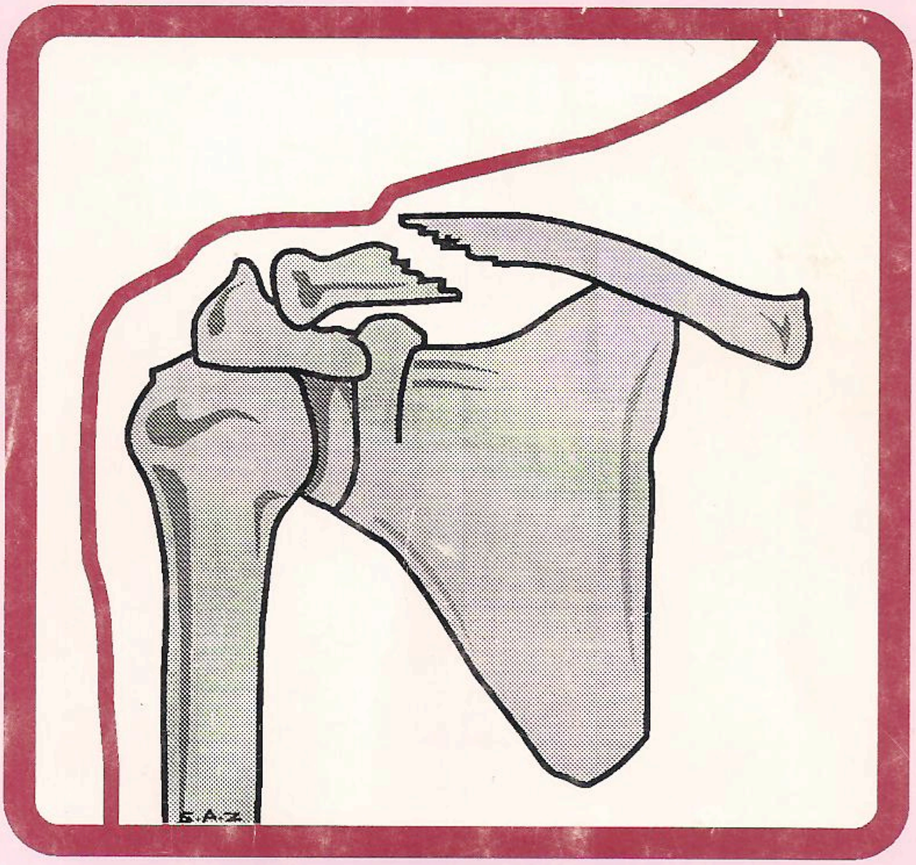
Fractures and Dislocations



BADR and SHAHEEN

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المدينة المنورة
على صاحبها الصلاة والسلام

Fractures and Dislocations

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Foreword

It is a pleasure to write a foreword for this new book on 'Fractures and Dislocations' for medical students and young doctors starting out in Orthopaedics.

This book is the labour of two Senior Orthopaedic Surgeons from King Khalid University Hospital, King Saud University. It is a modern textbook, dealing with the principles of diagnosis and treatment of fractures and dislocations that are commonly encountered in Orthopaedic practise.

The style is clear and easy to follow with beautiful line drawings which make the text comprehensive. The approach of this book has been to discuss the principles of fracture management, including the process of fracture healing. This is then followed by sensible and clearly explained sections on all fractures and dislocations. which involve the upper and lower limb and the spine including the pelvis.

One of the delights of this book is the frequent use of anatomical drawings to explain the fracture mechanism. The clinical approach draws heavily on the authors British training and the teaching of Mr. Graham Apley, and combines this with a sensible and logical approach to fracture treatment, by using the methods of the A-O school where and when the authors think appropriate.

This is clearly a book for Medical Students who will not only gain from its straight forward and uncluttered approach, but will get an insight into modern orthopaedics and the challenges that are present. It is also an excellent book for junior doctors who are working in Orthopaedic Departments. They will find much useful advise on how to diagnose and treat fractures and will also be able to clearly understand the process of the fracture mechanism.

Drs. Badr and Shaheen are to be congratulated on this fine work alongwith Mr. Ramilla the Medical artist.

I believe this book will be widely read, not only in their own country but in every department, where a concise, clearly illustrated modern work is required.

S.P.F. Hughes
Professor of Orthopaedic Sugery
University of Edinburgh
Scotland, U.K.

Preface to the Second Edition

Since the publication of the first edition there has been a continuing heavy demand for this book from medical students and trainees. In this edition many advances in the treatment of fractures and dislocations have been incorporated to update the text without increasing the size.

The aim remains the same basic, standard and simple but modern and up todate concentrating on principles rather than methods.

Our thanks and acknowledgement are extended to our students and trainees who recognised the value of the work. Thanks and appreciation are due to all colleagues in the Department of Orthopaedics in King Saud University for their constructive criticism and advice to keep the book up todate.

BADR & SHAHEEN

1417 A.H.

Preface to the First Edition

This book on Fractures and Dislocations is written originally for undergraduate students. The book has never presumed to be a complete text on the subject. We have always intended it to be a useful guide to undergraduate students and a companion to orthopaedic trainees.

Emphasis has been placed on the principles of fractures and dislocations and its clinical presentation. The principles of treatment are described omitting the fine details.

Our thanks are due to Mr. M. Mazhar Ullah for his diligence throughout the publication of this book. We also thank Mr. B.M. Ramilla, who has given a lot of time and effort in the production of diagrams.

We would like to acknowledge the encouragement and support extended to us by Prof. Price Evans as well as his assistance, unselfishly devoting his free time in checking and criticizing the proofs in order to expedite the completion of the book. Our thanks also to Professors S.P.F. Hughes, J. James, J. Gillingham and G.W. Taylor, for checking and correcting the manuscript.

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Part I
Principles of Fractures and Dislocations

DEFINITIONS

Fracture

A fracture is a break in the continuity of bone which could be complete (Fig. 1) or incomplete (green stick fracture) Fig. 2.

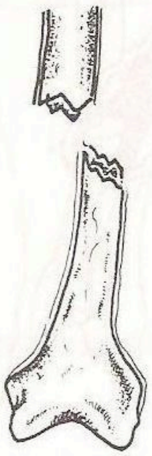


Fig. 1 Complete fracture

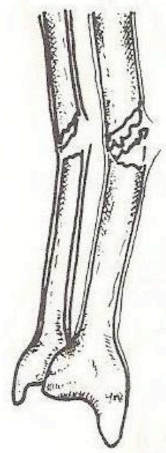


Fig. 2 Incomplete fracture

A closed fracture – simple

Is a fracture which does not communicate with the external environment (Fig. 3).

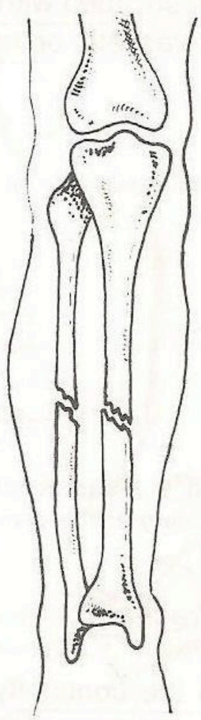


Fig. 3 Closed fracture tibia

An open fracture – compound fracture

Is a fracture in which the fracture site communicates with the external environment (Fig. 4).

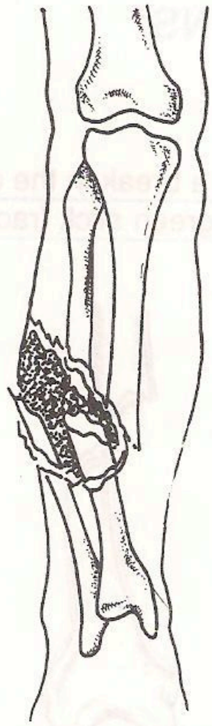


Fig. 4 Open fracture tibia

A complicated fracture

Is a fracture associated with damage to nerves, blood vessels, or internal organs (Fig. 5).

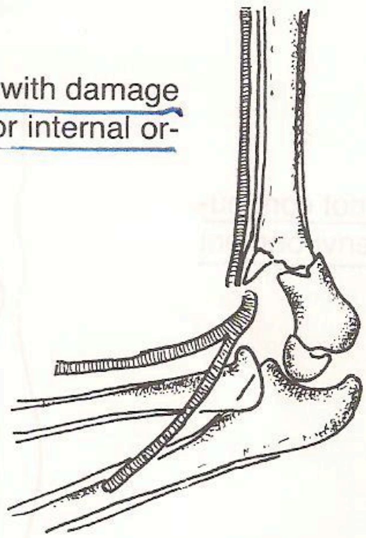


Fig. 5 A supracondylar fracture of the humerus with damage to the brachial artery

A pathological fracture

Is a break in the continuity of bone within an abnormal bone structure (Fig. 6).

Fig. 6 Pathological fracture – simple bone cyst

Dislocations

A dislocation is a complete separation of the articular surface. The dislocation is described as anterior, posterior, medial or lateral depending on the displacement of the distal articular surface relative to the proximal one (Fig. 7).

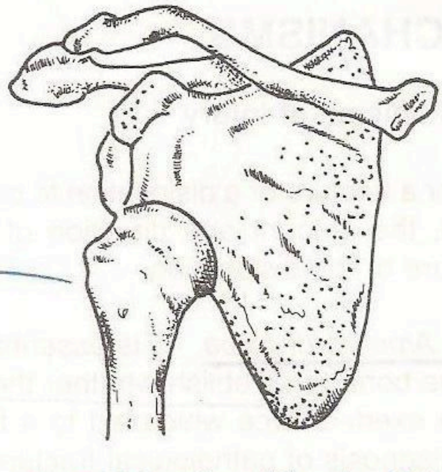


Fig. 7 Dislocation of the shoulder

A subluxation

Is a partial separation of the articular surface (Fig. 8).

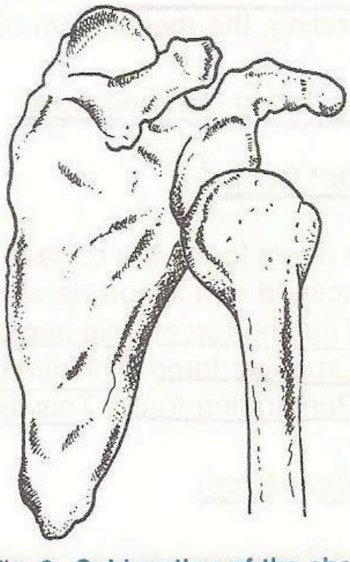


Fig. 8. Subluxation of the shoulder

A fracture dislocation

Is a fracture of one or more of the bony components of a joint associated with separation of that joint (Fig. 9).

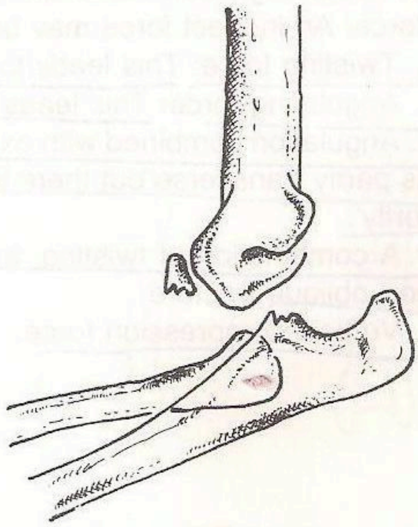


Fig. 9 Fracture dislocation of the elbow

MECHANISMS

Mechanisms of Injury

For a fracture or a dislocation to occur, the bone must be subjected to a physical force, the amount and direction of it will determine the line and extent of the fracture or the dislocation.

A. Amount of force It is essential to determine the amount of force exterted on the bone to establish whether the fracture is pathological or non-pathological. If the exerted force which led to a fracture was considered insufficient or trivial, the diagnosis of pathological fracture should be considered.

B. Direction of force This will determine the line of the fracture. For a better understanding, the mechanism of force will be discussed as follows:

1. Forces Acting on Long Bone

a. Direct force

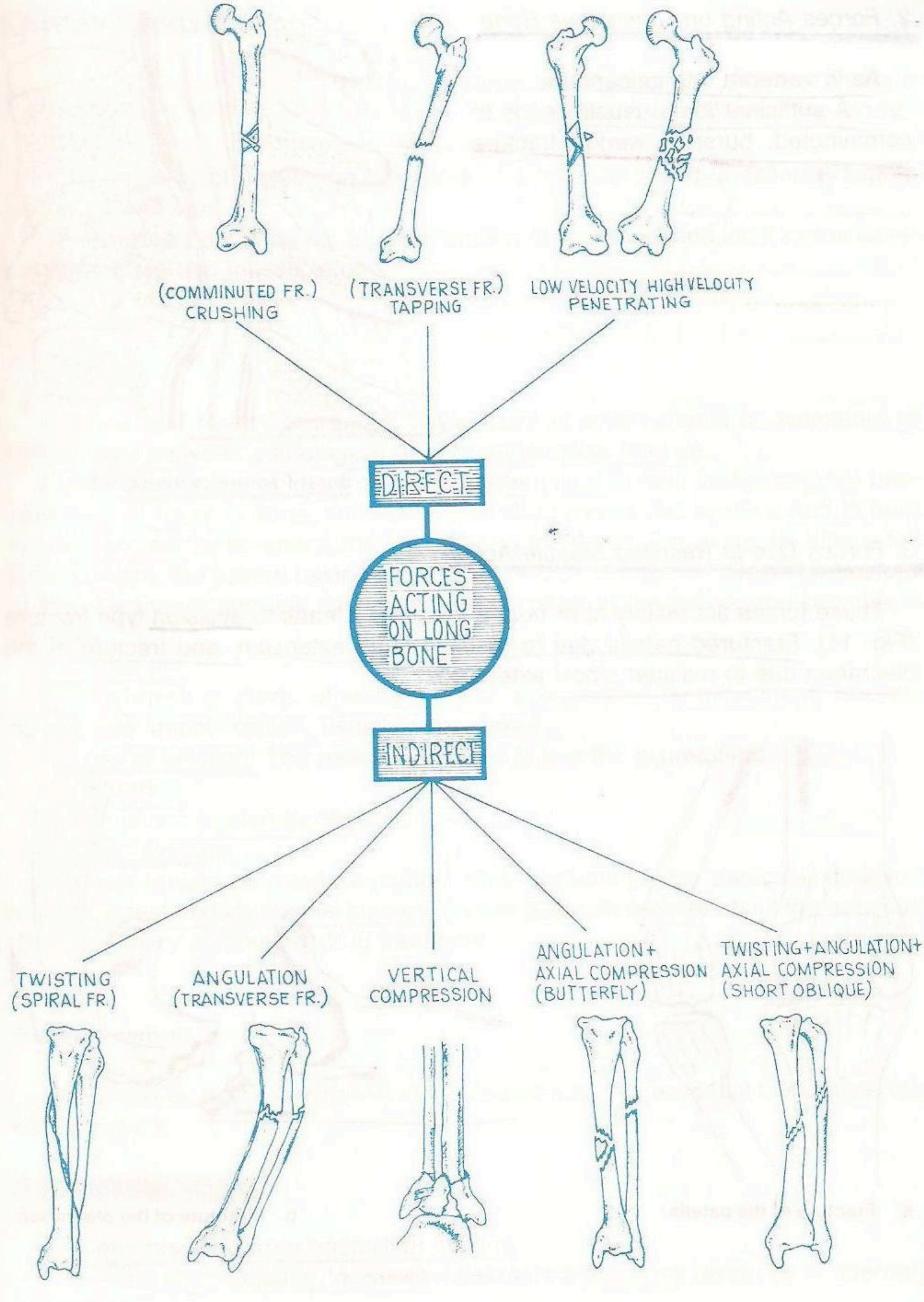
With a direct force, the bone is fractured at the point of impact, this would imply that associated soft tissue damage is great. A direct force may be:

i. Tapping force: This leads to a traverse fracture.
ii. Crushing force: This leads to a comminuted fracture.
iii. Penetrating force: This leads to a comminuted fracture.

b. Indirect force

Indirect force is a force which is exerted at a distance from the site of the fracture, accordingly soft tissue damage is expected to be less than those due to direct force. An indirect force may be:

i. Twisting force: This leads to a spiral fracture.
ii. Angulating force: This leads to a transverse fracture.
iii. Angulation combined with axial compression force: This leads to a fracture which is partly transverse but there is also a separate triangular fragment termed a 'Butterfly'.
iv. A combination of twisting, angulation and axial compression forces lead to a short oblique fracture.
v. Vertical compression force.


(COMMINUTED FR.)
CRUSHING
(TRANSVERSE FR.)
TAPPING
LOW VELOCITY HIGH VELOCITY
PENETRATING
DIRECT
FORCES
ACTING
ON LONG
BONE
INDIRECT
TWISTING
(SPIRAL FR.)
ANGULATION
(TRANSVERSE FR.)
VERTICAL
COMPRESSION
ANGULATION +
AXIAL COMPRESSION
(BUTTERFLY)
TWISTING + ANGULATION +
AXIAL COMPRESSION
(SHORT OBLIQUE)

2. Forces Acting on Cancellous Bone

As in vertebra and calcaneum:

A sufficient force usually leads to comminuted, burst or wedge fracture (Fig. 10).

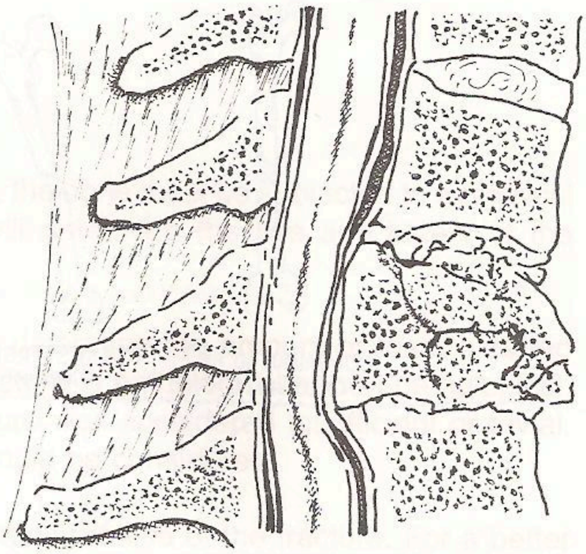
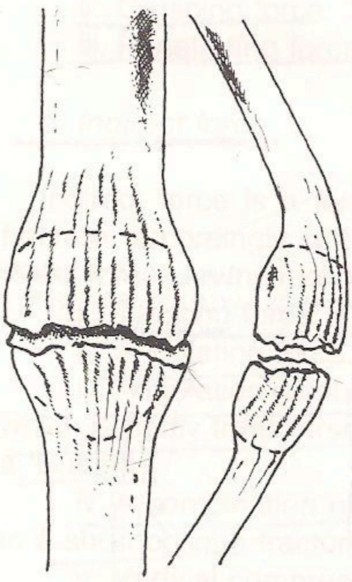


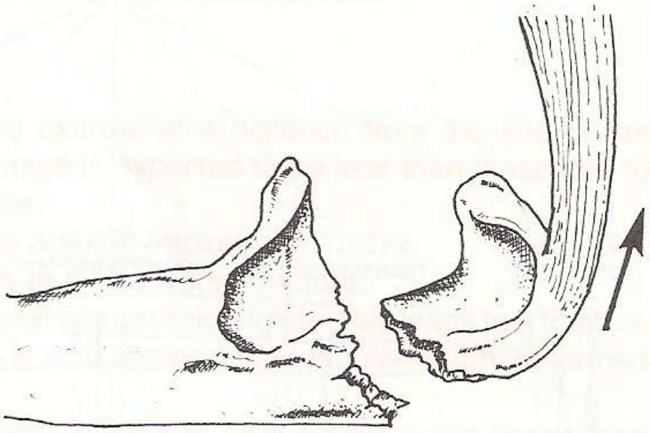
Fig. 10 Burst fracture of the vertebra

3. Forces Due to Resisted Muscle Action

These forces act mainly at or near a joint and it leads to avulsion type fracture (Fig. 11). Fractured patella due to resisted knee extension, and fracture of the olecranon due to resisted elbow extension.



a. Fracture of the patella.



b. Fracture of the olecranon.

Fig. 11 Avulsion fractures

DIAGNOSIS

'A Broken Bone is a Part of the Skeletal System which is a Part of the Body.'

In the majority of cases, the diagnosis of a fracture or a dislocation is simple and straightforward.

The diagnosis depends on: a) A full history, b) A general and local examination and c) X-Rays and investigations.

A. History

1. There is a history of trauma, the amount of which should be estimated to differentiate between pathological or non-pathological fracture.

2. The mechanism of injury should be determined to help in deciding the possible type of injury to bone, soft tissue and other associated injuries, and to help in management by reversing the force during reduction. For example, after a fall from a height, the patient having landed on his feet, one should suspect a fracture of the calcaneum possibly associated with another in the pelvis, and possible a vertebra.

3. Complaint

a) Pain which is sharp, of sudden onset, exaggerated by movement, relieved by rest and immobilization, usually not referred.

b) Loss of function: The patient is unable to use the injured limb.

c) Deformity.

d) Symptoms related to complications.

4. Other systems

Inquiries should be made regarding other systems paying particular attention to head, chest and abdominal injuries. Also one should enquire about the previous medical history particularly drug treatment.

B. Examination

In addition to local examination of the injured site, it is essential to examine the whole patient.

General examination

1. Signs resulting from fracture or trauma.

– Vital signs relating to airway obstruction, bleeding (external or internal) and shock.

– Associated damage to head, chest and abdomen.

2. Signs related to the cause of fracture specially in pathological types.

Local examination

It must be stressed that any patient with a possible fracture or dislocation must be handled with the utmost care and gentleness. It is inadvisable to elicit signs as crepitus and abnormal movement, since such a procedure will cause a lot of pain and distress to the patient.

1. *Inspection* – look: In a compound fracture there is skin damage at the fracture site while in simple fractures the skin is intact. Deformity is obvious with displaced fracture and dislocation. A fracture haematoma leads to a swelling.

2. *Palpation* – feel: There is localized tenderness at the fracture site.

3. *Move:* Active movement is usually impaired with pain and loss of function. Passive movements are painful, abnormal and usually associated with crepitus.

4. Do: (a) Special Tests - It is necessary to examine the limb distal to the fracture for neuro vascular damage.
(b) Measurements - Presence of shortening
in all local examinations always compare with the normal side.

C. X-rays and Other Tests If Required

The accurate diagnosis of a fracture, its site, line and displacement is made by examination of X-rays.

Requirements in X-rays:

Essential requirements

a. Two views

Two views at right angles to each other, antero-posterior and lateral are needed, firstly because some fractures may show on one view only *e.g.* undisplaced fracture of the neck of the femur, secondly to determine the degree of displacement at the fracture site.

b. Two joints

The joints above and below the site of the fracture must be examined, firstly to avoid missing an associated injury and secondly to determine the degree of angulation at the fracture. *E.G.* a forearm fracture of a single bone may be associated with a dislocation of joint above or joint below.

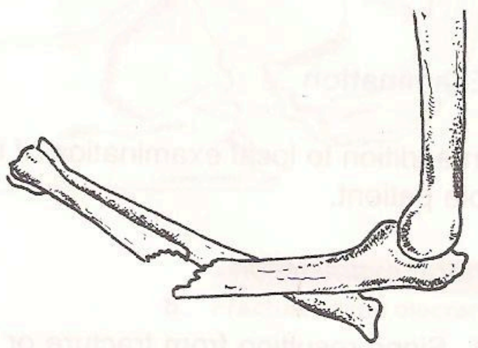


Fig. 12 Fracture of the ulna and dislocation of the upper radio-ulnar joint

Occassional requirements

a. Two limbs for comparison, this is of value usually in children, since radiological diagnosis of fractures can sometimes be difficult.

b. Two occasions: If the clinical diagnosis of a fracture is very likely and X-rays do not show a fracture, repeat of X-ray after 1–2 weeks is indicated. This is because resorption makes the fracture line obvious. This concept is most commonly applied to suspected fractures of the scaphoid.

c. In certain situations, special X-rays may be needed as *e.g.* stress films to demonstrate ligamentous injuries at the ankle or the knee (Fig. 13 and 14).

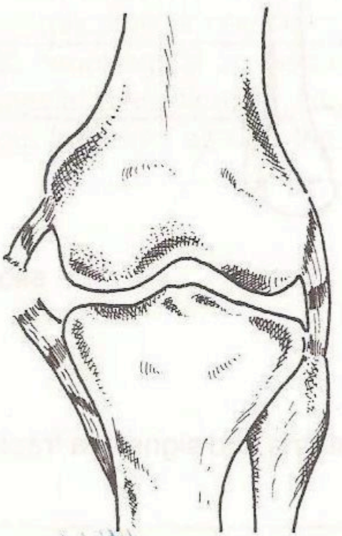


Fig. 13 The knee looks normal although the medial ligament is ruptured

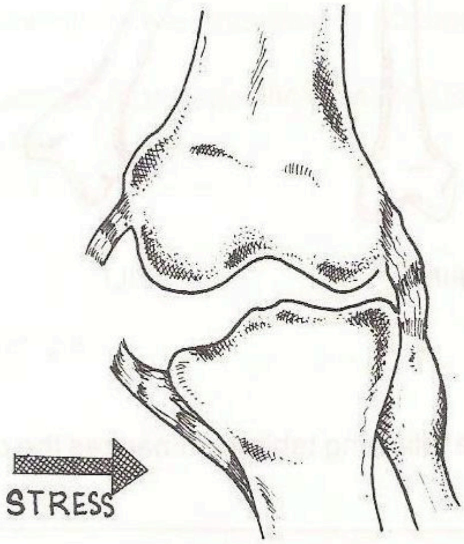


Fig. 14 Same knee under valgus tress shows widening due to the ruptured medial ligament.

Description of the fracture

The fracture is described according to:

1. Situation: Side of fracture (right or left). Site of fracture in relation to the bone (upper, middle, lower).
2. Line of the fracture (transverse, spiral and comminuted).
3. Displacement (Fig. 15) which could be:
   a. *Shift*: lateral, medial, anterior or posterior.
   b. *Tilt* – angulation: lateral medial, anterior or posterior.
   c. *Twist* – rotation: external or internal.
   d. *Shortening*: due to overriding of fracture ends.

In describing the displacement the distal fragment is related to the proximal one.

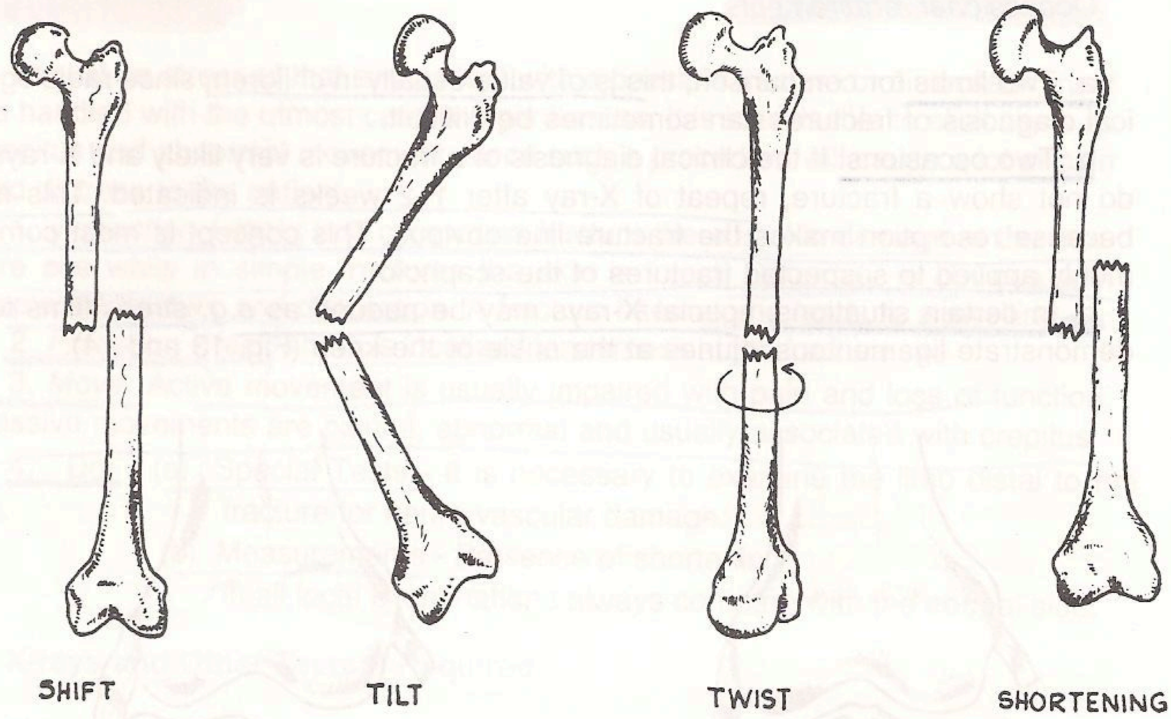


Fig. 15 Displacement

The following table summarizes the cardinal symptoms and signs of a fracture.

The cardinal symptoms and signs of a fracture	
History	Symptoms of the cause: Trauma Symptoms of the fracture: Pain – loss of function deformity Symptoms of the complications
Examination	Look: Skin – deformity Feel: Localized tenderness – sensation – pulse Move: Abnormal painful movement and crepitus Do: Special Tests and Measurements ALWAYS COMPARE WITH THE NORMAL SIDE Think: Is there associated damage elsewhere?
X-Rays	Essential Requirements: two views (A P & Lateral), Two Joints Occasional Requirements: Two Limbs, Two Occasions, Special X-Rays

CLASSIFICATION

Any useful classification for a fracture should help in:

1. Diagnosis
2. Selecting the method of treatment
3. Predicting the prognosis.

Fractures could be classified into:

1. Pathological or traumatic: Depending on the amount of force.
2. Simple or compound (closed or opened): Depending whether the fracture site communicates with the external environment or not.
3. Complicated or non-complicated: Depending on the presence or absence of visceral, neurological or vascular problems.
4. Special classification: In certain fractures, a more specific classification is used, eg. fractures around the hip, ankle ... etc.

MANAGEMENT

'Save Life
Save the Limb
Save Function'

Aims

When dealing with patients who sustain injury to one or more limbs, two aims should be achieved:

General To save the patient's life.

Local To achieve rapid recovery of the injured part and its function.

I. *General care of the patient: 'Save Life'*

The skeletal system is a part of the body, and the discovery of a fracture or a dislocation should not distract the attention from other parts and systems of the body.

A full general examination must be carried out, with special notice of possible associated injuries such as head, chest and abdominal injuries.

The general lines of treatment should concentrate on treating shock and other injuries which may, if neglected, threaten the patients life. (See page 194).

II. *Local care of the injured limb:*

1. *'Save the Limb':* The viability of a limb could be endangered by vascular injury or infection. Early detection and treatment is essential to prevent loss of the injured limb.

2. *'Save the Function':* The function of a limb could be endangered by local complications such as ischaemic damage, nerve damage, joint stiffness, infection, nonunion etc., Prevention, early detection and appropriate treatment is essential to save the limb and its function.

Methods

All fractures should be immobilized immediately by *e.g.* splints before definite treatment is carried out.

For the routine local care of a fracture the following steps should be undertaken:

1. *Reduction*

Displacement of the fragments must be corrected and redisplacement prevented. This can be achieved either by closed manipulation or open reduction.

2. Immobilization

The fragments must be immobilised until union is firm, this can be achieved by: a) Plaster of Paris, b) traction, c) internal fixation and d) external fixation.

3. Soft tissue treatment

This should not be neglected, fractures are always associated with soft tissue damage, and this is more obvious with direct force.

Elevation and active exercises are necessary to help in diminishing oedema, improve venous drainage and minimize muscle wasting.

4. Functional activity and rehabilitation

Joints and muscles which need not be immobilized should be exercised actively during treatment, and after healing.

Available methods

A form of general or local anaesthesia must be used when treating fractures or dislocations.

The following are the most commonly used methods:

A. *Conservative:*

1. Reduction by closed manipulation.
2. Immobilization by: a) Plaster of Paris and b) traction.

B. *Operative:*

1. Open reduction.
2. Internal fixation.

C. *Use of external fixator:*

An external fixator is a device aimed at stabilizing the injured site by means of pins which are inserted in the injured limb above and below the fracture. The pins are stabilized externally by rods.

MANAGEMENT – TECHNIQUES

Anaesthesia

To attempt the reduction of a fracture or a dislocation without anaesthesia is unfair to the patient and unfair to the surgeon.

General anaesthesia should be employed whenever possible, but if it is considered inadvisable for constitutional reasons, or the expertise of an anaesthetist is not available, other alternatives may be used.

I. *Local anaesthesia* (Rarely used)

This method implies injection of a local anaesthetic drug as *e.g.* 10-20 ml of 1% lignocaine through a long hypodermic needle, into the fracture haematoma or if the fracture is impacted, the local anaesthetic drug must be injected periosteally.

Advantages

1. None of the dangers of general anaesthesia.
2. Anaesthesia lasts for several hours, so remanipulation can be carried out if necessary.
3. Can be done if general anaesthesia is inadvisable or an anaesthetist is not available.

Disadvantages

1. Analgesia is not always perfect.
2. Infection could be introduced if sterile techniques are not implemented.

II. *Regional anaesthesia*

A. Nerve blocking by depositing a local anaesthetic drug into the fascial sleeve of the nerve that supplies the region for which manipulation or operation is needed.

In the upper limb, brachial plexus block is used for operation or manipulation of the whole limb. An elbow block i.e. injection of local anaesthetic drug around ulnar, median and radial nerves provides anaesthesia of the forearm and the wrist. A wrist block (Fig. 16) where a local anaesthetic drug is injected around ulnar, median and radial nerves just above the wrist, is useful for minor work on hand and fingers.

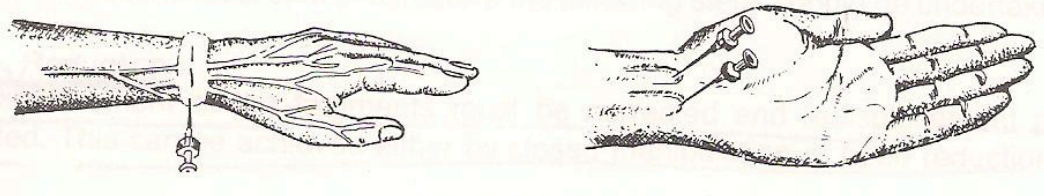


Fig. 16 Wrist block

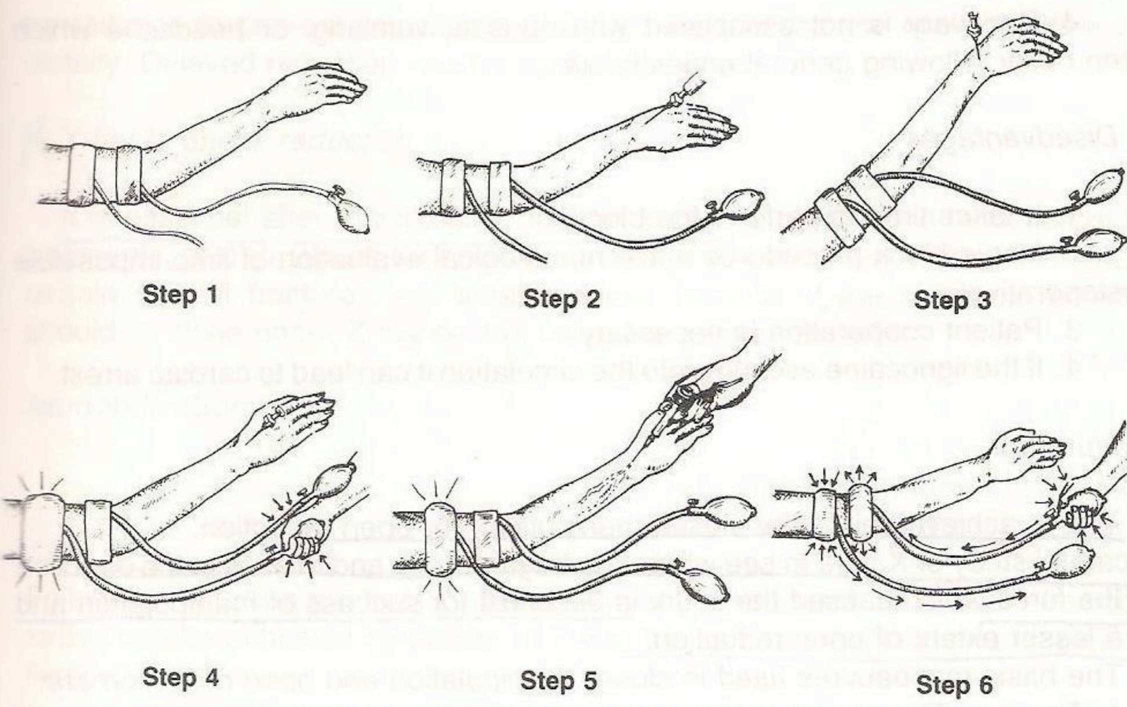


Fig. 17 Intravenous local anaesthetic block of the arm

In the lower limb, an epidural block provides anaesthesia for the whole of limb. Femoral and sciatic block by infiltrating a local anaesthetic drug around both nerves to anaesthetise the limb below the site of infiltration. Ankle block is achieved by infiltrating the tibial, sural, saphenous, superfacial and deep peroneal nerves.

B. Intravenous block could be used for both arms and legs but it is more suited for the arms (Bier's block – Fig. 17).

Steps

1. A double cuffed torniquet is applied to the upper arm.
2. A needle is inserted into a vein preferably as close to fracture as possible.
3. The arm is then exsanguinated by elevation or the use of a bandage.
4. The upper cuff of the torniquet is inflated.
5. A local anaesthetic (*e.g.* 20–30 ml of 0.5% lignocaine) is injected.
6. The lower cuff of torniquet is now inflated and the upper one is deflated.

Advantages of regional anaesthesia

1. Can be used in patients with full stomach.
2. Can be used in patients with head or facial injuries where general anaesthesia is prone to complications.
3. Has no side effect on respiratory of cardiovascular systems which is important in old and feeble patients.

4. Recovery is not associated with nausea, vomiting, or headache which often occur following general anaesthesia.

Disadvantages

1. It takes time to perform the blocks.
2. Nerve block procedures make neurological evaluation of limb impossible postoperatively.
3. Patient cooperation is necessary.
4. If the lignocaine escapes into the circulation it can lead to cardiac arrest.

Reduction

This is achieved either by closed manipulation or open reduction. A careful study of X-rays to see where the fragments lie and to assess the direction of the force which caused the injury is essential for success of manipulation and to a lesser extent of open reduction.

The basic manoeuvres used in closed manipulation and open reduction are:

1. Traction: This aimed at disimpacting the fracture or reducing overlapping of fracture ends.
2. *Reversal of mechanism of injury e.g.* abduction injury of the ankle is manipulated by adducting the ankle.
3. Direct pressure to reduce side to side shift or tilt.

Standard of reduction and acceptable positions

1. Anatomical reduction: This must be achieved in: a) dislocation, b) displaced fractures involving the joints specially in younger patients and c) forearm fractures, to avoid loss of pronation and supination.
2. Although all fractures should ideally be reduced anatomically, some loss of opposition and slight degrees of angulation (less than 10 degrees) can be accepted in fractured shafts of long bones.

Time of reduction

1. Fracture associated with vascular, spinal cord or prepheral nerve injuries are to be dealt with immediately.
2. Cases of compound fracture must be dealt with as soon as possible preferably within six hours otherwise the limb may be lost due to infection which also may endanger patient's life.
3. Dislocations must be reduced as an emergency mainly to avoid pressure on surrounding structures and to relief pain.
4. Simple fractures are less urgent to deal with, it is always advisable to treat the fracture as an emergency, but if facilities do not permit urgent management, the fracture should be immobilized to relieve pain and gross displacement should

be reduced to prevent vascular and skin damage at the site of the fracture and distally. Delayed reduction can be carried out later.

X-ray to check reduction

It is essential after manipulation to take X-rays to confirm the reduction of the fragments, and to repeat X-ray within few days to detect any redisplacement. In certain difficult fractures, eg. supracondylar fracture of the humerus reduction should be done under X-ray control using the image intensifier.

Immobilization

'Life Is Movement, Movement Is Life
Do Not Immobilize Any Joint Unnecessarily'

Following reduction the fracture must be held (immobilized) until union. Immobilization can be achieved by plaster of Paris, traction, internal fixation and external fixator.

1. Plaster of Paris

History of gypsum

Gypsum which is the precursor of plaster of Paris had been so named by the ancient Greeks, and has been known to man for thousands of years. When and why plaster came to be called plaster of Paris is not known for certain, but one explanation relates to the accidental discovery of plaster. The story tells of a house in France which was burned to the ground. In the heat of the fire, the gypsum deposit on which the house was built, produced a powder which subsequently combined with water from a rainstorm to form plaster. Since the building had stood in the vicinity of Paris, the term 'plaster of Paris' became common usage.

Chemistry of plaster of Paris

Gypsum is the precursor of plaster of Paris (P.O.P), chemically, it is known as calcium sulphate dihydrate.

Gypsum + Heat = P.O.P. + Water

Control of setting time

The normal setting time of a cast is about 4–5 min., this can be:

1. *Speeded by:* Warm water, soft water and addition of accelerator such as potassium sulphate to the water.

2. *Slowed by:* Cold water, hard water and addition of a retarder such as sodium borate 'Borax'.

Types and techniques

1. *Complete cast* (Fig. 18): The limb is covered with cotton wool, or stockinet depending on the required type, i.e. padded or unpadded.

The surgeon holds the limb reduced, while an assistant immerses plaster of Paris bandages in water (preferably warm) until all air bubbles within the bandage disappear. The bandage will, then, be removed from the water and squeezed gently to expell excess water.

The wet bandage is then applied around the limb with gentle firmness but not tightly. The direction of encircling movements should be whenever possible in the line of force needed to reduce the fracture.

The plaster should be smoothed and each circle should overlap about half the width of the previous one to make the plaster cast strong.

While the plaster is wet, the surgeon must mould it to conform to the contour of the limb.

Two rules govern the extent of plaster fixation in most limb fractures: a) immobilize the joints immediately above and below the fracture and b) try not to immobilize any joint unnecessarily.

The joints should be ideally immobilized in the following positions:

Knee : 10° flexion	Ankle : Neutral
Elbow : 90° flexion	Wrist : Neutral.

2. *Plaster slab:* A longitudinal piece of plaster prepared to the required length and width by folding a dry bandage to the required size. At least 6–8 layers of plaster are needed in a slab to give reasonable support. The slab is immersed in water, then gently squeezed and applied to the required padded site. A gauze bandage is generally used to hold it in place.

3. *Functional bracing:* The concept of functional bracing is based on the belief that function rather than rest is beneficial to tissue healing, and that motion which inevitably takes place at the fracture site during functional activity encourages osteogenesis.

The physiological use of the limb during the reparative processes diminishes the need for rehabilitation following completion of healing, muscle atrophy is minimized by the patient's ability to ambulate and use all joints and musculature, and the need for lengthy hospitalization is reduced.

This method is gaining popularity in the treatment of the following fractures:

a) Tibial fractures: At the time of the initial injury an above knee cast is used for 3–4 weeks. Following that a functional brace (patellar tendon bearing) is used.

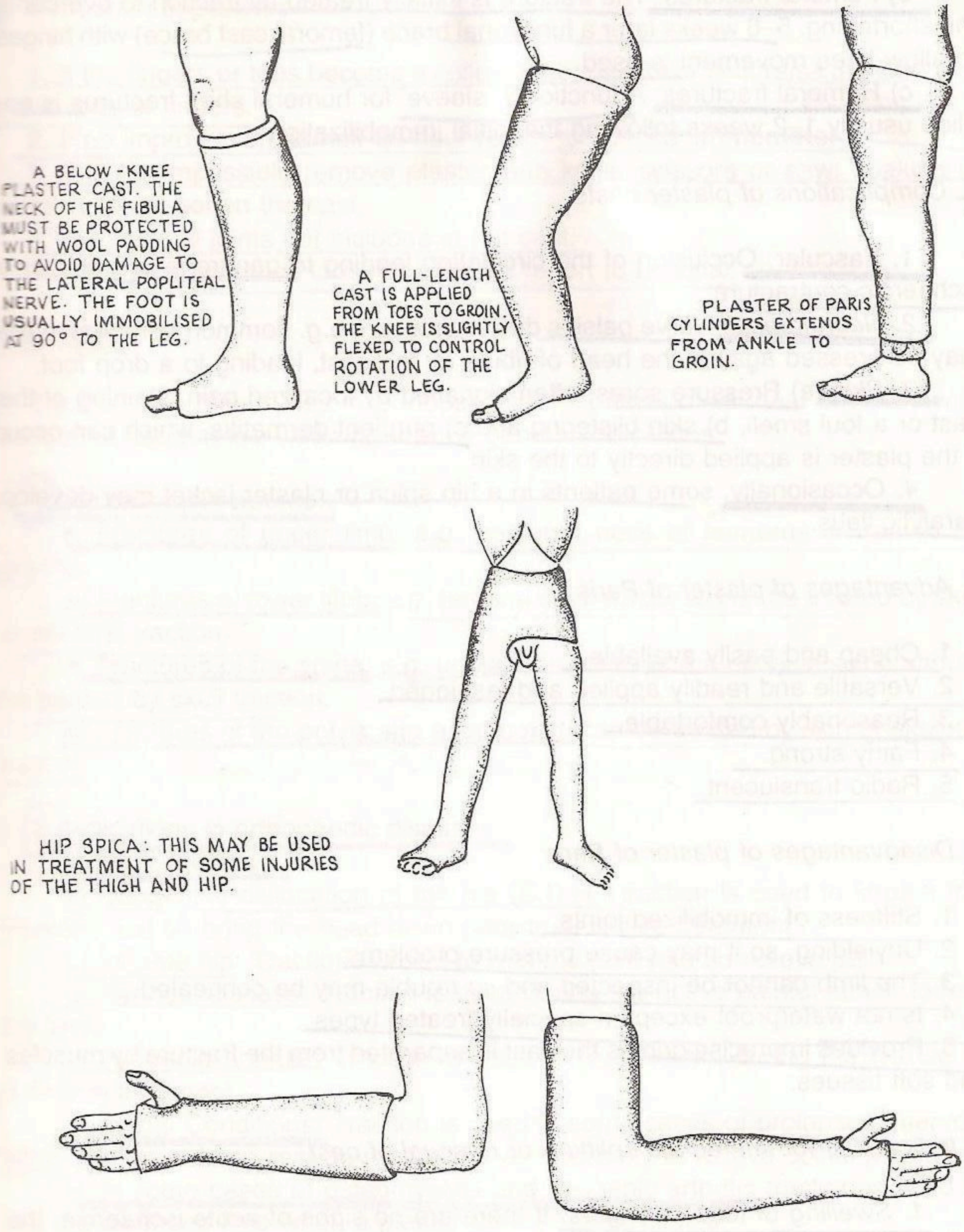


Fig. 18 Common types of full plaster casts

b) Femoral fractures: The fracture is initially treated by traction to overcome the shortening. 5–6 weeks later a functional brace (femoral cast brace) with hinges to allow knee movement is used.

c) Humeral fractures: A functional 'sleeve' for humeral shaft fractures is applied usually 1–2 weeks following the initial immobilization.

Complications of plaster casts

1. Vascular: Occlusion of the circulation leading to gangrene or Volkman's ischaemic contracture.

2. Neurological: Nerve palsies due to pressure *e.g.* common peroneal nerve may be pressed against the head of fibula by the cast, leading to a drop foot.

3. Skin: a) Pressure sores, often signalled by localized pain, staining of the cast or a foul smell, b) skin blistering and c) purulent dermatitis, which can occur if the plaster is applied directly to the skin.

4. Occasionally, some patients in a hip spica or plaster jacket may develop paralytic ileus.

Advantages of plaster of Paris

1. Cheap and easily available.
2. Versatile and readily applied and fashioned.
3. Reasonably comfortable.
4. Fairly strong.
5. Radio translucent.

Disadvantages of plaster of Paris

1. Stiffness of immobilized joints.
2. Unyielding, so it may cause pressure problems.
3. The limb cannot be inspected and so trouble may be concealed.
4. Is not waterproof except in specially treated types.
5. Provides imprecise grip as the cast is separated from the fracture by muscles and soft tissues.

Indications for immediate splitting or removal of cast

1. Swelling of toes or fingers: If there are no signs of acute ischaemia, the limb should be elevated and active movements encouraged, if swelling does not subside, splitting of the cast is indicated.

2. Symptoms and/or signs of ischaemia: a) Spontaneous pain which increases with passive dorsiflexion of toes and fingers, b) impairment of capillary circulation, c) paraesthesia, d) diminished heat in skin of toes or fingers and e) change in skin colour of toes, or fingers.

Instruction to patients

1. If the fingers or toes become swollen, blue, painful or stiff, raise the limb and move toes or fingers.
2. If no improvement in half an hour return to hospital **immediately**.
3. If (2) is impossible remove plaster with knife, scissors or saw; soaking in water helps to soften the cast.
4. Exercise all joints not included in the cast.
5. If the cast becomes loose or cracked report to hospital.

2. Traction

Traction has many uses in orthopaedics, this section will deal basically with traction in trauma, the following are the general indications:

1. Indications in trauma:
   - Fractures of upper limb: *e.g.* fractured neck of humerus is treated by gravity.
   - Fractures of lower limb: *e.g.* femoral shaft fractures can be treated by skin or skeletal traction.
   - Fractures of the spine: *e.g.* unstable fracture of the cervical spine should be treated by skull traction.
   - Fractures of the pelvis and acetabulum can be treated by skin or skeletal traction.

2. Indications in orthopaedic diseases:
   - Hip conditions:

     a) Congenital dislocation of the hip (C.D.H.) traction is used to stretch the muscles and so bring the head down prior to definitive treatment.

     b) Irritable hip: Traction is used to rest the joint and so relieve pain.

     c) Perthes' disease: Traction is used during the active painful attack to rest the joint.

     d) Pyogenic arthritis: Traction is used to rest the hip during the course of definitive treatment.
   - Spinal Conditions: Traction is used in some cases of prolapsed intervertebral disc to enforce rest on the patient and possibly to relieve spinal pressure.
   - In some cases of osteomyelitis and pyogenic arthritis traction is used to rest the diseased limb when a plaster cast is not advisable.

Principles of traction

The overriding which occurs following fractures of long bone is produced by contraction of the surrounding muscles, this tendency is greater when:

1. The muscles are powerful as in the thigh.
2. When the fracture is mechanically unstable because the fragments are not in opposition or the fracture line is oblique.

3. When the fracture is imperfectly immobilized so that there is pain and therefore muscle spasm.

Traction is aimed at relieving the muscle spasm and accordingly reduces overlap.

The following three important principles should be recognized:

1. The limb must be supported and stretched in such a direction as to align the bone fragments within it. In practice, traction is exerted on the distal fragment, aligning it with the less manageable proximal fragment, rather than vice versa.

2. The extremity must not be overstretched, thereby causing excessive distraction of the bone fragments.

3. The stretching forces must remain constant in amount and direction with respect to each other until the broken bones unite.

Methods of traction

1. Skin traction (Fig. 19)

Skin traction is achieved by attaching various types of adhesive strips over large areas of an extremity withstands about 5 kg of pull for about 4 weeks before slipping. This form of traction is particularly suitable for younger children, because of their fast healing time and the light forces required for reduction and immobilization. Furthermore, it presents no hazard of bone infection or damage to the epiphyseal growth apparatus. On the other hand, most young patients and some older ones exhibit an unfortunate tendency to disarrange the elastic bandage and

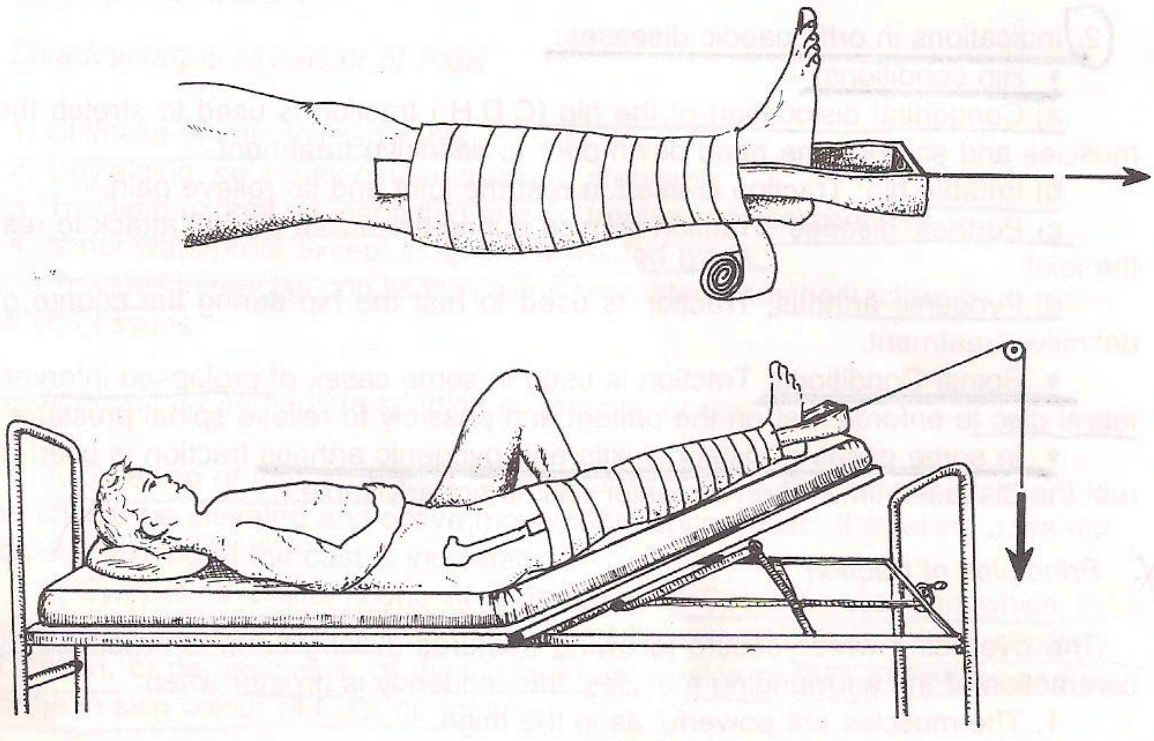


Fig. 19 Skin traction

to tunnel with their fingers under the traction tape. Skin traction cannot be used easily to control rotation. It cannot withstand the magnitude and duration of forces frequently required, and it should not be used over injured skin.

2. Skeletal traction

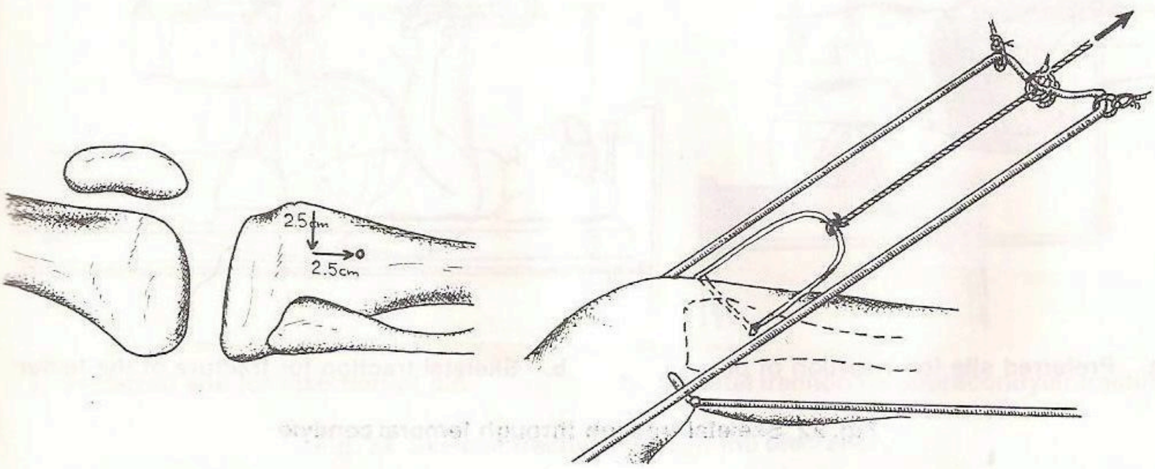
Skeletal traction, achieved by inserting a metal device directly into the bone, withstands very high forces for prolonged periods of time and is therefore, the most reliable means of securing an effective traction force. Various types of hooks, tongs, screws, pins and wires have been used for this purpose. In most cases either a Kirschner wire or a Steinmann pin is eminently satisfactory. Of these two, the Kirschner wire, with its smaller diameter, makes a smaller wound and causes less discomfort to the patient.

The duration of use of these devices may be limited by the development of sepsis in the tract through the bone. Such an infection usuallly subsides spontaneously upon removal of the wire. Rarely it may not subside and may prove troublesome, particularly in children, in whom it may involve the nearby epiphyseal plate and provoke a local growth disturbance.

Pain at the traction site beyond a few days after application is usually an indication that either there is a pin traction infection or the wire is not actually in the bone and is therefore pulling on soft tissue. The latter circumstance is usually caused by incorrect initial insertion of the wire. It is exceedingly uncommon for a properly placed traction wire to migrate in bone.

The most commonly used sites for pin insertion are:

A. Upper tibia (Fig. 20): A pin is inserted behind tibial tubercle for thigh, hip and pelvic injuries.

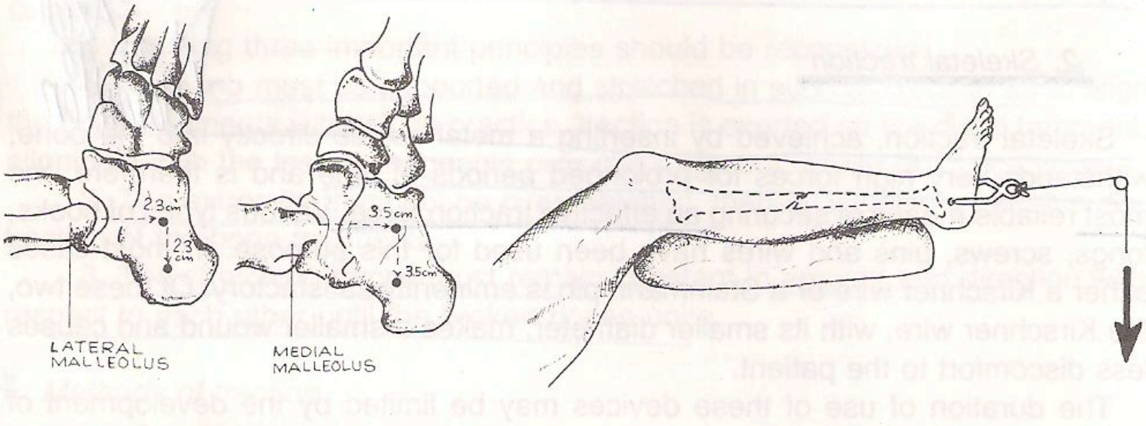


a. Preferred site for insertion of pin

b. Skeletal traction for fracture femur

Fig. 20 Skeletal traction through upper tibia

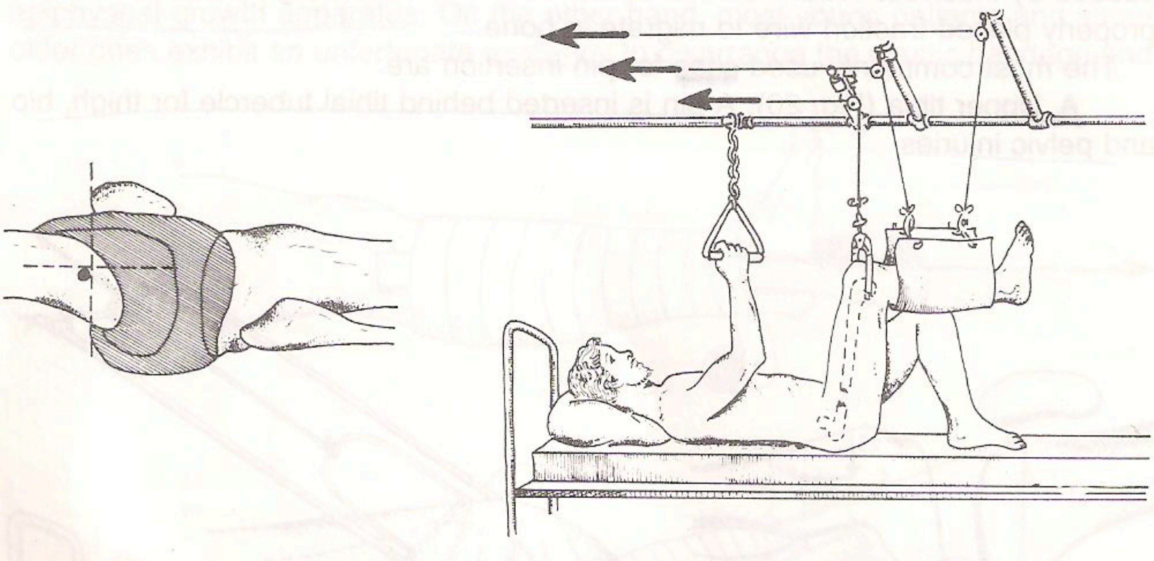
B. Calcaneum (Fig. 21): A pin is inserted through calcaneum for ankle and leg injuries.



a. Preferred site for insertion of pin **b. Skeletal traction for fracture of the tibia**

Fig. 21 Skeletal traction through calcaneum

C. Femoral condyles (Fig. 22): A pin through femoral condyles is used sometimes as an alternative to the upper tibia.



a. Preferred site for insertion of pin **b. Skeletal traction for fracture of the femur**

Fig. 22 Skeletal traction through femoral condyle

D. Skull (Fig. 23): In the presence of an unstable fracture or dislocation of the cervical spine immediate immobilization of the neck is mandatory. Special tongs applied to the long axis of the cervical spine, as indicated by the mastoid processes, are usually used.

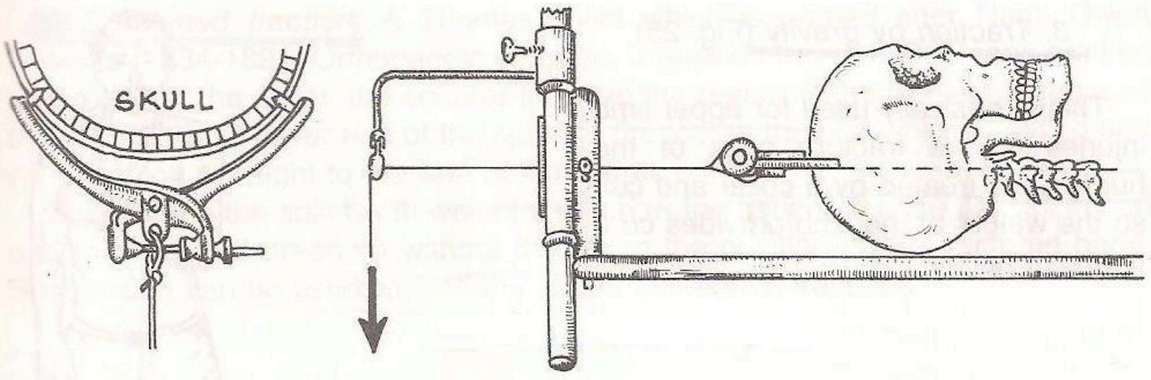
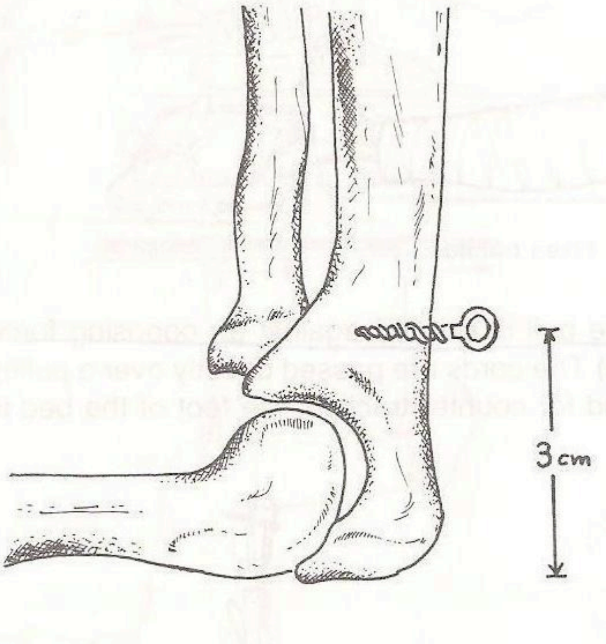
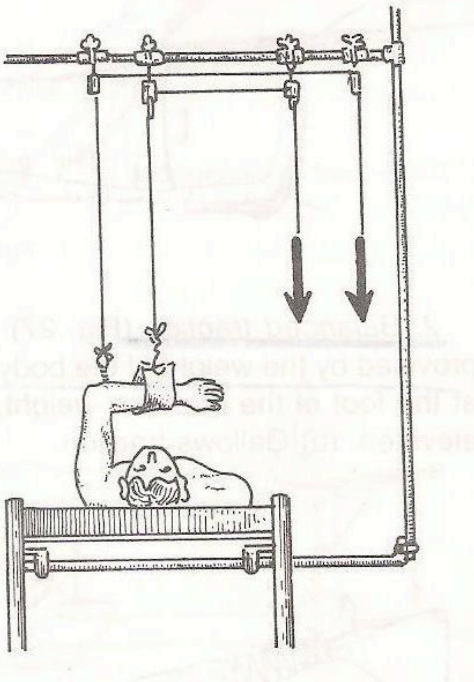


Fig. 23 Skull traction for cervical injury

E. Olecranon (Fig. 24): A pin through the olecranon is used sometimes in the management of difficult supracondylar fracture.



a. Preferred site for insertion of pin



b. Skeletal traction for supracondylar fracture

Fig. 24 Skeletal traction through the olecranon.

3. Traction by gravity (Fig. 25)

This is basically used for upper limb injuries *e.g.* a fracture neck of the humerus is treated by a collar and cuff so the weight of the limb provides continuous traction.

Fig. 25 Traction by gravity

Mechanics of traction

Traction must always be opposed by countertraction.

1. Fixed traction (Fig. 26): Traction is exerted against a fixed point. The tapes are tied to the cross piece of the splint and the leg is pulled down until the root of the limb abuts against the ring of the splint.

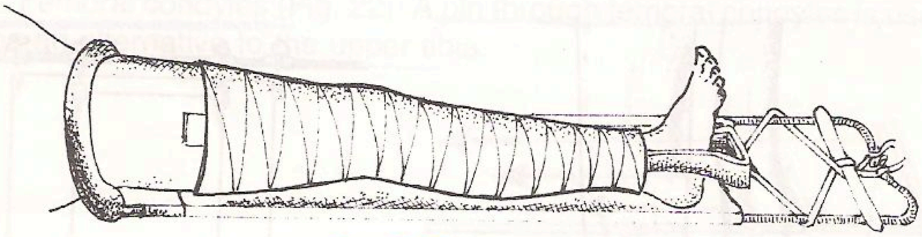
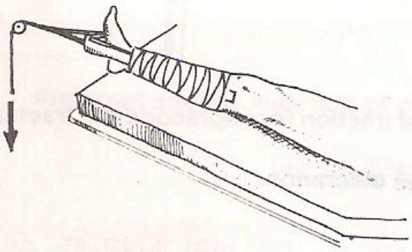


Fig. 26 Fixed traction

2. Balanced traction (Fig. 27): The pull is exerted against an opposing force provided by the weight of the body. (a) The cords are passed directly over a pulley at the foot of the bed to a weight, and for counter traction, the foot of the bed is elevated. (b) Gallows traction.



a. Balanced traction using weights

b. Gallows traction

Fig. 27 Balanced traction

3. *Combined traction*: A Thomas splint which is named after Hugh Owen Thomas (1834-1891. Orthopaedic surgeon, Liverpool) is used. The tapes are tied to the end of the splint, the counter-thrust in the region of the ischium is reduced by: (a) Fixing the lower end of the splint to the foot of the bed which is raised and (b) attaching a weight to the end of the splint.

