small joints of hands and feet are the common presenting complaints. Patient also gives history of weight loss, lethargy and depression. Joint swelling could be symmetrical and the patient presents with deformities of bones and joints in the late stages. The patient gives history of remissions and exacerbation of symptoms with seasonal variations. This is a very classical complaint in the absence of which diagnosis of rheumatoid arthritis should be carefully made. Symptoms fluctuate from day-to-day.

Table 29.1 shows the recent diagnostic criteria for rheumatoid arthritis.

TABLE 29.1: Recent diagnostic criteria for rheumatoid arthritis

According to American College of Rheumatology in 1987, revised criteria at least 4 out of 7 criteria should be fulfilled to make a diagnosis of rheumatoid arthritis.

- Morning stiffness.
- Arthritis or swelling of 3 or more joints for > 6 weeks.
- Arthritis or swelling of hand joints (wrist metacarpal) for more than 6 weeks.
- Symmetrical swelling (arthritis of same joint areas) more than 6 weeks.
- Serum rheumatoid factor present.
- Radiographic features of RA.
- Rheumatoid nodules.

Other presentations This consists of palindromic presentation involving one or two joints, systemic presentation usually seen in middle-aged men presenting with pleurisy, pericarditis, etc. It mimics malignancy. It may present as polymyalgia particularly in elderly patients. It may present as monoarthritic swelling. Some times the presentation may be very explosive unlike the usual chronic presentation.

Extra-articular features Two or more features are present in 75 percent of the cases. Rheumatoid factor is invariably present and indicates a bad prognosis.

- Subcutaneous nodules are present in 25 percent of the cases. It is seen over the elbow, sacrum and occiput. Nodules may also be present in lungs, eye, hearts, etc. When present over flexor tendon it may cause trigger finger.
- Widespread vasculitis.
- Blood abnormalities commonly encountered in rheumatoid arthritis are chronic anemia, iron deficiency anemia, vitamin B_{12} and folate deficiency, leucocytopaenia, thrombocytosis and marrow hypoplasia.
- Osteoporosis could be generalized or localized in bones around the joints.
- Eye changes seen in rheumatoid arthritis are kerato-conjunctivitis sicca or Sjögren's syndrome, episcleritis (common), scleritis (serious problem), secondary glaucoma and scleromalacia perforans.
- Lung affections in rheumatoid arthritis are pleurisy, pleural effusion, Caplan's syndrome (RA + pneumoconiosis involving the upper lobes) and fibrosing alveolitis in 2 percent.

- Heart affections in rheumatoid arthritis are pericardial friction (10%), pericardial effusion (30%), arrhythmias and heart block.
- Neuromuscular system involvement includes carpal tunnel syndrome, mononeuritis multiplex, muscle wasting, subluxation of C1 and C2, etc.
- Reticuloendothelial system affections include splenomegaly (5%), Felty's syndrome in 1% (RA+ splenomegaly + Neutropaenia), generalized lymphadenopathy and painless pitting edema of the feet and ankles.

ORTHOPEDIC DEFORMITIES IN RHEUMATOID ARTHRITIS

Rheumatoid arthritis can affect any joint in the body. It involves the peripheral joints more often and very rarely affects the larger joints. Of particular importance are the affection of the temporomandibular joint and atlantoaxial joint which can prove lethal due to the cord compression. Figure 29.1B shows frequency of involvement of various joints in rheumatoid arthritis.

Quick Facts

Joints involved in rheumatoid arthritis
- Metacarpophalangeal and interphalangeal joints of the hand and feet
- Shoulder, elbow and wrists.
- Hip, knee and ankle.

Others Temporomandibular joint, atlantoaxial joints and facet joints of the cervical spine.

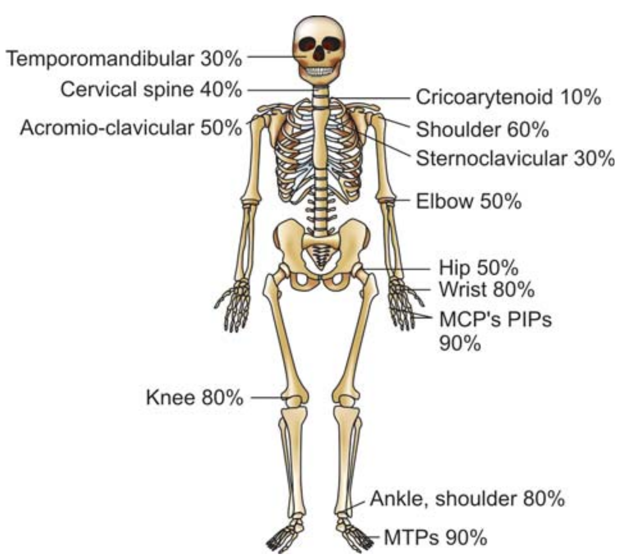
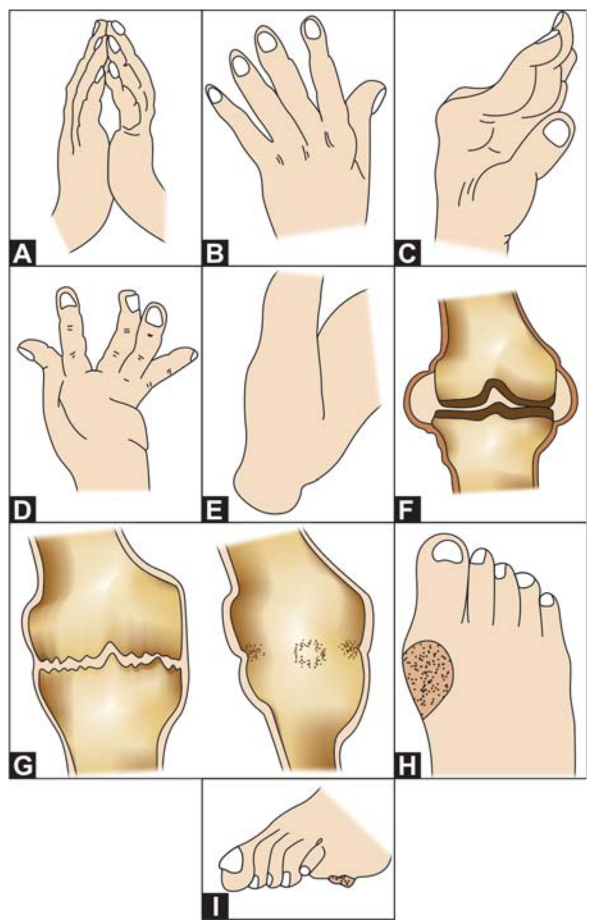


Fig. 29.1B: Showing frequency of involvement of different joint sites in established RA

Orthopedic deformities of the hand (rheumatoid hand) the following are some of the very common deformities seen in the hand (Figs 29.2A to I and 29.3A to C).

- Symmetrical peripheral joint swelling of metacarpophalangeal and interphalangeal joints (Fig. 29.2A).
- Ulnar deviation of the hand is due to rupture of the collateral ligaments at the metacarpophalangeal joints which enable the extensor tendons to slip from their grooves towards the ulnar side (Fig. 29.2B).
- Boutonniere's deformity is due to the rupture of central extensor expansion of the fingers resulting in flexion at the PIP joint.
- Swan neck deformity is due to the rupture of the volar plate of the PIP joints which enables the tendons to slip towards the dorsal side (Fig. 29.2C). This is also known as intrinsic plus deformity. Here there is hyperextension of the PIP joint and flexion of the DIP joints.



Figs 29.2A to I: Various orthopedic deformities in rheumatoid arthritis: (A) symmetrical swelling of peripheral joints, (B) ulnar deviation of the fingers, (C) swan neck deformity, (D) swan neck deformity thumb and Boutonniére deformity of the fingers, (E) subcutaneous nodules over the elbow, (F) rheumatoid knee synovial thickening, (G) rheumatoid knee: articular cartilage involved, bony ankylosis, (H) rheumatoid foot: hallux valgus with dorsal callosity, and (I) clawing of toes plantar callosity

Figs 29.3A to C: Clinical photographs of the (A) elbow, (B) wrist and (C) hand in rheumatoid arthritis

- Trigger fingers and trigger thumb are due to nodules over the tendons.

Rheumatoid foot It affects the forefoot, midfoot and hind foot. In the forefoot patient may develop hallux valgus deformity of the great toe, claw toes, callosity over the dorsum and the sole, widening of the forefoot, etc. The heel may show valgus deformity.

Other joints In the knee initially there is a gross soft tissue swelling due to synovitis and in the later stages, the patient may develop fibrous ankylosis or bony ankylosis due to widespread destruction of the articular cartilage by the pannus (Fig 29.2G). Similarly, other major joints of the body like the hip, ankle, shoulder, and elbow could be involved.

The rheumatoid knee

- Synovial hypertrophy and effusion which may become gross.
- Flexion and valgus deformity of the knee.
- Rarely, 'wind swept' deformity. (Valgus one knee, varus of the other).
- Baker's cyst may be present.
- Instability of the knee.
- Secondary OA may develop.

The rheumatoid hip

- Involved in over 40 percent of cases.
- Pain in the hip.
- Trochanteric bursitis may develop.
- X-ray may show protrusio acetabuli feature.
- Secondary OA may develop.

Investigations

Laboratory Hb percentage is low and shows normochromic, hypochromic anemia. WBCs are decreased or normal, there are increased lymphocytes and the ESR is raised.

Serological tests
Basis Rheumatoid patient's serum contains RA factor which in the presence of γ-globulin agglutinates certain strains of streptococci sensitized by sheep cells and latex particles.

Remember

RA factor is found in:

- 75 percent of rheumatoid arthritis cases
- 10 percent in healthy elderly people
- 10 percent in malaria, etc.

Radiological Features of Rheumatoid Arthritis

- Soft tissue swelling.
- Juxta-articular osteoporosis.
- Erosion of joint margins.
- Joint spaces are decreased.
- Deformities.
- Atlantoaxial subluxation.
- Subchondral erosions and cyst formation.
- Fibrous and bony ankylosis develops in the late stages (Figs 29.4A and B).

Other common abnormalities These include increased C reactive protein (CRP), increased alkaline phosphatase, increased platelets, and decreased serum albumin.

Synovial fluid analysis This is not performed routinely for diagnostic purposes but performed to exclude other causes of inflammation such as infection. Synovial fluid in RA is typically yellow, watery and turbid due to high WBC and has low sugar content.

Differential diagnosis of rheumatoid arthritis is mentioned in Table 29.2.

Fig. 29.4A: Radiological features of rheumatoid arthritis

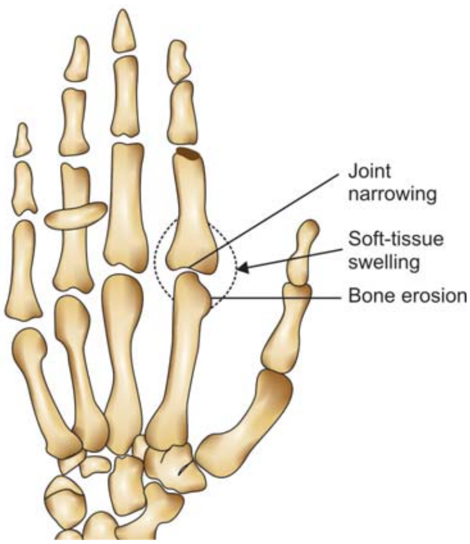


Fig. 29.4B: Showing radiological features of rheumatoid arthritis of hand

TABLE 29.2: Differential diagnosis of rheumatoid arthritis

Early disease	*Established disease*
Common • Viral arthropathy • Polymyalgia • Infection • Prodrome of hepatitis • Hypoparathyroidism	**Common** • Psoriatic arthritis • Erosive osteoarthritis • Chronic pyrophosphate disease • Chronic tophaceous gout • SLE • Reiter's syndrome • Ankylosing spondylitis
Rare • Sarcoidosis • Acute leukemia • Coeliac disease • Eosinophilic fascitis	**Rare** • Amyloid arthropathy • Multicentric reticulohistiocytosis

Quick Facts

Rheumatoid arthritis
- Most common chronic inflammatory disorder.
- 80 percent in women.
- Exact cause is not known.
- Rheumatoid unit is present.
- History of remissions and exacerbations present.
- Symmetrical peripheral joint involvement.
- Rheumatoid arthritis factor is +ve in 70 percent.
- Inhibition test is most sensitive.
- Extra-articular features are seen in 75 percent.

Management

Aims of treatment (Fig. 29.4C)
- To keep inflammatory process at a minimum, thereby, preserving joint motion, maintaining healthy muscles and preventing secondary joint stiffness and deformity.
- To keep constitutional symptoms at a minimum.
- The possible deformities are anticipated and prevented by appropriate splinting.
- Finally surgical measures to correct the deformities, eliminate pain and provide stability are undertaken.

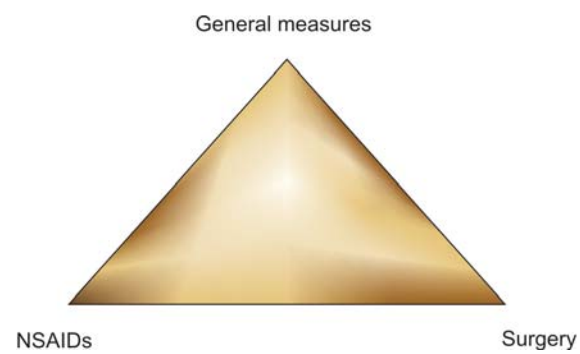


Fig. 29.4C: Treatment triad for rheumatoid arthritis

General measures It aims at improving the general condition of the patient and to keep the joints properly splinted in functional position to guard against the ensuing ankylosis.
- Rest in bed.
- Good diet, rich in proteins and minerals.
- Transfusion and haematinics to correct the anemia.
- Hormones combination of estrogen and androgen to improve the bone stock.
- Removal of infective foci.

Splinting in the functional position helps in the event that ankylosis ensues. The splint is removed daily. Hot packs are given or patient is placed in Hubbard tank at (92.6-102°F) and the joints are put into full range of motion. While the joints are immobilized, muscle setting exercises are advocated. After removal of the splints, resistance exercises are begun.

Splints These are known to serve three main functions:

- Rest and relief of pain (rest splints).
- Prevention and correction of deformity (corrective splints).
- Fixation of damaged joint in a good functional position (fixation splints).

Drug Therapy

Three classes of drugs are used regularly:

- Analgesics
- Anti-inflammatory drugs
- Disease modifying drugs.

Steroids especially intra-articular injections have an important role.

No treatment is ideal and it is important to assess the patient's response so that the most effective regimen is adopted. Commonly used methods of assessment include; duration of early morning stiffness, number of tender swollen joints. Functional assessment questionnaires, ESR, radiographs, etc.

Surgery

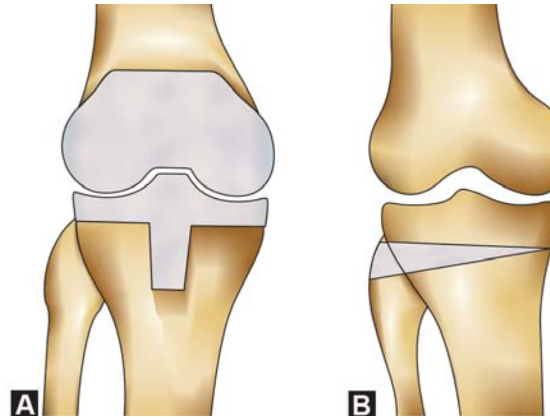
Aim of surgery in rheumatoid arthritis is to:

- Relieve pain.
- Correct the deformity of the joints.
- Reduce joint instability.
- Improve the range of movements of the joints.

Surgical advice should be sought only when the disease is clearly progressive and conservative measures are failing, but before the patient starts to lose a significant amount of bone stock. If surgery is delayed, more bone is lost, the soft tissue deteriorates and the deformity increases.

Preoperative considerations Before surgery for rheumatoid disease, a number of specific points should be checked. Related conditions such as diabetes, hypertension and anemia should be adequately treated and

- Steroid dosage should be reduced.
- There should be no active infection.
- A radiograph of the cervical spine should be obtained to exclude instability.



Figs 29.5A and B: (A) Total knee arthroplasty, (B) Osteotomy in rheumatoid knee

Surgical Methods (Table 29.3)

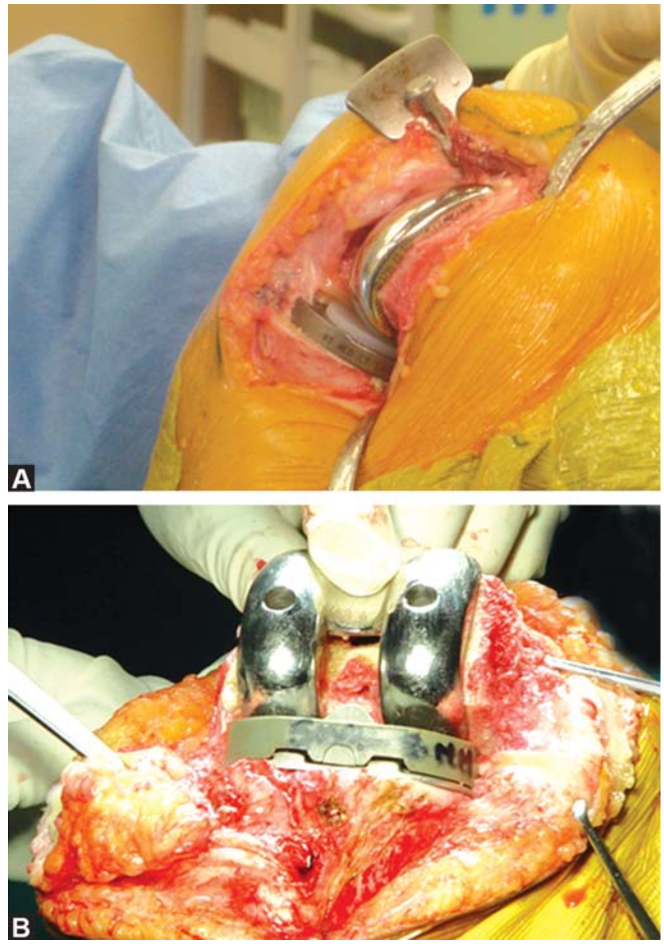
Synovectomy It may be indicated in patients with rheumatoid arthritis if joint destruction is minimal and if the main cause of pain and swelling is synovitis, which is resistant to medication and physiotherapy. Synovectomy is usually carried out over the knee and ankle, in the elbow with radial head excision if necessary. In the wrist, dorsal synovectomy and resection of the distal end of the ulna can prevent attrition and rupture of extensor tendons. Synovectomy has to be virtually complete to avoid regrowth with recurrence of symptoms.

Osteotomy (Fig. 29.5B) this should be considered in patients under the age of 60 years with osteoarthritis of the hip or knee due to rheumatoid arthritis. Osteotomy has the advantage of relieving pain without sacrificing the joint surfaces which have only been partially damaged.

TABLE 29.3: Modus operandi of surgical procedures in rheumatoid arthritis

Synovectomy	• Failed chemotherapy. • Joint destruction should be minimal. • Useful in knee/ankle.
Osteotomy	• Less than 60 years of age. • When joint is partially damaged. • Commonly done at hip (Intertrochanteric osteotomy and abduction osteotomy).
Arthrodesis	• Long-term relief. • Reserved for peripheral joints where arthroplasty results in pain. • Causes secondary osteoarthritis in bigger joints.
Arthroplasty	• Advanced stages. • In hip and knee.

Fig. 29.6: Plain X-rays showing partial knee replacement



Figs 29.7A and B: Clinical photograph showing unicondylar knee replacement (A) and total knee replacement (B) in rheumatoid arthritis

At the hip, intertrochanteric osteotomy which contains the femoral head within the acetabulum is preferred. At the knee, abduction osteotomy is preferred.

Arthrodesis of the joint gives excellent long-term pain relief. But the stress may cause secondary OA in the adjacent joints unless they are able to compensate for the loss of movement. Lack of movement after fusion of the wrist can be absorbed at the elbow and shoulder without significant functional impairment, but fusion of the hip puts considerable strain on the spine and the knee.

Arthrodesis therefore, tends to be preserved for peripheral joints, such as the wrist, ankle, and IP joints of the hands and feet where the functional loss is less disabling and arthroplasty is less reliable.

Arthroplasties of the hip (*see* Figs 29.5A and B), knee (Figs 29.5A, 29.6 and 29.7A, B), ankle, shoulder, elbow, wrist, and hand is indicated in advanced diseases causing severe pain and incapacitating disability due to stiffness and instability.

Postsurgical Physiotherapy in RA

Physiotherapy following surgeries like osteotomy, arthrodesis and arthroplasties has already been discussed in earlier sections.

Physiotherapy Measures for Rheumatoid Arthritis

During the Acute Phase

- Measures to control pain:
  - — *Cryotherapy* Cold application is preferred in active joints where intra-articular heat increase is undesired. Cold-pack, ice, nitrogen spray, and cryotherapy are different methods of applying cold therapy.
  - — *Thermotherapy* By using heat, analgesia is accomplished, muscle spasm relieved, and elasticity of periarticular structures obtained. Heat can be used before exercise for maximum benefit. Thermotherapy may be applied as a superficial hot-pack, infrared radiation, paraffin, fluidotherapy, or hydrotherapy. Applications are recommended for 10-20 minutes once or twice a day
- TENS and interferential current of 90-100 Hz is recommended: Electrostimulation is used in patients with RA to relieve pain. TENS is generally a short acting therapy (6-24 hours), and the most beneficial frequency is 70 Hz. It also has a high placebo effect. It cannot be used in every painful joint simultaneously, which is a disadvantage in patients with polyarticular involvement. Interferential current can also be used for analgesia. Studies have shown its efficacy on pain relief, swelling, and improvement in ROM.

- Deep breathing exercises.
- Isometric exercises to the shoulder, hip and knee muscles are recommended.
- Active ROM exercises to all the joints.
- Splints should be used to maintain the joints in functional position.
- PRE exercises to be instituted later.
- Postural guidance.
- Hydrotherapy (Pool therapy) helps to increase ROM, to strengthen muscles, to relieve painful muscle spasms and to improve the patient's well-being.

During the Chronic Phase

Measures to prevent joint contractures.

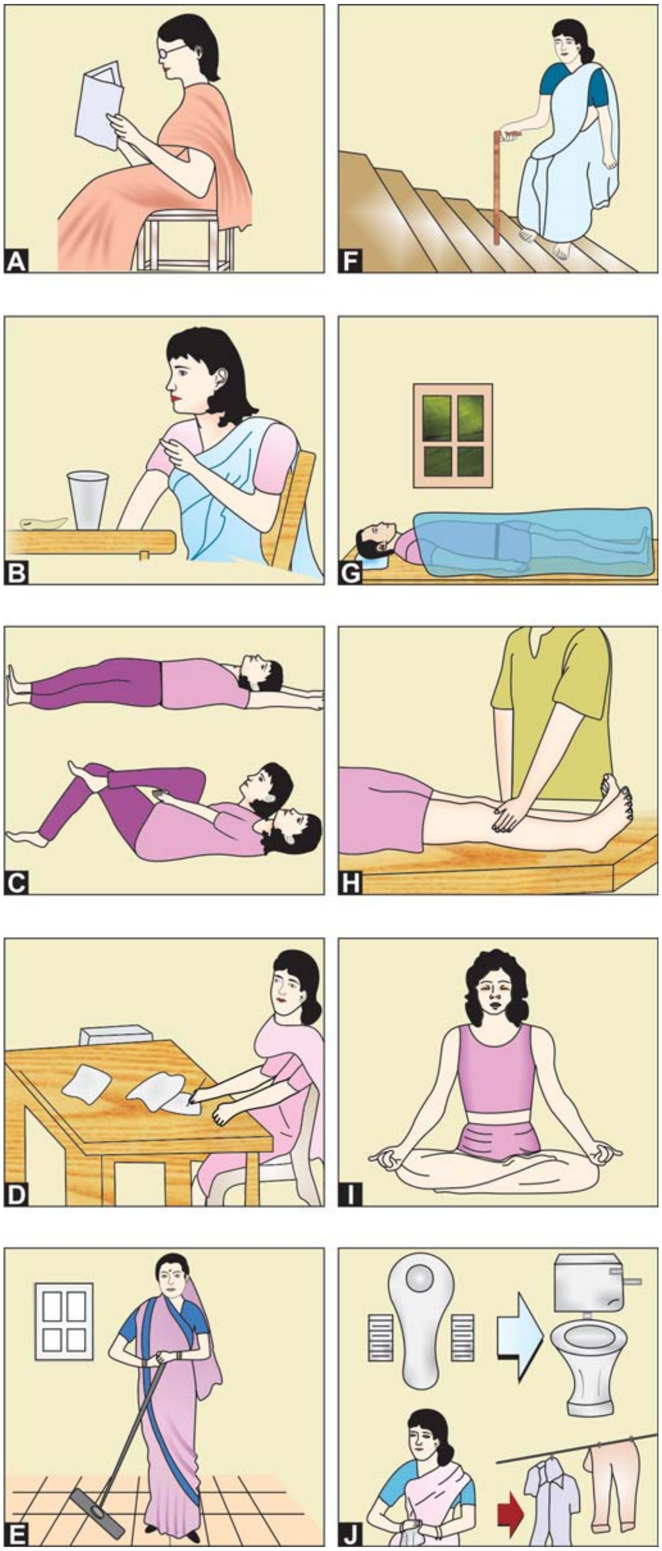
1. *Proper positioning of the joints:*
   - Spine is prone for flexion contracture, hence prone posture is encouraged.
   - *Hip joints* To prevent flexion contracture of the hip, prone lying position, firm bed, avoiding pillow under the knee are recommended.
   - *Knee joints* Efforts are made to avoid flexion attitude of the knee, by repeatedly stretching it, active and active assisted exercises, etc.
   - *Ankle and foot* Active ROM exercises to the ankle and foot are recommended.
   - *Shoulder* Full ROM exercises with the hand in collar and cuff should be encouraged to prevent limitation of abduction and external rotation.
   - Elbow is immobilized in extension to prevent the flexion contracture.
   - *Wrist and hand* Active ROM exercises to the hand and proper splinting are recommended to prevent the various deformities of the hand.
2. *Use of splints* Splints play a big role in not only preventing but also correcting various deformities of the joints due to RA.
   - Role of a splint
     — Provides rest and support.
     — Relieves pain and spasm.
     — Prevents deformities.
     — Corrects deformities.
     — Provides stability to the weak joints.
   - Disadvantages
     — Prolonged use causes muscle atrophy.
     — Improper use leads to loss of mobility and fixed joints.
   - Characteristics the splint should be:
     — Light weight and comfortable.
     — Inexpensive.
     — Fitting should be optimum.
     — Acceptable to the patient.
     — Light and strong.
   - Types of splints
     — Rest splints-provides rest and relieves pain.
     — Corrective splints to prevent and correct the deformities.
     — Fixation splints to fix the joints in good functional positions of the joint.
   - Self-management techniques in RA.

Self-management Techniques for Rheumatoid and other Forms of Arthritis

Self-management is the most important aspect of the treatment of rheumatoid and other forms of arthritis. People practicing self-management techniques tend to experience less pain and are more active than those who do not practice self management. In this management the patient is made aware of the disease and the rationale behind the treatment. They are made to realize that the success of the treatment is their ultimate responsibility.

Ten Self-help Techniques

1. *Positive mental attitude* Patient is told to focus on things other than pain and their own body. They are encouraged to think positively (Fig. 29.8A).
2. *Regular medication* Patient is told the value of regular and correct medication (Fig. 29.8B).
3. *Regular exercises* Patient should follow a regular and appropriate exercise programme, most suited for them (Fig. 29.8C). To improve the range of motion in arthritic joints, patients are instructed to perform exercises shown on page 454 (Figs 29.16 to 29.25).
4. *Use of joints* Patient is told the value of correct posture and the methods of using the joints wisely to reduce stress on the painful joints (Fig. 29.8D).
5. *Energy conservation* Patients are instructed to listen to the body's "inner signals" for rest. Slowing down and avoiding too many activities reduces the stress and strain on the joints.
6. *Assistive devices* Devices like splints, braces and walking sticks can help stabilize the joints, provide strength and reduce pain and inflammation (Fig. 29.8F).
7. *Adequate sleep* A good adequate sleep provides rest to the ailing joints and reduces the pain and swelling (Fig. 29.8G).



Figs 29.8A to J: Self-management techniques in the treatment of rheumatoid arthritis

8. *Massage* A good moderate massage brings warmth and relieves pain due to arthritis (Fig. 29.8H).
9. *Relaxation techniques* Relaxation techniques like Yoga, meditation, etc. help to relax the muscles, mind and controls respiration, heart rate, blood pressure. This helps in the control of pain (Fig. 29.8I).
10. *Modification in the daily activities*
    - Using western toilets (Fig. 29.8J).
    - Bath aids and railings.
    - Long handle broomstick and mop to clean the floors (Fig. 29.8E).
    - Use of walking sticks while walking, climbing, etc. (Fig. 29.8F).
    - High chairs.
    - Avoid squatting on the ground for food, etc. Use of dining table and chairs are recommended.
    - To avoid squeezing clothes after washing and just rinsing them dry (Fig. 29.8J).
    - To avoid walking on hard and uneven and rough surfaces.
    - To sleep on a hard surface.

Differential Diagnosis in RA

Seronegative spondyloarthropathies (discussed next) and OA are the important differential diagnosis in RA (Tables 29.4 and 29.5).

SERONEGATIVE SPONDYLOARTHROPATHIES

Seronegative spondyloarthropathies (SSA) group is gradually emerging as a new entity. These disorders are labeled as seronegative to indicate that they have in common the absence of the rheumatoid factor. The term spondyloarthropathies is used because in many cases there is involvement of the spine and sacroiliac joints. Hence, SSA can be defined as an acute or chronic condition with characteristic involvement of axial joints, absence of RA factor and HLA abnormality.

The clinical entities which appear to justify inclusions in the SSA group are as follows (Table 29.5):

- Ankylosing spondylitis
- Reiter's disease
- Psoriatic arthritis
- Ulcerative colitis
- Crohn's disease
- Whipple's disease } Enteropathic arthritis
- Behçet's syndrome }

TABLE 29.4: The differences between rheumatoid arthritis and osteoarthritis

Rheumatoid arthritis	*Osteoarthritis*
• It is an autoimmune disease and often strikes in the prime of life.	• It is an age related disease due to wear and tear of the cartilage.
• It is usually seen between the ages of 25 and 50 years of age but can also occur in children and infancy.	• It usually affects people after 40 years of age.
• It affects joints on both sides of the body and has a bilateral presentation.	• It usually affects isolated joints, or joints on only one side of the body at first.
• It causes redness, warmth and swelling of the joints.	• It usually does not cause redness and warmth of the joints.
• It affects many joints usually small joints of the hands and feet, and may affect the elbow, shoulders, wrist, hip, knee and ankles.	• It most commonly affects weight bearing joints or joints that are overused (e.g. knees and hip).
• It can affect the entire system, with general feeling of sickness and fatigue, as well as weight loss.	• Discomfort is usually related to the affected joint.
• There is history of prolonged morning stiffness.	• Brief morning stiffness.
• It causes major fatigue.	• It rarely causes fatigue.

TABLE 29.5: Differential diagnosis seronegative spondyloarthropathies

Disease	*Sex and age*	*Onset*	*Signs and symptoms*	*Joints involved*	*Extra-articular lesions*	*HLA-B_{27}*
Ankylosing spondylitis	Predominantly males < 40 years	Insidious	Low back pain, morning stiffness and pain > 3 months	Intervertebral joints	Uveitis, conduction defects in heart, CNS disturbances, pulmonary complications	94%
Psoriatic arthritis	Predominantly females > 50 years	Variable	Pain and stiffness of the affected joints	Distal and proximal IP joints	Uveitis, conjunctivitis, urethritis, and skin lesions	100%
Reiter's disease	Predominantly females. 16-35 years	Sudden	Pain and stiffness of affected joints, diarrhoea, dysuria, etc.	Weight-bearing joints (knee and ankle)	Conjunctivitis, uveitis, buccal erosions, urethritis	83%
Enteropathic arthropathies (Crohn's disease, ulcerative colitis, Whipple's disease)	Predominantly males. Age group is not clear	Variable	Pain and stiffness of the affected joints, weight loss, diarrhoea, abdominal pain	Knee, ankle (most common), shoulder wrist, elbow also involved	Aphthous ulcers, uveitis, erythema nodosum	50%
Behcet's syndrome	Predominantly males. 15-40 years	Variable	Pain and stiffness of affected joints.	Knee, hand, ankle and wrist joints are primarily affected. There is involvement of elbow, shoulder and hip joints	Painful oral ulcers, genital ulcers, ocular lesions, skin lesions.	16%

Etiology

The exact pathogenic mechanisms involved are not known. However, genetic factors appear to play an important role. The most complete evidence for familial aggregation is that for ankylosing spondylitis. The children of a person with HLA-B27 have a 50 percent chance of carrying the same antigen.

There are some postulations regarding the possible mechanism for the association of HLA-B27 and SSA.

- HLA-B27 is a marker for immune response gene that determines susceptibility to an environmental trigger.
- HLA-B27 may act as a receptor site for an infective-agent.
- It may induce tolerance to foreign antigen with which it cross-reacts.

Salmonella, Shigella, Chlamydia and other microorganisms are implicated in the pathogenesis of this group of arthritis.

Clinical Features

The clinical manifestations include articular as well as extra-articular features.

Articular features These include low back pain due to progressive sacroiliitis and spondylitis. Patient complains of morning stiffness and decreasing lumbar lordosis.

Diffuse swelling of fingers and toes may occur due to small joint synovitis and tenosynovitis. The manifestation is referred to as sausage digit. Enthesopathy i.e. pain at the site of insertion of ligaments and tendons can occur at Achilles tendon, plantar fascia and ischial tuberosities.

Extra-articular features These features include skin lesions such as psoriasis, pitting of nails, and penile ulcers, eye lesions like conjunctivitis, bowel disorders and genitourinary disturbances such as dysuria and urethral discharge.

Diagnosis

Radiological diagnosis forms one of the proven diagnostic techniques in diagnosing SSA. Radiological study of the affected joints will show punched-out areas exceeding deep into the subchondral bone.

CAT scan is also a very useful method that helps in the diagnosis. It is indicated when plain X-rays are normal. Early changes of sclerosis and bone erosion which are not visible on a plain X-ray can be clearly demonstrated on CAT scan.

HLA-B_{27} shows a strong association with SSA. Its presence adds weight to the diagnosis of these conditions. The frequency of its occurrence with SSA ranges between 16 to 100 percent. In ankylosing spondylitis the frequency of its occurrence is as high as 85 to 90 percent, while in Behcet's syndrome it is as low as 16 percent. In all patients of SSA, the RA factor is uniformly negative.

One of the diagnostic pitfalls encountered is a mistaken diagnosis of RA. Hence, at the very outset, it is essential to differentiate between these two conditions (Table 29.6).

TABLE 29.6: Comparison between SSA and rheumatoid arthritis

	Seronegative spondyloarthropathies	*Rheumatoid arthritis*
Age	Young usually less than 40 years	Any age group
Sex	Predominantly male	Predominantly females
Symmetry	Usually asymmetrical	Usually symmetrical
Number of joints involved	Oligoarticular	Polyarticular
Spine involvement	Common	Only cervical spine
Enthesopathy	Typical	Not a feature
RA factor	Typically -ve	Typically +ve
HLA-B27	+ ve in high%	-ve in normal population

Physiotherapy Measures for Seronegative Spondyloathropathies

These are the same as for rheumatoid arthritis.

ANKYLOSING SPONDYLITIS (AS)

(Syn: Marie-Strumpell Disease)

Definition

This is a chronic progressive inflammatory disease of the sacroiliac joints and the axial skeleton.

Causes

Causes are unknown. It is found to be strongly associated with HLA-B27 genetic marker is about 85 percent.

Age/sex Common in young male adults (M: F = 10:1).

Pathology

The initial inflammation of the joints is followed by synovitis, arthritis, and cartilage destruction, fibrous and later bony ankylosis. The joints commonly affected are SI joints, spine, hip, and knee and manubrium sterni.

Clinical Features

Patient usually complains of early morning stiffness and pain in the back. On examination patient has a stiff spine. Tests for sacroiliac joint involvement are positive (Figs 29.9 to 29.12).

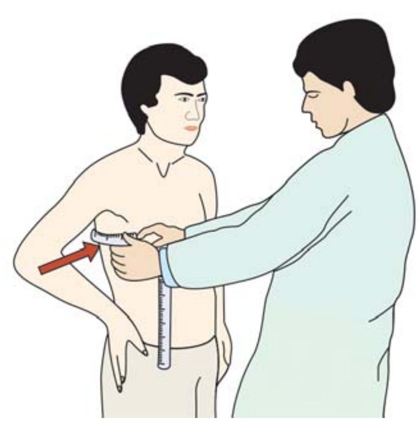


Fig. 29.9: Assessment of chest expansion in ankylosing spondylitis

Fig. 29.10: Sacroiliac joint involvement: Pump handle test

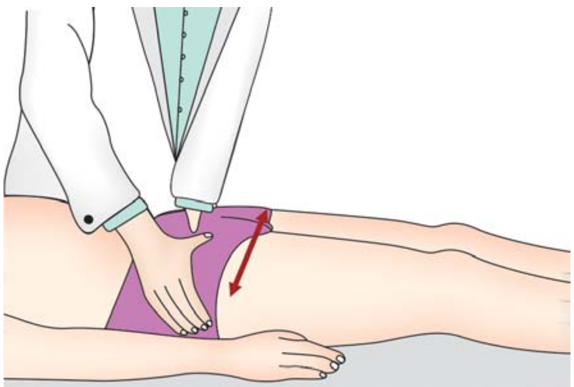


Fig. 29.11: Sacroiliac joint involvement: Pelvic compression test

Fig. 29.12: Sacroiliac joint involvement: Fabre test

Cervical spine involvement (Fig. 29.13) is tested by asking the patient to touch the wall with the back of the head without raising his or her chin (Fleche's test). If the chest expansion is less than 5 cm, involvement of thoracic spine is suspected (Fig. 29.9).

(For differential diagnosis *see* Table 29.5 to 29.7).

TABLE 29.7: Differential diagnosis of ankylosing spondylitis with other causes of backache

	Ankylosing Spondylitis	*Backache due to other causes*
Morning stiffness	Present	Nil or minimal
Effect of inactivity	Aggravates pain and stiffness	Relieves pain
Effect of physical activity	Relieves pain	Aggravates pain
Limitation of spine movement's	in all directions	only in some directions

Fig. 29.13: Clinical photograph of deformities of spine in AS

Extra-articular manifestations These include acute iritis (25%), pericarditis, aortic incompetence, subluxation of atlantoaxial joints, apical lobe fibrosis, generalized osteoporosis, etc.

Quick Facts

Important tests in AS

- Tests for SI joint
- Fleche's test-for involvement of neck
- Chest measurements

Investigations

Laboratory investigations may show raised HLA B 27,ESR, CRP,ANA and increased lymphocytes.

Radiographs of SI joint Show haziness, subchondral erosions, sclerosis (Fig. 29.14) widening of SI joint, etc.

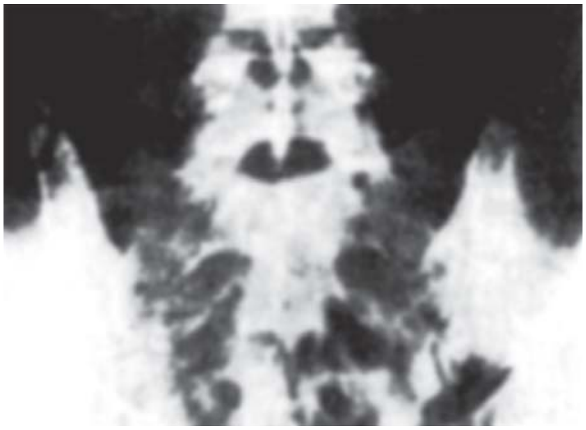


Fig. 29.14: X-ray pelvis showing sacroiliac joint sclerosis

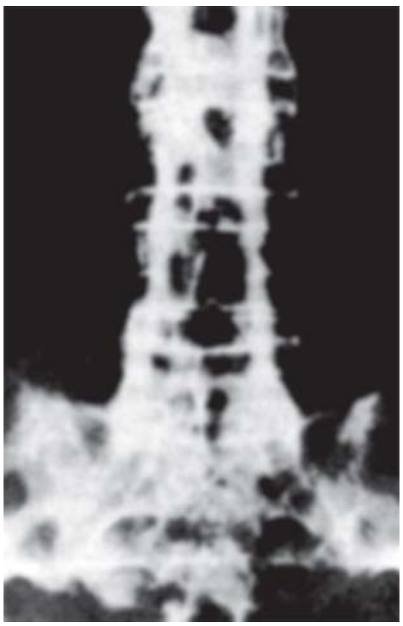


Fig. 29.15: X-ray of LS spine showing bamboo spine in ankylosing spondylitis

Radiographs of spine Show squaring of vertebra, loss of lumbar lordosis, calcification of anterior longitudinal ligament bringing osteophytes, bamboo spine (Fig. 29.15), etc.

Treatment

Conservative treatment consists of rest, NSAIDs (indomethacin), physiotherapy, back exercises, etc. Radiotherapy may also help. Surgical treatment consists of spinal osteotomy to correct spine deformity, total hip replacement and total knee replacement for hip and knee joint ankylosis.

General Principles

A patient suffering from ankylosing spondylitis will have the following postural abnormalities.

- Cervical spine Flexion deformity, atlantoaxial joint in hyperextension.
- Thoracic spine Marked kyphosis, rounded back.
- Hip and knee joints Flexion deformities.

> *Note* The gibbus deformity in ankylosing spondylitis can be measured by using a spondylometer and plotted on a graph called the spondylograph.

In the later stages, the whole spine is stiff and is referred to as the bamboo spine.

Measurements of these postural abnormalities are done at regular intervals.

Before initiating the physiotherapy treatment, accurate measurements of the neck, spine and hip movements have to be done and recorded carefully.

Respiratory function has to be evaluated, and chest expansion has to be done at two levels at the 4th rib near the nipple and another at the 7th rib near the xiphoid process.

Physiotherapy Management

- *Measures to relieve pain and spasm* Cryotherapy, thermotherapy, etc. are effective in relieving pain. Deep heating techniques are required during the chronic stages.
- Pool therapy is an excellent modality of treatment in these patients.
- *Measures to improve spine mobility* Repeated flexion, extension and rotational exercises of the spine along with small range mobilization of the spine is done.
- *Measures to improve breathing* Deep breathing exercises to improve the vital capacity of the lungs. To improve the breathing capacity localized thoracic breathing is encouraged.
- *Measures to improve muscle power* Active ROM exercises, PRE, passive ROM exercises, etc. for the spine, hip and other joints are indicated to improve joint mobility and the muscle power (Figs 29.16 to 29.25).
- *Measures to improve posture* Proper postural attitudes and body ergonomics are to be given lot of importance. Posture leading to deformities mentioned earlier should be strictly discouraged. The following measures are suggested:
  - — Chin should be tucked in.
  - — Repeated prone lying to prevent hip flexion contractures and dorsal kyphosis.
  - — Hip hyperextension in prone.

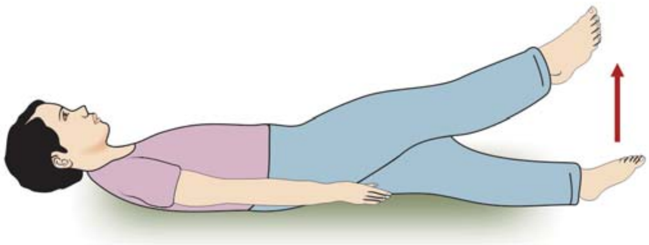


Fig. 29.16: Leg left: Lift one leg straight off the ground hold and count ten. Repeat with the other leg

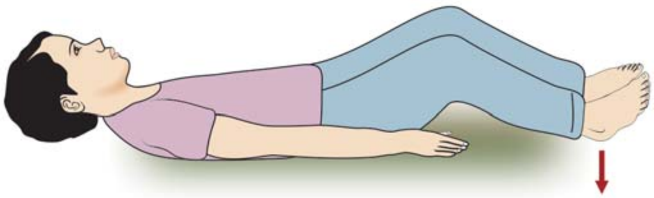


Fig. 29.17: Heel press: In the supine position with the knees slightly bent, press the bed with your heels and count ten

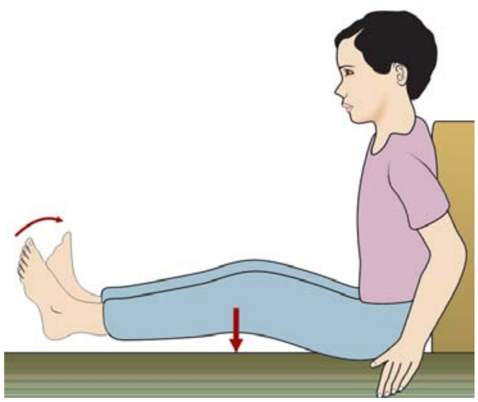


Fig. 29.18: Sitting leg flex: Sit on a bed or ground with the back supported. Try to straighten your knees and press them down against the bed or floor while gradually dorsiflexing your ankle joints. Hold and count ten

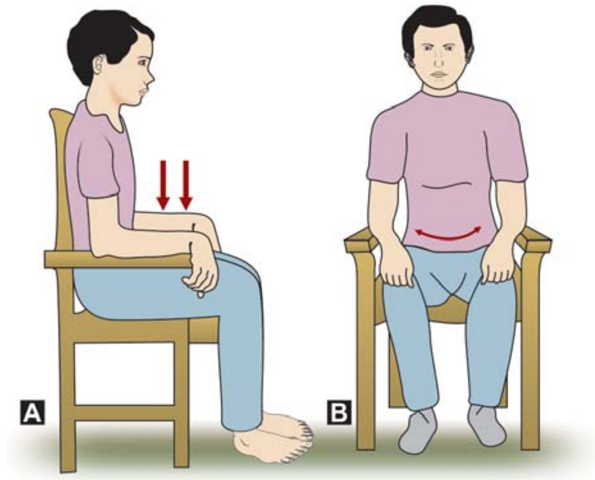


Fig. 29.19: Armrest push: (A) While sitting in a chair with armrest, press down on the armrest with your forearm once with the hand facing up and down, (B) Push the inner sides of the armrests with your forearm once with the hand facing up and down

Fig. 29.20: Forearm push: Push your forearm against the resistance offered by your other hand. Reverse and repeat

Figs 29.16 to 29.20: Exercises to improve range of motion in rheumatic arthritic joints

— Trunk lateral bending with deep breathing in prone.
— Avoid stooping posture, chest should be held up and the shoulders should be braced back.
— Isometric shoulder bracing are useful.
— Sleep on firm mattresses.
— Avoid using of spinal supports for a long time.
— Avoid prolonged bed rest.
— Swimming is encouraged particularly the front crawl and breast stroke.
— Group treatment in gymnasium and pool helps.

Following surgeries like THR, osteotomy of the spine, etc. appropriate physiotherapy measures suggested in earlier chapters should be instituted and followed.

Fig. 29.21: Hip stretch: In the supine position, with one leg straight, bend the other knee towards the chest. Count for ten and then repeat with the other leg

Fig. 29.22: Knee bender: In the supine position, keep both the knees bent—Now press one knee towards the chest and hold. Count up to ten and repeat with the other leg

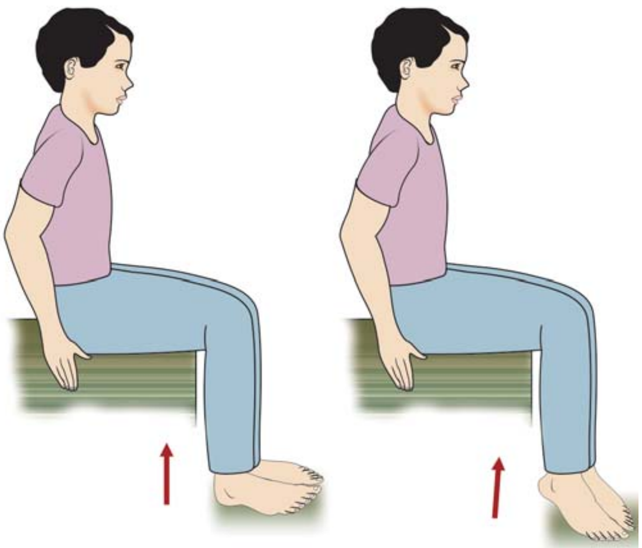


Fig. 29.23: Heel to toe stretch: Sit on the edge of a chair or bed keeping the feet flat on the ground raise the toes as high as possible with heel flat and then raise the heel while lowering the toes as much as possible. Count up hold and count up to ten

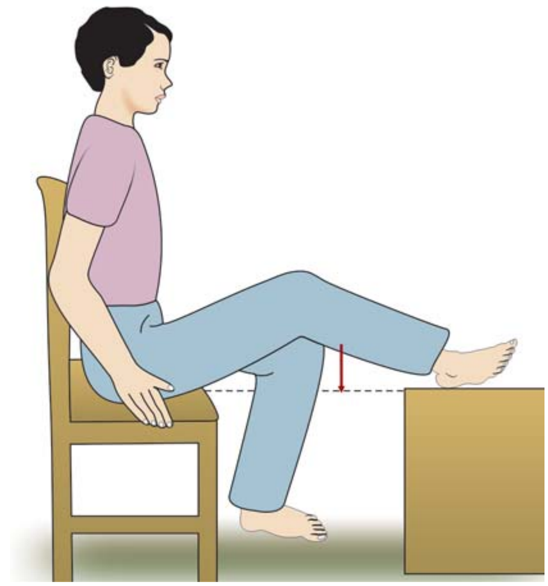


Fig. 29.24: Straightening the knee: While sitting on a chair, keep your leg on a stool. Now gradually straighten your leg while pushing the knee down. Hold and count for ten-repeat with the other leg

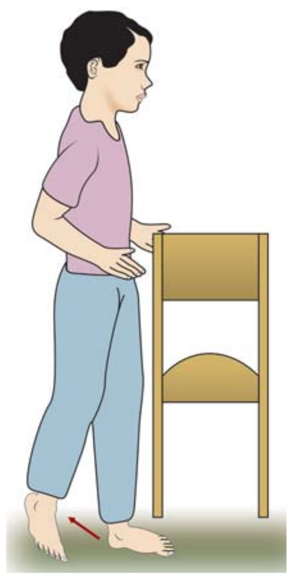


Fig. 29.25: Back-kick: With the hands supported, gradually lift one leg up and down keeping the knees straight hold and count ten. Now repeat with the other leg

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30

Chapter

Neuromuscular Disorders

CEREBRAL PALSY

This is a disorder of movement and posture caused by a non-progressive lesion in the immature brain. It was first reported in 1860 by William Little.

Lesions In cerebral palsy the lesion could be either in the brain or the upper cervical cord.

Incidence and Prevalence is 0.6-5.9/1000 livebirth. It is higher in males than in females and the ratio is 2:1. The prevalence at the school entry age is 2.4/1000 children.

Classification

Cerebral palsy can be classified based on clinical types or severity (Table 30.1).

Lesions in the brain In cerebral palsy the lesions in the brain can occur in the following four areas:

- *Cerebral cortex (spastic type)* Most common type and accounts for more than 50% of the cases.
- Midbrain (dyskinesia)
- *Cerebellum (ataxic)* It is rare and accounts for less than 10% of the cases.
- Widespread brain involvement (rigidity and mixed).

TABLE 30.1: Classification of cerebral palsy

Based on clinical types (Minear's)	*Based on severity*
• Spastic (65%) (Most common type) • Dyskinesia (25%) The following varieties are described **A**thetosis **T**remor **C**horeiform **D**ystonia **R**igidity • Ataxia • Mixed	• Mild (25%) Independent in daily activities. • Moderate (50%) Needs helping in daily activities and ambulation. • Severe Patient is bedridden and has a wheelchair existence.

TABLE 30.2: Causes of cerebral palsy

Prenatal	*Natal*	*Postnatal*	*Perinatal (0-7) days*
• Rubella infection • Fetal anoxia • Maternal diabetes	• Birth trauma • Anoxia • Prematurity	• Trauma • Encephalitis • Meningitis	• Most lesions causing CP occur during this period

Causes

In cerebral palsy the causes are different in prenatal, natal, postnatal and perinatal period and are listed as in Table 30.2.

Clinical Features

As mentioned earlier Spastic type is the most common and accounts for more than 70-80% of the cases. The presentation depends on the location of lesions in the brain and could be any one of the varieties depicted in Table 30.3. Single muscle involvement is rare as in polio and entire portion of the body supplied by that area of brain is involved, the patients show delayed milestones and primitive reflexes are usually preserved. Other clinical features depend on the geographic distribution of cerebral palsy and the associated handicapping situations.

However on the whole, all varieties of CP are characterized by abnormal muscle tone, reflexes, or motor development and coordination. There can be joint and bone deformities and

TABLE 30.3: Clinical presentation of spastic type of cerebral palsy

Geographic distribution of cerebral palsy	*Associated handicapping conditions*
• Monoplegia (0.3%)	• Sensory deficit in hand (50-60%)
• Hemiplegia (50%)	• Speech problems
• Paraplegia (21%)	• Mental retardation
• Triplegia (3.1%)	• Deafness
• Quadriplegia (25%)	• Visual defects
• Diplegia	• Seizures
• Double hemiplegia	• Perceptual problems
• Tetraplegia	• Emotional problems—most important
• Total body involvement	• Scoliosis

contractures. The classical symptoms are spasticities, spasms, other involuntary movements (e.g. facial gestures), unsteady gait, problems with balance, and/or soft tissue findings consisting largely of decreased muscle mass. Scissor walking and toe walking are common among people with CP who are able to walk, but overall, symptomatology of cerebral palsy is very diverse. The effects of cerebral palsy may vary from unnoticeable to "clumsy" and awkward movements on one end of the spectrum to such severe impairments that coordinated movements are almost impossible on the other end of the spectrum.

Babies born with severe CP often have an irregular posture and their bodies may be either very floppy or very stiff. Birth defects, such as spinal curvature, a small jawbone, or a small head sometimes occur along with CP. As a child grows older, symptoms may appear, change, or become more severe. Some babies born with CP do not show obvious signs in the beginning and may become evident as the baby reaches the developmental stage at 6/12 - 9/12 and is starting to mobilize, where preferential use of limbs, asymmetry or gross motor developmental delay is seen.

Secondary conditions can include *seizures, epilepsy,* speech (apraxia or dysarthria) in 31 to 88% of children and are associated with poor respiratory, laryngeal or oropharangeal dysfunction and oral articular disorderd due to decreased movement of the oral and facial muscles or communication disorders, eating problems, sensory impairments, *mental retardation, learning disabilities,* and/or behavioral disorders.

Orthopedic Deformities

The following are the common orthopedic deformities encountered in cerebral palsy (Fig. 30.1).

Fig. 30.1: Clinical photograph showing the orthopedic deformities in cerebral palsy

Upper limb
- Pronation contracture of the forearm.
- Flexion deformities of the wrist and fingers.
- Thumb in palm deformity.
- Swan neck deformity.
- Shoulder adduction and internal rotation deformity.

Lower limb
- Adduction deformity (most common).
- Flexion and internal rotation deformity.
- Dysplastic and subluxated hip.
- Dislocated hip.
- Pelvic obliquity.

Spine
- Scoliosis
- Kyphoscoliosis.

Knee
- Genu recurvatum
- Genu valgum
- Patella Alta
- Subluxation or dislocation of patella.
- Knee flexion contracture—Figure 30.2 (most common).

Foot
- Equinus deformity (Fig. 30.2).
- Varus or valgus (Fig. 30.3).
- Talipes equinovarus (Fig. 30.4).
- Calcaneus deformity.
- Talipes cavus.

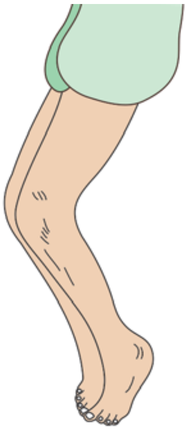


Fig. 30.2: Showing spastic contractures of the hip, knee and foot in cerebral palsy

Fig. 30.3: Showing spastic equinovalgus

Fig. 30.4: Showing bilateral spastic equinovarus

- Hallux valgus.
- Claw toes.

Quick Facts

Common causes of CP
- *Diplegia* Seen in premature infants
- *Athetoid* Kernicterus
- *Hemiplegia* Trauma, cerebrovascular accidents, infection, etc.
- *Quadriplegia* Brain anoxia

Treatment

Unfortunately, there is no cure for cerebral palsy. Hence the *aim of treatment is to increase patient's assets as much as possible and minimize his or her defects*. Treatment is usually symptomatic and focuses on helping the person to develop as many motor skills as possible or to learn how to compensate for the lack of them. Non-speaking people with CP are often successful availing themselves of augmentative and alternative communication systems such as *Blissymbols*.

Overall the treatment may include one or more of the following: physical therapy; occupational therapy; speech therapy; drugs to control seizures, alleviate pain, or relax muscle spasms (e.g. benzodiazepienes, baclofen and intrathecal phenol/baclofen); hyperbaric oxygen; the use of *Botox* to relax contracting muscles; surgery to correct anatomical abnormalities or release tight muscles; braces and other orthotic devices; rolling walkers; and communication aids such as computers with attached voice synthesizers.

Order of preference to improve the quality of life in cerebral palsy is as follows:
- Education and communication is the first priority.
- Activities of daily life.
- Mobility.
- Ambulation.

The role of an orthopedic surgeon starts when the child is 12 months of age and seldom before.

Treatment Methods in Brief
- Motor age test.
- Physiotherapy, occupational therapy, speech therapy, etc.

Physiotherapy Measures in Cerebral Palsy

This consists of passive stretching of the spastic joints, thermotherapy to reduce pain and exercises to mobilise and strengthen the joints. The programs are designed to encourage the patient to build a strength base for improved gait and volitional movement, together with stretching programs to limit contractures. It is believed that life-long physical therapy is essential to maintain muscle tone, bone structure, and prevent dislocation of the joints.

Occupational therapy helps adults and children maximise their function, adapt to their limitations and live as independently as possible.

Orthotic devices such as ankle-foot orthoses (AFOs) are often prescribed to minimise gait irregularities. AFOs have been found to improve several measures of ambulation, including reducing energy expenditure and increasing speed and stride length.

Speech therapy helps control the muscles of the mouth and jaw, and helps improve communication. Just as CP can affect the way a person moves their arms and legs, it can also affect the way they move their mouth, face and head. This can make it hard for the person to breathe; talk clearly; and bite, chew and swallow food. Speech therapy often starts before a child begins school and continues throughout the school years.

Hyperbaric oxygen therapy (HBOT), in which pressurized oxygen is inhaled inside hyperbaric chamber has been used to treat CP under the theory that improving oxygen availability to damaged brain cells can reactivate some of them to function normally. Its use to treat CP is controversial.

Nutritional counseling may help when dietary needs are not met because of problems with eating certain foods.

Massage therapy and **hatha yoga** are designed to help relax tense muscles, strengthen muscles, and keep joints flexible. Hatha yoga breathing exercises are sometimes used to try to prevent lung infections.

A new study has found that **cooling** the bodies and blood of high risk full term babies shortly after birth may significantly reduce disability or death.

Cord blood therapy There are no published trials of this treatment modality in cerebral palsy. In a clinical trial involving a child, his own cord blood that his parents had saved when he was born was injected. It was reported that within 5 days after the procedure he was walking on his own and talking, something his mother said he was not capable of on his own and it was doubtful he would ever be able to do on his own.

Conductive education (CE) was developed in Hungary from 1945 based on the work of *András Petõ* and is believed to improve mobility, self-esteem, stamina and independence as well as daily living skills and social skills. The conductor is the professional who delivers CE in partnership with parents and children. Skills learned during CE should be applied to everyday life and can help to develop age appropriate cognitive, social and emotional skills. It is available at specialized centers.

Biofeedback is an alternative therapy in which people with CP learn how to control their affected muscles. Some people learn ways to reduce muscle tension with this technique. Biofeedback does not help everyone with CP.

Neuro-cognitive therapy A new approach to treating cerebral palsy from [Snowdrop]. It is based upon two proven principles.

- *Neural plasticity* The brain is capable of altering its own structure and functioning to meet the demands of any particular environment. Consequently if the child is provided with an appropriate neurological environment, he will have the best chance of making progress.
- *Learning can lead to development* As early as the early 1900s, this was being proven by a psychologist named Lev Vygotsky. He proposed that children's learning is a social activity, which is achieved by interaction with more skilled members of society. There are many studies, which provide evidence for this claim. There are however, as yet no controlled studies on neurocognitive therapy.
- *Patterning* is a controversial form of alternative therapy for people with CP.
- *Drug therapy* The role of drug therapy is disappointing. Muscle relaxants, antiepileptic may have a role.

  Botulinum Toxin A (Botox) injections into muscles that are either spastic or have contractures, the aim being to relieve the disability and pain produced by the inappropriately contracting muscle.
- *Surgery*
  - — It is not done till 5 years of age.
  - — It is indicated to correct deformity in an ambulatory patient and to make him or her socially more acceptable.
  - — It is commonly indicated in spastic type of CP.

Aim of surgery in cerebral palsy is
- To correct the deformity
- To balance the muscle power
- To stabilize uncontrollable joints

Choice of Surgery

- Operation on nervous system:
  - — Sympathectomy, rhizotomy (anterior or posterior) involves cutting of the nerve roots.
- Operation on muscles and tendons:
  - — Tenotomy, tendon lengthening and tendon transfers.
  - — Myotomy and muscle transposition.
- Operation on bones and joints:
  - — Bone lengthening or bone shortening to equalize the limb lengths.
  - — Osteotomies to correct knock knee and other bone deformities.
  - — Arthrodesis of wrist, hip and foot to correct deformity, provide stability and to improve functions.
- The insertion of a Baclofen pump usually during the stages while a patient is a young adult. This is usually placed in the left abdomen. It is a pump that is connected to the spinal cord, whereby it sends bits of Baclofen alleviating the continuous muscle flexion. Baclofen is a muscle relaxant and is often given PO to patients to help counter the effects of spasticity.
- **Braces** Use of braces in CP cases is recommended to:
  - — Improve function.

— Control unnecessary movements.
— Prevent and correct deformities.

Prognosis in Cerebral Palsy

- There is no permanent cure.
- Athetoid child is more intelligent than spastic child.
- Twenty-five percent go to schools.
- Twenty-five percent are mentally retarded.
- Twenty-five percent are not educable.
- All hemiplegics will walk (by 12 to 16 months).
- Most diplegics will walk (by 4 years).
- Quadriplegics and total body involvement will never walk but can be propped sitters.

POLIOMYELITIS

This is a viral infection of the anterior horn cell of the spinal cord or nerve cells of brainstem, resulting in temporary or permanent paralysis. Common in children less than 5 years, often attacks young adults.

Viruses

The following Picorna group of viruses (25-27 mm in diameter) is known to cause poliomyelitis:
- Brunhilde (type I)
- Leon (type II)
- Lansing (type III).
  (Mnemonic LLB for the 3 viruses)

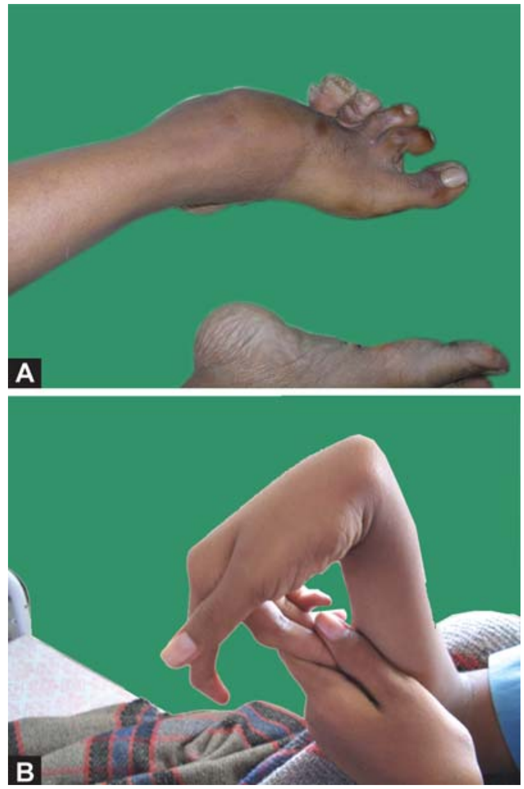
Pathogenesis

The virus is transmitted by droplet infection and through the faeco-oral route and enters the nervous tissue and destroys the nerve cells, anterior horn cells of the spinal cord and brainstem as a result of which the peripheral nerve degenerates resulting in muscle and tendon atrophy due to flaccid paralysis. The bones become small, the joint capsules and ligaments become lax as there is no protection by the healthy muscles. All these results in development of various deformities.

Clinical Features

Polio usually affects children less than 12 months. There is a mild episode of fever, headache and diarrhea. The incubation period is 3-30 days. On examination there could be mild neck stiffness and the child may find it difficult to move the affected limb (preparalytic). The lower limbs are more commonly affected and the paralysis could be partial or total (paralytic stage) (Flow chart 30.1).

The paralysis of the muscles whether spinal (75%) or bulbar (25%) usually lasts till two months. Then there may or may not be recovery for a period of two years. Any residual paralysis after two years of affection is permanent with no chance of recovery (Figs 30.5A and B). Bulbar poliomyelitis is rare and affects the respiratory muscles. It may be fatal. The sensory system is not affected.