Suspending the splint with weights will allow the patient to raise himself in bed and to move with freedom without disturbing the position of the fractured bone. Suspension can be used with all the above mentioned tractions.

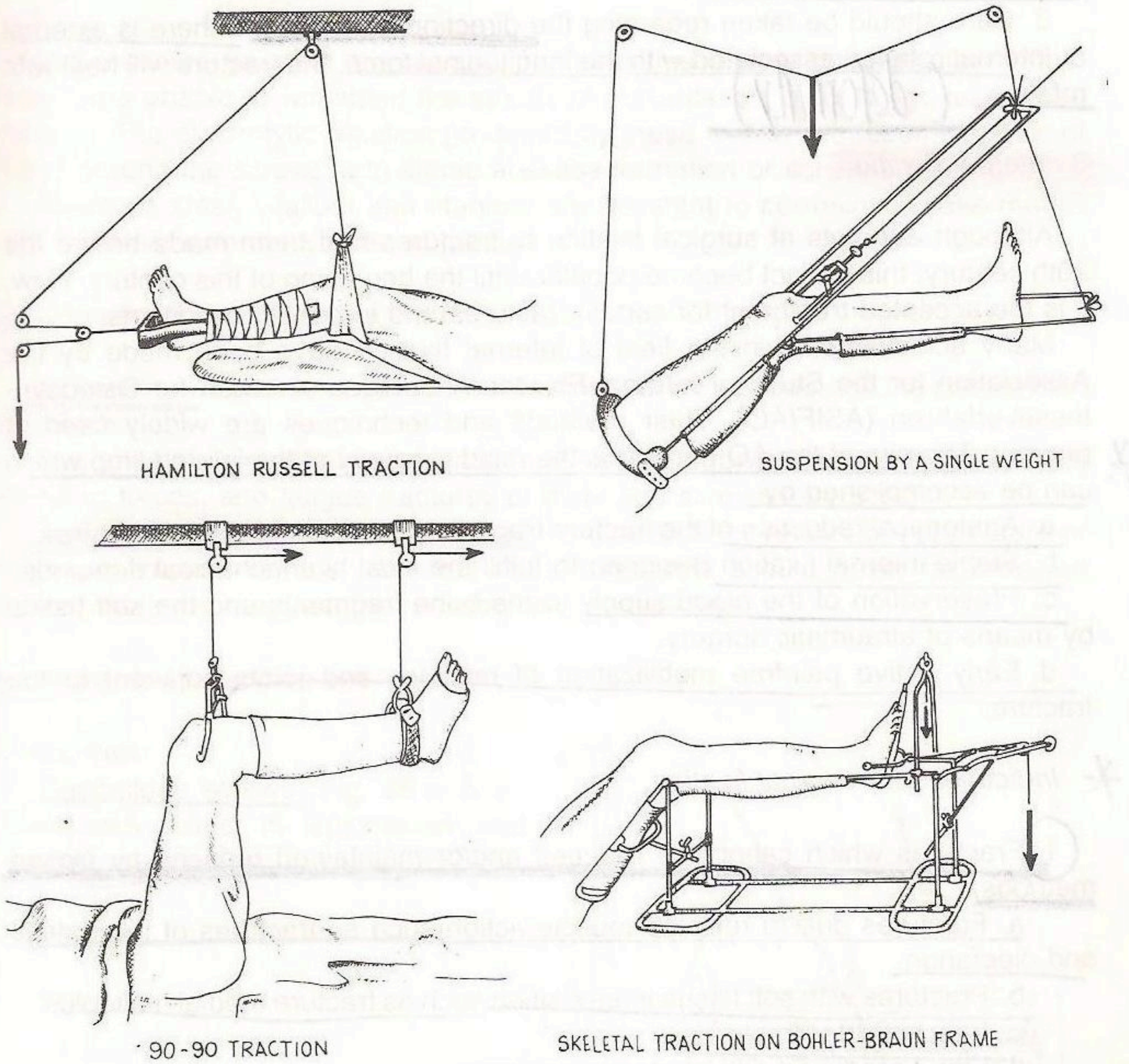


Fig. 28 Types of traction in common use

Complications of traction

1. Complications related to the method used:

a. Skin traction: Skin ulceration and sloughing due to strapping.

b. Skeletal traction: Pin tract infection may occur, this subsides after removing the pin.

2. Complications related to the amount of traction:

a. If traction is excessive, distraction at fracture site occurs which may lead to delayed or nonunion.

b. If traction is not adequate, overriding at the fracture site occurs which may lead to shortening of the limb.

3. Care should be taken regarding the direction of traction, if there is external or internal rotation associated with the longitudinal force, the fracture will heal with rotation.

3. Internal Fixation

Although attempts at surgical fixation of fractures had been made before the 20th century, this did not become popular until the beginning of this century. Now, it is the accepted treatment for certain fractures and in certain conditions.

Many achievements in the field of internal fixation have been made by the Association for the Study of Internal Fixation/Arbeitsgemeinschaft fur Osteosyntheseverfahren (ASIF/AO). Their methods and techniques are widely used at present. The aim of the AO method is the rapid recovery of the injured limb which can be accomplished by:

a. Anatomical reduction of the fracture fragments particularly in joint fractures.

b. Stable internal fixation designed to fulfill the local biomechanical demands.

c. Preservation of the blood supply to the bone fragments and the soft tissue by means of atraumatic surgery.

d. Early active painfree mobilization of muscles and joints adjacent to the fracture.

Indications for internal fixation

1. Fractures which cannot be reduced and/or maintained reduced by closed methods:

a. Fractures due to resisted muscle action such as fractures of the patella and olecranon.

b. Fractures with soft tissue interposition such as fracture medial malleolus.

c. Intra articular fractures.

d. Late unreduced and neglected fractures.

2. Complicated fractures: Major vascular rupture in association with a fracture is an indication for internal fixation, since arterial repair in the presence of a mobile fracture is useless.

3. Multiple fractures: It is common for the tibia and the femur to be broken on

the same side. Internal fixation of one or both is indicated so as to make nursing care easier.

4. Fractures in which conservative methods are inadvisable such as fractured neck femur which usually occur in old people, in whom if conservative methods are used general and local complications are likely to occur.

5. Pathological fractures: Internal fixation is indicated in long bone pathological fracture so as to achieve early mobilization and shorter hospitalization in a patient with a short life expectancy. Prophylactic internal fixation of a long bone with a metastasis which is likely to fracture is also used.

Implants in common use

In the earliest years of this century, the metals used were unsatisfactory in that they were unable to withstand the effects of implantation in electrolytically active tissues. The electrolytic reaction produced by these metals produced necrosis of bone around the screws with sterile abscess formation or screw loosening.

Stainless steel, vitalium and titanium are resistant to corrosion. These metals are the most commonly used at present.

Complication of internal fixation

1. Infection: Metal does not cause infection, but may encourage the persistence of infection.

2. Implant failure: Metal implants may not be strong enough to resist local bending forces, and fatigue fractures of plate and screws may occur.

3. Refractures after implant removal: Most refractures result from premature or improper implant removal, for that reason implants should never be removed before the bone has become radiologically consolidated.

Implants in common use

Screws:

Cancellous screws (Fig. 29 a & b): Classically used in epiphyseal and metaphyseal areas.

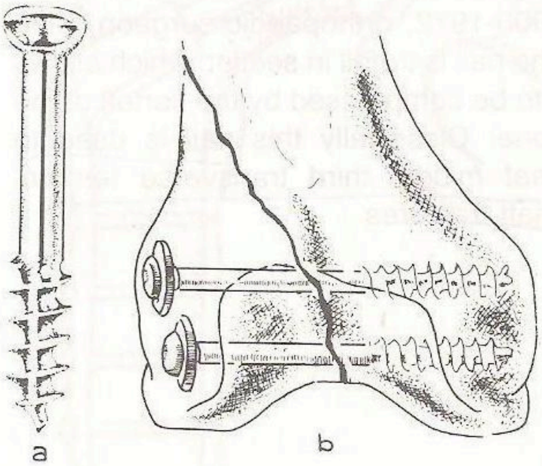


Fig. 29 Cancellous screws

Malleolar screws (Fig. 30 a & b): Classically used in medial and lateral malleolar fractures.

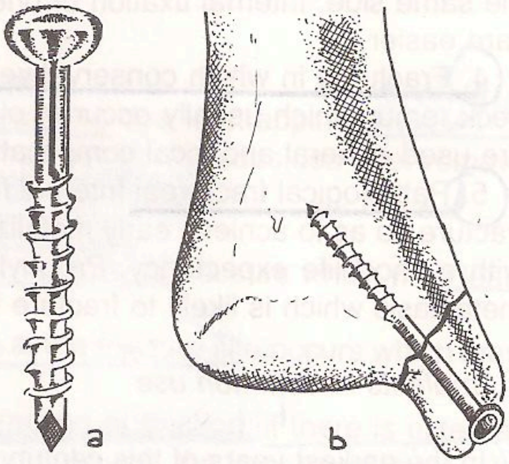


Fig. 30 Malleolar screws

Cortical screws (Fig. 31 a & b): Classically used for fixation of plates to bone.

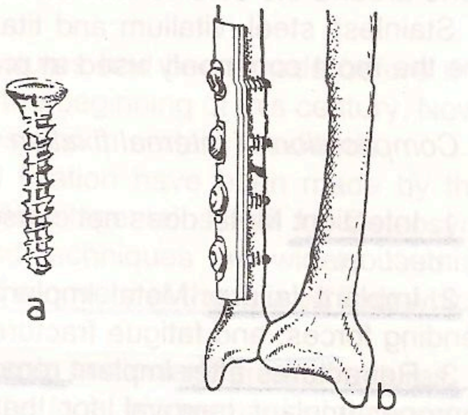


Fig. 31 Cortical screws

Intra medullary nails 'Kuntscher nail' (Fig. 32 a & b) (Gerhard Kuntscher – 1900-1972, orthopaedic surgeon, Kiel) The nail is trefoil in section which allows it to be compressed by the cortex of the bone. Classically this nail is used to treat middle third transverse femoral shaft fractures.

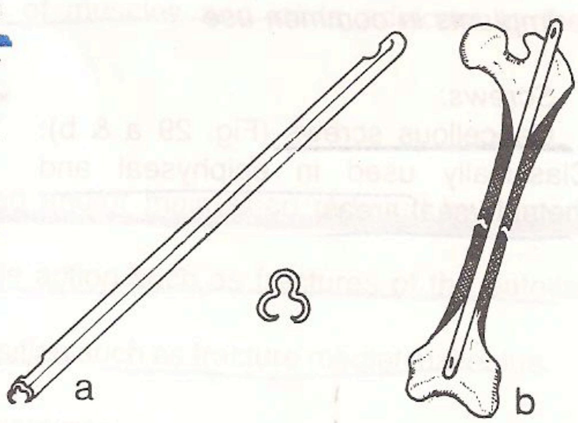


Fig. 32 Kuntsher nail

Rush nail: (Fig. 33 a & b) (L.V. Rush, orthopaedic surgeon, Meridian, Mississippi.) This nail is malleable and achieves fixation by three point fixation against cortical bone. Occasionally used to treat fractures of the ulna.

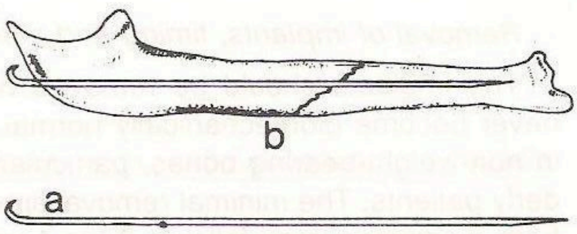


Fig. 33 Rush nail

Standard plates (Fig. 34):

1. Straight plates:
   a. Round hole plate
   b. dynamic compression plate (D.C.P.) which is a self compressing plate.

2. Special plates:
   c. buttress plates for the tibial plate.

3. Angled plates:
   d. condylar plate

4. Dynamic Hip Screws (Fig. 35): Are commonly used for fractured neck femur.

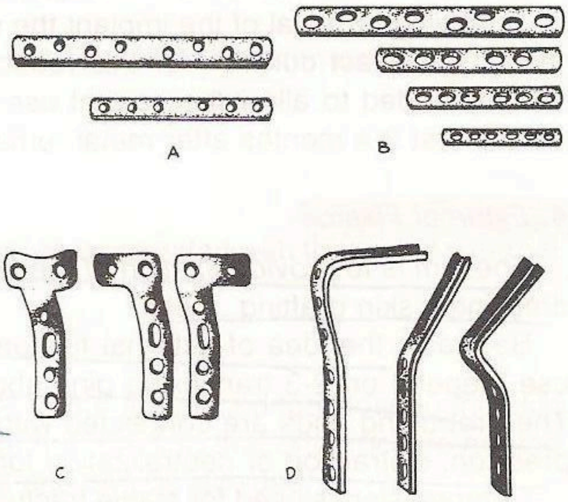


Fig. 34 Standard plates

K-wires: Are simple to use least traumatizing and can be used to transfix the fractures percutaneously in children or adults.

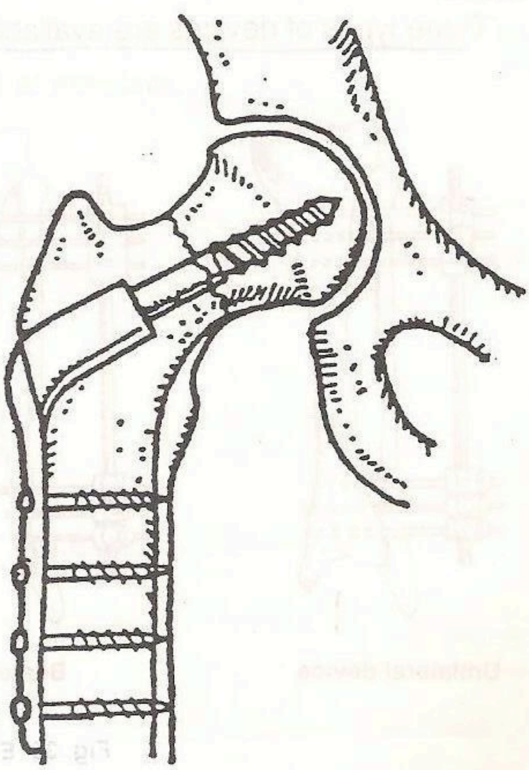


Fig. 35 Dynamic Hip Screw (DHS)

Removal of implants, timing and safeguards:

The implants should be removed because the bone under an implant may never become biomechanically normal. The exceptions to this rule are implants in non-weight-bearing bones, particularly the humerus as well as implants in elderly patients. The minimal removal time for the combination of screws and plates from diaphyses is as follows: Tibia 1 year, femur 2 years, forearm and humerus 1.5 to 2 years, intra-medullary nails should not be removed under 2 years, single screws can be removed from metaphyseal areas after 3-6 months.

Following removal of the implant the diaphysis loses 50% of its torsional resistance, the exact duration for this reduction in strength in man is unknown, it is recommended to allow the normal use of the limb but not any athletic activities for the first 3-4 months after metal removal.

4. External Fixator

The aim is to provide fixation of the fracture and to keep the limb amenable for dressings, skin grafting ... etc.

Basically, the idea of external fixators is simple. Most appliances in common use, depend on 2-3 transfixing pins above and 2-3 pins below the fracture site. The protruding ends are connected with rods with a device which can give compression, distraction or neutralization forces.

Compression is used for stable fractures, neutralization is applied frequently for unstable fractures, while distraction is used in cases of bone loss to maintain length.

Three types of devices are available, unilateral, bilateral and circular (Fig. 36).

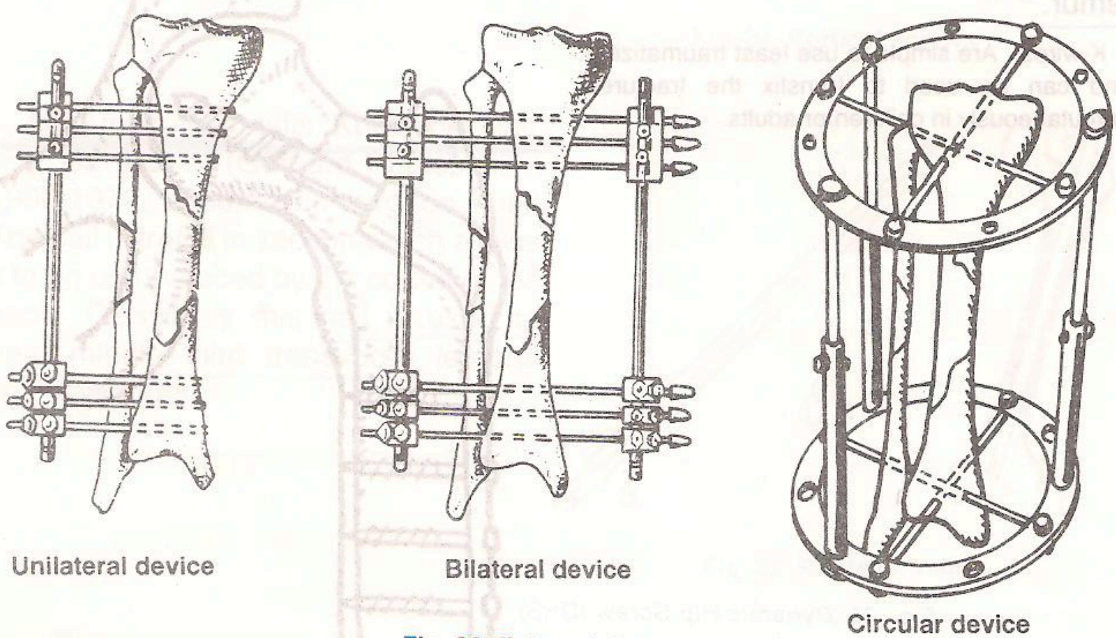


Fig. 36 External fixators

Indications in trauma

A. Primary:

1. Severe open fractures with extensive skin, subcutaneous and muscle damage.
2. Highly comminuted closed fractures.
3. Infected nonunion.
4. Arthrodesis.

B. Secondary:

1. Fracture stabilization to protect arterial or nerve anastomosis.
2. Cross leg skin graft.

Complications

There are three major types of complications associated with the use of external fixators:

A. Complications related to the frame:

Skin necrosis:

This may occur if the side bars of the frame are placed too close to the skin and do not leave enough room to allow for the swelling that often occurs around the pin sites. This complication is unusual and can be avoided.

B. Complications related to the pins:

These are most common and careful attention to detail should help to avoid them.

1. Pin tract infection.
2. Pin loosening which is often a result of infection.
3. Damage to nerves or vessels.
4. Fracture at pin site.
5. Pin breakage.

C. Delay in fracture healing.

OPEN FRACTURES

An open fracture (compound fracture) is a fracture in which the fracture site communicates with the external environment.

The management of a compound fracture is always an emergency and should be carried out as soon as possible. All compound fractures must be considered contaminated (presence of organisms in the wound). If treatment is delayed or inadequate, multiplication of the organisms occurs leading to infection.

The Management of Patients

A. General care

The aim is to save the patient's life. The patient should be resuscitated whenever it is necessary.

An antibiotic directed against staphylococci which are the most common infecting organism (Flucloxacillin, Cephalosporin ...) should be started. Antibiotics should not be a substitute for a meticulous surgical technique.

Prophylaxis against Tetanus (See page 43).

B. Local care

The aim is to save the limb and save function. The goals of the operative procedures should be removal of all contaminated and devitalized tissues.

Steps of operative procedures

1. Clean

Under anaesthesia and strict aseptic technique, the fracture site is covered with sterile gauze, then the skin is shaved, and the limb is cleaned thoroughly using an antiseptic solution such as 'Betadiene'.

2. Irrigate

Next the fracture site is irrigated with water or normal saline to flush the contaminants from the skin and from the depth of the fracture.

3. Debride/excise the wound

Literally to debride means to unleash a tight structure, in practical terms debridement of the wound means excising the edge of skin, fascia and dead muscles.

4. Decontaminate the bone

The bone is decontaminated by removing dirt from the bone ends using a curette and avoiding bone excision if at all possible.

5. Close the wound

Primary wound closure is carried out except in:

a. wounds over six hours old.

b. high velocity missile injuries.

c. highly contaminated wounds.

d. if closure causes tension of skin edges.

In these cases, the wound should be left and secondary wound closure is carried out later.

Primary suturing of damaged nerves and tendons associated with a compound fracture is indicated in clean cases within six hours of injury and when the ends do not need extensive dissection to bring them together.

6. Immobilize

Immobilization of the fracture, in most cases, can be achieved by a plaster cast especially in fractures of the forearm. In certain other sites, if a plaster cast is not advisable or practicable, skeletal traction or an external fixator can be used.

REPAIR OF FRACTURE

Repair of a fracture is primarily a local function of the tissues involved. But some factors such as: Patients age, line of the fracture, the presence of systemic or local diseases, may affect the rate and effectiveness of the repair process significantly.

Fracture Repair

A. Stages in fracture repair without rigid fixation

Stage I. Haematoma formation (Fig. 37-I)

Following injury, there is a variable amount of bleeding from torn vessels, if periosteum is torn, this blood may extend into the surrounding muscles.

Stage II. Traumatic inflammation (Fig. 37-II)

Tissue damage excites an inflammatory response, and exudate will add more fibrin to the clot already present.

There will be increased blood flow and polymorphonuclear leucocytic infiltration.

Stage III. Demolition (Fig. 37-III)

In this stage, macrophages invade the clot and remove the fibrin, red cells, inflamatory exudate and debris. Any bone fragment which is detached from its blood supply and undergoes necrosis will be attacked by macrophages and osteoclasts.

Stage IV. Formation of granulation tissue (Fig. 37-IV)

After stage of demolition, there is an ingrowth of capillary loops and mesenchymal cells derived from the periosteum and the endosteum of cancellous bone. These will form granulation tissue.

Stage V. Woven bone and cartilage formation (Fig. 37-V)

The mesenchymal osteoblasts differentiate to form either woven bone or cartilage.

In this stage either woven bone or cartilage or both might form, they are merely methods of temporarily uniting bone ends with calcified material – callus. (external, intermedial and external)

Stage VI. Formation of lamellar bone (Fig. 37-VI)

The woven bone or cartilage formed acts as a scaffold on which final adult lamellar bone can be built, this starts by invasion of the dead calcified cartilage or woven bone by capillaries headed by osteoclasts, which will remove the initial callus, while osteoblasts lay down osteoid which calcifies to form bone, with its collagen fibres arranged in orderly lamellar fashion.

Stage VII. Remodelling (Fig. 37-VIII)

The final process in repair of a fracture is achieved by continued osteoclastic removal and osteoblastic laying down of bone.

The external callus is slowly removed, the intermediate callus becomes converted into compact bone while the internal callus is hollowed out into a narrow cavity in which only few spicules of cancellous bone remain.

B. Fracture healing with rigid internal fixation – 'primary bone healing'

In the presence of rigid fixation the bone heals by primary vascular bone formation, healing occurs between the bone ends without the formation of external or internal callus.

In this type of healing, active haversian remolding occurs across the fracture site.

Time factor

Generally speaking, to estimate the time for the union of fractures, Perkin's formula is a useful guide. Union is defined as incomplete repair (the callus is calcified but still tender). Consolidation is complete repair (the calcified callus is ossified and the fracture site not tender and can withstand stress).

Expected time in weeks

	For union	For consolidation
Upper limb		
Spiral	3	6
Transverse	6	12
Lower limb		
Spiral	6	12
Transverse	12	24

N.B.: In children half of this time is needed.

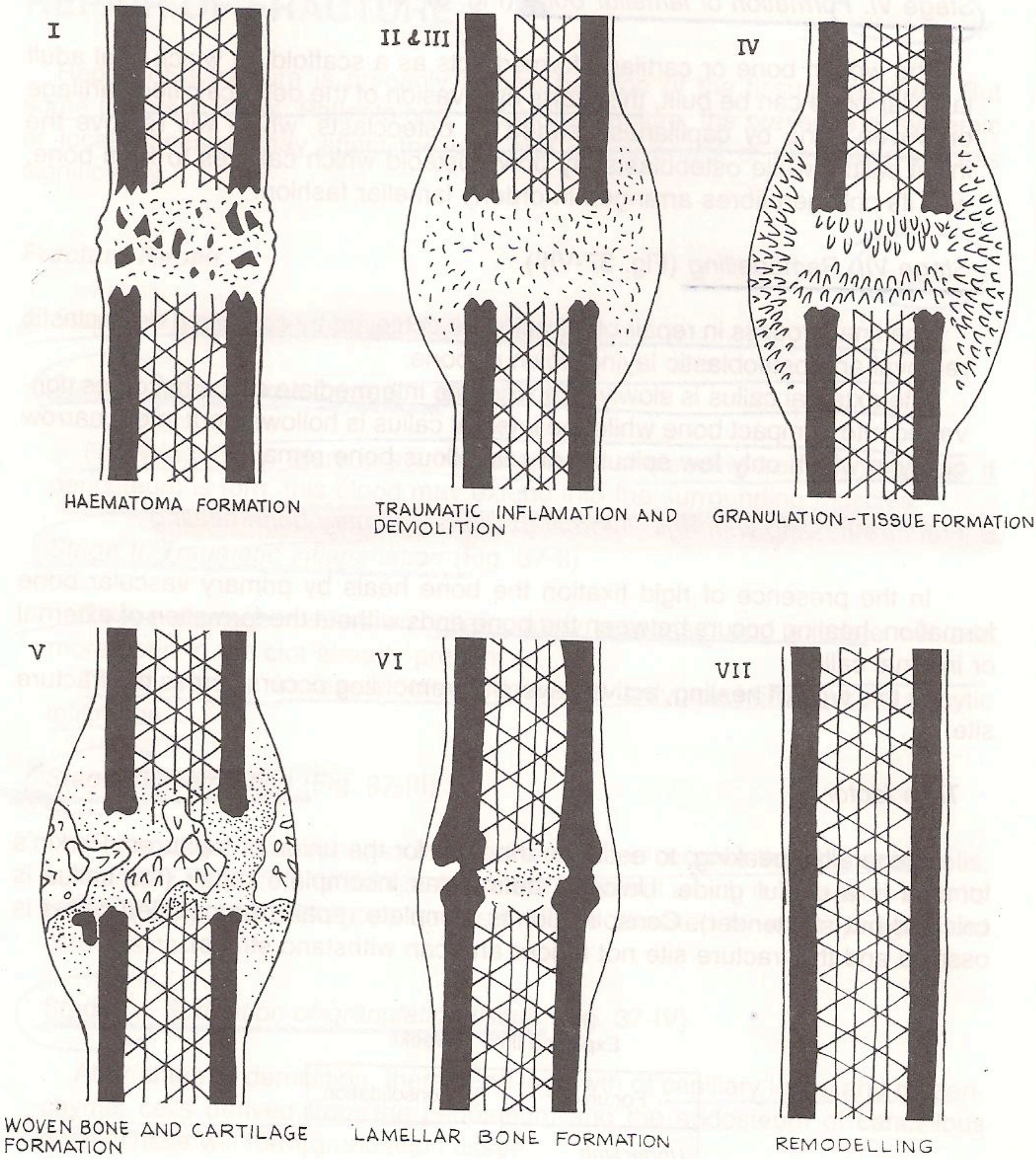


Fig. 37 Stages in fracture repair without rigid fixation

COMPLICATIONS OF INJURY

	General	Local
Immediate	1. Shock 2. Crush syndrome 3. Associated injury to important internal organs.	1. Skin: Loss 2. Vascular: Gangrene 3. Nerve damage.
Early	1. Deep venous thrombosis 2. Pulmonary embolism 3. Fat embolism 4. Tetanus 5. Gas gangrene 6. Hypostatic pneumonia 7. Bed sores	1. Skin Fracture blisters Plaster sores. 2. Vascular Volkman's ischaemia. Compartment syndrome. 3. Nerve Compression 4. Muscle and tendon Torn fibres-fibrosis. Tendon rupture Disuse atrophy.
Late	1. Accident neuroses 'compensation'	1. Bone Delayed-union Nonunion Malunion Avuscular neorosis 2. Joint Stiffness Instability Contracture Post traumatic osteo-arthrosis 3. Others Late tendon rupture Late neuritis

Shock: (See page 193)

Crush Syndrome

Crush syndrome may occur if a large bulk of muscle is crushed or if a tourniquet has been left on too long.

When compression is released, acid myohaematin is released into circulation to the kidney and blocks the tubules, Fig. 38.

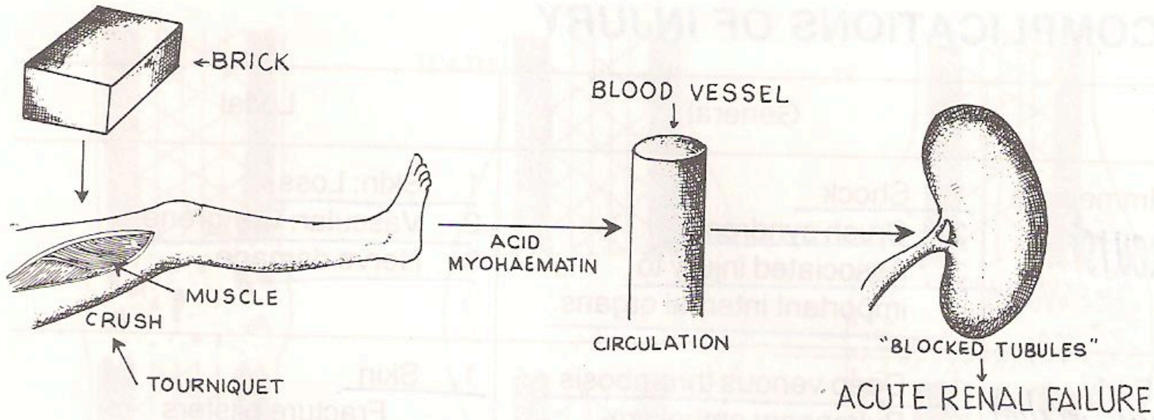


Fig. 38 Crush syndrome

Clinical picture

– *General:* Shock.
– *Local:* Limb is pulseless, later becomes red, swollen and blistered with loss of sensation and muscle power.
– *Kidney:* Oliguria – acute renal failure.

Treatment

A. *Preventive:* Amputate a severely crushed limb when presented after 6 hours.
B. In an established case, amputation is valueless, treatment is generally that of shock and acute renal failure.

Fat Embolism

This is a significant life threatening complication usually of multiple fractures. In the past this phenomenon was considered to be caused by numerous fat droplets from the fracture acting as emboli. However the basic problem is now recognized to be respiratory insufficiency as a sequel to injury and shock.

Diagnosis

A. Signs and symptoms

1. Change in mental state: agitation, confusion, headache and later on stupor progressing to coma.
2. Precordial pain.
3. Petechiae in buccal membrane, conjunctiva and over the skin of the neck and chest.
4. Tachycardia, tachypnoea and pyrexia.
5. Pulmonary oedema.

B. Laboratory findings

1. PO_2 level is below normal
2. Presence of fat in urine, sputum.

Treatment

A. Prophylaxis

1. Gentle handling of fractured limbs with effective fracture immobilization.
2. Prompt and effective treatment of shock.
3. To keep the possibility of fat embolism in mind and detect the early symptoms and signs if it occurs.

B. Treatment of established case

1. Oxygen: Attempt to maintain PO_2 over 60 mm. Oxygen can be introduced by a mask in mild cases while in severe cases intubation and ventilation may be required.
2. Maintain fluid balance.
3. Sedation.
4. Supportive measures such as steroids and diuretics to help reduce pulmonary oedema.

Tetanus

This severe disease is caused by the anaerobic spore-bearing rod shaped '*Clostridia tetani*'. The organisms do not destroy local tissue, but develop fierce exotoxins which reach the anterior horn cells where they have a stimulant effect, producing spasm of some or all of the patient's muscles. The incubation period is 8 days but may range from 1 to 30 days.

Clinical picture

A stiff neck, dysphagia or trismus may be the first signs, and the condition can eventually result in opisthotonos and respiratory arrest. The patient may die from respiratory arrest, heart failure due to exhaustion, or if enough food cannot be given to compensate for the raised metabolic rate caused by the clonic spasms.

Prophylaxis

A. For a previously immunised patient.

1. Remove all devitalised tissue.
2. Give a toxoid booster.

B. For the unimmunised patient.

The paramount step to be taken in any wound which is at risk from tetanus is to operate. The wound must be washed thoroughly and all dead tissue removed. Antibiotics are best given systemically, and a long and short acting preparation of penicillin is given. If wound is neglected, human anti-tetanus serum may be given.

A survivor from an attack of tetanus is not immune from a further attack, so these patients should have a booster every five years.

Treatment of an established case

1. Tetanus antitoxins intravenously (Human antitetanus serum)
2. The spasms must be stopped. Keep the patient in a dark quite room and give (Diazepam in mild cases, D-Tubocurarine in severe cases, sufficient curarisation to arrest the fits will also arrest the respiration, and intermittent positive pressure ventilation is mandatory).
3. Nutrition either intravenously or via a nasogastric tube.
4. Antibiotics and sedation.

Gas Gangrene

Gas gangrene is among the most lethal infections in man, it is due to one or more of several types of anaerobic gas-forming, sporebearing clostridia. (Cl. Welchii, Cl. Septicum and Cl. Oedematiens.) The incubation period is one to three days.

Clinical picture (Fig. 39 & 40)

There is always a wound in traumatic gas gangrene, which is painful hot and surrounded by swelling. A serosanguinous discharge soon contains bubbles, and the smell is at first unpleasantly sweet, but before long the typical stench develops. Gas infiltrating muscle layers can be felt as crepitation and its presence may be seen on X-ray. When the disease is fully developed, the patient is gravely ill with tachycardia pyrexia, anaemia, leucocytosis and oliguria.

It must be noted that gas can also be produced by other organisms such as clostridia cellulitis streptococcus, but in these cases there is no severe toxicity.

Prophylaxis

There is no evidence that polyvalent anti-gas gangrene serum has been effective, so that prophylaxis after wounding is purely surgical. The wound should be explored thoroughly, all foreign material, dead and damaged tissue must be removed. Following radical wound toilet, it is vital to give penicillin and cloxacillin in full doses.

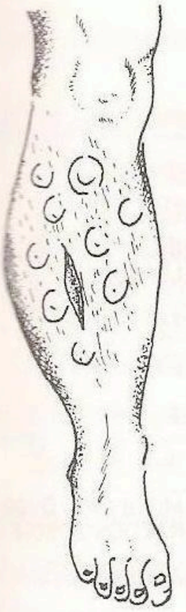


Fig. 39 Local signs

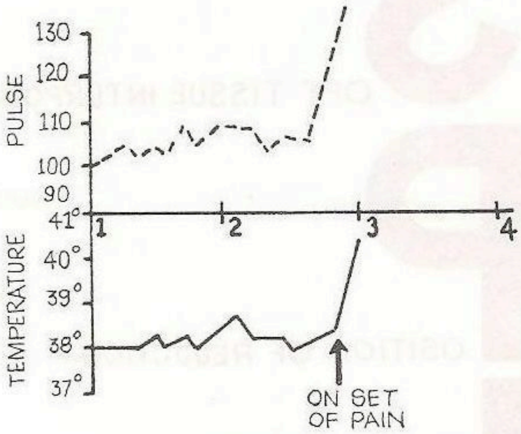


Fig. 40 Pulse and temperature

Treatment

In an established case, operative treatment is urgently needed, swabs must be taken from the wound for urgent identification of the organisms and their antibiotic sensitivities. The wound is extended widely to examine dead and diseased tissue, and to open up all affected planes to allow evacuation of pus and gas. Areas of muscle, fat and devitalized bone are removed. In advanced cases, especially if they have arrived late, amputation may be life-saving. Blood transfusion will be required.

Large doses of penicillin should be given intramuscularly.

In the severely toxic patient who may still have anaerobic infection present, or where there is evidence of septicaemic, treatment with hyper-baric oxygen must be considered.

Vascular Injuries Associated with Fractures See page 218.

Peripheral Nerve Injuries Associated with Fractures See page 199.

Delayed Union and Nonunion

Delayed union is bone repair in which the process although slower than average, is still active, the fracture site is tender. In nonunion, the reparative process has stopped and union is not possible without intervention, the fracture site shows painless abnormal movement.

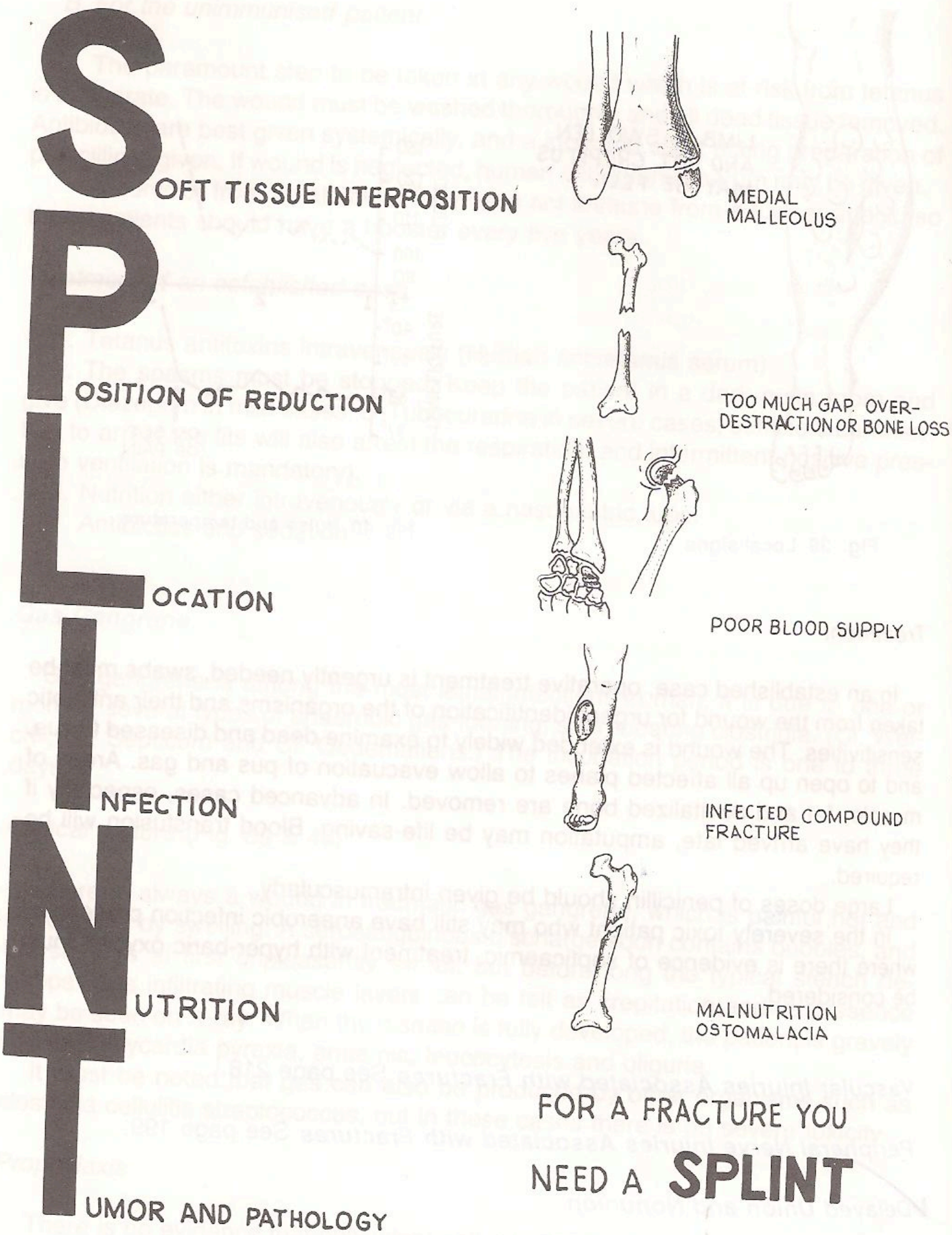


Fig. 41 Causes of nonunion

Causes of nonunion

A. *Local causes* (Fig. 41).

1. Soft tissue interposition.
2. Poor blood supply.
3. Infection of the fracture.
4. Inadequate immobilization.
5. Overdistraction of the fracture.
6. Tumours and some pathological fracture.

B. *General causes*

(Nutritional, bone diseases and old age).

Types of nonunion and their management (Fig. 42)

A. *Hypertropic – vascular*

This is characterized on X-ray by a florid bone reaction. The bone ends have excellent blood supply 'elephant foot type or horse hoof type'.

Hypertrophic nonunion mostly occurs with conservative fracture treatment. This type of nonunion has the best prognosis.

Treatment of this type is rigid immobilization of the fracture.

B. *Atrophic – avascular*

This type is characterized radiologically by abscence of bone reaction, sclerosed smooth bone ends and clear fracture line.

For treatment of this type, rigid internal fixation with extensive decortication and bone grafting is essential. Osteogenesis can also be stimulated by electricity directly by the use of percutaneous electrodes or indirectly through electromagnetic field.

C. *Infected nonunion*

This type carries the worst prognosis, two problems must be dealt with:
a. Infection. b. Nonunion.

The treatment of this type should concentrate firstly at achieving consolidation and secondly eradication of infection by excission of diseased area, antibiotics, stable fixation and stimulation of osteogenesis by bone graft or Ilizarov method or electric stimulation.

Ilizarov method for treatment of nonunion

Special apparatus is used to provide stable immobilization. stimulation of osteogenesis is also achieved by applying compression and/or distraction to the fibrous nonunion without the need for bone graft. If union fails grafting is done through minimal surgery.

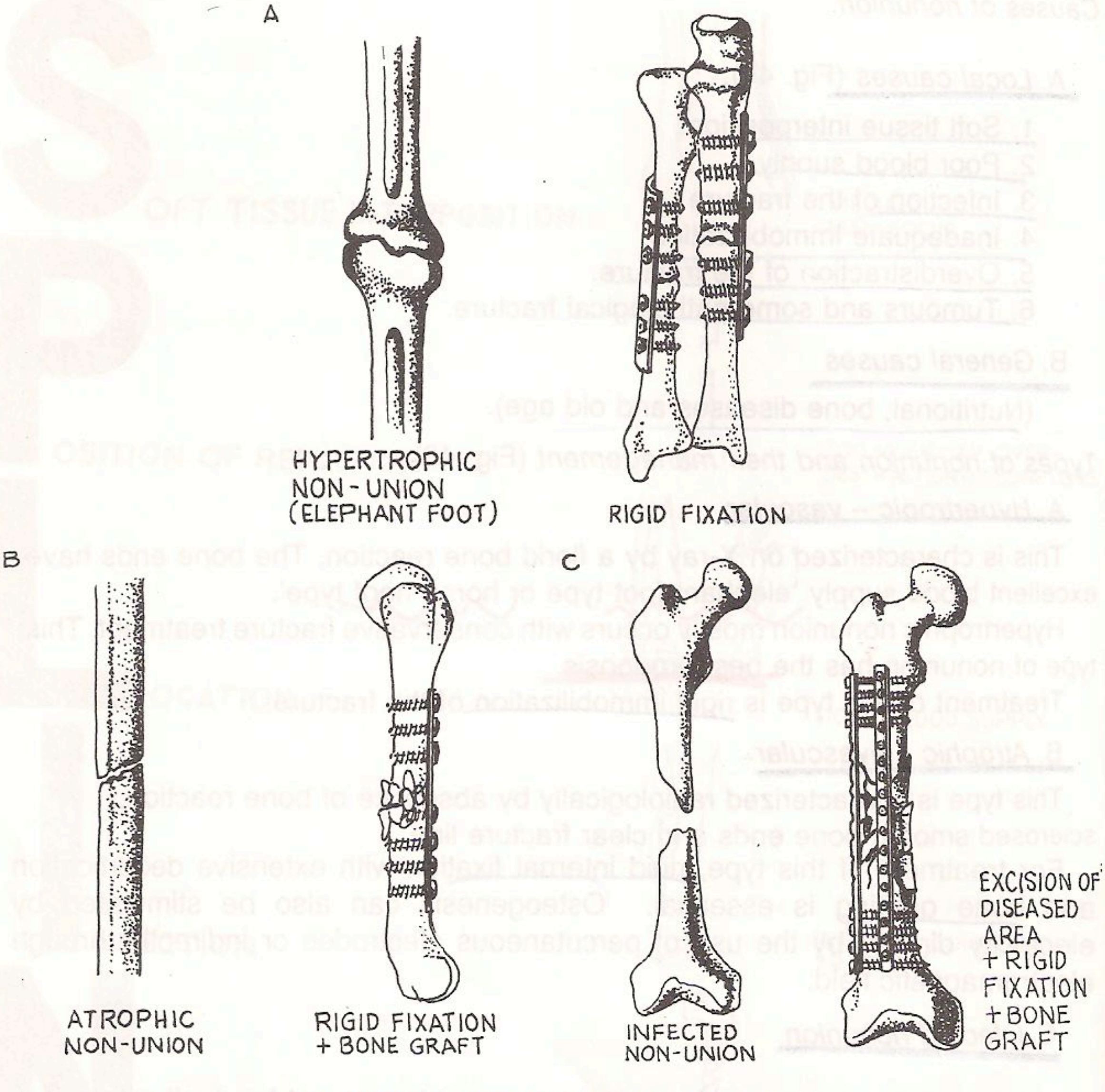


Fig. 42 Types and management of nonunion

The apparatus is useful in the management of infected nonunion as it allows more aggressive excision of the diseased part while concomitantly can restore length to make for the gap by bone transport.

Malunion (Fig. 43)

Proper management of fractures should anticipate and prevent most residual deformities.

In some instance, deformities are unavoidable, this is particularly true after crushing injuries to epiphyseal plates or fractures with extensive bone loss.

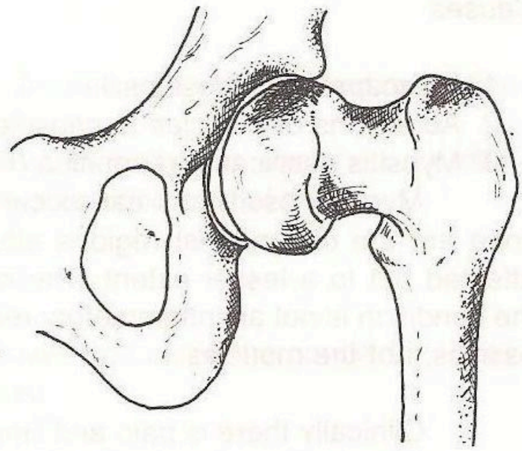


Fig. 43 Malunited fracture

When the deformity interferes with the function of the limb or is cosmetically unacceptable, surgical correction is indicated.

Avascular Necrosis (Fig. 44)

Avascular necrosis of bone implies death of bone resulting from impairment or total loss of its blood supply. It shows on X-rays as increased density and sclerosis of the affected bone.

Joint Stiffness

Limited movement of a joint, is one of the commonest complications of a fracture or a dislocation.

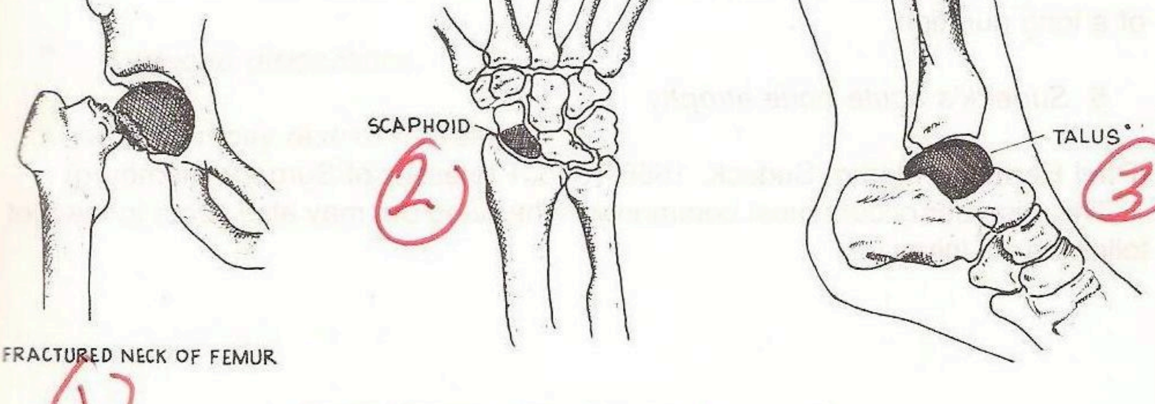


Fig. 44 Common sites of avascular necrosis

Causes

1. Intracapsular adhesions.
2. Adhesions of muscles to capsule or bone.
3. Myositis ossificans traumatica (Fig. 45)

Myositis ossificans can occur anywhere in the body, the elbow and the knee are the commonest regions affected, the thigh, shoulder and hip may be affected but to a lesser extent. The name of myositis ossificans is a misnomer, the condition is not an inflammatory reaction and it is the connective tissues which ossifies, not the muscles.

Clinically there is pain and limitation of movement, the diagnosis is confirmed by X-rays which initially shows the appearance of a cloud and later of a mass of mature bone.

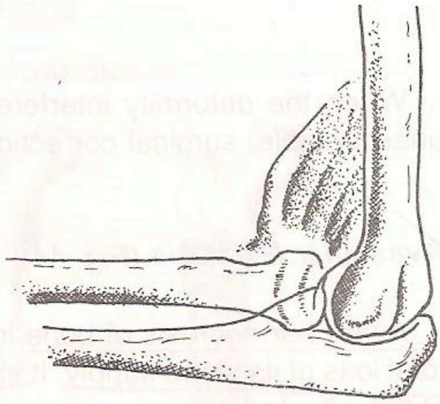


Fig. 45 Myositis ossificans of the elbow

Treatment

A. Preventive The incidence of myositis ossificans could be minimised by proper management of trauma; i) do not employ deep massage or passive stretching, and ii) treat injuries at the mentioned sites initially by rest.

B. Established cases are treated by: i) rest of the affected joint, and ii) excision of the mass should not be carried out before one year after injury because of the tendency of myositis ossificans to recur.

4. Infection

Infection of a compound fracture nearly always causes considerable stiffness of a long duration.

5. Sudeck's acute bone atrophy

(Paul Hermann Martin, Sudeck. 1866-1945, Professor of Surgery, Hamburg)
This disorder occurs most commonly in the hand but may also occur in the foot following an injury.

Diagnosis

a. *Patient complains of:* i) Intense pain, ii) swelling and iii) marked restriction of joint motion.

b. *Examination reveals:* i) Skin is glossy, smooth and stretched, ii) local temperature is increased, and iii) X-rays shows osteoporosis of bones.

Treatment

i. Intensive physiotherapy usually improves and cures the condition, it may take several months for the cure to be effected.

ii. Sympathetic block

iii. Regional block followed by gentle manipulation and dynamic splinting.

6. Post traumatic osteo-arthrosis (Fig. 46)

This is mostly seen after intra-articular fractures and malunited fractures in the proximity of a joint.

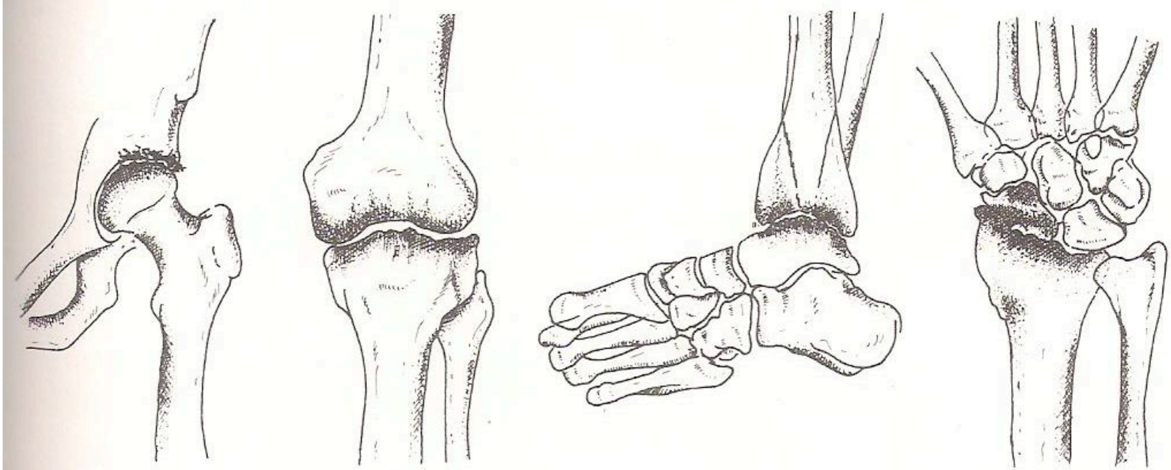


Fig. 46 Common sites of post traumatic osteo-arthrosis

7. *Unreduced dislocations.*

8. *Malunion may restrict movement.*

Part II
Regional Fractures and Dislocations

INJURIES OF THE UPPER LIMB

THE SHOULDER AND THE ARM

Anatomy

The shoulder is the most mobile and probably the least stable of all the joints of the extremities. Basically, it consists of the articulation of the glenoid fossa of the scapula with the head of the humerus (glenohumeral joint). However considering the mechanics of the shoulder with regard to injuries and motion, we must consider the articulations of the shoulder girdle to include (1) The glenohumeral (2) The sternoclavicular (3) The acromioclavicular and (4) The scapulothoracic joints (Fig. 47).

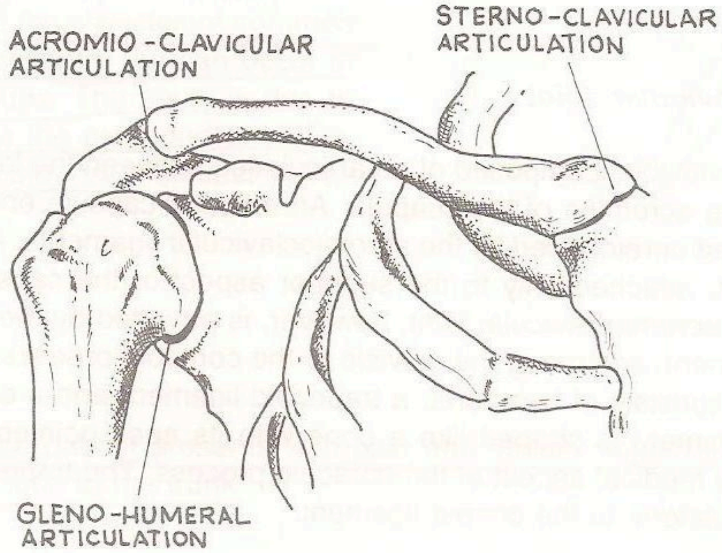


Fig. 47 Articulation of the shoulder girdle

1. The glenohumeral Joint, Fig. 48

This is a ball and socket joint possessing the greatest freedom of motion of all the joints of the body. Here, the large head of the humerus articulates with the shallow glenoid fossa of relatively smaller surface area.

2. Sternoclavicular Joint

This is a synovial joint formed by the articulation of the sternal end of the clavicle with the upper end of the sternum. An articular capsule surrounds the joint and is reinforced by anterior and posterior sternoclavicular ligaments. A fibrocartilaginous articular disc is interposed between the two articulating surfaces and possibly affords some stability and improves motion of the joints. The sternoclavicular joint represents the only point of bony articulation between the trunk and upper limb.

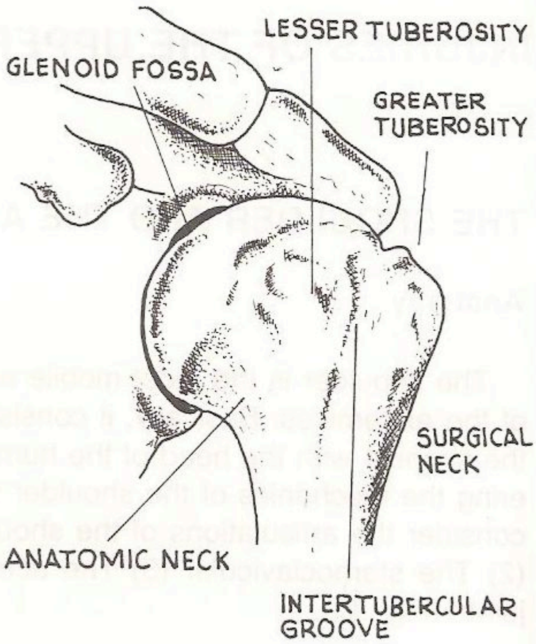


Fig. 48 Bony anatomy of the glenohumeral joint

3. Acromioclavicular Joint

This is synovial joint composed of an articulation between the lateral end of the clavicle and the acromion of the scapula. An articular capsule encloses the joint and is supported or reinforced by the acromioclavicular ligaments. A small articular disc is present, attached only to the superior aspect of the capsule. The major stability of the acromioclavicular joint, however, is provided by the strong coracoclavicular ligament, anchoring the clavicle to the coracoid process of the scapula. This ligament consists of two parts, a trapezoid ligament and a conoid ligament. The conoid ligament is shaped like a cone with its apex pointed distally and is attached to the medical aspect of the coracoid process. The trapezoid ligament is situated anterolateral to the conoid ligament.

4. Scapulothoracic Articulation

The articulation of the anterior surface of the scapula and the posterior rib cage, is not a true joint in that there is no apposition of bone to bone. Functionally speaking, however, in shoulder mechanics it behaves as a joint.

Restriction of motion at any of the four above junctions will restrict the total arc of motion of the shoulder.

Injuries of Shoulder Girdle

Fractures:

- Clavicle
- Scapula
- Proximal humerus

Dislocations:

- Shoulder
- Acromioclavicular
- Sternoclavicular

Fracture Clavicle

Mechanism of injury :

Fractures of the clavicle are common especially in children, but can occur in other age groups. The injury is due to either a fall on the extended arm (Fig. 49), or a direct blow as in contact sport.

Fig. 49 Mechanism of injury

Diagnosis

Typically, the patient presents with pain and usually supports his injured limb at the elbow close to the trunk.

Deformity

Most fractures occur in the middle 1/3 of clavicle and typically the shoulder is in a slightly downward and outward position. The proximal fragment may be elevated, producing an obvious deformity at the fracture site. In children green stick fracture is common and localized tenderness is an important sign. X-rays will confirm the diagnosis and establish the site and type of the fracture.

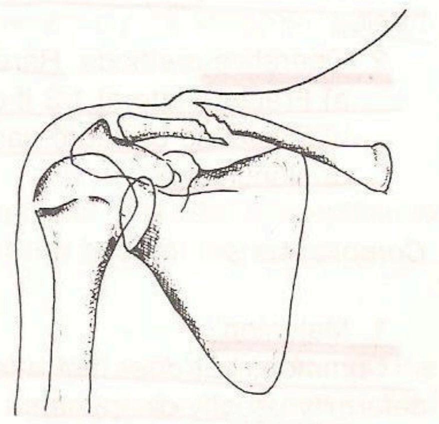


Fig. 50 Fracture clavicle typical site and deformity

Management

The goal is rapid recovery of the injured shoulder. Fractures of the clavicle almost always unite with or without treatment.

Healing occurs usually in 3-6 weeks, depending on age of the patient and the type of fracture.

Available methods

1. Conservative (the method of choice)

Accurate reduction is not necessary.

Immobilization: Traditionally this can be achieved by figure of 8 bandage and a sling, Fig. 51.

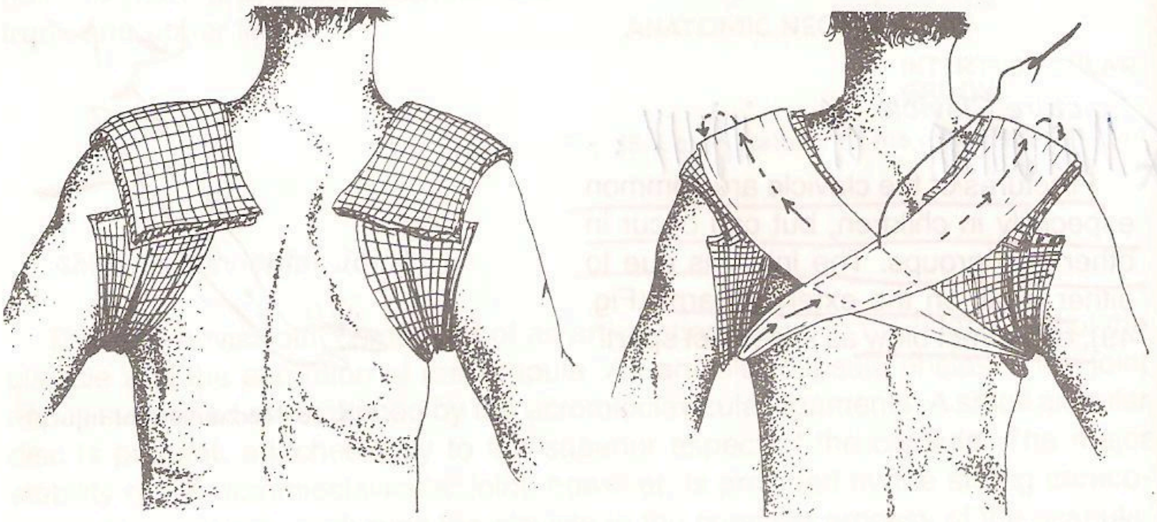


Fig. 51 Figure of 8 bandage

Rehabilitation: The patient should be instructed regarding hand wrist and elbow exercises during immobilization and regarding shoulder exercises once fracture healed.

2. Operative methods: Rarely indicated except in:

a) Fracture lateral 1/3 if conservative methods fail.

b) Presence of neuro vascular complications.

c) Nonunion.

Complications

1. Malunion

Common, but does not affect function, in children remolding does occur and deformity usually disappears.

2. Nonunion

Uncommon, its occurs mostly in cases who have had surgical intervention.

3. Neuro vascular injury is rare.

Fracture Scapula

The scapula is a large, flat, broad surfaced structure on the posterior aspect of the upper trunk. Fractures of the scapula are uncommon, because of its location. The injury is mostly due to a direct type such as a backward fall. Indirect trauma may also, and to a lesser extent, result in fractures of the scapula.

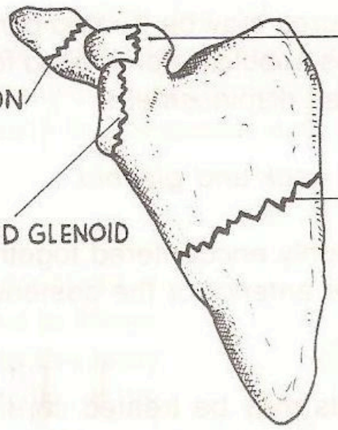


Fig. 52 Fractures of the scapula

Classification, Fig. 52

1. Fracture of the body and spine

These occur mostly due to a direct trauma *e.g.* a fall from a height with direct landing on the posterior aspect of the trunk. Since a force of great magnitude is required to produce these injuries, it is important to examine the patient for associated serious injuries specially chest injuries.

Treatment

Almost all these fractures can be treated conservatively by analgesics and a simple sling to rest the shoulder for 2-3 weeks.

2. Fracture of the acromion

Since the acromion forms the roof of the shoulder joint, it is very susceptible to direct trauma from above or to an upward thrust of the head of the humerus.

Treatment

Undisplaced fractures 'The majority' may be managed with a sling to rest the shoulder for 3 to 4 weeks. In markedly displaced fractures, the acromion should be reduced and fixed.

3. Fracture of the coracoid process

This may occur as a result of a direct or indirect injury. Indirect injury is usually due to acute muscle contraction of the pectoralis minor, short head of biceps or coracobrachialis leading to avulsion fracture.

Treatment

The majority of these fractures may be treated conservatively using a sling for 2-3 weeks. Vigorous exercises should be prohibited for 2 months. Open reduction is indicated in cases of marked displacement.

4. Fracture of the surgical neck and glenoid

These fractures are commonly encountered together, the usual mechanism of injury is a direct trauma to the anterior or the posterior aspect of the shoulder.

Treatment

The majority of the patients may be treated conservatively by a sling for 2-3 weeks. If there is a significant displacement of the glenoid, a shoulder spica in abduction may be used after reduction. Open reduction is indicated if there is isolated glenoid rim fractures associated with dislocation or subluxation of the shoulder.

Fractures of the Proximal Humerus

Fractures of the proximal humerus occur mostly in the older age group. Osteoporosis is a common finding in these patients.

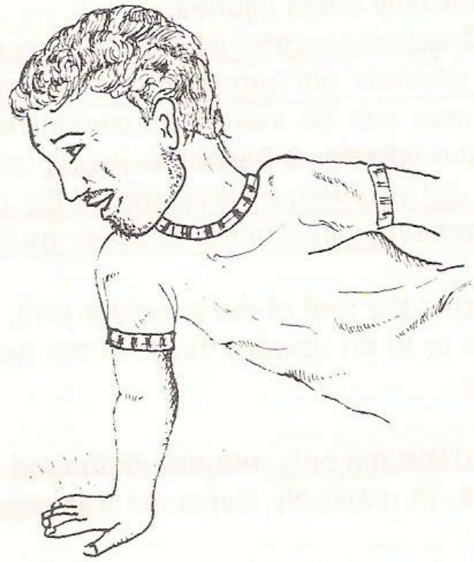


Fig. 53 Mechanism of injury

The blood supply of the humeral head enters anterolaterally above the common site of fractures of the surgical neck. Thus in fractures of surgical neck, blood supply to both bone ends is good and healing is rapid.

Mechanism of injury

The commonest injury is due to an indirect trauma as a result of a fall on the out stretched and pronated upper limb, Fig. 53.

Direct trauma to the anterior or posterolateral aspect of the shoulder may lead to fracture of greater tuberosity or surgical neck. Avulsion injury of the greater tuberosity may occur especially in association with shoulder dislocation.

Diagnosis

The typical posture of the patient is usually indicative, he will tend to immobilize the injured limb next to the body and support the arm with the use of the uninjured limb, Fig. 54.

It is essential to perform careful neurovascular examination of the limb, since displaced fractures may cause such damage. X-ray is essential to establish diagnosis, to determine the extent and the displacement of the fracture.

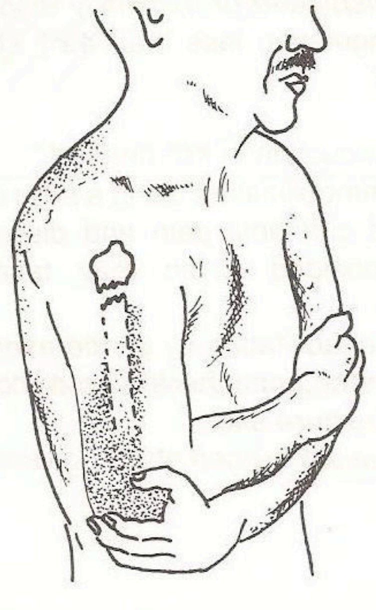


Fig. 54 Typical posture

Classification

1. *According to the site, Fig. 55*

   a) Fracture of the greater tuberosity.
   b) Fracture of the surgical neck.
   c) Fracture of the lesser tuberosity.
   d) Fracture of the anatomical neck.
   e) Combinations of the above.