Figs 30.5A and B: Clinical photograph showing lower limb deformities (A) and upper limb deformities (B) in PPRP

Quick Facts

Features of paralysis due to polio
- Lower limb is more commonly affected than the upper limbs.
- The involvement is asymmetric.
- Though incomplete most of the times quadriceps are more often affected.
- Tibialis anterior is most often completely paralyzed.
- The sensory system is not affected.
- In the residual stages (post polio residual stages) the common deformities are
  — *Hip* Flexion, abduction and external rotation
  — *Knee* Flexion, triple deformity and genu valgum
  — *Foot* Talipes equinovarus (Fig. 30.5A)

Flow chart 30.1 shows stages and corresponding clinical features of poliomyelitis

Flow chart 30.1: Shows stages and corresponding clinical features of poliomyelitis

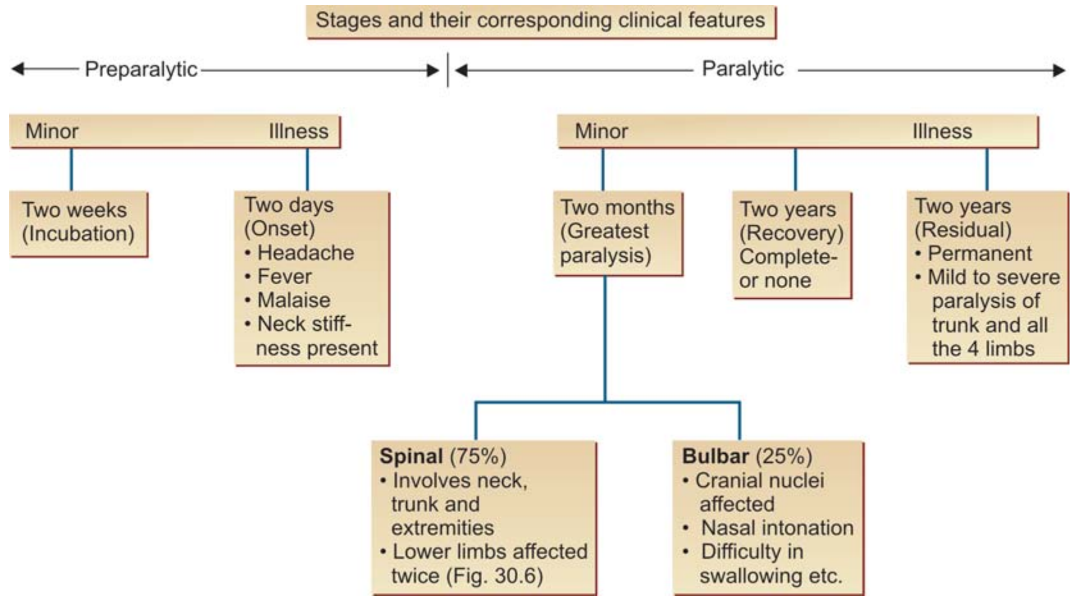


Fig. 30.6: Showing lower limb deformities in poliomyelitis

How does recovery in poliomyelitis take place?

- The injury to the cell which is not lethal recovers.
- The temporary interruption of the nerve cell conduction due to swelling following inflammation resolves as the inflammation resolves.
- The temporary dysfunction at the cortical and subcortical levels resolve.
- Some of the cells recur their earlier morphology.
- Some of the functional pathways adjust to the destruction re-routed.
- There may be axonal sprouting in the existing narrows.
- There may be hypertrophy of the existing muscle cells and also the nerves.

Quick Facts

Recovery from polio:
- 3rd-5th week maximum recovery.
- 6 month considerable recovery.
- By 12 month 95% recovery.
- After 16 months, remote.

Quick Facts

Precautions to be taken during the early stages of polio
- Avoid unnecessary activities.
- Avoid injections, surgical operations, etc.
- Avoid unnecessary transfers, etc.
- Avoid improper positions.

Orthopedic Deformities

Orthopedic deformities encountered in poliomyelitis are listed in the Table 30.4.

TABLE 30.4: Common orthopedic deformities encountered in poliomyelitis

Region affected	*Deformities*
• **Foot and ankle**	• Claw toes • Claw foot • Talipes equinus • Talipes equinovalgus • Flail foot • Pes cavus • Dorsal bunion • Talipes equinovarus • Talipes calcaneovalgus
• **Knee**	• Flexion contracture of the knee • Quadriceps paralysis • Genu recurvatum • Flail knee
• **Hip**	• Flexion abduction contractures of the hip • Paralysis of gluteus medius, maximus • Paralytic dislocation of hip
• **Iliotibial Band Contractures** (Results in 9 classical deformities)	• Lumbar scoliosis • Pelvic obliquity • Hip flexed and abducted • External rotation of femur • Flexion and valgus of knee • Posterior and lateral subluxaion of tibia • External rotation of tibia • Foot in equinus • Shortening
• **Spine**	• Kyphosis • Scoliosis • Kyphoscoliosis
• **Upper limbs**	• Paralysis of shoulder, elbow, forearm and hand muscles

Quick Facts

Causes of the deformity

- During the acute phase
  - — Muscle spasm
  - — Faulty limb positioning
  - — Habitual postures
- During the sub acute phase
  - — Muscular imbalance (due to asymmetric paralysis)
  - — Extensor
- During the chronic phase
  - — Muscle and soft tissue contractures

Differential Diagnosis

Poliomyelitis has to be differentiated in the acute stages from:

- Pyogenic meningitis
- Guillain-Barré syndrome
- Postdiphthertic paralysis
- Acute osteomyelitis
- Scurvy, etc.

In the late stages from

- Cerebral palsy
- Spina bifida
- Myopathies
- Muscular dystrophies, etc.

Treatment of Poliomyelitis

Broad principles of the treatment

- To prevent deformities from developing.
- To assist returning of muscle power by graduated exercises.
- To reduce disability by appropriate appliance or by operations on joints and muscles.

Treatment Methods

Early stages (< 3 weeks) During the stages of onset, maximum paralysis and the stages of recovery the following treatment is recommended, the child is admitted into the hospital, and supportive treatment is given. The child is put on a ventilator support if there is respiratory paralysis due to bulbar polio. *Warm and moist packs are given to the joints and all intramuscular injections are avoided during this phase*. The affected joints are immobilized by plaster splints in functional positions to prevent contractures. Supportive measures are given for relief of muscle pain and spasm.

Recovery stages (4 weeks to 18 months) In this stage the joints are properly splinted through various appliances (Table 30.5) to prevent or correct the deformities.

Other measures during the recovery stage

- Exercises to increase the muscle mass of the intact muscle fibers. Tricycle exercises are ideal.
- *Hydrotherapy Warm* water pool therapy is found to be very effective during this phase.

TABLE 30.5: External appliances in poliomyelitis

Appliances	*Functions*
• Spinal brace	To support weak spine
• Abdominal support	To check abdominal protrusion when abdominal muscles are weak
• Hip, knee, ankle, foot Orthosis with or without pelvic support (HKAFO)	For deformities of the hip, knee and ankle
• Knee caliper (KAFO)	To hold knee extended in quadriceps palsy
• Below knee brace	To stabilize a flail ankle or foot
• Single below knee (Lateral or medial)	To control varus or valgus
• Drop foot appliance	For mobile equinus deformity

- PNF techniques.
- Unnecessary immobilization by splinting should be avoided.
- Orthotic support should be provided to children who attempt to walk and bear weight.
- One or two exercises for important muscles should be taught to the parents and the child for carrying it out at home.
- Premature weight-bearing at this stage of the disease should be discouraged.
- The importance of regular check-up and treatment by a physiotherapist should be high-lighted.
- After 6 months to 1 year graded resistive exercises, preferably during the activities of daily living greatly improves the resistance and strength of the existing muscles.
- Swimming, jogging, walking and other aerobic exercises should be greatly encouraged.

Home treatment regimen during early recovery stage
- Simple exercises for important muscle groups in the beginning.
- Emphasizing prevention of early weight bearing to prevent deformities.
- Methods to prevent contractures should be taught to the mother and the child.
- The value of regular physiotherapy follow-up should be explained to the parents.
- Only one or two exercises are taught in one session.

Quick Facts

Conservative treatment	
• **Stage of onset**	Bed rest
• **Stage of greatest paralysis**	Splints Artificial respiration, etc.
• **Stage of recovery**	Physiotherapy Walking aid Crutches, etc
• **Stage of residual paralysis**	Can be corrected by provision of suitable Orthotic appliances or by operation

Role of Appliances

The purpose of external appliances (Fig. 30.7) is to support joints that have lost their normal control. They are more often required for lower limbs rather than upper limbs. The commonly prescribed appliances in Table 30.5.

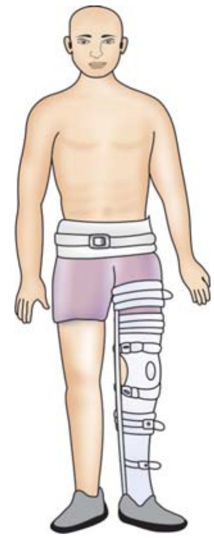


Fig. 30.7: Showing an above knee caliper (KAFO) in a polio patient

Stage of postpolio residual paralysis (> 18 months) During this stage the role of orthopedic surgeon is predominant and surgery is the treatment of choice.

Treatment during Postpolio Paralysis

After 2 years, the chances of neurological are remote. Functional recovery with appropriate guidance, training, supports, aids, etc. are encouraged in this phase rather than individual muscle exercises. Compressive and stretching forces on the affected joints should be avoided.

Care should be taken to avoid compensatory muscle movements (trick movements) to take the place of functional activity during the phase of recovery. However, after the phase of recovery is over, compensatory movement in place of functional activities is encouraged and developed by strengthening exercises.

Fatigue to the muscles should be avoided by proper orthotic supports.

Goals of surgery
- To obtain muscle balance.
- To prevent or correct soft tissue contractures.
- To prevent or correct bony deformities.
- To improve functioning tendon transfers.
- To improve limb length discrepancy.

Surgical methods
- *Soft tissue release* for soft tissue contractures, e.g.
  — *Soutter's release* Structures arising from anterior superior iliac spine are released for hip contractures.

— *Ober-Yount's procedure consists* of sectioning the iliotibial band (ITB) contractures.
— *Tendo-Achilles* Lengthening for equinus deformity of the foot.
— *Steindler's release* of plantar fascia for cavus foot.

- *Tendon transfers* this is indicated when dynamic muscle imbalance produces deformity requiring brace protection.
  Aims of tendon transfers
  — To replace the function of a paralyzed muscle.
  — To remove the deforming force.
  — To provide stability by improving the muscle balance. Tendon transfers are not limited to any age group.
- *Arthrodesis* This is done to:
  — Stabilize a flail joint.
  — Eliminate the need for brace and to improve function.
  — For permanent method of joint stabilization.
- *Osteotomies* to correct deformities like genu valgum, varum, flexion, etc.
- Ilizarov technique for leg length equalization can be done by lengthening of the shortened femur or tibia.

Surgical Methods for Correction of Limb Length Discrepancy

Table 30.6 shows the surgical methods for correcting various limb length deformities.

Postsurgical Physiotherapy in Poliomyelitis

After release of soft tissue contractures The following measures are suggested:

- *Measures to prevent recurrence* After the release of contractures, recurrence have to be prevented by appropriate joint positioning.
- *Measures to mobilize the joints* Active and passive ROM exercises are advised to mobilize the joints.
- *Measures to strengthen the muscles* To prevent recurrence, the antagonistic muscles should be exercised to strengthen them and increase their endurance.

Quick Facts

Surgery	*Position*
• After hip contracture release	Prone lying
• After iliotibial and hamstring release	Knee extension
• TA Z-plasty	Dorsiflexion in neutral position

TABLE 30.6: Specific surgical methods

Deformity	*Recommended surgical methods*
Upper limbs	
• Shoulder abduction	• Trapezius transfer to the neck of humerus • Shoulder arthrodesis
• Elbow flexion paralysis	• Steindler's flexor plasty—transfer of common flexor origin at the medial epicondyle of the humerus to the anterior aspect of the lower end of humerus
• Wrist paralysis	• Tendon transfers • Arthrodesis
• Hand	For thumb abduction sublimis tendon from the middle phalanx is transferred to the abductor pollicis brevis
Spine	Spine fusion with or without anterior or posterior instrumentation
Lower limbs	
• Hip flexion contracture	Soutters release
• Knee	• Mild—division of iliotibial tract • Moderate—lengthening of hamstrings • Severe—Wilson's operation (hamstring lengthening and posterior capsulotomy of knee)
• Ankle equinus	Tight tendo-Achilles Z plasty
• Foot	Tight plaster fascia
Cavus	Steindler's operation
Tendon transfer surgeries	*Transfer*
• Hip—gluteal maximus	Iliopsoas and rector spinae into paralysis gluteus maximus
Gluteal medial paralysis	Tensor fascia into gluteus medius
• Knee	
Quadriceps paralysis	Hamstring transfer into patella
• Foot	
— Talipes equinus	Triple arthrodesis (Lambrunidi type)
— Talipes calcaneus (Due to paralysis of gastrocnemius)	• One stage-To correct cavus. Fusion of talonavicular joint and Steindler's release • Second stage-transfer of tibialis posterior, or peroneals or long toe flexor into tendo-Achilles
— Talipes varus (paralysis of peroneal muscles)	Transfer tibialis tendon to the cuboid bone
— Talipes valgus (Due to paralysis of tibialis anterior muscle)	Transfer of peroneals muscles into the cuboid bone
— First metatarsal drop	Modified Jones operation. Transfer of extensor hallucis into neck of first metatarsal and fusion of the IP joint of the great toe

- *Measures of home treatment programme* the patient should be taught proper positioning, exercises, weight-bearing, etc. to be followed at home for better recovery.
- *Retraining measures* After the surgery, patient should be retrained in gait, weight-bearing joint movements, etc.

After tendon transfers here reeducation of the transferred tendon for its newly acquired role is very vital. The following measures are suggested:
- Gentle passive stretching exercises.
- Gradual active and active assisted movements.
- The process of electrical stimulation greatly helps.
- Dynamic orthotics may help in some cases.

After arthrodesis
- Strengthening exercises to the adjacent joints are given.
- Patient is trained in non-weight bearing crutch walking.
- Mobilization regime after arthrodesis is planned. Single leg balance, walking aids, weight transfers, etc. are some of the recommended measures.

After limb lengthening procedures
- Active ROM exercises to unaffected joints.
- Isometric exercises to quadriceps and glutei after removal of the fixator.
- Training in gait, balance, weight bearing and weight transfers are given.

Quick Facts

Principles of postpolio surgical physiotherapy	
Surgical procedure	*Emphasis on*
• Contracture release	To prevent recurrence
• Tendon transfers	Reeducation and retraining of transferred tendons
• Arthrodesis	Retraining to use the limb functionally

ARTHROGRYPOSIS MULTIPLEX CONGENITA (AMC) [Also Called Multiple Congenital Contractures (MCC)]

In the year 1841, Otto first described AMC. Swinyard and Beck gave the name MCC. AMC is a nonprogressive syndrome characterized by
- Rigid and deformed joints.
- Muscle absence or atrophy.
- Cylindrical or ellipsoid joints with skin crease loss and subcutaneous atrophy.
- Contractures of capsules and periarticular structures.
- Dislocation of joints like hip and knee.
- Normal mentality and intact sensation.

Causes

Intrauterine immobilization of joints at various stages of development is due to:
- Myopathic cause seen in 10 percent of cases. Autosomal recessive.
- Neurogenic cause is due to reduced number or improper organization of anterior horn cells, peripheral nerves and motor end plates, weakness of muscles, etc.
- Mechanical causes like breech, twins, oligohydramnios amniotic bands, etc. which reduce the intrauterine space.

Classification (Sharrard, Brown and Robson)

Eight types Two upper limb and six lower limb deformities are encountered.

Common variety is quadriplegic type (Fig. 30.8). Scoliosis is associated in 20 percent of the cases of AMC; webbing of the knees is seen in some.

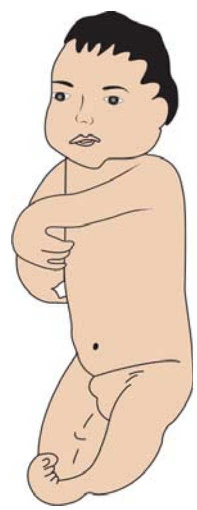


Fig. 30.8: Quadriplegic type is the most common variety of arthrogryposis multiplex congenita (AMC)

Common Orthopedic Deformities in AMC

Figure 30.9 shows common orthopedic deformities in AMC like:
- *Foot* Planovalgus and equinovarus.
- *Knee* Flexion contracture and fixed in extension.
- *Hip* Extension, abduction, external rotation.

Fig. 30.9: Clinical photograph showing the deformities in AMC

- *Shoulder* Medial rotation of shoulder.
- *Elbow and wrist* Flexed attitudes.

Investigations

- Muscle biopsy.
- Electromyography.
- Nerve conduction studies.
- Radiograph for scoliosis, dislocation, etc.
- Chromosomal studies.

Treatment

The treatment consists of passive stretching exercises, serial splinting of the limbs and surgical correction.

Principles of orthopedic treatment

- Muscle balance is to be restored if tendons are available for transfers.
- Recurrence is the rule due to tough, inelastic capsule and soft tissues.
- Tenotomies should be accompanied by capsulotomy and capsulectomy.
- Osteotomies are to be carried out once skeletal growth is over, otherwise recurrence occurs.
- Maximum correction is to be obtained during the initial surgery. There is no role of wedging, etc.

LEPROSY IN ORTHOPEDICS

Leprosy is a chronic infectious disease caused by *Mycobacterium leprae*. It affects mainly the peripheral nerves and also affects the skin, muscles, bones, testes and internal organs.

Clinically It is characterized by:

In early stages:

- Hypopigmented patches (Fig. 30.10).

Fig. 30.10: Clinical photograph showing the rashes in leprosy

- Loss of cutaneous sensation.
- Thickened nerves.
- Presence of acid-fast bacilli in the skin or nasal smears.

In late stages:

- Trophic ulcers.
- Foot-drop/claw toes.
- Claw hand.
- Nasal bridge collapse.
- Loss of fingers or toes.

National Leprosy Eradication Program

It was launched in 1983, with the goal of arresting the disease by the turn of century based on multidrug therapy.

Problems of leprosy in India

- Four million cases
- Prevalence rate—5.7/1000
- Fifteen to twenty percent cases of population are multibacillary
- Twenty percent result in deformities.

Three classifications are proposed as given in Table 30.7.

TABLE 30.7: Classification in leprosy

Indian	*Madrid*	*Ridley and Joppling*
Indeterminate	Indeterminate	Tuberculoid
Tuberculoid	Borderline	Borderline tuberculoid
Lepromatous	Tuberculoid	Lepromatous
Borderline	Lepromatous	Borderline both
Neuritic		Lepromatous

Investigations

- Bacteriological examination of material obtained from the skin or nasal smears
- Foot pad culture of mice is 10 times more sensitive than the skin slit smears
- Histamine test
- Biopsy
- Immunological tests.

Tests for detecting CMI
- Lepromin test
- Lymphocyte transformation test

Tests for detecting humoral antibodies
- ELISA test, etc.

Treatment

Primary prevention by vaccine is not possible, so leprosy control is based on effective chemotherapy.

Chemotherapy is the mainstay of treatment and consists of drugs like Rifampicin,Dapsone, Clofazamine, etc. Table 30.8 shows the drugs and their dosages used in leprosy. If Clofazimine is not acceptable, ethionamide—250-375 mg/day is advised.

TABLE 30.8: Drugs and their dosage in leprosy

Multibacillary	*Paucibacillary*
Rifampicin-600 mg/month	R-cin 600 mg/month for 6 months
Dapsone 100 mg/day	+
Clofazimine 300 mg/month	Dapsone 100 mg/day for 6 months

Duration of treatment is at least for 2 years till smear is negative.

BCG vaccine showed a high degree of protection in 80 percent and 30 percent in some cases.

Orthopedic Deformities In Leprosy

Ankle and foot Every kind of deformity is seen in the foot. Deformity is gross, because patient continues to use the foot despite loss of sensations. Ankle is rarely affected in this disease.

In leprosy due to loss of sensation, there is absence of warning pain as a result of which, there is injury. Secondary infection following an injury is common.

Classification of foot deformities in leprosy as depicted in Table 30.9.

TABLE 30.9: Classification of foot deformities in leprosy

Forefoot	*Midfoot*	*Hind foot*
• Plantar ulcers • Toe deformities • Chronic osteo-myelitis of metatarsals • MTP joints destruction	• Aseptic necrosis of talus, etc. • Infective arthritis and osteomyelitis • Degenerative arthrolysis • Proliferative ankylosing arthropathy	• Chronic Osteomyelitis of calcaneum • Plantar ulcers • Calcaneal spur • Gross destruction

Fig. 30.11: Clinical photograph showing the foot drop

Foot Drop

This is one of the very common complications encountered in leprosy. It is seen in 2 percent of the cases (Fig. 30.11).
- Common peroneal nerve is more commonly involved.
- Usually it is completely damaged, sometimes only deep peroneal or superficial branch is involved.
- Occasionally only external hallucis longus muscle is involved.

Consequence of Paralysis

- Foot drop, drop toes, inversion and plantar flexion of the foot is decreased.
- High stepping gait.
- Instability of gait.
- Deformity due to contractures of tendocalcaneus and capsules of subtalar and ankle joints.
- Fixed equinovarus deformity.
- Destruction of foot.

Treatment

- *For recent or incomplete drop foot:* Toe rising spring, physiotherapy, short wave diathermy, ultrasound, local steroids, etc. are the recommended forms of treatment.
- *If more than one year after affection or if the lesion is complete* surgical correction is needed.

Before the surgical correction ensure the following
- Non-involvement of medial plantar nerve.
- No contractures of tendo-Achilles.
- At least 20° of dorsiflexion should be present.
- Tendo-Achilles shortening requires physiotherapy in the early stages and in the later stages tendo-Achilles lengthening.

Surgical Methods for Foot Drop

- When there is no contracture and if the foot is mobile, tibialis posterior transfer is indicated.
- Triple arthrodesis of Lambrunidi for fixed equinovarus deformity of the foot.

Plantar Ulcers

This is the other important foot complication in leprosy. It is also known as trophic ulcers due to neurological deficit. It has a spontaneous onset, it is painless, persists, and recurs. Healing process is not defective. Recurrent ulceration causes progressive destruction of the skeleton (Figs 30.12A and B).

Aims of treatment
- To get the ulcer healed.
- To prevent its recurrence.

Sites Plantar ulcers are commonly seen over the ball of feet especially first metatarsal, and heel.

Figs 30.12A and B: Clinical photograph showing the plantar ulcers

Treatment of Plantar Ulcers

Table 30.10 clearly shows the treatment plan in the management of plantar ulcers.

TABLE 30.10: Treatment plan in plantar ulcers

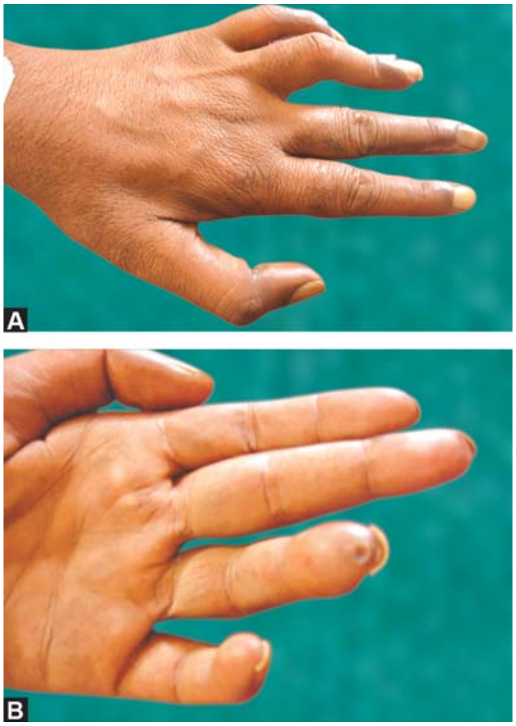
To heal the ulcer	*To Prevent Recurrence*
Principles *Provide rest* *Control infection* *Promote healing*	**1. Non-surgical measures** • Healthy instructions • Protective foot-wear – To protect skin from injury—use tough outer sole
State of ulcer 1. If acute • Rest, elevation • Eusol applications • Antibiotics • Incision and drainage • Dressing	– To reduce stress of walking— use MCR rubber in sole – To relieve vulnerable sites from pressure modification of foot - wear or use orthosis
2. If chronic • Rest • Below knee caliper • Below knee plaster cast	**Methods to relieve pressure** • Metatarsal bar (20%) • Arch support (30%) • Moulded insole (40%) • PTB cast rest
3. Complicated ulcer When it spreads to Deeper structures like bone joints, tendon, etc. • Ulcer debridement • Once infection is controlled treat it later as chronic ulcer as mentioned above. • Protective footwear later	**2. Surgical measures** Supplements and not substitutes for non-surgical measures. **Methods** • Scar excision • Osteotomies • Arthrodesis • Resection, etc. depending on indications *Note:* • MCR—Microcellular rubber

Deformities of the Hand in Leprosy

The following are the common hand deformities encountered in leprosy (Figs 30.13A and B).
- *Ulnar claw hand* is due to affliction of ulnar nerve at the elbow.
- *Total claw hand* is due to the affliction of ulnar nerve at the elbow and median nerve at the wrist.
- *Triple nerve palsy* the following nerves are affected:
  — Ulnar nerve at the elbow.
  — Median nerve at the wrist.
  — Radial nerve at the spiral groove.

Surgery for Hand

- *Brand's many tailed tendon transfer operation (EF4T)* Developed by Paul Brand at the Christian Medical College, Vellore, India.



Figs 30.13A and B: Clinical photograph showing the hand deformities in leprosy

- Extensor carpi radialis longus is released from its insertion and brought into the flexor aspect of the forearm. Free graft from palmaris longus tendon is taken and is split into 4 strips which are then attached to the extensor expansion of the respective fingers (EF4T).
- *Restoration for opponens palsy* Flexor digitorum superficialis is detached from its insertion rooted through the palm and attached to the lateral margin of the extensor expansion.
- *Ulnar claw hand S.* Bunnel's operation.
- *Triple nerve palsy* this is difficult to correct surgically.

Physiotherapy Measures

See the chapter 17 "Peripheral Nerve Injury".

MUSCULAR DYSTROPHIES

These are difficult problems to treat and the cause is usually not known.

*Duchenne Muscular Dystrophy

This is the most common type of muscular dystrophy encountered.

*Duchenne** (1806-1875) of Paris. Described muscular dystrophy.

Figs 30.14A and B: Clinical photograph showing the deformities in muscular dystrophies

Clinical Features

This consists of delayed walking, abnormal gait and multiple falls (in less than 3 years child). Gower's sign is positive, hypertrophy of calf muscles, waddling gait, increased lumbar lordosis, weakness of shoulder muscles around 5 to 6 years, serrati, pectorals, deltoid, latissimus dorsi, biceps, triceps and brachialis muscles are weak. In lower limbs weakness of hip flexors, evertors of feet, tibialis anterior are seen, ocular, pharyngeal and masticatory muscles are never involved. Knee jerk is absent earlier than ankle jerk. Tendo-Achilles contractures appear first, later hamstrings, hip flexors and elbow follow. Intellectual impairment is present. Death below 16 years is due to respiratory infection or cardiac failure (Figs 30.14A and B).

Investigations

- Serum glutamic oxaloacetic transminase (SGOT), serum glutamate pyruvate transaminase (SGPT), lactate dehydrogenase5 (LDH5) aldolase and creatinine phosphokinate (CPK) levels are raised.

TABLE 30.11: Classification of muscular dystrophies

Sex linked dominant	*Autosomal recessive*	*Autosomal recessive*
• Duchene's • Becker's • Emery and Dreifus	• Facioscapulohumoral • Scapuloperoneal • Distal • Occulopharyngeal	• Limb girdle • Childhood variety • Congenital dystrophy • Limited to quadriceps

- Muscle biopsy and electromyography (EMG) helps.
- Electrocardiogram (ECG) shows biventricular hypertrophy.

Classification

Classification of muscular dystrophies is depicted in Table 30.11.

Facioscapulohumeral Muscular Dystrophy

This is seen in second decade of life and the fascial musculature is involved early. Patient complains of inability to close the eyes, slurred speech, etc. Elevation of the scapula on abduction is characteristic. In the upper limbs deltoid and wrist flexors are spared. In the lower limbs anterior tibial muscle is involved earlier. Majority of the patient suffering from this dystrophy have a normal life span.

Limb Girdle Muscular Dystrophy

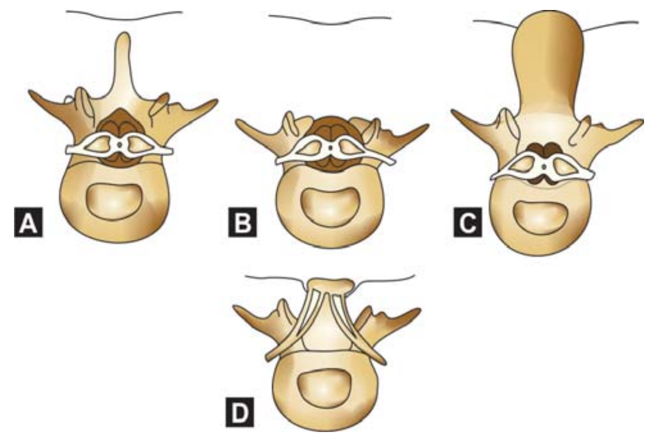
It is seen in the second or third decade. Lower limb girdle weakness appears first followed by upper limb. Muscular hypertrophy is rare. Winging of the scapula is seen. There is no involvement of cardia.

Treatment Measures and Physiotherapy Treatment for Muscular Dystrophies

This consists of physiotherapy, mental and physical support, speech therapy, and mechanical aids like splints, walking aids, etc.

SPINA BIFIDA

(Latin - SPLIT SPINE)
This is due to the failure of the fusion of the two vertebral arches in the embryological stages of development of spine. The failure of fusion could be limited, only to the spinous process resulting in *spina bifida occulta*, the most common variety or the entire vertebral arch including the neural elements may fail to fuse giving rise to the rare variety of *spina bifida aperta* (Figs 30.15A to D).



Figs 30.15A to D: Showing different types of spina bifida: (A) Spina bifida occulta, (B) Spina bifida aperta (meningococele), (C) Myelomeningocoele, (D) Myelocoele

Incidence

Spina bifida is one of the most common birth defects, with an average worldwide incidence of 1-2 cases per 1000 births, but certain populations have a significantly greater risk.

Causes

Spina bifida is caused by the failure of the neural tube to close during the first month of embryonic development (often before the mother knows she is pregnant). Normally, the closure of the neural tube occurs around 28 days after fertilization. However, if something interferes and the tube fails to close properly, a neural tube defect will occur.

- *Unknown* In majority of cases the cause is still not known.
- *Medications* During pregnancy like anticonvulsants, diabetes,
- *Genetic* It could run in families and there could be a genetic basis for the condition. As with other human diseases such as cancer, hypertension and atherosclerosis (coronary artery disease), spina bifida likely results from the interaction of multiple genes and environmental factors.
- *Obesity* Obese pregnant ladies are more prone.
- *Raised body temperature* from fever or external sources such as hot tubs and electric blankets can increase the chances a woman will conceive a baby with a spina bifida.
- *Folic Acid deficiency (folate)* is a contributing factor in the pathogenesis of neural tube defects, including spina bifida. Supplementation of the mother's diet with folate can reduce the incidence of neural tube defects by about 70 percent, and can also decrease the severity of these defects when they occur. It is unknown how or why folic acid has this effect.

Fig. 30.16: Radiograph of the spine showing spina bifida

SPINA BIFIDA OCCULTA

This is the most common variety and is generally mild. Lumbosacral spine and the first sacral vertebra are commonly affected (Fig. 30.15A).

Clinical Features

The disease is most of the times asymptomatic. But however in few cases the overlying skin may be normal or there may be presence of a tuft of hair, pigmentation, lipoma, dimple, etc. There may be muscle imbalance in the lower limbs resulting in equinovarus or cavus deformity of the foot due to tethering of the cord by a membrane either to the skin or filum terminale. Rarely there could be a bifid cord.

Radiograph

Plain X-ray of the affected spine helps to identify the defect in the spine (Fig. 30.16).

Treatment

Asymptomatic cases require no treatment except physiotherapy and back exercises. Surgical correction of foot deformities is as discussed in earlier chapters.

SPINA BIFIDA APERTA

Here the defect involves the vertebral arches, skin meninges and cord. The following varieties are described (Figs 30.15B to D).

- *Meningocoele* in which there is protrusion of the meninges.
- *Myelomeningocoele* in which there is protrusion of meninges and cord (Fig. 30.17).

Fig. 30.17: Clinical photograph showing the Meningomyelocele

- *Syringomyelocoele* in which the central canal of the cord is dilated and the cord is protruded.
- *Myelocoele* in which the central cord remains unfused and exposed.

Clinical Features

Next to spina bifida occulta, myelocoele is the next common variety. Most of the cases of spina bifida aperta are either stillborn or die within few days of birth. The surviving children may suffer from severe orthopedic deformities, bladder and bowel incontinence and foot deformities.

Treatment

Principles of treatment

- There is no cure for neurological damage due to spina bifida.
- To prevent further damage of the nervous tissue and to prevent infection, the opening on the back is closed and for spina bifida cystica, the spinal cord and its nerve roots are put back inside the spine and covered with meninges.
- A shunt may be surgically installed to provide a continuous drain for the cerebrospinal fluid as in hydrocephalus. Shunts most commonly drain into the abdomen.
- If spina bifida is detected during pregnancy, then open fetal surgery can be performed.

- Myelomeningocele cases require periodic evaluations by specialists including orthopedists to check on their bones and muscles, neurosurgeons to evaluate the brain and spinal cord and urologists for the kidneys and bladder. Such care is best begun immediately after birth.
- Most affected individuals will require braces, crutches, walkers or wheelchairs to maximize their mobility. The higher the level of the spina bifida defect the more severe the paralysis.
- Low level cases may need only short leg braces while those with higher levels do best with a wheelchair.
- Many will need to manage their urinary system with a program of catheterization.
- Most will also require some sort of bowel management program.

Treatment is thus aimed to correct the spina bifida, foot deformities and other orthopedic deformities. Bladder incontinence may require urological treatment.

Physiotherapy Measures in Spina Bifida

- *Measures to correct deformities*
  This consists of:
  - Night splints
  - Passive stretching of soft tissues contractures
  - Proper positioning and re-education of the tendons after tendon transfers.
- *Measures to manage paralysis of muscles*
  - To enable crutch walking, strength and develop the arm and shoulder muscles.
  - Strengthening exercises to the weight bearing muscles like hip extensors and abductors, knee extensor, ankle plantar and dorsiflexors.
  - Measures to train body equilibrium.
  - Retraining and re-education of the transplanted muscles.
- Proper skin to prevent pressure sores and ulcers.
- Proper bowel and bladder care *(see* chapter 16 on Spinal Cord Injury).
- Measures of ambulation and gait training.

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31

Chapter

Bone Neoplasia

Like other systems in the body, musculoskeletal system may also develop tumors, either as a ***primary*** from this system itself or as a ***secondary*** from a distant primary location. The *latter appears to be more common*. Some of the tumors are benign and others are malignant. The accurate diagnosis of a neoplasm is a must before planning the treatment strategy. Diagnosis is best established by history, a proper physical examination and investigations like histological examination, biochemical assays, X-ray, CT scan, MRI, bone scans, arteriography, ultrasound, biopsy (both frozen section and permanent paraffin section), etc.

Primary bone tumors may be benign or malignant. Here is a quick review of the differences between benign and malignant tumors (Table 31.1).

Since the cells of the skeletal system are derived from the mesoderm, primary malignant bone tumors are called *sarcomas.*

Tumors spreading secondarily to the bone are generally primary carcinomas of breast, kidney, thyroid and lung. These tumors are called *metastasis carcinomas* because the tissue of origin is ectoderm.

TABLE 31.1: Differences between benign and malignant tumors

Benign tumors	*Malignant tumors*
• Slow growing	• rapidly growing
• Well circumscribed	• Not well circumscribed
• Non-invading	• Invading
• No or few symptoms	• Associated with pain and disability
• Do not metastasize	• Metastasizes
• X-ray shows lesions confined to the bone	• X-ray shows ill-defined borders, mottled appearance, cortex may be broken
• Do not cause death of the patient	• May cause death of the patient

Tumor cells may produce either tumor bone or osteoid (e.g. osteogenic sarcoma) or may cause reactive bone formation. Periosteal response may also be seen (e.g. Codman's triangle or onion peel appearance, etc.).

Treatment of benign tumors is usually by excision, and if the defect is large, it is packed with bone grafts. Malignant tumors require a multipronged approach in the form of surgery, radiation, chemotherapy, immunotherapy, etc. With a combination of the above modalities of treatment the recurrence rate has dropped considerably.

Knowledge of the origin, biologic behavior and treatment of bone tumors is quite incomplete at the present time and much of the information is conflicting and controversial.

GENERAL PRINCIPLES OF TUMORS

A proper understanding of the general principles of tumors enables one to make a correct diagnosis, choose the correct line of treatment which helps to minimize the recurrence rate and improve the survival rate.

The following are the parameters of general principles of tumors:

History Salient features are:

- Pain, mass, disability is the usual presenting symptoms.
- Anorexia, weight loss and fever are more pronounced in malignant tumors.
- Onset—it is acute in malignant tumors and insidious in benign tumors.
- Age—certain tumors have predilection for certain age groups, e.g. Ewing's sarcoma has a predilection for children.

Clinical Examination

General examination for evidence of anemia, cachexia, lymphadenopathy, etc.

Local examination To know the extent, plane, of the tumor, presence of pathological fractures, etc.

Joint examination To know the involvement of the joint, mechanical effects, etc.

Neurological examination To assess the damage to the peripheral nerves due to the spread of tumor.

Assessment of the status of arterial and or venous circulation.

Investigations

Routine laboratory investigation Hb percentage is decreased, total WBC count and differential count is increased or decreased, ESR is increased, urinalysis. Serum calcium and phosphorous is increased, serum alkaline phosphatase is increased in tumors like osteogenic sarcoma, serum acid phosphatase is increased in metastatic tumors, etc.

Special investigations
Radiological examination of the part is done in two planes anteroposterior and lateral.

Chest radiographs for evidence of secondaries.

CT scan detects pulmonary metastasis at the earliest. It picks up the metastasis of the size of 2 mm compared to X-ray which does so at 2 cm size. It also helps in cross-sectional study of the tumor.

Arteriography This helps to determine the spread of the tumor to the vessel.

Ultrasonography This helps in some situations, though it has a very limited role.

MRI This is the most accurate method of assessing the bone and soft tissue involvement. It also helps in assessing the medullary spread of the tumor.

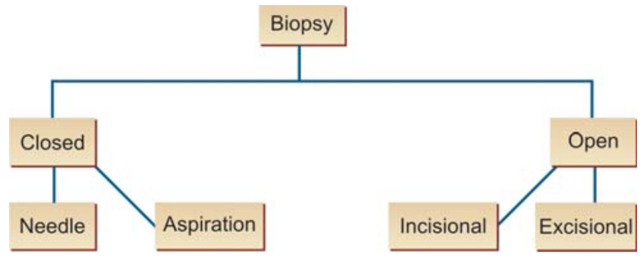
Bone scans help to detect the extent of spread of bone tumor to other areas of skeletal system and also to detect occult bone metastasis.

Biopsy This is an ultimate diagnostic technique in diagnosing bone tumors (Flow chart 31.1).

Usually closed biopsies are preferred in malignant tumors. Needle biopsy has an accuracy rate of over 90 percent in malignant tumors. If incisional biopsy is chosen the incision should be placed longitudinally and should not exceed more than 2 cm.

Types

Flow chart 31.1: Showing different types of biopsies



Remember

Tumor biopsy rules
- In malignant tumors, remove the tumor *en bloc.*
- No transverse incisions.
- No important neurovascular structures should be exposed.
- It should traverse only one compartment.
- Collect the sample from periphery of the tumor.
- If bone sample is to be taken, make a small circular or oval hole in the bone to prevent pathological fracture.

All the above investigations help to stage the bone tumor. Staging helps in detecting the type of surgical procedures needed for local control of the tumor.

Enneking's Staging

Enneking's staging is based on three criteria, histological grading, anatomical site, presence or absence of regional or distant metastasis.

IA *Low-grade* Intracompartmental (lesion confined to single anatomical plane)
IB *Low-grade* Extracompartmental (beyond a single compartment)
IIA *High-grade* Intracompartmental
IIB *High-grade* Extra compartmental.
III *Lesion high or low-grade* Intra or extra compartmental with distant or regional metastasis.

The high- or low-grade is a histological grading done on the basis of changes within the cells like pleomorphism, anaplasia, multicellularity, etc. due to malignancy.

0—benign; 1 = low-grade malignancy; 2 = high-grade malignancy.

Surgical Techniques

Curettage Many benign bone tumors and locally malignant tumors are treated this way but it leaves microscopic remnants. It gives good results if combined with cryosurgery, bone cement, or allograft, etc. If the lesion is diaphyseal, bone grafting is rarely necessary but if it is epiphyseal or metaphyseal allografting is necessary. Since curettage alone is associated with a high rate of recurrence its role is limited.

Resection or excision Tumor removing procedures not involving amputation are called as local (limb sparing) excision or resection. It may be any one of the following.

- *Debulking or intralesional excision* Here excision is done within the lesion.
- *Marginal margins* Here excision is done through the pseudo capsule which is a thin rim of fibrous tissue formed by the surrounding tissues due to the compression by the tumor mass.
- *Wide margin* Here the excision is carried out through the surrounding normal tissues. It is not useful in high-grade tumors because here the spread is along the fascial planes and this method still leaves some metastasis.
- *Radical resection* Here all normal tissues of one or more compartments involved are removed from the origin to the insertion.
- *Radical amputation* Here amputation is done at a high level.

Choice of the Surgical Procedures

Surgery is usually advocated for local control of the tumor. Enneking's staging of the tumor decides the choice of surgery as shown in Table 31.2.

TABLE 31.2: Enneking's staging of bone tumors

Stages	*Surgical procedures*
Grade IA	Requires local procedure
Grade IB	Wide excision
Grade IIA	Radical excision
Grade IIB	Radical amputation
Grade III	Multipronged approaches like Surgery + Chemotherapy + Radiotherapy

Adjunctive Therapy

Radiotherapy It should not be used for benign tumors (exception, pigmented villonodular synovitis) for the fear of inducing malignant changes within the cells. Its role is mainly *palliative* in non-resectable malignant tumors but sometimes it has a *definitive role* in shrinking the size of the tumor making the surgery less traumatic and it is also known to make the cells *non-viable* and thereby minimize the chances of metastasis elsewhere, when these cells get into the circulation during the surgical procedure.

Chemotherapy This is the treatment of choice for micro metastasis with almost 100 percent cure rate. If it is given early it prevents the formation of metastasis. If given late it shrinks the size of the tumor and thereby facilitates excision. It is highly effective against small tumors when given in combinations. Dosage, sequence, schedule and proper monitoring are matter of extreme importance.

Frequently a combination of treatment modalities like radiotherapy, chemotherapy, etc. is used along with surgery. In these cases less radical surgery are used to achieve local control. Limb sparing procedures are preferred over amputations.

Newer Modalities of Treatment

- *Hyperthermia* This is usually tried in combinations with radiotherapy or chemotherapy.
- *Therapeutic embolisation*
- *Immunotherapy* Bacille Calmette Guerin (BCG) vaccines are found to be of use in control of certain tumors. The above three treatment modalities are at an experimental stage and are outside the scope of discussion here.

Classification of Bone Tumors

Various classifications (Table 31.3) have been proposed for bone tumors like Dahlin's classification, Mercer's classification, Turek's classification, etc. The ABC classification of *Bristol Bone Tumor Registry* proposed by *Charles Price* is by far the easiest to understand and remember.

BONE TUMORS OF CARTILAGINOUS ORIGIN

OSTEOCHONDROMA

This is the most common benign bone tumor. It is an offshoot from the spongy bone tissue covered with a cartilaginous cap (size of the cap may vary from 1 to 40 cm).

Age It is common during the growth period.

Sex It has a male preponderance.

Area Location favors the sites of *tendinous attachments* which are usually around the metaphysis of long bones in the region of knee, ankle, hip, shoulder and elbow.

TABLE 31.3: Classification of bone tumors

Section	*Benign*	*Malignant*
Section A Angioid tumors	• Angioma • Aneurysmal bone cyst • Glomus tumor	• Angiosarcoma
Section B Bone forming tumor	• Osteoma • Osteoblastoma • Osteoid osteoma	• Osteosarcoma • Parosteal osteosarcoma
Section C Cartilage Forming tissue	• Chondroma • Osteochondroma • Chondroblastoma	• Chondrosarcoma
Section D Dental and Allied structure	• Odontogenic cyst • Amelloblastoma	• Malignant odontoma
Section E Embryonic Vestigial tissue		• Chordoma
Section F Fibroblastic	• Fibroma	• Fibrosarcoma
Section H Heterotrophic tissue	• Dermoid	• Adamantinoma of long bones
Section N Non-osseous connective tissue	• Lipoma • Neurofibroma • Neurilemmoma	• Liposarcoma • Reticulum cell sarcoma • Myeloma • Leukemia • Hodgkin's • Ewing's • Leiomyosarcoma
Section S Synovial tissue	• Synovioma • Chondroma	• Synovial sarcoma
Section U Undifferentiated connective tissue	• Osteoclastoma	• Malignant osteoclastoma
Section X	• Undiagnosed primary bone tumors	• Undiagnosed primary bone tumors

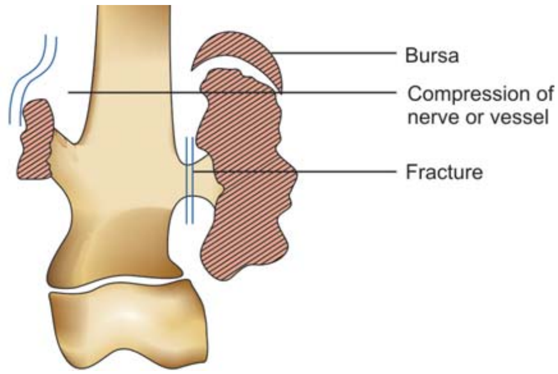


Fig. 31.1A: Osteochondroma and some of its complications

Fig. 31.1B: Plain X-ray showing osteochondroma upper end of the humerus

Clinical Features

Symptoms Usually, it is symptom less but patient may complain of pain, swelling, etc. once complications like bursitis, malignant change, fracture, etc. have developed (Fig. 31.1A).

Signs A firm non tender swelling fixed to the bone around the joints is the most common clinical finding. A bursa if inflamed will give rise to tenderness and local warmth. Joint movements may be decreased because of the tumor causing a mechanical block rather than the extension of the tumor into the joint.

Radiograph

Plain X-ray shows outgrowth of bone at the metaphysis (Fig. 31.1B). This attachment is sessile or pedunculated. The tumor is composed of cortical and medullary portions *which are continuous with the main bone.* The cartilage and capsules are not seen *unless it calcifies.*

Treatment

Usually, it requires no treatment but complete surgical excision is indicated in the following situations.

- *Joint interference* If the tumor is large and obstructing the joint movements, it needs excision of the tumor along with its periosteal cover to prevent recurrence of the tumor.
- *Painful bursitis* A bursa usually develops because of the constant friction between the tumor and the surrounding soft tissues. If inflammation develops within this bursa, it gives rise to pain necessitating its excision.
- *Fracture* of the bony stalk may occur due to trauma.
- *Malignant change* (1-2%) Local irradiation may convert this benign tumor into malignant. It grows rapidly and has to be excised.
- *Pressure on the neighboring vessels* and nerves may give rise to neurovascular complications.

CHONDROMA
(ENCHONDROMA, CHONDROMYXOMA)

This is a benign cartilaginous tumor centrally located when it occurs in phalanges and humerus. It causes destruction of the cancellous bone and has a potential for undergoing malignant change, especially when it is situated in the long bones.

- Age—10 to 50 years.
- Site—metaphysis is usually involved. It is common in the phalanges of hand (little finger common) and feet. Innominate and large long bones may also be involved.

Clinical Features

- Symptoms are practically none. There may be slight pain and the phalanx may be enlarged (Fig. 31.2A).
- The course of the tumor is very slow.

Radiograph

The tumor appears cystic (loculated or non-loculated), cortex is thin and expanded, it may be perforated and at the centre fibrous septa may be seen inters-persing the central cavity (Fig. 31.2B). Stippling or calcification may be present. There is *no reactive bone formation.*

Treatment

Curettage is done and the wall is cauterized if the tumor is small. The surgery done in cases of large tumors is excision and removal of the capsule to prevent recurrence. Radical resection is done for tumors of long bones and pelvis. *Recurrence is common with chondromas of the long bones.*

Prognosis

The incidence of malignant change is 25 percent especially in the pelvis.

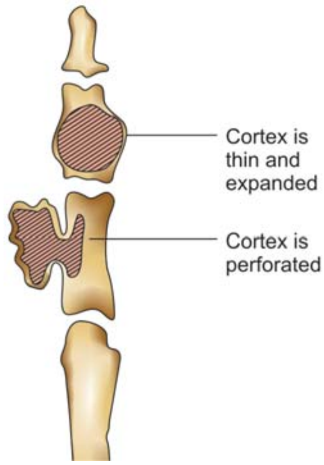


Fig. 31.2A: Enchondroma and its features

Fig. 31.2B: Showing radiological features of enchondroma

CHONDROBLASTOMA

This is a highly cellular, vascular and cartilaginous benign bone tumor of the cancellous bone. Here the cancellous bone is destroyed and multiple calcium deposits are usually found within the tumor.

Age 10 to 20 years.

Sex Male preponderance.

Sites Epiphyseal ends of long bones are commonly affected.

Clinical Features

The patient may present with pain, swelling, joint effusion, etc.

Radiograph

Radiographic features of the tumor are areas of rarefaction at epiphysis, eccentric position of the tumor, thin cortex and mottled areas of calcification.

Treatment

This consists of curettage and bone grafting if the lesion is small, excision in bigger tumors. If it is accidentally irradiated, it may turn malignant. Recurrence rate after excision is 25 percent.

CHONDROSARCOMA

This is *second* in frequency to osteosarcoma. It arises from the cartilage cells. It is a malignant but *slow* growing tumor. It has a long history and a better prognosis. Unlike osteogenic sarcoma, there is *no neoplastic osteoid formation and alkaline phosphatase is usually not raised.* It ranges from being locally aggressive to high grade malignancy.

Classification

Primary/secondary Secondary tumors develop when benign cartilaginous tumors are irradiated.

Peripheral/central/juxtacortical depending on the situation of the tumor within the bone.

Low, medium and high grade malignancy depending on the cellularity.

Antecedent lesions
- Multiple enchondroma (Ollier's disease)
- Osteochondroma, etc.

Location It is common at the sites of proximal femur, humerus, ribs, scapula, innominate bones, rare in hands and feet except in calcaneus, occur in pelvis or upper femoral.

Sex Males are more commonly affected than females.

Age Twenty to sixty years, rare below 20 years, peak in the sixth decade.

Clinical Features

The duration of symptoms are usually less than 2 years in 75 percent of the cases and less than 5 years in the remaining 25 percent. Pain is usually not a prominent feature unlike osteogenic sarcoma. The central tumor remains entirely asymptomatic till it has eroded and penetrated the cortex or caused a pathological fracture. A palpable firm mass attached to the bone is the common physical sign. The tumor may assume large proportion (Figs 31.3 and 31.4).

Fig. 31.3: Chondrosarcoma affecting the upper end of the femur

Fig. 31.4: Pathological specimen of upper end of chondrosarcoma of femur

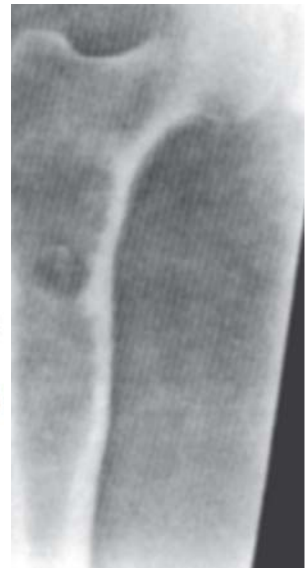


Fig. 31.5: Radiograph showing chondrosarcoma of upper end of femur

Investigations

Plain X-ray helps to identify the site and extent of the lesion (Fig. 31.5). Biopsy helps to confirm the diagnosis.

Treatment

Surgery is the treatment of choice.

Low and medium grade lesions require wide excision, e.g. Forequarter amputation (Thikor-Linberg) for the shoulder girdle; hindquarter amputation for the pelvic girdle.

High grade lesions require radical marginal excision Role of systemic chemotherapy in chondrosarcoma is controversial.

Palliative radiotherapy is indicated when the tumor cannot be resected because of its enormous size or if the tumor is present in an inaccessible region.

Quick Facts

In chondrosarcoma
- Second in frequency to osteosarcoma.
- No neoplastic osteoid.
- Long history.
- Pain is not a prominent feature.
- X-ray—*popcorn* appearance.
- Wide excision is the treatment of choice.
- Better survival rate.

CHONDROMYXOID FIBROMA

This is the least common benign cartilaginous bone tumor.

Age Young adults in the 2nd and 3rd decade are commonly affected.

Sex Equal incidence.

Location Metaphyseal ends of the long bones are commonly involved.

Clinical Features

Usually, the patient does not give a history of pain but complains of increasing swelling. A tender tumor mass may be palpable. Symptoms are more severe if the tumor develops in patients less than 10 years of age. Usually it does not show sarcomatous change or metastasis (Fig. 31.6).

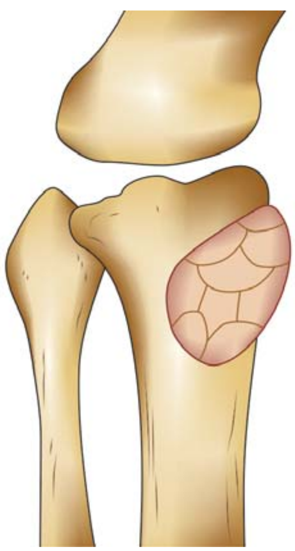


Fig. 31.6: Chondromyxoid fibroma, characteristic findings, lytic lesion, trabecular pattern and cortex slightly expanded

Radiograph

Plain X-ray shows eccentrically located tumor in the metaphysis. Cortex is expanded, thin and interrupted. Medullary margins are scalloped and sclerosed, the base of the tumor shows triangular periosteal bone formation.

Treatment

The treatment of choice is local excision and bone grafting for small tumors, wide *en block* excision for large tumors.

OSSEOUS ORIGIN BONE TUMORS

OSTEOMA

Osteoma is a benign bone tumor, occurs in membranous bones of skull and face. Usually there are very few complaints, the history is long and the finding is a diffuse bony hard tumor. It rarely requires treatment.

*OSTEOID OSTEOMA

This is a benign osteoblastic tumor with a well demarcated nidus of less than 1 cm surrounded by a distinct reactive bone (Fig. 31.7).

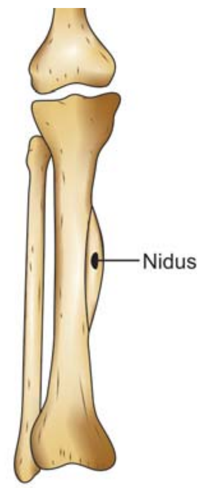


Fig. 31.7: Showing osteoid osteoma in tibia

This tumor presents very interesting clinical features. It is a tumor of young adults, benign in nature and occurs in enchondral bones.

Age It is common in young adults between 10 to 25 years of age.

Sex Male preponderance (M: F = 2:1).

Sites Long bones usually tibia and femur are more commonly affected.

Clinical Features

Patient complains of vague and intermittent pain which is more at night. The pain dramatically decreases after giving aspirin so much so that this is called the *therapeutic test.* Patient also

*__Osteoid osteoma__. This was described by Jattle H.L. of USA in the year 1935.

Fig. 31.8: Radiograph showing osteoid osteoma

Fig. 31.9: Showing osteogenic sarcoma lower end of femur

complains of limp due to pain. There is a mild swelling, the local area may be tender, temperature is not raised, and the skin is not stretched, shiny or warm. When the lesion occurs in the spine, patient presents with acute low backache.

Investigations

Radiology usually shows small rarefied lesion < 2 cm in diameter found in either the cortex, sub cortical or subperiosteal regions. It is surrounded by a thick sclerotic bone. A small dense centre of ossification seen in the centre as the *nidus* (Fig. 31.8). Five percent of the cases of sciatica are due to osteoid osteoma.

CT scan and MRI also helps in diagnosing this tumor.

Treatment

Conservative line of treatment consists of rest to the part and analgesics. If the tumor is too troublesome, complete excision of the cortex containing the nidus is sufficient.

OSTEOGENIC SARCOMA

Osteogenic sarcoma is a highly malignant bone tumor. Here tumor cells invariably form a neoplastic osteoid or bone or both. It arises from a common multifactorial mesenchymal tissue and hence the tumor could be either *fibroblastic, osteoblastic* or *chondroblastic* (Fig. 31.9).

This is the most frequent primary bone tumor next only to multiple myeloma.

Age It is common in the second decade, rare below 10 years of age, 75 percent of the cases are seen below the age of 25 years.

Sex Male preponderance, when found in females it starts at an early age.

Incidence is 1/75,000 population.

Site Ninety percent of the tumor occurs in the metaphysial region of the ends of long bones. It has a predilection around the knee and upper humerus. It may affect the jaws in the aged.

Secondary osteosarcoma *This is less malignant than the primary, develops in bones affected with Paget's disease, diaphyseal aclasia, enchondromas, irradiation, etc. It is more common in older age groups and is treated on the same lines as the primary*.

Lichtenstein's criteria to identify osteogenic sarcoma include the presence of the following:

- Sarcomatous stroma
- Spindle cells
- Direct formation of neoplastic osteoid and bone.

Clinical Features

The patient usually presents with pain as the first symptom. It precedes the tumor, is seen first at night and is intermittent in nature. History of trauma is a common feature. Patient

Figs 31.10A and B: Clinical photograph of upper end of osteosarcoma of upper end and lower end of femur

complains of tired feeling and limp. General condition is good till the late stages. Pyrexia is seen with increased WBCs. Patient is usually anemic than cachectic. Skin over the tumor is stretched, shiny and mobile. Local temperature is increased, consistency of the tumor is variable, dilated veins are present (and is evident at an early stage). Pathological fracture is not typical of osteogenic sarcoma since the swelling and pain keeps the patient off his or her feet. The nearest joint may show pain and effusion. Joint movements may be unimpaired (Figs 31.10A and B).

Radiograph

The affected metaphyseal end of a long bone may show sclerotic, osteolytic, radiating spicule or mixed changes. Sun ray appearance, Codman's triangle or pathological fracture is the other characteristic findings (Figs 31.11 and 31.12).

Fig. 31.11: Radiograph of osteogenic sarcoma lower end of the femur

Fig. 31.12: Osteosarcoma upper end of tibia

Spread

- It is mainly by blood spread, lungs are involved in 80 percent of the cases.
- Lymphatic spread to regional lymph nodes is seen in 30 percent of the cases.

Treatment

General principles

- Early radical amputation is done to remove the primary tumor.
- An attempt is made to prevent metastasis or control it, if it has already formed by preoperative irradiation, chemotherapy or both.
- Resection of large pulmonary metastasis is carried out.

Surgery Early and radical ablation is the surgical procedure of choice. Having first established the diagnosis by biopsy, the level of amputation is determined after carrying out the various investigations mentioned above. Surgery is done at the *earliest* possible time.

Quick Facts

Osteosarcoma: Levels of amputation

- Upper end of humerus: Forequarter amputation.
- Upper end of tibia: Midthigh amputation.
- Upper end of femur: Hindquarter amputation and hip disarticulation.
- Lower end of femur: Midthigh amputation and hip disartication.

Megavoltage radiotherapy Megavoltage irradiation is given preoperatively before amputation to decrease the *viability* of the cells that may be disseminated into bloodstream by surgical trauma. It is a useful adjunct in the treatment of resectable tumors. Its efficacy is doubtful in the non-resectable tumors, e.g. vertebra. Irradiation destroys tumor cells with minimal effect on the uninvolved parts.

Preliminaries before irradiation

- Bone scans are done to detect the skip lesions.
- Biopsy scar is limited to < 2 cm size to avoid skin necrosis.
- Chemotherapy is given to increase the susceptibility of tissues to irradiation.
- Dose—Total dose of irradiation is 6000-8000 rads or 230 rads/day or 1000 rads/week.

Chemotherapy (CT) Role of chemotherapy is as follows:

- After ablation of the primary tumor, it produces a disease-free state for many months.
- If given before the metastasis is apparent, it improves the 5-year survival rate by 60 percent.
- Chemotherapy approach assumes that at least 80 percent of the patients have microscopic foci in the lungs at the time of initial diagnosis.
- Chemotherapy started early after the diagnosis destroys the microscopic foci at a stage when they are most susceptible to the action of chemotherapy drugs.
- It prevents metastasis in 60 percent of the cases. The remaining 40 percent become disease free due to aggressive attack on the metastasis. After metastasis has occurred chemotherapy decreases the tumor size and enables easy surgical removal.
- When patient refuses amputation, but accepts local resection and implant, chemotherapy decreases the size of the tumor.

Earlier osteogenic sarcoma was refractory to chemotherapy. But it has now been found that high doses of methotrexate, citrovorum factor rescue (CFR) and Adriamycin are effective. By using the above drugs in short cyclical courses, toxic effects can be held to a minimum. Addition of an alkylating agent like cyclophosphamide has increased the interval between the administrations of individual drugs. This has markedly reduced the toxicity of the drugs. The treatment triad in order of sequence is shown in Figure 31.13.

In summary, after having established the diagnosis of osteogenic sarcoma with certainty, patient is initially put on chemotherapy. The role of chemotherapy has already been discussed. Local irradiation of the tumor is done next. Early radical surgical ablation is then carried out at the appropriate time.

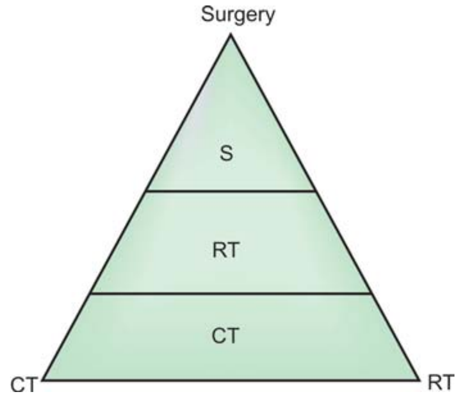


Fig. 31.13: Triad of treatment in osteogenic sarcoma

Treatment of Pulmonary Metastasis

Pulmonary micro emboli are best managed by chemotherapy. Large lesions require removal by wide resection or lobectomy after giving chemotherapy.

Another experimental approach to manage the lethal metastasis is the immunological approach. The immunological status is increased by giving specific antibiotics, BCG vaccine, and allogenic sarcoma tumor cell vaccine for two years, interferon therapy, etc.

Remember

Characteristic facts of osteogenic sarcoma

- Highly malignant bone tumor.
- Arises from multipotent cells.
- Most frequent primary bone tumor next only to multiple myeloma.
- Seventy-five percent are below 25 years of age.
- Ninety percent occur in the metaphysis.
- Neoplastic osteoid is always present.
- Both osteosclerotic and osteolytic variety is the most common.
- Leg of mutton appearance.
- Spindle cells.
- No giant cells.
- Pain is the first symptom.
- Skin is stretched; shiny, dilated veins are present.
- Pathological fractures are not common.
- Eighty percent has blood spread.
- Sunray appearance and Codman's triangle are special X-ray features.
- Multipronged approach gives better survival rate.

Prognosis

Prognosis of osteogenic sarcoma has dramatically improved by the combined approach of ablation, megavoltage irradiation and chemotherapy.

In untreated cases survival time after pulmonary metastasis has developed is around 2.9 percent.

With the combined approach of chemotherapy, radiotherapy and pulmonary resection, the five year survival rate has increased by 60 percent.

RESORPTIVE BONE TUMORS

These are not true tumors but tumor like conditions (hamartoma). These are benign and may cause pathological fractures.

ANEURYSMAL BONE CYST

Aneurysmal bone cyst (Fig. 31.14) is a benign lesion eccentrically situated in the metaphyseal ends of the long bones. It grows outwards and is located subperiosteally.

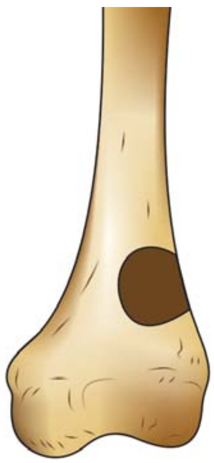


Fig. 31.14: Showing features of aneurysmal bone cyst

Age 10 to 30 years.

Sex Males are more commonly affected than females.

Clinical Features

Patient usually gives history of mild trauma. Pain and swelling are the main complaints. Joint movements may be decreased.

Radiograph

Plain X-ray of affected bone shows accentric lytic lesions near metaphyseal region (Figs 31.15A and B).

Figs 31.15A and B: Radiograph of ABC lower end of the tibia

Treatment

Surgery is the treatment of choice. Curettage and bone grafting is the procedure commonly followed.

UNICAMERAL BONE CYST

Unicameral bone cyst (Fig. 31.16) was first described by Jaffe and Lichtenstein in the year 1942. It is an uncommon, non-neoplastic lesion commonly seen in the first two decades of life. It is situated in the metaphysis of the long bones and its proximity towards the epiphysis may affect the growth plate. Pathological fracture is a common entity. The cyst will not disappear on its own and remains so unless obliterated by surgery.

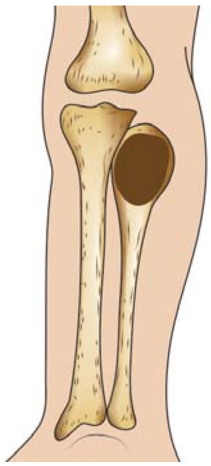


Fig. 31.16: Showing features of unicameral bone cyst

Age Fifty percent lesions are seen in less than 10 years of age, forty percent between 10 and 20 years.

Sex The male to female ratio is 2:1.

Location Upper end of humerus in 55 percent, upper end of femur in 26 percent.

Clinical Features

The tumor is asymptomatic till fracture occurs through the cyst wall which causes pain and draws the attention of the patient towards the problem. In most cases the cyst is juxta-epiphyseal. Due to its proximity to the growth plate the cysts may cause shortening, lengthening, coxa vara or coxa valga deformities. The tumor weakens the bone and the patient is susceptible to pathological fractures. Spontaneous obliteration of the cyst is seen in 15 percent of the cases and in 30 percent of the cases, cyst is displaced down the shaft due to continuous bone growth.

Radiograph

Plain X-ray shows lytic lesions at the metaphyseal region (Fig. 31.17).

Fig. 31.17: Radiograph of UBC of the upper end of the humerus

Treatment

Surgical excision is the treatment of choice. The following are some of the surgical procedures.

Types of Surgery

- *Curettage and bone grafting* This procedure is associated with high rate of recurrence.
- *Subtotal resection and bone grafting* Here 1 cm of the normal bone above and below the lesion is excised.
- *Total resection and bone grafting* is the other method of treatment.
- *Intracystic injection of corticosteroids* Steroids injected into the cysts is known to cause obliteration of the cyst. 40 to 80 mg of prednisolone for smaller cysts is recommended and larger cysts may require 200 mg of prednisolone.

Complications

Since the tumor is situated in the juxta-epiphyseal region, complications like shortening, coxa vara, coxa valga and bone overgrowth may develop.

BENIGN GIANT CELL TUMOR (GCT)

(Syn: Osteoclastoma)

Benign giant cell tumor is an osteolytic tumor arising from the *epiphysis* and is common in young adults. Though it is benign, it is *locally* malignant. The presence of *tumor giant cells* is the hallmark of this tumor.

Sex The male: female ratio is 1.5:1.