The most commonly encountered fractures are those of the greater tuberosity and surgical neck.

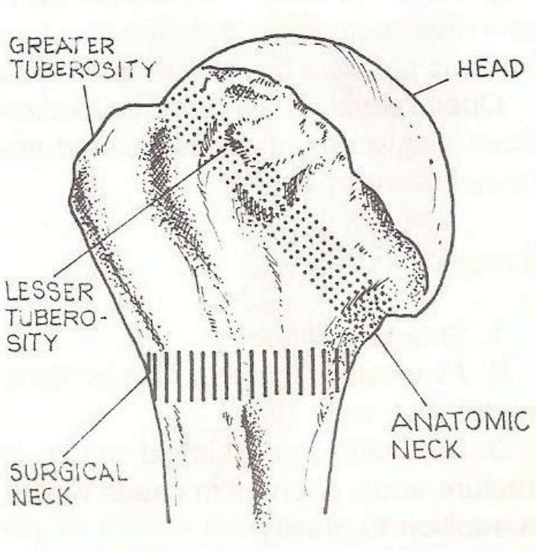


Fig. 55 Anatomy of proximal humerus

2. According to displacement

a) Undisplaced or minimally displaced.

b) Displaced (fragments are displaced greater than 1 cm or angulated more than 45°)

Management

Our aim should be recovery of satisfactory functional motion of the injured shoulder.

Undisplaced or minimally displaced: (Separation of fragments less than 1 cm and angulation less than 45°) These fractures are best treated conservatively, Fig. 56.

a) Reduction is not needed.

b) Immobilization using a sling or collar and cuff until pain and discomfort has subsided which may take 1-2 weeks.

c) Rehabilitation by gentle exercises should start once there is no discomfort at the fracture site.

Fig. 56 Treatment of undisplaced fractures

Displaced fractures: (Separation over 1 cm, Angulation more than 45°). The conservative method as mentioned above can be used, in which the weight of the limb will act as a distraction force 'Traction by Gravity'.

Open reduction and internal fixation (Fig. 57) is indicated in: a) Cases of significant displacement, b) associated tears of the rotator muscles, and c) failure of conservative treatment.

Complications

1. Shoulder stiffness.
2. Avascular necrosis: This is more commonly associated with fractures of the anatomical neck.
3. Nonunion and delayed union: Is mostly seen if there is overdistraction of fracture ends, such as in cases where hanging cast is used to provide distraction in addition to gravity.

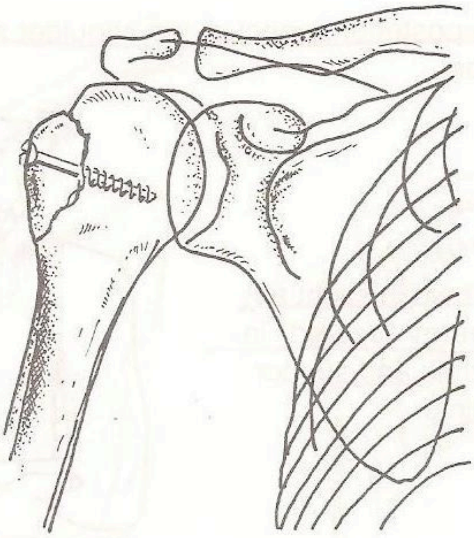


Fig. 57 Internal fixation of displaced fracture greater tuberosity

Dislocations of the Shoulder Girdle

Shoulder Dislocation

Shoulder dislocation is a common injury which mostly affect young adults with a definite male predominance.

The dislocation is classified according to the position of the head of the humerus into:

1. Anterior dislocation (commonest)
2. Posterior dislocation (uncommon)
3. Inferior dislocation (rare)

Anterior dislocation

It is mostly caused by abduction and external rotation force. Fig. 58 (indirect trauma).

Fig. 58 Anterior dislocation-indirect trauma

2) Direct trauma to the posterior aspect of the shoulder as in football injuries may also produce dislocation.

Diagnosis.

Posture: Fig. 59.

Typically the limb is held in slight abduction with the forearm located in close proximity to the trunk and supported by the uninvolved limb.

Fig. 59 Typical posture in anterior dislocation

Special features, Fig. 60

The typical appearance is loss of the normal round contour of the shoulder and the limb looks longer. Palpation of the shoulder area will reveal a depression just under the acromion, the head may be felt in its dislocated position. Shoulder movements are painful and restricted. It is essential to examine for neurovascular damage. Since injury to axillary, nerve, and axillary vessels may occur.

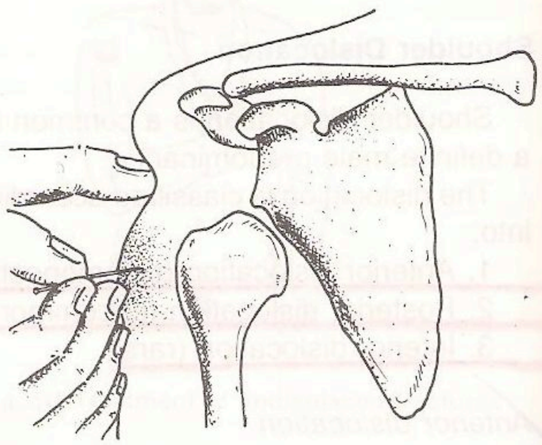


Fig. 60 Diagnosis – anterior dislocation

X-rays: Although the clinical diagnosis is obvious, X-rays are needed to confirm the diagnosis, establish the site of the head and to exclude the possibility of associated fractures, (Fig. 61). According to the site of the dislocated head, anterior dislocation is described as a) Subcoracoid, b) subclavicular, c) subglenoid and d) intrathoracic.

Management

A dislocated shoulder should be reduced anatomically as soon as possible, and immobilization should be continued for a period of 3 weeks so as to minimize the incidence of recurrence. An acutely dislocated shoulder can almost always be reduced by conservative methods:

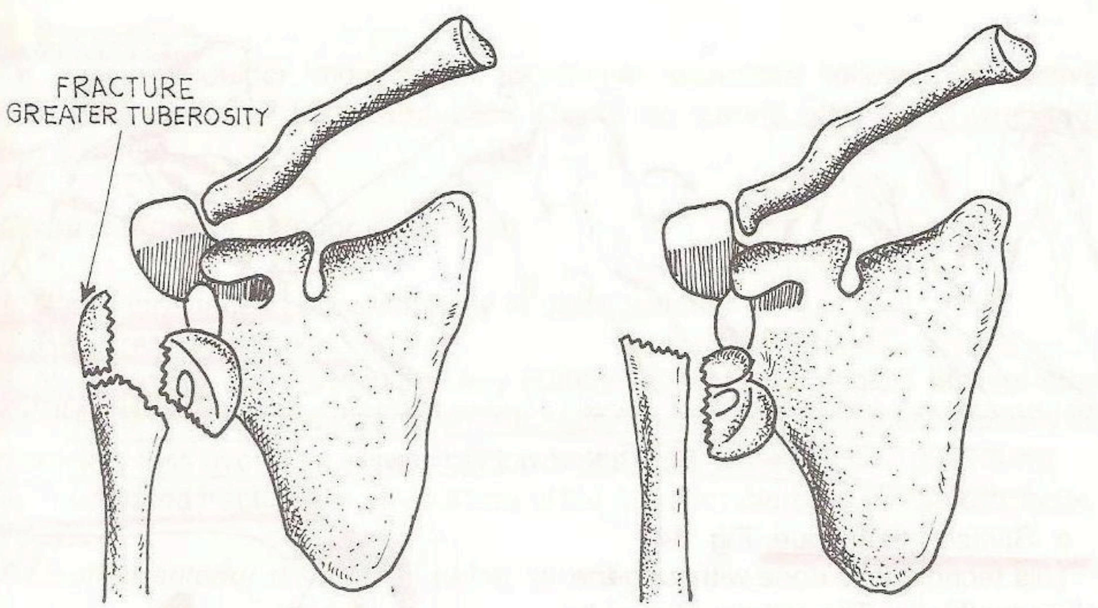


Fig. 61 Fracture dislocation shoulder

1. Reduction

Manipulation to reduce a dislocated shoulder should ideally be carried out under general anaesthesia with muscle relaxation.

a. Hippocratic technique, Fig. 62. (Hippocrates, 460-367 BC. Physician, Cos, Greece.) While the patient is in the supine position, the involved extremity is grasped by the physician at the forearm and wrist, and the physician's bare foot is placed in the axilla, the reduction is accomplished by the physician's applying longitudinal traction to the involved extremity, while at the same time applying countertraction through the foot in the patient's axilla.

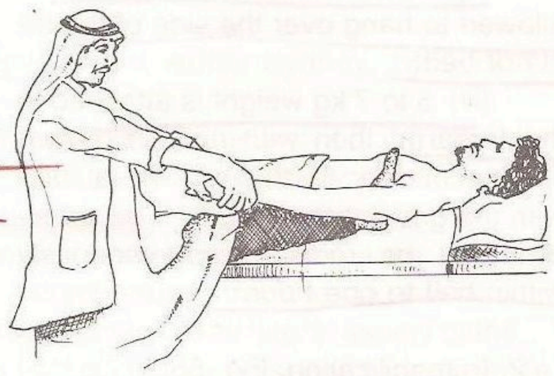


Fig. 62 Hippocratic technique

b. Kocher's technique, Fig. 63. (Kocher, Emil Theodor, 1917-1981, Prof. of Surgery, Berne, Switzerland)

(i) Flex patient's elbow to 90°, hold elbow with one hand and the forearm at the wrist with the other hand, then exert longitudinal traction through the humeral shaft.

(ii) Gradually and slowly externally rotate the abducted arm.

(iii) Adduct the arm across the anterior aspect of the chest to approximately the midline.

(iv) Internally rotate the arm until the hand is placed on the opposite shoulder.

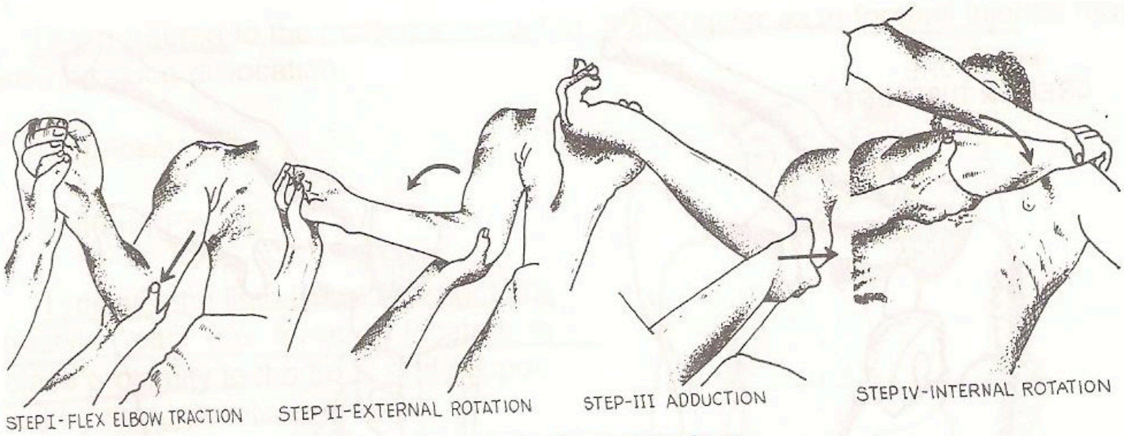


Fig. 63 Kocher's technique

c. Stimson technique, Fig. 64

This technique is done without general anaesthesia. The patient should be given a powerful analgesic such as pethedine, morphine or diazipam.

(i) Then patient lies in a prone position on the edge of the table or bed, a sandbag is placed under the clavicle.

(ii) The involved extremity is then allowed to hang over the side of the table or bed.

(iii) 5 to 7 kg weight is attached to the forearm, then with muscle relaxation secondary to the analgesia, and with the gravitational traction the shoulder may be reduced spontaneously within half to one hour.

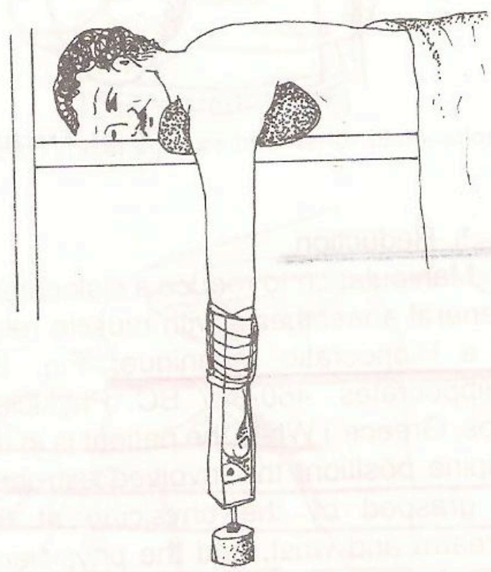


Fig. 64 Stimson technique

2. Immobilization, Fig. 65.

The reduced shoulder should be immobilized for 3 weeks in adduction and internal rotation, a simple method is the use of a sling or collar and cuff with the arm kept under the patients vest and the hand should reach opposite shoulder.

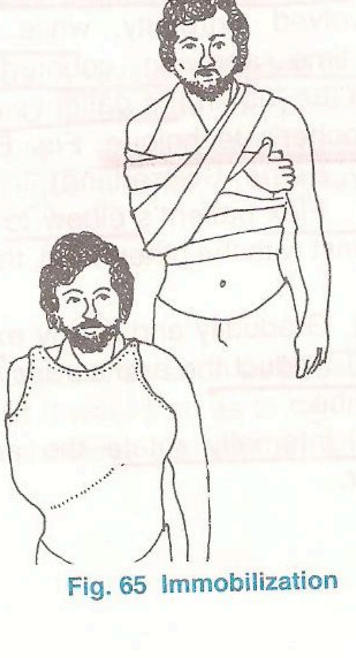


Fig. 65 Immobilization

3. Exercises
To regain shoulder movements, pendulum exercises followed by active flexion, extension and lastly abduction should be started after the 3 weeks of immobilization.

Complications of anterior dislocation

1. Shoulder stiffness occurs mainly in older patients.
2. Recurrent dislocation.
3. Nerve injury due to traction: Any combination of neurological lesions may occur, the commonest is circumflex nerve injury leading to deltoid muscle paralysis and sensory loss over a small area of skin on the outer aspect of the upper arm.
4. Associated fractures such as those of the greater tuberosity or humeral neck.

Recurrent anterior dislocation of the shoulder

Of all the joints in the human body the shoulder is the one that is most subject to recurrent dislocation. It is a troublesome condition since it mostly occurs in young and athletically active individuals, and it may occur even after adequate treatment of the initial injury.

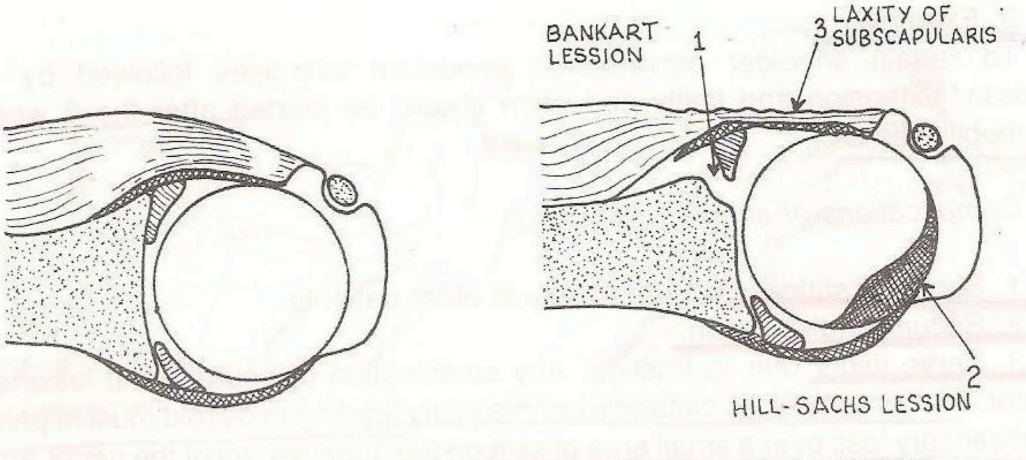
Associated pathological features, Fig. 66.

1. The glenoid labrum: 'Bankart Lesion' (Bankart, Arthur Sydney. 1879-1951, Orthopaedic surgeon, London).
Detachment of the fibrocartilagenous labrum and/or detachment of the capsule from the glenoid rim is thought to cause instability of the shoulder joint.
2. The posterolateral notch in the humeral head: 'Hill-Sachs Lesion'.
It is now generally accepted that the posterolateral indentation in the humeral head formed with recurrent dislocation is a compression fracture caused by impingement of the anterior glenoid rim on the posterior and lateral aspect of the humeral head during the dislocation. This defect could predispose to recurrence of dislocation.
3. Laxity and detachment of the subscapularis.
In recurrent dislocation, laxity and detachment of the subscapularis from its scapular origin may occur leading to loss of its important dynamic anterior buttress.

Diagnosis

The patient usually describes some form of abduction and external rotation component in the production of dislocation. Progressively less trauma is required on each occassion and eventually the patient may be able to reduce the dislocation voluntarily. Pain is not quite as severe as that of the initial dislocation.

During an attack of dislocation, the posture, deformity and X-ray findings would be the same as described in acute dislocation. In between attacks, attempted external rotation and abduction of the limb will cause apprehension and resistance (positive apprehension test).



a. Normal appearance   b. Associated pathology

Fig. 66 Associated pathological features

Management

If more than two episodes of dislocation occurred, operative treatment is indicated. Before surgery is contemplated, radiological evidence to prove that the dislocation was anterior is essential.

Most commonly used operations:

1. Putti-Platt operation = subscapularis shortening (Fig. 67) (Putti, Vitores. 1880-1940, Prof. Orthpaedic surgeon Bologna. Platt, Henry. Emeritus Prof. Orthopaedic Surgery, Manchester.)

Restricting external rotation and forming barrier of tissues in front of the shoulder.

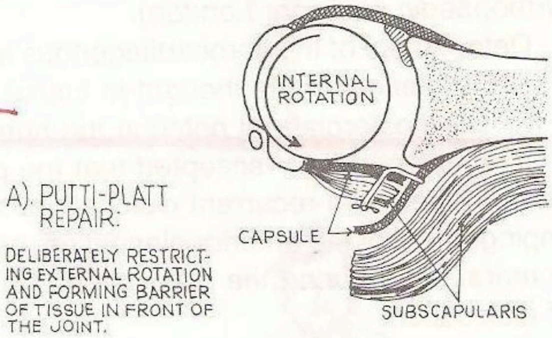


Fig. 67 Putti-Platt repair

2. Bankart operation = Anterior capsular repair (Fig. 68)

Fixation of the lateral part of the capsule to the raw edge of the glenoid.

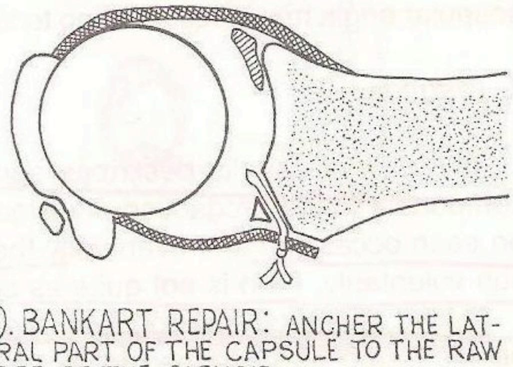


Fig. 68 Bankart repair

3. Magnuson – Stack operation = subscapularis transfer (Fig. 69)

Reinsertion of the subscapularis lateral to the bicipital groove and inferior to the original insertion.

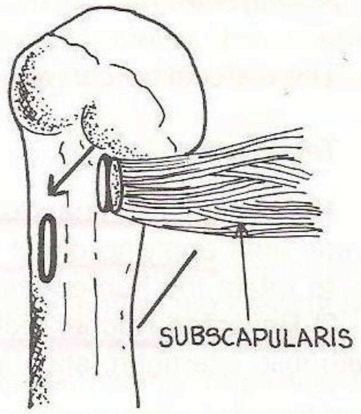


Fig. 69 Magnuson – Stack operation

Post operative care:

Arm is kept in adduction and internal rotation for 4-6 weeks. Followed by gradual graded exercises to regain shoulder movement.

Posterior dislocation

This uncommon injury is often overlooked because the physical signs are not obvious and an anteroposterior radiograph of the shoulder may show little abnormality to the inexperienced.

Mechanism of injury

Posterior dislocation may be due to either:

1. Direct injury

This is relatively rare, and is due to a blow on the anterior aspect of the shoulder that drives the humeral head in a posterior direction.

2. Indirect injury

More common, and it is due to adduction and internal rotation of the arm.

Diagnosis

The limb is held in adduction and internal rotation, typically there is loss of anterior contour of the shoulder with prominence of the humeral head posteriorly. AP radiographs may be difficult to interpret by the inexperienced, but axillary views will confirm the diagnosis.

Management

The dislocation can almost always be reduced by closed manipulation.

Technique

1) Apply longitudinal downward traction to the involved extremity while at the same time applying direct pressure over the posterior aspect of the shoulder so as to rotate the humeral head back into the glenoid fossa.

2) Reversed Kocher technique: Apply gentle slow, gradual traction on the limb with mild internal rotation followed by external rotation.

Inferior dislocation (Luxatio erecta)

This is a rare type of shoulder dislocation. Typically the patient presents with the arm pointing in an upward direction.

Acromioclavicular dislocation

This is a common injury, particularly among young athletic individuals. The diagnosis of this injury is not difficult but the form of treatment remains controversial.

Mechanism of injury

The injury is mostly due to a fall or a direct blow. Indirect injury such as a fall on the outstretched arm or flexed elbow has also been implicated.

Diagnosis

In mild cases (Sprain) there is swelling and localised tenderness over the joint. In severe form (complete disruption of acromioclavicular and coracoclavicular liga-

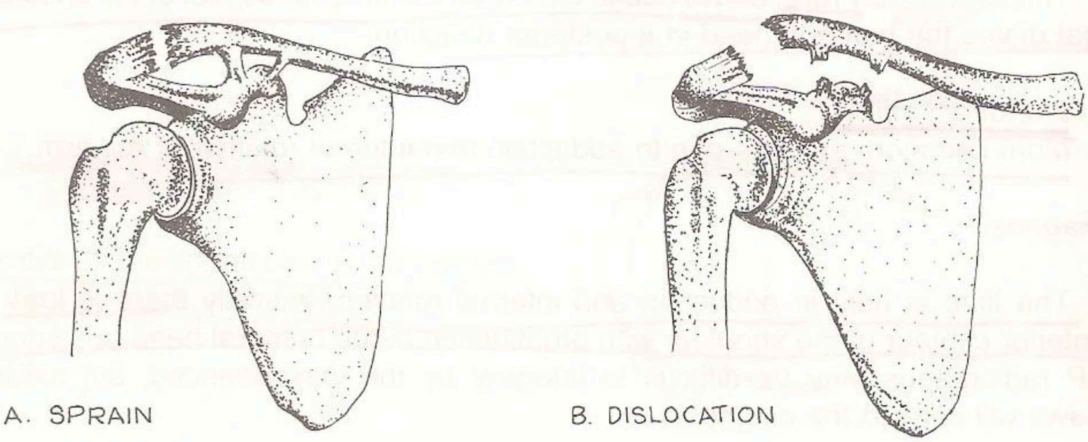


Fig. 70 Acromio clavicular injury

ments) the distal end of the clavicle will be elevated above the acromion (Fig. 70).

Routine X-rays will confirm the diagnosis and occasionally stress films in which a routine AP view is taken while the patient is carrying 5 kg in his hand is adequate to reveal the extent of the disruption.

Management, Fig. 71

1) In mild and moderate cases, conservative treatment is advisable, the dislocation can be reduced by downward pressure on the lateral end of the clavicle and the reduced position can be maintained by external strapping.

2) In severe form (complete disruption) there is a controversy regarding the method of choice, with conservative treatment the ruptured ligaments will unite with some elongation and so as residual deformity but normal function is the rule, internal fixation, on the other hand, is difficult and frequently followed by a lengthy recovery period, at the end of which the fixation device must be removed.

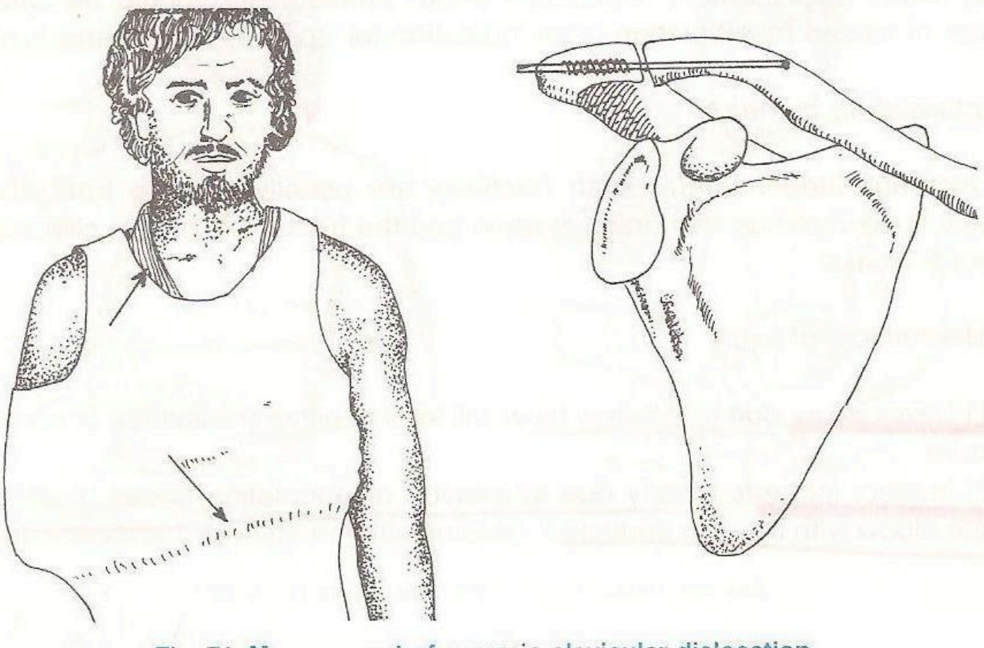


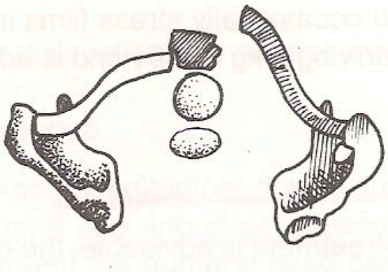
Fig. 71 Management of acromio clavicular dislocation

Sternoclavicular dislocation

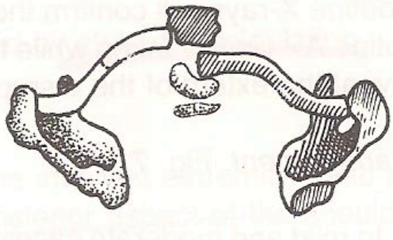
This is not a common injury, the dislocation could be either anterior or posterior, (Fig. 72) by far the commonest is the anterior type, fortunately the posterior type which is prone to significant complications such as difficulty in breathing and dysphagia due to direct pressure is rare.

Treatment

1) Minor displacement: Minor subluxations should be accepted, although some asymmetry of the supra-sternal notch may persist, but a pain free result is usual.



a. Anterior



b. Posterior

Fig 72 Sternoclavicular dislocation

The arm should be rested in a sling for two to three weeks until acute pain has settled.

2) Gross displacement: Reduction under anaesthesia should be carried out, failure of closed manipulation is an indication for open reduction and fixation.

Fracture shaft humerus

Uncomplicated humeral shaft fractures are usually easy to treat, the blood supply is so vigorous that union is rapid and the fracture is or firm clinically within about 6 weeks.

Mechanism of injury

1) Direct injury due to a heavy blow will lead to either transverse or comminuted fracture.

2) Indirect injury is mostly due to rotation or angulation forces, such as a fall on the elbow with the arm abducted, causing either a spiral or transverse fracture.

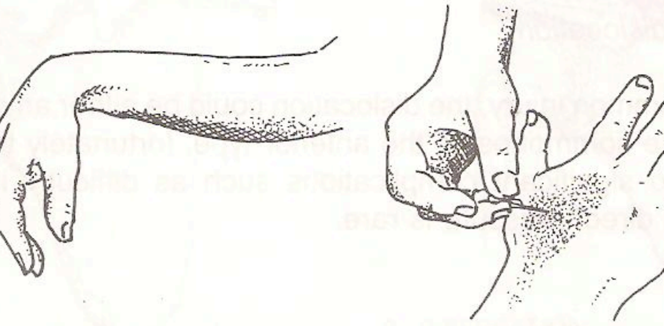


Fig. 73 Radial nerve injury

Diagnosis

Beside the cardinal signs and symptoms of fracture a careful examination for associated radial nerve injury which is occasionally damaged in fractures of middle 1/3 must be carried out, Fig. 73.

Management

1) Uncomplicated humeral shaft fractures: The majority of the cases can be managed conservatively, manipulation under anaesthesia is needed in badly displaced fractures. Immobilization can be achieved by U shape slab, Fig. 74. Recently functional braces have been advocated. Exercise of wrist and fingers during period of immobilization must be encouraged.

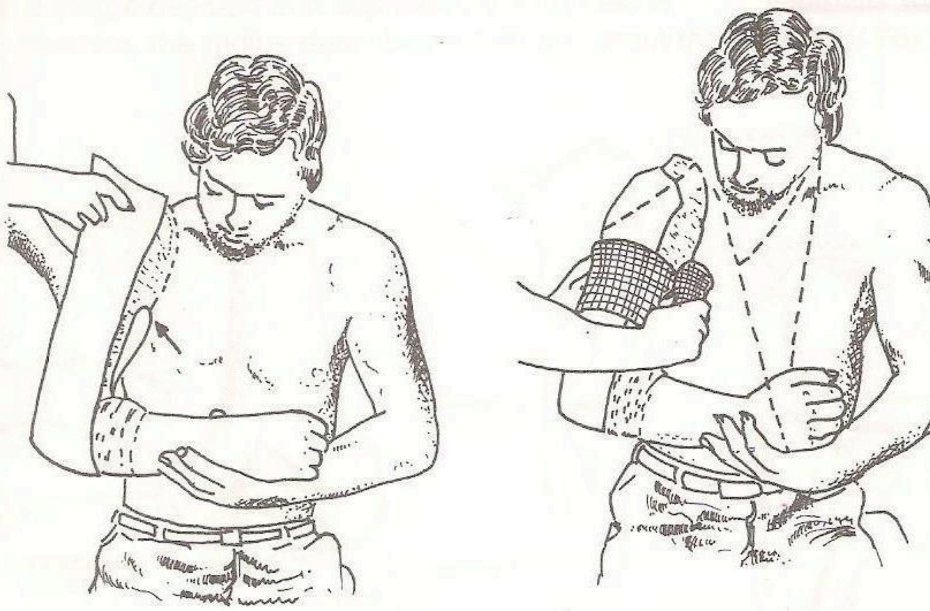


Fig. 74 U shape slab for humeral shaft fracture

Operative

Open reduction and internal fixation is indicated for:

a) Treatment of complications: Delayed union, nonunion and radial nerve injury

b) Multiple injuries: In patients who need a prolonged period of recumbency.

2) Management of humeral shaft fracture complicated by radial nerve injury: There is rarely any indication to explore the radial nerve at the time of injury except in:

a) Compound fractures

b) Spiral fractures at the junction of middle and lower third of the bone, in this type the nerve is frequently found lying between the bone ends. Exploration to release the nerve and internal fixation of the fracture is indicated.

In all other circumstances, the fracture is allowed to unite, the wrist drop being treated meanwhile with a cock-up or lively splint. Once the fracture has united at 8-12 weeks, the nerve could be explored if no recovery has occurred, however it is rarely necessary. If the damage to the nerve indicates that recovery is unlikely, the wrist drop is treated by flexor to extensor tendon transfers.

Complications of humeral shaft fractures

1. Radial nerve injury.
2. Delayed union and nonunion may occur in transverse fractures especially when there is excessive traction leading to distraction and a gap between the end of the bone fragments.
3. Malunion.
4. Joint stiffness.

THE ELBOW AND THE FOREARM

Anatomy

The elbow is a synovial joint formed by the articulation of the distal humerus (Fig. 75a) with the proximal ulna (Fig. 75b) and radius, forming a humeroulnar and humeroradial articulation. In addition, there is a junction of the head of the radius with the ulna forming a proximal radioulnar articulation. The elbow is a hinge joint and its movements consist of flexion and extension (Fig. 75c), the ulna moving on the trochlea and the head of the radius on the capitellum of the humerus. However, the flexion-extension movements of the ulna do not constitute a pure swing but are accompanied by a small degree of rotation, the ulna is slightly pronated during extension and supinated during flexion.

In the forearm, the radius describes a 160 arc about the ulna (Fig. 76). This is

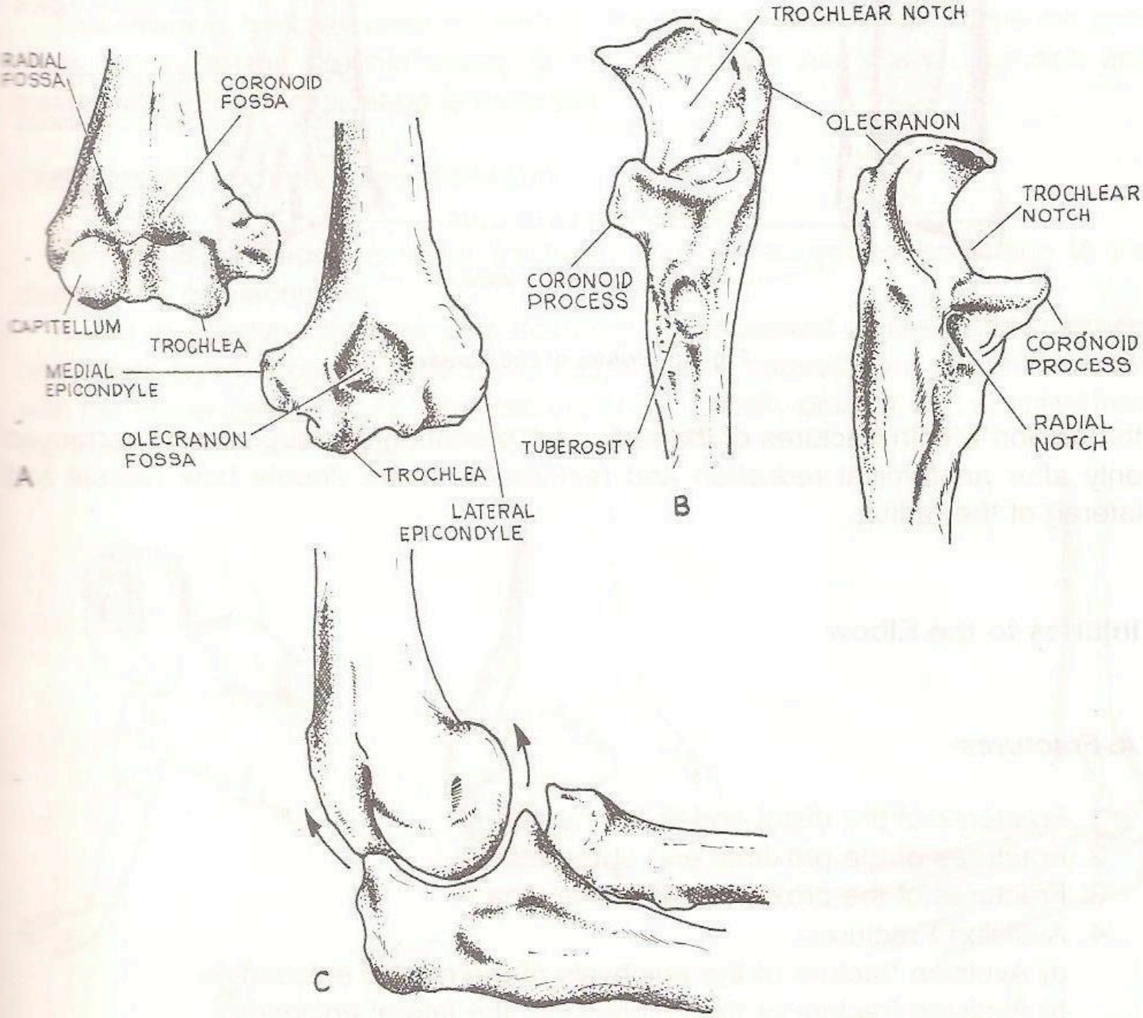


Fig. 75 Articulation of the Elbow

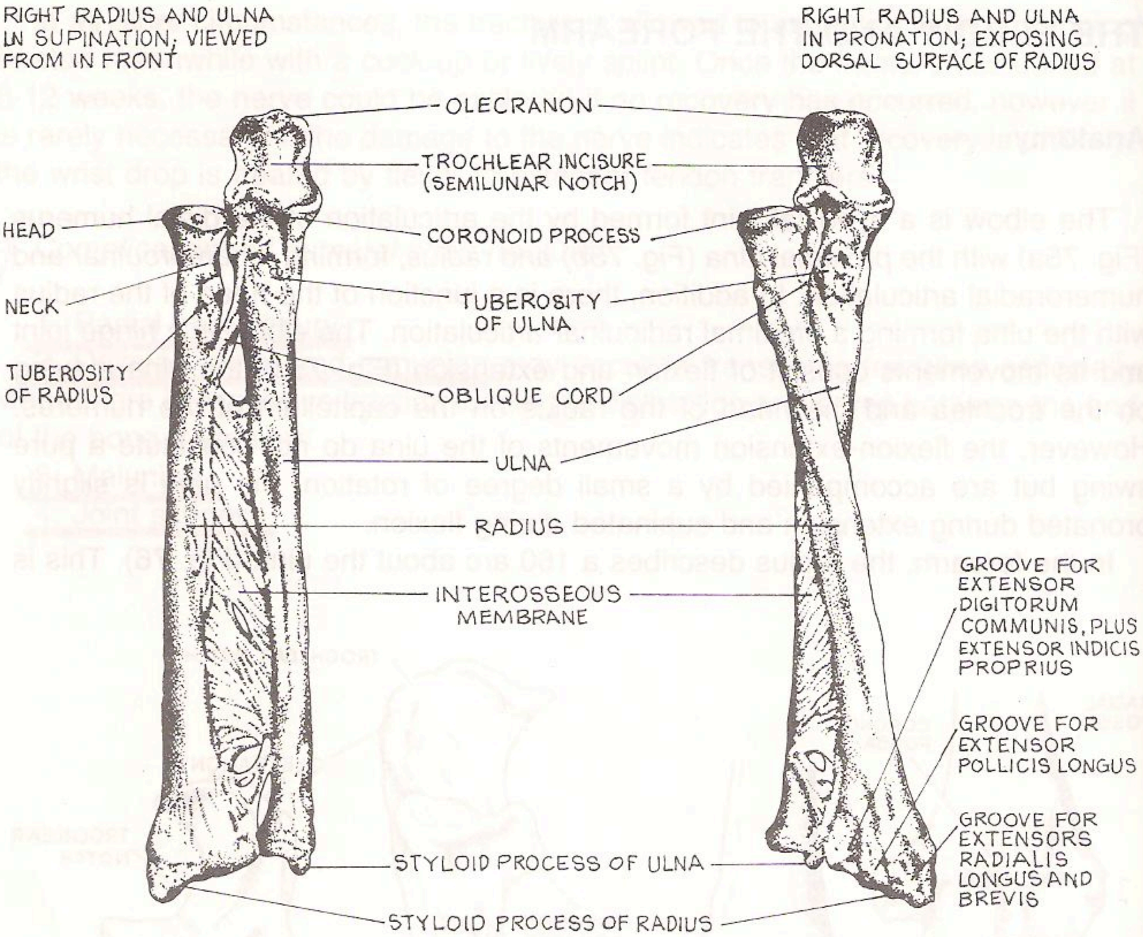


Fig. 76 Bones of the forearm

the reason why in fractures of the radius full pronation and supination is achieved only after anatomical reduction and restoration of the double bow (dorsal and lateral) of the radius.

Injuries to the Elbow

A. Fractures

1. Fractures of the distal end of the humerus.
2. Fractures of the proximal end of the radius.
3. Fractures of the proximal end of the ulna.
4. Avulsion Fractures.
   a) Avulsion fracture of the epiphysis of the medial epicondyle.
   b) Avulsion fracture of the epiphysis of the lateral epicondyle.

B. Dislocations

1. Dislocation of the elbow.
2. Pulled elbow.

Fractures

Fractures of the distal end of the humerus

Classification

1. Supracondylar
2. Condylar
3. Intercondylar

Supracondylar fracture

This injury is typically seen in children, the fracture occurs just above the condyles. Injury to the brachial artery is not uncommon and early diagnosis and treatment of this complication is essential.

Classification and mechanism of injury

Two types of supra condylar fractures can be recognised according to the direction of displacement.

A. Supra condylar fracture with posterior displacement of the distal fragment (extension type) accounts for 95% of cases and is caused by a fall on the hand with the elbow bent, Fig. 77. The fracture line is usually oblique and directed from the front of the bone upward.

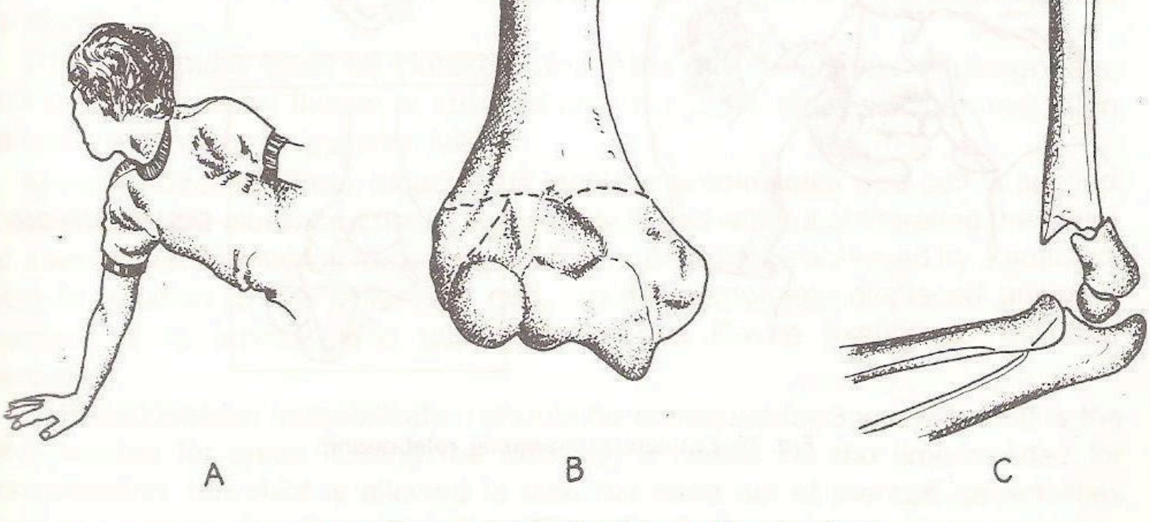


Fig. 77 Supracondylar fracture – extension type

B. Supracondylar fracture with anterior displacement of the distal fragment (flexion type) this accounts for 5% of cases and is caused by a fall on the hand with the elbow extended, Fig. 78. In this uncommon injury the fracture line is usually oblique and directed from the back of the bone upwards.

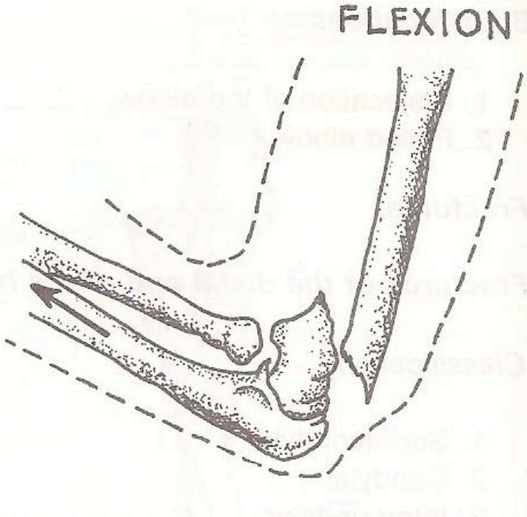


Fig. 78 Supracondylar fracture – flexion type

Diagnosis

Following the fall, the child complains of pain in the elbow. The child generally resists examination and there is tenderness over the distal humerus. There may be marked swelling and deformity but the olecranon and medial and lateral epicondyles preserve their normal equilateral triangular relationship (Fig. 79) which differentiates a supracondylar fracture from dislocation of the elbow.

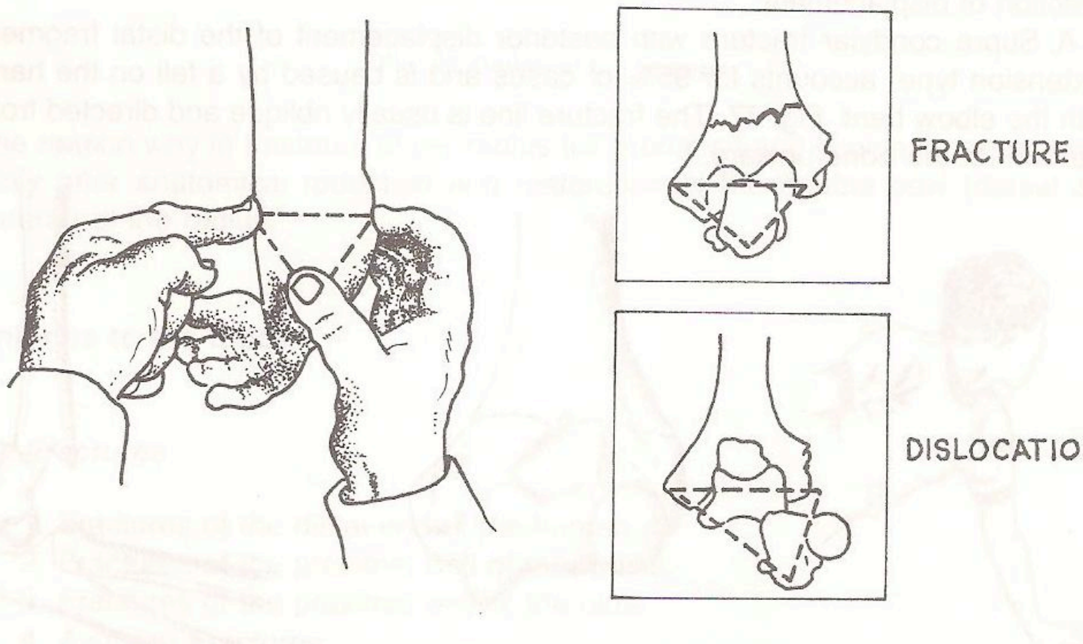


Fig. 79 Equilateral triangular relationship

It is essential to examine for neurovascular damage. The brachial artery may be affected by the proximal fragment when there is appreciable displacement of the fracture (Fig. 80). In the majority of the cases, this is no more than a kinking of the vessel or compression by haematoma but occasionally structural damage to the wall may occur.

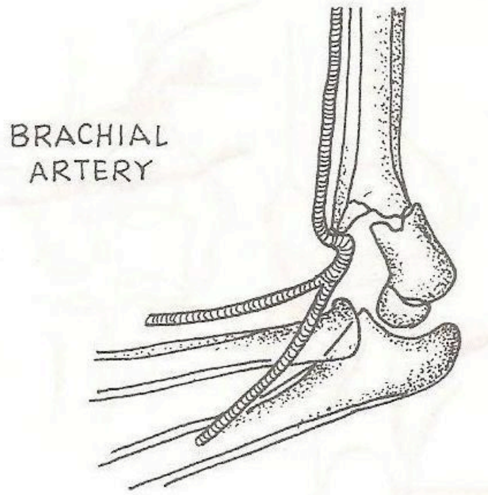


Fig. 80 Vascular complications

Management

Accurate reduction especially of angular and rotational deformities of the fragments is essential for the function and shape of the elbow. Persistence of posterior angulation of the lower fragment will cause limitation of flexion while persistence of anterior angulation will limit extension. Lateral angulation will lead to cubitus valgus or cubitus varus deformities. Rotatory malalignment may cause an apparent cubitus varus.

1. Supracondylar fracture with posterior displacement: Our aim is to secure reduction with no angulation or rotation.

a) Reduction: This can be achieved by manipulation under anaesthesia by the following manoeuvre. (Fig. 81)

The surgeon exerts traction on the injured limb with the elbow slightly flexed, and without releasing traction he corrects sideways displacement, angulation or rotation.

Then, he flexes the elbow to 80° while pushing forward the lower fragment with his thumb.

The radial pulse must be checked, and if the pulse weakens or disappears, the degree of elbow flexion is reduced until the pulse returns. Open reduction should be done if manipulation fails.

b) Immobilization: If the reduction is stable a simple collar and cuff is applied. Occasionally the elbow can not be sufficiently flexed without obliterating the pulse, so a less flexed position is necessary and immobilization is achieved by a posterior slab in addition to the collar and cuff. In the completely displaced unstable fracture, it is advisable to use percutaneous K-wire fixation to maintain reduction.

c) Rehabilitation: Immobilization should be continued for 3 weeks which is the time needed for union. During the following 3 weeks i.e. the time needed for consolidation, the child is allowed to take the hand out of the cuff for activities such as washing, dressing and writing. Elbow flexion is encouraged but not exten-

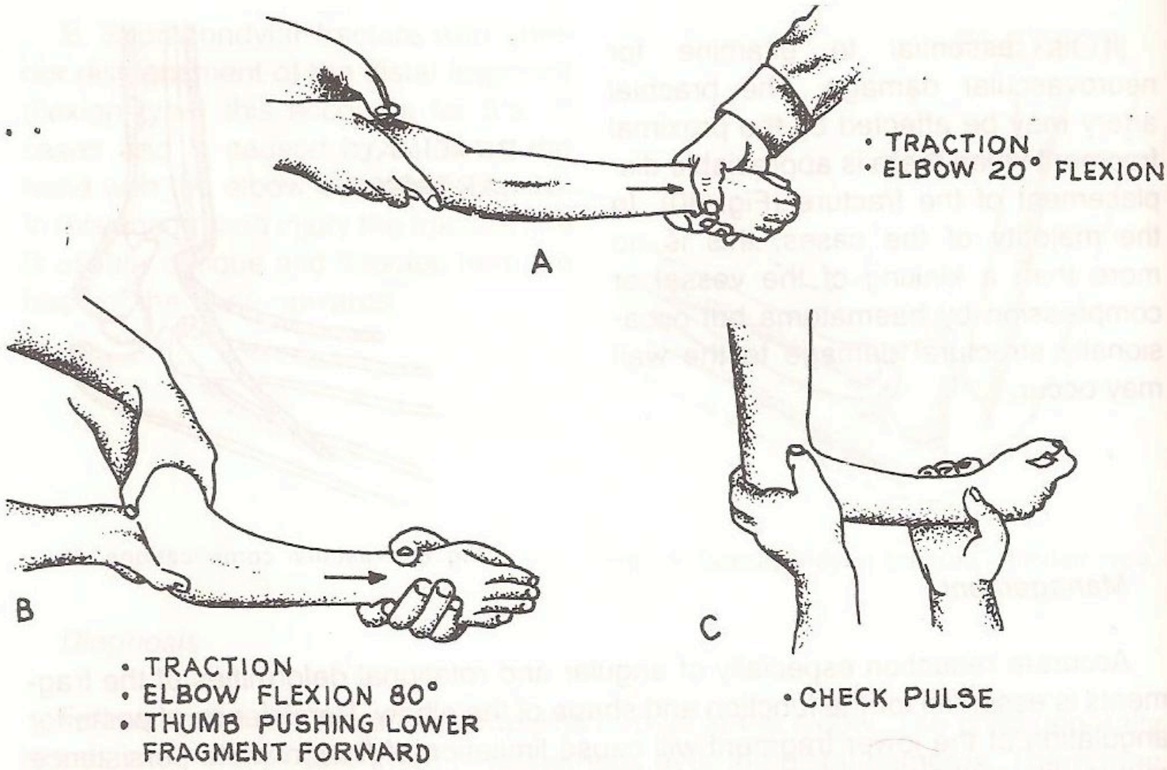


Fig. 81 Closed reduction of supra condylar fracture with posterior displacement

sion. Passive movements are prohibited at all times.

If an acceptable position can not be obtained by manipulation, traction either skin or skeletal using wire through upper ulna can be used.

The operative method is indicated if conservative reduction fails also it is necessary in cases associated with vascular damage that require surgery. Following exploration and artery repair, the fracture may be fixed using Kirschner wires.

2. Supracondylar fracture with anterior displacement: This uncommon type is usually reduced by pulling the arm with the elbow fully extended. Immobilization is achieved by a plaster slab with the elbow extended for 3 weeks followed by active gradual elbow flexion exercises. Percutaneous K-wire fixation is useful in the unstable fracture.

Complications of supracondylar fracture:

1. Early complications

a) Vascular injury which if untreated will lead to Volkmann's ischaemia.

b) Nerve injury: The median, ulnar and radial nerves are sometimes injured but usually recover spontaneously. The most commonly affected is the median nerve.

2. Late complications:

a) Myositis ossificans

b) Stiffness

c) Malunion

d) Late ulnar nerve palsy.

Condylar fracture, Fig. 82

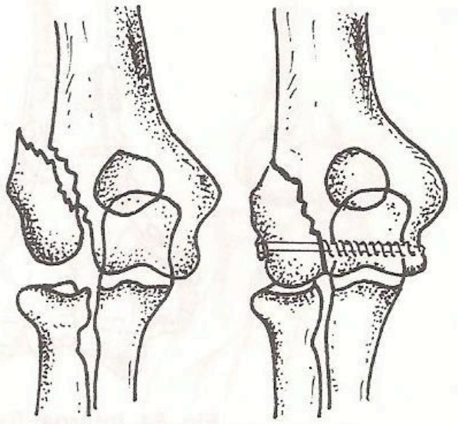


Fig. 82 Condylar fracture

Fractures of a single condyle are relatively uncommon. Since they are intra articular fractures, anatomical reduction is necessary.

Displaced fractures of either medial or lateral condyles are best treated by open reduction and internal fixation since conservative measures could not be expected to produce satisfactory results.

Inter condylar fractures (T or Y shaped fractures), Fig. 83

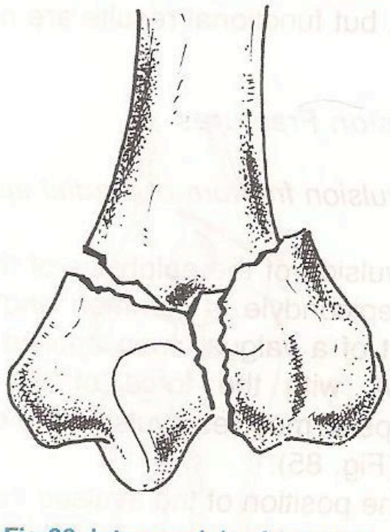


Fig 83 Intercondylar fractures

This injury usually results from a fall onto the elbow, the medial and lateral condyles are separated from each other and rotated downwards and outwards by the pull of the forearm flexors and extensors.

Treatment of intercondylar fractures

These fractures are perhaps one of the most difficult to treat, the functional results without reduction are generally poor, and even when accurately reduced some residual loss of function is usual.

Open reduction and internal fixation requires a high degree of skill, it is indicated in young adults, Fig. 84.

Treatment by early activity is suitable in elderly patients who usually sustain a comminuted type of fracture (bag of bones), and surprisingly the functional results are satisfactory.

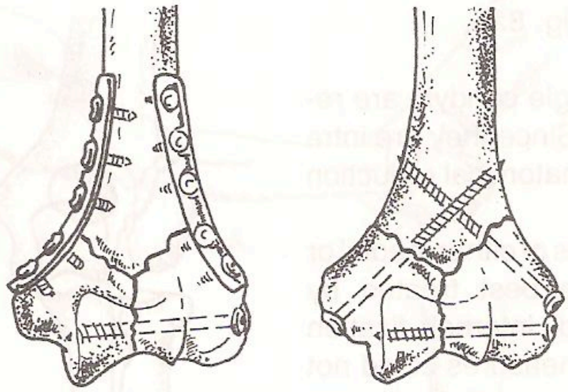


Fig. 84 Internal fixation of inter condylar fracture

Skeletal traction through the olecranon is advocated by some surgeons as an alternative method to open reduction, this has the advantages of being easier and safer, but functional results are not as good.

Avulsion Fractures

Avulsion fracture of medial epicondylar epiphysis

Avulsion of the epiphysis of the medial epicondyle is common and is the result of a valgus strain applied to the elbow, with the force of the flexor groups of muscles avulsing the epiphysis, (Fig. 85).

The position of the avulsed fragment may range from minimal separation to gross displacement with the epicondyle being pulled into the joint and trapped between humerus and olecranon, (Fig. 86).

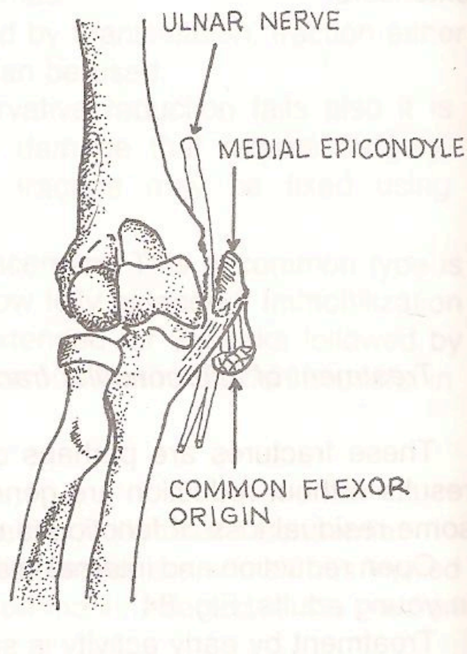


Fig. 85 Fracture medial epicondyle

Treatment

Minor separation may be discarded, no reduction is needed but the elbow should be rested in a collar and cuff for 3 weeks. With gross displacement and if an epicondyle is trapped in the joint, reduction by manipulation is sometimes successful, but if this fails open reduction and internal fixation is indicated, (Fig. 87).

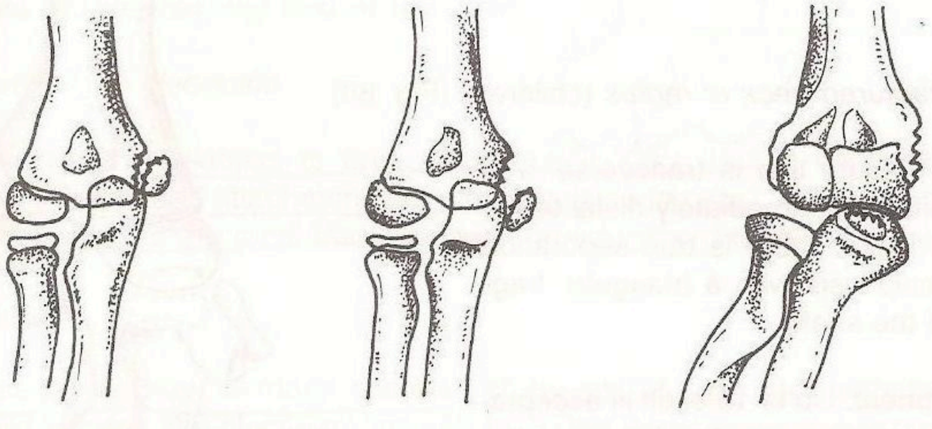


Fig. 86 Displacements of fractured medial epicondyle

Avulsion of the lateral epicondylar epiphysis

The lateral epicondyle is usually ossified in extension from the epiphysis of the capitellum, but occasionally there is a separate center of ossification appearing at the age of 11 and fusing to the main epiphysis at the age of 13 or 14. During this time interval there is a separate ossicle of bone to which the common extensor tendon is attached and traction of these muscles from varus strain of the joint may avulse the lateral epicondyle. Since the lateral epicondylar epiphysis is inconstant and even if it appears separately it exists only for a year or two, it is obvious that such avulsion fracture is rare.

Fig. 87 Internal fixation of medial epicondyle

Fractures of the Proximal End of Radius

The diagnosis of these injuries is not difficult, there is usually a history of a fall upon the hand combined with complaint of pain in the elbow. Elbow movements are restricted and pressure over the radial head is painful.

X-ray examination will reveal the fracture, its type and site.

Types

1. *Fractured neck of radius* (children) (Fig. 88)

The fracture line is transverse, it is either situated immediately distal to the growth disc or there is true separation of the epiphysis with a triangular fragment of the shaft.

Treatment: Up to 15°of tilt is acceptable, beyond that reduction is necessary, manipulation under anaesthesia should be tried first, if it fails open reduction is performed, internal fixation is not usually needed.

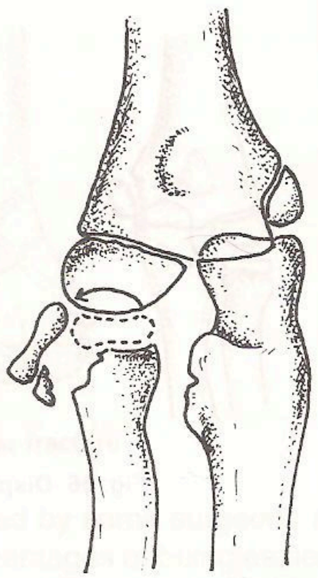


Fig. 88 Radial neck fracture

2. *Fracture head radius* (adults) (Fig. 89)

This could a) Vertical spilt: This can be treated by rest in a collar and cuff for 3 weeks followed by active exercise. b). Single fragment of the lateral portion of the head broken off and usually displaced distally. This is treated by pinning back the fragment with a Kirschner wire or small screw. c) Comminuted fracture: This is best treated by early excision of the head, this usually gives an excellent result. Silastic radial head replacements are available, but simple excision on the radial head is adequate.

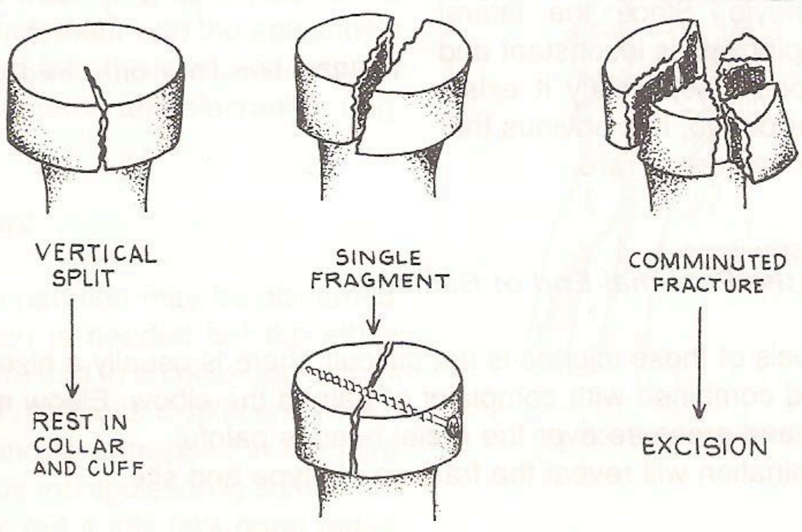


Fig. 89 Fractures of the head of the radius – types and management

Fractures of the proximal end of the ulna

A. Fracture of the olecranon

The olecranon is subject to both direct and indirect trauma because of its superficial position and attachment to a strong muscle (triceps). Fractures may be seen at any age but are most frequent in young adults and the elderly patients.

Diagnosis

The diagnosis may be made because of the site of pain and tenderness. In displaced fractures, the olecranon may be felt in the lower arm and a gap may be palpable. X-ray will confirm the diagnosis but it must be remembered that children have an epiphysis at the tip of the olecranon which should not be confused with a fracture.

Management

The treatment varies somewhat according to the type of injury.

1. Undisplaced fracture: This is best treated conservatively by immobilization with a plaster of Paris slab. The elbow should be just short of right angle flexion. Gentle mobilization can be commenced after 3 weeks.

2. Comminuted fracture: In this type, the fracture is disregarded, treatment is aimed at regaining function by encouragement of early active exercises, and the elbow is rested in a sling for comfort.

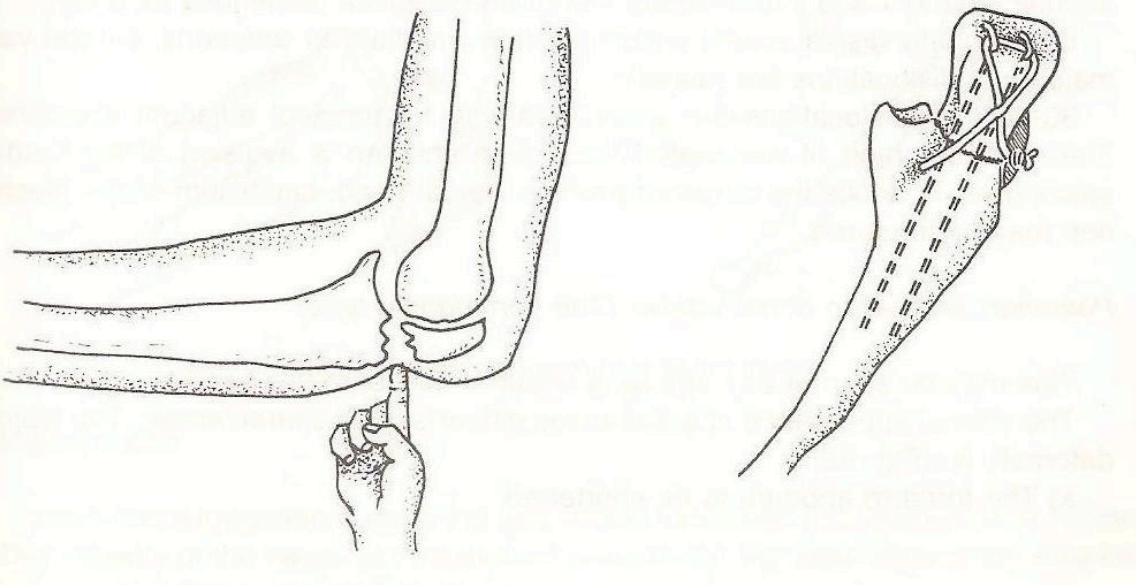


Fig. 90 Transverse fracture of the olecranon

3. Transverse fracture: Conservative treatment is useless. Closed reduction is easy, but maintaining the reduction is only possible by splinting the elbow in extension. Stiffness in this position is disastrous.

Open reduction and internal fixation using tension wire band should be the method of choice (Fig. 90). A sling is worn for 3 weeks post operatively and remobilization is commenced following that.

B. Fracture coronoid process (Fig. 91)

The coronoid process is the bony insertion of the brachialis muscle and the fractures are usually of the avulsion variety. Treatment by rest in a sling is the method of choice except when a large fragment results in elbow instability, then open reduction and internal fixation is indicated.

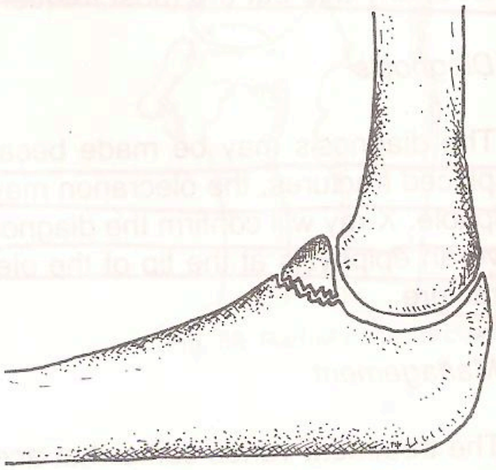


Fig. 91 Fracture of the coronoid process

Dislocations

1. Dislocation of the elbow

Except for the shoulder, the elbow joint is the joint most frequently dislocated.