Age It is common between 15 and 35 years (80% occur in more than 20 years of age and the average age group is 35 years).

Areas affected are asymmetric portions of the epiphysis of long bones. About 75 percent of GCT occurs in lower end of femur, upper end of tibia, fibula and the distal end of radius (Fig. 31.18A).

Clinical Features

The course of the tumor is chronic. Unlike osteogenic sarcoma pain is not the presenting feature but trauma is, the patient

Fig. 31.18A: Showing features of benign giant cell tumor

Fig. 31.18B: Giant cell tumor of the lower end of radius

complains of swelling which is situated on one side of the bone. Skin over the tumor is stretched but there are no dilated veins. Tenderness is moderate or absent, *egg shell crackling* sensation may be present or absent. Limitation of joint movements is not seen till the late stages. There is no increase in joint fluid and the joint is rarely invaded. Pathological fracture is a late feature.

Radiograph

Plain X-ray shows a lytic lesion with a characteristic soap bubble appearance (Fig. 31.18B).

Malignant GCT

Types

Primary This develops as a frank sarcomatous lesion.

Secondary This develops at the site of previously treated GCT.

The patient will present with more aggressive symptoms and signs unlike benign GCT. The swelling will be gross with evidence more destruction (Fig. 31.19).

Fig. 31.19: Clinical photograph of malignant giant cell tumor of the lower end of the radius

Fig. 31.20: Radiograph of malignant GCT lower end of the radius

Radiograph

Plain X-ray of the affected part shows extensive destruction of the bones (Fig. 31.20).

Treatment of GCT

Table 31.4 shows the different surgical methods in the management of GCT.

TABLE 31.4: Treatment facts of GCT

Site	*Surgical option*
• Upper limb	
— Lower end of ulna	Excision
— Lower end of radius	Excision with reconstruction by Ipsilateral fibula
• Lower limbs	
— Lower end of femur	Excision with Turn-O-graft
— Upper end of tibia	Excision with Turn-O-graft

Principles of tumor treatment

- The tumor is invasive and aggressive.
- It commonly recurs, may become malignant after unsuccessful removal.
- Recurrence is treated with *en bloc* excision.
- *En bloc* excision is also indicated if the tumor has eroded the cortex and extended into the soft tissues.

Quick Facts

GCT

- Locally malignant.
- Affects young adults.
- Arises from the epiphysis.
- Giant cells are characteristic.
- Egg shell crackling may be present.

- Soap-bubble appearance is characteristic.
- *En bloc* excision and reconstruction is the surgical method of choice.
- One-third are benign, one-third is locally malignant and one-third is malignant.

TUMORS OF NON-OSSEOUS ORIGIN

*EWING'S SARCOMA

Ewing's sarcoma was first described by ***Ewing*** in the year 1928. This is a rare primary malignant bone tumor (10-14% of all malignant bone tumors) affecting children. It is a lethal tumor with a poor 5-year survival rate.

Age persons commonly affected are 4-25 years of age group (about 80%).

Sex More common in males.

Site Long bones affected are femur, tibia, fibula and humerus in that order (Fig. 31.21A). About 20 percent of tumors are seen in flat bones.

Location Diaphysis of the long bones is commonly affected.

Clinical Features

Signs and Symptoms

Patient presents with pain which is intermittent in nature. The pain is worse at night. The tumor is fixed to the bone, skin is red, dilated veins may be present. Some times the tumor may present with constitutional symptoms like fever, sweating, chills, leucocytosis, and anemia. This may create confusion as it mimics acute osteomyelitis.

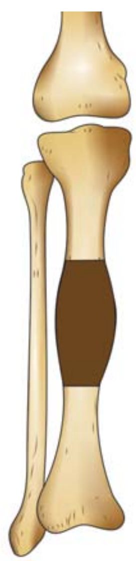


Fig. 31.21A: Showing features of Ewing's sarcoma

Fig. 31.21B: Radiographic features of Ewing's sarcoma

*James Ewing** (1866-1943), Oncologist (USA). It was first described by Ewing in the year 1928.

Radiograph

Plain X-rays shows the characteristic diaphyseal lesion with an *onion peel* appearance (Fig. 31.21B).

Course

- Exacerbation and remission is characteristic.
- Blood and lymphatic spread is common.
- Metastasis to other bones like skull, vertebrae, ribs, lungs, etc. may occur.

Treatment

This tumor is highly radiosensitive, disappears with radiation only to recur back again (melts like snow). Hence a combination of local radiotherapy with systemic chemotherapy brings down the recurrence rate dramatically. But even this treatment has a recurrence rate of 20 to 30 percent and because of the possibility of radiation induced sarcomas; surgical resection for the control of the primary lesion is being used. The surgery planned is conservative in nature and aims at limb preservation.

Chemotherapy is given using newer chemotherapeutic drugs like Ifosfamide, cisplatinum, epipodophyllin toxin for a short period of time.

Radiation is the mainstay of local treatment especially in axial skeleton. Dose required is high 4000 rads for the entire limb and 1000 rads as boost to the tumor.

Surgery Conservative surgery like debulking of the tumors or limb preservation surgery has a role.

Prognosis

Unfavorable prognostic features are:
- Male patients.
- Humerus if involved.
- Pelvic bones if involved.
- Distant metastasis.

Primary irradiation followed by amputation has a 2-year survival rate of 15 percent. A combination of chemotherapy, radiotherapy with surgery improves the survival rate to 50 to 75 percent for 3 to 5 years.

Quick Facts

Ewing's sarcoma
- Rare primary malignant tumor.
- Common between 5 and 15 years.
- Tumor of the diaphysis.
- Clinically may mimic acute osteomyelitis.

- X-ray shows moth-eaten appearance and onion peel appearance.
- Tumor is highly cellular.
- Highly radiosensitive (melts like snow).
- High rate of recurrence.
- Combination of radiotherapy, chemotherapy and surgery has improved 2-year survival rate.

MULTIPLE MYELOMA (PLASMACYTOMA)

This is the most common bone tumor in adults. It accounts for 50 percent of all bone tumors. Here plasma cells replace the bone. It affects elderly persons between 40 and 60 years of age.

Sex Males and females are equally affected.

Clinical Features

Tumor runs a chronic course. It is silent at first, later on the patient complains of vague pain which is mild and intermittent in the beginning. It also affects lumbar spine, sacral region, chest and ribs. Severe attacks of sharp pain, superimposed at intervals may develop. Often the patient may complain of a diffuse, persistent, backache. It might occur in the skull also.

Findings

In the early stages there are hardly any clinical findings. Later on the patient may complain of soft tissue swelling in about 10 percent of cases. Signs of pathological fracture are present in about 20 percent of cases. The sternum and ribs may be tender and there may be signs of vertebral collapse.

Course

The tumor is chronic, later the marrow replacement causes anemia, thrombocytopenia and hemorrhages. Renal failure due to tubular block by protein casts may also be seen *(myeloma kidney)*.

Investigations

Laboratory tests The presence of Bence Jones proteins is quite characteristic.

Plain X-ray of the skull shows the typical punched out lesions (Fig. 31.22).

Treatment

When the tumor is widespread it is usually fatal and then treatment is only palliative. The tumor is radiosensitive.

Fig. 31.22: Radiograph showing the punched out appearance of the skull in multiple myeloma

Chemotherapy Agents like steroids, cyclophosphamide, urethane and melphalan *(SCUM)* are found to be effective.

Surgery

- Laminectomy is done when there is evidence of compression of spinal nerves.
- Intramedullary fixation is done for pathological fractures of long bones.

METASTATIC TUMORS OF BONES

These are cancerous tumors originating in other organs and involving the skeletal structures of the body (Table 31.5).

Bones may be involved by:

- Direct invasion.
- Blood born metastasis (most common route).
- Very rarely through the lymphatic.

Blood borne metastases to the bone greatly out number the primary bone tumors.

Incidence is 27 to 70 percent.

TABLE 31.5: Tendency percentagewise

Region	*Percentage*
Ca Breast	73 percent
Ca Lungs	32 percent
Ca Kidneys	24 percent
Ca Rectum	13 percent
Ca Stomach	11 percent

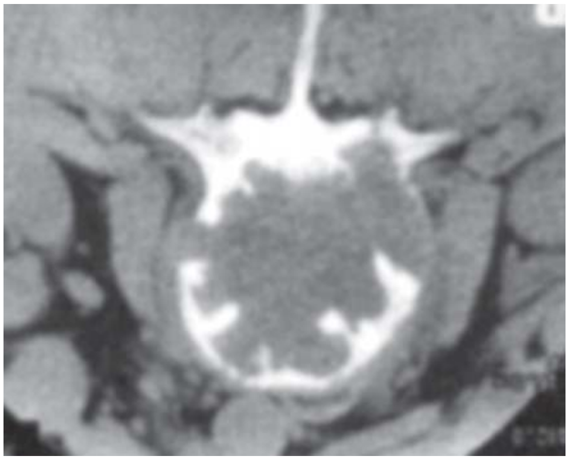


Fig. 31.23: Metastasis in a vertebral body

Fig. 31.24: Radiograph of the pelvis showing osteoblastic changes in secondaries

Sites The secondary bone tumors commonly involve vertebrae (Fig. 31.23), ribs, pelvis, sternum, skull and proximal ends of femur and humerus. It is unusual for metastatic neoplasms to involve bones distal to the elbows or knees.

Metastatic bone tumor occurs in three clinical settings:
- Pain in the spine or extremity without a known history of primary tumor *(rare)*.
- Pathological fracture with or without known primary tumor.
- The third and most common is a patient with a known primary tumor with a painful lesion in the spine or extremities.

Clinical Features

Patient is usually an adult, in the middle or late life, and may present with pain, pathological fracture or anemia. Patient complains of headache if the skull is involved. Spine involvement causes girdle pains, spastic paralysis, etc. Pathological fractures are frequent in femur. Collapse of vertebrae may be present.

Investigations

Laboratory test
- Blood picture may be normal or bizarre showing features of anemia, thrombocytopenia or thrombocytosis, leucocytosis or leucopenia, eosinophilia, etc.
- Sometimes anemia is associated with leucoerythroblastic reaction.
- Sometimes a syndrome of hemolytic anemia, thrombocytopenia, and fibrinogenopenia can be seen with cancer of stomach and pancreas, etc.
- Alkaline phosphatase is increased normally, but acid phosphatase increases in cancer of prostate.

Investigations

Radiology shows two types lesions in the bone. It fails to detect secondaries in the bone in 20 to 25% of the cases.

Two types of bone lesions in secondaries are:
- Osteolytic variety shows decreased density or lytic lesions. This is more frequent.
- Osteoblastic variety shows increased density (e.g. cancer prostate) (Fig. 31.24).

Periosteal reaction and mottled or marble appearance are the other radiographic features.

Bone scan This is the most sensitive method of investigation.

Fine needle biopsy is accurate in over 90 percent of the cases.

Treatment

The following are the various modalities of treatment.

Radiotherapy is by ^{60}Co 3000 to 4000 rads for 3 to 4 weeks.

Surgery If the patient has developed pathological fracture, internal fixation with acrylic cement is done. Decompressive laminectomy is done for secondary in the spine. Endocrine surgery for cancer breast, cancer prostate, etc.

Hormone therapy
- For prostatic cancer, oestrogen.
- For breast cancer, diethylstilboestrol.
- For thyroid cancer, T3 and ^{131}I.

Radioisotope therapy is by using
- Radioactive phosphorus
- Radioactive ^{131}I

Chemotherapy is by using drugs like alkylating agents, antimetabolites, etc.

Treatment of hypocalcemia is by using cortisone, mithramycin, etc.

Amputation is indicated for intractable pain and as a last resort.

Prophylactic nailing is considered for those cases with more than 50 percent destruction of the cortex.

INCLUSION TUMORS

SYNOVIOMA (SYNOVIAL SARCOMA)

Definition

Synovioma is a slowly growing malignant tumor occurring in juxtaposition to and attached to the synovial tissue but almost invariably lies outside the joint.

Clinical Features

This is a tumor of young adults, rare in people more than 40 years of age, common in the lower extremity, around the knee. Soft tissue outside the joint is involved, painful swelling, slowly increasing in size, firm or soft and tender. Restriction of joint movements may be seen.

Course

The course is very slow, metastasizes is eventually into the lungs.

Radiograph

Soft tissue shadows are seen. Stippling is observed if the tumor contains small areas of calcification (Fig. 31.25).

Fig. 31.25: Radiograph showing synovial chondromatosis

Treatment

Synovioma is a slow growing tumor. It metastasizes late. Surgery is the treatment of choice and includes local excision. Radical amputation is preferred if the tumor has a widespread involvement.

Physiotherapy Management for All Bone Tumors

- Measures to control limb edema
  - Limb elevation
  - Retrograde massaging
  - Intermittent compression
  - Active movements of the affected joints.
- Measures to improve movements and muscle strength
  - Passive ROM exercises.
  - Active and resistive exercises.
  - Gentle active movements of the joint

Note Exercises are not taken up at the initial stages.

- Measures to control depression
  - Psychological reassurance.
  - Counseling.
  - Mental, Social, Occupational Rehabilitation programmes.
  - Functional use of the limbs is initiated at the earliest.
  - Yoga and meditation helps to calm the agitated mind.
- Measures to control pain
  - Analgesic and anti-inflammatory drugs.
  - Muscle relaxants.
  - Opiates in advanced cases.
  - Cryotherapy helps to alleviate pain.

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32

Chapter

Osteoarthritis

It is defined as a degenerative, non-inflammatory joint disease characterized by destruction of articular cartilage and formation of new bone at the joint surfaces and margins *(OA = Can also be called O—Old age, A—Arthritis).*

Though OA can occur in all the joints due to ageing, it is more commonly seen in weight-bearing joints like knee hip, ankle and spine (Fig. 32.1). Finger joints are also frequently affected. Among all the joints in the body, osteoarthritis affects the knee joints most and it could be primary or secondary.

PRIMARY OSTEOARTHRITIS OF THE KNEE

Etiological causes for primary osteoarthritis Though exact cause is not known, the following factors are suspected to play an important role in the causation of primary osteoarthritis—obesity, genetics and heredity, occupation involving prolonged standing, sports, multiple endocrinal disorders and multiple metabolic disorders.

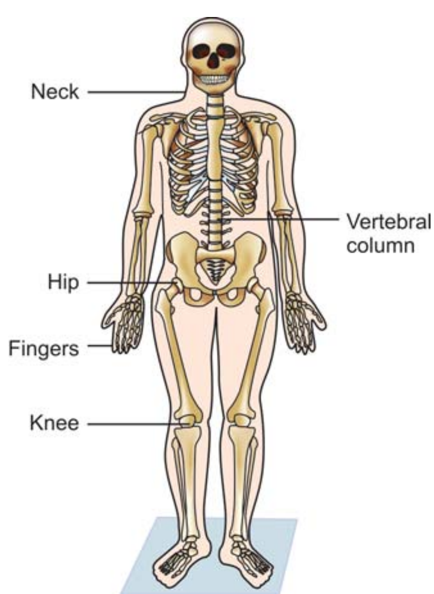


Fig. 32.1: Showing common sites of osteoarthritis

Features

- It commonly affects the knee joint.
- All races are susceptible.
- Common in older age groups.
- Eighty percent of people are affected by 40 years, but only 40 percent show symptoms.
- It causes varus deformity (Fig. 32.2) of the knee in the late stages.

Quick Facts

Osteoarthritis

Who is prone to get osteoarthritis?

- Middle-aged patients.
- Women have a greater tendency than men.
- One in three people over 60 years is affected and more than three in four persons over the age of seventy show some radiographic evidence of the condition.
- Very rarely it can be seen in younger people.

What are the typical symptoms of osteoarthritis?

- Pain
- Early morning stiffness.
- Restricted range of joint movements.
- Swelling of the joints.

What joints are usually affected?

- Weight bearing joints like hip, knee, ankle, etc.

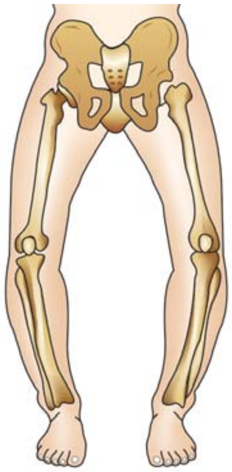


Fig. 32.2: Genu varum deformity in osteoarthritis of knee

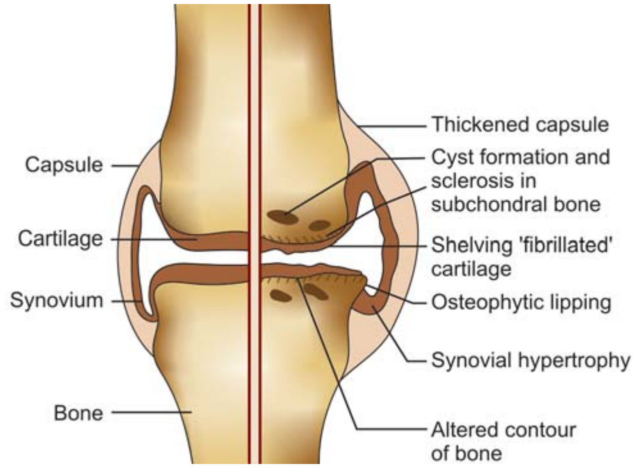


Fig. 32.3: Pathological features of the osteoarthritis knee

- Spine
- Fingers

What causes osteoarthritis?
- Age more than 40 years.
- Female
- Hereditary conditions.
- Previous joint injuries.
- Obesity
- Diseases of the joints.
- Poor posture.
- Occupational stress and strain.
- A combination of the above factors.

How to make a diagnosis?
- Physical examination.
- Symptomatology
- Radiography
- Blood tests
- CT scan and MRI.

Sequence of pathological events in osteoarthritis Fibrillation due to loss of water of the weight bearing articular cartilage is seen in early stages of the disease followed by complete loss of articular cartilage. This puts enormous pressure on the underlying bone which causes sclerosis and later eburnation. Cysts may develop in the subchondral area due to micro-fractures that degenerate. New bone formation takes place and results in osteophyte formation (Fig. 32.3).

Clinical Features

Predominant symptom is pain which decreases on walking. The pain is poorly localized and is dull aching in nature. Patient

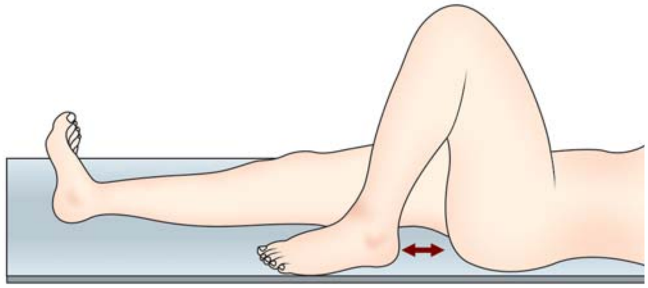


Fig. 32.4: Loss of terminal flexion in osteoarthritis knee

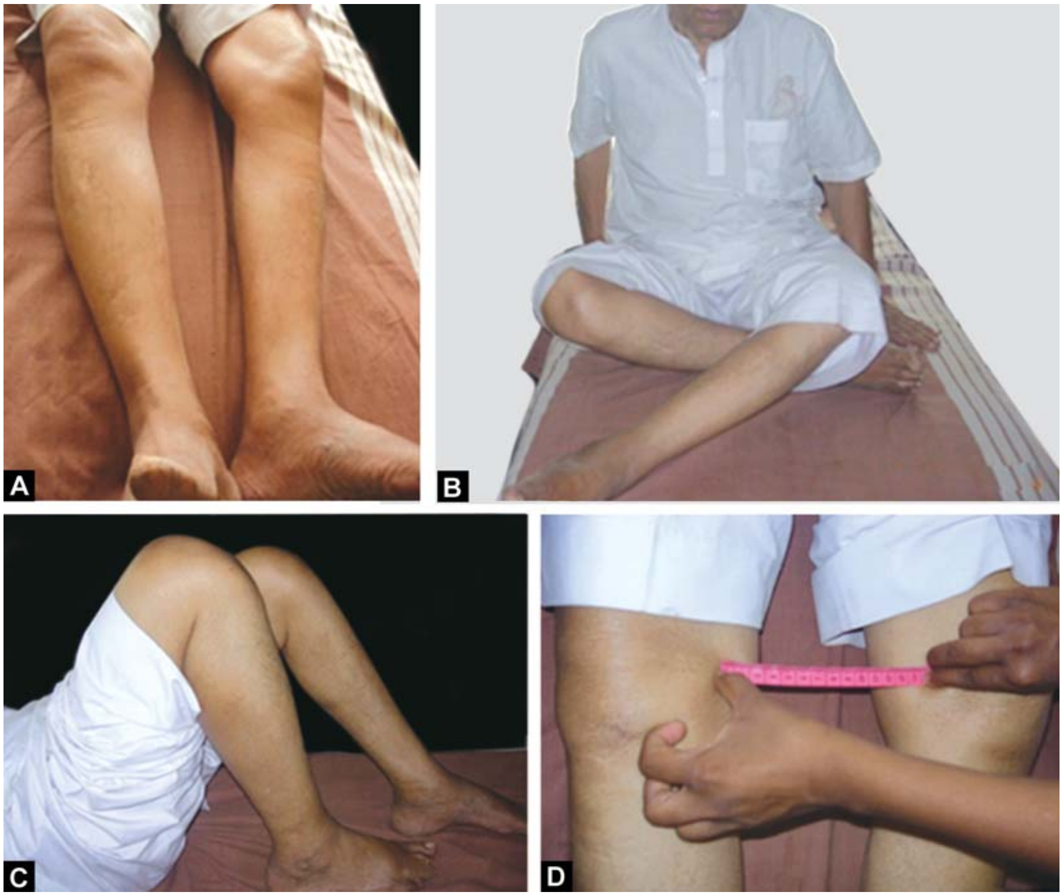
has mild swelling of the knee joint (Fig. 32.5A) and complains of early morning stiffness. Minimal tenderness and coarse crepitus can be elicited. If there are loose bodies in a joint, patient gives history of locking or giving way. Terminal movements of the knee are restricted (Figs 32.4 and 32.5B, C). Patient complains of early morning stiffness which subsides over the day after some activity. Genu varum deformity may be seen in very advanced cases (Fig. 32.5D).

Investigations

Laboratory investigations are usually within normal limits. Radiological examination of the knee joint is the most important diagnostic tool.

Radiograph

Plain X-ray of the knee joints show the following are the features seen in osteoarthritis (Fig. 32.6) of the knee.
- Loss of joint space (due to destruction of articular cartilage).
- Sclerosis (due to increase cellularity and bone deposition).



Figs 32.5A to D: Clinical photographs of the presentation of osteoarthritis of the knee joint

Fig. 32.6: X-ray showing knee joint: Loss of joint space, osteophytes, subchondral sclerosis and varus deformity

- Subchondral cysts (due to synovial fluid intrusion into the bone).
- Osteophytes (due to revascularization of remaining cartilage and capsular traction).
- Bony collapse (due to compression of weakened bone).
- Loose bodies (due to fragmentation of osteochondral surface).
- Deformity and malalignment (due to destruction of capsules and ligaments).

Other Investigations

Synovial fluid analysis shows non-inflammatory picture. Bone scan shows increased uptake of technetium-99m, MRI and CT scan also helps to diagnose, subchondral cysts, osteophytes, etc.

Treatment

Conservative methods This forms the mainstay of management in osteoarthritis of the knee. About 50 percent of patients respond to conservative treatment which consists of the following measures:

- Reduction of weight.
- Isometric quadriceps exercises.
- Non-steroidal anti-inflammatory drugs (NSAIDs) and muscle relaxants. Newer drugs like glucosamine, chondroitin sulphates are known to help in the regeneration of articular cartilage.
- Intra-articular injections of steroids (not more than 3 recommended, local anesthetic is avoided for fear of developing neuropathic joint).
- Walking and light aerobic exercises.
- Heat therapy, etc.

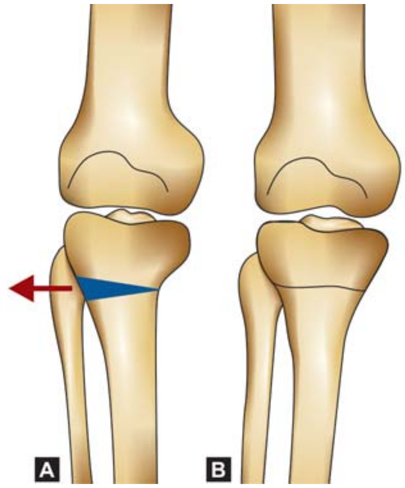
Surgery

Indications for surgery

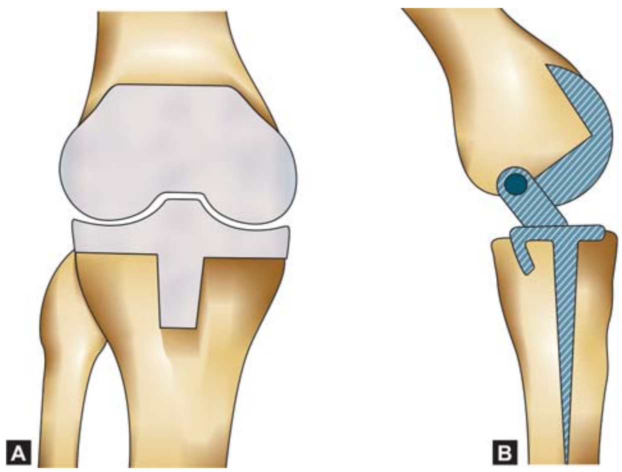
- Pain—refractory to conservative measures.
- History of frequent locking episodes.
- Haemarthrosis due to loose bodies or osteochondral fractures.
- Deformity, usually genu varum.
- Joint instability.
- Progressive limitation of knee motion.

Surgical Methods

- *Excision of osteophytes* is rarely done alone.
- *Excision of loose bodies, meniscectomy, synovectomy*, and *reconstruction or joint debridement* are best done by arthroscopy.
- *Proximal tibial osteotomy (Slocum's)* Indicated for uni-compartmental osteoarthritis of knee with pain and also to correct varus (less than 15°) or valgus deformity (less than 12°). Pain is decreased in 80 percent of the cases following surgery as osteotomy changes the line of weight bearing and brings the more normal surface to carry out the function of load transmission (Figs 32.7A and B).
- *Distal femoral osteotomy* is indicated when varus or valgus deformity of the knee is more than 12 to 15°.
- *Total knee arthroplasty* This is indicated when both the compartments of the knee joint are destroyed or if valgus or varus deformity is more than 15°. It is also indicated in failed conservative treatment (Figs 32.8A, B and 32.9).
- *Arthrodesis* is indicated less commonly than arthroplasty. If the patient is young and involved in heavy occupations, arthrodesis is indicated to give him a stable and strong knee. However, arthrodesis results in a stiff knee which is a severe disability.
- *Patellectomy* It is rarely done except as a last resort. Contemplated in osteoarthritis present for several years.



Figs 32.7A and B: High tibial osteotomy in osteoarthritis: (A) Before operation, (B) After operation



Figs 32.8A and B: (A) Showing total knee replacement for OA knee, (B) Total knee replacement for osteoarthritis knee

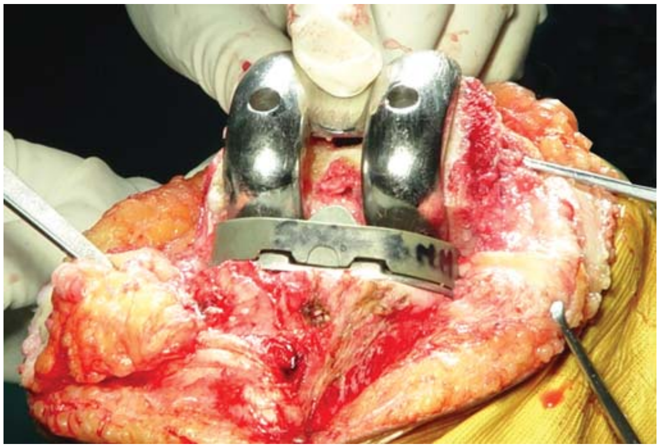


Fig. 32.9: Showing total knee replacement in OA knees

SECONDARY OSTEOARTHRITIS OF KNEE

The causes for secondary osteoarthritis of the knee are as follows:

- Obesity, valgus and varus deformities of the knee.
- Intra-articular fractures of the knee, etc.
- Rheumatoid arthritis, infection, trauma, TB, etc.
- Hyperparathyroidism.
- Hemophilia.
- Syringomyelia.
- Neurological disease like diabetes.
- Overuse of intra-articular steroid therapy.

It is generally observed that secondary osteoarthritis occurs in the younger age groups and is more severe than the primary. Apart from all the features of osteoarthritis, secondary osteoarthritis has the features of the corresponding etiological condition.

Remember

Major complication of osteoarthritis

- Joint deformities
- Subluxation
- Ankylosis
- Intra-articular loose bodies

Remember

O's in osteoarthritis

- **O**besity
- **O**ccupation
- **O**ver 40 yrs age
- **O**ther predisposing joint diseases
- **O**steophytes main characteristic feature of osteoarthritis
- **O**utward deviation of knee
- **O**steotomy required correcting bone deformities

Physiotherapy Management

Measures to Relieve Pain and Muscle Spasm

During the acute(flare up) phase During this phase pain can be satisfactorily controlled by TENS, ultrasound, shortwave diathermy, hydrotherapy, cryotherapy, etc.

During the chronic phase Deep heating by ultrasound or diathermy helps.

Exercise Regimen

Exercises are the single most effective therapeutic modality in treating OA of the knee. The various forms of exercises recommended for OA knee are:

Isometric exercises Strong isometric exercises of the quadriceps and hamstrings done for 5 minutes every hour is found to be very effective. Quadriceps is known as the powerhouse of the knee. A strong quadriceps helps to protect the knee and reduces the load on it and thereby reduces the pain in the knees (Figs 32.10A and B).

Types

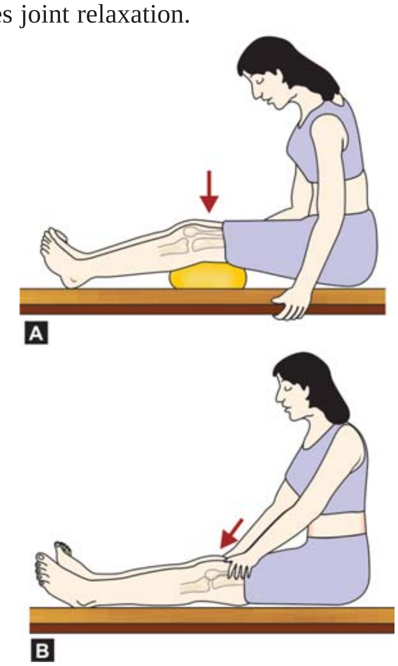
- *Speedy type* Helps to reduce knee effusion
- *Slow and sustained type* Helps reduce pain and improves the muscle strength.

Methods of doing Quadriceps Exercises

Active ROM exercises Here the patient sits at the edge of the bed or chair and actively flexes and extends the knee joint in a free swinging movement within the limits of pain.

Advantages

- Easy to perform.
- Improves the range of motion at the knee.
- Facilitates joint lubrication.
- Provides joint relaxation.



Figs 32.10A and B: Showing isometric quadriceps exercises: (A) Pushing against soft pillow placed beneath the knee, (B) While contracting the knee cap offering resistance by pushing down with help of hand

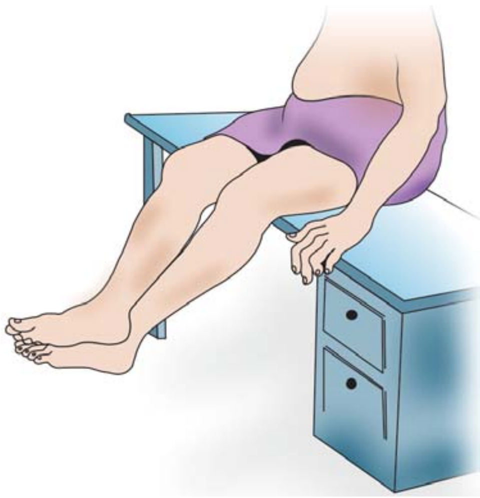


Fig. 32.11: Self resisted active isokinetic knee exercises

Isokinetic exercises in this group of exercises, resistance to the movement is either given normally by the therapist or by the patient himself with the other leg (Fig. 32.11).

Advantages
- Self-controlled.
- Easy to do.
- Can be done frequently.
- Improves the muscle strength.

Straight leg raising exercises Bilateral SLR, with isometrics to the quadriceps and dorsiflexion of the ankle is very effective. By adding weight or by offering resistance by the other leg, this exercise can be made resistive (Fig. 32.12).

Advantages This exercise provides stability to the knee during weight bearing.

Hamstring stretching exercises This exercise helps to prevent flexion deformity of the knee. In this exercise, the patient attempts to touch the toes while the knee is extended in the sitting posture (Fig. 32.13).