Generally, the radius and the ulna which are firmly bound together by the annular ligament and interosseous membrane displace posteriorly as a unit.

Occasionally displacement occurs laterally, medially or anteriorly, but the vast majority of dislocations are posterior.

30-40% of dislocations are associated with fractures of adjacent structures. The most common of associated fracture in children is avulsion of the medial epicondyle. In adults the coronoid process, radial head, capitellum or the olecranon may be fractured.

Posterior dislocation of the elbow: (The commonest type)

This may be seen at any age as a result of falls onto the hand.

The clinical appearance of a dislocated elbow is quite characteristic. The typical deformity is: (Fig. 92)

a) The forearm appears to be shortened.

b) The olecranon is very prominent and the triceps appears as a tight band.

c) The line between lateral and medial epicondyles and olecranon is disrupted. (See Fig. 79).

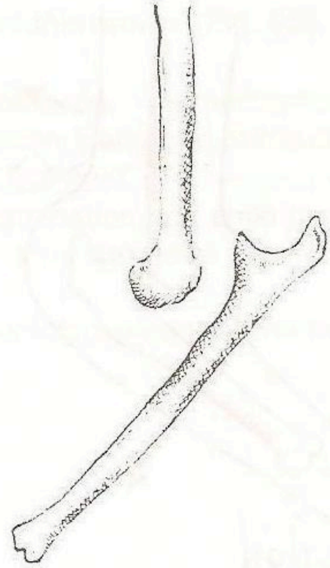


Fig. 92 Posterior dislocation of the elbow

Since there is always a risk of neuro vascular injury, a careful examination to exclude such a possibility is essential.

Although the clinical diagnosis is obvious, X-rays are essential to confirm the diagnosis and to see an associated fracture if it is present (Fig. 93).

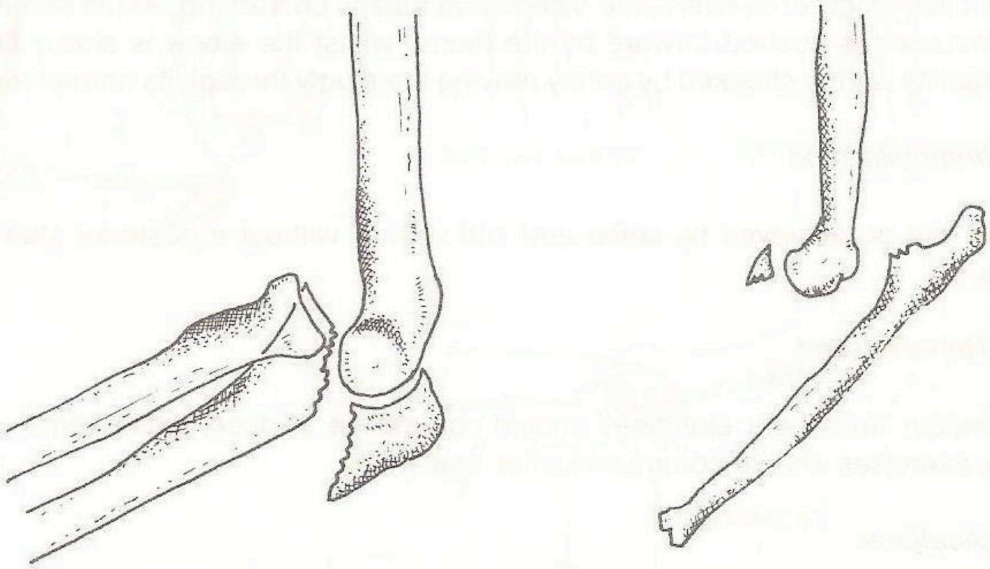


Fig. 93 Fracture dislocation of the elbow

Management

Anatomical reduction is essential and should be carried out as soon as possible. The majority of the cases are treated conservatively. Surgical intervention may be indicated for the associated fractures.

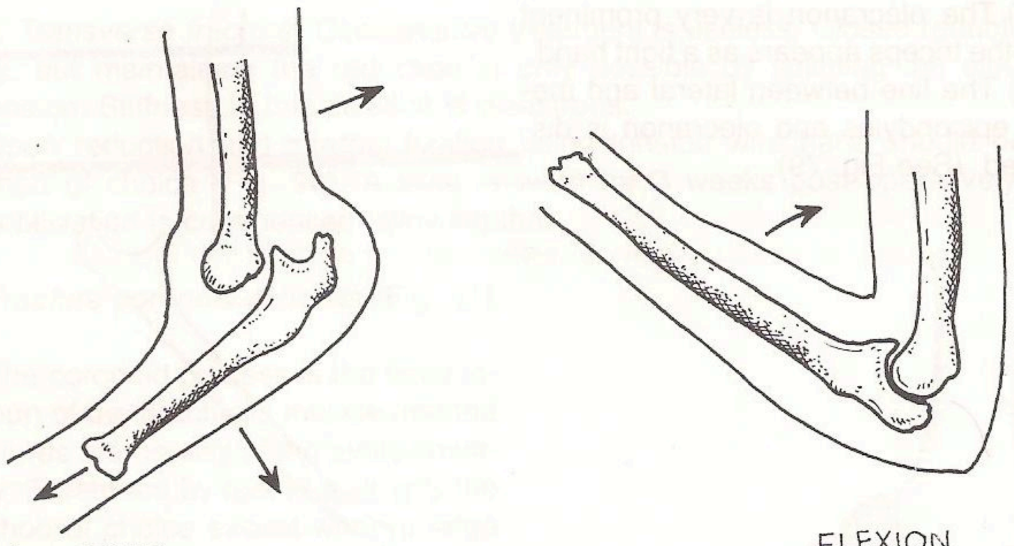


Fig. 94 Closed reduction of dislocation of the elbow

a) Reduction (Fig. 94)

It is usually impossible to reduce elbow dislocations without general anaesthetic. The maneuver employed consists of traction on the forearm in the position in which it lies, in order to overcome biceps and triceps shortening. At the same time the olecranon is pushed forward by the thumb whilst the elbow is slowly flexed. The stability is then checked by gently moving the elbow through its normal range.

b) Immobilization

This can be achieved by collar and cuff with or without a posterior slab for 3 weeks.

c) Rehabilitation

Shoulder and finger exercises should commence at once, while gentle active elbow exercises should commence after one week.

Complications

a) Vascular injury of the brachial artery may occur but with a lesser frequency than in cases of supracondylar fractures.

b) Nerve Injury: The medial and ulnar nerves may be affected. The lesion is usually of the neuropraxia type and it nearly always recovers spontaneously.

c) Myositis ossificans, which is more common if passive exercise is inflicted on the patient.

d) Recurrence of the dislocation may occur if the bony, ligamentous, and muscular support structures are disrupted sufficiently.

2. Pulled Elbow – Subluxation of the head of the radius (Fig. 95)

This condition occurs in infancy and early childhood. The mechanism of injury is a traction force applied to the elbow in pronation leading to subluxation of the head which becomes impacted in the orbicular ligament.

The diagnosis is based purely on clinical examination, the child presents with a painful elbow, pronated forearm, tenderness, over the head of the radius with full range of movement at the elbow.

This condition responds dramatically to a quick movement of the forearm into full supination.

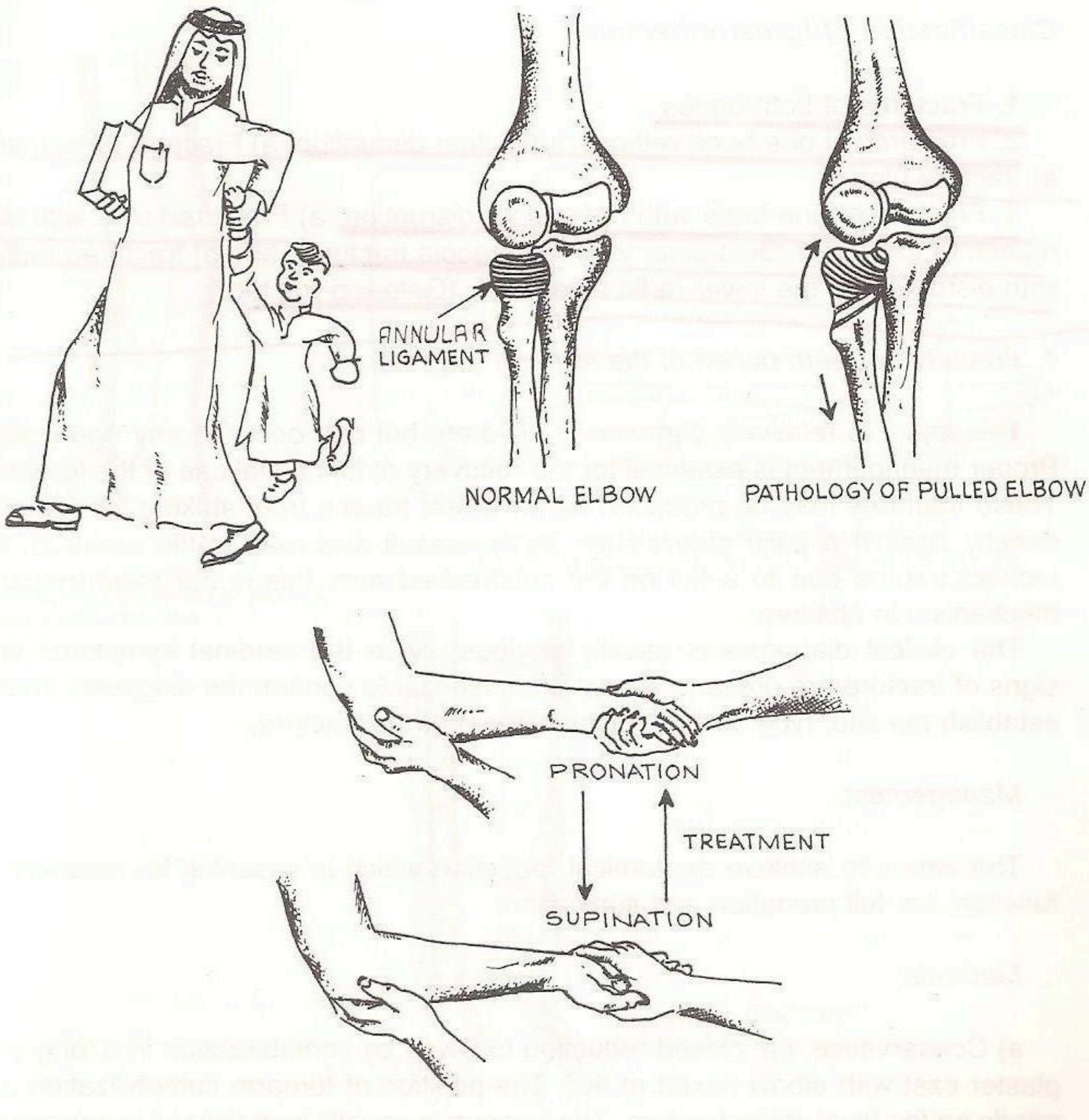


Fig. 95 Pulled elbow

Fractures of the Forearm

Fractures of the forearm occur in all age groups. It is extremely important to pay strict attention to both the elbow and the wrist joints in the assessment of forearm fractures since a dislocation of radio ulnar joints may be associated with a fracture of one bone, *e.g.* Monteggia, Galeazzi fractures. In treating forearm fractures, anatomical reduction is essential, otherwise limitation of supination and pronation may occur.

In recent years there has been a definite trend towards open reduction and internal fixation. This provides in addition to anatomical reduction, early functional activity.

Classification of forearm fractures

1. Fractures of both bones
2. Fractures of one bone without radio ulnar disruption: a) Fracture radius, and b) fracture ulna
3. Fracture of one bone with radio ulnar disruption: a) Fractured ulna with disruption of the upper radio ulnar joint (Monteggia fracture), and b) fractured radius with disruption of the lower radio ulnar joint. (Galeazzi fracture)

1. Fractures of both bones of the forearm (Fig. 96)

This injury is relatively common in children, but can occur at any age group. Proper management is essential for the recovery of functional use of the forearm. These fractures may be produced by (a) Direct trauma from striking the forearm directly against a solid object such as in assault and road traffic accident. (b) Indirect trauma due to a fall on the outstreched arm, this is the most frequent mechanism in children.

The clinical diagnosis is usually obvious, since the cardinal symptoms and signs of fracture are present. X-rays are essential to confirm the diagnosis and to establish the site, type and the displacement of the fracture.

Management

The aim is to achieve anatomical reduction which is essential for recovery of function, *i.e.* full pronation and supination.

Methods

a) Conservative, *i.e.* closed reduction followed by immobilization in a long arm plaster cast with elbow flexed at 90°. The position of forearm immobilization depends on the level of the fracture. The forearm is usually immobilized in supination with upper third fractures, in neutral position with middle third fractures and in full *pronation with lower third fractures. This method is suitable for undisplaced or green stick fractures in children.*

b) Operative: In displaced fractures, it is almost impossible to achieve and maintain anatomical reduction by conservative means, *with the result that open* reduction and internal fixation using a plate is the treatment of choice.

Complications

a) Nonunion.
b) Malunion.
c) *Cross union.*
d) Volkmann's ischaemia.

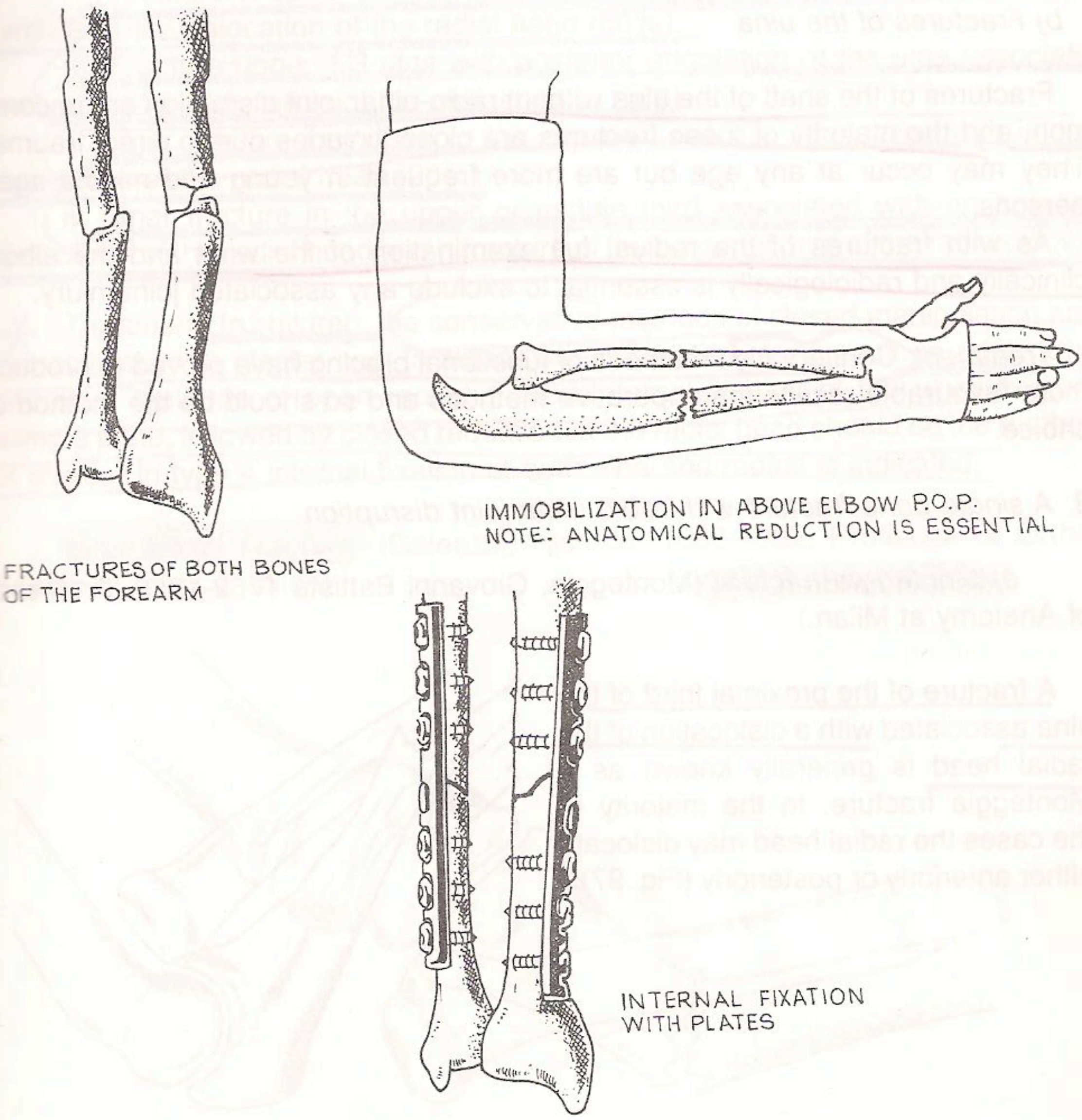


Fig. 96 Fractures of both bones of the forearm

2. Fractures of a single bone of the forearm without radio ulnar disruption

a) Fractures of the radius

Isolated fractures of the shaft of the radius are relatively uncommon, it can occur as a result of both direct and indirect trauma. Pain, localised tenderness and swelling will suggest the diagnosis and X-ray will confirm it. It is essential always to examine the elbow and the wrist clinically and radiologically to exclude any associated injuries or disruption of the radio-ulnar joints.

Treatment: Undisplaced fractures may be treated conservatively by a long arm plaster of Paris. Displaced fractures are best treated operatively by open reduction and internal fixation using a compression plate.

b) Fractures of the ulna

Fractures of the shaft of the ulna without radio-ulnar joint disruption are uncommon, and the majority of these fractures are closed injuries due to direct trauma. They may occur at any age but are more frequent in young and middle aged persons.

As with fractures of the radius, full examination of the wrist and the elbow clinically and radiologically is essential to exclude any associated joint injury.

Treatment: Conservative methods of functional bracing have proved to produce more favourable results than operative methods and so should be the method of choice.

3. A single bone fracture with radio ulnar joint disruption

a) Monteggia fracture (Monteggia, Giovanni Battista 1762-1815. Professor of Anatomy at Milan.)

A fracture of the proximal third of the ulna associated with a dislocation of the radial head is generally known as a Monteggia fracture. In the majority of the cases the radial head may dislocate either anteriorly or posteriorly (Fig. 97).

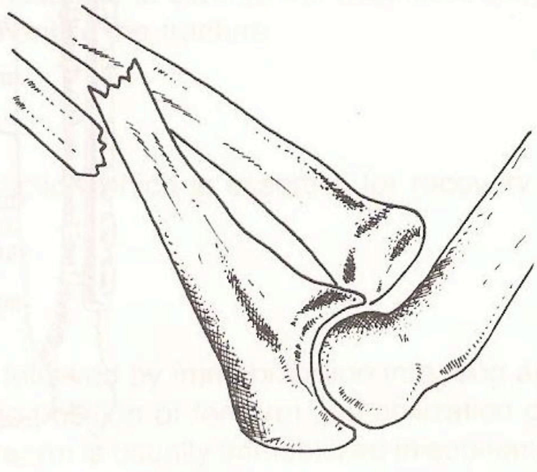


Fig. 97 Monteggia fracture

Mechanism of injury: Two specific causes have been suggested, the first is a direct blow over the posterior aspect of the ulna, and the second is a fall on the outstretched upper limb with the forearm in marked pronation.

Diagnosis: Clinical examination will show an obvious deformity, the radial head may be palpated either anteriorly or posteriorly depending on the type of the fracture. There is also significant pain in the vicinity of the elbow with attempted movement. Associated nerve lesions (radial nerve, posterior interosseous nerve) may occur and should be looked for by examining the wrist and fingers extensors. X-ray is essential to confirm the diagnosis and establish the type of displacement.

Classification (Bado 1967)

i. Fracture of upper 1/3 ulna with anterior angulation of the ulna associated with anterior dislocation of the radial head (60%).

ii. Fracture upper 1/3 ulna with posterior angulation of the ulna associated with posterior dislocation of the radial head (15%).

iii. Ulnar fracture just distal to the coronoid process associated with lateral dislocation of the radial head (20%).

iv. Ulnar fracture in the upper or middle third associated with an anterior dislocation of the radial head and a fracture of the proximal third of the radius (5%).

Treatment: In children, the conservative methods of closed manipulation and immobilization in plaster cast in supination give satisfactory result. In adults, the operative methods of open reduction and internal fixation of the ulnar fracture using a plate, followed by closed reduction of the radial head should be the method of choice. In type 4 internal fixation of both ulna and radius is indicated.

b. Galeazzi Fracture: (Galeazzi, Ricardo. 1866-1952, Professor of Orthopaedic Surgery at Milan)

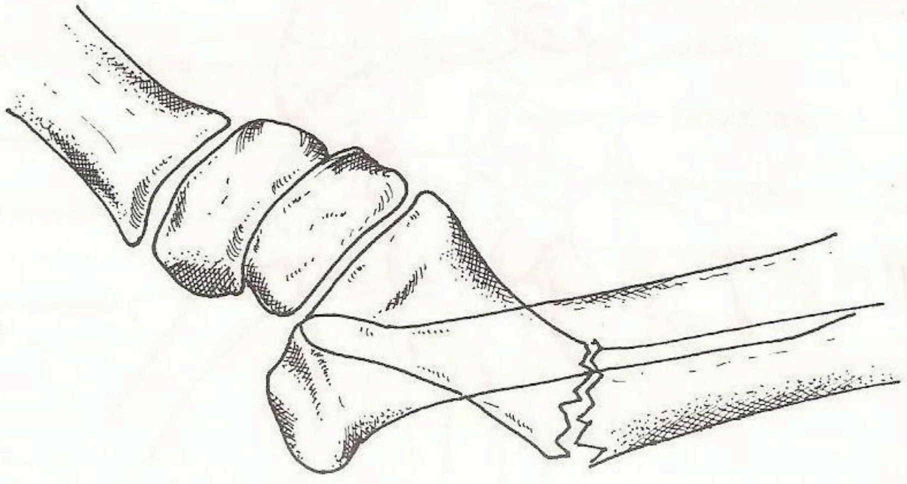


Fig. 98 Galeazzi fracture

This is a fracture at the junction of the middle and distal third of the radius associated with subluxation or dislocation of the distal radio ulnar joint (Fig. 98).

Mechanism of injury: This fracture could result from both direct trauma to the lateral aspect of the distal radius and indirect trauma such as a fall on the outstretched forearm.

Diagnosis: The patient presents with pain and localized tenderness along the distal third of the radius, there is also pain and discomfort along the distal radio ulnar joint with prominence of the distal aspect of the ulna. Movements of the wrist are painful. X-rays will confirm the diagnosis.

Treatment: Conservative methods, *i.e.* closed manipulation and immobilization in a plaster cast are usually unsatisfactory since this fracture is very unstable. In children the conservative method should be tried first, while in adults the operative method, *i.e.* open reduction and internal fixation of the radius by a compression plate to be followed by closed reduction of the distal end of the ulna should be the method of choice. If the distal end of the ulna appears to be unstable inspite of internal fixation of the radius, it is probably best to transfix it with two crossed Kirschner wires after it has been reduced.

THE WRIST AND THE HAND

Anatomy (Fig. 99)

The wrist is composed of multiple synovial joints formed by the articulation of the (1) distal radius (2) carpal bones (3) metacarpals.

The carpal bones are eight in number arranged roughly in two transverse rows. A proximal row formed of scaphoid, lunate, triquetral and pisiform, and a distal row formed of trapezium, trapezoid, capitate and hamate.

The wrist can be divided into 3 articulating rows:

1. Radiocarpal joint: This is the articulation between the distal end of the radius and the scaphoid and lunate bones.
2. Midcarpal joints: The articulations between the proximal and distal row of carpal bones.
3. Carpometacarpal joints: The articulations of the metacarpals with the distal row of carpal bones.

Movements at the wrist joints consist of:

a) Dorsiflexion: 0-80°
b) Palmer flexion: 0-85°
c) Ulnar deviation: 0-35°
d) Radial deviation: 0-20°

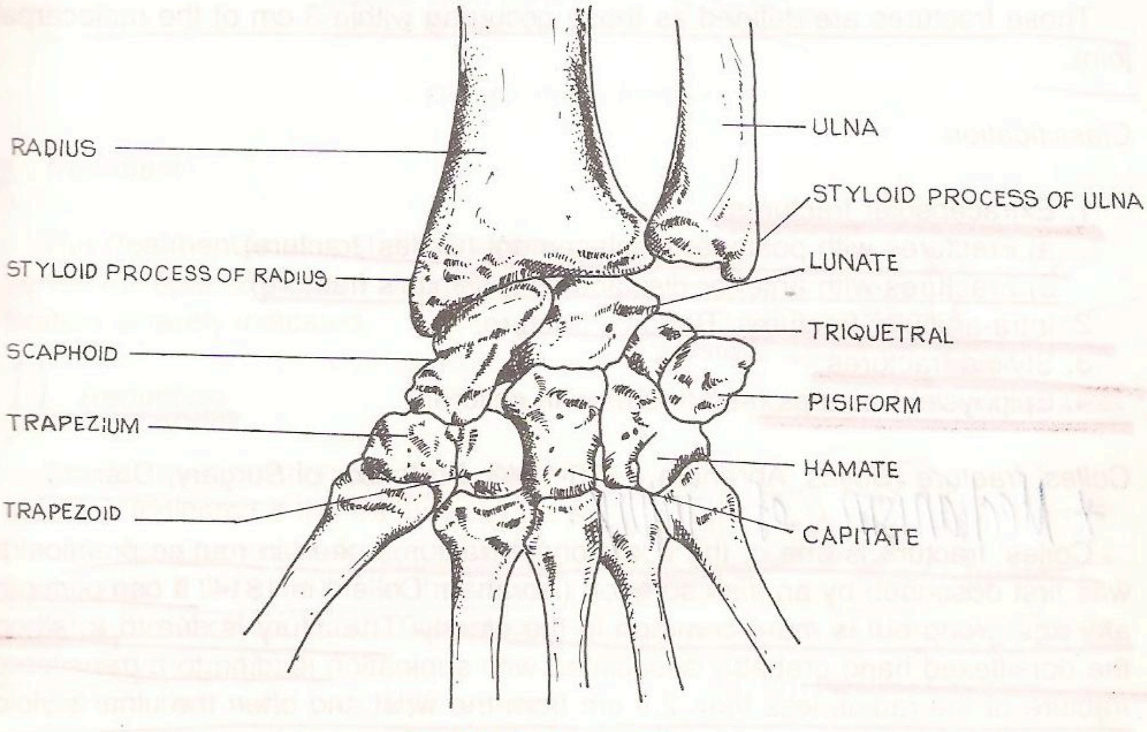


Fig. 99 Anatomy of the wrist

Injuries of the Wrist

The wrist is the foundation of the hand, and as such wrist injuries which are extremely common can disable the function of the hand. They present difficulties not only in treatment but in diagnosis due to complexity of the wrist with its 21 separate articulations with their network of ligamentous connections.

Classification of wrist injuries:

A. Fractures

1. Fractures of the distal ends of the radius and ulna.
2. Fractures of the carpal bones.

B. Dislocations

1. Radioulnar dislocation.
2. Radiocarpal dislocation.
3. Perilunar dislocation.
4. Dislocations of the lunate.

C. Sprains of the wrist

Fractures of the Distal Ends of the Radius and Ulna

These fractures are defined as those occurring within 3 cm of the radiocarpal joint.

Classification

1. Extracapsular fractures
   a) Fractures with posterior displacement (Colles' fracture).
   b) Fractures with anterior displacement (Smith's fracture).
2. Intra-articular fractures: Barton's fracture.
3. Styloid fractures.
4. Epiphysial fractures (see fractures in children).

Colles' fracture (Colles, Abraham, 1773-1843. Professor of Surgery, Dublin.)

* Mechanism of injury:

Colles' fracture is one of the commonest fractures seen in routine practice. It was first described by an Irish surgeon (Abraham Colles) in 1814. It can occur in any age group but is more common in the elderly. The injury is due to a fall on the dorsiflexed hand probably associated with supination leading to a transverse fracture of the radius less than 2.5 cm from the wrist and often the ulnar styloid process is broken off.

Diagnosis (Fig. 100)

The injured wrist is swollen, painful and may show the typical 'dinner fork deformity'. Palpation of the radial and ulnar styloid processes will demonstrate proximal migration of the radial styloid process. The X-ray appearances are characteristic.

The six characteristic features of a displaced Colles' fracture are: a) Impaction, b) supination, c) dorsal displacement, d) dorsal angulation, e) radial displacement, f) radial angulation.

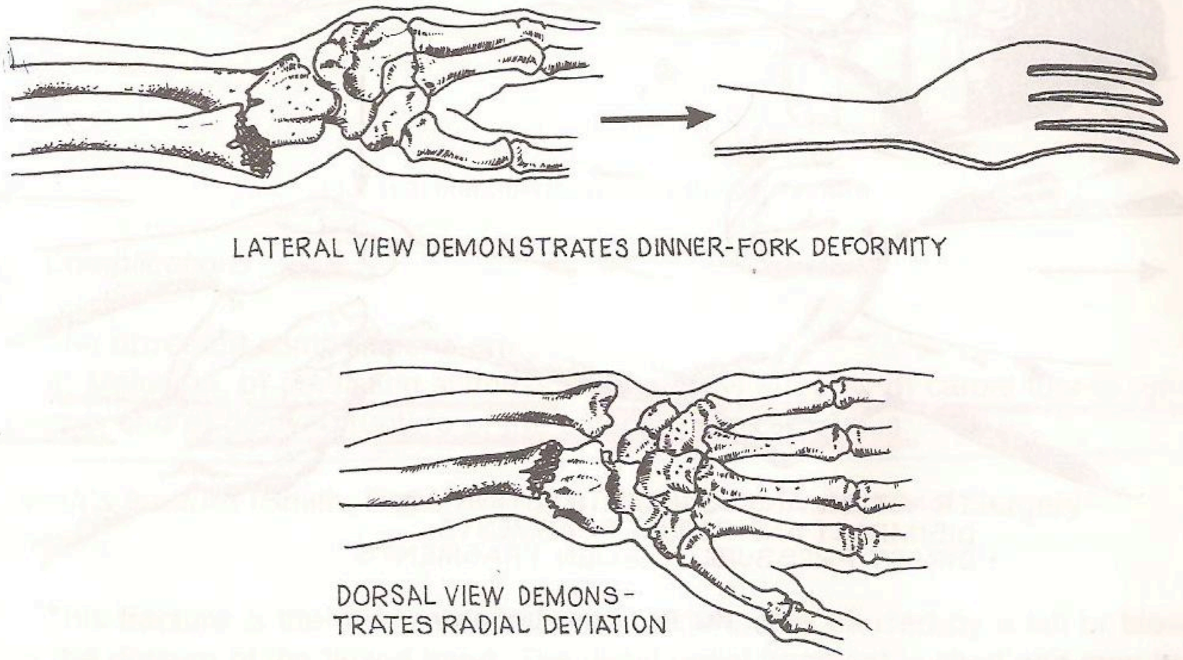


Fig. 100 Colles fracture

Treatment

The treatment is almost always conservative, open reduction and internal fixation is rarely indicated.

1) *Reduction*

Closed manipulation under anaesthesia is indicated if the fracture is displaced. As a general rule manipulation is indicated if the joint line in the lateral view of the X-ray is tilted 10° or more posteriorly (Fig. 101).

But in the very old, frail patient somewhat greater degrees of deformity may be accepted.

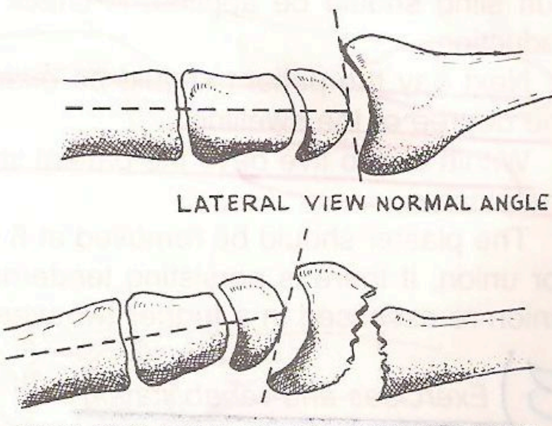


Fig. 101 Displaced fracture

Reduction Technique (Fig. 102)

The reduction is achieved by:

a) Disimpacting the lower fragment by traction applied in the line of the forearm, b) correcting the radial displacement and angulation, c) reducing the dorsal displacement and angulation, and d) lock in ulnar deviation and flexion.

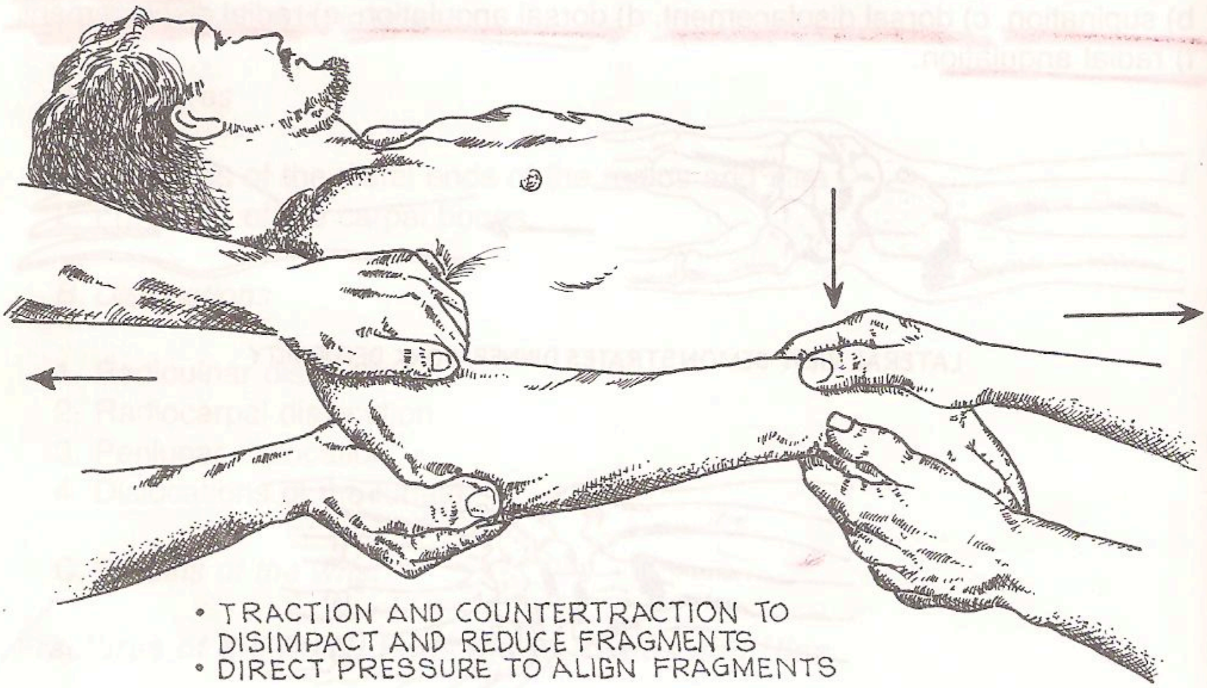


Fig. 102 Reduction technique

2) *Immobilization* (Fig. 103)

This can be achieved initially by a back slab of plaster of Paris, a collar and cuff sling should be applied. A check X-ray is taken to confirm the position of reduction.

Next day the patient should be examined for adequacy of the circulation and the degree of the swelling.

Within two to five days the patient should be seen with a view to completion of the plaster.

The plaster should be removed at 5 weeks and the fracture assessed clinically for union, if there is persisting tenderness a fresh plaster should be applied and union re-assessed in a further two weeks.

3) *Exercises and rehabilitation*

The patient is instructed from the start in elbow, shoulder and finger exercises, following removal of the plaster the patient should be encouraged to practice wrist and finger exercises preferably in a physiotherapy department.

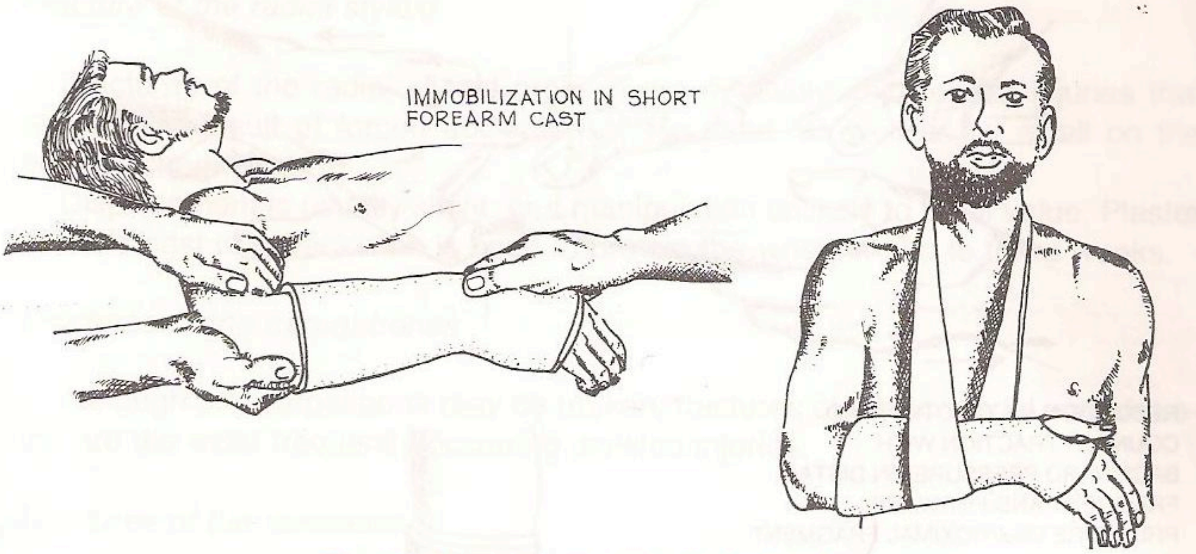


Fig. 103 Immobilization of a Colles fracture

Complications

The observed complications are:
a) Malunion, b) persisting stiffness, c) Sudeck's atrophy, d) carpal tunnel syndrome, and e) delayed rupture of the extensor pollicis longus.

Smith's fracture (Smith, Robert William. 1807-1873, Professor of Surgery – Dublin)

This fracture is the reverse of a Colles fracture. It is caused by a fall or blow on the dorsum of the flexed hand. The distal radial fragment is tilted and may be displaced anteriorly, the fracture is usually impacted. The typical deformity is described as a garden-spade deformity. The diagnosis is confirmed by X-ray (Fig. 104).

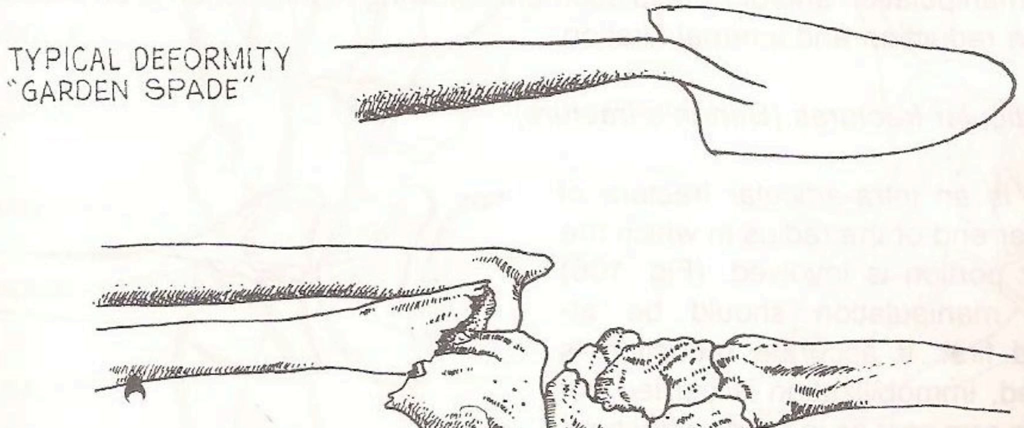


Fig. 104 Smith's fracture typical deformity

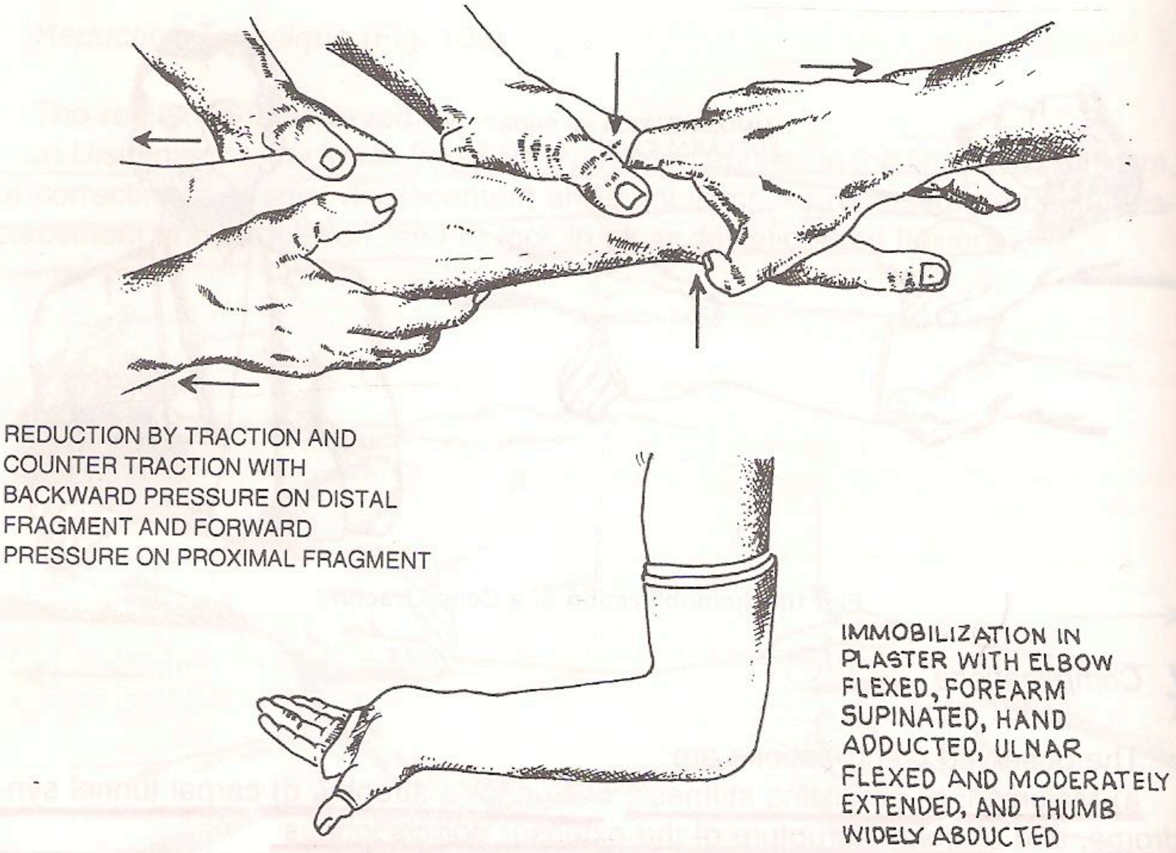


Fig. 105 Treatment of Smith's fracture

Treatment (Fig. 105)

Closed manipulation should be attempted first. If accurate reduction is achieved the limb should be immobilized in a full arm cast with the hand supinated and dorsiflexed. The position should be checked radiologically at intervals. Failure of closed manipulation and/or re-displacement following manipulation is an indication for open reduction and internal fixation.

Intra-articular fractures (Barton's fracture)

This is an intra-articular fracture of the lower end of the radius in which the anterior portion is involved. (Fig. 106) Closed manipulation should be attempted first. If accurate reduction is achieved, immobilization is carried out in a long arm cast as in Smith's fracture. Failure of closed manipulation is an indication for open reduction and internal fixation.

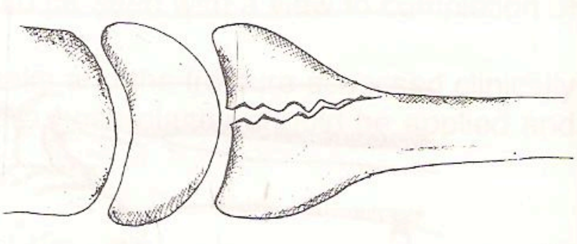


Fig. 106 Intra-articular fractures

Fracture of the radial styloid

Fractures of the radial styloid process are relatively unimportant injuries that occur as a result of forced abduction of the hand, as well as by a fall on the out-stretched hand.

Displacement is usually slight, and manipulation unlikely to be of value. Plaster of Paris cast or a back slab is used to protect the wrist for two to three weeks.

Fractures of the carpal bones

Although any carpal bone may be broken, fractures of the scaphoid and triquetral are the most frequently occurring isolated injuries.

Fractures of the scaphoid

Anatomy and blood supply (Fig. 107)

The scaphoid (navicular) is named for its resemblance to a boat. It is the largest bone of the proximal row of the carpus, and in most positions of the wrist, spans the midcarpal joint and tends to lie in both the proximal and distal row. Its shape and its location are the two reasons which make it the most carpal bone prone to fracture. The blood supply of the scaphoid arises from branches of the radial and volar interosseous arteries. The vessels enter the scaphoid at two sites, through the lateral volar and dorsal surfaces near the waist, and at its distal aspect, the tubercle. Those that enter the tubercle supply primarily a circumscribed area in the distal part of the bone. The proximal pole has no major vessels entering it but receives its blood supply from branches of the main arteries entering at the waist and also some vessels which are shared with the carpal lunate.

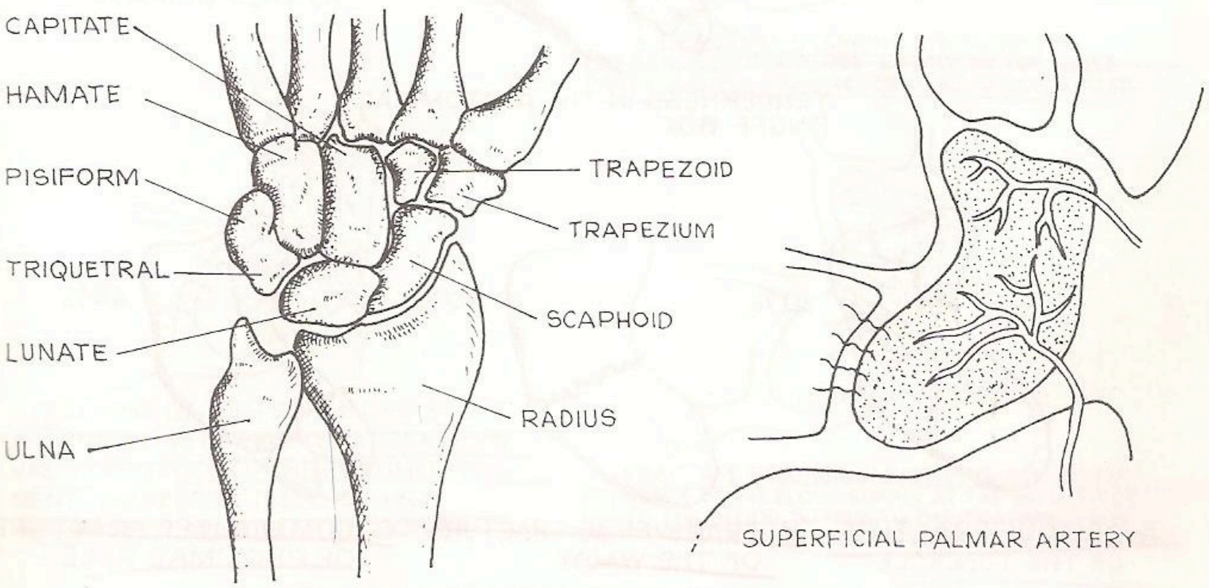


Fig. 107 Anatomy and blood supply of the scaphoid

Mechanism of injury

Although the scaphoid is counted amongst the proximal row of the carpus, its distal half in fact occupies the plane of the distal row of bones. Any force which tends to flex or extend the mid-carpal joint will tend to shear through the waist of the scaphoid whose proximal pole is tethered to the lunate and distal pole is tethered to the capitate, trapezoid and trapezium. If the force is such that the mid-carpal joint dislocates, this is usually associated with a fracture through the scaphoid. If the force is insufficient to dislocate the mid-carpal joint, a simple fracture of the scaphoid results.

Diagnosis (Fig. 108)

Fractures of the scaphoid may be suspected when there is complaint of pain on the lateral aspect of the wrist following any injury. Tenderness in the anatomical snuff box is suggestive. X-rays are essential to confirm the diagnosis and establish the site of the fracture.

If the clinical features are suggestive but no fracture is seen on X-ray as may frequently happen, treatment should start as for a definite fracture then X-rays should be repeated ten to fourteen days later when due to resorption of bone a fracture line may be seen.

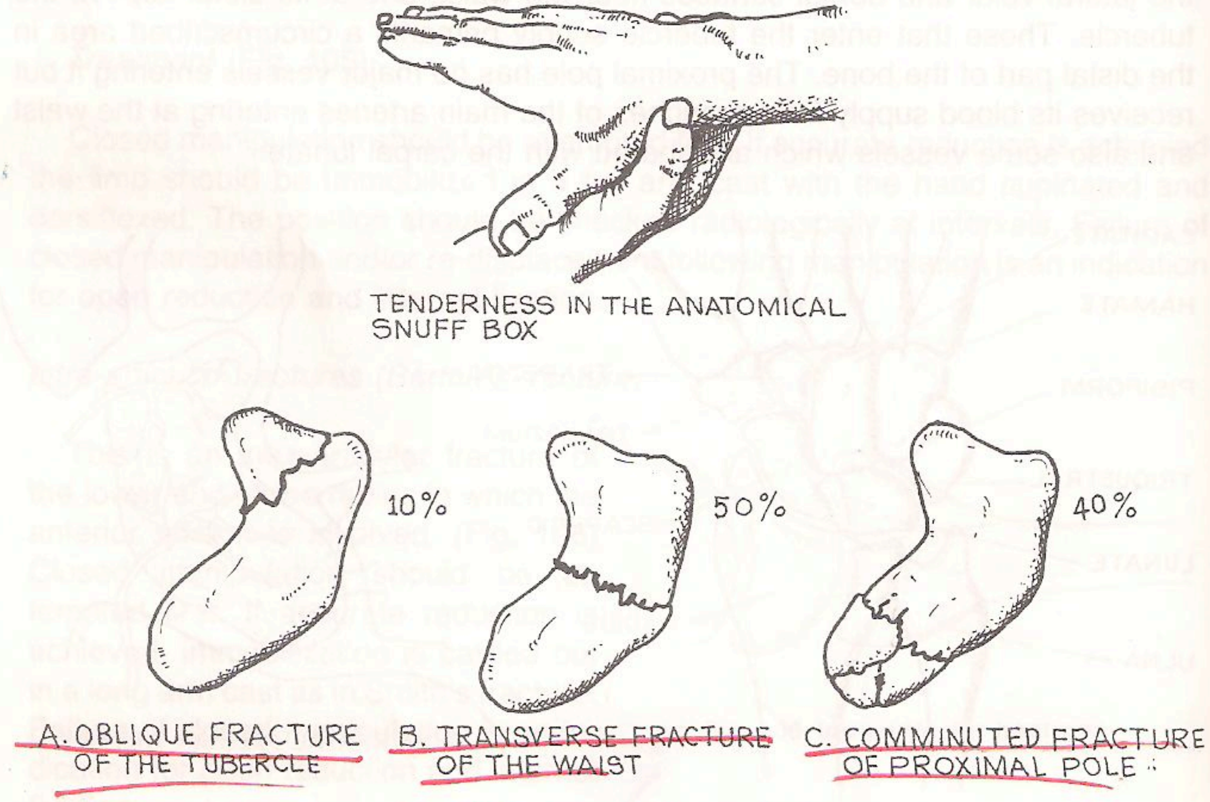


Fig. 108 Fracture of the scaphoid

Treatment and prognosis (Fig. 109)

1. Suspected fracture: If no fracture is visible on the initial radiographs, the wrist is immobilized in a scaphoid plaster. At the end of two weeks, the wrist is radiographed again. If a fracture line is evident at this time, treatment in plaster of Paris is continued. If no fracture line is evident full recovery can be anticipated within a week or so.

2. Definite fracture: Immobilization in a scaphoid plaster is continued for eight weeks. If united radiologically at the end of this time, the wrist is set free and full recovery should occur in about one month. If the fracture has failed to unite by eight weeks a further period of treatment for eight weeks is continued.

If evidence of healing is not apparent, even after prolonged immobilization, operative treatment must be considered. Operative treatment for simple non-union depends upon whether or not there is a coexisting traumatic arthritis of the wrist joint.

a) Non-union not complicated by a traumatic arthritis: A bone graft may be inserted across the fracture site. It should fit well into the fragments, which should then be impacted. Immobilization should be maintained for at least 10 weeks postoperatively.

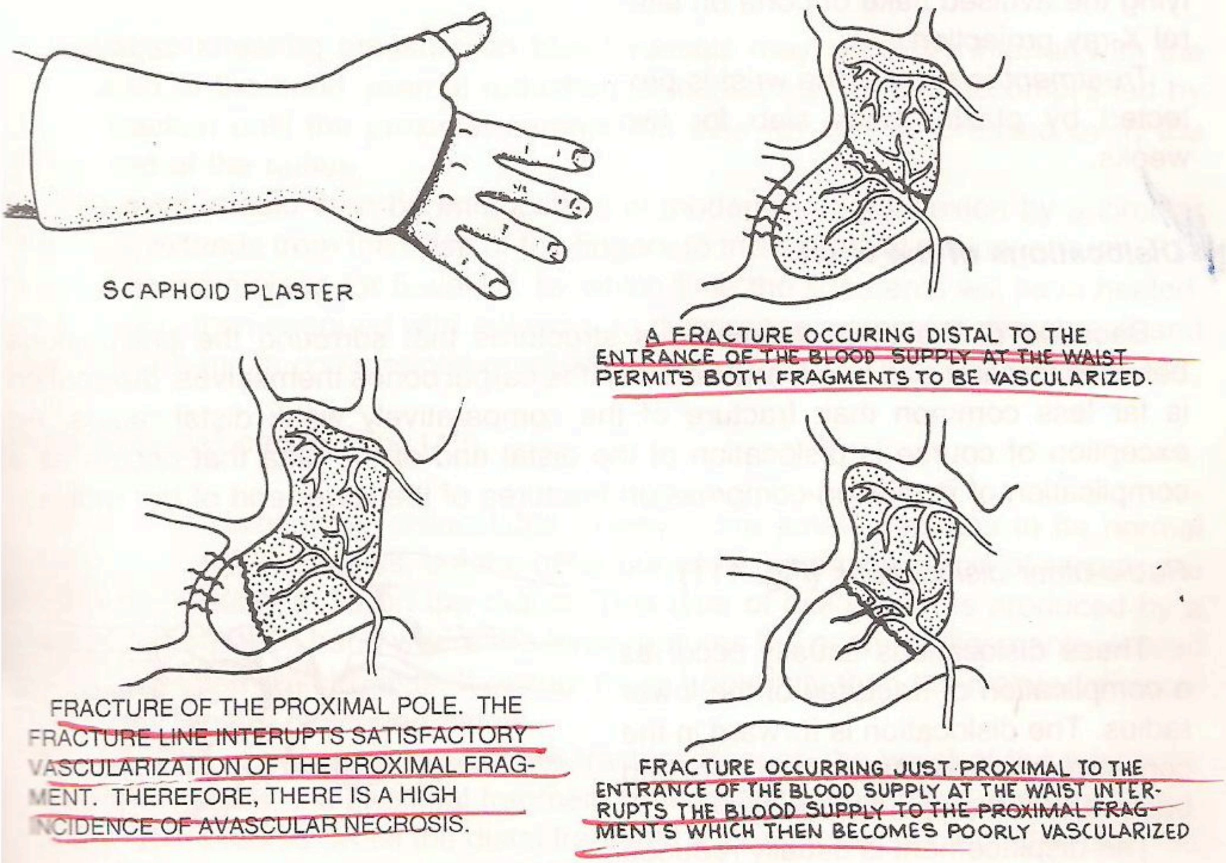


Fig. 109 Treatment and prognosis of scaphoid fracture

b) Nonunion with traumatic arthritis: When this complication is present, a painful disability of the wrist will persist even though union of the scaphoid is brought about. Therefore, arthrodesis or excision of part of the proximal carpal row must be considered.

Complications

The observed complications are:
a) Sudeck's atrophy, b) nonunion, c) avascular necrosis, and d) post-traumatic osteo-arthrosis.

Fracture of the triquetral (Fig. 110)

Fractures of this bone are usually insignificant flake fractures of the dorsum of the bone. They are usually caused by a fall on the flexed wrist held in radial deviation.

Pain, swelling and tenderness on the dorsum of the wrist are nonspecific and the diagnosis is only made by identifying the avulsed flake of bone on lateral X-ray projection.

Treatment is simple, the wrist is protected by plaster back slab for two weeks.

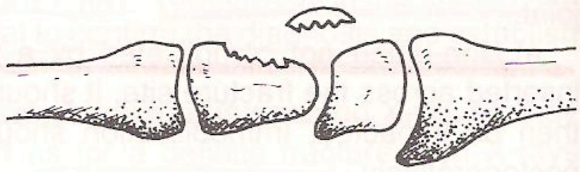


Fig. 110 Fracture of the triquetral bone

Dislocations of the wrist

Because of the stout ligamentous structures that surround the articulations between forearm and hand, and between the carpal bones themselves, dislocation is far less common than fracture of the comparatively weak distal radius. An exception of course is dislocation of the distal end of the ulna that occurs as a complication of extension-compression fractures of the lower end of the radius.

Radio-ulnar dislocations (Fig. 111)

These dislocations usually occur as a complication of fractures of the lower radius. The dislocation is forward in the common extension type of fracture, and backward in the rare flexion type.

The displacement is usually reduced when the fracture is reduced, and no special treatment is needed.

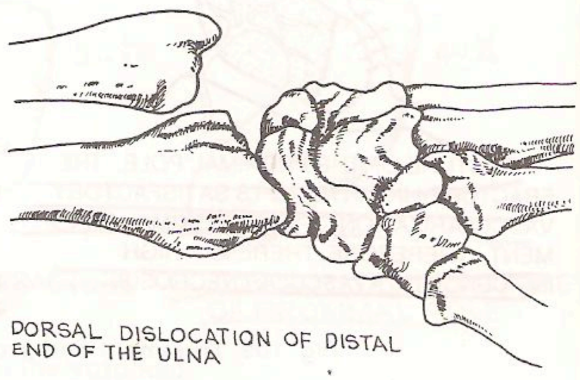


Fig. 111 Radio-ulnar dislocation

Radiocarpal dislocation (Fig. 112)

These dislocations are rare. When they do occur, they are usually posterior, the proximal row of carpal bones lying on the dorsum of the radius and ulna. For this type of dislocation to occur, all of the ligaments around the radiocarpal joint are either ruptured or torn from their bony attachments. The extensor tendons are stripped away from the dorsum of the radius. The flexor tendons and nerves are stretched across the lower border of the forearm bones and may be seriously injured. Usually there is an associated fracture of the posterior articular margin of the radius. Occasionally, both styloid processes are torn away.

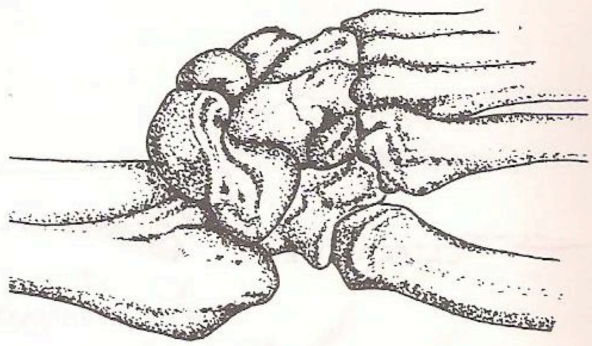


Fig. 112 Radiocarpal dislocation

Treatment

Because shearing pressure on blood vessels may seriously interfer with the circulation of the hand, prompt reduction is mandatory. This is accomplished by direct traction until the proximal carpals slip over, or can be pressed over, the lower end of the radius.

The wrist should then be immobilized in moderate dorsal flexion by a circular cast that extends from the base of the fingers to the middle of the upper arm. This should be maintained for 5 weeks, by which time the ligaments will have healed. The wrist is then wrapped with adhesive to discourage excessive movement, and use of the hand is commenced gradually.

Peri-lunar dislocation (Fig. 113)

This term designates dislocations in which the lunate remains in its normal relationship with the radius, but the other bones of the proximal row of carpals are displaced dorsally to lie on the radius. This type of dislocation is produced by a fall on the extended hand where the force ruptures the posterior ligaments instead of fracturing the distal radius. It occurs more frequently than the isolated dislocation of the lunate, described below.

Frequently, there is an associated fracture through the waist of the scaphoid. When this occurs, the proximal fragment remains with the lunate, in normal alignment with the radius, while the distal fragment accompanies the triquetral in dorsal displacement.

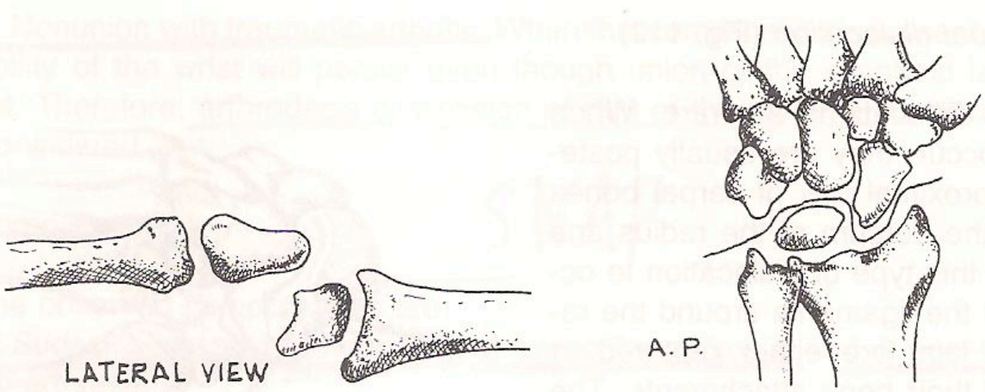


Fig. 113 Perilunar dislocation

Diagnosis

The deformity resembles that of a Colles' fracture (dinner fork deformity) the diagnosis is confirmed by X-ray, particularly in the lateral view.

Treatment

With the patient under general anaesthesia, the surgeon grasps the hand and applies strong traction with the wrist in dorsiflexion. At the same time the opposite thumb exerts pressure on the displaced carpals. When the carpals have been brought into their normal position, the wrist is carried into the neutral position by gradual flexion.

The wrist is then maintained in slight dorsiflexion with plaster, which is carried two-thirds up the forearm and extends to the palmar crease. This is maintained for six weeks. X-ray should be repeated several times following immobilization, because the dislocation may recur from muscle pull even with a well-fitting cast.

Dislocation of the lunate (Fig. 114)

In a severe fall on the hyperextended hand, the lunate may be squeezed through the volar ligaments, so as to lie partially or wholly within the carpal tunnel and thus impinge on the median nerve. In almost all cases, the bone remains attached to the palmar radiocarpal ligament through which it derives its blood supply.

Diagnosis

Swelling and localized tenderness is present over the volar aspect of the wrist. The fingers are held in slight flexion. Flexion of the wrist is limited and painful. Within a relatively short time, hyperaesthesia or anaesthesia of the palm and fingers on the radial side of the hand may be present due to pressure on the median nerve.

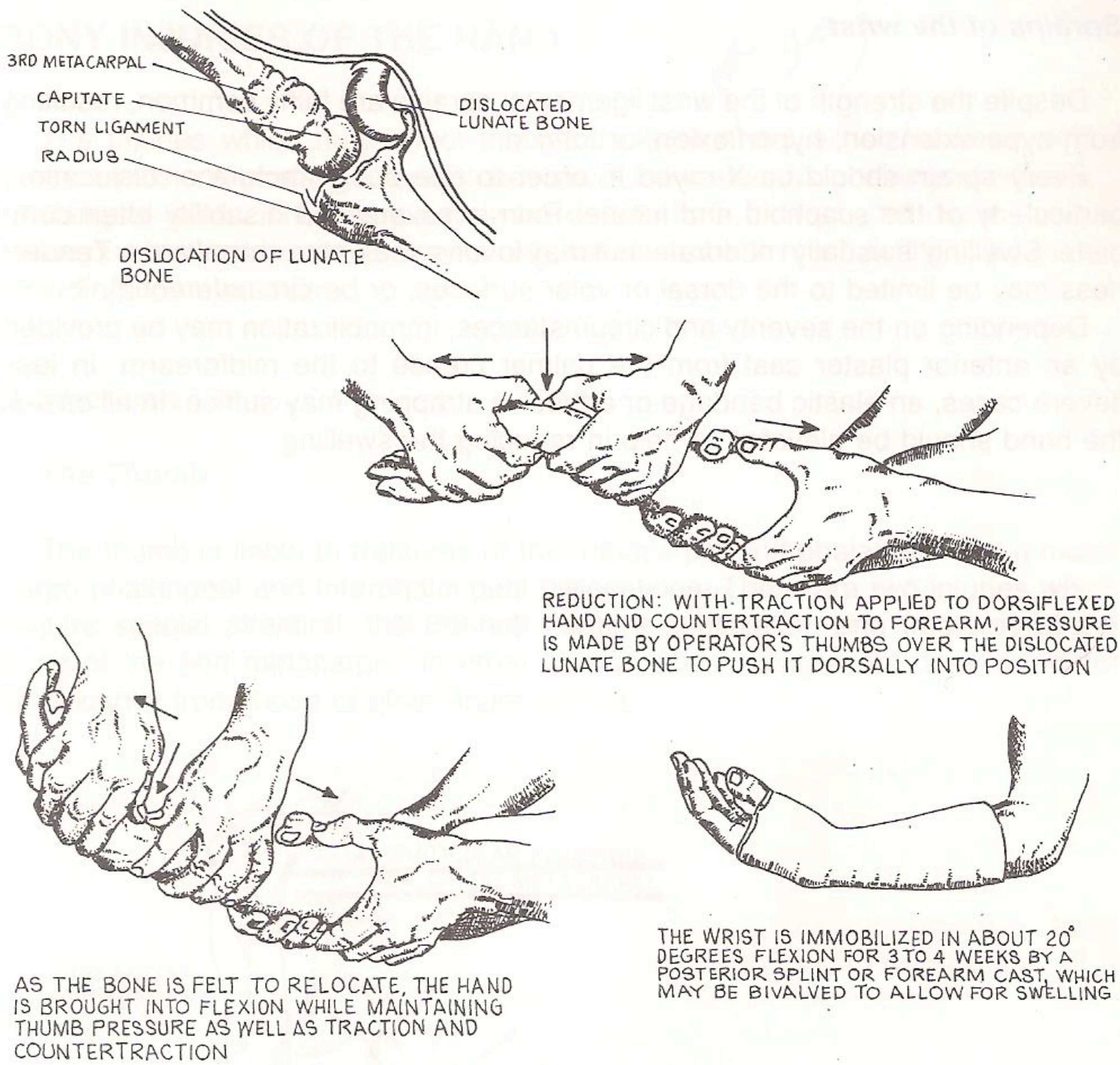


Fig. 114 Lunate dislocation – diagnosis and treatment

Treatment

Reduction should be accomplished as soon as possible. With the patient under general anaesthesia, moderate traction is applied to the dorsiflexed hand. At the same time, pressure is made with the other thumb over the dislocated lunate to push it dorsally into its normal position. As the bone is felt to relocate, the wrist is brought into a mild degree of flexion.