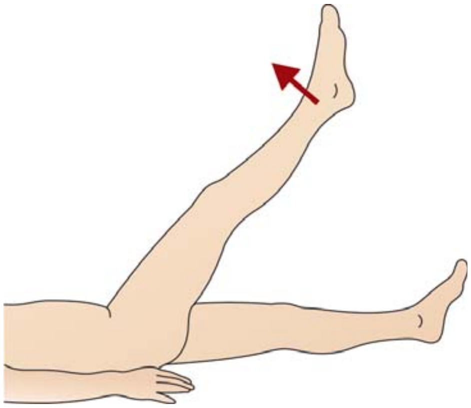


Fig. 32.12: Active straight leg raising exercises

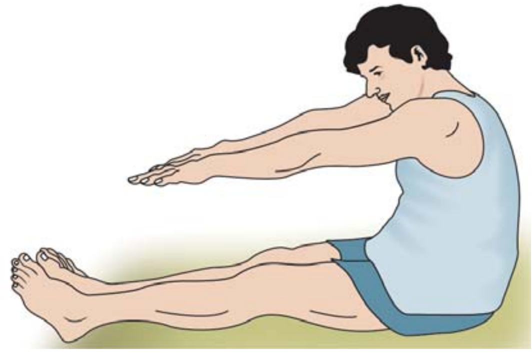


Fig. 32.13: Active hamstring stretch exercises by toe-touching method

Measures to Reduce Compressive Forces on the Knee

Compressive forces on the knee can be avoided by correcting the faulty posture and using assistive devices like orthosis, walkers, walking sticks, etc.

Properly measured wedge insole also helps in relieving the compressive forces on the knee (useful up to 3 radiological stages of OA and not 4 or 5. The height of the sole should be between 7-12 mm as to tilt the calcaneus laterally at 50° from the floor).

Self-help Measures

Patient has got a very important role to play in the management of OA knee. Some of the measures are:
- Reduction of weight, so that load on the joint comes down.
- Walking on the level ground and avoiding uneven surfaces.
- Frequent standing and sitting to be minimized (*see* page 503 for the other important measures).

Quick Facts

What are the things a patient with OA knee should avoid like a hot potato?
- Squatting on the ground.
- Using Indian toilets.
- Unnecessary bending, standing and walking.
- Jogging and long walks.
- Kneeling.
- Unsupported climbing, getting up, etc.
- Carrying heavy weights.
- Unarmed chairs.
- Depression and anxiety.

Note Slogan for an OA knee patient. "Care for the joint to have a care free joint in old age".

Physiotherapy Measures after Surgery in OA Knee

Following surgery, the physiotherapy measures are the same as discussed in relevant sections for osteotomy, TKR, arthroscopy, patellectomy, etc.

OSTEOARTHRITIS HIP

(Familiarly Called as Malum Coxa Senilis)

This is second in frequency to knee joint, and it could be primary or secondary.

PRIMARY OSTEOARTHRITIS OF HIP

This is idiopathic and forms 50 percent of the osteoarthritis of the hip. In this variety the exact cause is not known and the causative factors suspected are increased ante-version and trabecular micro fracture causing stiffening of the subchondral bone.

Pathology

The changes in the articular cartilage vary from fibrillation to complete destruction depending on the severity of osteoarthritis. The synovium is thick and congested. The subchondral bone shows sclerosis and cyst formation. The capsule is thick and fibrosed. New bone growth results in osteophyte formation in areas not under pressure.

Clinical Features

In osteoarthritis of the hip joint patient is asymptomatic in the early stages, later patient may complain of slight pain lasting for 1 to 2 days. Stiffness of the hip, muscle spasm, limp, restriction of terminal hip movements is the other complaints. As the disease advances pain decreases but the hip becomes more and more stiff. A mild flexion, adduction and external rotation deformity may be seen.

Radiograph

Primary osteoarthritis In the early stages no changes are seen. In the later stages joint space is reduced, subchondral sclerosis, cysts, osteophytes, etc. may be seen (Fig. 32.14).

Secondary osteoarthritis Apart from features of osteoarthritis, features of the predisposing causes are also seen.

Fig. 32.14: Radiograph of osteoarthritis of hip

Treatment

Conservative measures Consist of rest, heat, NSAIDs, muscle relaxant, massage, traction, manipulation, intra-articular steroids, etc.

Surgical Careful selection of the cases is done. Primary aim of surgery is relief of pain, while, secondary aim is to restore movements, increase stability and deformity correction.

In the early stages of the disease when a fair amount of hip movements are still present, osteotomy helps.

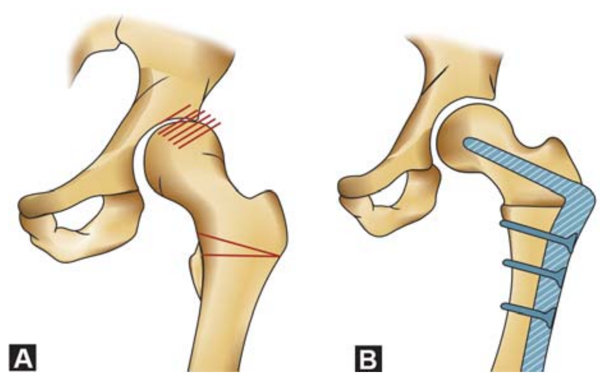
Choice of osteotomy

Pauwell's varus osteotomy It is done if osteoarthritis is due to coxa valga.

Valgus osteotomy This is more common and is done in adduction deformity of the hip.

Displacement osteotomy (McMurray's) This is indicated in severe osteoarthritis of hip with large osteophytes.

Osteotomy helps by changing the line of weight bearing and bringing the normal surface into the line of weight transmission (Figs 32.15A and B).



Figs 32.15A and B: Osteotomy for hip in osteoarthritis: (A) Before operation, (B) After operation

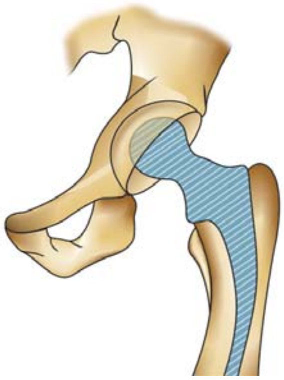


Fig. 32.16: Total hip replacement for osteoarthritis of hip

Arthrodesis and Arthroplasty In the late stages of osteoarthritis, in elderly and in restriction of flexion less than 70°, osteotomy is of no value. The choice is then between cup arthroplasty, arthrodesis, hemi replacement arthroplasty and total hip replacement (Figs 32.16 to 32.18).

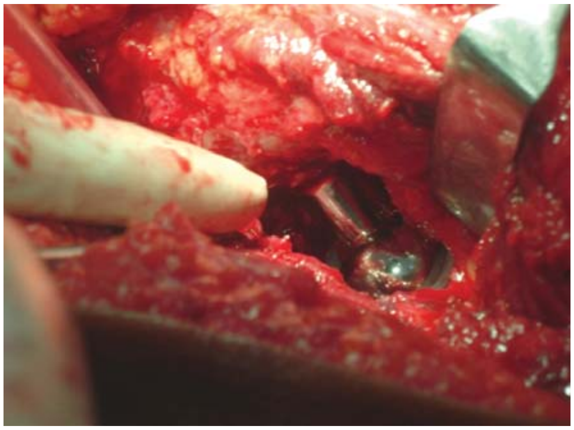


Fig. 32.17: Operative photograph showing THR in OA hip

Fig. 32.18: Radiograph showing THR

Physiotherapy Management

The following physiotherapy measures are suggested:

- *Measures to relieve pain*
  - — In the acute phase: Cryotherapy, thermotherapy, TENS, interferential currents, etc. helps.
  - — Gentle intermittent or sustained low traction helps to relieve pain, spasm and prevent deformities.
- *Measures to mobilize the joints*
  - — Active ROM exercises to the hip, knee and ankle.
  - — Relaxed passive ROM exercises carried out by the physiotherapist for all the movements of the hip joint.
  - — Free assisted active movements by using pedo-cycle, stationary cycle, etc.
  - — Hydrotherapy improves mobility and muscle strength.
  - — PNF techniques and Maitland technique of low-grade mobilization initially progressed to high grades gradually.
- *Muscle strengthening exercises*
  - — Isometric exercises to the glutei, quadriceps, hamstrings, and hip abductor muscles.
  - — Active ROM exercises to the knee and ankle joint muscles.
  - — Progressive resistive exercises are advised in the later stages.
- *Modifications in activities of daily living:* See below.

Postsurgery Physiotherapy for OA Hip

This is the same as discussed in relevant sections like THR, Osteotomy, etc.

Other Useful Approaches in the Management of OA of Hip and Knee Joints (Modifications)

Simple changes around the home and daily activities cause dramatic improvement in the symptomatology of osteoarthritis. The following are some of the measures:

- Use of higher chair which require less effort to get in and get out should be considered (Fig. 32.19).
- Changes to be made in the bathroom:
  - — Use of Western toilets and avoiding the Indian types (Fig. 32.20).
  - — To fit the bath aids to facilitate easy getting in getting out of a bath.
  - — To fit railings next to the toilet and bath to facilitate ease of movement.
- Patients are advised to *climb* the stairs leading the *good leg* taking one stair at a time and to *descend* the stairs

Fig. 36.19: Modification of living habits in the management of osteoarthritis of hip and knee: Higher chairs, less effort

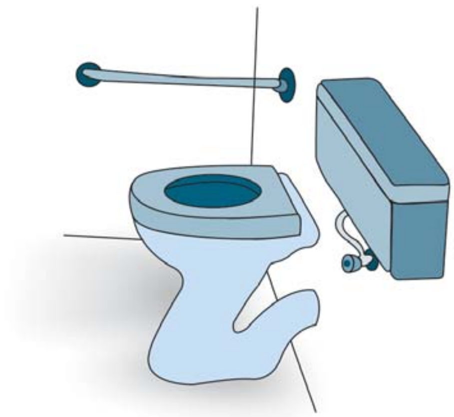


Fig. 32.20: Modified western toilet recommended for patients with OA hip and knee

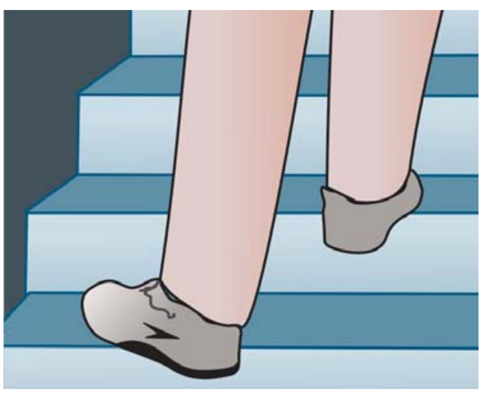


Fig. 32.21: Modification of living habits in the management of osteoarthritis of hip and knee: stairs often present a problem

leading with the *bad leg*, again taking one stair at a time (Fig. 32.21).

- To reduce the force acting across the injured joint patient is advised to use a walking stick which acts as a *third limb.*

Fig. 32.22: Cane support in OA hip of knee

The stick should be held in the hand opposite to the affected hip or knee. Initially it should be used around the home. The top of the stick should come up to the wrist when the patient stands and the tip should be provided with a firm rubber to avoid slipping. A walking stick, by providing a third limb through which forces can be transmitted, enables the reduction of force across the injured joint from peak values of 5 to 1.5 times the body weight (Fig. 32.22).

- Footwear with hard soles and high heels should be avoided.
- Cars with raised platforms and seats which facilitate easy getting in and getting out should be used.
- If the patients are overweight, reduction in the weight helps to reduce the load on the joints.
- General advice:
  - — Keep as upright as possible as this helps to put equal weight on both the legs.
  - — Avoid sitting on a low or soft chair.
  - — Avoid curling up in bed.
  - — To stretch the front of the thigh and hip, lie on the stomach at least once a day for five minutes to thirty minutes.
  - — To use a walking stick when walking inside or outside the house (Fig. 32.23).
  - — To avoid uneven and rough ground or surfaces while walking.
  - — To wear comfortable footwear.
  - — Avoid squatting on the ground.

Role of Exercises in the Management of OA of the Hip

Exercises from the mainstay of the patients own contribution in the treatment of osteoarthritis of the hip.

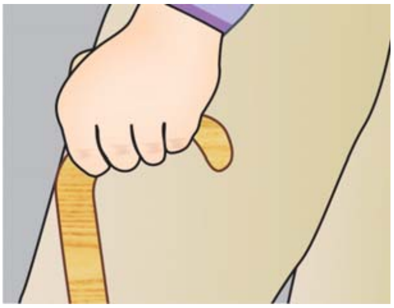


Fig. 32.23: Modification of living habits in the management of osteoarthritis of hip and knee: walking sticks of the right height

Quick Facts

Aims of the exercises in osteoarthritis hip:
- To increase the range of movements.
- To increase stability and shock absorption.
- To prevent deformity.
- To improve posture.
- To reduce pain and stiffness.

Rules of the exercises
- Build-up the exercises gradually.
- Avoid rough ground while exercising.
- To take warm baths before starting the exercises.
- To perform the exercises 20 times each twice a day and later four times a day.

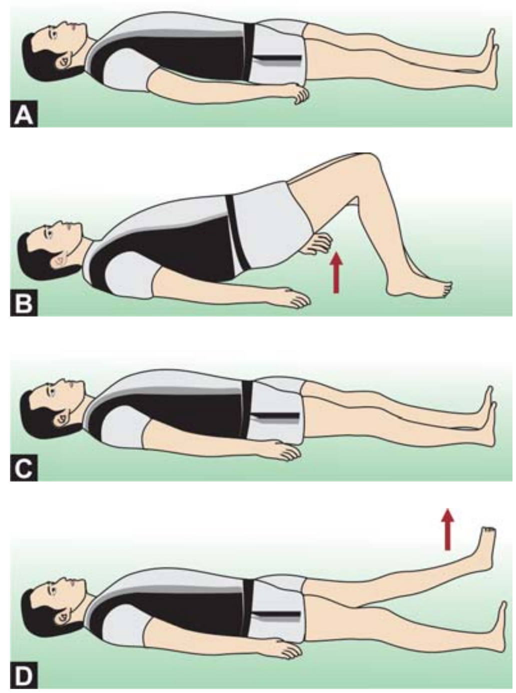
Types of Exercises in OA of Hip and Knee

Exercises Lying on the Back (Figs 32.24A to D)

- *Pelvic tilt* Tighten the thigh and buttock muscles, pushing the knees flat, hold for a count of five and relax (Fig. 32.24A).
- *Pelvic lift* Bend both the knees up, push on the feet and lift, hold for a count of five and relax. (Fig. 32.24B).
- *Leg stretch* Push one leg along the floor as though you are trying to make it longer than the other. Hold for a count of five and then repeat with the other leg (Fig. 32.24C).
- *Alternate leg raising* Keeping the knees straight, lift alternate legs six inches from the ground (Fig. 32.24D).

Exercises Lying on your Side, with the Painful Hip-up (Figs 32.25 to 32.26A and B)

Side leg raising Keep the top leg straight and lift it up as high as possible, hold for a count of five and relax (Figs 32.26A and B).



Figs 32.24A to D: Exercises on lying back: (A) Pelvic tilt, (B) Pelvic lift, (C) Leg stretch, (D) Alternate leg raising

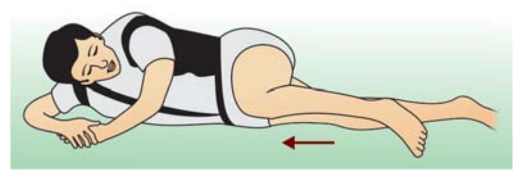
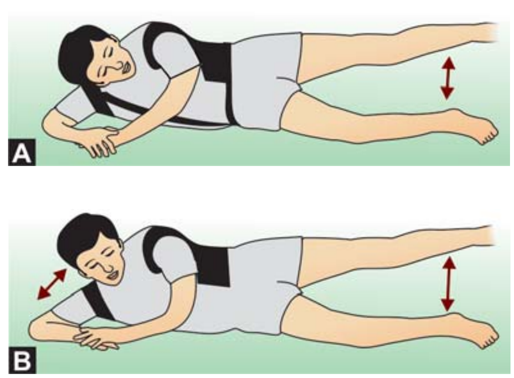


Fig. 32.25: Exercises lying on side knee and hip flexion



Figs 32.26A and B: Exercises lying on side: Side leg raising

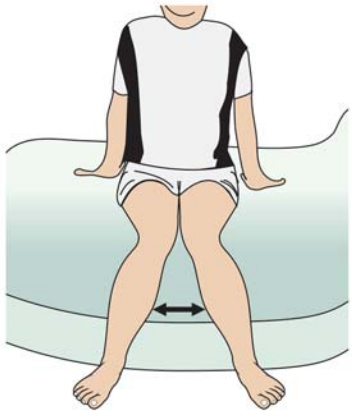


Fig. 32.27: Exercises while sitting knees together feet apart

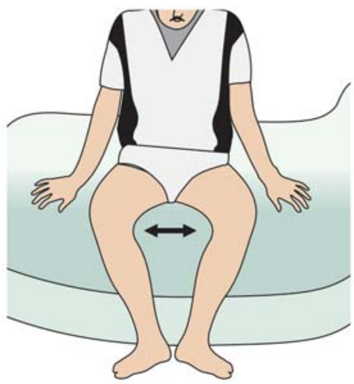


Fig. 32.28: Exercises while sitting feet together, knees apart

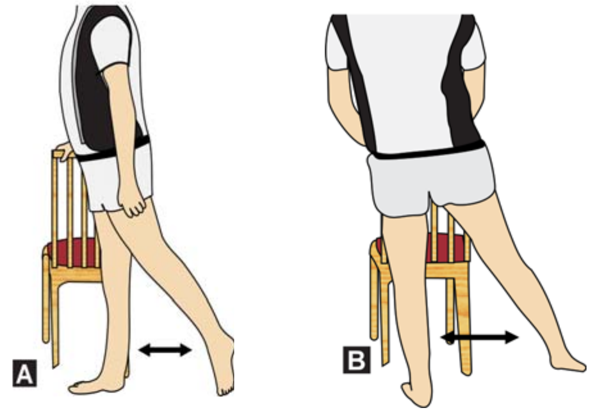
Knee and hip flexion Bend the hip and knee of the top leg forwards, and hold for a count of five. Then straighten the leg and stretch backwards as far as it will go, hold for a count of five, then relax (*see* Fig. 32.25).

Exercises in Sitting Posture (Figs 32.27 and 32.28)

- *Knees together, feet apart* keep the knees together and move the feet apart, hold for a count of five then relax (Fig. 32.27).
- *Feet together, knees apart* Keep the ankles together and move the knees apart, then relax (Fig. 32.28).

Exercises in Standing Posture (Figs 32.29A and B)

- *Standing leg swing* Hold into a table or chair with one hand, swing one leg forward and backward. Try to get the backwards swing as wide as possible (Fig. 32.29A).
- *Standing side leg swing* Hold on to a chair with both hands. Swing bad leg out as far as it will go and then in. The outward swing is the hardest part and the leg should be allowed to fall back under muscular control (Fig. 32.29B).



Figs 32.29A and B: Exercises in standing (A) Standing swing, (B) Standing side leg swing

SECONDARY OSTEOARTHRITIS OF HIP

The following factors are responsible for the development of secondary osteoarthritis of the hip joint:

- *Incongruity of the articular surface* For example, trauma, Perthes, etc.
- *Instability of the hip* For example, subluxation
- *Concentration of pressure load* For example, coxa vara. Ante version.
- *Direct injury* For example, infection, trauma, etc.
- *Constitutional causes* For example, obesity, hyperthyroidism, etc.

Remember

About secondary osteoarthritis:

- Progress is relentless.
- Occurs in younger age group.
- Non-surgical treatment is futile.
- If surgery is prolonged for long, the optimal time for surgery is missed.

Osteoarthritis In Other Regions

Osteoarthritis spine (lumbar spondylosis) It is usually seen in the elderly age group and the patient presents with low backache. X-ray of the LS spine in lumbar spondylosis shows loss of disc space, sclerosis and osteophyte formation (Fig. 32.30). Osteophytes may compress the nerve roots at their exit at the intervertebral foramen and may cause neurological disturbances. Conservative treatment usually helps but

Fig. 32.30: Lumbar spine: Narrowing of disc space and osteophyte formation

Fig. 32.31: Cervical spine: Loss of intervertebral disc space and osteophyte formation

surgery may be required for prolonged pain and neurological deficits.

Physiotherapy Treatment for Lumbar Spondylosis

- Bed-rest helps to alleviate pain.
- Drugs—NSAIDs, muscle relaxants, antidepressants, etc.
- Injections—local infiltration of hydrocortisone and epidural steroid injection.
- Thermotherapy and cryotherapy to relieve pain and spasm.
- Spinal exercises with special emphasis on flexion—rotatory exercises (*see* Chapter 22 on Low Backache).
- Spinal braces or corsets.
- Back ergonomics.

OA Cervical Spine This leads to cervical spondylosis and has been discussed in great detail in regional conditions of neck. Figure 32.31 shows radiological features in cervical spondylosis.

Osteoarthritis of the Hand

Osteoarthritis of the hand is rare but is seen more commonly in elderly women in the dominant hand due to excessive wear and tear (Fig. 32.32). It affects the peripheral joints of the hand and foot. It may cause ankylosis at an increased rate in these joints (Fig. 32.32).

Fig. 32.32: Osteoarthritis of the carpometacarpal joint of the thumb: Loss of joint space and sclerosis

Sites

- DIP joints commonly affected
- PIP joints less common
- Metacarpophalangeal joints are affected in the later stages.

Clinical Features

Patient complains of pain and stiffness in the fingers of the hand. The hand function is decreased. Heberden's nodes at the

DIP joints and Bouchard's nodes the PIP joints are painfully palpable.

Radiograph

Plain X-ray of the hand shows the degenerative changes in the joints.

Treatment

Conservative measures NSAIDs muscle relaxants, etc. help to relieve pain and spasm.

Physiotherapy measures
- Thermotherapy and cryotherapy helps to reduce pain.
- Active ROM exercises to the fingers.
- Relaxed passive ROM exercises to the fingers.
- Hand elevation and splinting.
- Wax bath therapy helps considerably.

Surgery Arthrodesis, arthroplasty, etc. are the recommended surgical methods of treatment in very advanced and disabling cases.

Remember

In osteoarthritis of small joints
- *Heberden's node* Osteophytes around distal interphalangeal joints of the hand.
- *Bouchard's node* Osteophytes along proximal interphalangeal joints.
- *Mucinous cysts* Cysts containing degenerative myxomatous fibrous tissue at the distal or proximal interphalangeal joints.
- Bunion is a combination of osteoarthritis and valgus angulations of the first metatarsophalangeal joint of foot.
- *Erosive osteoarthritis* It is a hereditary severe osteoarthritis involving distal and proximal interphalangeal joints. Joint deformities and ankylosis result more often.
- *Osteoarthritis of the first carpometacarpal joint of the thumb* Seen in women more than 50 years (Fig. 32.37). They complain of pain and loss of grip.
- *Osteoarthritis of the wrist* Seen in Kienbock's disease, trauma, gout, nonunion scaphoid, etc.
- *Osteoarthritis of the acromioclavicular joint* This is quite common.

CRYSTALLINE ARTHROPATHIES

This group includes two interesting clinical entities:
1. Monosodium urate arthropathies (gout)
2. Calcium pyrophosphate deposition disease (CPPD).

MONOSODIUM URATE ARTHROPATHY (GOUT)

This is known as *gout* and may manifest itself as *acute* or *chronic* (Figs 32.33 and 32.34).

Sites It is usually monoarticular and the first metatarsophalangeal joint is the most common site of involvement. Ankle, knee, wrist, fingers and elbow are other joints affected. *Distal and lower extremity joints are involved more often.*

Role of hyperuricaemia Gout is usually associated with hyperuricaemia and may be associated with hypertension, obesity and atherosclerosis.

Clinical Features

It has an abrupt onset. Patient may complain of pain, swelling, tenderness and increased temperature of the first metatarsophalangeal joint. Frequent gouty attacks disturb the sleep. Sometimes the inflammation is so gross that it may resemble

Fig. 32.33: Clinical photograph of acute gout

Fig. 32.34: Clinical photograph of chronic gout

cellulitis (Fig. 32.33). Attacks are provoked by surgery, trauma, etc. Mild attacks resolve spontaneously within two days, more severe attacks may last for 7 to 10 days.

Investigations

Laboratory tests: Leucocytosis, ESR is increased.

Synovial fluid study is done under polarized microscopy for the presence of monosodium urate crystals. *This is the most important diagnostic method*.

Radiograph

It is usually normal but may provide a helpful clue to detect chondrocalcinosis.

Treatment

Conservative method is the mainstay of treatment. The following measures are recommended: Indomethacin 75 to 100 mg oral initially. Later it is given as 50 mg every 6 hrs. As the attack subsides the drug may be tapered off. Intra-articular steroid also helps. Recurrent gouty arthritic attacks can be prevented by prophylaxis with colchicines (0.5 mg BD) or indomethacin (25 to 50 mg everyday). When the above two drugs do not help, Allopurinol is indicated on a long-term basis.

PSEUDOGOUT (CPPD)

Pseudogout is due to deposition of calcium pyrophosphate in the joints. Larger joints are more affected and 50 percent involve the knee joints unlike in gout. Other areas commonly involved are elbows, wrists, ankles, shoulder and hip. Synovial fluid study under polarized microscopy reveals CPP crystals. The disease is not as severe as gout and is much rarer.

Physiotherapy Measures

These are the same as for OA knee.

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7

Section

MISCELLANEOUS

33. Amputations, Prosthetics and Orthotics
34. Sports Injuries
35. Arthroscopy
36. Arthroplasty

33
Chapter

Amputations, Prosthetics and Orthotics

AMPUTATIONS

Definition

Amputation is defined as removal of the limb through a part of the bone. Disarticulation is the removal of the limb through the joint.

Incidences

Age Common in 50 to 75 years age group.

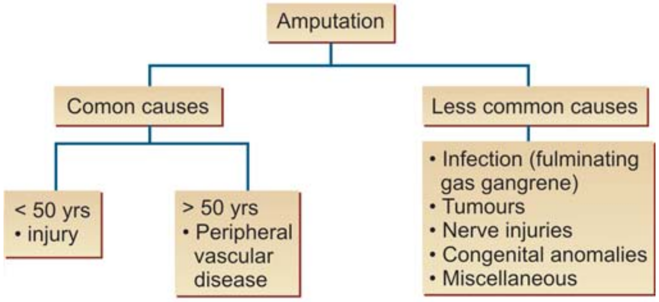
Sex Seventy-five percent men, 25 percent women.

Limbs Eighty-five percent is through the lower limbs, 15 percent is through the upper limbs.

Indications

The indications for amputation differs as per the age group as shown in Flow chart 33.1.

Flow chart 33.1: Showing causes for amputation



Note Injury is the most common cause for amputations.

Common Causes

In patients less than 50 years of age Trauma due to RTA, industrial accidents, etc. are common in young people. Crush injuries devoid of blood and nerve supply warrant amputations.

More than 50 years Diseases like Buerger's disease, diabetes, atherosclerosis, etc. are common after 50 years. These diseases usually lead to gangrene which warrant amputations.

Less Common Causes

Infections Severe infections like gas gangrene, Hansen's disease, severe osteomyelitis, etc. rarely require amputation and are indicated when all other measures fail.

Malignancy Advanced stages of malignant bone tumors need amputations.

Nerve injuries A severe anesthetic limb due to extensive nerve injuries requires amputation.

Severe congenital anomalies Rudimentary limbs, accessory thumb, congenital absence of bones, etc. need amputations.

Severe cold or heat Severe burns or extreme cold, like frostbite, electrical burns, etc. require amputation of the limbs in rare instances.

Amputation Levels

Table 33.1 shows various amputation levels.

Aim The amputation should be carried out at a level which will give a stump of optimum length to facilitate prosthetic fitting at later stages.

UPPER LIMB AMPUTATIONS

Figure 33.1 shows different upper limb amputations.

Forequarter amputations Here the amputation is carried out proximal to the shoulder joint and part of the scapula and clavicle are removed along with the shoulder girdle muscles. *Indications* Malignant bone tumors of the upper end of the humerus, etc.

TABLE 33.1: Shows various amputation levels

Upper limbs
- Shoulder disarticulation
- Short above elbow
- Standard above elbow
- Elbow disarticulation
- Very short below elbow
- Medium below elbow
- Long below elbow.

Lower limbs
- Hip disarticulation
- Very short above knee
- Short above knee
- Medium above knee
- Long above knee
- Very long above knee
- Knee disarticulation
- Very short below knee
- Short below knee.

Ankle amputation
- *Syme's amputation* Here the level of bone section is 0.6 cm proximal to the ankle joint.
- *Sarmiento's amputation* Here the level is 1.3 cm proximal to the joint.
- *Wagner's* is two-stage Syme's amputation.
- *Boyd's* This consists of talectomy and calcaneotibial arthrodesis.
- *Pirogoff's amputation* In this only anterior part of the calcaneum is removed.

Foot amputation
- Amputation of great toes and other toes.
- Amputation through the metatarsal bones.
- *Lisfranc's operation* Amputation is at the level of the the tarsometatarsal joints (Lisfranc joint).
- *Chopart's operation* Amputation is through the midtarsal joints.

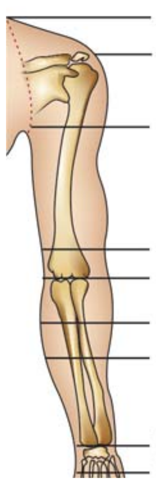


Fig. 33.1: Showing different levels of amputations in the upper limb

Fig. 33.2: Clinical photograph of above elbow amputation

Disarticulation of shoulder This is not commonly done. Head of the humerus is preserved even during disarticulation to preserve the contour of the shoulder.
Indications Same as above.

Above elbow amputation Ideal stump length is 20 cm long stump, measured from the tip of the acromion (Fig. 33.2).

Below elbow amputation

Stump levels—minimum 7.5 cm
—optimum 20 cm

This is measured from the tip of the lateral epicondyle of the humerus.

Krukenberg amputation This is a below elbow amputation done usually on both sides. Here the forearm is split between the radius and ulna. This can be used like a fork and it provides a 'pincer grip.' A below elbow prosthesis or a 'hook prosthesis can be put over the stump to lift the heavy objects.

Amputation through the hand Here the dictum is to preserve as much length as possible. This holds good for the thumb also. But for the proximal phalanx of other fingers, a short stump will not serve any purpose; hence amputation through the neck of the metacarpal bone is preferred.

AMPUTATIONS THROUGH THE LOWER LIMB

Figure 33.3 shows different types of amputations of the lower limb.

Hind quarter amputation (Hemipelvectomy) Here part of the pelvis is removed along with the lower limbs.

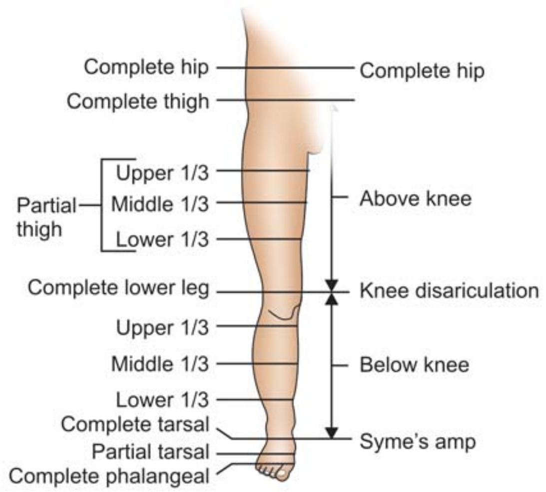


Fig. 33.3: Showing different levels of amputations in lower limbs

Indications: Malignant tumors of the pelvic bone and upper end of femur, etc.

Hip disarticulation: Indications same as above.

Above knee amputation

— Minimum stump—7.5 cm
— Maximum stump—25-30 cm

Knee disarticulation not a very popular method due to the bulky stump.

Below knee amputation This is the most commonly performed amputation.

Indications

— Crush injuries of the foot
— Malignant bone tumor of lower end of tibia, etc.

Minimum stump length is 14 cm.

PTB (patellar tendon bearing) prosthesis, is commonly used for an amputation done at the ideal level and a below knee prosthesis for a short stump.

Syme's amputation Here the tibia and fibula are divided just above the ankle joint. The heel with or without the calcaneum is attached back to the end of the stump. This gives on excellent end bearing stump.

Note Ratio of upper limb vs. lower limb amputations is 1: 24.

Remember

The only real absolute indication for amputation is irreparable loss of blood supply of a diseased or injured limb.

Types of Amputations

Closed amputation This is done most of the times as an elective procedure and may be above knee or below knee, above elbow and below elbow, etc. Here after the amputations, the soft tissues are closed primarily over the bony stump.

Open amputation In open amputation, the wound is left open over the amputation stump and is not closed. This is done as an emergency procedure in the face of life-threatening infections. There are two types in this depending upon the skin flaps.

1. Open amputations with inverted skin flap.
2. Circular open amputation

   In this type of amputation skin is closed at a later date.

Principles of Amputations

Closed Type

Figure 33.4 shows the different steps of closed amputation. In this the skin is closed primarily after amputation.

- *Tourniquets* These are desirable except in ischemic limbs.
- *Level of amputation* As in the past the level of amputation is no longer important, thanks to the modern and sophisticated present-day prosthesis.

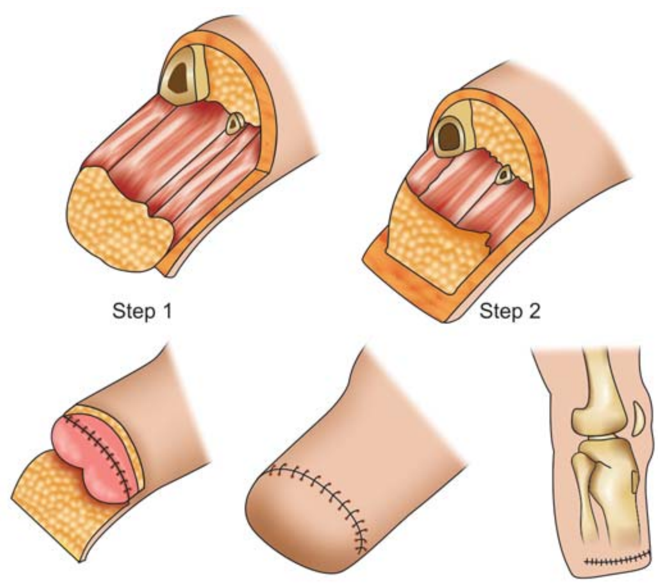


Fig. 33.4: Showing below steps of knee amputation: **Step 1**—A long posterior flap is created. **Step 2**—The edges of the tibia is bevelled. **Step 3**—Myoplasty is done. **Step 4**—The final closure. **Step 5**—In the final stump, fibula is higher than the tibial stump.