The wrist is then immobilized in about 20° flexion for three to four weeks.

With early reduction, prognosis is excellent. However if neglected, closed reduction may be impossible, and open reduction is required. In dislocations that have been present for two months or more, both the bone and its cartilage will become softened. If this is so, it may be better to excise the bone.

Sprains of the wrist

Despite the strength of the wrist ligaments, sprains are fairly common, resulting from hyperextension, hyperflexion, or torsion.

Every sprain should be X-rayed in order to rule out a fracture or dislocation, particularly of the scaphoid and lunate. Pain is severe and disability often complete. Swelling is usually moderate, but may involve the entire carpal area. Tenderness may be limited to the dorsal or volar surfaces, or be circumferential.

Depending on the severity and circumstances, immobilization may be provided by an anterior plaster cast from the palmar crease to the midforearm. In less severe cases, an elastic bandage or adhesive strapping may suffice. In all cases, the hand should be elevated to help in reducing the swelling.

BONY INJURIES OF THE HAND

The injuries which may affect the hand skeleton are either fractures of the metacarpals and phalanges or dislocations of the metacarpophalangeal and interphalangeal joints. The injuries may be due to both indirect and direct trauma, those due to direct trauma are commonly associated with much soft tissue damage including open wounds.

A. Fractures

The Thumb

The thumb is liable to fractures of the metacarpal and phalanges and a metacarpo-phalangeal and interphalangeal dislocations. There are two injuries which require special attention, the Bennett fracture subluxation and fractures of the base of the first metacarpal. In other injuries, the management does not differ significantly from those of other finger injuries.

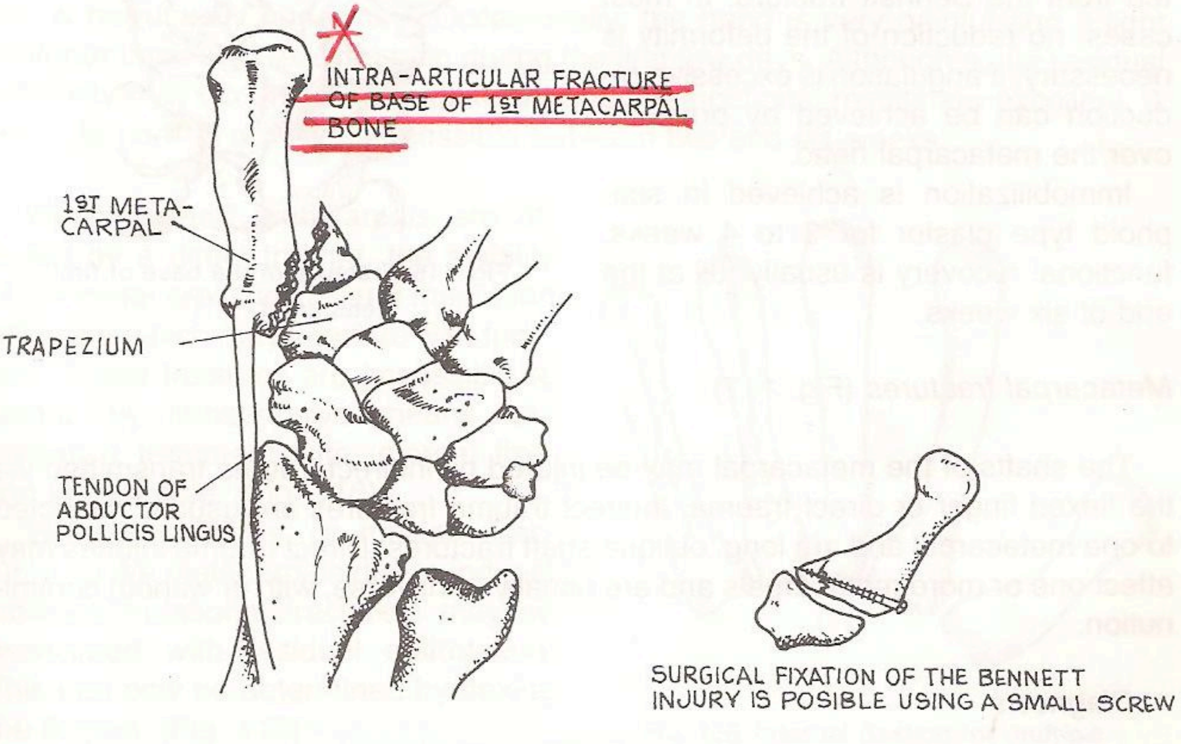


Fig. 115 Bennett fracture-subluxation

Bennett fracture-subluxation (Fig. 115)

(Edward Bennett, 1837-1907. Professor of Surgery, Dublin)
This injury results from hyperextension of the thumb and occurs commonly as a result of a sport, particularly boxing. The diagnosis is unlikely to be made without radiographic examination. The fracture line runs obliquely into the middle of the articular surface, resulting in the complete separation of a triangular fragment. This separation is increased, and tends to be perpetuated by the pull of the abductor policis longus on the radial side of the base of the remainder of the bone.

Treatment

Reduction is usually easy. Maintenance of position is difficult but can be achieved by accurately fitting plaster, or internal fixation.

Fracture of the base of first metacarpal (Fig. 116)

This fracture is usually due to flexion injury. Clinically, it cannot be differentiated from the Bennett fracture. In most cases, no reduction of the deformity is necessary, if angulation is excessive reduction can be achieved by pressure over the metacarpal head.

Immobilization is achieved in scaphoid type plaster for 3 to 4 weeks, functional recovery is usually full at the end of six weeks.

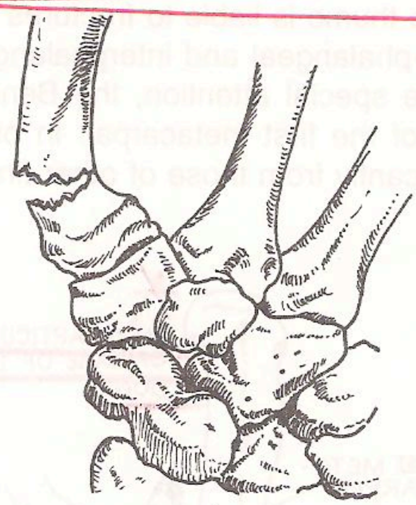


Fig. 116 Fracture of the base of first metacarpal

Metacarpal fractures (Fig. 117)

The shafts of the metacarpal may be injured by indirect trauma transmitted via the flexed finger or direct trauma. Indirect trauma fractures are usually restricted to one metacarpal and are long, oblique shaft fractures. Direct trauma injuries may affect one or more metacarpals and are usually transverse, with or without comminution.

Diagnosis

The diagnosis is not difficult. There is swelling on the dorsum of the hand and tenderness restricted to the affected metacarpal or metacarpals. In late cases, after the lapse of a day or more, bruising in the palm of the hand is frequently a notable feature. There is rarely any difficulty in recognising these injuries radiologically.

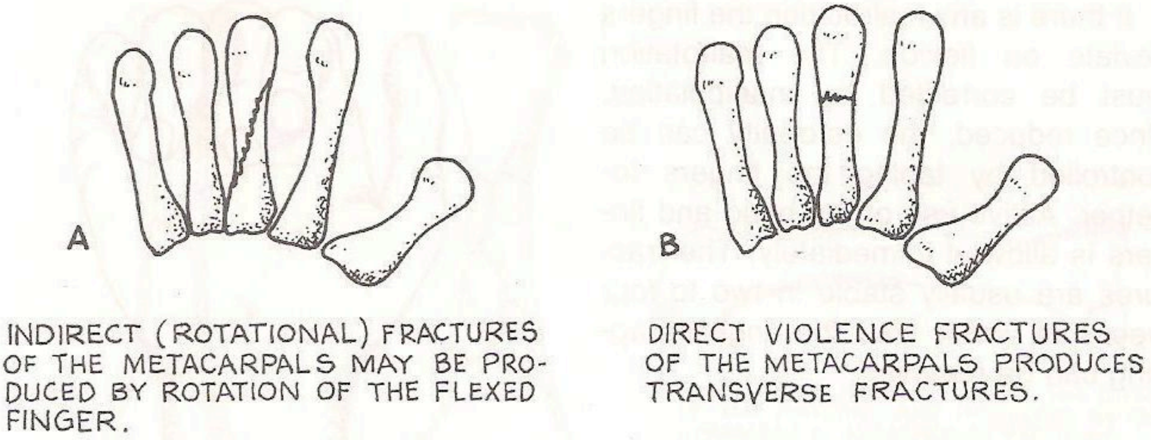


Fig. 117 Metacarpal shaft fractures

Treatment

Isolated fractures of one metacarpal require no special measures, if due to direct violence. The fracture is adequately supported by the adjacent metacarpals and bony union usually occurs within about six weeks. Active use of the fingers and hand should be encouraged early to maintain function and plaster immobilisation is not usually necessary. Occasionally, the hand is very painful and a light posterior back slab relieves pain during the first few days. Although some residual deformity may occur is it not significant and the functional results are excellent. A return to normal activities is possible between two and six weeks.

When several metacarpals are affected by a direct trauma, the stability of the metacarpus is lost and mal-union will occur which may interfere with function. These fractures are impossible to control by conservative means and operative treatment with internal fixation is desirable. (Fig. 118)

Isolated fractures, or multiple fractures, of the metacarpals due to indirect violence (rotational fractures) may be associated with residual malrotation. This can only be determined by flexing the fingers. (Fig. 119)

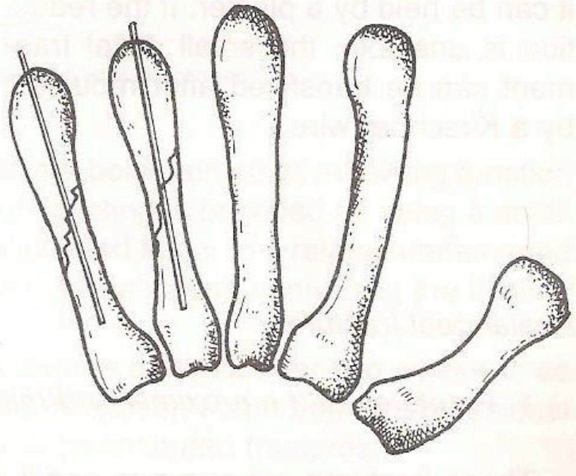


Fig. 118 Internal fixation for multiple metacarpal fractures

If there is any malrotation the fingers deviate on flexion. The malrotation must be corrected by manipulation. Once reduced, the deformity can be controlled by taping the fingers together. Active use of the hand and fingers is allowed immediately. The fractures are usually stable in two to four weeks at which time the finger strapping can be removed.

Fig. 119 Malrotation

Fracture of the metacarpal neck (Fig. 120)

Fractures of the metacarpal neck particularly the fifth commonly result from punching injuries.

Fractures with slight displacement are best left undisturbed. The residual deformity is slight and the functional results are excellent. Fracture with considerable displacements are reduced by direct pressure. If the reduction is stable it can be held by a plaster. If the reduction is unstable, the small distal fragment can be transfixed after reduction by a Kirschner wire.

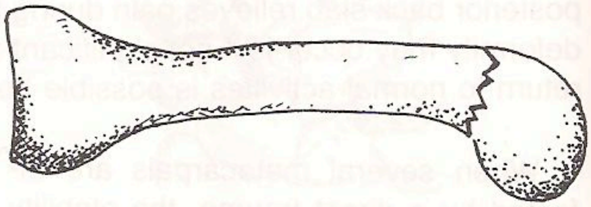


Fig. 120 Fracture of the metacarpal neck

Phalangeal fractures

1. Fractures of the proximal and middle phalanges

These fractures are common and if incorrectly treated may give rise to disproportionate degree of disability. The treatment depends on the type of the fracture and degree of displacement.

(a) Undisplaced fractures (Fig. 121) These are stable fractures which may be solitary crack fractures, comminuted fractures and various minor avulsion fractures. The treatment of these injuries should be as simple as possible, and rigid

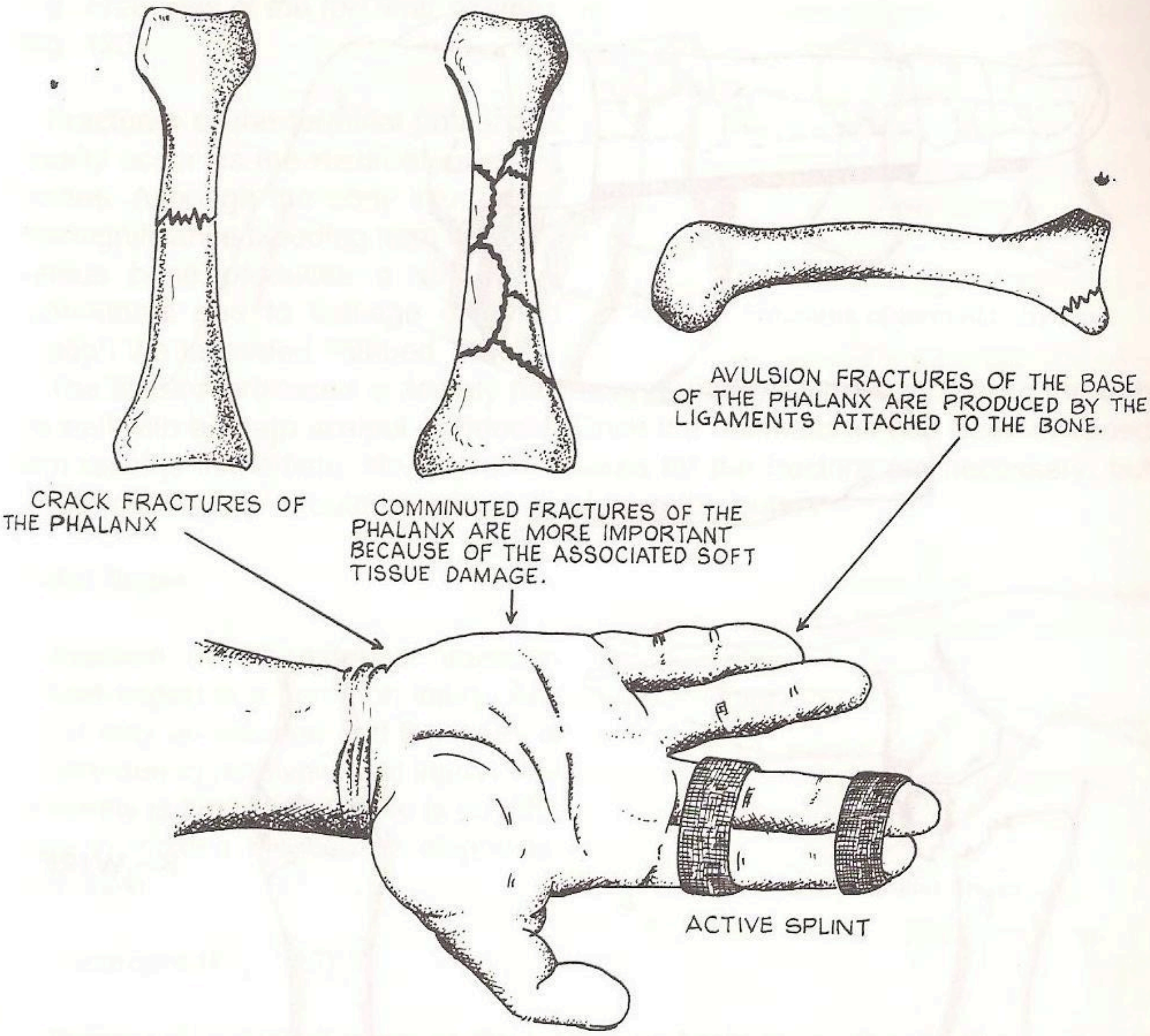
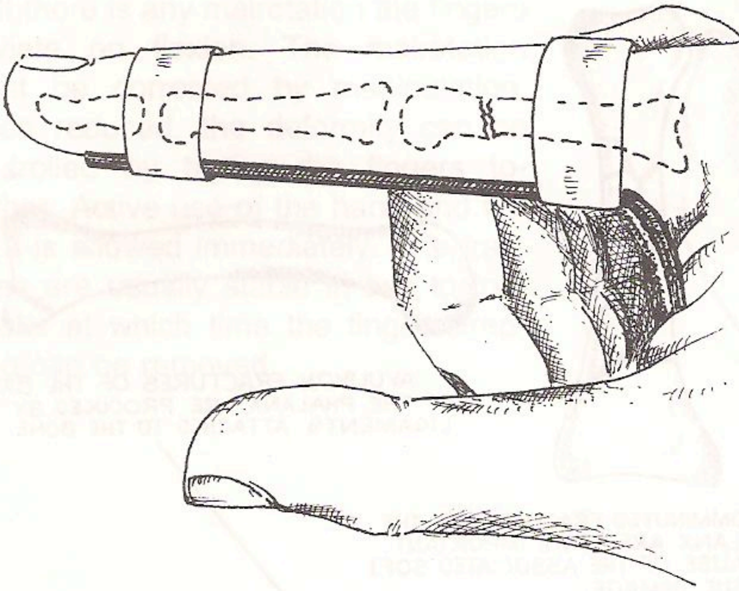


Fig. 121 Undisplaced phalangeal fractures

splintage is generally contraindicated treatment being aimed at regaining function as rapidly as possible. The simplest form of splinting is provided by using a small strip of zinc oxide tape to tape the tip of the affected finger to a related undamaged finger. This provides stability and acts as an 'active' splint, reinforcing the flexion/extensor power of the affected finger.

Undisplaced fractures of the phalanges require protection for two weeks or so and the functional end result is usually good. However, some permanent residual joint stiffness is not uncommon, especially in comminuted fractures.

(b) Displaced fractures (Fig. 122) The common injuries are extension injuries of the neck or shaft of the phalanx and fractures of the condyles. Fracture of the neck, shaft and base of the phalanx are usually stable in flexion and can be reduced by traction upon and flexion of the finger. The reduction is maintained by splinting the finger using *e.g.* Zimmer splint. Care must be exercised to correct any rotational deformity by checking that the adjacent, undamaged fingers flex in



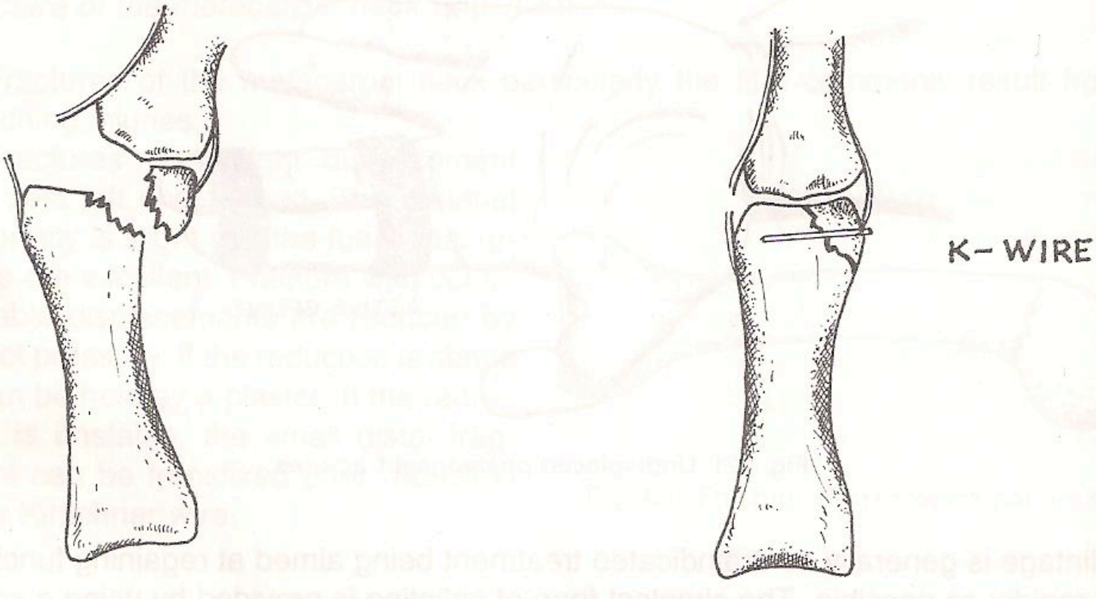


Fig. 122 Displaced phalangeal fractures

parallel lines. The acutely flexed position necessary in the initial stages leads to irrecoverable flexion deformity if adopted for more than ten to fourteen days. Fortunately, these fractures are usually stable by this stage and remobilization can be commenced by taping the injured finger to the adjacent undamaged finger, as in the treatment of stable fractures. Active splintage of this type is continued until the fracture is sound (usually a further two to four weeks).

Condylar fractures cannot be adequately controlled by conservative means. They are best treated by early operation with wire or screw fixation. Whatever treatment is applied to these displaced fractures the functional result is usually less than perfect as some residual restriction of movement, particularly extension, commonly results.

2. *Fractures of the terminal phalanx* (Fig. 123)

Fig. 123 Fractures of terminal phalanx

Fractures of the terminal phalanges usually occur as the result of crushing injuries. Although the bony injury is of little significance bleeding from the cancellous bone produces a subungual haematoma due to leakage of blood through the lacerated nail-bed.

The tension produced is acutely painful and readily relieved by drilling through the nail with a sharp scalpel or needle. Once the haematoma has been released pain relief is immediate. No active measures for the fracture are necessary, but active movements should be encouraged from the outset.

Mallet finger

Avulsion of the extensor insertion (mallet finger) is a common injury. Any finger may be affected and the injury is usually due to relatively mild injury. The deformity is typical and there is no difficulty in making the correct diagnosis. (Fig. 124)

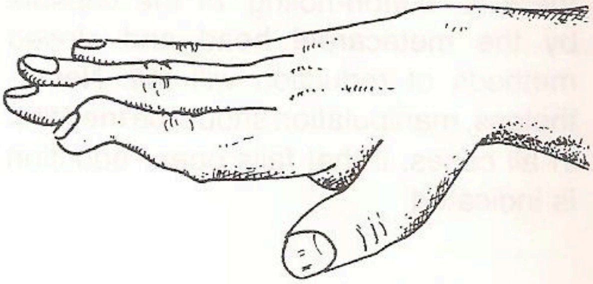


Fig. 124 Mallet finger

Treatment (Fig. 125)

Treatment is difficult because the tendon end retracts so that healing is imperfect and occurs with lengthening, with the result that some residual deformity is inevitable. The disability produced by a mallet finger however is negligible once

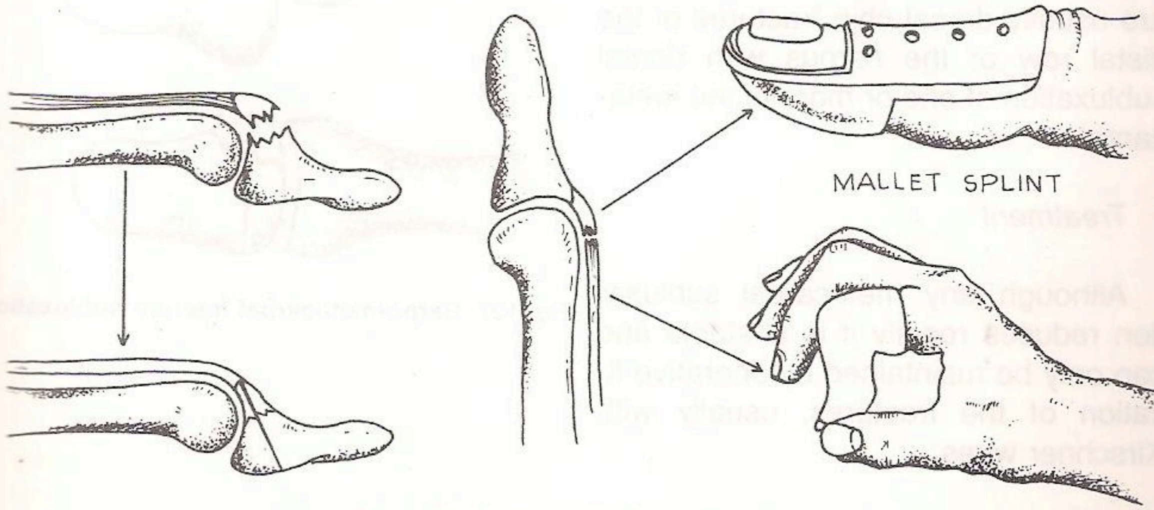


Fig. 125 Treatment of mallet finger

the pain and swelling have subsided. Immobilization of the distal interphalangeal joint in extension for eight weeks is frequently recommended. Surgical treatment by tendon repair is not indicated because the tendon is too fine to hold a suture. Surgical treatment is only indicated if the deformity is associated with a fracture of the phalanx in which case the fragment should be re-attached with a small pin.

B. Dislocations

Carpo-metacarpal dislocation of the thumb (Fig. 126)

This injury results from forcible hyperextension of the thumb. It is common in children. In a number of cases there is 'button-holing' of the capsule by the metacarpal head and closed methods of reduction will fail. Nevertheless, manipulation should be tried first in all cases, if that fails open reduction is indicated.

Fig. 126 Carpo-metacarpal dislocation

Carpo-metacarpal fracture subluxation (Fig. 127)

Injuries of the carpo-metacarpal joints are usually fracture subluxations which result from violence transmitted along the metacarpals. The fractures are usually dorsal chip fractures of the distal row of the carpus with dorsal subluxation of one or more of the metacarpals.

Treatment

Although any metacarpal subluxation reduces readily it is unstable and can only be maintained by operative fixation of the fractures, usually with Kirschner wires.

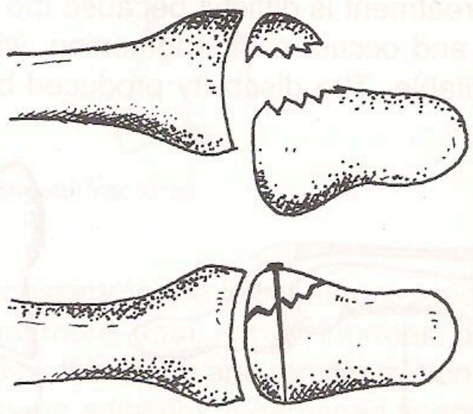


Fig. 127 Carpo-metacarpal fracture subluxation

Interphalangeal dislocations (Fig. 128)

Interphalangeal dislocations are usually posterolateral dislocation. They are reduced by traction on the finger and once reduced are usually stable. Active movements should be encouraged by taping the affected finger to an adjacent normal finger. Although the functional results are satisfactory, some residual loss of flexion and extension is usual as a result of capsular damage.

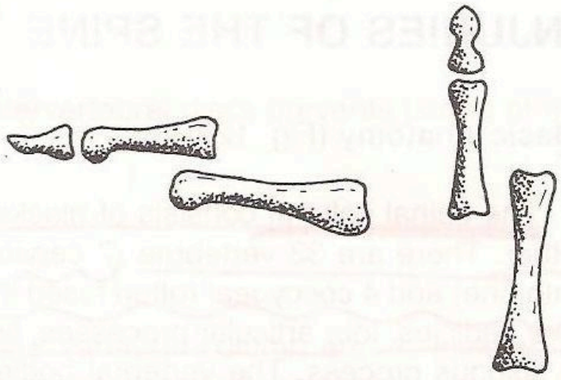


Fig. 128 Interphalangeal dislocation

INJURIES OF THE SPINE

Basic Anatomy (Fig. 129)

The spinal column consists of blocks – vertebrae – stacked one on top of the other. There are 33 vertebrae (7 cervical, 12 thoracic, 5 lumbar, 5 sacral (fused into one) and 4 coccygeal (often fused into one). Each vertebra consists of a body, two pedicles, four articular processes, two laminae, two transverse processes and a spinous process. The vertebral bodies articulate posteriorly between adjacent articular facets which are true synovial joints, anteriorly the bodies are joined by the intervertebral disc. The spinal nerves leave the vertrebral canal via the intervertebral foramina which are bounded anteriorly by the intervertebral disc, above and below by the pedicles, and posteriorly by the facet joints.

Stability of the vertebral column is mainly dependent upon the posterior ligamentous structures (posterior complex) which consists of: Supraspinous, Interspinous, ligamentum flavum and the facet joints, and to a much lesser extent on the anterior structures which consists of the intervertebral disc with the associated anterior and posterior longitudinal ligaments. In spinal injury, the integrity of these structures will determine the type of the fracture. (1) Stable fractures in which the posterior complex is intact, the cord is rarely damaged. (2) Unstable fractures in which the posterior complex is damaged, the cord may have been damaged but, if it has escaped, it may be injured by subsequent movement.

The spinal column provides the following mechanical functions:

1. Axial support for the trunk.
2. Flexibility to permit movement and locomotion.

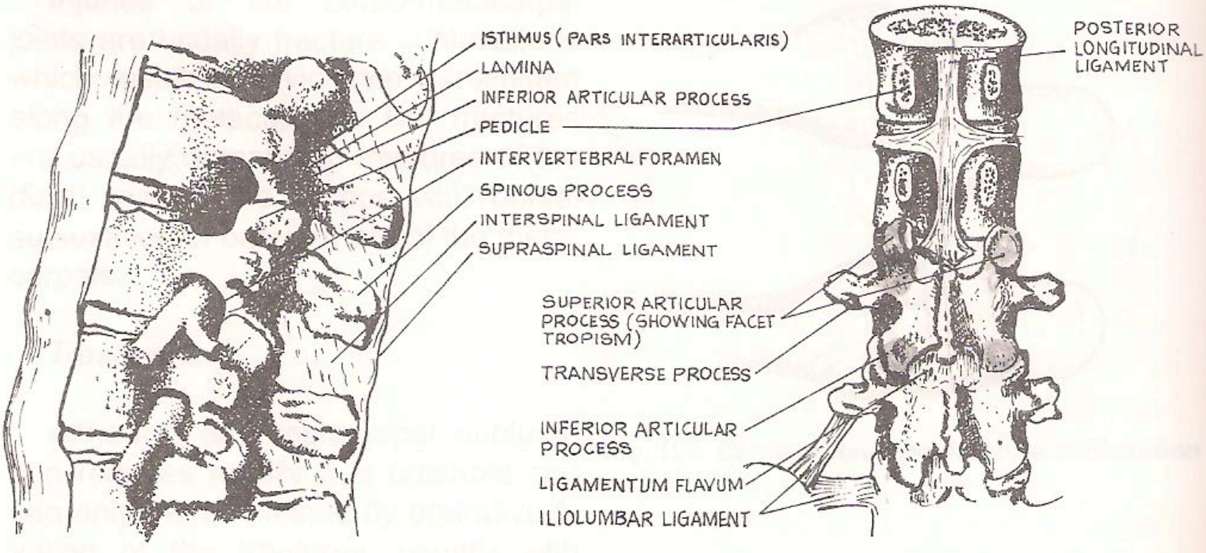


Fig. 129 Anatomy of spinal column

3. Protection:

a) Shield for cord and nerves.

b) Shock absorption ability of the intervertebral discs prevents jarring of the brain.

Mechanism of Injury and Pathology

The forces which may be applied to the vertebral column are: 1. Flexion, 2. hyperextension, 3. compression, and 4. shearing (specially rotation).

N.B.: For sake of simplicity, avulsion fractures of transverse or spinous processes and penetrating injuries will not be considered in this section.

1. Flexion force (Fig. 130)

Forward hinging injuries are most common in the lumbar and dorso-lumbar spine following a fall in the bent position or a weight falling on the bent back.

To a lesser extent, this injury may occur in cervical spine, but it rarely involves the thoracic spine which is secured by the ribs.

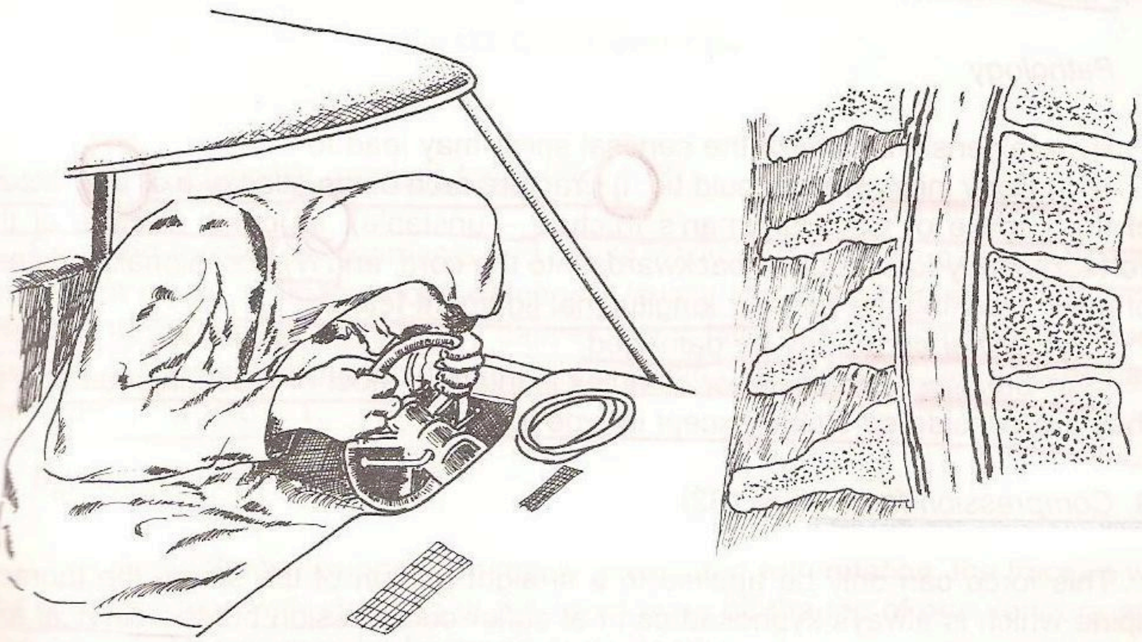


Fig. 130 Flexion injury

Pathology

a) *Body:* Wedge fracture.

b) *Spinal Cord:* usually not affected.

c) *Stability:* Posterior complex is intact and so fracture is considered stable.

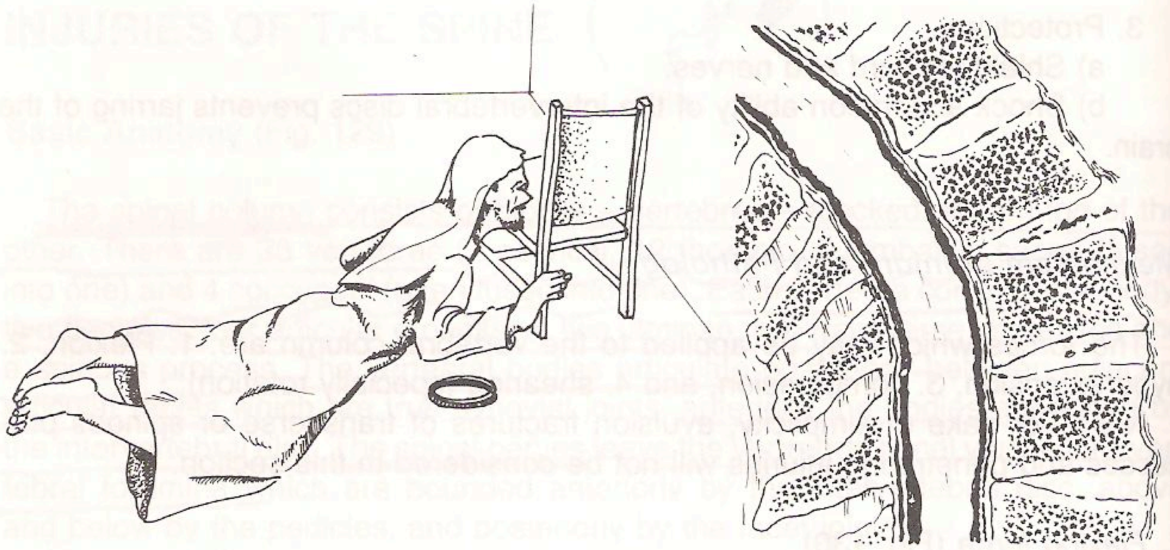


Fig. 131 Hyperextension injury

2. Hyper extension force (Fig. 131)

These injuries are mostly seen in the cervical region and, to a lesser extent, in the lumbar spine.

Pathology

Hyperextension injury of the cervical spine may lead to:

a) Body injury which could be: i) Fracture arch of the atlas or axis, ii) fracture of the pedicle of C2 (Hangman's fracture – unstable), iii) crush fracture of the vertebral body forcing bone backwards into the cord, and iv) occasionally, instead of bone breaking the anterior longitudinal ligament tears.

b) *Spinal cord:* may be damaged.

c) *Stability:* The posterior complex is intact in most of these injuries and so they are considered stable except in type ii.

3. Compression force (Fig. 132)

This force can only be applied to a straight portion of the spine, the thoracic spine which is always kyphosed can not suffer compression but the cervical and lumbar spines may sometimes be straight and so can be compressed as in a fall from a height affecting lumbar spine or diving injuries affecting the cervical spine.

Pathology

a) *Body:* Vertical, burst fracture occurs.

b) *Spinal cord:* usually not affected, but may be damaged by backward displaced fragments.

c) *Stability:* posterior complex is intact and so fracture is considered stable.

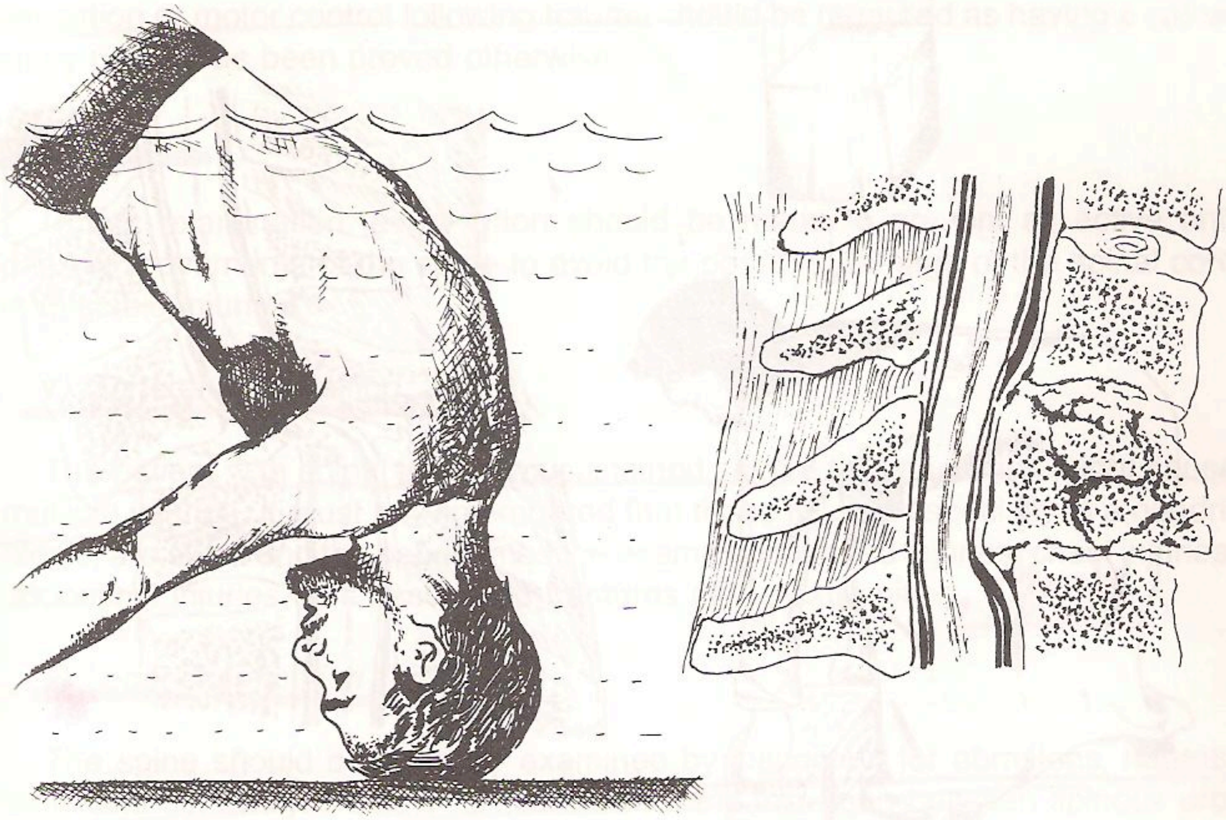


Fig. 132 Compression injury

4. Shearing (specially rotation) force (Fig. 133)

Shearing forces tear ligaments and cause instability. Rotation particularly is an important cause of ligamentous damage. Usually the rotation is associated with flexion. In the lumbar spine likely causes are a fall from a height with the body twisted or a weight falling asymmetrically onto the back. Most of these injuries are between T 10 and L 1.

Pathology

a) Body: Since flexion is commonly associated with rotation, the fracture will be a wedge type with shearing of a slice of bone off the top of one vertebra and the posterior facets may be fractured or dislocated.

b) Spinal cord: Usually affected.

c) Stability: The posterior complex will be damaged and so the fracture is unstable.

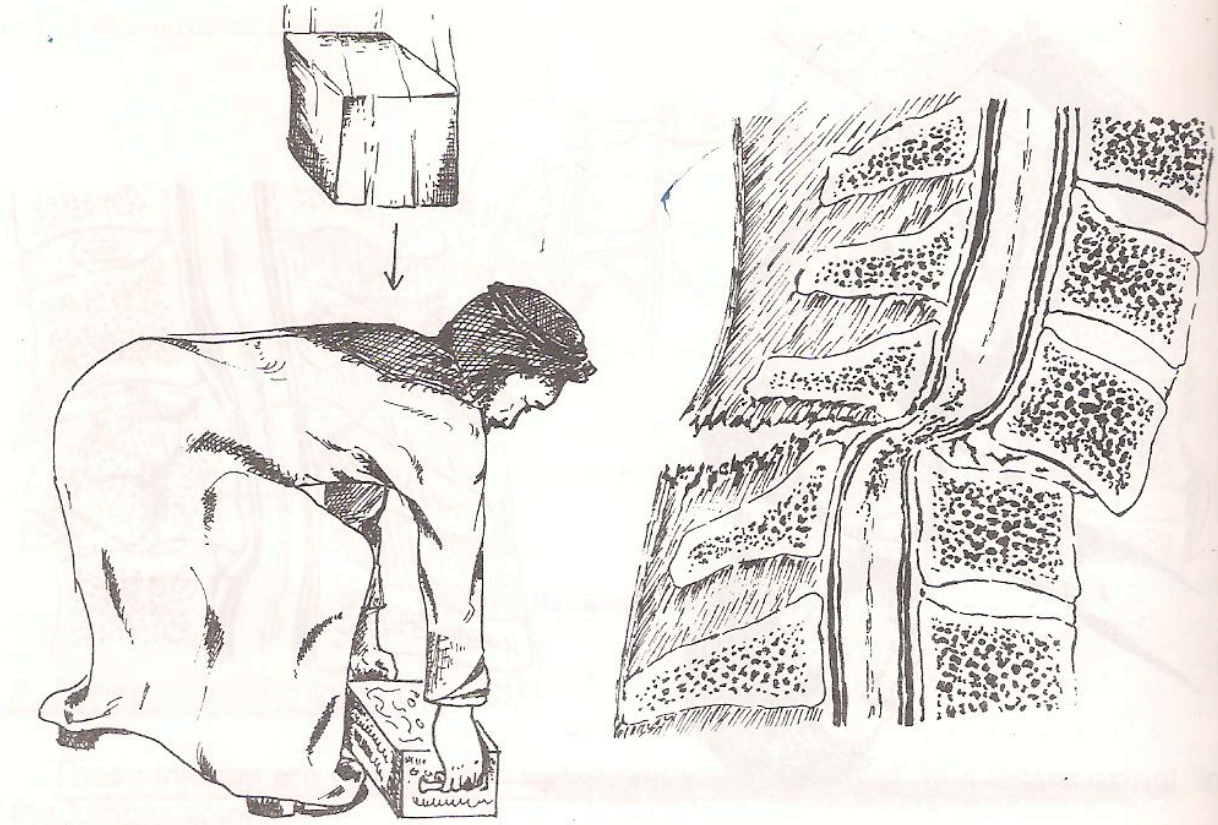


Fig. 133 Shearing force

The following table summarizes the mechanisms and pathology of spinal column injuries.

Force	Segment affected	Type of fracture	Stability	Spinal cord injury
Flexion	Cervical Dorsal Lumbar	Wedge	Stable	Usually not affected
Hyperext.	Cervical	Many forms	Mostly stable	May be affected
Compression	Cervical Lumbar	Burst	Stable	May be affected by backward displacement of bone.
Shearing	Cervical Dorsal Lumbar	Body: slice of bone. Facets: fracture or dislocation	Unstable	Usually affected.

Diagnosis of Spinal Injuries

History

A careful history of exact circumstances and nature of the accident and of the presenting symptoms is important.

Any patient who complains of severe pain in the back with or without loss of sensation or motor control following trauma should be regarded as having a spinal injury until it has been proved otherwise.

Examination

During examination, every effort should be made to prevent all active and passive movements of the spine to avoid the possible damage of the spinal cord in unstable injuries.

1) General examination

The patient with spinal injury has sustained severe trauma, which might cause multiple injuries. It must be remembered that those injuries especially in a quadriplegic, are silent and the patient must be examined for head injuries, chest injuries, abdominal injuries, and associated fractures of the extremities.

2) Local examination

The spine should be carefully examined by inspection for abrasions, haematoma and deformity. Palpate for tenderness and for a gap between spinous processes. The presence of a gap indicates unstable injury.

3) Neurlogical examination

A detailed neurological examination of the patient should be conducted, recording the precise level of sensory and motor deficits using standard dermatome and myotome references (Fig. 134). All deep tendon reflexes and superficial reflexes should be checked including those of the superficial abdominal, the cremasteric, and the plantar reflex (Babinski sign).

4) Investigation

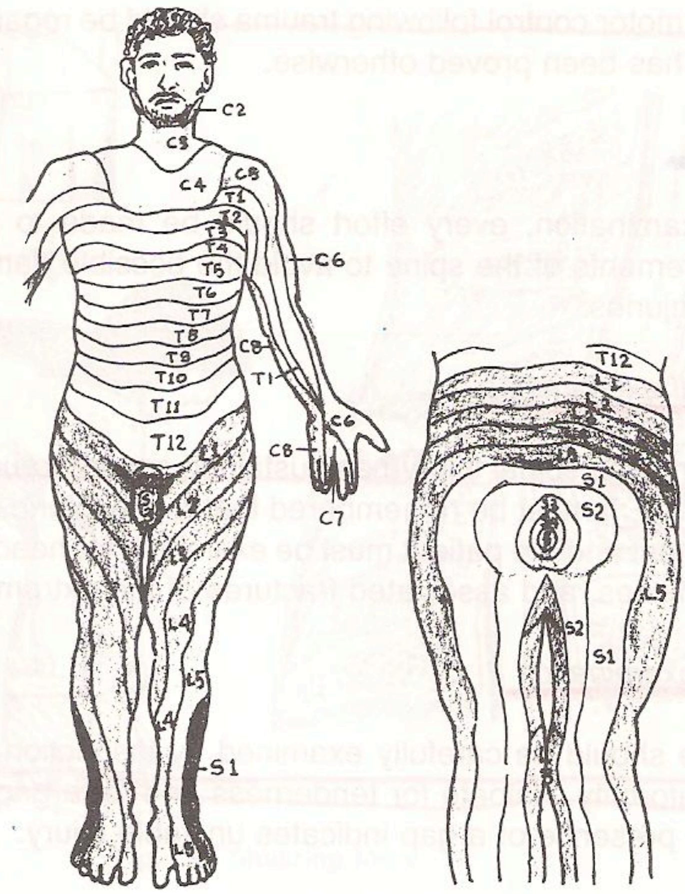
a) Routine X-rays

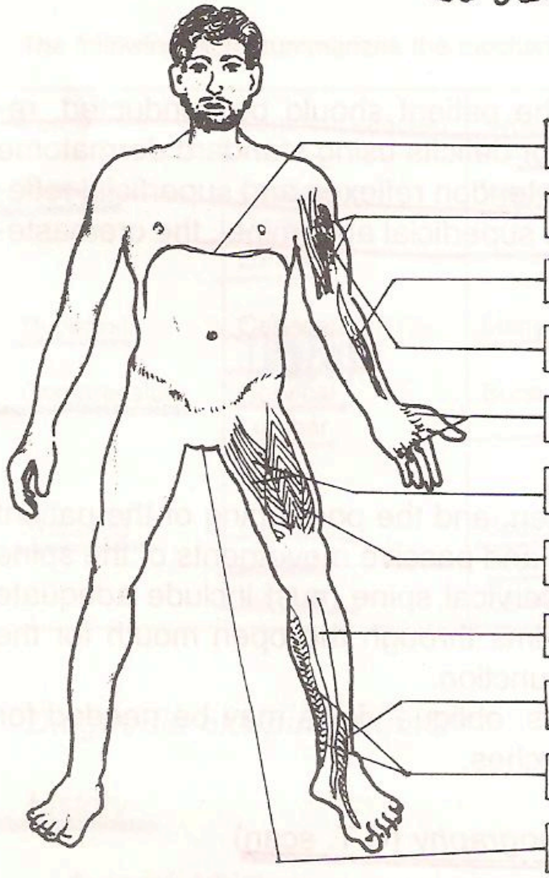
X-rays of the injured areas should be taken, and the positioning of the patient must be done carefully to minimize all active and passive movements of the spine and so prevent further damage. X-rays of cervical spine must include adequate views of the first two vertebrae (including films through the open mouth for the odontoid process) and the cervico thoracic junction.

In addition to routine AP and lateral views, oblique views may be needed for visualization of the facet joints and neural arches.

b) Tomograms and Computerised Tomography (C.T. scan)

These may be useful for clarifying injuries to cervicothoracic junction and the dorsolumbar spine.





FUNCTION	MUSCLES	SEGMENTS
INSPIRATION	DIAPHRAGM	C3, 4, 5
ELBOW FLEXORS	BICEPS BRACHII, BRACHIALIS	C5, 6
WRIST EXTENSOR	EXTENSOR CARPI RADIALIS LONGUS AND BREVIS	C6, 7
ELBOW EXTENSOR	TRICEPS BRACHII	C7, 8
HAND INTRINSICS	INTEROSSEI, THENAR GROUP	C8, T1
HIP ADDUCTORS	ADDUCTOR LONGUS AND BREVIS	L2, 3
KNEE EXTENSORS	QUADRICEPS	L3, 4
ANKLE DORSIFLEXORS	TIBIALIS ANTERIOR	L4, 5
GREAT TOE EXTENSOR	EXTENSOR HALLUCIS LONGUS	L5, S1
ANKLE PLANTARFLEXORS	GASTROCNEMIUS, SOLEUS	S1, 2
ANAL SPHINCTER	SPHINCTER ANI EXTERNUS	S2, 3, 4

Fig. 134 Sensory and motor impairment related to the level of spinal cord injury

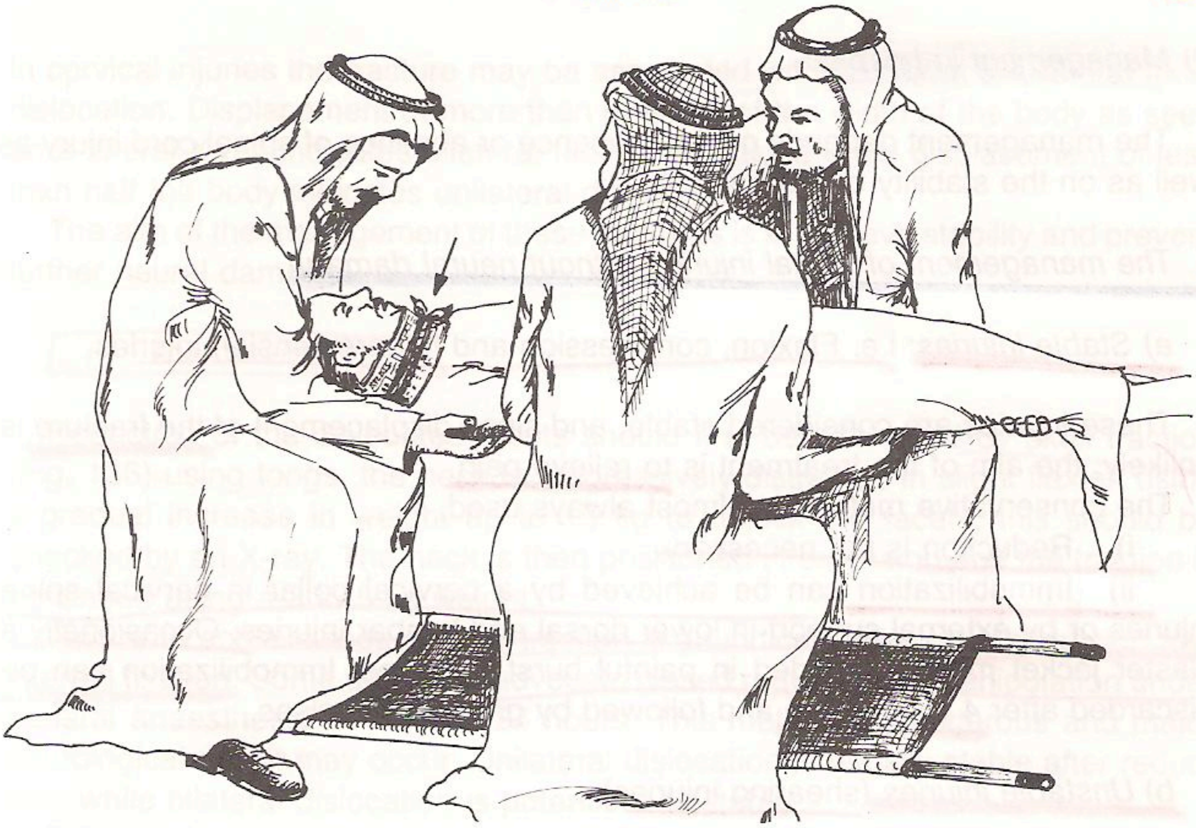


Fig. 135 Lifting a patient with suspected spinal injury

c) Myelography

Myelography for evaluating spinal cord injury is a controversial subject. On some occasions, it may be used to establish sites of obstructions if surgery is contemplated.

d) Magnetic Resonance Imaging (M.R.I.)

This modality helps in evaluating difficult fractures as it shows bones and soft tissues more clearly.

Management of Spinal Injury

1) Rescue and first aid treatment (Fig. 135)

Every effort should be made by the rescuer, at the scene of the injury, to prevent all active and passive movements of the spine specially the cervical spine. Recent evidence has shown that early expert handling of the patient by trained personnel have diminished the incidence of further spinal cord damage.

After ensuring that ventilation and circulation are adequate, the patient should be rolled onto his back. He should ideally be transferred to the ambulance after strapping him to a board or a prepared splint placed behind or under his back and neck. If this is not available or cannot be achieved, the patient must be lifted by three or four people who should maintain horizontal stability and longitudinal traction. Following that, the patient must be transported to the nearest hospital where emergency life saving measures can be carried out if needed.

2) Management in hospital

The management depends on the presence or absence of spinal cord injury as well as on the stability of the fracture.

1. The management of spinal injuries without neural damage

a) Stable injuries; i.e. Flexion, compression and hyperextension injuries.

These injuries are considered stable, and since displacement of the fracture is unlikely, the aim of the treatment is to relieve pain.

The conservative method is almost always used.

i) Reduction is not necessary.

ii) Immobilization can be achieved by a cervical collar in cervical spine injuries or by external support in lower dorsal and lumbar injuries. Occasionally a plaster jacket may be needed in painful burst fractures. Immobilization can be discarded after 4 to 6 weeks and followed by gradual exercises.

b) Unstable injuries (shearing injuries)

These injuries are unstable due to severe disruption of the posterior complex. Further displacement of the fracture and the possibility of neural damage is likely.

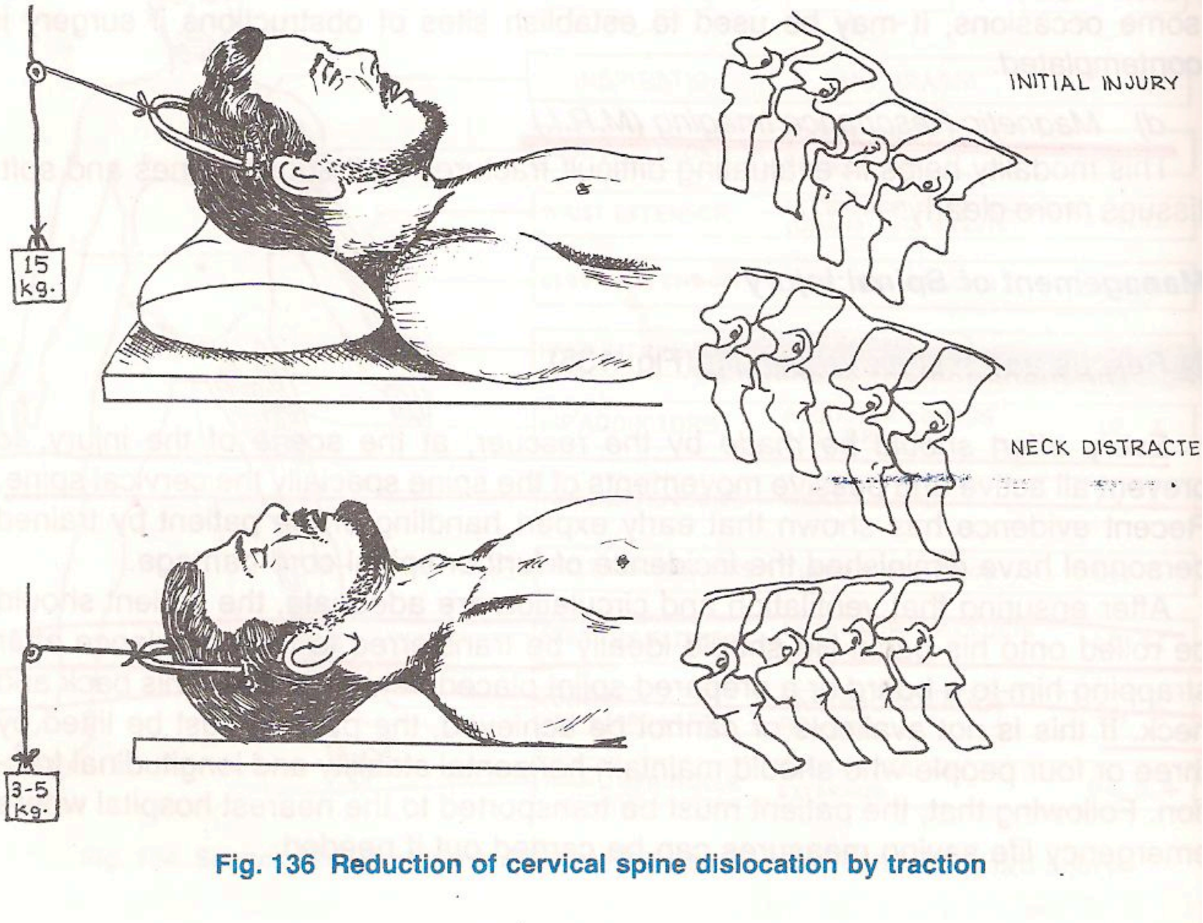


Fig. 136 Reduction of cervical spine dislocation by traction

In cervical injuries the fracture may be associated with unilateral or bilateral facet dislocation. Displacement of more than one half of the width of the body as seen on a lateral X-ray indicates bilateral facet dislocations while displacement of less than half the body indicates unilateral dislocation.

The aim of the management of these fractures is to achieve stability and prevent further neural damage.

i) The cervical spine

Reduction of the dislocated facets should first be attempted by skull traction (Fig. 136) using tongs, the neck is progressively distracted in slight flexion using a gradual increase in weight up to 15 kg to unlock the facets, this should be checked by an X-ray. The neck is then positioned in extension and the traction is continued using a 3 to 5 kg weight.

Failure to achieve reduction by traction is an indication for open reduction and internal fixation. Some surgeons advocate closed reduction by manipulation under general anaesthesia in the first 24 hours. This method is dangerous and major neurological deficit may occur. Unilateral dislocation is usually stable after reduction, while bilateral dislocation is potentially unstable.

Following reduction 6 weeks of bed rest in traction followed by 6 weeks out of bed with external support (cervical collar, Minerva plaster) is usually sufficient to allow for healing of the posterior ligament complex. At the end of this time, if spontaneous ankylosis has not occurred and there is still evidence of instability, spinal fusion should be performed.

ii) Dorso lumbar spine

Open reduction, internal fixation using special screws and plates or rods and fusion of the injured vertebra is preferred. This method has the advantages of restoring alignment, achieving early mobilization and preventing neural damage as well as late instability and re-dislocation.

2. The management of spinal injury with neural damage

a) Local management of the spine

Most spinal surgeons today advocate surgical treatment in order to: Aims

i) Restore alignment.

ii) Decompress neural tissue.
iii) Stabilize the spine by fixation and fusion.
iv) Allow early mobilization and thus help in general care.

Those who advocate conservative management argue as follows:

i) Aligment can be restored in many cases conservatively by traction, manipulation or posturing.

ii) Decompression is not necessary since it has never been demonstrated that fragments of bone or disc in the neural canal either cause further injury or retard recovery.

iii) Most injuries except shearing injuries are inherently stable and so operative stabilization is unnecessary.

iv) Some mobilization can be achieved through active physiotherapy while the patient is still confined to bed.

Both schools of thought agree that surgery is clearly indicated in the following situations:

i) Open wounds like gunshot wounds or stab wounds.
ii) Incomplete neural injury with deterioration.
iii) Gross or late instability.

b) General Management

Spinal cord injury is not simply a malady of the spine, the loss of spinal cord function alters the function of other body systems which must constantly be considered during all phases of treatment.

In patients with cord damage, attention must be directed to:

i) Care of the skin

Insensitive skin will develop trophic ulcers very rapidly if subjected to continuous pressure. To avoid this, the patient should be turned two hourly and the skin kept clean and dry by regular washing and drying with spirit and talcum powder.

ii) Care of the bladder

Following a cord lesion, the bladder is paralysed so that it fills until it overflows (retention with overflow). The bladder should be decompressed by catheterisation until reflex bladder emptying occurs. If infection supervenes, antibiotics are given.

iii) Care of the bowel

Paralysis of abdominal muscles and gut wall give rise to constipation and eventually to 'spurious' diarrhoea. Bowel care is directed towards vacuation by enemas and giving a low residue diet.

iv) Care of the muscles and joints

Passive movements of the joints through full range should be carried out twice a day to prevent flexion deformities.

v) Psychological care

This is aimed at helping the patient and family to deal effectively with all the emotionally unsettling aspects of this injury.

vi) Physical and occupational therapy

This is aimed at teaching the patient skills to achieve optimum function and skills required for self care, such as feeding, bathing, dressing and control of a modified manual or powered wheel chair if the patient is quadriplegic.

vii) Looking to the future

Adaptations may be required to the home such as ramps instead of steps, grab handles, hand nails etc. The work of installing these should be started as soon as it is clear they will be needed. A change of occupation may be required and the patient can use his time in hospital to select and study for a new line of employment.

Injuries at Special Sites

Injuries of C1 and C2 (Atlas and Axis)

These are among the most lethal neck injuries.

1. Flexion forces (Fig. 137)

These forces may produce dislocation associated with rupture of the transverse ligament, although reduction can be achieved by traction with the neck slightly extended, the transverse ligament heals with considerable elongation allowing subluxation of the atlas on the axis. For this reason posterior fusion of C1 to C2 is usually indicated.

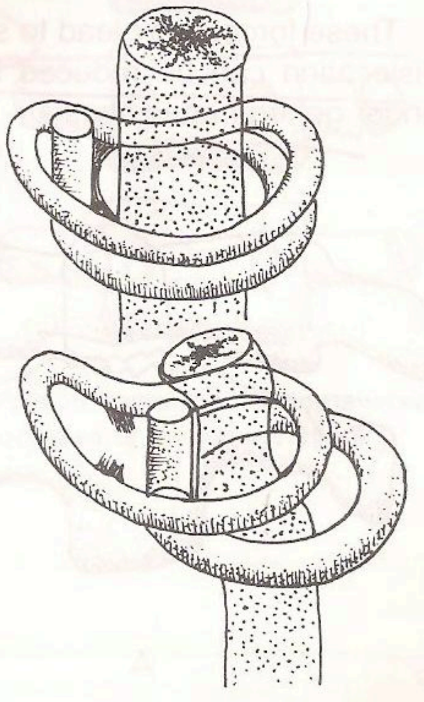


Fig. 137 Rupture of the transverse ligament

2. Extension forces

These forces may produce:

a) Fracture of the anterior arch of atlas

This is usually comminuted and there is rarely any significant displacement. The arch heals well if rested in a collar for about 3 months.

b) Fracture of the Odontoid (Fig. 138)

These may be either displaced or undisplaced.

Undisplaced fractures are not associated with cord damage. They can be seen radiologically if an AP X-ray is taken through the open mouth. Immoblization in a collar for three months is usually sufficient. If the fracture is not united in this time then posterior fusion is indicated.

Displaced fractures are often accompanied by cord damage and a fatal outcome is common. These fractures often fail to unite because the odontoid process is relatively avascular and so posterior fusion of C1 and C2 is usually indicated.

3. Vertical compression forces

These forces rarely produce cord damage. They may lead to a crush fracture of the lateral mass of the atlas. They can be treated in a cervical collar for 8 to 12 weeks which is time needed for the fracture to heal.

4. Rotational forces

These forces may lead to subluxation or dislocation of atlanto-axial facets. The dislocation can be reduced by either continuous skull traction or manipulation under general anaesthesia.

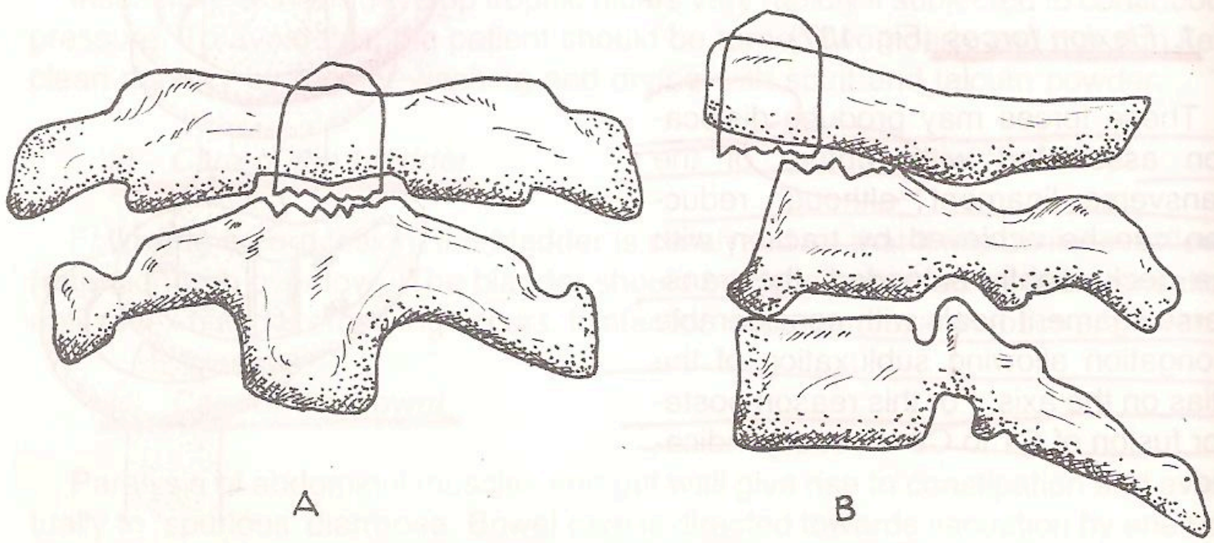


Fig. 138 Fracture of the Odontoid

Whiplash injury

Sudden acceleration in motor vehicles is the usual cause of this injury. The diagnosis of this condition is of considerable medico legal importance. It can be made from the history, the presence of tenderness in cervical spine on deep palpation of the front of the neck and the absence of radiological signs of fracture. Treatment by immobilization in a collar for 6 weeks usually produces satisfactory result.

Avulsion fractures

These occur as a result of resisted muscle action.

In the cervical region, the spinous process of C6 and C7 can be avulsed by the trapezius. This injury is called clay shoveller's fracture (Fig. 139). Treatment is by rest in a collar for 6 weeks.

In the lumbar region, one or more transverse processes can be avulsed by the psoas muscle (Fig. 140). This injury is treated symptomatically. If paralytic ileus develops, as it may in any lumbar vertebral fracture, it will require treatment by gastric aspiration, intravenous fluids and electrolyte balance.

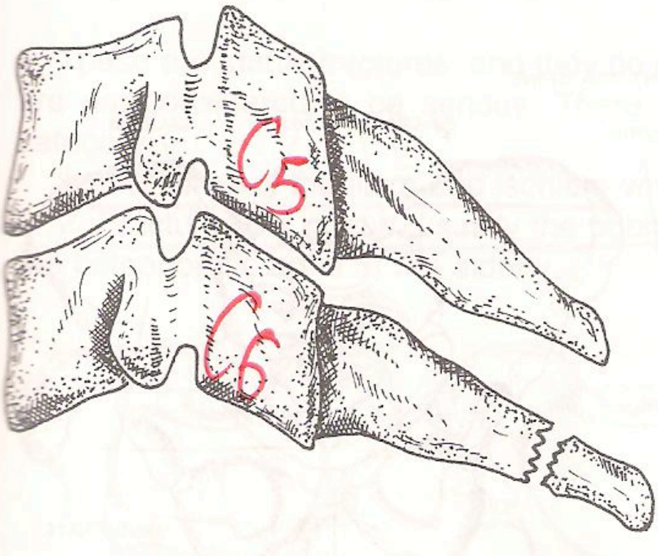


Fig. 139 Clay shoveller's fracture

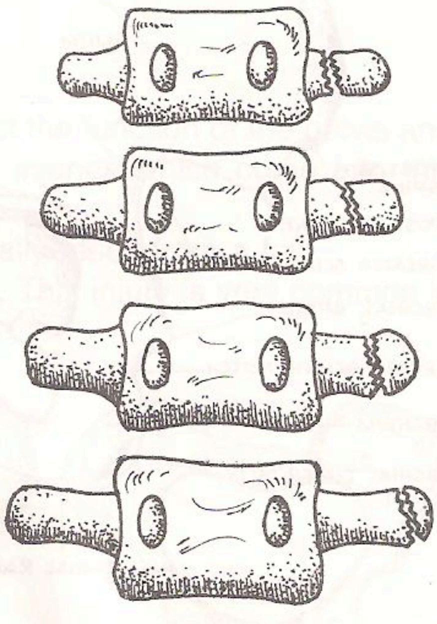


Fig. 140 Avulsion fracture of the transverse processes of the lumbar spine

INJURIES OF THE PELVIS

Anatomy (Fig. 141)

The pelvis consists of a bony ring developed from three main bones namely: Pubis, Ilium and Ischium.

It surrounds and protects the pelvic viscera, lower intestinal tract, the urogenital structures and many large vessels and nerves. In pelvic fractures, injuries of these soft tissues can occur which are more serious than the bony lesion.

The pelvis also affords extensive muscle attachments for the abdominal and lower limb muscles. In the erect position the pelvis is inclined forward with the result that the wedge shaped sacrum tends to force the iliac bones apart. This is prevented by the sacroiliac ligaments particularly those on the dorsum of the sacroiliac joints.

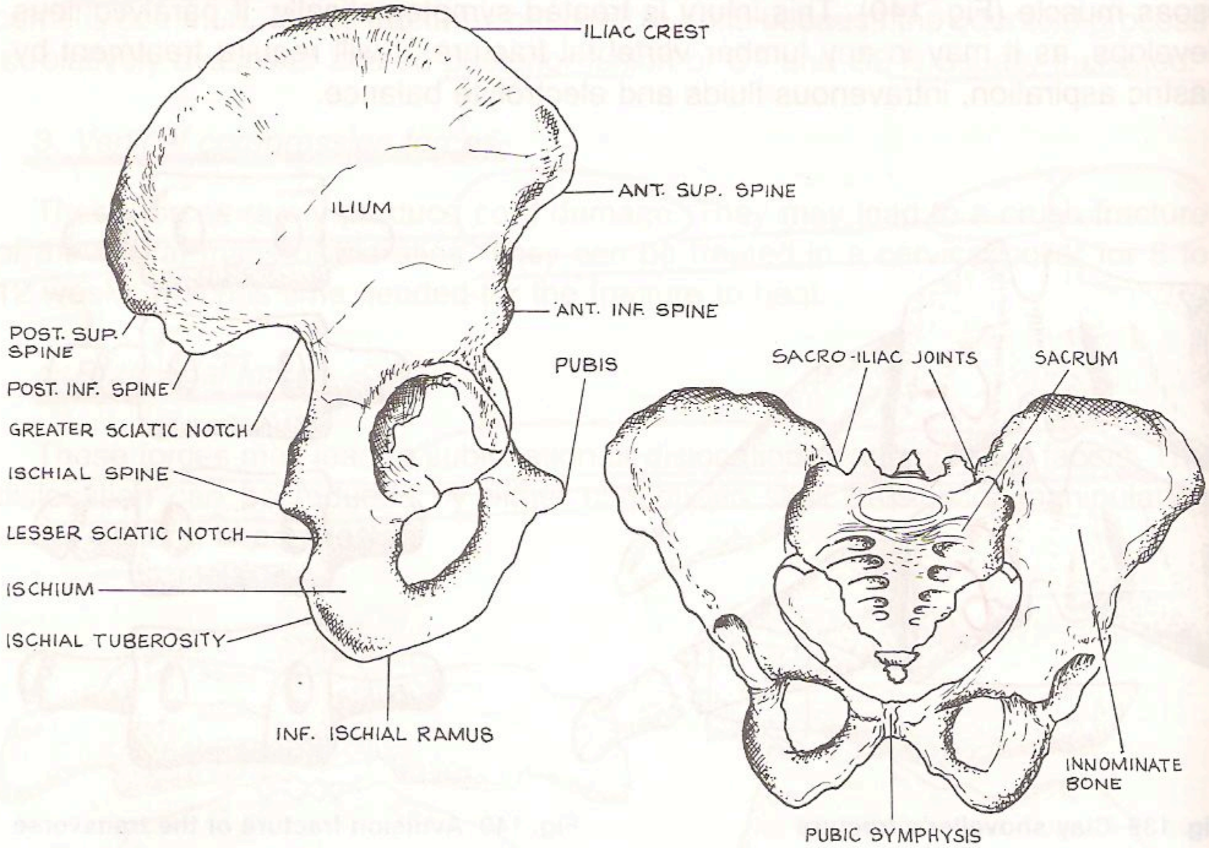


Fig. 141 Anatomy of the pelvis

The mechanical functions of the pelvis

1. Transmission of the body weight.
2. Protection of: a) Blood vessels and nerves, and b) urogenital structures, pelvic viscera and lower intestinal tract.

Classification of Pelvic Injuries

1. Fractures of the pelvis
   a) Stable fractures:
      i) Avulsion fractures, and ii) Single bone fracture
   b) Unstable ring fractures.
2. Sacro coccygeal fractures.
3. Acetabular fractures.

Stable Fractures

Avulsion fractures

These are due to sudden uncontrolled effort of the muscles arising from the pelvis:
1. Avulsion of anterior inferior iliac spine by the rectus femoris muscle.
2. Avulsion of anterior superior iliac spine by the sartorius muscle.
3. Avulsion of a piece of pubis by the adductor longus.

These avulsion fractures do not affect the function of the pelvis and are treated by rest for few days if necessary because of pain.

Single bone fractures (Fig. 142)

These are stable fractures, and they do not affect the function of the pelvis and are not considered to be serious. There are two injuries which come into this category:
1. Fractures of the ilium and ischium which usually result from a fall.
2. Fracture of a ramus, usually the pubic ramus. This injury is very common in the osteoporotic bone of the elderly.

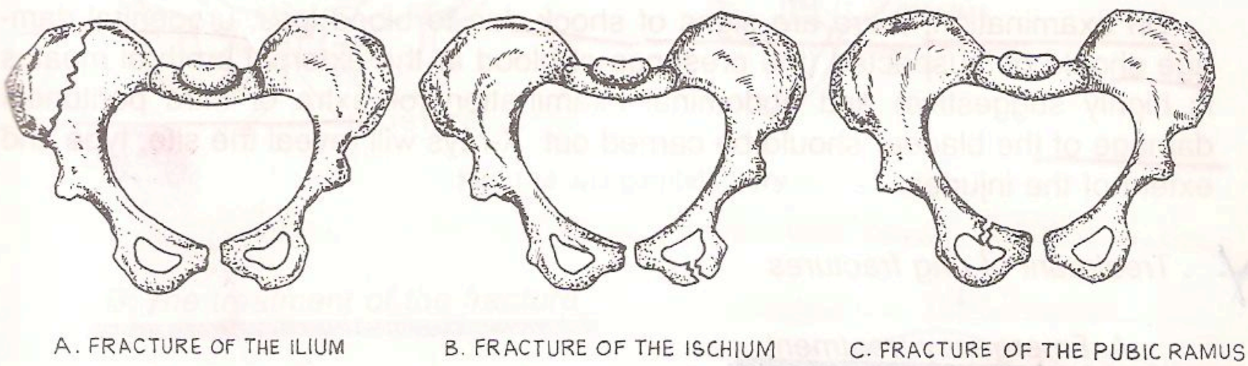


Fig. 142 Single bone fracture

Treatment

These fractures do not affect the stability and usually are not associated with injury to internal organs. Treatment is symptomatic by allowing the patient to rest until sufficiently comfortable to commence walking.

Unstable ring fracture (Fig. 143)

In these injuries the bony ring gives way into two places which may affect both functions of the pelvis.

The possible mechanisms of injury are:

1. Antero-posterior compression which fractures the pubic rami on both sides.
2. Hinge force, which is applied to one blade of the ilium and opens the pelvis. (open book pelvis)
3. A vertical force due to a fall onto one leg, causing vertical displacement of the pubis and ilium on the same side.

Clinical picture

The unstable ring fractures are extremely serious injuries. The incidence of visceral damage, retro-peritoneal haematoma and affection of weight transmission is high. The patient presents with pain and inability to stand or walk and may also be unable to micturate.

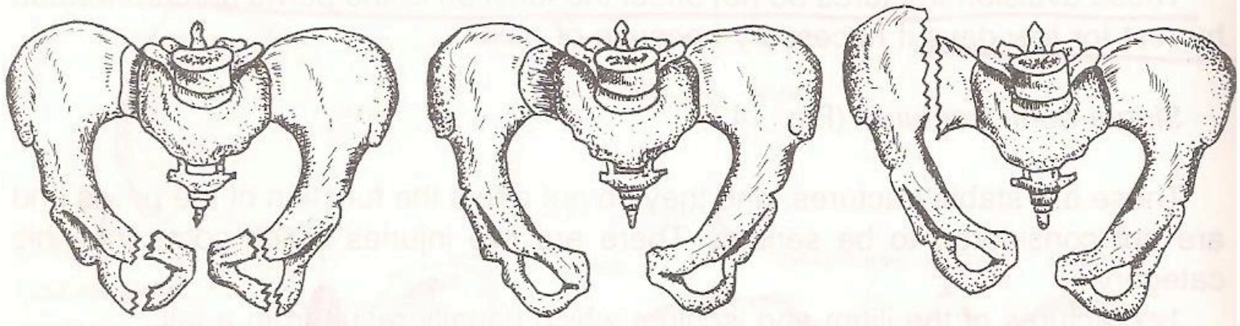


Fig. 143 Unstable ring fracture

On examination, there are signs of shock due to blood loss, urogenital damage should be suspected (the presence of blood at the external urethral meatus is highly suggestive) and abdominal examination for extra or intra peritoneal damage of the bladder should be carried out. X-rays will reveal the site, type and extent of the injuries.

Treatment of ring fractures

A. Emergency treatment

This should be directed towards treating hypo-volaemic shock, urogenital damage (Fig. 144) and to stabilize the fracture.

i) Bladder injuries: These can be intra or extra peritoneal. Once diagnosed, the treatment is surgical. The bladder rupture is repaired and the bladder drained via catheter.

ii) Rupture of the urethra: This injury should be suspected in any male with a pelvic disruption, particularly a pubic symphysis disruption. Clinically the patient is usually shocked, there may be considerable scrotal bruising and swelling which extends into the perineum, and there is frequently some meatal bleeding. The diagnosis can be confirmed by a retro-grade urethrography using a dilute aqueous contrast medium, or by gentle catheterization.

The treatment of the urethral rupture is surgical by re-alignment and suturing of the ends of the urethra. A catheter is left in situ for 3 weeks and the retro-pubic space is drained.

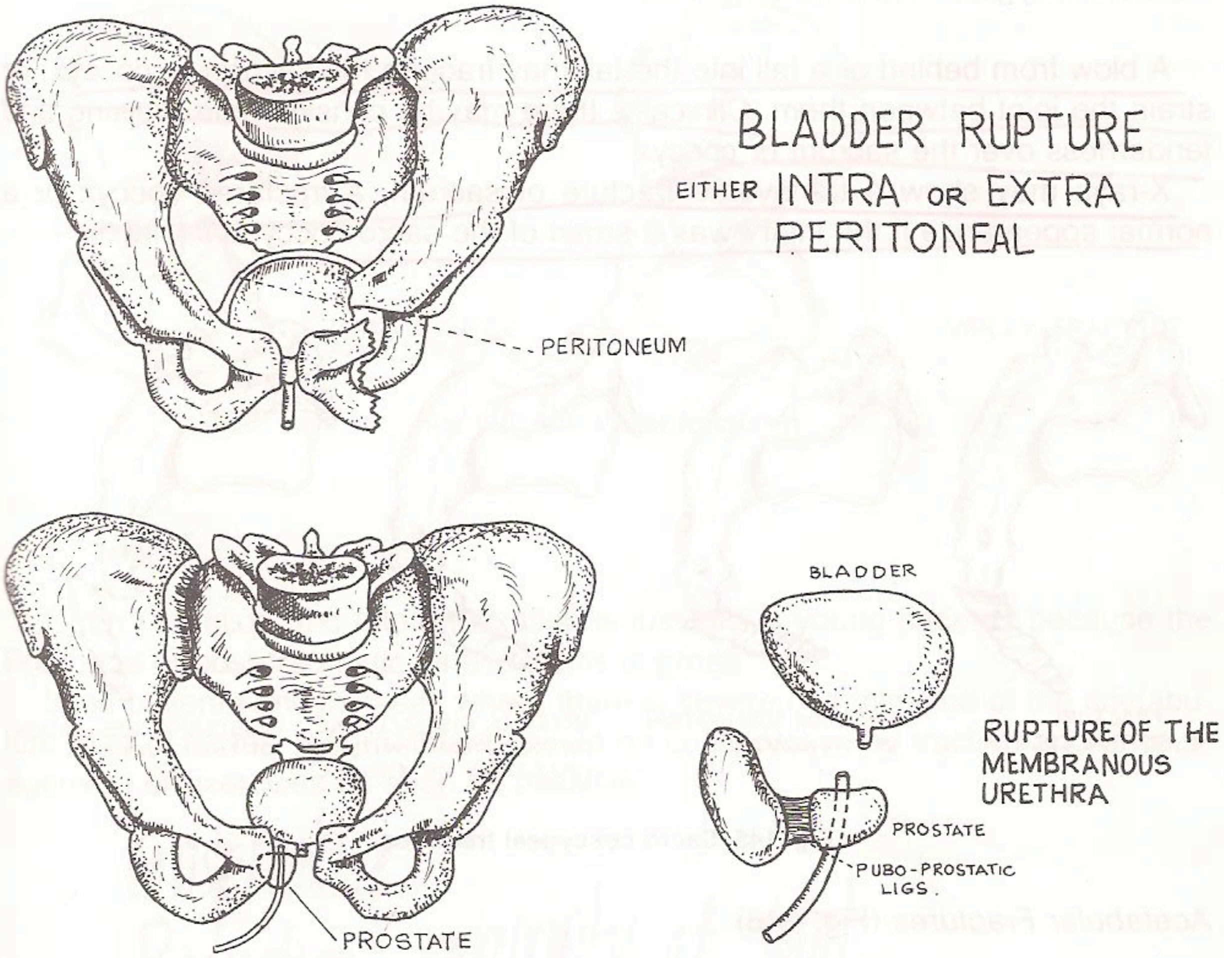


Fig. 144 Urogenital injury

B. The treatment of the fracture

i) The compression type: The patient should be rested in bed for three weeks, during which active movement of the hip and spine are encouraged. Following this, walking and normal weight-bearing are commenced. Displacement or failure of union does not interfere with weight bearing.

ii) Hinge type: Reduction is possible either by conservative methods in which cross traction is applied or manipulation under anaesthesia wherein the patient is rolled onto his unaffected side, and the surgeon leans on the affected side and so closes the pelvis. If closed methods fail, open reduction with internal fixation, or an external fixator may be used. It usually takes 3 to 4 months before the patient has regained full activity.

iii) Vertical force type: The fracture can be reduced by longitudinal downward pull of the leg on the affected side under anaesthesia followed by skeletal traction for 6 weeks. The patient is then allowed up with crutches, but should not bear weight for 3 months after the injury.

Sacro Coccygeal Fractures (Fig. 145)

A blow from behind or a fall into the tail may fracture the sacrum or coccyx, or strain the joint between them. Clinically, there may be considerable bruising and tenderness over the sacrum or coccyx.

X-rays may show a transverse fracture of sacrum, a fractured coccyx or a normal appearance if the injury was a strain of the sacro-coccygeal joint.

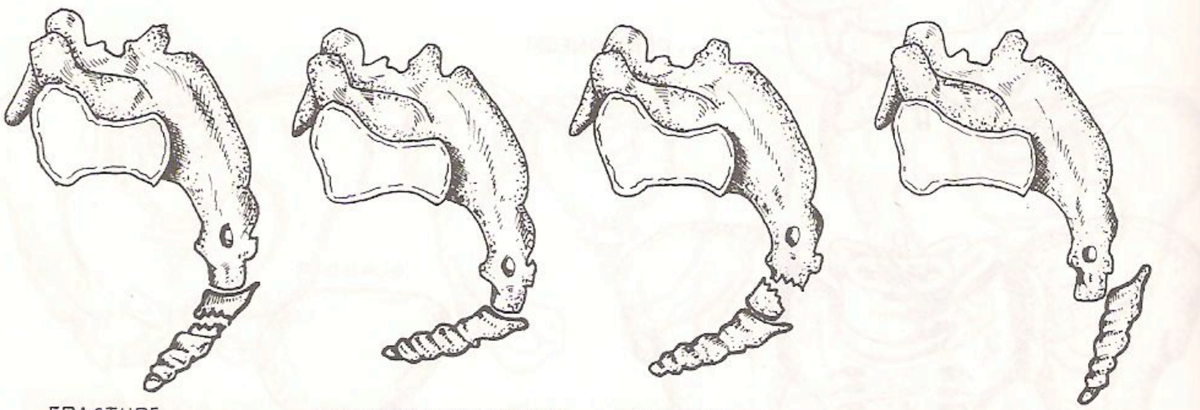


Fig. 145 Sacro coccygeal fractures

Acetabular Fractures (Fig. 146)

There are four major types of acetabular fractures.

i) Fracture of the anterior pillar: This is uncommon and does not involve the weight bearing area.

ii) Fracture of the posterior pillar: This fracture involves the weight bearing area and is usually associated with posterior hip dislocation. Injury to the sciatic nerve may occur.

iii) Tranverse fracture.

iv) Complex Fracture.

Most acetabular fractures are complex injuries which damage either the anterior or posterior segments or both, as well as the roof of the acetabulum. These fractures are difficult to reduce and the end result is likely to be less than perfect.

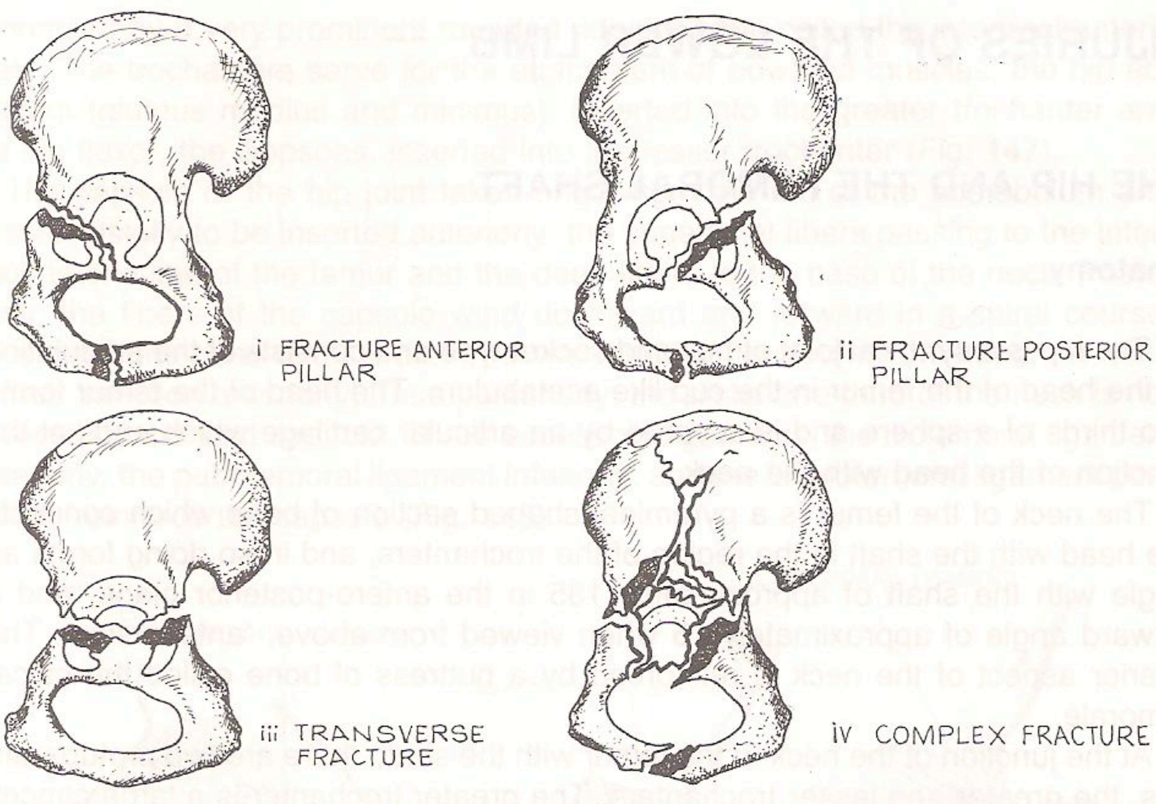


Fig. 146 Acetabular fractures

Treatment

Open reduction and internal fixation is justified in young patients because the likelihood of post-traumatic osteoarthritis is great.

In all patients and in cases where there is severe comminution of the acetabulum 'bag of bones' the treatment should be conservative by traction and encouragement of exercises as soon as possible.

- Conservative :
  Reduction - conjruity of joint
- Operative :
  ORIF

- Sciatic nerve injury
- Urogenital injuries
- Osteoarthritis hip
- Heterotropic ossificati

INJURIES OF THE LOWER LIMB

THE HIP AND THE FEMORAL SHAFT

Anatomy

The hip is a synovial joint of ball and socket type and consists of the articulation of the head of the femur in the cup like acetabulum. The head of the femur forms two thirds of a sphere and is covered by an articular cartilage which ends at the junction of the head with the neck.

The neck of the femur is a pyramidal shaped section of bone which connects the head with the shaft in the region of the trochanters, and in so doing forms an angle with the shaft of approximately 135 in the antero-posterior plane, and a forward angle of approximately 15 when viewed from above, 'anteversion'. The inferior aspect of the neck is reinforced by a buttress of bone called the calcar femorale.

At the junction of the neck of the femur with the shaft, there are two protuberances, the greater and lesser trochanters. The greater trochanter is a large cancellous bony prominence at the upper outer end of the shaft of the femur which can be easily palpated through the skin. The lesser trochanter is a conical prominence projecting medially at the junction of the inferior aspect of the neck and the shaft of the femur.

On the anterior surface, the trochanters are joined by a rough, oblique ridge of bone called the intertrochanteric line which runs from the greater trochanter to a point just anterior to the lesser trochanter, and, on the posterior aspect, they are

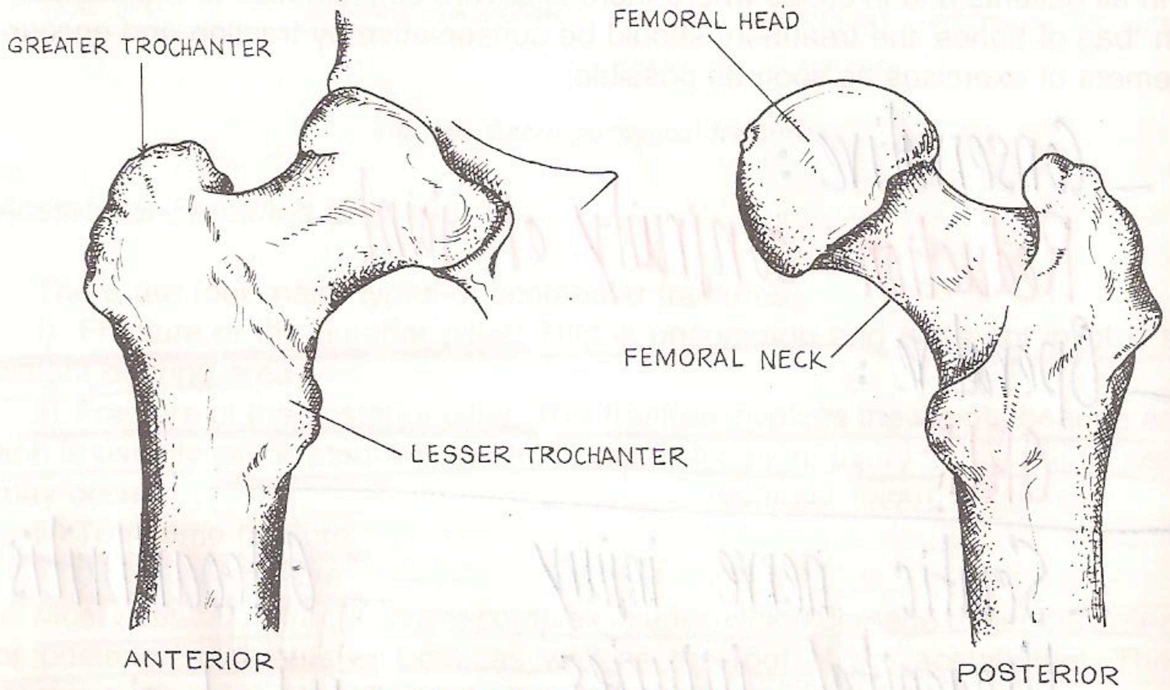


Fig. 147 Bony anatomy of the hip

connected by a very prominent rounded ridge of bone called the intertrochanteric crest. The trochanters serve for the attachment of powerful muscles, the hip abductors (gluteus medius and minimus), inserted into the greater trochanter and the hip flexor, the iliopsoas, inserted into the lesser trochanter (Fig. 147).

The capsule of the hip joint takes origin from the rim of the acetabulum and passes distally to be inserted anteriorly, the superficial fibers passing to the intertrochanteric line of the femur and the deep fibers to the base of the neck. Posteriorly, the fibers of the capsule wind downward and forward in a spiral course, enveloping the head and the proximal two-thirds of the neck of the femur en route to their insertion anteriorly. Thus posteriorly, the distal one-third of the neck is not covered by the joint capsule. Three accessory ligaments, the iliofemoral ligament anteriorly, the pubofemoral ligament inferiorly, and the ischiofemoral ligament posteriorly reinforce the capsule (Fig. 148).

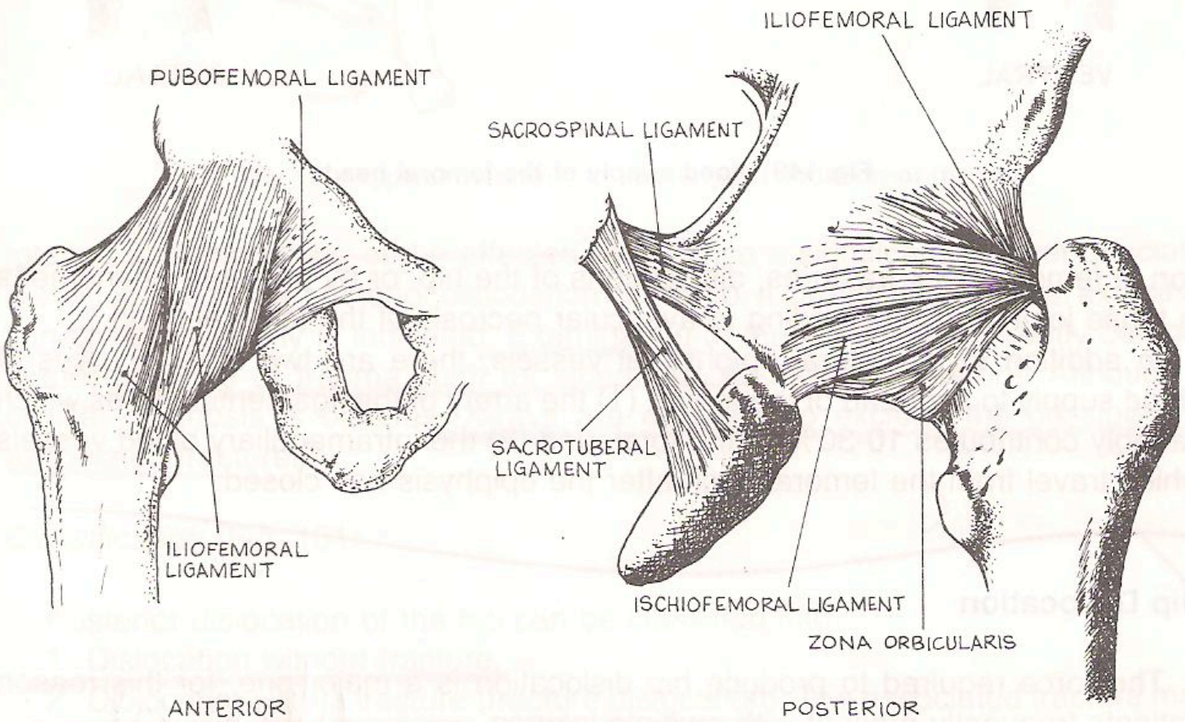


Fig. 148 Capsular and ligamentous attachments of the hip

Within the capsule, the hip joint is lined by a synovial membrane except where there is articular cartilage. This synovial membrane is raised into several longitudinal loose folds around the neck of the femur called the retinaculum, in which the arteries ascend to supply the head of the femur.

The arterial blood supply to the femoral head (Fig. 149) is derived from several sources, with the major contribution coming from the lateral epiphyseal vessels which are branches of the medial femoral circumflex artery. These vessels enter the hip joint at the base of the femoral neck predominantly on the posterosuperior aspect, and travel along the femoral neck in the retinacular lining, closely apposed to the bone reaching and piercing the head at the junction of the head and neck.

The clinical relevance of this blood supply is its extreme vulnerability to disrup-

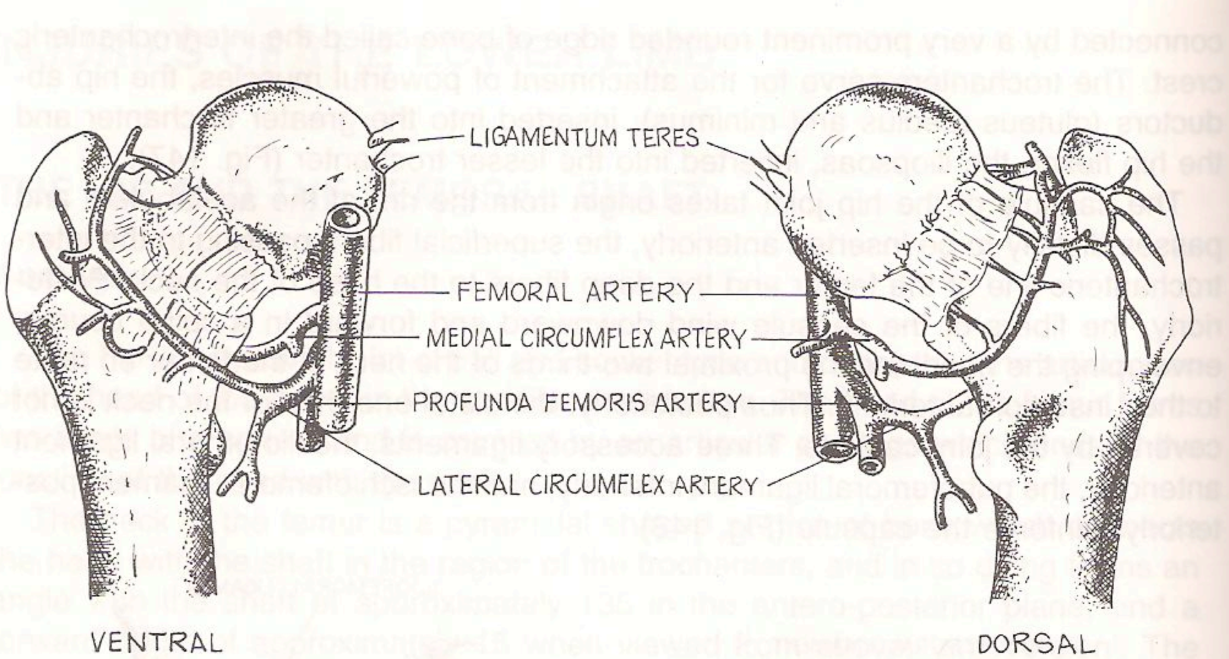


Fig. 149 Blood supply of the femoral head

tion in femoral neck fractures, dislocations of the hip, or by pressure phenomena in tense joint effusions leading to avascular necrosis of the femoral head.

In addition to the lateral epiphyseal vessels, there are two other sources of blood supply to the head of the femur, (1) the artery of the ligamentum teres which variably contributes 10-30% of the total, and (2) the intramedullary blood vessels which travel from the femoral neck after the epiphysis has closed.

Hip Dislocation

The force required to produce hip dislocation is a major one, for this reason patients frequently present with multiple injuries.

Depending on the degree and direction of the force, the hip may dislocate: (1) Posteriorly, (2) centrally, and (3) anteriorly.

1. Posterior Dislocation

This is the most common type. The vast majority of cases are due to road traffic accidents in which the patient's knee strikes the dashboard with the hip slightly adducted.

Diagnosis

Following the injury, the patient complains of severe pain in the hip region and inability to move. The typical deformity (Fig. 150) is flexion, adduction, internal

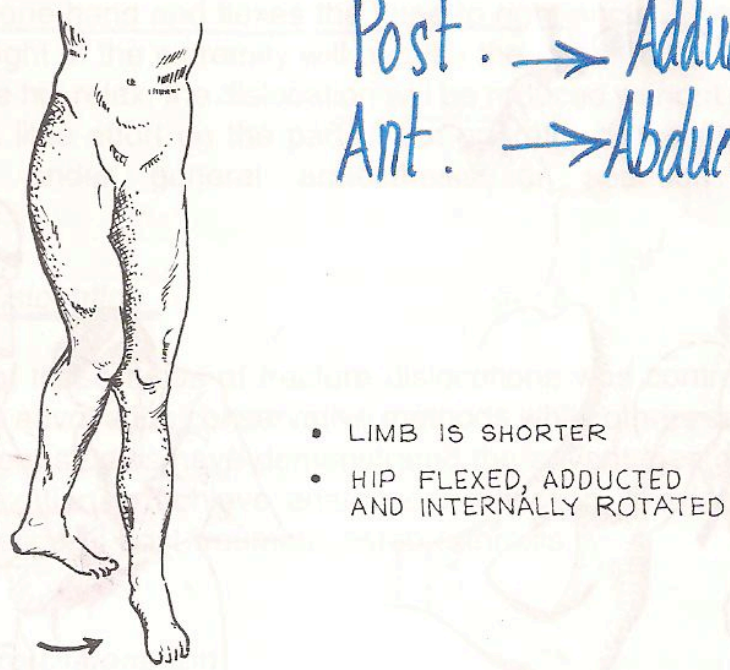


Fig. 150 Typical deformity in posterior dislocation of the hip

rotation and shortening of the affected limb. Since a significant number of sciatic nerve injuries follow posterior dislocation of the hip, a careful neurological examination of the extremity is indicated. Examination of the knee will frequently demonstrate evidence of trauma such as laceration, abrasion or fracture. Although a clinical diagnosis is obvious, X-rays are essential to exclude the possibility of associated fractures.

Classification (Fig. 151)

Posterior dislocation of the hip can be classified into:

1. Dislocation without fracture.
2. Dislocation with a fracture (fracture dislocation): The associated fracture may be large single fracture of posterior rim (the commonest), comminuted fracture of acetabulum rim, fracture of acetabular rim and floor or fracture of the femoral head.

Management

1. Dislocation without fracture

Anatomical reduction of the dislocated hip should be carried out as an emergency so as to minimize the incidence of complications. This can be achieved, almost always, by conservative method, *i.e.* closed reduction by manipulation under general anaesthesia, followed by immobilization using traction with the hip in slight abduction. Once there is painless motion at the hip the patient will be allowed up on crutches. Protective weight bearing is then carried on for a total of 10 to 12 weeks.

Fig. 151 Posterior dislocation of the hip

Fig. 152 Allis technique

Techniques of manipulation

a) Allis technique (most commonly used), Fig. 152: Under general anaesthesia the patient lies supine on his back, an assistant immobilizes the pelvis by pressing downwards on the anterior superior spines, the operator then flexes the hip and knee to right angles while maintaining the lower extremity in slight adduction and internal rotation, the flexed limb is then lifted upward drawing the head of the femur over the rim of the acetabulum and through the rent in the capsule. The limb is then gently lowered and traction for immobilization is then applied.

Fig. 153 Stimson technique

b) Stimson technique (Fig. 153): The concept is to use the weight of the extremity to aid in the reduction, the patient is placed face down and both lower limbs hanging over the edge of the table, the operator grasps the ankle of the involved limb with one hand and flexes the knee to right angle. The hip is now at 90° flexion, the weight of the extremity will provide the required traction. Once the muscles around the hip relax, the dislocation will be reduced without difficulty. This technique requires little effort on the part of the operator or the patient and can be done either under general anaesthesia or sedation using morphine or diazepam.

2. *Fracture dislocation*

The treatment of these types of fracture dislocations was controversial in the past, some authors advocating conservative methods while others prefered operative methods. Recent studies have demonstrated the advantages of open reduction and internal fixation to achieve anatomical reduction, provide stability and minimize the incidence of post-traumatic osteo-arthrosis.

2. Central Fracture Dislocation

A direct lateral blow to the trochanteric area may fracture the acetabular floor and thus thrust the femoral head into the pelvis. This occurs mostly in road traffic accidents and occassionally following a fall on the side.

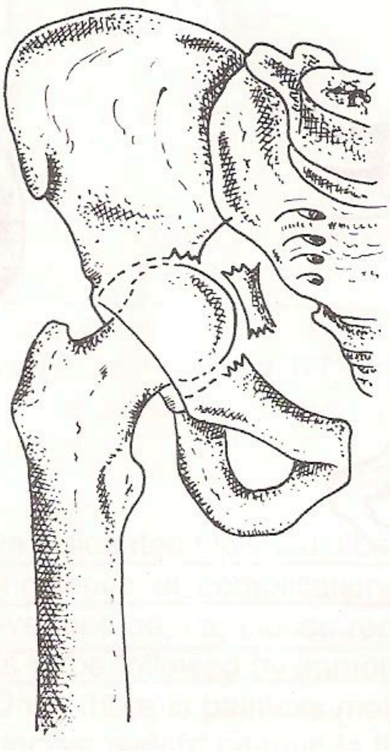


Fig. 154 Central fracture dislocation

Diagnosis

The patient complains of severe pain and inability to move the hip following trauma. Local examination reveals no obvious deformity, *i.e.* the limb looks normal, a bruise and tenderness over the trochanteric and/or hip area is present. Attempts to move the hip are very painful. A routine x-ray will show the central fracture dislocation (Fig. 154). To assess the injury of the inner wall of the acetabulum, CT scan (computerized tomography) is valuable.

Classification

Type 1. Intact acetabular roof with a large displaced fragment.
Type 2. Completely disorganised acetabulum (bag of bones).

Management

In type 1 anatomical reduction is possible and advisable so as to minimize the incidence of complications. This could be achieved by operative means, *i.e.* open reduction and internal fixation (Fig. 155).

In type 2 anatomical reduction is not possible, so our aim is to mould a new socket within the frame work of the medially displaced and shattered acetabulum. This is best achieved by conservative means, *i.e.* traction for six weeks followed by mobilization with minimal weight bearing for three months. The patient should use crutches during that period.

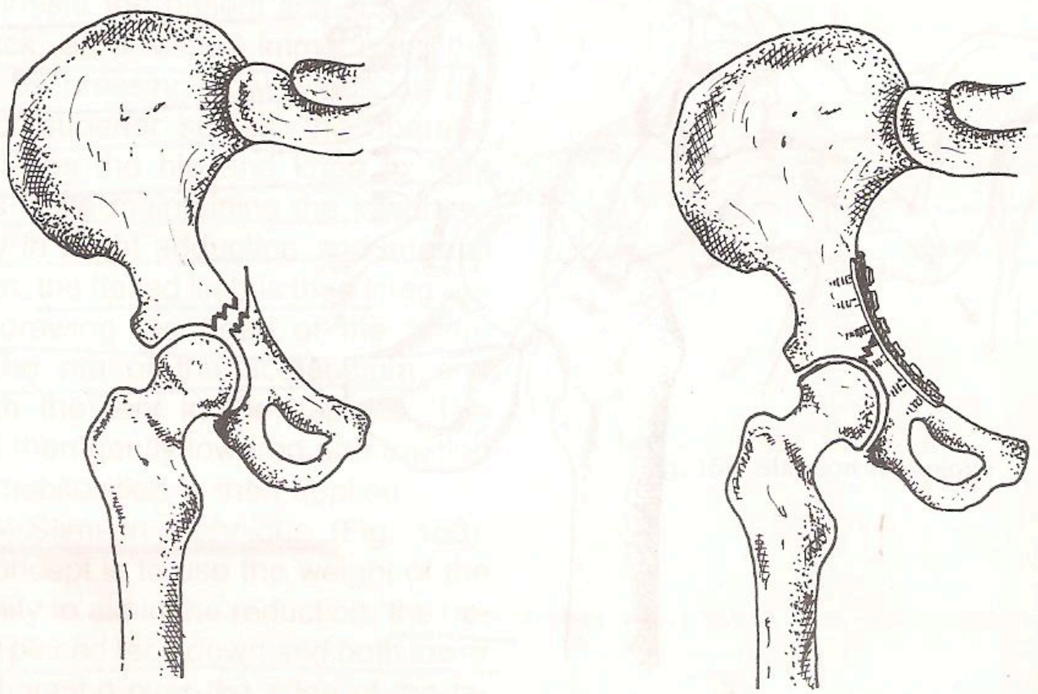


Fig. 155 Internal fixation of type 1 central fracture dislocation

3. Anterior Dislocation

This is the least common type, it occurs mostly in road traffic accidents when the patient's knee is driven against the dash board with the thigh in a position of abduction. Also a direct blow on the posterior aspect of the abducted and externally rotated thigh, as caused by a fall from a height may cause anterior dislocation.

The patient complains of severe pain and inability to move the hip. The typical deformity is flexion, abduction, and external rotation of the involved limb (Fig. 156). In thin patients the head of the femur may be palpated in the groin or in the vicinity of the anterior iliac spine.

In dashboard injury, examination of the knee will frequently demonstrate evidence of trauma such as laceration, abrasion or fracture.

X-ray: Routine AP and lateral views will reveal the dislocation of the hip and the position of the femoral head (Fig. 157).

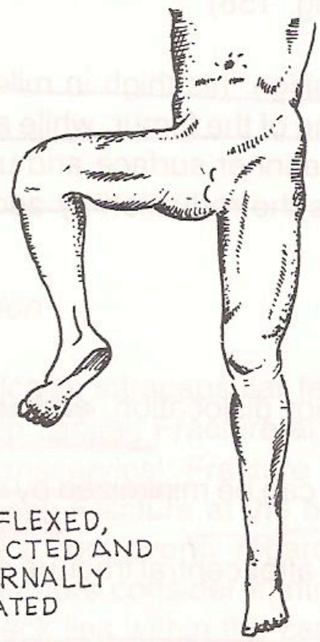


Fig. 156 Typical deformity

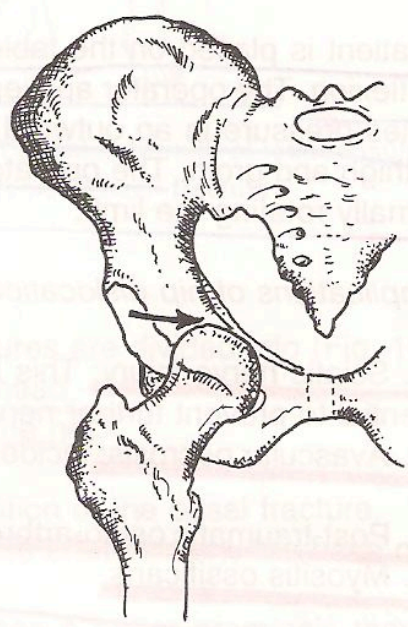


Fig. 157 Anterior dislocation of the hip

Management

Anatomical reduction of the dislocated hip should be carried out as an emergency so as to minimize the incidence of complications. This could be achieved almost always by conservative method, *i.e.* closed reduction by manipulation under general anaesthesia, this to be followed by immobilization using traction with the hip in slight abduction. Once there is painless motion at the hip the patient is allowed up on crutches. Protective weight bearing is then carried on for a total of 10 to 12 weeks.

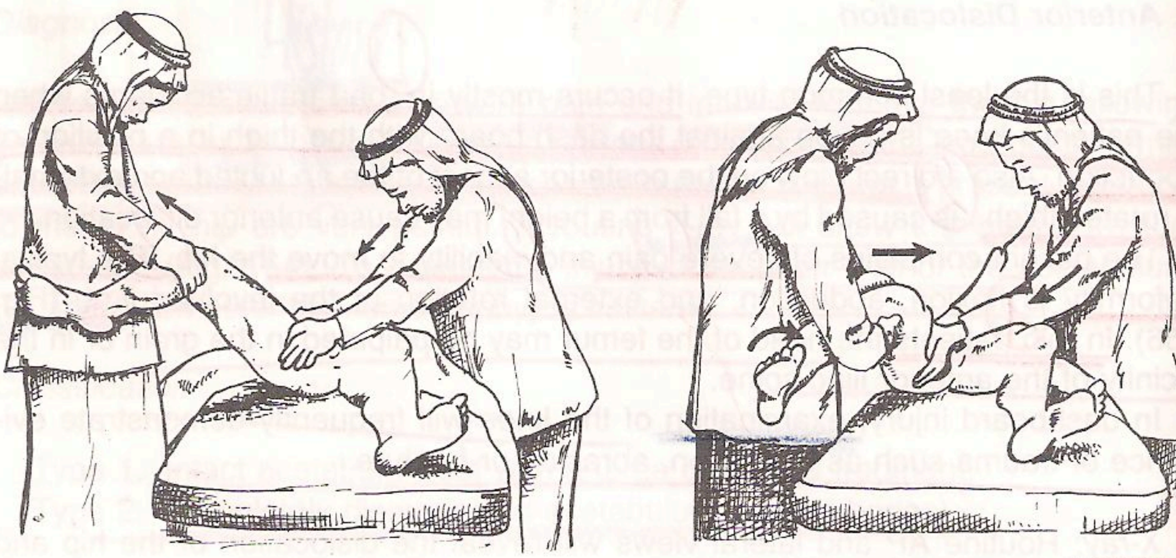


Fig. 158 Reduction of anterior dislocation of the hip

Technique of manipulation (Allis technique, Fig. 158)

Patient is placed on the table in a supine position, his thigh in mild abduction and flexion. The operator applies traction in the line of the femur, while an assistant applies pressure in an outward direction over the inner surface and upper 1/3 of the thigh and groin. The operator then completes the reduction by adduction and internally rotating the limb.

Complications of hip dislocation

1. Sciatic nerve injury: This is seen in posterior dislocation, early reduction is essential to prevent further nerve damage.
2. Avascular necrosis: Incidence 20-30%, this can be minimized by early reduction.
3. Post-traumatic osteo-arthrosis (mainly seen after central fracture dislocation).
4. Myositis ossificans.

Fractures of the Femoral Neck

Fractures of the femoral neck are primarily an injury of the aged. It was first diagnosed by Ambrose Pare (1510-1590), at that time treatment depended on splints, and bed rest. In 1902 Whitman introduced the concept of closed manipulation followed by immobilization in a hip spica. Surgical intervention was introduced by Smith Peterson who, in 1931, reported a series of patients treated by triflange nail. Since that time more advances were made to improve the devices for internal fixation.

Fractures of the femoral neck are generally divided into: a) Intra capsular, and b) extra capsular.

1. Intra Capsular Femoral Neck Fractures

This fracture is mostly due to an indirect type of injury such as a fall. The force is usually trivial. It mostly affects older age group with a female predominance.

Diagnosis

Following the injury the patient presents with pain in the hip region and is unable to walk.

The typical deformity is external rotation and shortening of the affected limb (Fig. 159). There is local tenderness in the groin and the movements are painful. X-rays will confirm the diagnosis and establish the site, type and grade of the fracture.

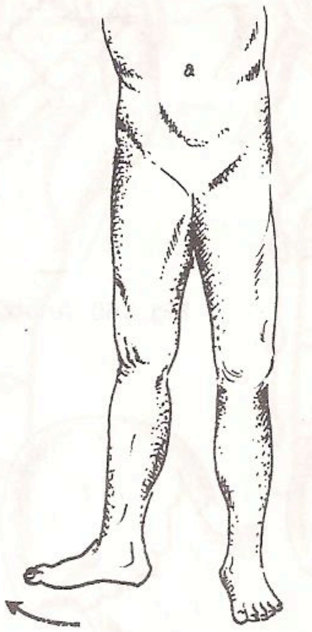


Fig. 159 Typical deformity of intracapsular femoral neck fracture

Classification

Anatomically, intracapsular femoral neck fractures are divided into (Fig. 160):

1. Sub capital: Fracture at the base of the head.
2. Transcervical: Fracture in midportion of the neck.
3. Basal: Fracture at the base of the neck.

There is a controversy regarding the classification of the basal fracture.

Some authors consider it intracapsular because anatomically, the base of the fermoral neck lies within the capsule anteriorly.

Others consider it extracapsular because it has a better prognosis than the subcapital and transcervical ones.

With this classification, the prognosis and possible complications can not be easily predicted, and for that reason other classifications have been devised such as Garden's classification which is based on the anatomical relationship of the proximal to the distal fragment (Fig. 161).

Type I: Incomplete fracture.
Type II: Complete fracture with no or minimal displacement.
Type III: The fracture is displaced but the posterior retinaculum is intact.
Type IV: The fracture is displaced and the posterior retinaculum is disrupted.

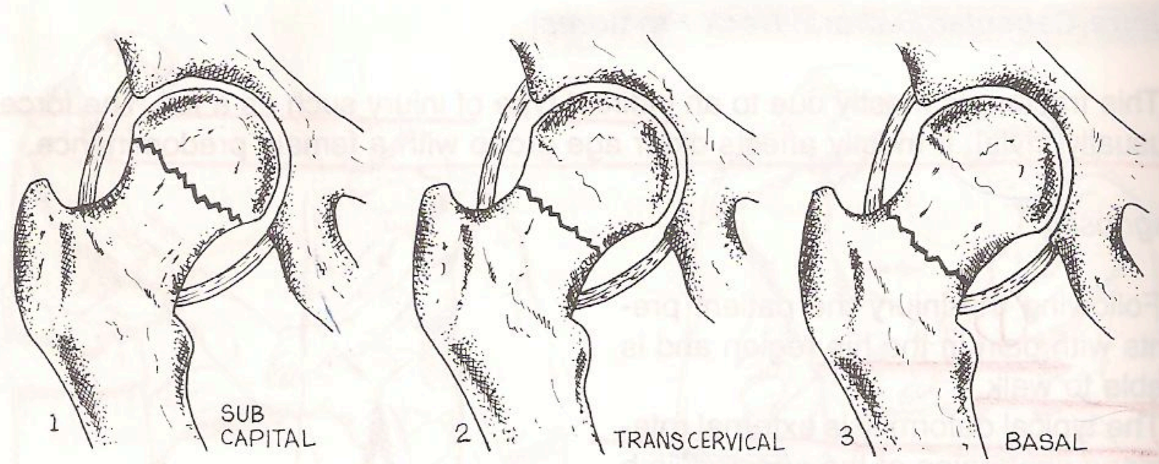


Fig. 160 Anatomical classification

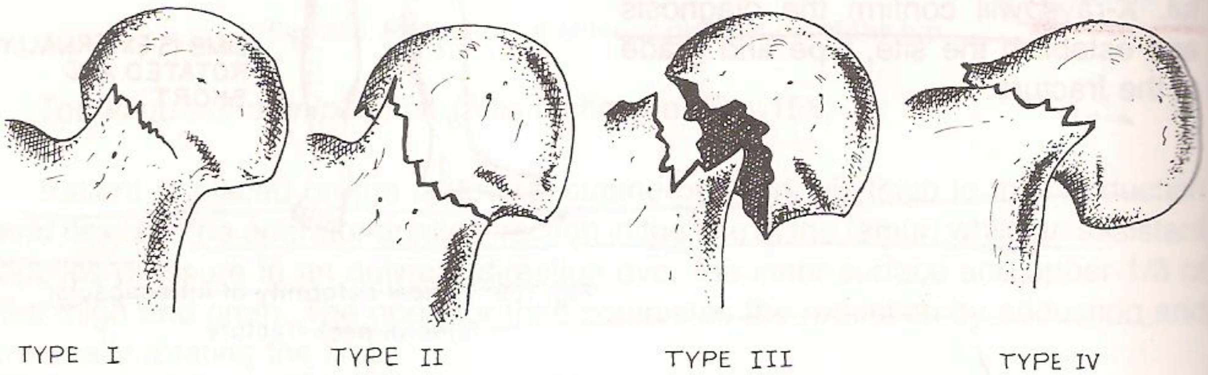


Fig. 161 Garden's classifications

Management

In the management of intracapsular femoral neck fractures, our aims should be:

1. Prevention of movement at fracture site so as to prevent further damage to the blood supply of the head to minimise complications such as avascular necrosis and nonunion.

2. Mobilization of the patient as quickly as possible to avoid the disastrous complications of prolonged immobilization such as hypostatic pneumonia, deep venous thrombosis and bed sores.. etc.,

To accomplish these aims, operative treatment is almost always indicated. The following is a simplified programme for selecting the procedure of choice.

1. Undisplaced fractures (Garden I and II)

These types are best treated by internal fixation using, e.g., angled blade plates, or cannulated screws or Dynamic Hip Screws (Fig. 162).

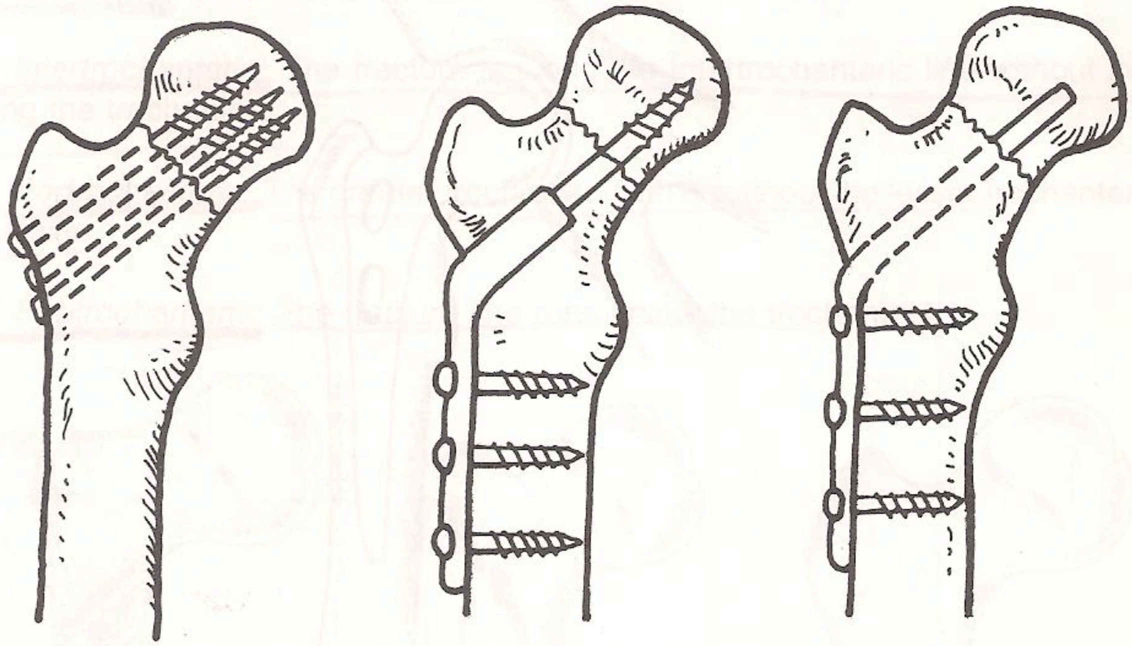


Fig. 162 Methods of treatment of intracapsular fractures

2. *Displaced fractures* (Garden III and IV).

The method of choice in these types depends on the patients' age:

1. Patients aged 65 or less: These are best treated by closed or open reduction followed by internal fixation as in group A.

2. Patients over 65: These are best treated by replacement arthroplasty such as an Austin Moore prosthesis (Fig. 163). This is advocated because at this age life expectancy is short and the probability of secondary surgery to treat local complications is high if internal fixation is used.

Local complications

1. *Avascular necrosis:* This is the most common complication, it is due to disruption of blood supply to the femoral head.

2. *Nonunion:* This is the second most common complication. Prevention depends on accurate reduction and fixation of the fracture.

3. *Postoperative infection*

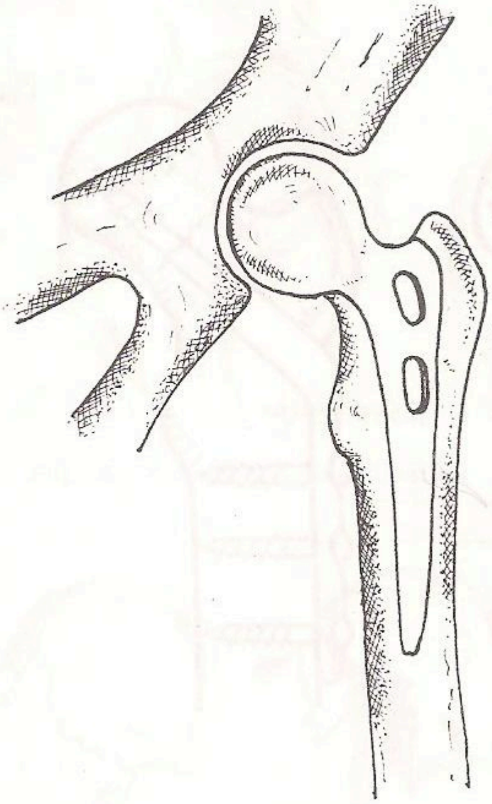


Fig. 163 Treatment of displaced fractures – patients over 65 years

2. Extra Capsular Femoral Neck Fractures

These fractures occur in an older age group. Many of these patients have been very inactive prior to the injury and frequently have medical problems.

Direct trauma is the usual cause, the patient stumbles and falls striking the hip directly.

Diagnosis

Following the injury, the patient presents with pain in the hip and inability to walk. The typical deformity is limb shortening, abduction and external rotation. The external rotation is greater than that seen in the intracapsular femoral neck fractures (Fig. 164). There is localized tenderness over the greater trochanter and movements are painful. X-ray will confirm the diagnosis and establish the site and type of the fracture.

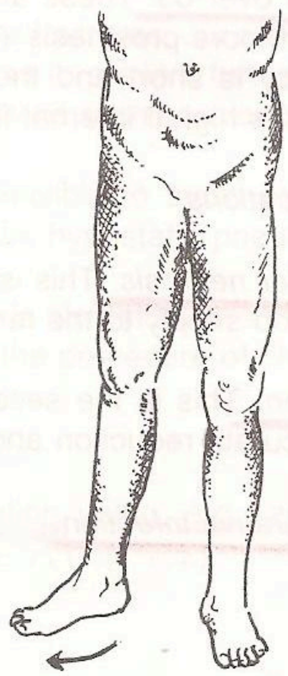


Fig. 164 Typical deformity of extra capsular femoral neck fracture

Classification

Anatomically, these fractures are divided into: (Fig. 165)

I. Intertrochanteric: The fracture is along the intertrochanteric line without involving the trochanters.

II Pertrochanteric: The greater trochanter, with or without the lesser trochanter, is involved.

III. Subtrochanteric: The fracture line runs below the trochanters.

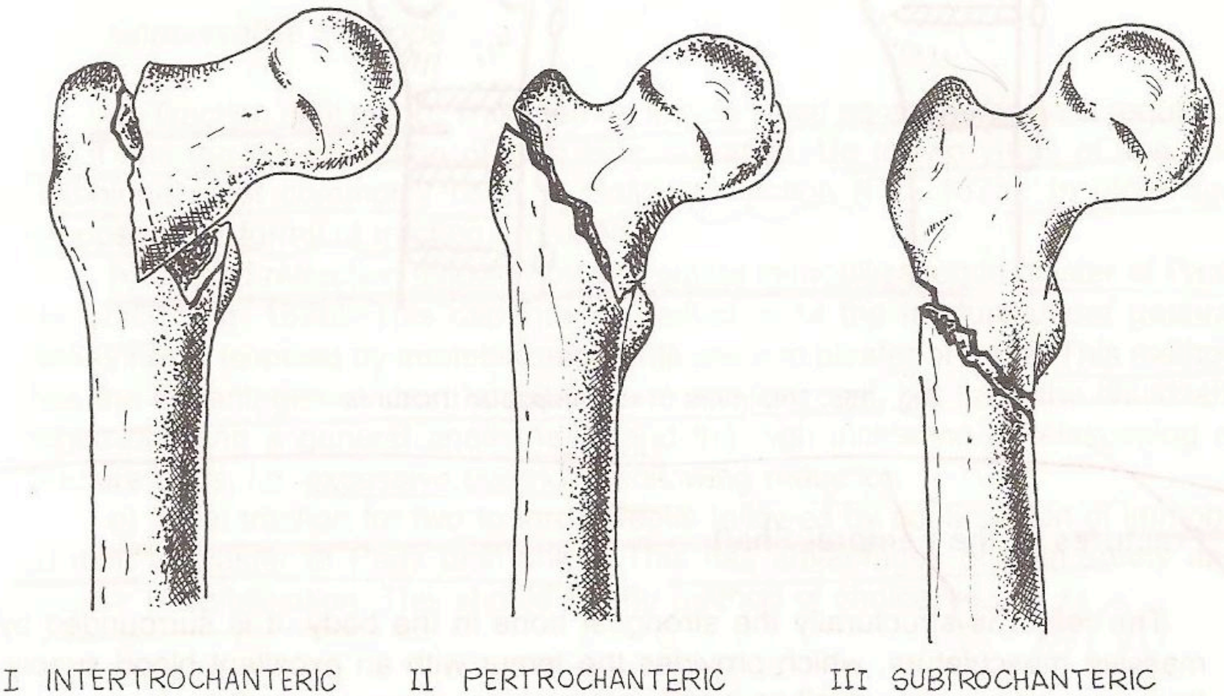


Fig. 165 Anatomical classification

Management

The aim of treatment is to provide satisfactory fixation in order to mobilize these patients quickly to prevent general complications. Since there is abundant blood supply at the fracture site, there is no danger of avascular necrosis. This aim is best achieved by operative methods, *i.e.* open reduction and adequate internal fixation (Fig. 166). If operative treatment cannot be carried out for medical or other reasons, the fracture can be treated conservatively by traction.

Local complications

1. Malunion in varus.
2. Nonunion: The incidence is low (less than 10%) because of the abundant blood supply.
3. Postoperative infection.

Neck → elderly
Shaft → adults

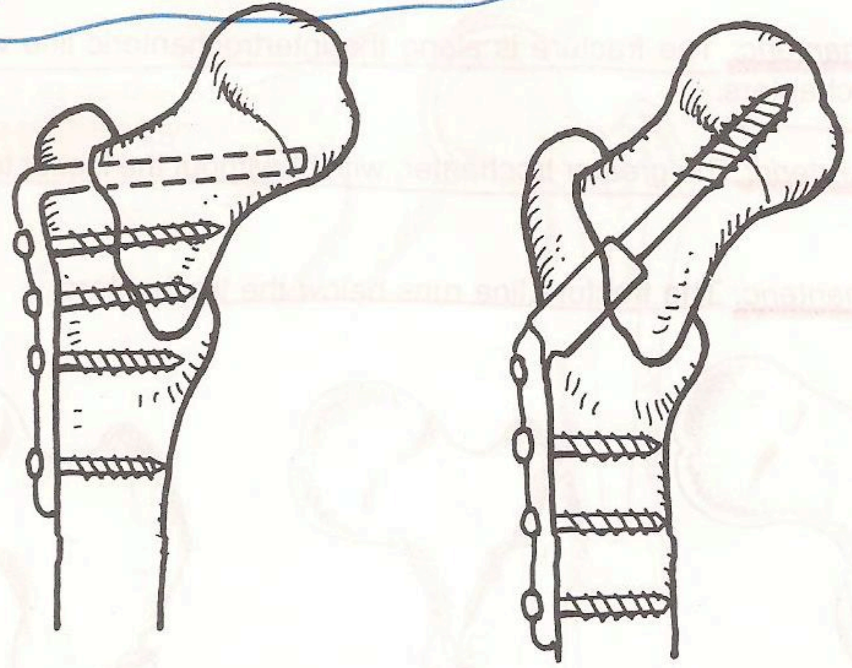


Fig. 166 Treatment of extracapsular fractures

Fractures of the Femoral Shaft

The femur is structurally the strongest bone in the body, it is surrounded by massive musculature, which provides the femur with an excellent blood supply, thus nonunion is not usually a significant problem. Femoral shaft fractures occur most commonly in young adults, and usually result from major violence such as road traffic accidents or falls from a height. They are frequently associated with multiple system injury.