Remember

The cardinal rule
Amputate through the tissues that will heal satisfactorily and preserve all possible lengths consistent with good surgical judgment.

- *Skin flaps* Good skin coverage for the amputation site is of vital importance. The skin should be mobile and sensitive. Location of the scar is not important.
- *Muscles* The muscle is divided at least 5 cm distal to the level of intended bone section and sutured.

Remember

Two methods of muscle suture
- *Myodesis* Here muscle is sutured to the bone.
- *Myoplasty* Here muscle is sutured to the opposite muscle group under appropriate tension.

These two techniques of *myodesis and myoplasty* helps improve the function of the muscles and circulation in the stump and thereby helps to prevent phantom pain.

- *Nerves* The nerves are cut proximally and allowed to retract.
- *Blood vessels* are doubly ligated and cut.
- *Bone* The bone is sectioned above the level of muscle section.
- *Drains* are removed after 48 to 72 hours.

Open Type (Guillotine operation)

In this type of amputation the skin is not closed primarily and later it is followed by any one of the closure methods like secondary closure, re-amputation, revision amputation or plastic repair.

Indications
- Severe infections
- Severe crush injuries.

Types

Open amputations with inverted skin flaps is the method of choice.

Circular open amputation Here the wound is kept open and closed secondarily either by secondary suture after a few days, split thickness skin graft, revision of the stump or by reamputation.

After treatment following amputations
Two concepts are widely accepted.

Rigid dressing concept (Pylon) Here plaster of Paris cast is applied to the stump over the dressing after surgery. This presents the following advantages:
- Prevents edema.
- Enhances wound healing.
- Decreases postoperative pain.
- Encourages early upright posture which has both physiologic and psychological benefits.
- Reduces hospital stay.
- Helps in early temporary prosthetic fitting.

Soft dressing concept This is the conventional method wherein the stump is dressed with a sterile dressing and elastocrepe bandages are applied over it. The bed is elevated to facilitate venous drainage and prevent stump edema. The sutures are removed after 10 to 14 days and the muscle exercises are commenced. Prosthetic fitting is taken up as the last step.

IMPORTANT AMPUTATIONS OF LOWER EXTREMITY

Amputations of lower extremity accounts for nearly 85 percent of all amputations. *To successfully use prosthesis, it is desirable to perform amputations of the lower limb at the distal most possible level.*

Below knee amputation This is the most common amputation performed. Techniques vary in non ischemic and ischemic limbs (Fig. 33.5).

Non-ischemic limbs Here the ideal level of amputation is at the *musculotendinous junction of the gastrocnemius* because distal to this level the tissues are relatively avascular and soft tissue padding is scanty. Though soft tissue may heal early, it

Fig. 33.5: Clinical photograph showing below knee amputation

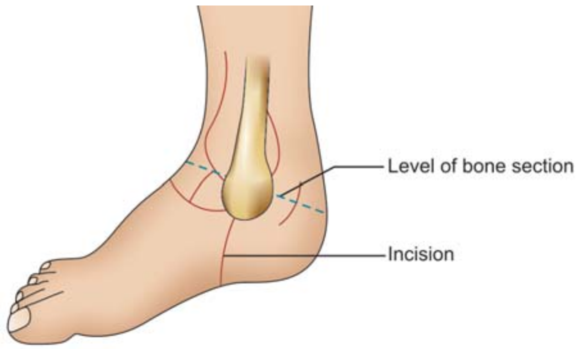


Fig. 33.6: Syme's amputation

usually breaks down later due to the prosthetic use and advancing physiologic age.

Ischemic limb Here the skin's blood supply is better to the posterior than the anterior. *Hence a long posterior flap is preferred in ischemic limbs*. To preserve vascular connections, unnecessary dissections are avoided. Unlike in non-ischemic limbs, amputation is performed at a higher level. Tension myodesis and myoplasty are contraindicated for fear of damaging the already precarious blood supply.

Knee disarticulation This gives an excellent end bearing stump. Large end bearing surfaces of the distal femur are naturally suited for weight-bearing and the prosthesis will be stable.

Amputation through the thigh This is second in frequency to the knee. Because knee joint is lost, it is extremely important that the stumps be as long as possible to provide a strong lever arm for the control of prosthesis.

***Syme's amputation (Fig. 33.6)** It is indicated in severe crush injuries of the forefoot. A healthy heel pad is required for the successful outcome of this surgery.

Physiotherapy Management in Amputations

Management of the Stump

Edema of the stump is a troublesome problem and can be contained if the following measures are adhered to:

- Limb should be kept elevated with elastocrepe bandage.
- All the joints including the stump are subjected to resistive exercises.
- Stump bandaging (Fig. 33.7) is an art and a skill, very useful in preventing the edema. Observe the following points.
  - — A 6" elastic bandage for the lower limb and a 4" for the upper limb.
  - — The bandage should be applied with optimum pressure neither less nor more.

*James Syme** (1799-1870) Edinburgh British Surgeon described it in 1843.

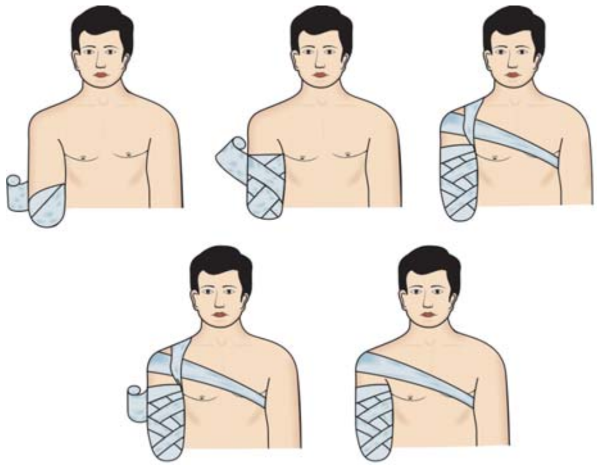
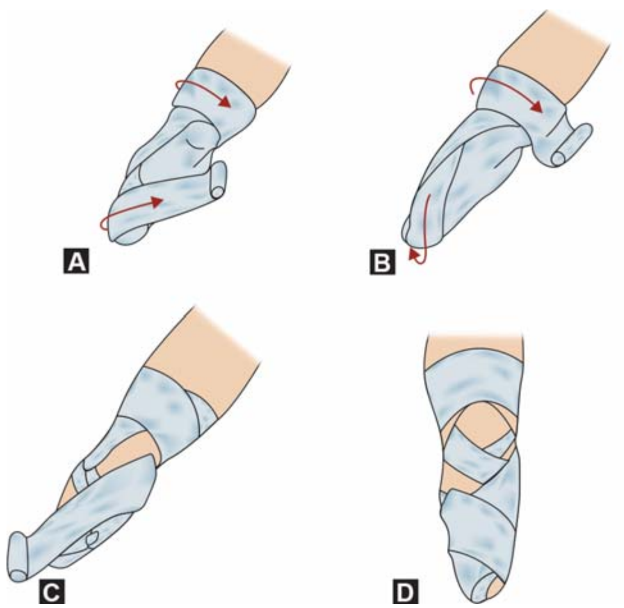


Fig. 33.7: Different steps in the stump bandaging of the above elbow amputation



Figs 33.8A to D: Bandaging of the below knee stump: Anterior views (A and B). Posterior views (C and D)

  - — The bandage should be taken off during exercises.
  - — The pressure of the bandage should be evenly distributed with extra pressure only near the corners.
  - — Circular turns leads to a tourniquet effect choking the stump, hence diagonal, oblique or spiral turns should be used.
  - — In above knee amputation it should be extended upto the groin and the hip should be in extension and adduction.
  - — The below knee stump should be in flexion (Figs 33.8A to D). For method of below knee stump bandaging.

Quick Facts

Causes for stump edema
- Bad bandaging technique—most common cause
- Diabetes
- Atherosclerosis
- TAO
- Kidney diseases, etc.

Quick Facts

An approach to a patient facing impending amputation:
- Mental preparation of the patient is vital to accept the loss.
- A thorough evaluation of the skin, ROM, muscle strength, circulation, sensory system of the affected and unaffected limbs.
- The status of vision and hearing analyzed as, a new proprioceptive system needs to be developed and understood by the patient after amputation.
- Treat the underlying diseases like, TAO, diabetes, etc.
- Study his mental makeup, his family, his work and his society and offer suitable guidance.

Trainings so vital for a patient undergoing amputations
- Chest exercises.
- ROM exercises of all the joints to prevent thrombosis, improve mobility, strength, etc.
- Mobility training for trunk, shoulder, pelvis, etc.
- Walking training with special emphasis on balance, equilibrium.
- Resistive exercises practiced on the sound limb.
- Training for weight transfer, use of crutches, wheelchairs, etc.
- Training for single limb standing and balancing.
- Mental preparation to anticipate and overcome post amputation, complications like phantom limb, etc.
- Training of lying, turning and limb positioning on bed.

Last but not the least
- Lots and lots of talking and boosting of the morale of the patient.
- Plenty of sympathy and psychological reassurances.

Quick Facts

Must do things after amputation
- Encourage prone lying to prevent hip flexion contractures.
- Avoid pillows beneath the knee to prevent flexion deformities of the knee.
- Avoid long periods of sitting for the same reasons mentioned above.
- Avoid dragging on the bed; rather push up the forearm to get up.
- Advise vigorous ROM and strengthening exercises to practically all joints of the body.
- Strong isometrics, to the glutei and thigh muscles, for the stump after 3-4 days.
- Introduce transfer activity once the patient is able to sit up and push his body in sitting.

Note Other important measures to prevent and control stump edema.
- Shrinker socks—elastic stump socks.
- Rigid dressing with a POP cast.
- Controlled air pressure apparatus.

Other Important Aspects of Stump Management

Stump cleanliness
- Regular cleaning of the stump with warm disinfected soap solution.
- Thorough drying.

Stump conditioning
- Regular and correct application of a firm elastic bandage.
- Regular isometric exercises to the stump muscles proximal to the amputation.
- Repeated massaging to improve the tone of the muscles.
- Electrical stimulation to the muscles.
- Exposing the stump to pressure by gradual weight-bearing on a soft cushioned stool within the parallel bars and over the pylon. For above knee amputation crawling on a bed or knee walking on the bed is ideal exercises in weight bearing.

The All Important Stages of Mobilizing the Patient

It is a new experience and a tough challenge for a patient who has undergone an amputation to resume mobility. It is an enormous physical, mental and psychological challenge to be surmounted by an indomitable will by the patient, as is braces himself for a new life without an all-important member of his body.

The Steps

- Encourage crutch walking at the earliest.
- Teach the patient to balance and maintain the normal alignment of the pelvis while crutch walking. Tendency to tilt the pelvis should be avoided.

TABLE 33.2: Showing various muscles to be strengthened after different amputations

Level of amputation	*Muscles to be strengthened*
• Disarticulation of shoulder joint	• Shoulder elevators, depressors. • Mobility exercises to the trunk/neck.
• A/E amputation	• Flexors, extensors and adductors of the shoulder. • Elevators of the scapula on the normal side.
• B/E amputation	• Elbow flexors and extensors. • Forearm supinators and pronators. • Trunk mobilization.
• Hip disarticulation	• Pelvic rotators and elevators.
• A/K amputation	• Shoulder girdle muscles. • Hip extensors, flexors and adductors.
• B/K amputation and Syme's	• Knee flexors and extensors. • Hip extensors, flexors and adductors.

- Teach the patient to resist the habit of keeping the stump in flexion during crutch walking.
- Teach ambulation initially within the parallel bars.
- PRE, PNF methods of strengthening exercises is indicated to all the joints of the body (Table 33.2).
- ROM exercises to all the joints of the body particularly the muscles of the stump.

Complications

Hematomas This delays the wound healing and acts as a culture media for the growth of the organisms.

Infections This is more common in peripheral vascular disease and diabetics.

Necrosis of the skin flaps are usually due to insufficient circulation and require revision amputations.

Contractures This is largely preventable by positioning the stump properly. Flexion contractures of hip and knee are very common.

Neuromas form always at the end of a cutaneous nerve and any pain from a neuroma is usually caused by traction on a nerve when it is embedded within the scar tissue.

Phantom sensation This is a pseudo feeling of the presence of the amputated limb. It could be of a painless or a painful variety. This is due to persistence of nerve impulses.

Treatment method consists of reassurance, ultrasound therapy, TENS, percussion, cryotherapy, steroid injections, exploration of the neuroma, etc.

Causalgia It is due to division of the peripheral nerves. Even local stimulus can trigger pain.

Remember

In amputations

- Eighty-five percent amputations are through the lower limbs.
- Severe injury forms the most common indication.
- Level of amputation is no longer important as in the past due to efficient prosthesis.
- The latest concept is to preserve as much stump length as possible.
- Guillotine amputations are salvage procedures for life-threatening infections.
- Stump care is very vital to prevent post-amputation problems.

PROSTHETICS

Prosthesis in Greek means "in addition". Thus prosthesis is *defined as a replacement or substitution of a missing or a diseased part.*

Prosthetics is the theory and practice of the prescription, fitting, design, assessment and production of prosthesis.

Table 33.3 shows the different materials used in the manufacture of prosthesis.

TABLE 33.3: Showing various materials used for making prosthesis

Materials used	*Prosthetic types*
• Wood	• Socket material • Prosthetic foot
• Leather	• Soft variety—suspension straps • Hard variety—thigh and socket corsets
• Plastics	• Plastic foam—for support of the distal stump • Polypropylene—for making of sockets
• Metal	• Steel—for knee and hip mechanism • Duraluminium–for outer shelf and socket

Classification

Endoprostheses These are implants used in orthopedic surgery to replace joints, e.g. Austin-Moore prosthesis.

Exoprostheses These are for replacement externally for a lost part of the limb. They are more extensively used in the lower limbs.

Types

- *Temporary prosthesis* (e.g. Pylon). These are used following an amputation till the patient is fitted with permanent prosthesis after 2 weeks after removal of the suture.

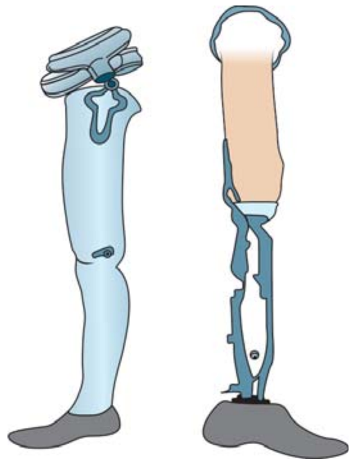


Fig. 33.9: Prosthesis for above-knee amputation

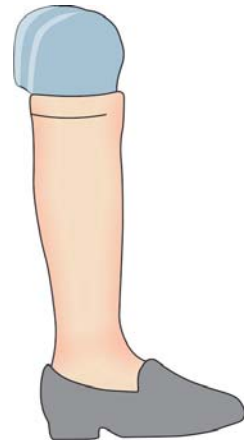


Fig. 33.10: PTB prosthesis

- *Permanent prosthesis.* This is fitted after making a final clinical assessment. The following are some of the important ones:

Prosthesis for the lower limbs Prosthesis for the lower limbs is required in the following situations:
- For disarticulation of hip and hemipelvectomy.
- Following transfemoral amputations: Two types of prostheses are recommended (Fig. 33.9).
  - — *Suction-socketed limb* This is useful in young adults and is best suited for cylindrical stumps. It snuggly fits and has a two-way valve mechanism to maintain negative pressure.
  - — *Non-suction-socketted limb* Here no negative pressure is employed to hold the prosthesis, but pelvic bands or harness are made use of for holding (Fig. 33.9).

The advantages of suction-socketed limb are that skin infection is less common, there is freedom from harness of any kind, greater feel of close contact of the prosthesis and the patient feels that it belongs to him or her. Stump socks are not necessary in this variety. On the contrary, the advantages of non-suction socketed limb are, it is easy to wear, there is no perspiration, it provides a comfortable fit, and there is no difficulty in changing the stump circumference.

Component of Prosthesis

- *Socket* This provides a receptive area for the stump and helps in weight-bearing.
- *Suspension* This fastens the prosthesis to the stump.
- *Joints* These are artificial mechanical joints which replace the original joints.
- *Base* This is in touch with the floor.

Note Types of artificial joints:
- Manually operated.
- Semi-automatic
- Automatic.

Prosthesis for through knee amputation As already mentioned knee disarticulation gives a good, stable, long weight-bearing stump which enables to operate the prosthesis with comfort (Table 33.4).

TABLE 33.4: Prosthesis for above knee amputation

Features	*Knee disarticulation*	*A/K amputation*
• Socket	Thigh corset	Quadrilateral H-socket
• Suspension	Rigid pelvic band or shoulder suspension or waist band	• Double swivel pelvic band • Rigid pelvic band • Suction socket valve
• Knee	Uniaxial joint with manual or automatic locking	• Modular prosthesis — Hand operated or — Semiautomatic locking
• Feet	SACH foot or uniaxial foot	SACH or uniaxial foot

Prosthesis for below knee amputations Two varieties are described here:

Patellar tendon bearing (PTB) prosthesis The socket is made in such a way that it fits exactly over the patellar tendon and the sides of the tibial condyles such that when in full extension the weight is transferred to some extent through this to the prosthesis (Fig. 33.10). This has the advantage over the conventional prosthesis which requires the knee supports (Table 33.5).

TABLE 33.5: Prosthesis for below knee amputation

Features	*Conventional prosthesis*	*PTB prosthesis*
• Socket	• Extends 3 cm above the lower pole of patella • A metal, wood and polyester proximal weight-bearing socket	Soft inner socket with a hard covering
• Suspension	• Rigid pelvic band • If required shoulder strap or waist belt	Elastic stocking, Suspension and Supracondylar cuff
• Knee joint	Uniaxial joint	—
• Feet	Uniaxial	Uniaxial Multiaxial SACH foot

Quick Facts

- Quadrilateral socket prosthesis for above knee amputation.
- PTB prosthesis for below knee amputation.
- Syme's prosthesis for Syme's amputation.
- Shoe fillers for partial foot amputation.

Conventional type prosthesis This consists of the thigh corset, the side steels, the knee joint, shin piece, ankle joint unit and the foot piece. It definitely has the disadvantage in that it is more cumbersome to put on and use it when compared to the PTB prosthesis (Table 33.5).

Prosthesis for Syme's amputation This is a below knee prosthesis used after Syme's amputation (Fig. 33.11). These prostheses may have closed sockets or open sockets and may be full weight-bearing or modified end bearing.

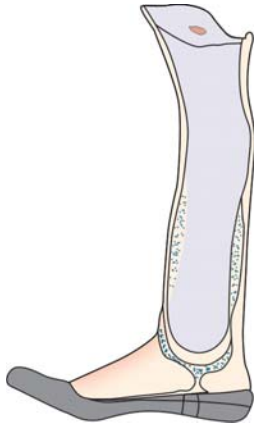


Fig. 33.11: Syme's prosthesis

Quick Facts

Factors to be considered before prosthetic filling:
- Age of the patient
- Sex
- General build
- Personal and professional requirement of the patient
- Circulation status of the stump
  NB—suction socket is not indicated for ischemic limbs
- ROM of all the joints and the affected limb.
- The muscle strength of the affected limb.

Prosthesis for Hemipelvectomy and Hip Disarticulation

The prosthesis for the above conditions (Fig. 33.12) should have the following designs:

- *Socket*
  — Totally embracing socket enclosing both iliac crests.
  — Weight-bearing areas
    i. Hemipelvectomy—Ischial tuberosity and buttock of the other side.
    ii. Hip disarticulation—Ischium and buttock of the same side.
- *Suspension* This is through the total tissue contact with locking on the iliac crests.
  Sometimes additional shoulder suspension is required.
- *Hip joint* Two types of locking are in use:
  — *Standard locking* These locks automatically on hip extension.

Fig. 33.12: Showing prosthesis for hemipelvectomy and hip disarticulation

— *Canadian locking* This also locks automatically when the patient stands and is placed anteriorly.
During swing phase of the gait, it allows 20° of flexion.

- *Knee joint* To offer stability during the stance phase, the knee joint is placed in hyperextension. This lock could be manual, semiautomatic or automatic.
- *Feet* To offer maximum stability during standing Solid Ankle Cushion Heel (SACH) are preferred.

Note Uniaxial foot—permits only dorsiflexion and plantar flexion. Biaxial foot—permits the above and also foot inversion and eversion.

- Double swivel joint—permits all movements of the hip.
- Rigid pelvic band—permits only hip flexion and extension.

Quick Facts

Indications for conventional prosthesis

- Heavy manual laborers
- Patellar defects
- FFD of knee > 25°
- Unstable knee
- Very short stump
- Anesthetic stump

Quick Facts

Conventional vs. PTB
Advantages of PTB

- Permits normal gait
- Permits early rehabilitation
- Convenient for patients with a long stump.

Quick Facts

Prosthesis for Syme's amputation

- *Enclosed metal Syme* In this there is a leather liner with a posterior flap. Uniaxial foot is used.
- *Tongue and butt Syme* Here two side steels connect the socket to the foot piece. It has a leather socket which opens in front.
- *Plastic Syme* There is a hard plastic outer socket with a thin pelite liner inside with medial or posterior access panel.
- *Three strip posterior steel socket this* is connected in front by two side steels and an inverted Y-shaped front steel parts.
- The socket which is made up of leather has an opening posterior and is fully articulated to the foot.

Prosthesis of partial foot amputation Two varieties are described.

- Shoe fillers made up of leather.
- Ankle corset attached to the wooden foot inside the foot.

Prosthesis for bilateral amputations

For bilateral above knee amputations

- Wheelchair for elderly patients.
- Short arm crutches with plastozoate stump covers (Fig. 33.13).

For bilateral hip disarticulation

- Axillary crutches.
- Ambulation through a fiber glass special sitting shell and push up blocks.

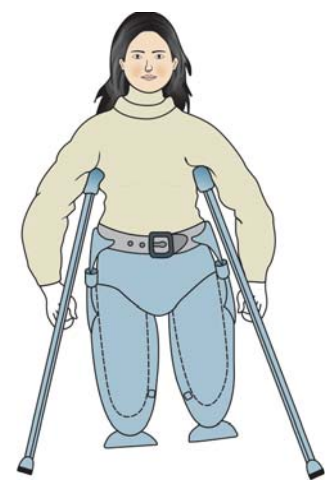


Fig. 33.13: Showing short arm crutches for bilateral above knee amputation (stubbies)

Prosthesis for upper limb amputations

Forequarter amputations Here the prosthesis merely serves a cosmetic purpose. A sleeve fitter prosthesis with a plastozoate cap padded inside with foam and retaining straps is used.

Shoulder disarticulation
Shoulder piece Extended cap to hold the prosthesis.
Elbow piece It can be flexed by pulling on the flexion cord with the protractors of the shoulder.
Hand piece Either cosmetic or splint hook type.

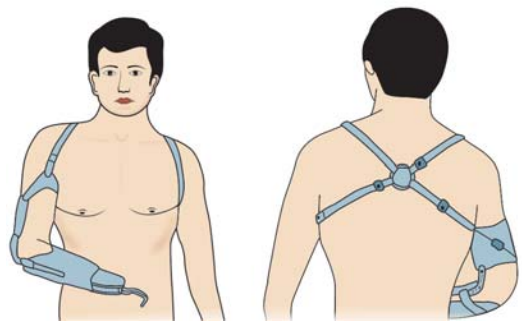


Fig. 33.14: Showing prosthesis for above elbow amputation

Above elbow amputation Same as above except that the elbow flexion is stronger due to the action of the arm muscles along with the protractors of the shoulder (Fig. 33.14).

Below elbow amputation Here there is a cup socket attached to the terminal device through an operational cord. The terminal device can be activated through a loop harness (Fig. 33.15).

For wrist disarticulation In this a split socket forearm and a wrist rotation device is provided. A device can be provided to lock for supination and pronation.

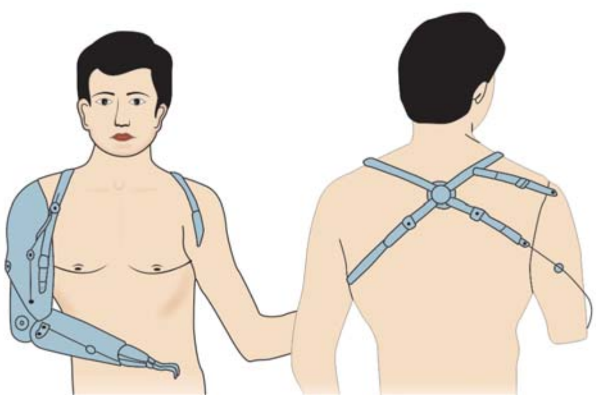


Fig. 33.15: Showing below elbow prosthesis

Quick Facts

The terminal devices for the upper limb prosthesis.
- *Splint hook* This has 2 jaws, one is fixed and the other one moves by the power of shoulder girdle muscles. This is a popular device.
- *Mechanical* Thumb abduction device.
- Mechanical hand providing flexion of the thumb, middle and index fingers.
- A battery operated myoelectric device for grip

Quick Facts

Vital points before prosthetic application.
- Check the joint alignment and its movements.
- The socks should be pulled up and fastened firmly.
- The prosthesis is applied in the functional position.
  — Upper limb prosthesis applied in sitting position.
  — Lower limb prosthesis applied in standing with 2" apart in parallel bars.
- Check the anatomical alignment in respect to normal limbs.
- Check the heels of the body from front, back-sides.
- Check for any discomfort in weight-bearing areas.
- Check the axis of weight-bearing and prosthetic joint.
- Check the overall fitting of the socket.
- Check for the proper fitting for the corset.
- Check for the proper fitting of the suspension.
- Check the prosthetic joints.
- Check the length of the prosthesis especially that of the lower limbs.
- Check the SACH, uniaxial or biaxial foot.

What does a patient wearing the prosthesis need to learn?
- How to apply and remove the prosthesis correctly.
- How to identify complications arising out of fitting and use of prosthesis.
- How to walk over with the prosthesis.
- How to maintain and take care of the prosthesis.
- To acquire functional training in upper limb amputees.
- A knowledge about the structure and function of the prosthesis.

How is a patient trained to walk on the prosthesis?

Steps
- Training is given in the parallel bars.
- First, standing balance on both the legs is taught.
- Second, taking the body weights on both the legs alternatively.
- Third, with bilateral hand support, coordinated stepping is taught.
- Fourth, it is now progressed to single hand support.
- Fifth, sitting to standing and vice versa is taught.
- Sixth, turning, side walking, climbing taught next.

Note Patient is taught balance and equilibrium during all the above activities.

- Once the patient has gained sufficient mastery in the parallel bars, he is next made to walk on the footmarks over the floor in front of a mirror.
- PNF techniques of resistive gait are practiced.

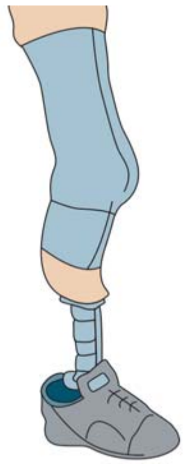


Fig. 33.16: Showing a temporary prosthesis

The physiotherapist should be able to identify if there is any gait deviation from the normal gait pattern, detect the cause for it and rectify it.

Temporary Prosthesis

Fitting of prosthesis soon after an amputation (Fig. 33.16) offers the following advantages:

- Minimizes stump edema.
- Prevents contractures and deformities.
- Prevents phantom limb.
- Reduces hospital stay.
- Helps to regain the normal gait pattern at the earliest.
- The unstable crutch walking could be avoided
- Helps in proper stump conditioning.
- Reduces the neurological complication below the level of amputation.
- It re-establishes the propriception and feedback mechanism by establishing the contact with the proximal part quickly.
- It helps in ambulation, weight transfer and stabilization.

How to construct a temporary prosthesis?

- A good functional stump is first created.
- A sterile stump socks is applied.
- A rigid dressing is done by applying a POP cast.
- Into the above cast is incorporated a device with steel straps.
- To this is applied a pre-measured walking palm with SACH foot.
- After 3 weeks, the cast is split and measurements are taken for the final prosthesis.

Note On a temporary prosthesis:

- Standing and partial weight-bearing is begun the next day
- Full weight-bearing by 6 weeks.

Re-educating an upper limb amputee

Goal Here the goal is to train the patient for functional activities.

The above goal can be achieved by observing the following principles:

- For the absence of the true limb, the adjacent parts should be trained to increase their mobility.
- Strengthening exercises to the muscles needed for operating the prosthesis.
- To prevent contractures in the important muscle groups like shoulder adductors, elbow flexors, etc.

For above elbow amputation Here, the movements of the neck, trunk, scapulohumeral and scapulothoracic muscles should be strengthened.

The flexors, extensors and adductors of the shoulder are put through vigorous muscle strengthening and endurance exercises to bring about flexion of the prosthesis at the elbow.

For below elbow amputation Here along with the above, strengthening exercises are given for the elbow flexors, extensors and forearm muscles.

Teaching a patient how to operate the prosthesis of the upper limb:

- First step, train the patient how to perform true shoulder flexion (i.e. without movement at the shoulder girdle).
- Second, patient with below elbow amputation, training is given to flex the elbow to 90° and then flex the shoulder to activate the terminal device.
- Third, in patients with above elbow amputation, by following the first step mentioned above, patient is taught to flex the elbow of the prosthesis.

  Then with the prosthetic elbow locked, the terminal device is activated by flexion at the shoulder. This is the dual control system.
- Triple control system for above elbow amputee.
  — Flex the elbow by true shoulder flexion.
  — Lock the prosthetic elbow by arm extension control motion.
  — Activate the terminal device by shrugging the normal shoulder.

Ankle Units and Artificial Feet

Solid action cushion heel (SACH) (Fig. 33.17) foot has no ankle joint but a simulated action is gained by the compression of wedge-shaped rubber heel and the whole foot is incorporated with various layers of rubber with its density varying, all placed over a wooden insert for the heel and wooden side keel. This allows smooth movements of the foot.

Fig. 33.17: Showing solid action cushion heel (SACH) foot

Remember

Aims of prosthetic fitting
- To substitute for a lost part.
- To restore a lost function.
- In lower limbs it must provide a comfortable ambulation with minimal expenditure of energy.

Remember

In prosthesis for lower extremities:
Long stump is prosthetic ally superior to a shorter one because it provides
- Longer lever arm.
- More sensory feedback.
- Greater area for distribution of pressure forces.

ORTHOTICS

Orthosis is an appliance which is *added* to the patient to enable better use of that part of the body to which it is fitted.

Prosthesis replaces a missing part of the body.

An orthotist is a person qualified to measure and fit all types of orthoses.

Classification

One single classification is very difficult. Hence GK Rose has grouped them as follows.
- Functional biomechanical
- Functional descriptive
- Nosological (according to disease)
- Regional.

Terminology for orthosis The three major anatomical regions of the body are divided as follows and the initials given are as in Table 33.6.

Orthotic facts

Nomenclature for orthosis now used has the first letter of the name of each joint which the orthosis crosses in power sequence, and the letter 'O' for orthosis is attached at the end. Accordingly we have the following types of orthoses:

TABLE 33.6: Showing orthotic terminologies

Upper limbs		*Lower limbs*	*Spine*
S-Shoulder		H-Hip	C-Cervical
E-Elbow		K-Knee	T-Thoracic
W-Wrist		A-Ankle	L-Lumbar
H-Hand		F-Foot	S-Sacroiliac
F-Fingers	MP	Subtalar	
(2-5)	DIP	Midtarsal	
	PIP	Metatarsal	
Thumb	CM		
	MP		
	IP		

- CO—Cervical orthosis
- CTLSO—Cervico-thoraco-lumbar-sacral orthosis
- WHO—Wrist-hand orthoses
- HKAFO—Hip-knee-ankle-foot orthoses
- KAFO—Knee-ankle-foot orthoses
- KO—Knee orthosis
- AFO—Ankle-foot orthoses

Action of orthosis The action of an orthosis on a joint is indicated by initials which are as follows:

F—Free
A—Assist
R—Resist
S—Stop
H—Hold
V—Variable
L—Lock.

SPINAL ORTHOSES

These fall into two categories:
1. Supportive
2. Corrective.

Functions of spinal orthosis
- To relieve pain.
- To support weakened paralyzed muscles.
- To support unstable joints.
- To immobilize joints in functional position.
- To prevent deformity.
- To correct deformity.

Supportive Spinal Orthosis

Belts and corsets These are most commonly used for the treatment of low backache. *Belts are prescribed for men and corsets for women*. These orthoses encircle the sacral region and extend a variable distance upwards, the term applied to them depends upon their depth posteriorly (sacroiliac, lumbosacral (Fig. 33.18), thoracolumbar). Anteriorly they have buckles.