Diagnosis

The presence of cardinal symptoms and signs of the fracture make the clinical diagnosis obvious. Since major violence is needed to fracture femoral shaft, a thorough general examination is essential to exclude injuries at other sites. X-rays will confirm the diagnosis and establish the site (upper, middle or lower third), line (transverse, oblique, spiral, comminuted and green stick), extent and displacement of the fracture.

Management

1. Children 'Age 0-14'

Fracture shaft femur in children almost always heals as long as there is bone contact. The remoulding power of young bone is excellent and up to 10° of angulation can be corrected. Rotational deformity cannot be corrected by remoulding and so should not be accepted. Growth stimulation occurs, for this reason an overlap of 1 to 1½ cm is acceptable and desirable.

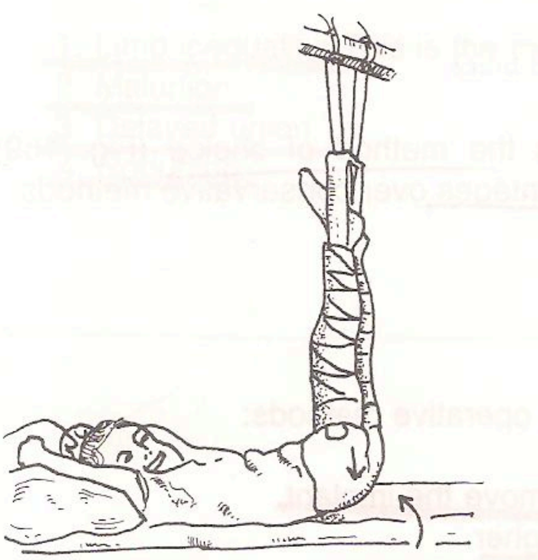
Treatment of these fractures is almost always conservative, operative methods are rarely indicated except for compound fractures and soft tissue interposition.

Conservative methods

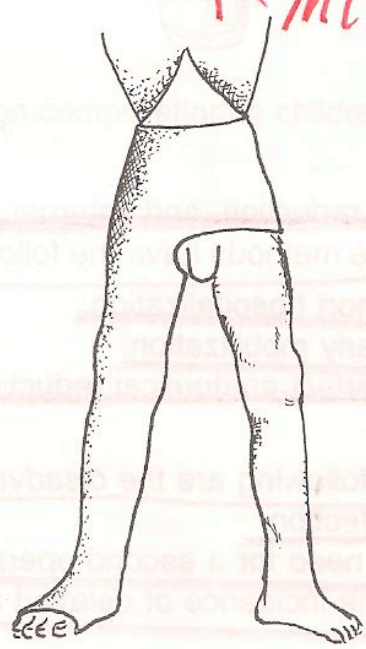
a) Traction until union: This method is safe since no anaesthesia is required, but it has the disadvantage of long hospitalization. Up to two years of age, the technique most commonly used is Gallow's traction (Fig. 167a). In older age groups, other forms of traction are used.

b) Closed reduction followed by immediate immobilization in plaster of Paris hip spica (Fig. 167b): This depends on reduction of the fracture under general anaesthesia followed by immobilization until union in plaster of Paris. This method has the advantages of short hospitalization and low cost, but have the disadvantages of using a general anaesthesia and the high incidence of telescoping of fracture ends, *i.e.* excessive overriding following reduction.

c) Initial traction for two to three weeks followed by continuation of immobilization in plaster of Paris until union: This has advantages of both safety and shorter hospitalization. This should be the method of choice. MCQ



(a) Gallow's traction



(b) Hip spica

Fig. 167 Fractured femoral shaft-children

2. Adults

The aim of treatment is to achieve union in an acceptable position, *i.e.* no rotation, less than 10° of angulation and minimal or no overriding. Both conservative and operative methods are used, each has its advantages and disadvantages. Conservative methods depend on reduction of the fracture followed by immobilization using traction until callus is no longer tender, this is usually followed by continued immobilization of the fracture but mobilization of the joints using a cast brace (Fig. 168).

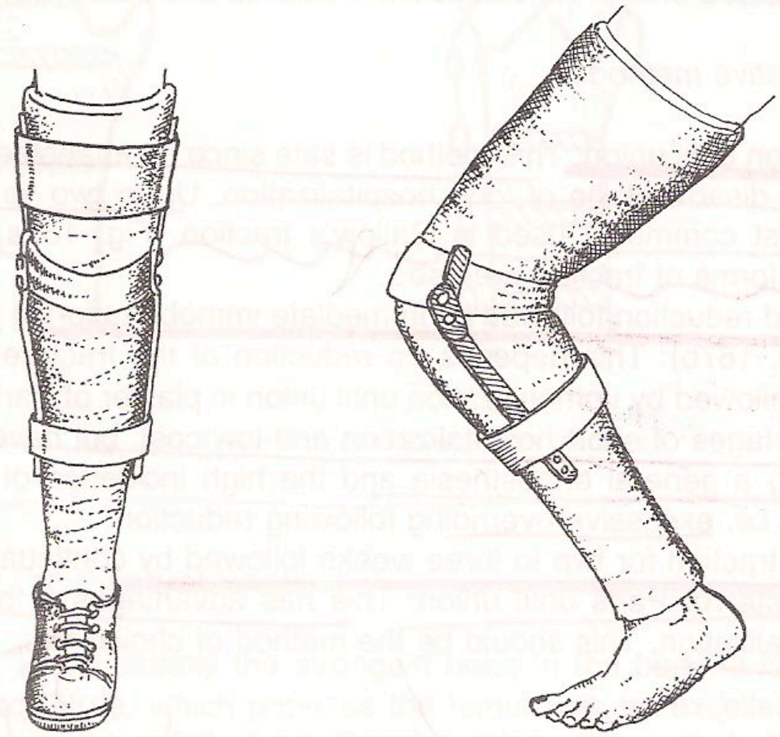


Fig. 168 Cast brace

Open reduction and internal fixation is the method of choice (Fig. 169). Operative methods have the following advantages over conservative methods:

1. Short hospitalization.
2. Early mobilization.
3. Perfect anatomical reduction.

The following are the disadvantages of operative methods:

1. Infection.
2. A need for a second operation to remove the implant.
3. The incidence of delayed union is higher.

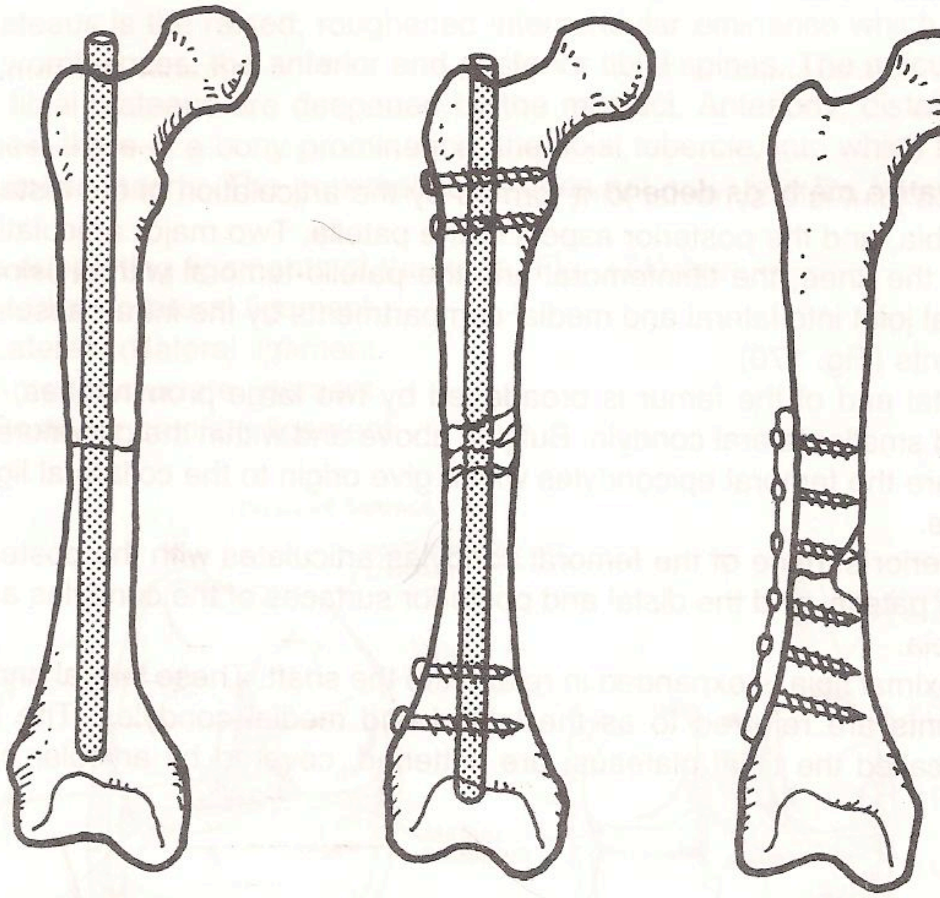


Fig. 169 Internal fixation

Complications of femoral shaft fracture

1. Limb inequality: This is the most common complication in children.
2. Malunion.
3. Delayed union.
4. Nonunion.

THE KNEE AND THE LEG

Anatomy

The knee joint is a synovial joint formed by the articulation of the distal femur, proximal tibia, and the posterior aspect of the patella. Two major articulations are present in the knee, the tibiofemoral and the patello-femoral with division of the tibiofemoral joint into lateral and medial compartments by the intra-capsular cruciate ligaments (Fig. 170).

The distal end of the femur is broadened by two large prominences, a larger medial and smaller lateral condyle. Bulging above and within the curvatures of the condyles are the femoral epicondyles which give origin to the collateral ligaments of the knee.

The anterior surface of the femoral condyles articulates with the posterior surface of the patella, and the distal and posterior surfaces of the condyles articulate with the tibia.

The proximal tibia is expanded in relation to the shaft. These lateral and medial enlargements are referred to as the lateral and medial condyles. The articular surfaces, called the tibial plateaus, are flattened, covered by articular cartilage,

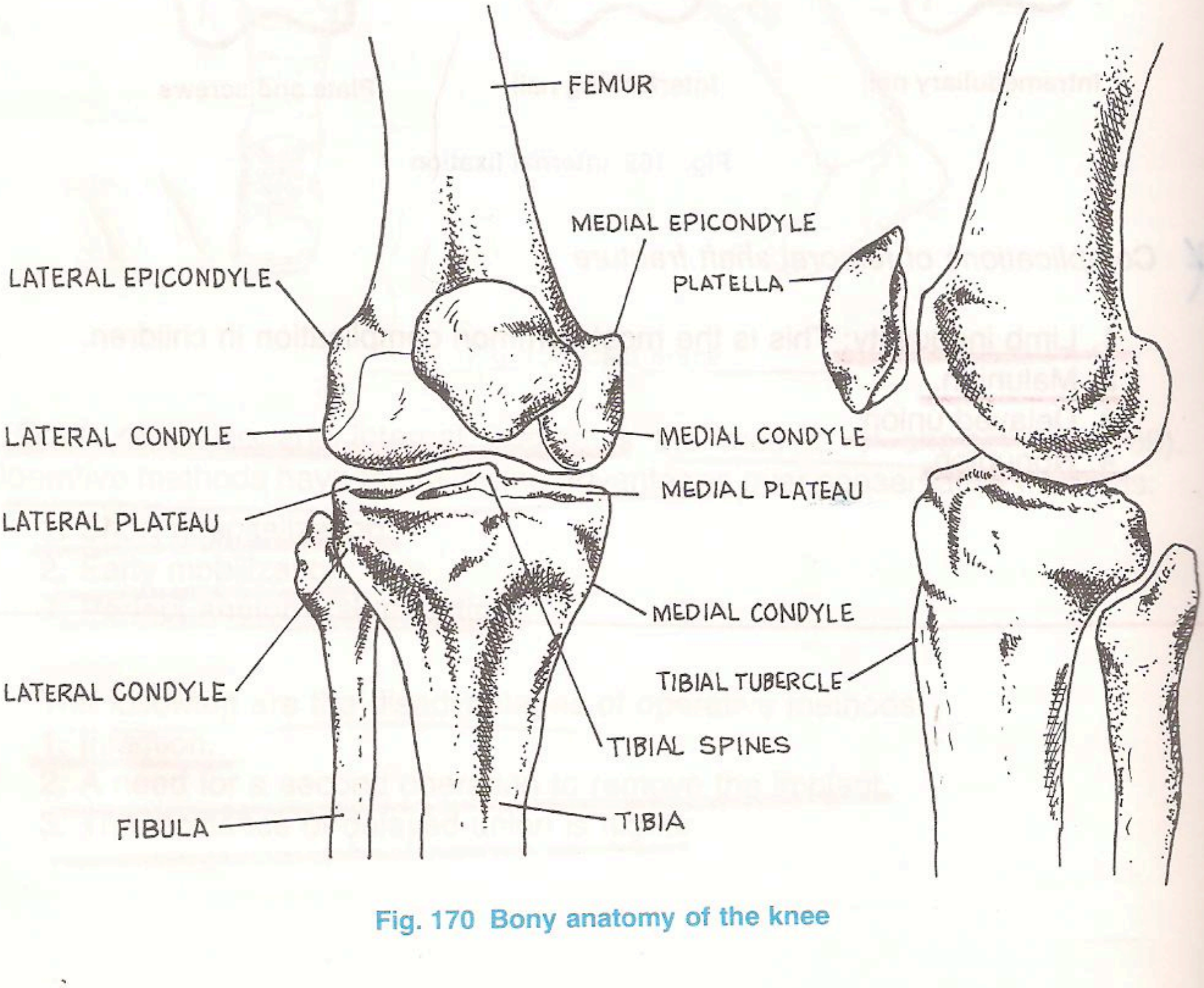


Fig. 170 Bony anatomy of the knee

slightly concave in nature, and receive the condyles of the femur. Between the two plateaus is the raised, roughened intercondylar eminence which ends in two small prominences, the anterior and posterior tibial spines. The articular surfaces of the tibial plateaus are deepened by the menisci. Anteriorly, distal to the tibial condyles, there is a bony prominence, the tibial tubercle, into which the ligamentum patellae inserts. The proximal fibula does not enter into the knee joint articulation.

The supporting ligaments of the knee (Fig. 171) are:

1. Medial collateral ligament.
2. Lateral collateral ligament.
3. Anterior cruciate ligament.
4. Posterior cruciate ligament.

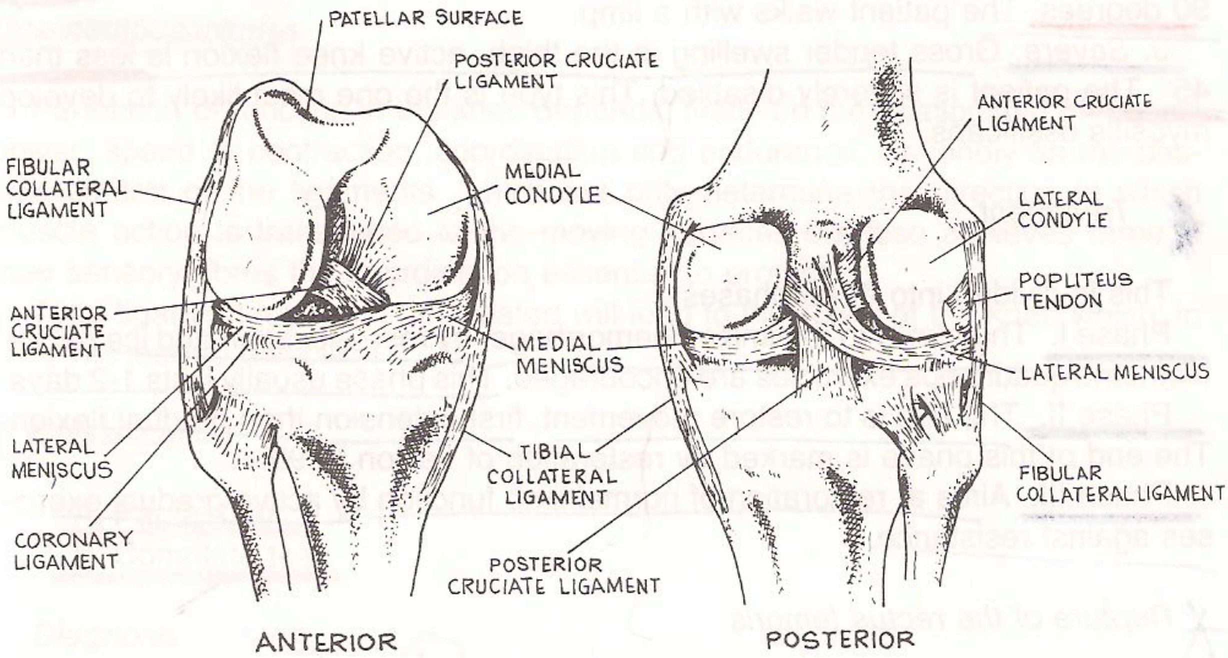


Fig. 171 The ligaments of the knee

Injuries of the Knee

A. Soft Tissue Injuries

1. Injuries of extensor apparatus.
2. Myositis ossificans traumatica.
3. Ligamentous injuries.
4. Meniscal injuries.

B. Fractures

1. The distal femur.
2. The proximal tibia.
3. The patella.

C. Dislocations

1. The tibiofemoral articulation.
2. The patellofemoral articulation.

Injuries of the extensor apparatus

Contusion of the quadriceps

This is usually due to a sports injury. They are classified into the following groups:

1. Mild: There is localised tenderness but active knee flexion is over 90°.

2. Moderate: Tender swelling in the thigh, active knee flexion is between 45 to 90 degrees. The patient walks with a limp.

3. Severe: Gross tender swelling in the thigh, active knee flexion is less than 45°. The patient is severely disabled. This type is the one most likely to develop myositis ossificans.

Treatment

This is divided into three phases:

Phase I. The aim is to minimize haemorrhage, by rest, elevation and ice packs. Isometric quadriceps exercises are encouraged. This phase usually lasts 1-2 days.

Phase II. The aim is to restore movement, first extension then gradual flexion. The end of this phase is marked by restoration of flexion to 90°.

Phase III. Aims at restoration of normal limb function by active gradual exercises against resistance.

Rupture of the rectus femoris

Rupture of few fibers of the rectus femoris is of common occurrence in athletes. The patient complains of severe pain on contracting the muscle, and local examination reveals a swelling, an area of tenderness and a gap may be felt in large ruptures.

Treatment

Repair of the rupture is technically difficult and not required except for cosmetic appearance. The treatment of early cases is aimed at relieving pain.

Myositis ossificans traumatica

The name is a misnomer, the condition is not an inflammatory reaction and it is the connective tissues which ossify, not the muscle.

The diagnosis is usually made 3 weeks after injury when X-rays show a cloudy shadow in the soft tissues of the middle third of the thigh, and later on, a mass of mature bone appears.

Treatment

The incidence of this condition could be minimised by proper management of the initial trauma to the thigh. Deep massage or passive stretching of the knee should not be employed.

Established cases are treated by bed rest and/or plaster back shell, and the bone mass tends to undergo spontaneous absorption. If no recovery occurs after 1 to 2 years and knee flexion is restricted, surgical excision of the mass is indicated.

Ligamentous injuries

Perfection of function in the knee depends, firstly on the relationship of muscle power, speed of contraction, coordination and endurance. Secondly on the passive control of the ligaments, which not only determine the direction in which muscle action is transmitted to the moving surfaces but also achieves through their sensory fibres the coordination essential to protection.

Total ligament rupture if not treated will lead to instability of the knee which, in turn, will lead to disability.

Classification

A. Partial tear.
B. Complete tear.

Diagnosis

The patient describes a tearing sensation and pain following the initial trauma. The more complete the rupture, the less the pain.

Local examination may reveal a swelling which is worse with a partial tear since with a complete tear the ruptured capsule permits leakage and diffusion. Haemarthrosis is evident, and localised tenderness over the ligament and site of tear can be elicited. Partial tears permit no abnormal movement, while a complete tear permits abnormal movement which is, sometimes, painless. Stress tests for lateral and medial collateral ligaments are positive in complete tears as well as anterior and posterior drawer signs in anterior and posterior cruciate ligament tears. Routine X-rays will show if an avulsion fracture has occurred. Stress films will show a wide separation in complete rupture (Fig. 172).

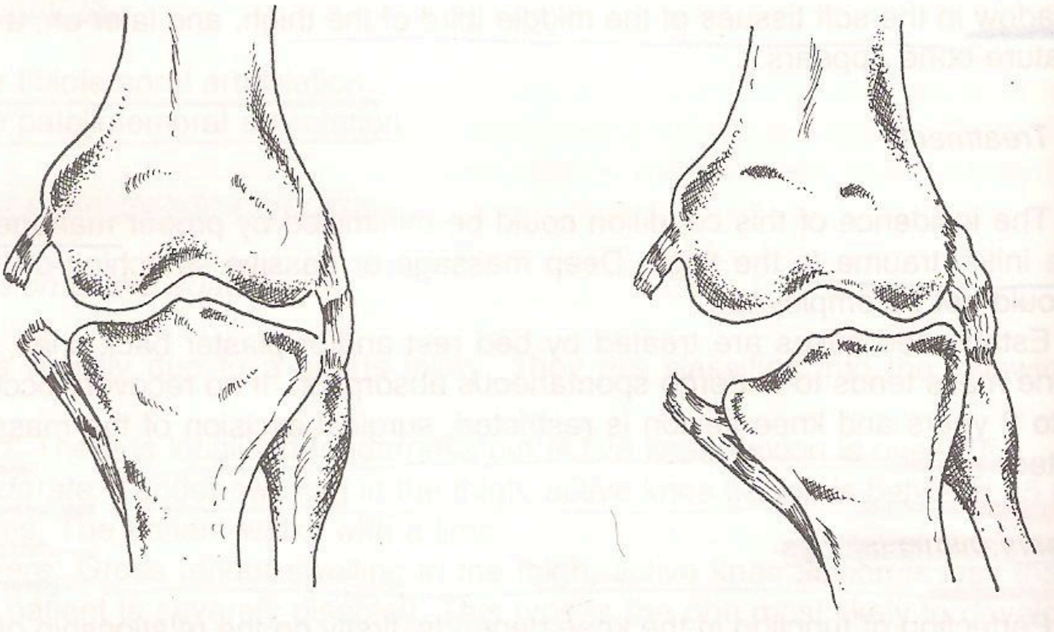


Fig. 172 Stress films

Treatment

1. Partial tear

This is essentially symptomatic (analgesic for the pain) and protective by providing an elastic bandage to the knee, which promotes absorption of the products of injury by elastic compression. The patient is then instructed to use crutches and start weight bearing. Active knee exercises should be commenced as soon as possible to prevent adhesion.

2. Complete tear

The aim is restoration of ligament continuity and the method of choice is operative repair of the ruptured ligament whenever possible

Complications

1. Adhesions: This could be prevented by active exercises in 1st and 2nd degree tears.

2. Instability: Failure to treat complete tears will cause instability which eventually may lead to degeneration.

Meniscal injuries

The lateral meniscus is less likely to tear than the medial because its attachment permits freer mobility.

Medial meniscal injury (Fig. 173)

A twisting injury of the flexed weight bearing knee is the classical example which usually occurs while playing football.

A middle life when fibrosis has further restricted the mobility of the meniscus, tears occur with relatively little force.

Diagnosis

In the initial injury, the patient develops pain on the inner side of the knee, this is followed by a swelling few hours later. The patient may sometimes come with locking of the knee, *i.e.* the knee will be held in 10 to 20° of flexion. Full extension is impossible and attempts to achieve it provokes pain. Flexion is almost full and usually painless.

If the joint is not locked, examination may reveal an effusion, local tenderness over the medial joint line, a full range of movement, and positive McMurray's and grinding tests.

X-rays: Routine X-rays show no abnormality. Arthrography may help. Magnetic Resonance Imaging (MRI) is greatly helpful in the diagnosis.

It is essential to confirm the diagnosis before treatment. Arthroscopy is mandatory and has reduced the need of total menisectomy. Partial menisectomy for partial tears and suture of peripheral tears are possible through the arthroscope.

Fig. 173 Meniscal injury

Fractures of the Distal Femur

Fractures of the distal femur are classified anatomically into:

1. Supracondylar fractures.
2. Condylar fractures.
3. Intercondylar fractures.

Supracondylar fractures

Fractures occurring above the femoral condyles are referred to as supracondylar fractures. Direct force is the usual cause. When the lower fragment is intact the pull of gastrocnemius may flex it, endangering the popliteal artery.

Diagnosis

The patient complains of severe pain and inability to walk, local examination reveals a swollen deformed knee. Movement is too painful to be attempted.

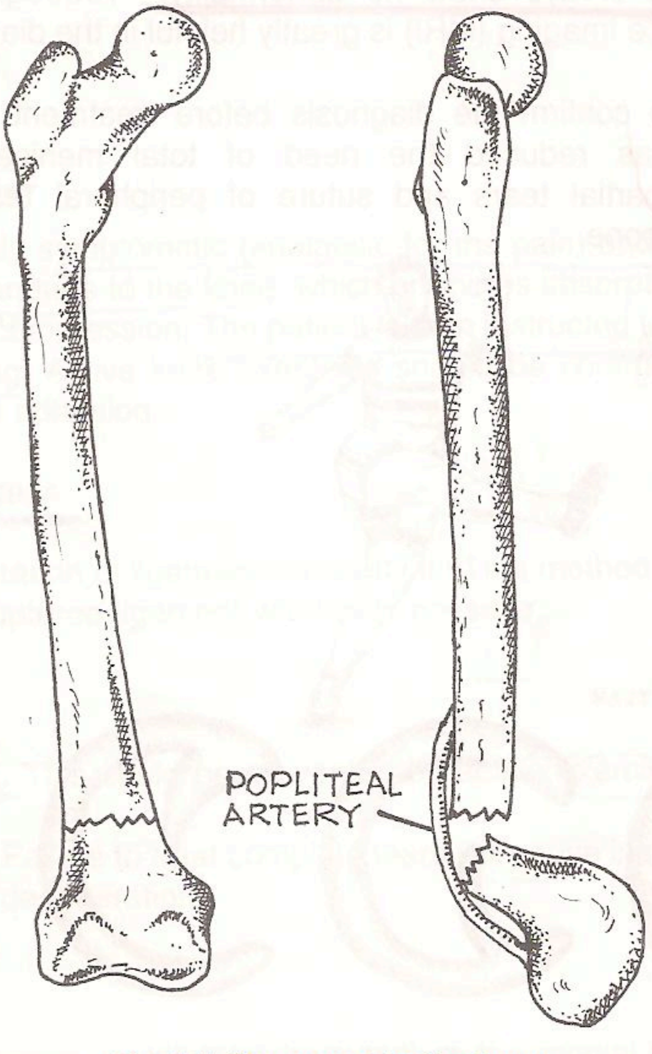


Fig. 174 Supracondylar fractures

It is essential to examine for neurovascular damage since the flexed distal fragment may endanger the popliteal artery (distal pulse should always be checked and recorded).

X-rays will confirm the diagnosis and determine the type of fracture which can be transverse, oblique, or comminuted (Fig. 174).

Management (Fig. 175)

The aim of the treatment is to achieve early active movement of the knee. Both conservative and operative methods are used. The method of choice depends on many criteria, the most important of them is the type of the fracture.

The following is a guideline towards the method of choice:

1. Impacted or minimally displaced supracondylar fractures are best treated by plaster cast.

2. Unstable, displaced fractures are best treated by operative methods. If operation is contraindicated, skeletal traction may be used.

3. Comminuted fractures are initially treated by traction until the fracture is clinically firm and no longer painful, this phase is followed by a cast brace until union.

These fractures take about 12 weeks to unite, if conservative methods are

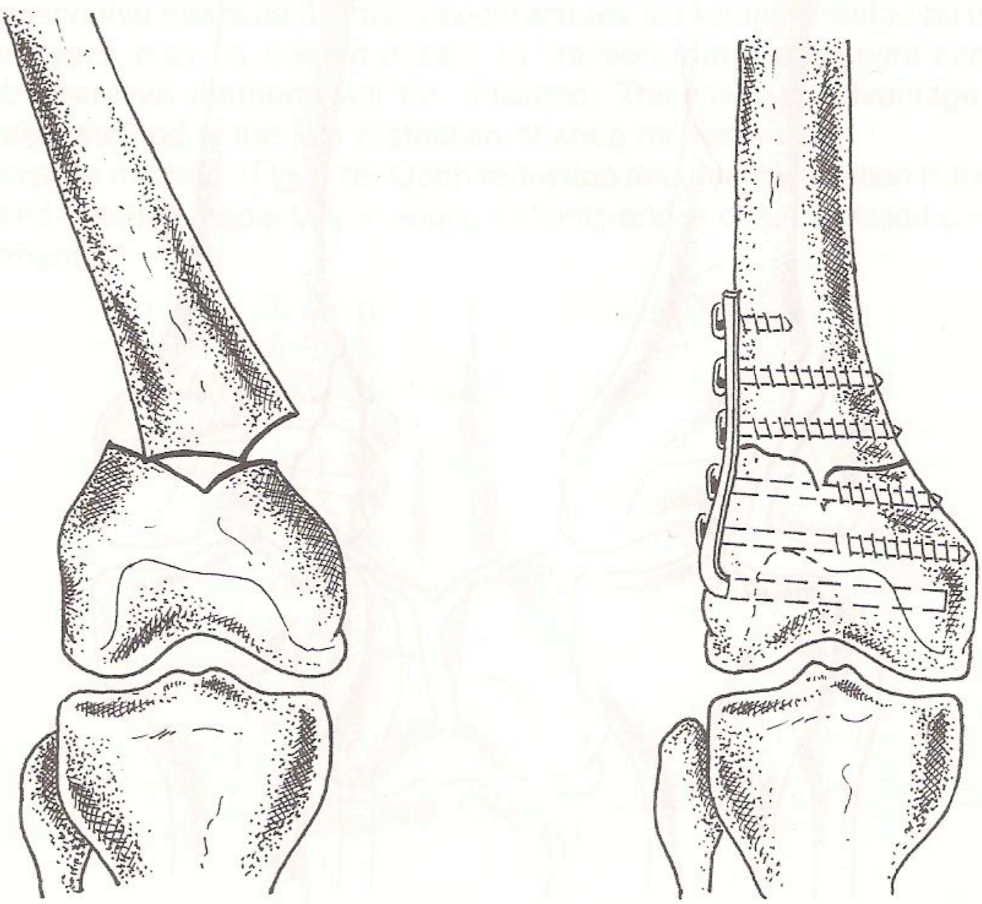


Fig. 175 Treatment of supracondylar fractures

used, the plaster cast or traction must be maintained during that time. A further 12 weeks are needed for consolidation and during that time partial weight bearing with crutches is allowed.

Complications of supracondylar fractures

1. Arterial damage: Injury to the popliteal artery may occasionally occur.
2. Knee stiffness: This is the most common late complication. A long period of exercises is necessary, but full movement is rarely regained.
3. Malunion.
4. Nonunion.

Condylar fractures, (Fig. 176).

Isolated fractures of the femoral condyles are rare. They are caused by a direct force or a fall from a height. Clinically the knee is swollen, tender, too painful to move and haemarthrosis is present. X-ray will confirm the diagnosis. These fractures are usually unstable and the incidence of delayed or nonunion is high with conservative methods of treatment.

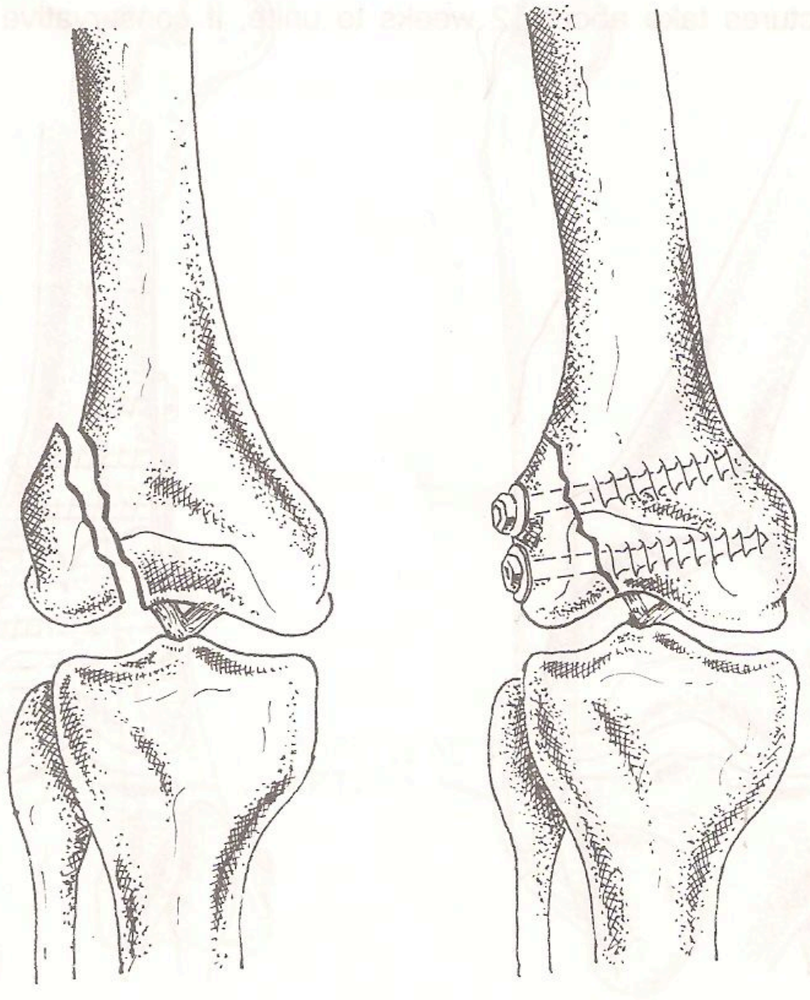


Fig. 176 Condylar fractures

The method of choice in treating all condylar fractures is operative, *i.e.* open reduction and internal fixation.

Intercondylar fractures

A fracture of the supracondylar area of the femur with a condylar fracture is a challenging and complex therapeutic problem.

The prognosis and end result depends upon the initial damage to the joint and the surgeon's success in restoring the anatomical congruity of the joint. Road traffic accidents and falls from heights account for most of these cases.

Clinically, the knee is swollen, deformed, tender, too painful to attempt movements and haemarthrosis is present.

X-rays will confirm the diagnosis and determine site, displacement and type of the fracture (T shaped or Y shaped) (Fig. 177).

Management

The aim is to achieve anatomical reduction and early recovery of knee movements so as to minimize the incidence of post traumatic arthrosis and stiffness. Both conservative and operative methods are used depending basically on the fracture displacement.

A. Conservative methods: Undisplaced fractures are usually treated by traction. The other types may be treated initially by traction, but if alignment cannot be achieved, operative methods will be indicated. The main disadvantage of the conservative method is the late restriction of knee movement.

B. Operative method: (Fig. 178) Open reduction and internal fixation is indicated in displaced fractures especially in young patients and in cases of failed conservative treatment.

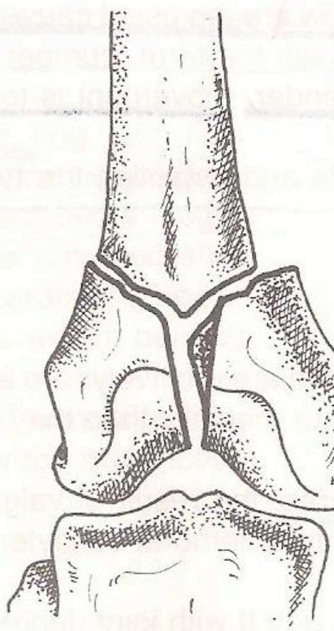


Fig. 177 Intercondylar fractures

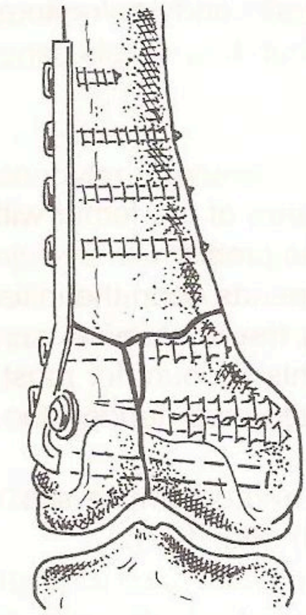


Fig. 178 Internal fixation of an intercondylar fracture

The complications of intercondylar fractures are:

1. Knee stiffness.
2. Post traumatic arthrosis.

Fractures of the Proximal Tibia

Tibial plateau fractures

A fall from a height or a direct blow are the usual causes. The commonest injury is a fractured lateral condyle for which the term 'bumper fracture' was applied.

Clinically the knee is swollen, tender, movement is too painful to attempt and haemarthrosis is present.

X-rays will confirm the diagnosis and establish the type and displacement of the fracture.

Classification (Fig. 179)

Type I. Pure wedge fracture, these are relatively rare and occur most commonly laterally or posteriorly. If they occur medially then they give rise to a corresponding varus deformity.

Type II. Pure depression fractures, the result of valgus overload. The lateral tibial plateau is pushed in by the lateral femoral condyle. The plateau itself is not widened.

Type III. Combination of types I and II with joint depression and fracture of the lateral cortex.

Type IV. The Y and T fractures or comminuted fractures of both condyles.

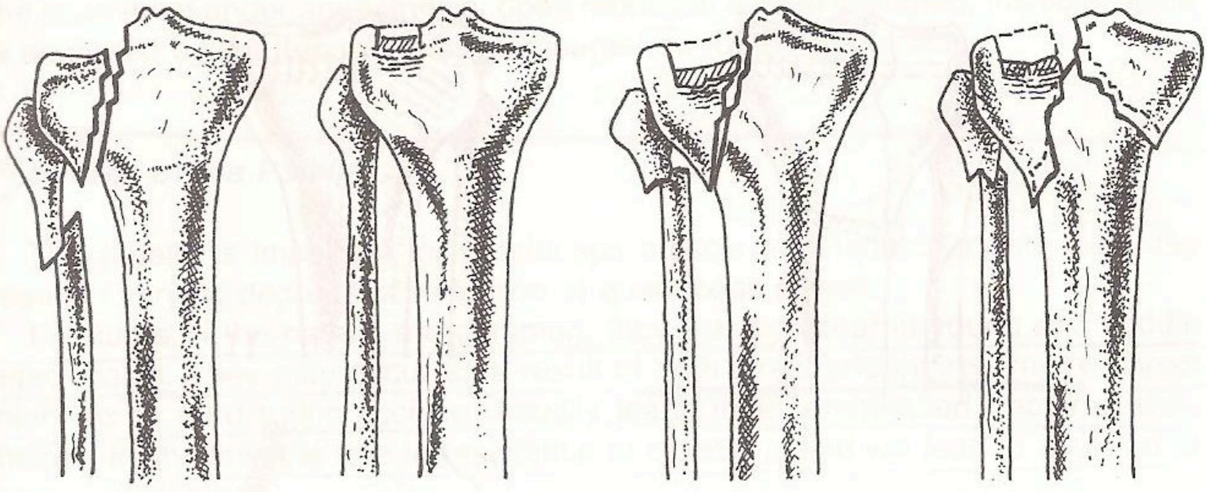


Fig. 179 Tibial plateau fractures – Types

Management

The aim is to achieve restoration of normal joint function and prevention of late post-traumatic arthrosis.

1. *Undisplaced fractures* (0 to 5 mm of depression or widening)

These are best treated conservatively by:

a) Traction: This is simple and usually produces good results, its main disadvantage is long hospitalization. Traction is maintained for six weeks which is the time needed for union. The patient is then allowed up using crutches. Full weight bearing should be avoided for a further six weeks which is the time needed for consolidation.

b) Plaster cylinder, (Fig. 180) This has the advantage of short hospitalization, but knee movement takes longer to return. The plaster is removed after six to twelve weeks according to the severity of the injury, and weight bearing is then permitted.

With both methods of immobilization, it is essential to encourage quadriceps muscle exercises.

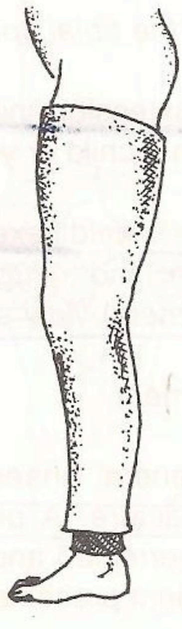


Fig. 180 Plaster cylinder

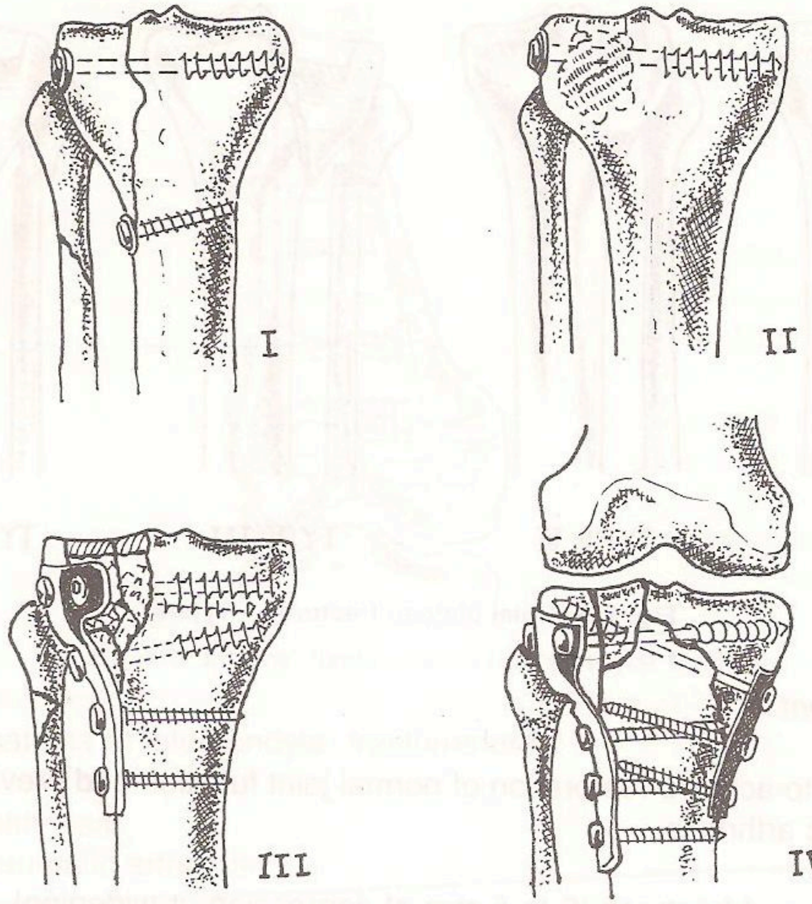


Fig. 181 Operative treatment of tibial plateau fractures

2. *Displaced fractures* (Over 5 mm depression or widening)

Anatomical reduction is essential, if closed reduction fails, open reduction and internal fixation is indicated (Fig. 181).

Fracture of the tibial spine

A hyperextension injury may tear the anterior cruciate ligament; sometimes, especially in a child or young adult, the ligament remains intact but the tibial spine is avulsed.

The knee is held flexed and is swollen. Because of haemarthrosis the joint feels tense, tender and 'doughy', movement is too painful to be attempted.

X-ray a lateral view shows the anterior tibial spine elevated from the tibia.

Management

Under general anaesthesia, the knee is aspirated and forced straight to reduce the fracture. A plaster cylinder is applied and worn for 6 weeks, weight bearing is permitted and quadriceps muscle exercises are encouraged.

If the patient presents, few weeks after injury it may be impossible to straighten the knee even under anaesthesia, open reduction is then indicated, the tibial spine is anchored by sutures into a cavity gouged out of the upper tibia.

Fractures of the Patella

The patella is important for quadriceps muscle mechanism and its loss may result in varying degrees of reduction of quadriceps power.

Fractures of the patella are common, they usually occur in young and middle aged males. They may occur as a result of both direct and indirect injury. Direct injury as in road traffic accident usually leads to a comminuted fracture, while indirect injury which is due to resistance of muscle action will lead to avulsion or transverse fracture.

Diagnosis (Fig. 182)

The patient complains of knee pain and inability to walk. Examination will reveal swelling and haemarthrosis of the knee, in transverse fractures a gap between fracture ends may be felt. If there is damage to the extensor tendon the patient will not be able to raise his leg with the knee extended.

X-rays will reveal the type and extent of the fracture.

Management

The aim should be the restoration of the anatomy and function whenever possible. The method of choice depends on the type and displacement of the fracture.

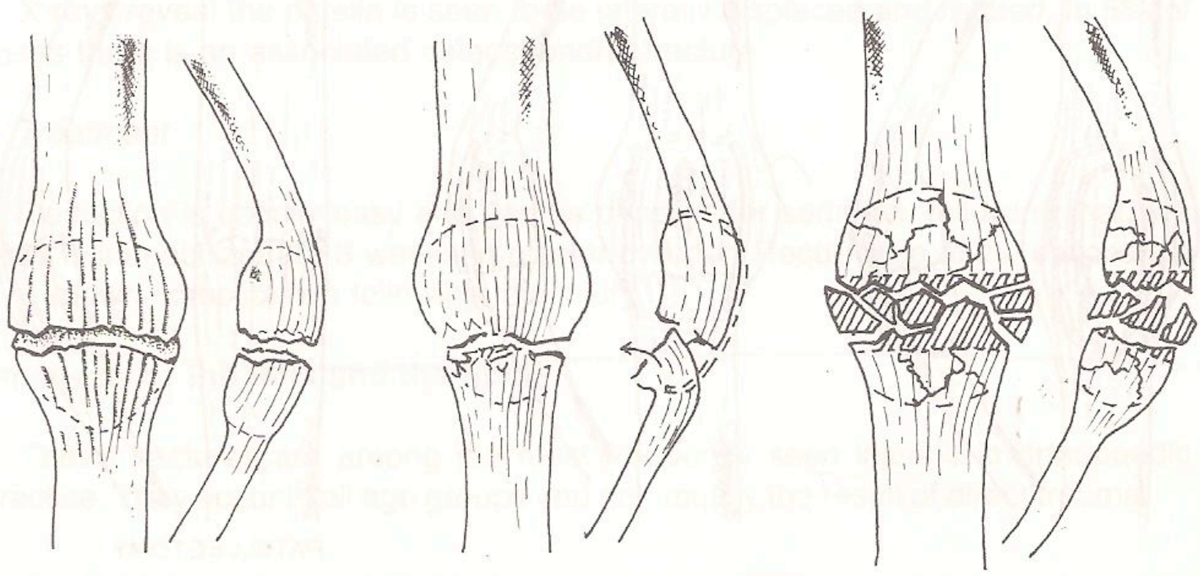


Fig. 182 Fractures of the patella

1. Undisplaced or minimally displaced fractures

These are best treated conservatively by: Aspiration of haemarthrosis and immobilization in a plaster cylinder for 4 to 6 weeks.

2. Displaced fractures (Fig. 183)

These are best treated operatively, the available techniques are:

(a) Reassembly of two or more fragments by open reduction and internal fixation using tension band wiring, K wires or screws.

(b) Repair of quadriceps apparatus retaining one large fragment: This is indicated if restoration of normal anatomy cannot be achieved and the fracture has one large fragment which can be retained.

(c) Total excision – patellectomy: This is indicated in communited fractures when either of the previous techniques cannot be carried out.

Dislocation

Dislocation of the Knee (tibiofemoral articulation)

Dislocations of the knee are rare injuries caused by severe violence. Clinical diagnosis is not difficult and X rays are taken to confirm the clinical impression and to exclude associated fractures.

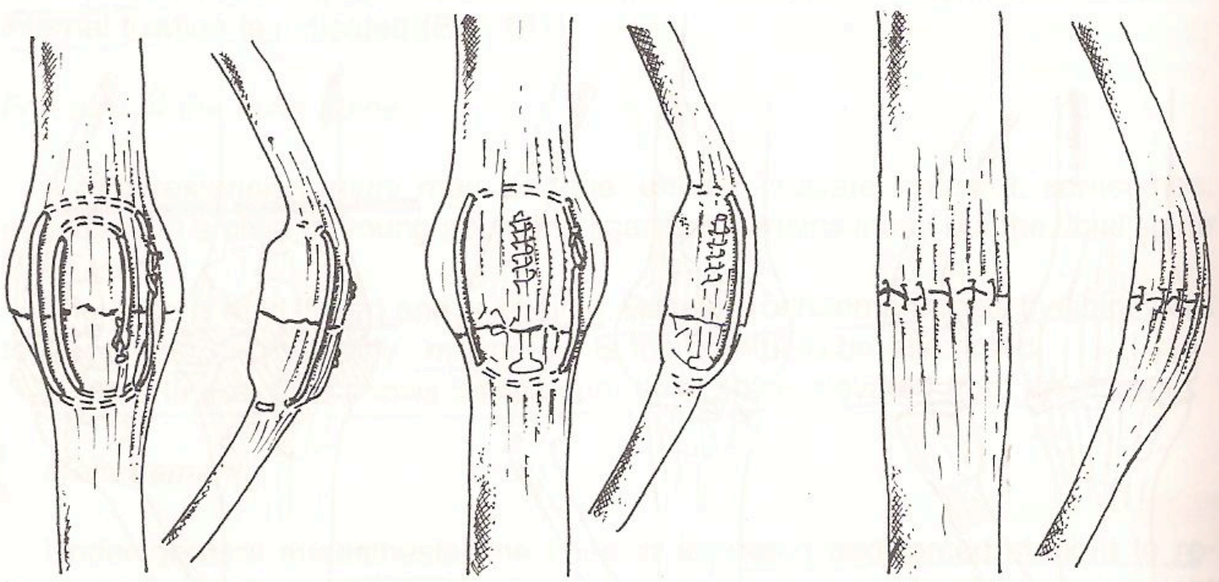


Fig. 183 Operative treatment of fractures of the patella

Classification

The dislocation is described in terms of tibial displacement with respect to other structures about the knee, accordingly five types are recognised: (1) Anterior, (2) posterior, (3) lateral, (4) medial, and (5) rotatory.

Treatment

Immediate reduction under general anaesthesia can be accomplished easily by gentle sustained traction. This must be followed by careful evaluation of circulatory status of the limb. If there are signs of occlusion vascular surgery to restore circulation is indicated. Early repair of damaged ligaments is advisable to prevent instability. Following reduction the knee is immobilized in a plaster cast for 12 weeks.

Dislocation of the patella

While the knee is flexed and the quadriceps muscle relaxed, the patella may be forced laterally by direct violence. It may perch temporarily on the ridge of the lateral femoral condyle and then either slip back into position or be displaced to the outer side, where it lies with its anterior surface facing laterally.

Diagnosis

The knee usually collapses and the patient may fall to the ground. There is obvious if somewhat misleading deformity: the displaced patella is not easily noticed as the uncovered medial femoral condyle is unduly prominent and may be mistaken for the displaced patella. The patella can be felt on the outer side of the knee. Neither active nor passive movement is possible.

X-rays reveal the patella is seen to be laterally displaced and rotated. In 5% of cases there is an associated osteochondral fracture.

Treatment

Reduction is usually easy and can be done under sedation, following that, the knee is immobilized for 3 weeks in plaster cylinder. Recurrence of the dislocation is a known complication following this injury.

Fractures of the tibia and the fibula

These fractures are among the most frequently seen injuries in orthopaedic practice. They occur in all age groups and are usually the result of direct trauma.

Mechanism of Injury

The fractures can occur either due to:

1. Direct injury as in road traffic accidents and gun shot injuries; these lead to transverse or comminuted fractures.

2. Indirect injury as in falling, twisting, and skiing injuries; these lead to oblique and spiral fractures.

The clinical diagnosis is obvious. The cardinal symptoms and signs of fracture are present, routine X-rays will confirm the diagnosis and establish the site, type and displacement of the fracture.

Classification, 'Ellis classification' (Fig. 184)

1. *Minor:* Fracture is undisplaced, with no angulation, no or minor comminution and skin is intact (union usually occurs in 10 weeks, the incidence of delayed or nonunion is about 2%).

2. *Moderate:* The fracture is displaced, angulated with moderate comminution and minor wound. (Union usually occurs in 15 weeks, the incidence of delayed or nonunion is about 11%).

3. *Severe:* A fracture is displaced, angulated, major comminution and major wound (union occurs in 23 weeks, the incidence of delayed or nonunion is about 60%).

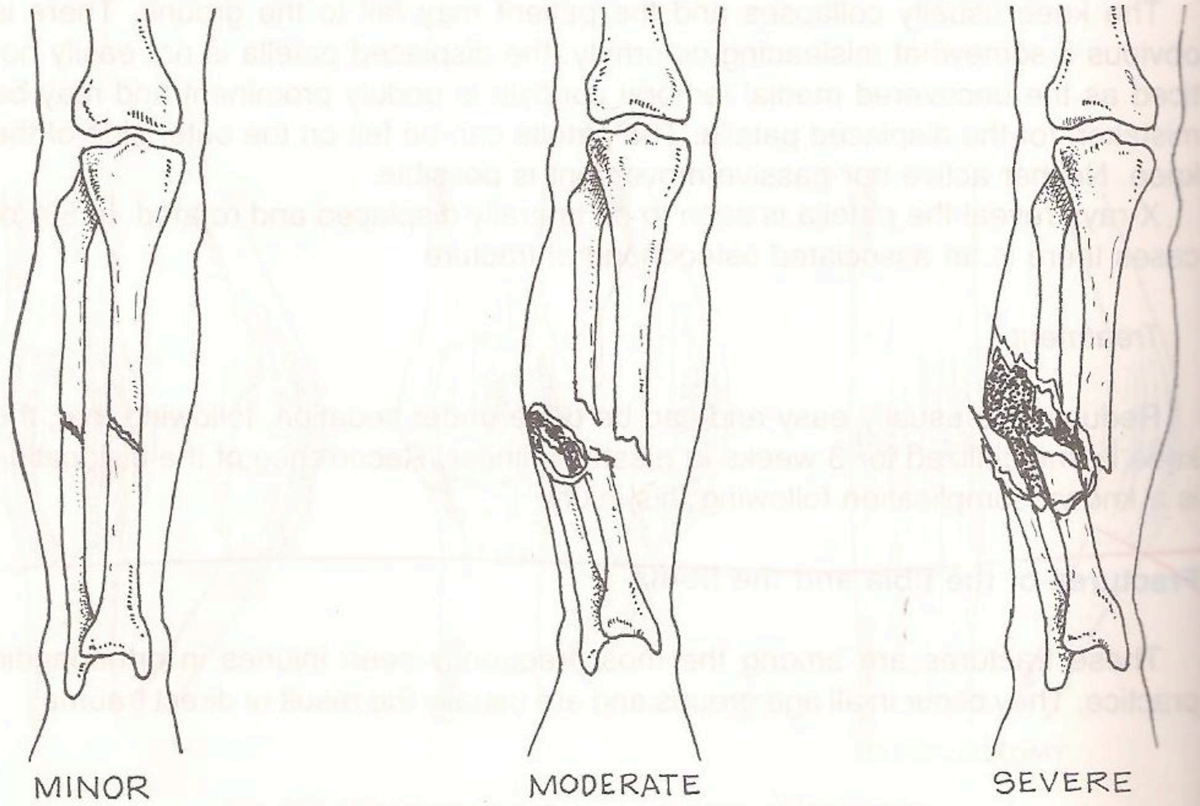


Fig. 184 Fractured tibia and fibula – classification

Management

The aim is to achieve full functional recovery of the limb. Anatomical reduction is ideal but 50% opposition, less than 10 degrees angulation and no rotation is considered acceptable.

1. The conservative method: The majority of the cases can be treated conservatively by closed reduction and immobilization initially in a full length above knee plaster cast (Fig. 185).

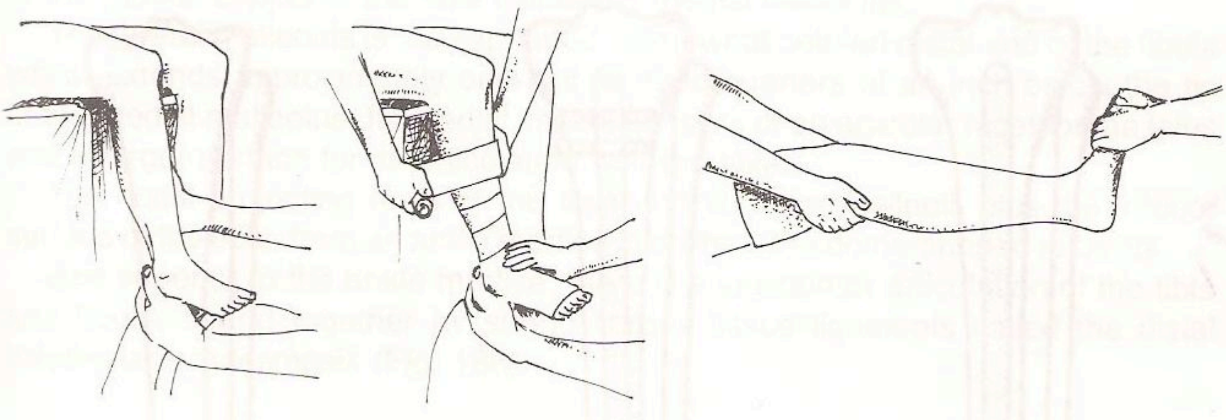


Fig. 185 Above knee plaster cast

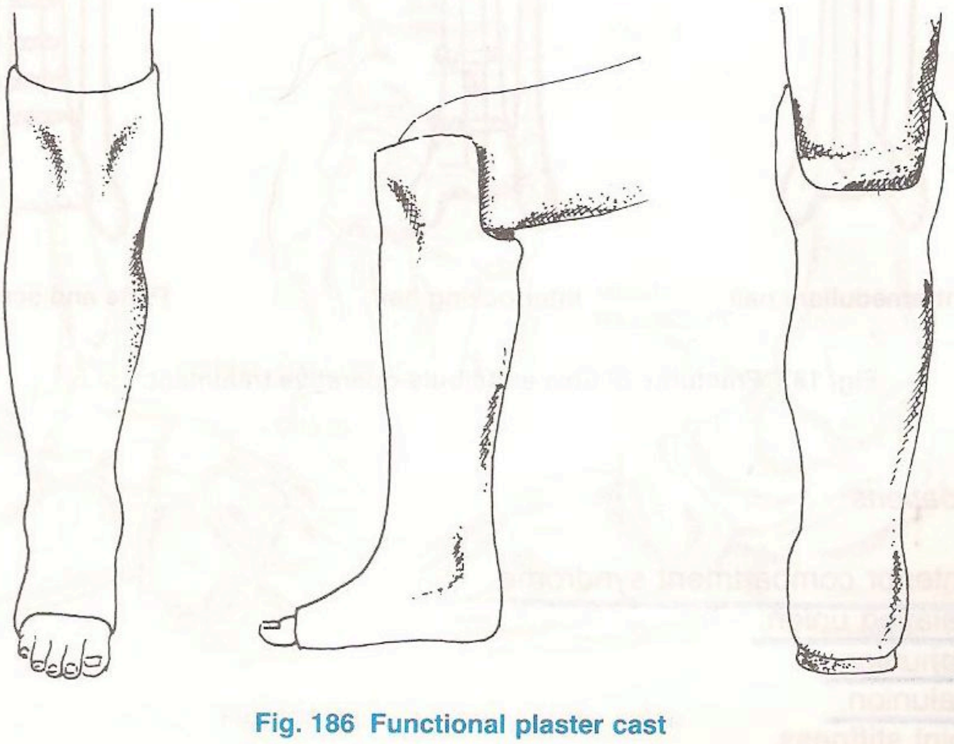


Fig. 186 Functional plaster cast

3 - 4 weeks later, a functional plaster cast which librates the knee and takes some pressure on the patellar tendon can be used (Fig. 186).

2. The operative method (Fig. 187): Open reduction and internal fixation has the advantages of early mobilization and perfect anatomical reduction. *Fixation can be achieved by the use of AO intramedullary nails or plates and screws.*

In the severe type of injury, the use of an external fixator is helpful in immobilizing the fracture and leaving the limb exposed for the treatment of soft *tissue injuries.*

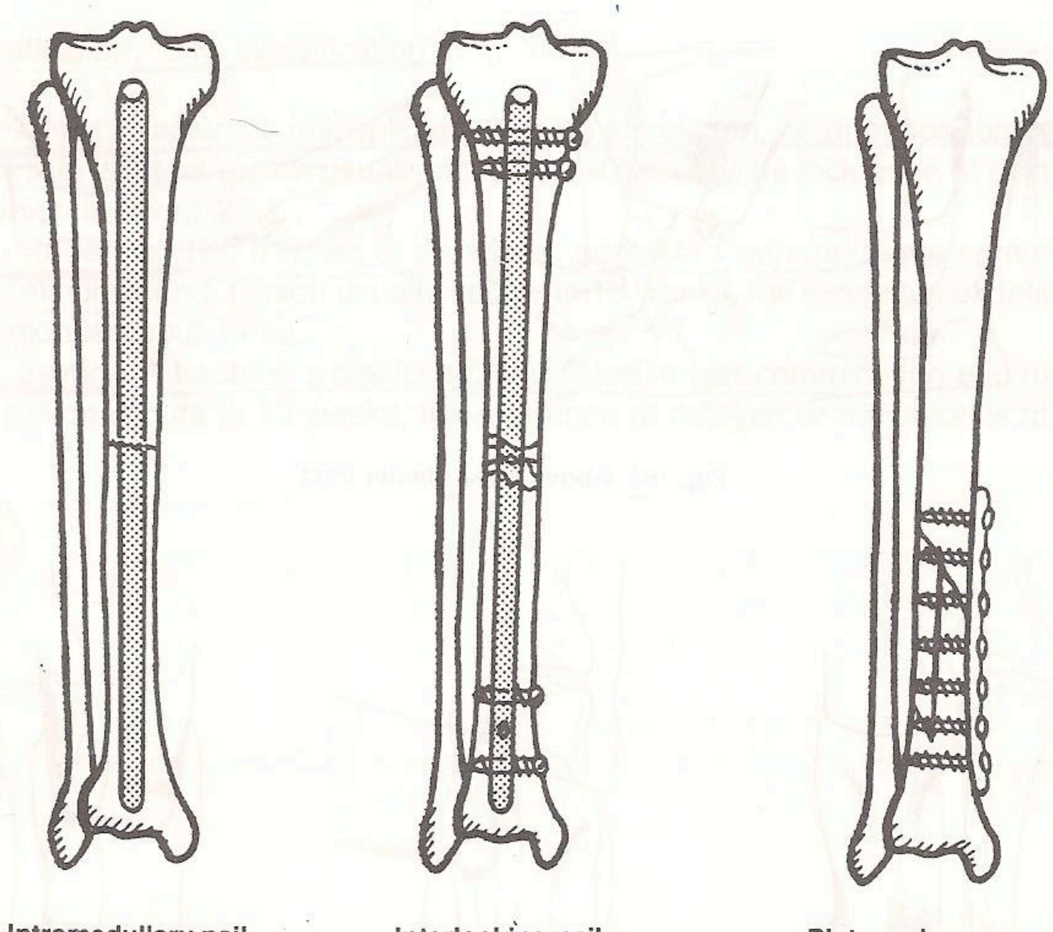


Fig. 187 Fractures of tibia and fibula-operative treatment.

Complications

1. Anterior compartment syndrome.
2. Delayed union.
3. Nonunion.
4. Malunion.
5. Joint stiffness.

THE ANKLE AND THE FOOT

Anatomy

The ankle is a synovial joint of the hinge variety, composed of an articulation of three bones: the distal end of the tibia, the distal end of the fibula, and the talus.

The distal aspect of the tibia is somewhat broadened and includes an inferior articular surface which articulates with the superior surface of the body of the talus, a lateral surface with a triangular depression for the articulation with the fibula, and a blunt projection which extends inferiorly as the most distal projection of the medial aspect of the tibia called the medial malleolus.

The lateral malleolus is the expended, somewhat pointed distal end of the fibula which extends approximately one-half to three-quarters of an inch below the tip of the medial malleolus. Its medial aspect consists of an articular facet for the talus and a larger surface for its articulation with the tibia.

The distal projecting ends of the tibia and fibula or malleoli, plus the inferior surface of the tibia, form an ankle mortise into which the dome-shaped talus fits.

Just superior to the ankle mortise, there is a junction or articulation of the tibia and fibula, bound together by strong fibrous tissue ligaments called the distal tibiofibular syndesmosis (Fig. 188).