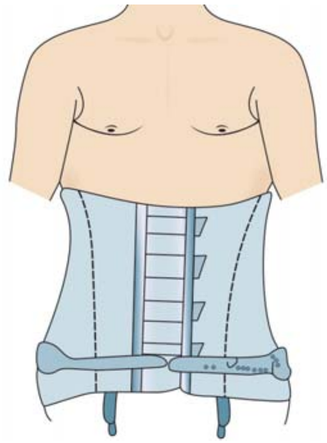


Fig. 33.18: Lumbosacral belt

Remember

The role of belts
- They do not immobilize the spine but only restrict extremes of forward, lateral flexion and extension.
- They supply subjective support.
- They remind the patients to avoid movements.

Rigid spinal brace All rigid spinal orthoses are constructed on the basis of a metal frame which takes firm support from the pelvis. To this is added the metal uprights which are joined by cross bars and straps, e.g. tailor brace, night tailor brace, etc.

Moulded spinal orthosis of leather, plastic, etc.

Indications for supportive spinal orthosis
- Sacroiliac strain.
- Low backache.
- Prolapsed intervertebral disc.
- Spondylolisthesis, etc.

Remember

The mechanisms of pain relief by spinal orthoses
- Psychological.
- Increases intra-abdominal pressure.
- Decreases lumbar lordosis.
- Causes local inactivity of associated muscle groups and ligaments.

Corrective Spinal Orthosis

Milwaukee braces This is an active corrective spinal orthosis used almost exclusively in the ambulant treatment of structural scoliosis (Fig. 33.19).

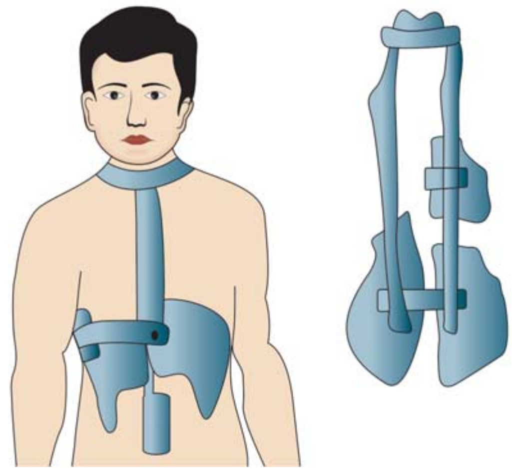


Fig. 33.19: Milwaukee brace

The main aim of Milwaukee brace is to postpone, temporarily or permanently, the need for operation.

ORTHOSIS FOR CERVICAL SPINE

- ***Cervical collar*** Many different forms of cervical collars or supports are available and are called ***Thomas's collars*** (Fig. 33.20). Metal was used earlier, but now thick plastic sheets are preferred. These collars are readymade and are supplied in different sizes or are adjustable. *For a good fit the collar should be secured firmly around the neck, rest upon the chest and shoulders and support the chin, jaw and occiput.*
- ***SOMI*** (sterno-occipit mandibular immobilization) brace.
- ***Four postcervical brace.***
- ***Halo body orthosis.***
- ***Minerva jacket*** In lesions of uppermost part of the cervical spine, the forehead must be included in the external support (Fig. 33.21). In such situations, Minerva jacket made from plaster of Paris is used.

Fig. 33.20: Showing cervical collar

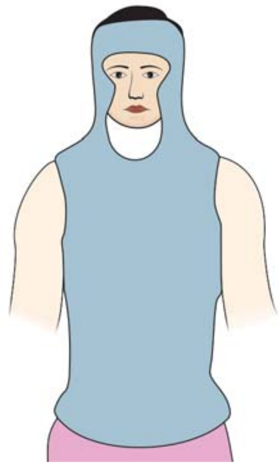


Fig. 33.21: Showing minerva jacket

LOWER LIMB ORTHOSIS

Caliper is an orthosis for the lower limb which may be used permanently or for a very short time only.

Remember

The functions of calipers
- It provides stability.
- It relieves weight-bearing.
- It relieves pain.
- It controls deformity.
- It restricts movements.
- It assists movements.
- A combination of the above functions.

Knee-Ankle-Foot Orthosis (KAFO)

These are either weight relieving or non-weight relieving calipers (Fig. 33.22). It consists of the following parts, an upper end which may be made up of ring, cuff or bucket top. It has two side bars or upright, the knee joint, the ankle joint, a shoe, thigh, knee and calf bands.

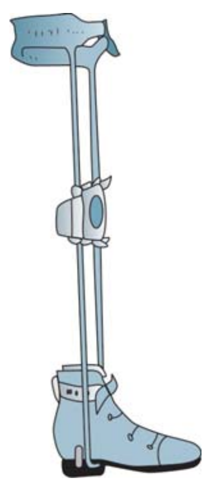


Fig. 33.22: Knee-ankle-foot orthosis (KAFO)

Hip-Knee-Ankle-Foot Orthosis (HKAFO) and Lumbosacral Hip-Knee-Ankle-Foot Orthosis (LSHKAFO)

A pelvic band may be attached to the KAFO with or without a hip joint to convert to an HKAFO (Fig. 33.23). And if this is extended upwards, a lumbosacral support is obtained converting it to an LSHKAFO.

The purpose of the pelvic band at the hip joint is to:
- Prevent development of a flexion deformity in polio, cerebral palsy.
- To increase the stability of spine.

Ankle-Foot Orthosis (AFO)

This is a below-knee orthosis in which the ankle joint can be controlled by mechanical ankle joints or by heel straps (Fig. 33.24).

All the above lower limb orthoses so far mentioned are useful either to prevent or correct deformities due to polio, cerebral palsy, spina bifida, etc. They can be used either temporarily or permanently.

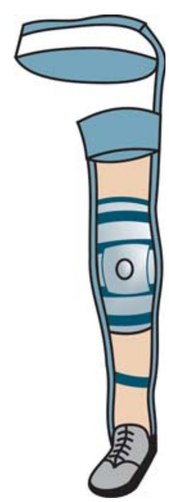


Fig. 33.23: Showing a knee-ankle foot orthosis with a pelvic band

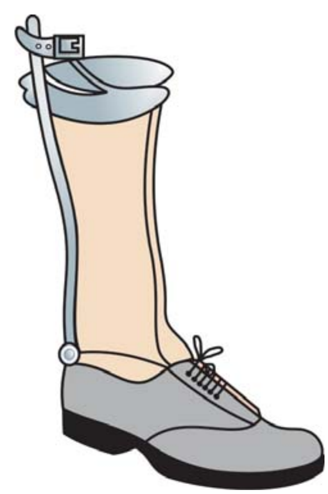


Fig. 33.24: Ankle-foot orthosis AFO (plastic)

Footwear and its Modifications

The following are some of the modifications of foot-wear useful in the clinical situations mentioned below (Table 33.7).

TABLE 33.7: Surgical footwears

Footwear with	*Indications*
• Thomas heel	Flat foot
• Arch support	Flat foot
• CTEV shoes	For CTEV
• Heel pad	Calcareal spur and plantar fascitis
• Metatarsal pad	For corns
• Metatarsal bar	Metatarsalgia
• Medial raise	Genu valgum
• Lateral raise	Genu varum
• Universal	For short leg

- *Rocker bar* for hallux rigidus.
- *Outside heel float* for lateral ligament injuries of the ankle.
- *Heel pad* for heel pain.
- *Medial longitudinal arch support* to relieve pain the following supports are used.
  - — Valgus insole
  - — Thomas heel (extension of medial aspect of the heel)
  - — Filling of the medial half of the shank of the shoes (medial shank filler).
- *Metatarsal arch* is supported by the doom-shaped metatarsal bars.
- *More roomy footwear* To accommodate deformed toes.

UPPER LIMB ORTHOSIS

Upper limb orthoses ranges from a simple splint to the very complex varieties which are manufactured to the following basic requirements:

- Limitation of movements could be either total or partial.
- Exercise of muscles and joint range against energy storing devices such as springs or elastics.
- Replacement of paralyzed muscles using similar devices.
- Preventive deformity control.

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34

Chapter

Sports Injuries

Our cricketing icon Sachin Tendulkar, ace spinner Anil Kumble, Mysore Express Javagal Srinath the effervescent VVS Laxman and the rock of Gibraltar Rahul Dravid all were in the news for sports injuries. For once, these injuries out famed and outshine these cricketing demigods and were discussed and talked by everyone than the cricketers themselves. So these injuries fall within the gambit of sports medicine which is a fact developing science with tremendous potential. With more and more people taking up sports as a career, the sports related injuries are on the rise.

Sports medicine like all other branches of medicine aims at the complete physical, mental and spiritual well being of a sportsperson. A healthy mind in a healthy body is a concept which is more true to a sportsperson than any body else. Positive thinking, fairplay and sportsmanship should be the hallmark of a true sportsman. We doctors and the therapists aim to keep a sportsperson physically fit so that the rest of the objectives mentioned above are attained automatically.

Like in other branches of medicine so in sports medicine, prevention is better than cure. To prevent sports injuries, the first step is to ascertain whether a person choosing sports is fit to take it. An unfit person taking up sports is a sure prescription for future sports injuries. A fitness testing for those who wish to take up sports as their career should include various relevant parameters (see box).

Quick Facts

Sports vs. fitness testing

- Muscle power should be adequate.
- Active joint movements.
- Range of passive movements.
- Body balance.
- Coordination skills.
- Symmetrical and coordinated movements between the limbs and the body.
- Elasticity and extensibility of muscles and ligaments.
- Presence of any unwanted or accessory movements.

These and a lot of other factors determine whether a person is fit enough to take to sports.

But one has to remember that fitness testing is not done only at the initial stages but needs to be done repeatedly at every stage of an athlete or a sportsperson life. The second stage of prevention of sports related injuries is assessing whether a sportsman is fit enough to resume the sporting activity after the initial layoff. There is nothing more dangerous than an unfit or a partially fit person resuming the sporting activity. It may spell a doom to his otherwise flourishing career in sports. A sportsperson has to satisfy certain norms before he can finally be sent back to the field (see box).

Quick Facts

A sportsperson has to satisfy the following norms before he resumes sports again:

- Should be able to jump from a height of 1 meter.
- Full range of painless active movements.
- Slight pain at extreme movements against resistance.
- No running limp.
- Can fully squat with one or both legs.
- Can do full press up.
- Can extend the knee with 20 lb × 10 in 45 secs.
- Persons engaged in contact sports should be able to lift 45 lb × 10 in less than 45 secs.

- The sportsperson should be independent of any strapping or support.

If a person satisfies all the above criteria, he can be safely returned back to his passion i.e. sports.

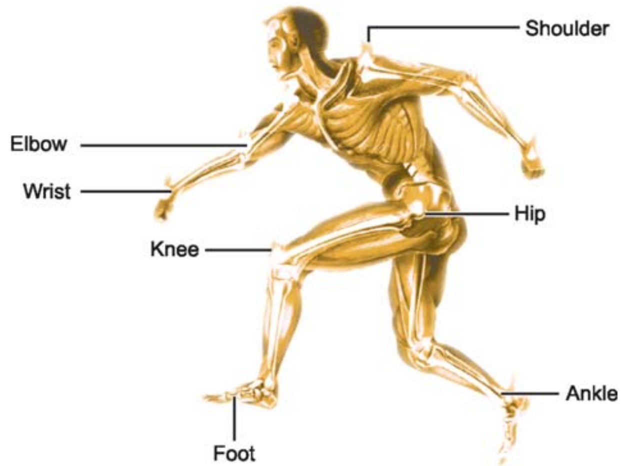
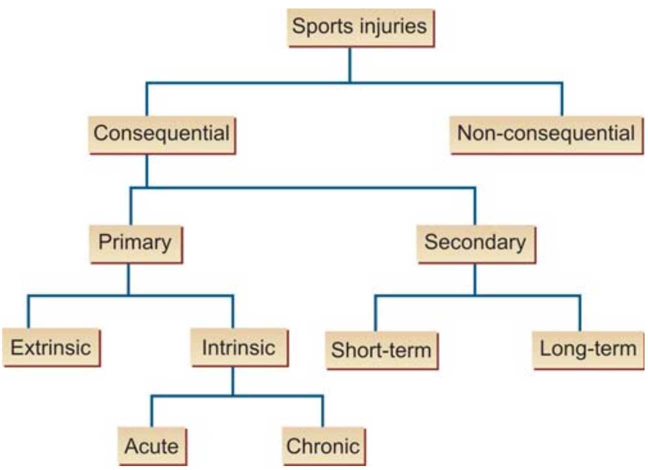


Fig. 34.1: Showing common sites of soft tissue injuries in sports

CLASSIFICATION OF SPORTS INJURIES

Among the various classifications proposed for sports injuries the one proposed by Williams (1971) is widely used and recommended (Flow chart 34.1).

Flow chart 34.1: Showing the classification of sports injuries



Among the Consequential Injuries

Primary extrinsic This is further subdivided into:

- *Human* Black eye due to direct blow
- *Implemental* May be incidental (as in blow from a hard ball) or due to overuse (blisters from oars).
- *Vehicular* Clavicle fracture due to fall from cycle, etc.
- *Environmental* Injuries in divers.
- *Occupational* Jumper's knee in athletes, chondromalacia in cyclists, etc.

Primary intrinsic

- *Incidental* Strains, sprains, etc.
- *Overuse*
    - Acute, e.g. Acute tenosynovitis of wrist extensors in canoeists.
    - Chronic, March fracture in soldiers, etc.

Secondary short-term For example, Quadriceps weakness.

Secondary long-term Degenerative arthritis of the hip, knee, ankle, etc.

Nonconsequential Injuries

These are not related to sports but are due to injuries either at home or elsewhere and are totally not connected to any sports (e.g. slip and fall at home).

COMMON SPORTS INJURIES

Sports medicine usually deals with minor orthopedic problems like soft tissue trauma. Figure 34.1 shows common sites of injuries in sports. Frequent falls, contact injuries and high speed activities are the common causes of sports injuries (Fig. 34.2). Very rarely there may be serious fractures, head

Fig. 34.2: Common causes of sports injuries

injuries or on the field deaths. There is nothing unusual about these injuries except that a sportsperson demands a 100 percent cure and recovery while an ordinary person is satisfied and happy with a 60-80 percent recovery. The difference is because of the desire of the sportsperson to get back to the sport again which require total fitness.

Note The incidence of sports injuries among all orthopedic injuries is 5-10 percent.

The following are some of the most common sports related injuries one encounters in clinical practice.

Upper Limbs

- *Shoulder complex*
  - Rotator cuff injuries
  - Shoulder dislocations
  - Fracture clavicle
  - Acromioclavicular injuries
  - Bicipital tendinitis or rupture.
- *Elbow*
  - Tennis elbow (Fig. 34.3)
  - Golfer's elbow
  - Dislocation of elbow.

Fig. 34.3: Professional tennis players most commonly suffer from a famous sports disorders Tennis elbow

- *Wrist*
  - Wrist pain
  - Carpal tunnel syndrome
- *Hand*
  - Mallet injury (Fig. 34.4)
  - Baseball finger
  - Jersey thumb
  - Injuries to the finger joints

Fig. 34.4: Mechanism of Mallet finger injuries in cricketers while trying to catch a ball

Lower Limbs

- *Hip*
  - Iliotibial or tract syndrome
  - Quadriceps strain
  - Hip pain
  - Groin pain due to adductor strain.
- *Knee joint*
  - Jumpers knee
  - Chondromalacia
  - Fracture patella
  - Knee ligament injuries
  - Meniscal injuries
- *Legs*
  - Calf muscle strain
  - Hamstrings sprain
  - Stress fracture tibia
  - Compartmental syndrome of the leg.
- *Ankle injuries*
  - Ankle sprain
  - Injuries to tendo-Achilles
  - Tenosynovitis.
- *Foot*
  - March fracture
  - Jones fracture
  - Forefoot injuries
  - Injuries of sesamoid bone of the great toe.

Head, Neck, Trunk and Spine

- Head injuries
- Whiplash injuries
- Rib fractures
- Trunk muscle strains

- Abdomen muscle strain
- Low backache.

All these injuries have been discussed in relevant sections.

Investigations

These are the same as for any orthopedic related disorders and consists of plain X-rays, CT scans, bone scans, MRI, arthroscopy, arthrography, stress X-rays, etc.

Treatment of Sports Injury

This is discussed under three headings prevention, treatment proper and training.

Preventive Measures

The best way to treat a sports injury is to prevent it from happening. Nothing is better than preventing the injury.

Quick Facts

Preventive measures
- Proper clinical examination to identify any bodily defects.
- Fitness training.
- Correcting the wrong body mechanics and posture.
- Conditioning exercises to overcome particular deficiencies.
- Cardiopulmonary conditioning exercises to develop endurance.
- Proper warm up exercises and relaxation techniques before and after the sports.
- Wearing proper footwear's and other protective devices like helmet gloves, etc.
- To prevent overuse syndrome, taking adequate breaks in between the vigorous sports is advised.
- Avoiding sports in very high or low temperature climates.
- Not allowing aggravating minor problems like contusion, sprain, etc. by taking adequate rest and treatment.

Treatment Proper

Treatment of individual sports related disorders are discussed under suitable sections. However, a mention is made here of the general principles of treatment which is applicable to all sports injuries.

General Principles

- *Concept of RICEMM* This sums up the early treatment methodology of sports injuries and consists of:
  R—Rest to the injured limb
  I—Ice therapy
  C—Compression bandaging
  E—Elevation of the injured part
  M—Medicines like pain killers, etc.
  M—Modalities like heat, straps, supports, etc.
- After immobilization and rest, early vigorous exercises should be commenced at the earliest to prevent muscle weakness and atrophy.
- To prevent joint stiffness early mobilization has to be done first by passive movements and later by active movements. To improve the strength resistive exercises are added.
- Unlike the conventional once a day treatment, a sportsperson needs to be seen at least 2-3 times a day.
- As mentioned earlier allow resumption of sporting activity only after the sportsperson assumes 100 percent fitness.
- Mind training is as important as physical training. By repeated counseling improve the psychological status of the patient to avoid depression, anxiety and negative attitudes which may develop during the injury.
- Orthopedic and surgical treatment to be undertaken at appropriate situations.

Training

The physiotherapist has to train a sportsperson in various exercises to enable him to keep his fitness level very high. After conducting a fitness testing, (mentioned earlier) the therapist has to subject an athlete to various forms of exercises to increase the endurance, strength, running, weight-bearing, etc. The following are the various forms of exercises.

Exercises to Increase the Cardiopulmonary Capacity

These exercises are done to increase the endurance level of an athlete or sportsperson. This has been discussed at length in the first chapter (*see* page 9).

Exercises to Increase the Muscle Strength

By carefully planned graded progressive resistive exercises, the therapist aims at improving the strength of the muscles of the upper limbs, lower limbs, trunk and spine.

Quick Facts

PRE

- For upper limb muscles—bench press
- For lower limb muscles—squatting exercises
- For trunk and muscles of the limbs—power clean.

Exercises for Free Weight Training

Strength training with machines has a disadvantage in training only the prime movers. This anomaly is converted by free weight training which helps to strengthen not only the prime movers but also the synergistic and stabilizing groups of muscles (e.g. exercises with dumbbells). They are also known to increase the tensile strength of the muscles, ligaments and tendons.

Measures to Improve the Agility

The measures to improve the agility levels of sportsperson are two leg hops, one leg hop, cross over-run turning, bending and backward running. These exercises help to improve balance, co-ordination and movements at a faster rate.

Measures to Improve the Speed-Polymetrics

In this the neuromuscular system is trained to such an extent that it can react very quickly to sudden increase of speed and power which is so often required in sporting activities.

Quick Facts

About Polymetrics

- Hops
- Speed jumps
- Running drills
- These above exercises must be done very fast with sudden burst of energy.
- The speed strength of a sportsperson depends on how fast the muscle action changes from eccentric to concentric ones.
- This is then followed with graded resistance exercises.

Measures of Relaxation

After the vigorous workout mentioned above the sportspersons are taught methods of relaxation and body stretches.

Before an athlete or a sportsperson resumes his sporting activities, a fitness testing is carried out (*see* page 318) and only then he is allowed to take to the sports provided he is 100 percent fit.

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35

Chapter

Arthroscopy

ARTHROSCOPY

Thousands of years ago, star gazing to unravel the secrets of the skies was a favorite pass time of the yesteryear Greek scientists. The human eye could not match this enthusiasm and belied all their interests. Then came Galileo with his phenomenal invention of a telescope which opened up the secrets of astronomy and to and behold the beautiful galaxy was now suddenly seen in all its sppendor and glory.

Something similar happened in the field of surgery. The morbidity and mortality associated with long incision, wide surgical approaches was getting increasingly alienated. The patients and the surgeons yearned for something small and less morbid. They realized that they had to open less, see more, and do more. How could that be possible they wondered. Again that wonder tool called the telescope made this a reality. Peeping inside a joint through a telescope suddenly exposed the joint in all its grandeur. That joint which had a myriad of fascinating structures within it could be accessed for diagnosis and thereafter treatment by a telescopie like instrument that was christened as Arthroscopy. Like telescope, arthroscope revolutionized the way we look and treat joint conditions. Great deeds could now be performed through small nicks courtesy arthroscopy. Joint now heaved a sigh of relief that no longer they need to be subjected to mutilating knives of a marauding surgeon.

What is an Arthroscope?

It is a 4 mm telescope like optical instrument (range 1.7 to 7 mm) used to visualize the inside of a joint, detect pathology if any and then treat it. The angle of inclination of the scope at the tip varies from 25 to 90°. The former is commonly used and the latter helps to see corners of the joints. Thus, the equipment for arthroscopy consists of the following:

- An arthroscope.
- A fiber optic light source to adequately and effectively light up the interior of the joints.
- A video camera to catch the glimpses and visualize the joint interiors
- A TV monitor to see the interiors of the joints in all its grandeur on the screen.

If after introduction and inspection of the joint, a pathology is seen and needs to be tackled by an operation following instruments are required:

- *A probe* This is the most vital instrument which is known to extend the surgeons fingers inside the joint to palpate its structures. This also helps in the all important triangulation techniques.
- *Scissors* Obviously have to be small (3-4 mm) to cut, trim and remove the damaged and frayed joint structures. The jaws of the scissors could be straight or hooked.
- *Punch or basket forceps* This enables to remove or punch the damaged structures and flush it out with saline later. It makes pulling the forceps out to deliver the debris out unnecessary.
- *Grasping forceps* Obviously are used to grasp the loose bodies, meniscus, synovial folds, ligaments, etc. while operating.
- *Blade knives* Inserted through a cannula to prevent damage to surrounding structures and minimize the chances of breakage, blades could be straight, curved, hooked, retrograde, undercut, etc.
- *Motorized shavers* These are used to shave the damaged joint structures. To do this there is a hollow rotating cannula with compounding windows within a sheath.

- *Electrocautery* This is an underwater cutting cautery and is used for cutting and hemostasis purposes.
- *Laser* It can be used for cutting purposes that is precise and causes minimal thermal damage. But it has its own disadvantages like bone and joint damage and is yet to be used widely.
- *Implants* Include suture anchors, materials for cartilage repair, tendon and ligament fixation, etc. and can be both metallic or biodegradable with the latter being slightly better.
- *Sheaths and trocars* To pass and hold arthroscopic instruments.
- *Irrigation systems* This consists of a 6 to 6.2 mm sheath to allow ringer lactate or normal saline to flow inside a joint for continuous joint irrigation.
- *Tourniquet* To obtain a bloodless field for surgery.
- *Leg holder* To position the legs properly for the procedure.

Indications for Arthroscopy

Cartilage conditions
- Excision of damaged cartilage
- Mosaicplasty

Figure 35.1 shows extensive destruction of the cartilage in OA knee.

Synovium conditions
- Excision of the plicas
- Trimming of the plicas
- Synovial biopsy
- Synovectomy

Meniscal pathology
- Repair
- Resect

Fig. 35.1: An internal arthroscope view showing cartilage destruction in OA knee

Ligament structures
- Repair
- Reinforce
- Reconstruct

Loose bodies
- Crushing
- Removal

Patellar problems
- Lateral release
- To correct maltracking

Joints pathology
- Arthrolysis
- Debridement
- Shaving
- Stabilization as in recurrent dislocation of shoulder
- Excision of the joints, e.g. ACM joint
- Fusion o the joints
- To detect and reconstruct tibial plateau fractures.

Procedure

A step by step account of the surgical steps is given here to make it easy for the students to understand.
- Patient is under spinal or general anesthesia
- Tourniquet is applied
- Legs are positioned properly
- Painting of the limb is done
- Draping is done next
- Through an anterolateral portal the scope is introduced (Fig. 35.2)

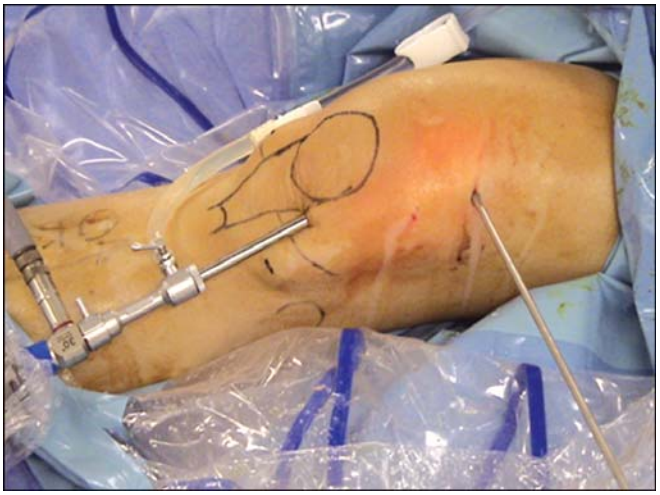

Fig. 35.2: Operative photograph showing instruments of the arthroscope through anterolateral approach

Fig. 35.3: An arthroscope requires considerable skill

- The joint is distended with running RL or saline
- Through an anteromedial portal the instruments are introduced
- The joint structures are now visualized on a TV monitor
- Thorough inspection of the joint structures is done
- Achieve triangulation by bringing the scope and the instruments in front of the telescope (Fig. 35.3)
- Joint is continuously irrigated
- The required procedure is carried out
- Thorough joint lavage is done
- Compression bandage applied
- Mobilize the patient the same day or the next day.

Advantages

- Less morbid
- Faster return to activity
- Less bleeding
- Less damage to structures
- Smaller incision and hence smaller scar
- Live joint assessment
- Dynamic joint assessment possible
- Better diagnostic potential
- Faster rehabilitation.

Limitations

- Steep learning curve
- Great surgical skill required
- Sophisticated instrumentation
- Good infrastructure needed
- Instruments are costly and expensive
- Not useful in conditions like infection, bleeding diathesis, neutropathic conditions, etc.
- Not useful in recurrent dislocations as in shoulder and patella.

Physiotherapy Measures after Arthroscopy

This has been discussed in Chapter 13 on Injuries of the Knee Joints.

36

Chapter

Arthroplasty

ARTHROPLASTY

Total knee and hip athroplasty has become the definitive treatment for rheumatoid arthritis and end stage osteoarthritis. They have proved to be reliable and successful allowing patients to resume their normal activities. Hip arthroplasty can be performed using cement or biologic fixation.

History

- In 1960, Sir John Charnely first replaced a hip with metallic femoral stem and a polyethylene acetabular cup.
- In 1968, Frank Gunston performed the first knee replacement surgery.
- In 1972, John Insall designed the modern knee designs.

Total Hip Replacement

Total hip replacement has stood the test of time and today commands its own place as an effective option for end stage arthritis of the hip.

In cement fixation, there is mechanical interlock of methylmethacrylate to the interstices of bone. Biological fixation can be either a porous-coated metallic surface that provides bone ingrowths fixation or by a grit-blasted metallic surface that provides bone ongrowth fixation.

The choice of method of fixation remains controversial. In hip arthrplasty, the tendency is towards the use of uncemented prosthesis in younger active patients because cemented prosthesis have reported a higher loosening rate in long-term follow-up. In total knee arthroplasty, the cemented prosthesis have reported good results in long-term follow-up and is more widely used than the cementless ones.

Aseptic loosening is the most common indication for revision surgery. In cemented hip, the most common reason for revision in failure of the cemented acetabular component, while in the uncemented ones the most common cause for failure of the femoral component. In knee arthroplasty, aseptic failure can be caused by many factors as component loosening, polyethylene wear, ligament instability and patellofemoral maltracking.

Articular bearing in hip arthroplasty is mainly on “hard on soft couple” which include metallic heads coupled with polyethylene cup (Fig. 36.1). The other hard on soft couple is ceramic head with polyethylene cup (Fig. 36.2). Titanium alloy head should be avoided because it is liable to scratching which will cause rapid wear of the polyethylene surface. In knee arthroplasty, the majority of articular bearing components are

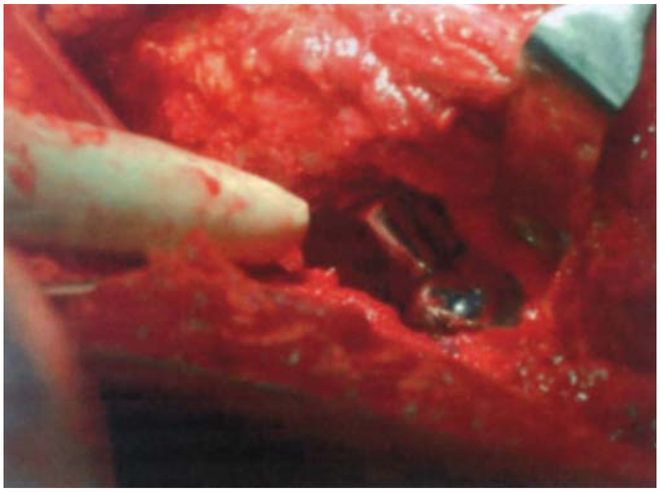

Fig. 36.1: Surgical photograph of total hip replacement

Fig. 36.2: Plain X-ray of THR

metallic femoral surface (cobalt, chromium) coupled with polyethylene tibial surface.

In 1997, Birmingham hip resurfacing was introduced using metal on metal prosthesis. It is a bone conserving operation with minimal or virtually no dislocation which makes it ideal for young active people (Fig. 36.3).

Indications

- Osteoarthritis
- Rheumatoid arthritis
- Secondary osteoarthritis
- Avascular necrosis of the head of femur

Fig. 36.3: Birmingham hip resurfacing

- Failed hemi replacement arthroplasty
- Ankylosed hip.
- Tuberculosis hip.

Contraindications

- Infection is an absolute contraindication
- Poor medical risk
- Poor anesthetic risk
- Obesity
- Neuropathic joints.

Complications

- DVT
- Fat embolism
- Infection
- Breakages of implants
- Loosening of implants
- Osteolysis
- Periprosthetic fractures
- Dislocation
- Heterotrophic ossification
- Vascular and nerve injuries.

Physiotherapy Measures after THR

This has been discussed in Chapter 18 on General Principles of the Treatment of Orthopedic Disorders.

Total Knee Replacement

This is increasingly gaining popularity thanks to the high incidences of osteoarthritis of the knee joints worldwide. Though not as popular or as successful as total hip replacement, TKR nevertheless is catching the attention of both orthopedic surgeons and patients alike and is being commonly performed across the country. Figures 36.4 and 36.5 show the total knee replacement. Plain X-ray of TKR is shown in Figure 36.6.

Types

- *Unicondylar replacement* Here only one condyle of the tibia is replaced.
- *Total knee replacement* Here both the condyles of the tibial are replaced. This could be cemented or uncemented, PCL sacrificing or sparing or rotating platform.
- *Minimally invasive TKR* Here the surgical incision taken is smaller than the conventional TKR and thereby bleeding will be less, tissue trauma will be minimum and the postoperative recovery and rehabilitation will be faster.

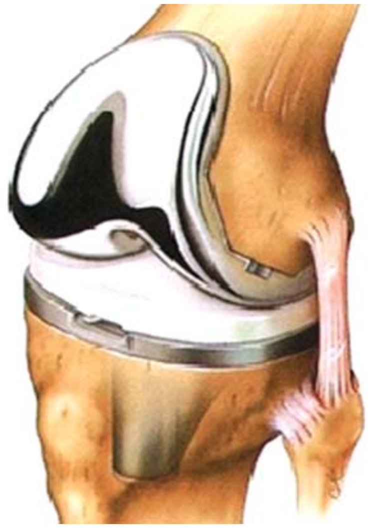

Fig. 36.4: Total knee replacement (TKR)

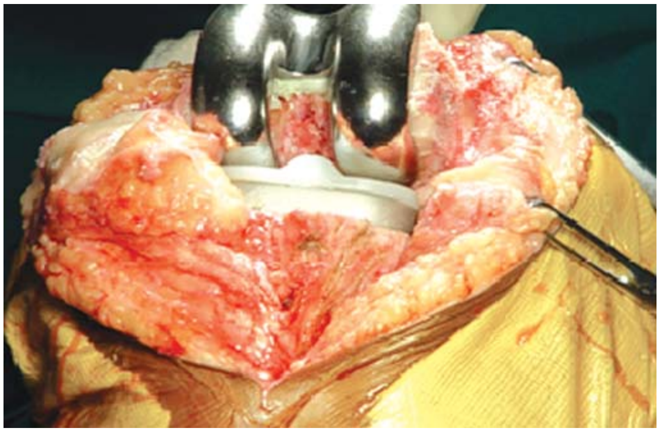

Fig. 36.5: Surgical photograph of total knee replacement (TKR)

Fig. 36.6: Plain X-ray of total knee replacement

Total shoulder, total elbow, total ankle are the other prosthetic replacement surgeries graining importance worldwide.

Physiotherapy Measures after TKR

This has been discussed in Chapter 18 on General Principles of the Treatment of Orthopedic Disorders.

Components

- A metallic femoral component
- Tibial base plate
- A plastic component
- A patellar component

Indications, contraindications and complications more or less remain the same as for THR.

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