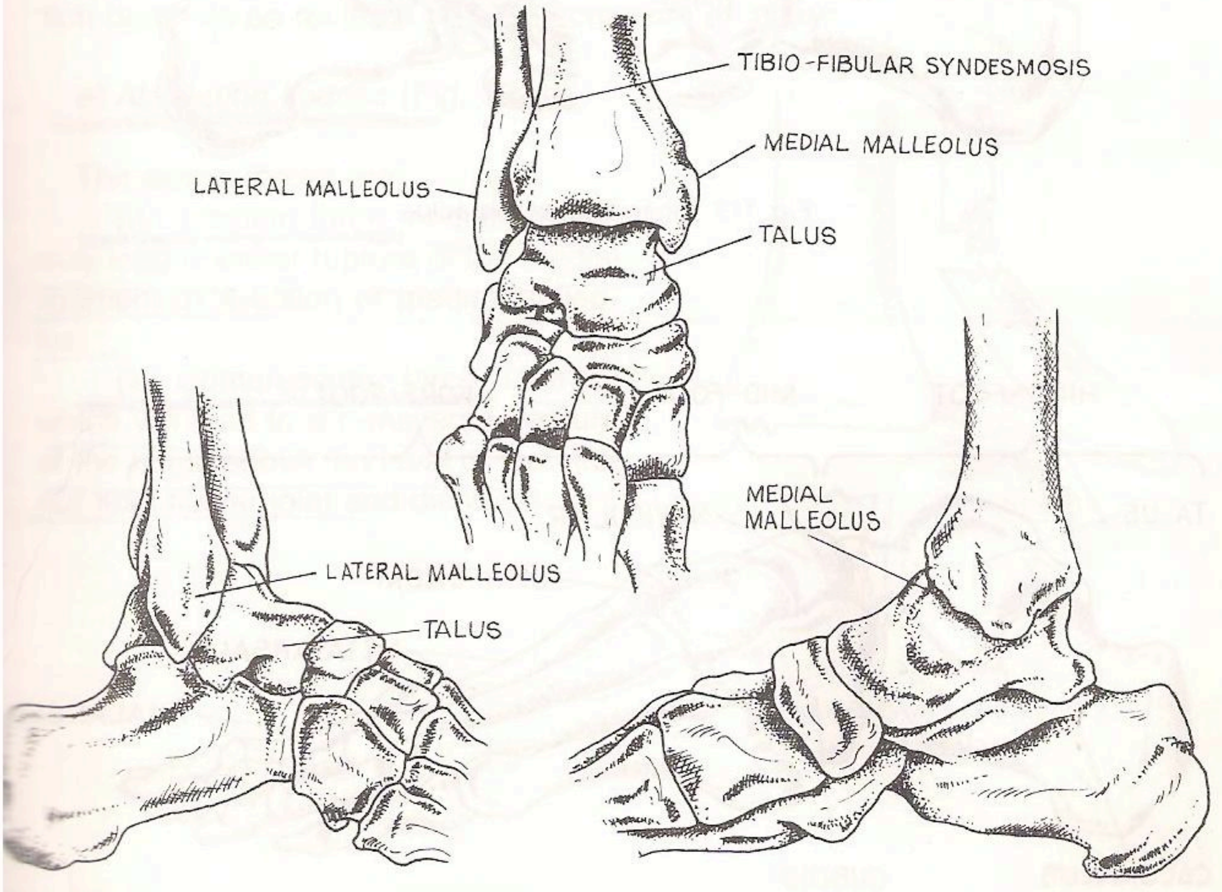


Fig. 188 Bony anatomy of the ankle

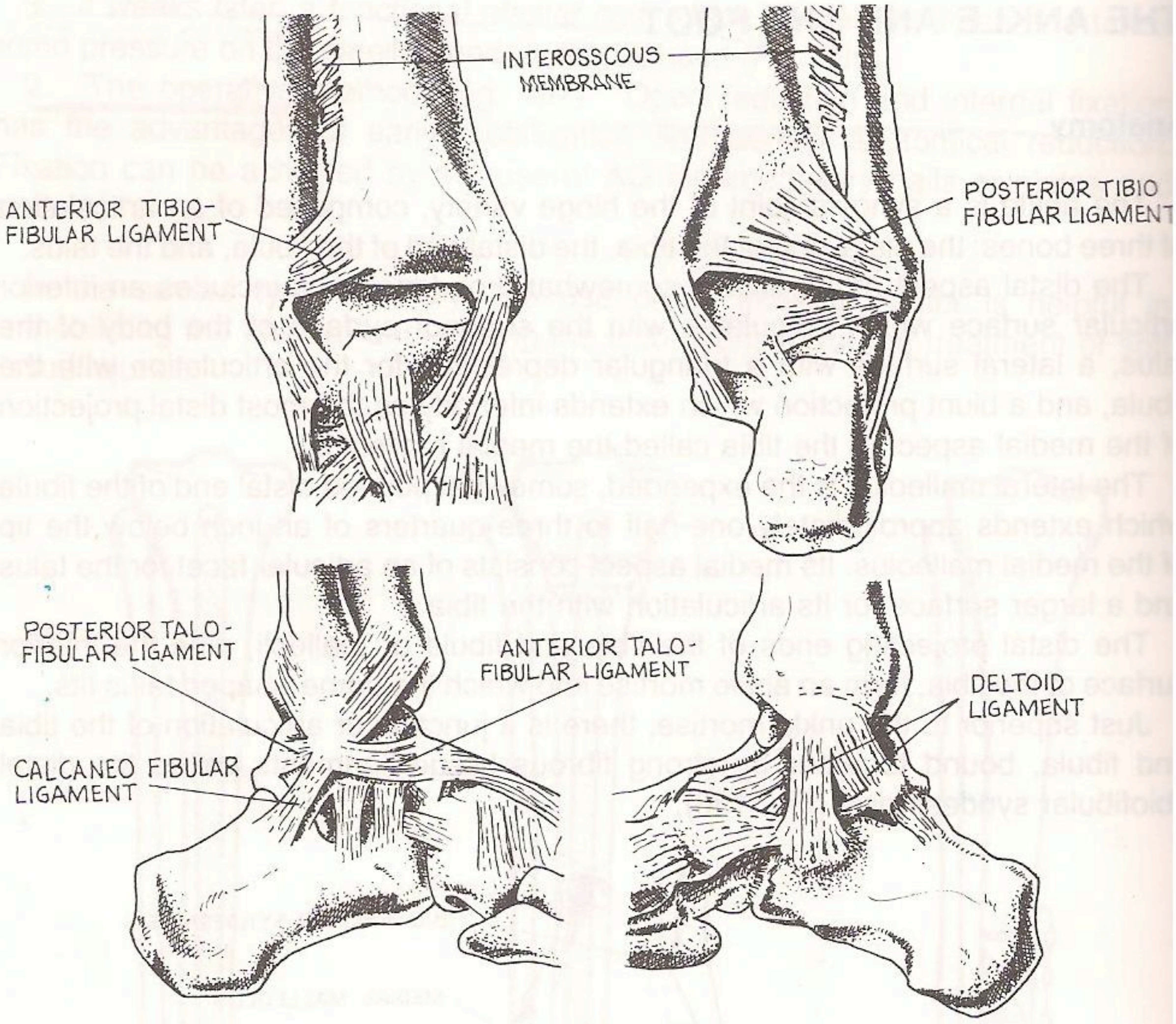


Fig. 189 Ligaments of the ankle

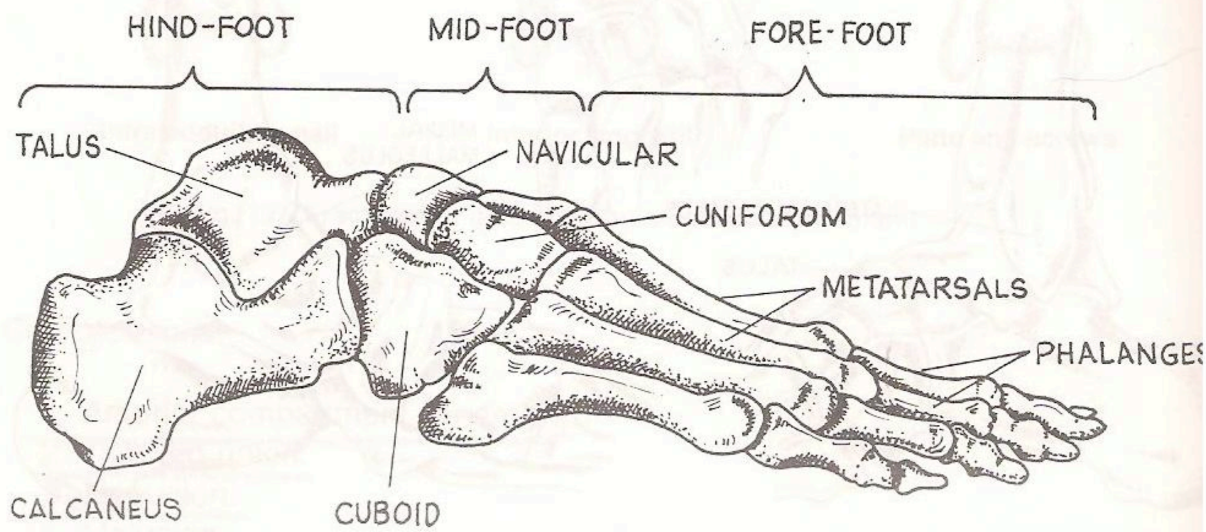


Fig. 190 Bony anatomy of the foot

The medial collateral ligament is a strong, somewhat triangular structure attached to the tip of the medial malleolus, and flares out inferiorly to insert into the talus, calcaneus, and navicular. The lateral ligaments, are three in number, attached to the tip of the lateral malleolus and inserted into the talus and calcaneus (Figs. 189, 190).

Ankle Fractures

Most ankle fractures are indirect injuries resulting from subluxation or dislocation of the talus out of the ankle, usually the foot is anchored to the ground while the momentum of the body continues forwards.

The diagnosis is usually obvious, the ankle is swollen and deformity may be seen. The routine X-rays will confirm the diagnosis and establish the type of the injury.

Classification

1. Lauge – Hansen classification

This is based on mechanism of injury, which is important to know since reduction depends on reversal of the mechanism of injury.

a) Abduction Injuries (Fig. 191)

The acting forces are:

(i) Traction force medially which may lead to either rupture of the medial ligament or avulsion of medial malleolus.

(ii) Compression force laterally which will lead to a transverse fracture of the fibula above the level of the inferior tibio fibular joint and diastasis.

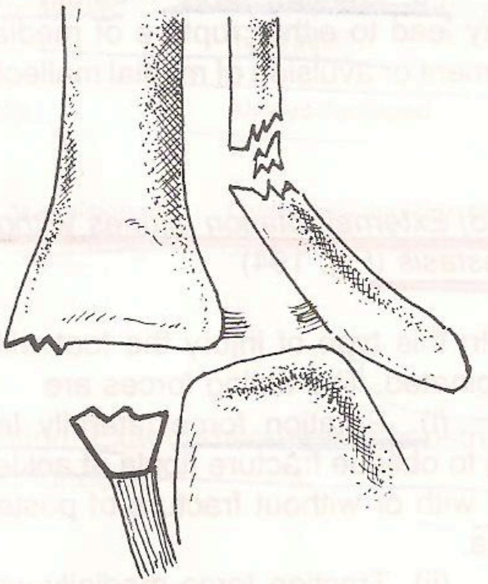


Fig. 191 Abduction injury

b) Adduction injuries, (Fig. 192)

The acting forces are:

(i) Traction force laterally which may lead to either rupture of the lateral ligament or avulsion of lateral malleolus.

(ii) Compression force medially which will lead to a near vertical fracture of the medial malleolus.

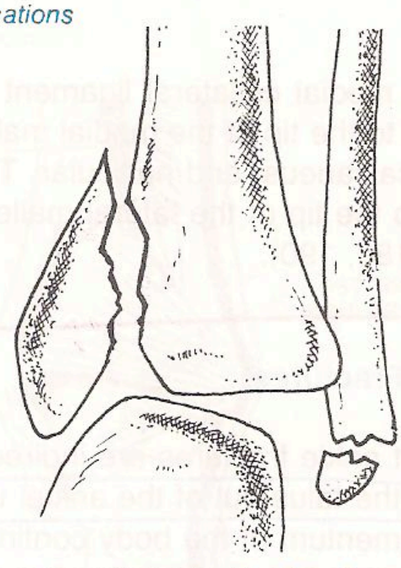


Fig. 192 Adduction injuries

c) External rotation injuries with diastasis (Fig. 193)

In this type of injury, the foot will be pronated. The acting forces are:

(i) Rotation forces laterally. This will lead to oblique fracture of the fibula above the tibiofibular syndosmosis with diastasis.

(ii) Traction force medially. This may lead to either rupture of medial ligament or avulsion of medial malleolus.

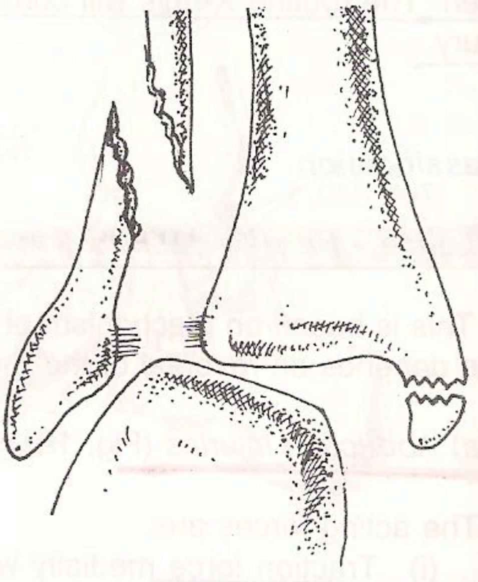


Fig. 193 External rotation injury with diastasis

d) External rotation injuries without diastasis (Fig. 194)

In this type of injury the foot will be supinated. The acting forces are

(i) Rotation force laterally leading to oblique fracture fibula at ankle level with or without fracture of posterior tibia.

(ii) Traction force medially which may lead to rupture of the medial ligament or avulsion of medial malleolus.

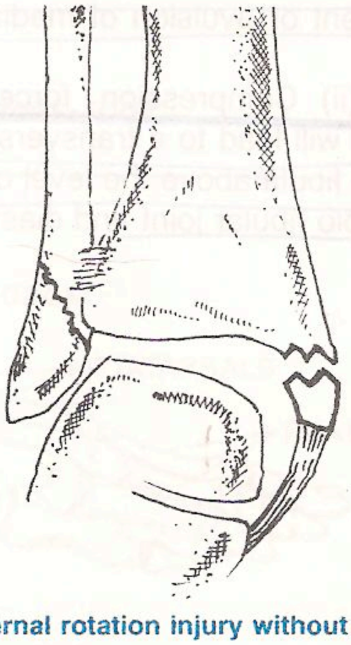


Fig. 194 External rotation injury without diastasis

e) *Vertical compression injuries* (Fig. 195)

These may lead to fracture medial malleolus, fracture distal tibia extending into the joint and fracture fibula.

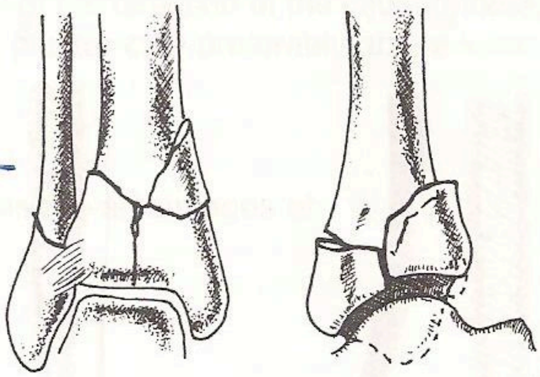


Fig. 195 Vertical compression injury

2. *Weber classification – A.O.* (Fig. 196)

Three types of fractures are recognised according to the level of the fibular fracture. The higher the fibular fracture, the more extensive the damage to the tibiofibular ligaments and the greater the danger of an ankle mortice insufficiency.

	TYPE 'A'	TYPE 'B'	TYPE 'C'
1. Lateral malleolus and fibula	Transverse avulsion fracture at the level of the ankle or below.	Spiral fracture beginning at level of syndesmosis.	Fracture anywhere between the syndesmosis & the head of fibula.
2. Medial malleolus	Intact or sheared	Intact or avulsed	Avulsion fracture or ligament injury.
3. Tibiofibular ligmantous complex.	Always intact	Partially	Always damaged.
4. Posterior edge of tibia	Usually intact	Intact or avulsion of Volkmann's triangle.	Commonly avulsion of Volkmann's triangle.

Management

The aim is to achieve union in a perfect position. Exact anatomical reconstruction of the ankle mortise is essential for perfect function.

The integrity of ankle mortise depends upon:

a) The correct length of the fibula.
b) The integrity of the tibio-fibular syndesmosis.

1. *Conservative methods*

For the success of conservative treatment, the fracture has to be reduced anatomically and to remain undisplaced in plaster until union, these goals are uncommonly achieved by this method.

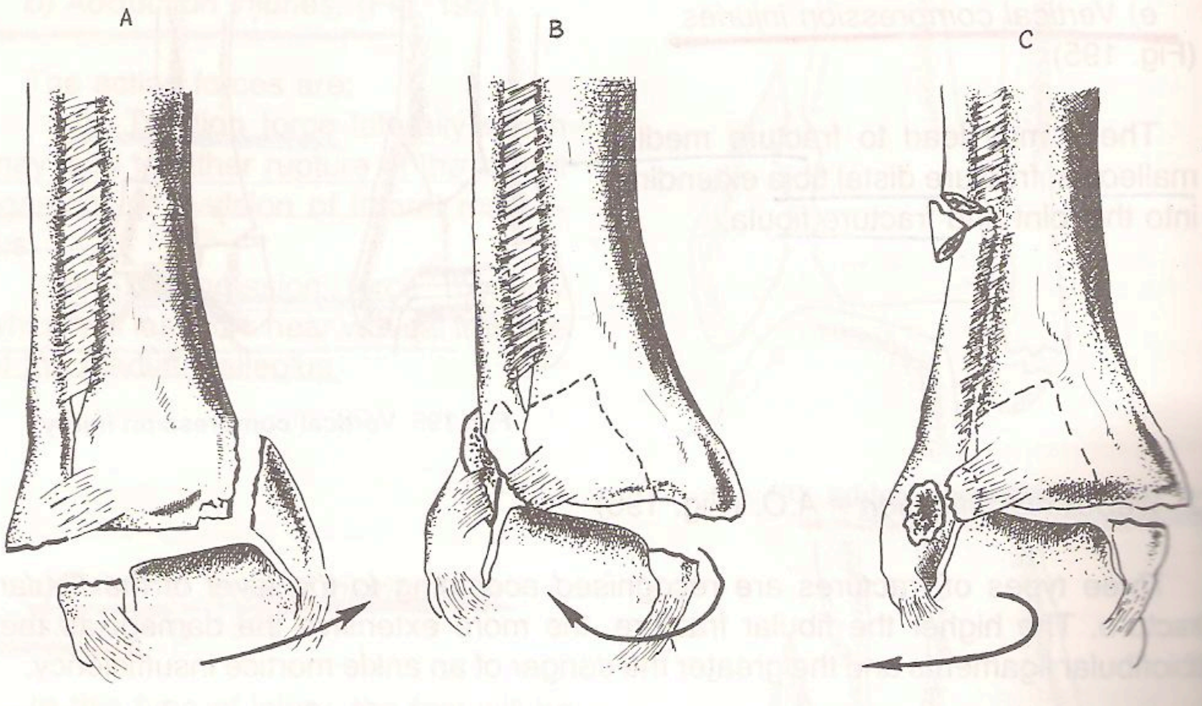


Fig 196 Weber Classification of ankle fractures

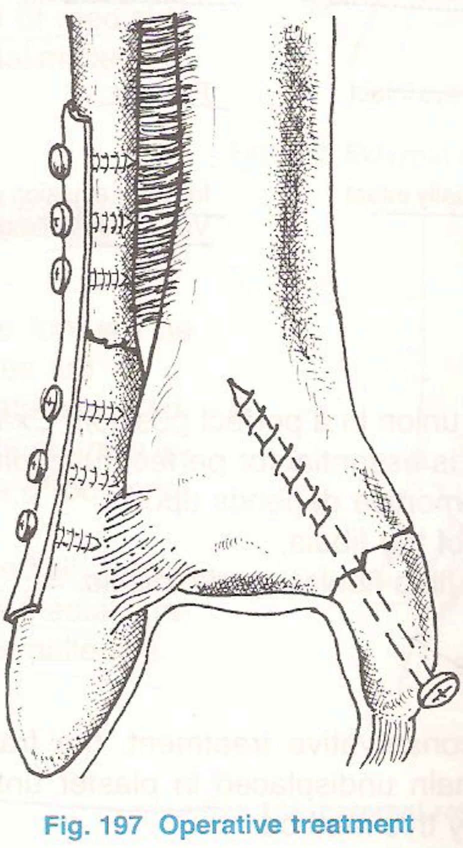


Fig. 197 Operative treatment

Reduction can be achieved by reversal of the direction of the injuring force, the reduced position is then maintained by a plaster cast preferably above knee.

2. *Operative methods* (Fig. 197)

Open reduction and internal fixation has the advantages of
a) perfect reduction.
b) maintaining the reduction.
c) facilitating early movement.

Complications

1. Nonunion: Occurs mainly at medial malleolus if a periostial flap is interposed.
2. Malunion.
3. Joint stiffness: Usually due to neglecting the treatment of soft tissues.
4. Post traumatic osteoarthrosis.

Ankle Ligament Injuries

These injuries can be either partial or complete. Ruptures may occur within the substance of the ligament, at its bony attachment or through the bone itself with avulsion of a small fragment of the bone. The lateral collateral ligaments are more commonly injured than the medial ligament (deltoid).

Injuries of the Lateral Collateral Ligaments

Injuries of the lateral ligaments occurs following adduction type of force, such injuries are most common in the second decade of life mostly due to sports.

Most adduction injuries occur with the ankle in plantar flexion, this leads to rupture of the anterior talofibular ligament, if the force continues the ankle is usually moving toward neutral position so that stress is next thrown on the calcaniofibular ligament which may also tear. The posterior talofibular ligament is rarely injured.

Diagnosis and management

A history of adduction injury is usually reported. Examination reveals swelling, tenderness and ecchymosis. X-rays may show soft tissue swelling and may be a small avulsed fragment of bone. Stress films are used to evaluate the severity of the injury.

1. Minor injuries: The clinical findings are minimal and the ankle is stable to stress. For this type, an elastic or crepe bandage is used for comfort and ambulation is allowed.

2. Moderate injuries: The clinical findings are more severe, stress films show abnormal talar tilt in plantar flexion but not in the neutral position which implies a rupture of the anterior talofibular ligament only. This type is treated by immobilizing the ankle in the neutral position for 3 to 4 weeks in a below knee plaster cast.

3. Severe injuries: clinical and stress films suggest disruption of the anterior talofibular and the calcaniofibular ligaments and capsule. This type is best treated by surgical repair followed by immobilizing the ankle in a below knee cast for 3 to 4 weeks.

Injuries of the Medial (Deltoid) Ligament

Injury of the deltoid ligament may be produced by either external rotation or abduction forces. Partial tears, involving the anterior fibers of the ligaments, occur more often than complete rupture. Tears of the deltoid ligament are manifested clinically by swelling, ecchymosis and tenderness over the damaged part.

If routine X-ray films show widening of the space between the medial malleolus

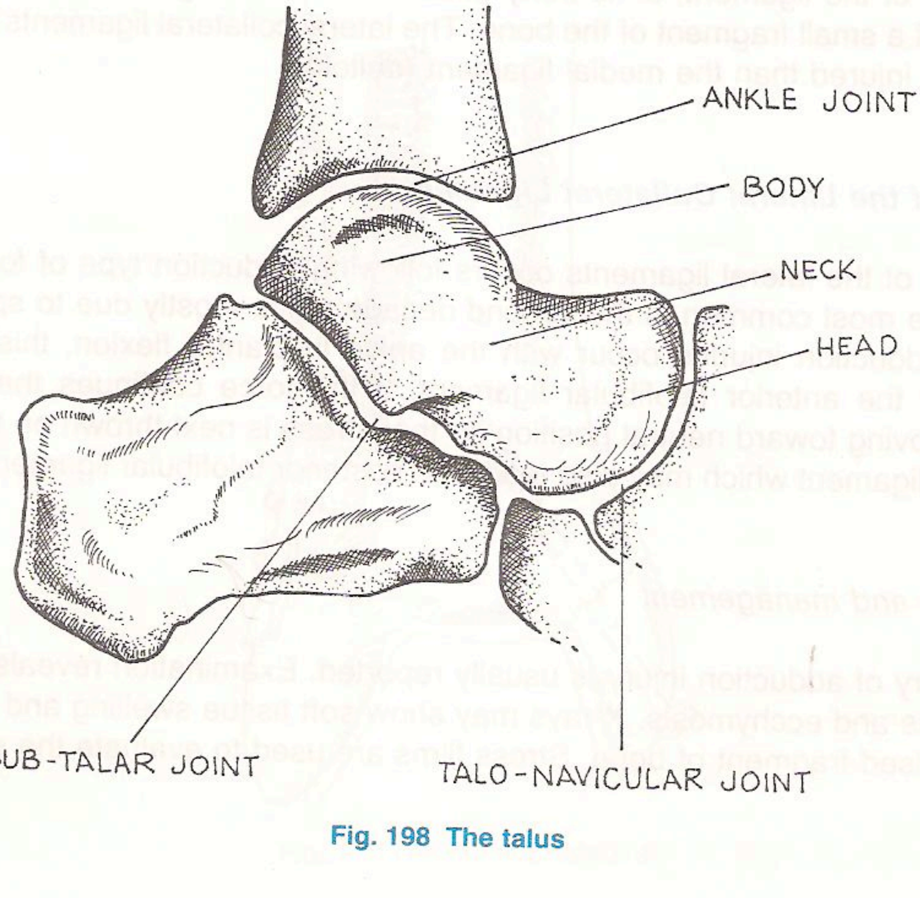


Fig. 198 The talus

and the talus, a tear of the deltoid ligament is suspected. Confirmation of the diagnosis can be obtained by abduction – external rotation stress films.

A partial tear of the deltoid ligament is treated conservatively by immobilizing the ankle in a below knee plaster cast for 3 to 4 weeks.
Both surgical repair and closed treatment have been advocated for a complete deltoid tear.

Fractures of the Talus

The talus is a dome-shaped bone. It is the only bone in the foot which does not provide attachments for any muscle but does serve for the attachment of several ligaments.

It is divided into head, neck and body (Fig. 198).

The arterial blood supply of the talus arises predominantly from branches of the anterior and posterior tibial arteries (Fig. 199).

Disruption of the blood supply internally by comminution and externally by ligamentous rupture and dislocation can lead to avascular necrosis of the body of talus.

Fractures of the talus are uncommon and due to considerable force. A direct compression force may lead to crushing of the talus, while a dorsiflexion force usually leads to fractures of the neck of the talus. Fractures may occur in the head, neck, body or lateral process of the talus.

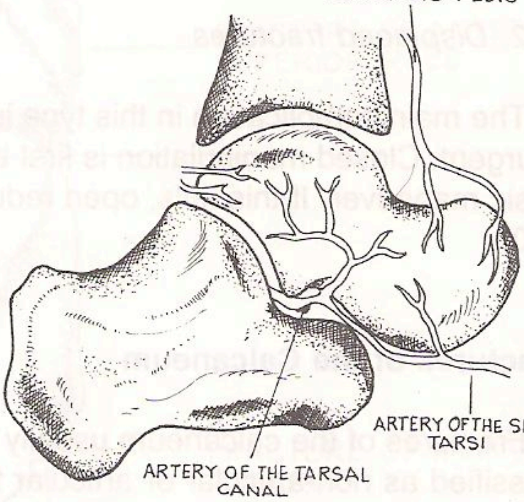


Fig. 199 Blood supply

Treatment

1. Undisplaced fractures

Reduction is not needed, and the limb should be immobilized in a below knee plaster cast.

Weight bearing is allowed with fractures of the head but not with fractures of the body or neck. The cast is removed at 6-8 weeks.

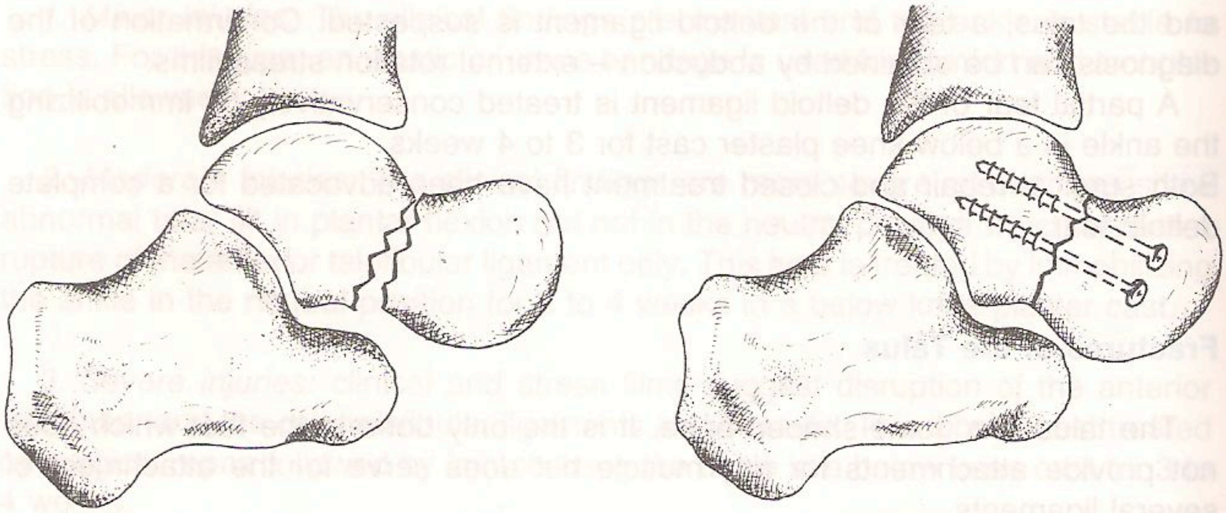


Fig. 200 Fracture neck of the talus – internal fixation

2. Displaced fractures

The main complication in this type is avascular necrosis of the body. Reduction is urgent. Closed manipulation is first tried and forced plantar flexion is usually the basic maneuver. If this fails, open reduction and internal fixation is indicated (Fig. 200).

Fractures of the Calcaneum

Fractures of the calcaneum usually result from falls onto the foot. They may be classified as non-articular or articular fractures.

1. Non-articular fractures of the calcaneum

The fractures in this group include:

a) Beak fractures (Fig. 201)

This is essentially an avulsion fracture. It can be treated conservatively by closed manipulation and immobilization in a below knee plaster cast in an equinus position, but it is best treated by open reduction and internal fixation.

b) Other fractures (Fig. 202)

Fractures of the medial tuberosity, anterior superior pole and sustentaculum tali can occur, but they are relatively unimportant fractures and require no special treatment apart from protected weight bearing until painless.

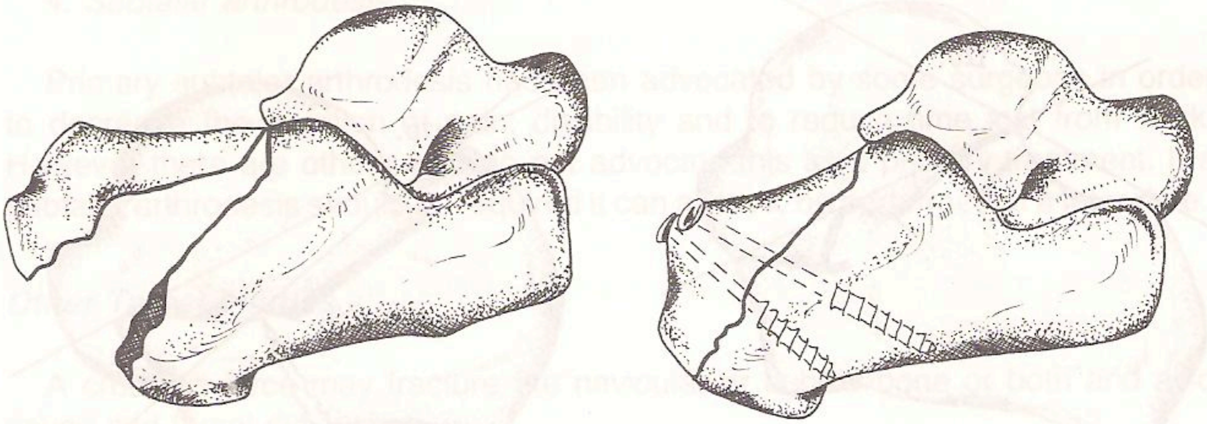


Fig. 201 Beak fracture – internal fixation

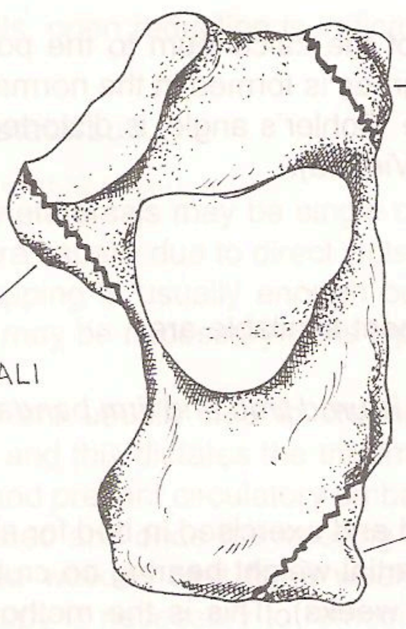


Fig. 202 Non-articular fractures of the calcaneum

2. Articular fractures of the calcaneum

As result of falls onto the heels from a height, the calcaneum is driven up against the talus and is frequently crushed.

The diagnosis can be made from the history of a fall, pain in the heel, and bruising, swelling and tenderness on clinical examination: It must be noted that the same accident may also have damaged the hips, pelvis and spine and all these must always be examined in calcaneal fractures.

X-rays may show the fracture lines but the calcaneum may be so crushed that a fracture can not be seen, and careful examination of the x-rays is necessary to confirm the diagnosis. If a line drawn from the back of the superior angle of the calcaneum to the posterior aspect of the subtalar point and another line is drawn

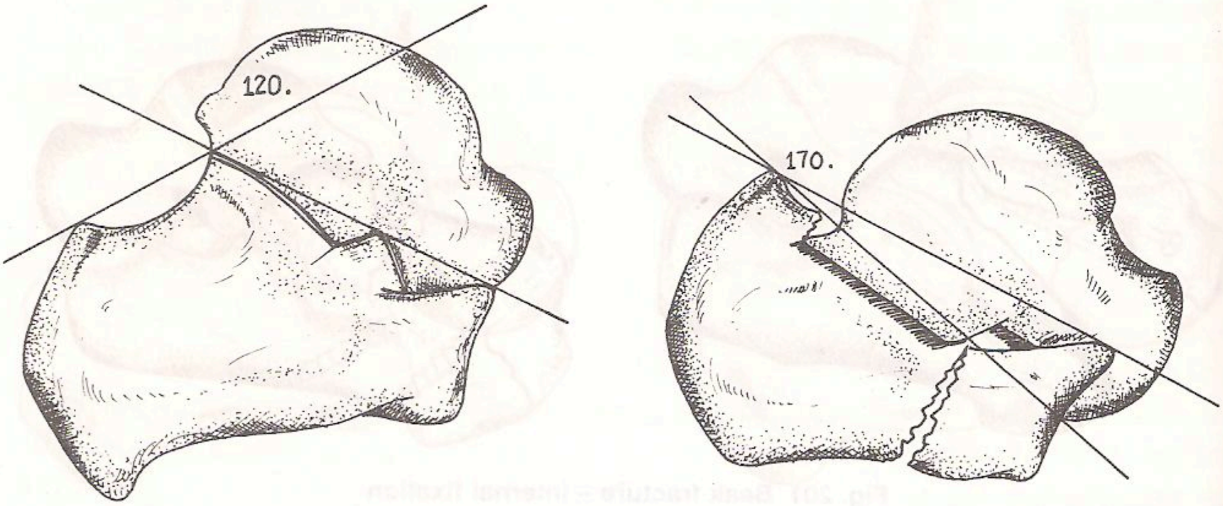


Fig. 203 Bohler's angle

form the anterior superior pole of the calcaneum to the posterior aspect of the subtalar joint an angle of 120 degrees is formed in the normal foot. However if the calcaneum is crushed, this angle 'Bohler's angle' is distorted (Fig. 203). (Bohler, Lorenz – Orthopaedic Surgeon, Vienna).

Treatment

The various methods of treatment available are:

1. Functional – elevation of the injured limb and firm bandaging combined with physiotherapy

The foot is elevated, bandaged and exercised in bed for about two weeks. The patient is then allowed up with partial weight bearing on crutches until the calcaneum has consolidated (8 to 10 weeks). This is the method of choice for most surgeons.

2. Reduction and plaster immobilization

By using a pin inserted into the calcaneum as a lever, it is possible to elevate the depressed articular surfaces. Following reduction a plaster cast is applied for 6 to 8 weeks.

Although this method may improve the X-ray appearance, but the results in terms of performance of the joint are not better than those of the functional treatment.

3. Open reduction and internal fixation

Open reduction can be accurate and radiologically rewarding, but full function is rarely regained.

4. *Subtalar arthrodesis*

Primary subtalar arthrodesis had been advocated by some surgeons in order to decrease the duration of pain, disability and to reduce time lost from work. However there are others who do not advocate this as a primary treatment. If a subtalar arthrodesis should be required it can always, be performed at a later date.

Other Tarsal Injuries

A crushing force may fracture the navicular or cuboid bone or both and also cause mid-tarsal dislocation.

Treatment of these injuries is mostly conservative, dislocation or displacement is reduced under anaesthesia and the foot is immobilized in a below knee plaster cast for six weeks.

If manipulation fails, open reduction is indicated.

Fractures of the Metatarsus

Fractures of the metatarsals may be single or multiple.

Single fractures are usually due to direct violence or muscle avulsion, treatment is symptomatic, strapping is usually enough but if pain is severe a below knee walking plaster cast may be necessary. This type of fractures usually unite in 3 to 6 weeks.

Multiple fractures are usually due to crushing injuries, extensive soft tissue damage is common and this dictates the treatment. The primary aim is to control soft tissue swelling and prevent circulatory embarrassment and skin necrosis. The limb should be elevated and once the swelling has subsided, the foot is immobilized in a below knee walking cast for 6 weeks. Following removal of the cast intensive physiotherapy is necessary to remobilize the foot.

Stress Injury (March Fracture)

Stress fractures of the metatarsals are common. They affect the longest metatarsal which is subjected to abnormal stress if there is any forefoot malfunction. The term march fracture, or march foot is commemorative of the fact that this injury occurred frequently in new recruits into the army during the two world wars. The initial radiographs are frequently normal but hypertrophic callus soon develops, making the diagnosis simple.

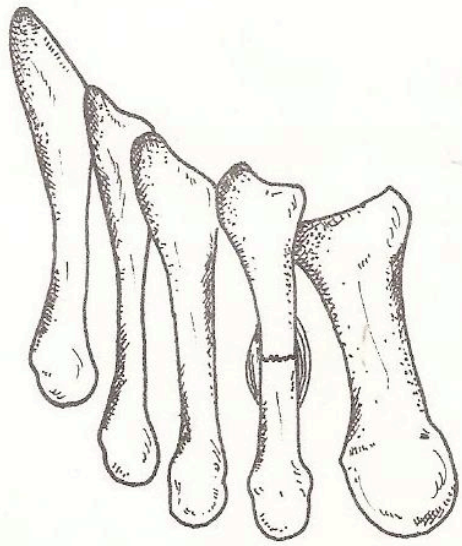


Fig. 204 March fracture

Pain can be relieved by the use of a metatarsal pad under the foot, and physiotherapy may be helpful in neglected cases.

Injuries of the Phalanges

The phalanges are subject to fractures and dislocations. A heavy object falling on the toes may fracture phalanges; if the skin is intact the fracture is disregarded and treated symptomatically.

Metatarso-phalangeal and inter-phalangeal dislocations are infrequent, they are most readily identified in the lateral radiographs. Reduction by traction upon and flexion of the toes is simple under general anaesthesia. Following reduction no special treatment is necessary.

Part 3
Special Topics

MANAGEMENT OF SEVERELY INJURED PATIENTS

The management of patients with multiple injuries is an urgent and complex task. The first need is an organization that will enable the victim to be diagnosed and treated without delay and with the least possible disturbance. The clinical management must be tailored to the presenting priorities which are in turn changeable, and treatment will often commence before definite diagnosis is possible.

The aims should be, firstly, to save the patient's life and, secondly, to repair damage in order to save the injured parts and their function. To simplify the problem, we will discuss management under the following three headings:

Stage I Resuscitation and life saving operations.

Stage II Examination and stabilization:

Stage III Repair and reconstruction.

The following table shows priorities in evaluation and resuscitation of the injured patient:

Rapidly fatal conditions	Respiratory failure Circulatory failure Central nervous system failure.
Injuries requiring prompt therapy or diagnostic studies	Face and jaw injuries Abdominal injuries Spinal injuries Wounds Fractures.

Stage I Resuscitation and Life-saving Operations

This stage is aimed at recognition, treatment and prevention of any threat to life.
The rapidly fatal conditions following multiple injuries are:
Respiratory failure, circulatory failure and central nervous system failure.

Chest Injury – Respiratory Failure

Much information about chest injury and the need for measures such as pleural drainage and artificial ventilation can be obtained by clinical examination.

Although radiography is of value, it is not immediately practical in the early stages of resuscitation.

Physical signs of chest injury:

1. *Inspection*

a) Respiratory distress.
b) Cyanosis – which can be difficult to recognise after severe injury and in poor light.
c) Jugular – venous distention.
d) Surgical emphysema.
e) Loss of symmetry of both shape and movement of the chest. (Stove in chest, flail chest and paradoxical movement)

2. *Palpation* The trachea may be displaced.

3. Percussion and auscultation may reveal signs of haemothorax and/or pneumothorax.

Management of chest injury

The immediate therapeutic aims are:

1. Establish, maintain and protect a clear air passage (Fig. 205). Airway has to be cleared of foreign materials (blood-clots, vomitus, broken teeth) sweep fingers around posterior pharyngeal wall. Use tongue forceps and mouth gag if necessary, extension of head and elevation of jaw will overcome hypoxia caused by swallowing the tongue, move the cervical spine with great care since unstable fracture may not have been diagnosed.

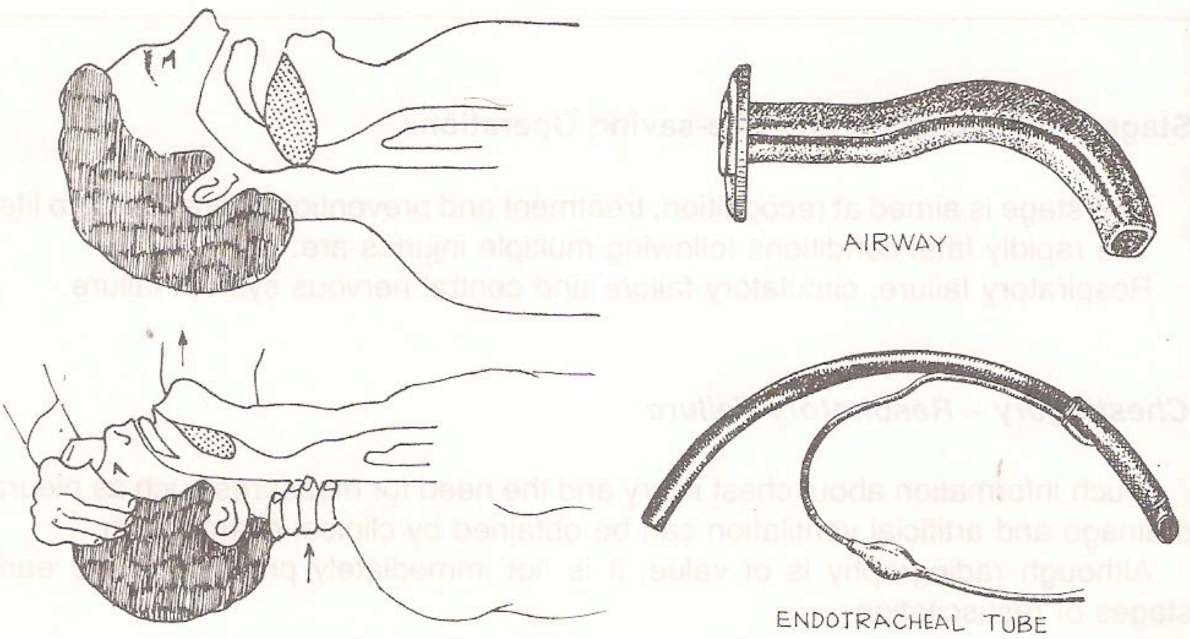


Fig. 205 Clear, maintain and protect air passages

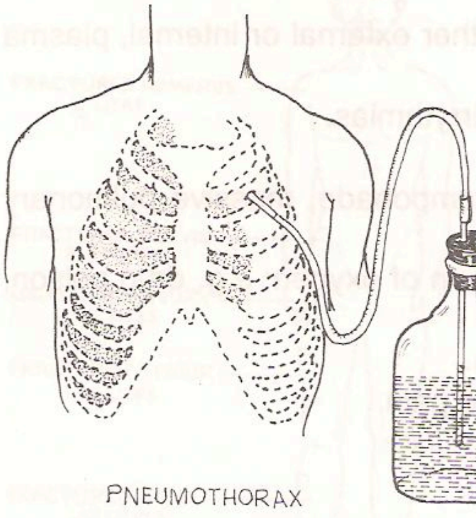


Fig. 206 Drainage of pneumothorax

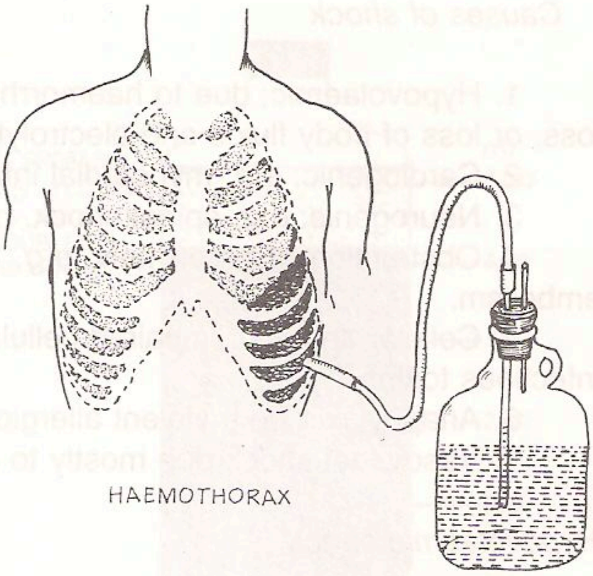


Fig. 207 Drainage of haemothorax

Maintaining the cleared airway can be achieved by oropharyngeal or endotracheal tube as necessary.

Once secured, airway should be protected against inhalation of blood and vomit by turning patient on his side (Tonsillar position) if possible.

2. Restore ventilation of the lung by natural or artificial means, in this respect it must be remembered that artificial ventilation should include the use of a large drainage tube for air if there is any possibility of a rapidly expanding pneumothorax, which can occur with artificial ventilation.

3. Restore full expansion of the lung by removing air or blood from the pleural space, Fig. 206 & 207.

4. Stabilization of the chest wall (Flail chest)

This is best achieved by intermittent positive pressure ventilation (I.P.P.V).

5. *Tracheostomy*: This is seldom necessary for initial maintenance of airway, however it may be life saving and therefore mandatory in *e.g.* impacted foreign bodies, injuries of face, jaw and neck involving the integrity of the upper respiratory tract.

Circulatory Failure

Shock

Shock is a state of impaired cellular metabolism that usually results from inadequate capillary perfusion.

Causes of shock

1. Hypovolaemic; due to haemorrhage whether external or internal, plasma loss, or loss of body fluids and electrolytes.
2. Cardiogenic: *e.g.* myocardial infarction, arrythmias.
3. Neurogenic: *e.g.* spinal shock.
4. Obstruction of blood flow: *e.g.* cardiac tamponade, massive pulmonary embolism.
5. Cellular shock or impaired cellular utilization of oxygen: *e.g.* drug poison, infectious toxins.
6. Anaphylaxis from violent allergic reaction.
7. Vasovagal shock due mostly to excessive pain.

Hypovolaemic shock

The most frequent cause of shock after injury is haemorrhage. Reflex and other causes of shock can play a part, but they are unlikely, by themselves, to give rise to more than temporary anxiety.

Diagnosis

The patient may complain of thirst, nausea, vomiting. Clinically the skin and lips are pale and extremities are cold and clammy. The respiration is shallow and rapid. As compensation fails the pulse becomes rapid and weak while the blood pressure drops. The state of consciousness changes from anxiety to apathy to unresponsiveness.

Treatment

1. Restore normal blood volume

The surgeon's most important tasks are:

a) Stop bleeding.

b) Recognize and diagnose the site of, and manage internal bleeding.

c) Decide whether the patient needs blood, and if so, how soon, and in what quantity.

The likely need for blood can be estimated with useful accuracy by expressing the injuries in terms of the estimated amount of blood loss they cause, Fig. 208.

2. Monitor vital signs

a) Pulse – B.P.

b) Central venous pressure.

c) Haematocrite.

d) Urine output.

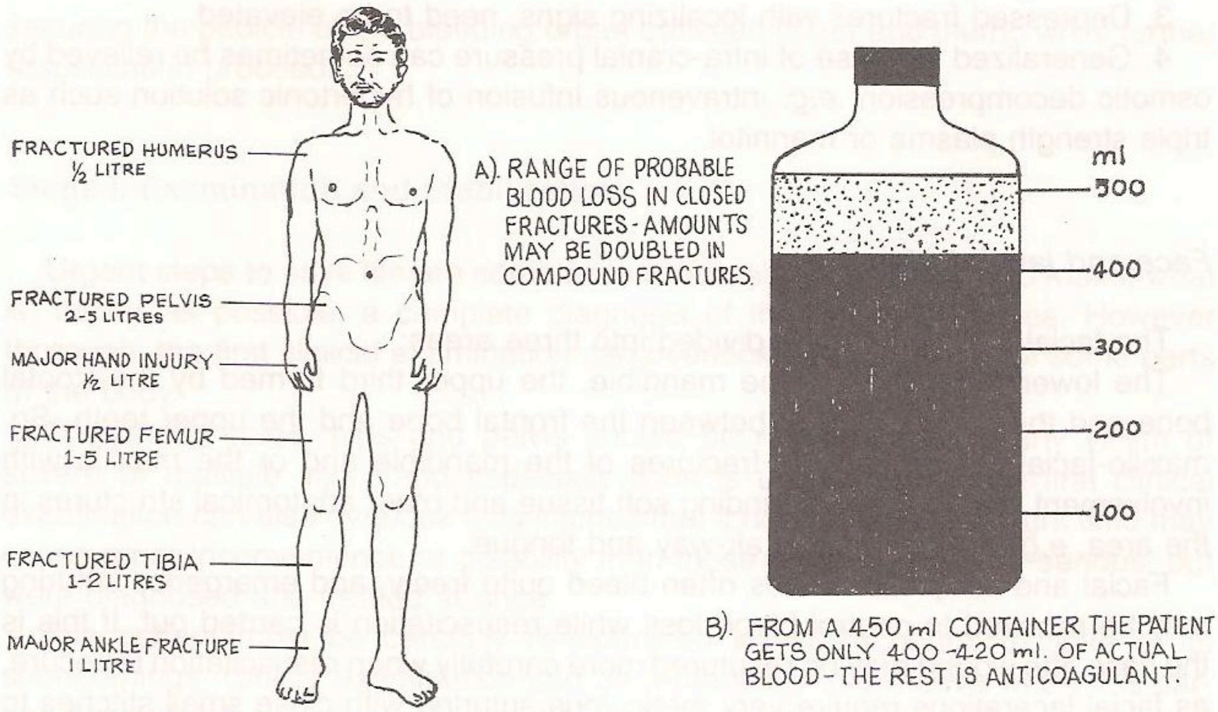


Fig. 208 Blood loss in fractures

3. Give additional support

a) Respiratory assistance.
b) Digitalization for cardiac failure.
c) Steroids to stabilize cellular & intercellular membranes.

Head Injury

The most common head injury is concussion. It requires no special treatment beyond rest, but careful observation is necessary because compression from intra-cranial haemorrhage or oedema may supervene.

Clinical examination is essential to establish a base-line of information regarding the level of consciousness, the pupil and its reaction, blood- pressure, pulse-rate, respiration and motor-power in the limbs. Frequent examinations are required to establish the progress of injury. Special investigations such as plain X-rays, computerized tomography and carotid angiography are of value in establishing the diagnosis of lesions such as intra or extra cerebral haematoma, contusions and oedema, thus simplifying management.

Treatment

1. It is essential to establish and maintain a clear air-way to prevent hypoxia which could lead to cerebral damage.
2. Extra-dural haemorrhage is treated by craniotomy.

3. Depressed fractures with localizing signs, need to be elevated.

4. Generalized increase of intra-cranial pressure can sometimes be relieved by osmotic decompression, *e.g.* intravenous infusion of hypertonic solution such as triple strength plasma or mannitol.

Face and jaw injuries

The facial skeleton can be divided into three areas:

The lower third which is the mandible, the upper third formed by the frontal bone and the middle third in between the frontal bone and the upper teeth. So, maxillo-facial injuries include fractures of the mandible and or the maxilla with involvement also of the surrounding soft tissue and other anatomical structures in the area, *e.g.* the orbit, nasal air-way and tongue.

Facial and scalp lacerations often bleed quite freely, and emergency suturing may be required to control blood loss while resuscitation is carried out. If this is the case, the wound may be resutured more carefully when resuscitation is secure, as facial lacerations require very meticulous suturing with close small stitches to ensure a satisfactory cosmetic result. Excision of wound edges and the performance of delayed suture so often necessary in other areas of the body are only necessary in facial and scalp lacerations under quite exceptional circumstances, owing to the very marked capacity that facial and scalp tissues have for healing.

In severe injuries, tracheostomy may be needed to ensure an adequate airway. Reduction and fixation of the fracture itself is less urgent. It is usually safe to wait until the services of a facio-maxillary surgeon can be obtained.

Abdominal injury

The most useful signs of abdominal injury are:

1. Increasing and spreading discomfort and tenderness.
2. Increasing muscle resistance to palpitation.
3. Unexplained signs of bleeding.
4. Bruising of abdominal wall.

Plain X-ray in different positions and intravenous pyelography and cystography may be needed to help in diagnosis. Diagnostic peritoneal tap is a useful procedure but it may give false negative results in a small number of cases.

The most important abdominal injuries are: rupture of viscera, *e.g.* ruptured spleen, liver, and of blood vessels.

Once diagnosis of abdominal injury has been made, treatment is surgical by laparotomy and repair of the injury or removal of the injured part if it is beyond repair, *e.g.* splenectomy, nephrectomy.

It is usually wise to resuscitate the patient before submitting him to laparotomy, but occasionally where bleeding is outstripping efforts at such resuscitation, there is no choice but to operate at once, if only to stop the internal haemorrhage by securing the pedicle of the bleeding organ between finger and thumb while further resuscitation proceeds.

Stage II Examination and Stabilization

Urgent steps to save life are sometimes a necessary preliminary to make, what is, as far as possible, a complete diagnosis of the patient's injuries. However thorough, the first clinical examination can overlook severe injuries of some parts of the body.

The chest, spine, hips and pelvis should be radiographed in any victim of severe or multiple injury and especially if he is unconscious. The first clinical examination can also overlook mild injuries that if not treated at the right time may cause more inconvenience or disability than those which were more serious, but were diagnosed and treated at once.

The patient must be carefully re-examined within 24 hours. In spite of its shortcomings, clinical examination can be remarkably informative when it is carried out with full awareness, firstly of the injuries which are likely to have resulted from the accident and secondly of the combinations of injuries that can be expected after a serious accident.

It may be only in this second stage that the patient can be fully undressed. After severe injury, it is often wise to defer what can be a lengthy and disturbing process until the patient can withstand it.

Patterns of injuries

Injuries of the musculo-skeletal system follow certain patterns in severe trauma, also combination or paired injuries may be occurred.

The initial search for injuries should be repeated within 24 hours and carried out with no less care and attention than the first, because it so happens that tell tale bruising and swelling takes several hours to appear.

1. Pedestrians knocked down by vehicles are liable to suffer injuries from head to foot, mainly on one side. Each of the possible injuries should be sought in turn.

2. Occupants of motor-cars suffer a different pattern of injuries, particularly when they are not restrained. Pairs of injuries to be borne in mind are:

   a) Signs of injury of the face or brow and hyper-extension of the neck.
   b) Severe injury of the pelvis with rupture of the diaphragm.
   c) Injuries of the knee with dislocation of the hip.
   d) Fracture of the femur with injury of the hip.
   e) Fracture of the leg and ankle and injuries of the foot.

3. Fall from a height gives a combination of fractures, calcaneum pelvis or hip and spine.

Apart from the necessary examination and recording at this stage, wounds need to be dressed. Tetanus toxoid is usually needed either to initiate or to boost immunity. Antibiotics may also be necessary.

Injured limbs need comfortable support by either inflatable splints or even sand bags.

The continued observation during Stage II may show failure to make the expected response to resuscitation and may, therefore, raise the possibility of hidden and unsuspected bleeding into chest, abdomen and pelvis.

Stage III Repair and Reconstruction

Following resuscitation and possibly stabilization, operative procedures to repair the damages are undertaken at this stage.

An orderly sequence is important:

1. Stop bleeding:

In order of importance are: Intracranial, intrathoracic and intra-abdominal bleeding.

2. Treat major chest injuries:

This may necessitate thoracotomy, tracheostomy etc.

3. Laparotomy and repair of ruptured abdominal viscera.
4. Open wounds are excised and dressed.
5. Fractures are splinted, and internal fixation may be needed in cases of multiple injuries. This should not be delayed as early definitive treatment reduces morbidity and mortality.

PERIPHERAL NERVE INJURIES

Anatomy (Fig. 209)

The separate nerve fibres are loosely bound together by a fine meshwork of collagen, known as the endoneurium, the various bundles or fasciculi of nerve fibres are each enclosed by the perineurium and all bound together by a relatively coarsely structured fibrous sheath, the epineurium, in which run the blood vessels supplying the nerve.

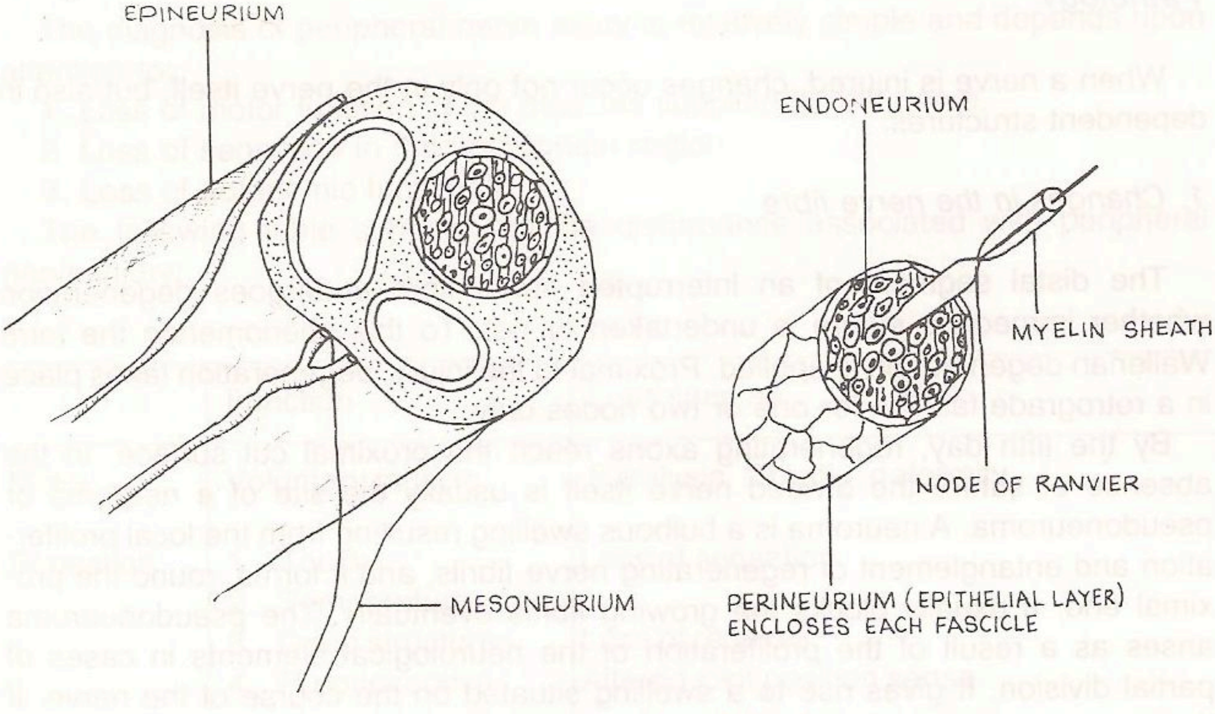


Fig. 209 The anatomy of a peripheral nerve

Functions of a Peripheral Nerve

1. Motor.
2. Sensation.
3. Autonomic.
   a) Vasomotor.
   b) Sudomotor.
   c) Pilomotor.

The following anatomical sites are the most common where nerves tend to be damaged or entrapped:

a. The radial nerve in the spiral groove of the humerus.
b. Ulnar nerve behind the medial epicondyle of the humerus.
c. The lateral popliteal nerve as it spirals round the neck of the fibula.

Mechanism of Injury

Nerve injuries can be associated with fractures in a variety of ways.

1. Direct injury by the displaced fragments (commonest cause).
   a) Stretching, and
   b) laceration.
2. Indirect injury (delayed injury) resulting from.
   a) Callus and scar tissue
   b) deformity, and
   c) ischaemia from injury to vessels.

Pathology

When a nerve is injured, changes occur not only in the nerve itself, but also in dependent structures.

1. Changes in the nerve fibre

The distal segment of an interrupted nerve fibre undergoes degeneration whether immediate suture is undertaken or not. To this phenomenon the term Wallerian degeneration is applied. Proximal to the injury, degeneration takes place in a retrograde fashion for one or two nodes only.

By the fifth day, regenerating axons reach the proximal cut surface. In the absence of suture the divided nerve itself is usually the site of a neuroma or pseudoneuroma. A neuroma is a bulbous swelling resulting from the local proliferation and entanglement of regenerating nerve fibrils, and it forms, round the proximal end. It usually blocks the growing fibrils eventually. The pseudoneuroma arises as a result of the proliferation of the neurological elements in cases of partial division. It gives rise to a swelling situated on the course of the nerve. If the nerve was repaired, the regenerating axons cross the site of repair and grow at the rate of about 1 mm per day.

2. Changes in dependent structures

Many other structures and functions, are liable to suffer following peripheral nerve division.

a) Skin changes

The loss of autonomic control leads to smooth atrophic skin, with loss of hair, and skin papillae, poor temperature response and loss of subcutaneous fat.

b) Muscle changes

Muscles become wasted, atrophic and deformities may occur due to imbalance.

c) Skeletal changes

The skeletal tissue of a denervated limb undergoes bony osteoporosis, with fibrotic and degenerative changes occurring in joints unless careful measures are taken to keep the limb moving passively.

Most of the structures and organs in a limb, including muscles and sensory end-organs, are apparently capable of surviving for about a year without innervation, but after this time they become increasingly less likely to regain function, even if successful axonal regeneration occurs.

Diagnosis

The diagnosis of peripheral nerve injury is relatively simple and depends upon attention to:

1. Loss of motor function in the muscles supplied by the nerve.
2. Loss of sensation in the appropriate region.
3. Loss of autonomic functions.

The following table summarises the disturbance associated with peripheral nerve injury:

	Function	Loss seen as
Motor	Voluntary muscle	Paralysis, atrophy, deformity.
Sensation	1. Touch	Loss of sensation
	2. Temperature	
	3. Deep structures	Loss of reflexes
	4. Proprioceptive	Altered joint position sense.
Autonomic	1. Vasomotor	Vasodilatation, vasoconstriction
	2. Sudomotor	Loss of sweating
	3. Pilomotor	Loss of follicular pimples.

Classification

1. Neurapraxia

This term is used to describe injury in which the nerve is contused, compressed, or stretched, without disruption of the axons. This condition is associated with early recovery.

2. Axonotmesis

The nerve has been contused, compressed or stretched. The axon has been disrupted. All of the nerve investments remain intact. The injury has been severe enough that Wallerian degeneration will take place.

3. Neurotmesis

The nerve has been completely or partially divided, it is commonly associated with an open wound. Repair is required before regeneration can take place.

Treatment of Peripheral Nerve Injuries

The treatment of nerve injuries may be either conservative or operative.

1. Conservative treatment

In every case of nerve injury, the first procedure to adopt is the splintage of the limb in the position which will most completely relax the affected muscles. The most important objective in this treatment is to preserve the mobility of the whole limb and every part of it.

Splintage has to be carefully used, therefore, and at least once every day every joint must be put through its full range of movement.

2. Operative treatment

a) Nerve repair

Nerve repair is indicated for neurotmesis. Primary repair should be carried out in open injuries if the wound is clean. If the wound is ragged and contused secondary repair is advisable ideally two or three weeks post injury.

b) Reconstructive surgery

Secondary reconstruction of the affected extremity in the form of joint arthrodesis or tendon transfer is indicated when operations on the nerve itself are not appropriate or failed.

Nerve Injuries in the Upper Limb

Brachial Plexus Injuries

Injuries to the brachial plexus, that is roots, trunks and divisions, are not infrequent. The majority of such lesions are traction lesions and are commonly due to high speed road accidents.

Anatomy (Fig. 210)

The brachial plexus is formed by the anterior primary divisions of the fifth, sixth, seventh, and eighth cervical and first thoracic nerves, which join and then subdivide according to a constant plan. The plexus may be reinforced by a contribution from the fourth cervical, when it is known as a pre-fixed plexus; or a reinforcement may be present from the second thoracic, in which case it is known as a post-fixed plexus.

An accurate examination can identify the site of neurological injury. Many of the large muscles are innervated from several segments, but usually isolated injuries of the plexus bear heavily on certain muscles. The following list gives the commonest effects of section of the individual roots in terms of paralysis:

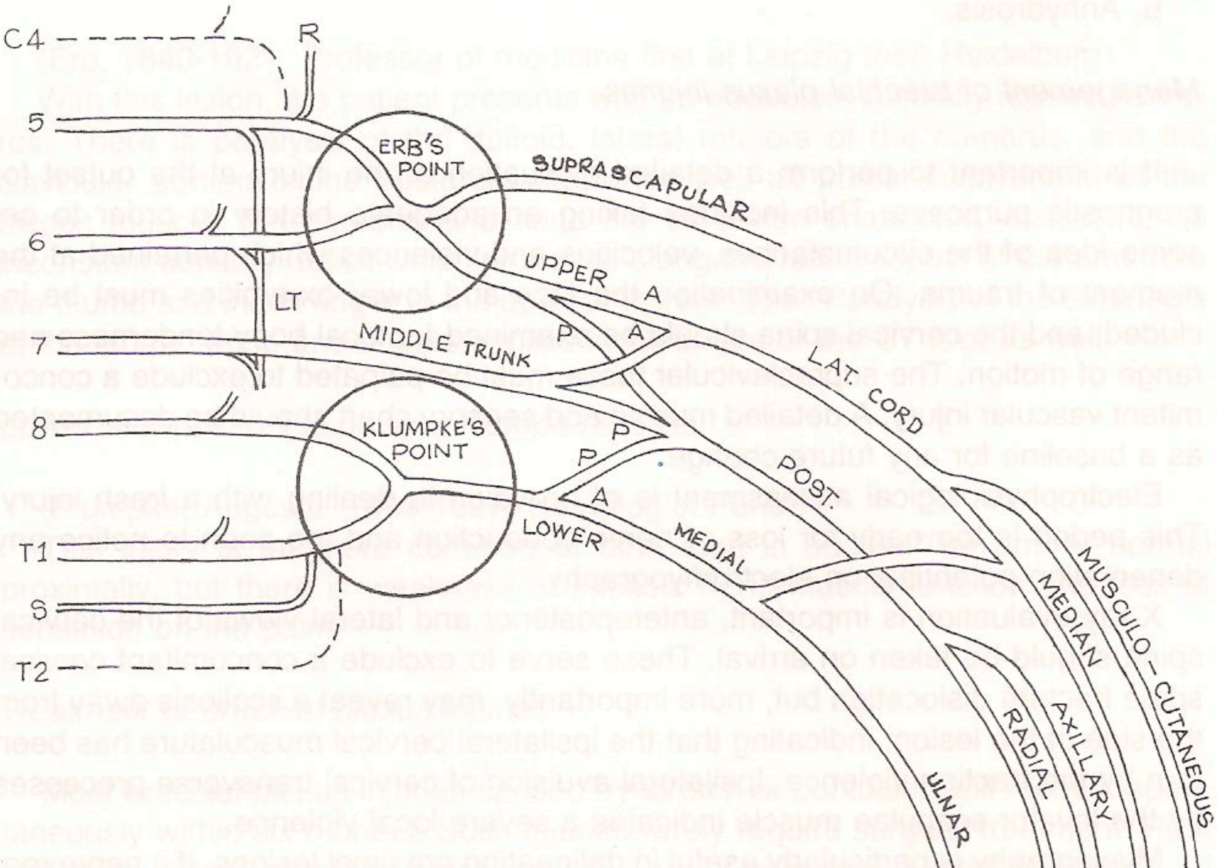


Fig. 210 Anatomy of the brachial plexus

C5 Rhomboids, deltoid, supra and infra spinatus, biceps, brachialis, clavicular head of pectoralis major.

C6 Sternal head of pectoralis major and triceps.
C7 Extensors of wrist and fingers.
C8 Flexors of wrist and fingers.
T1 Intrinsic muscles of hand.

The lowest root of the plexus carries in it for a short distance some of the sympathetic fibres which have left the cord in the anterior roots of the first and second thoracic segments. Rupture of the former root will, therefore, be accompanied by Horner's syndrome as well as by paralysis of the small muscles of the hand.

Signs of Horner's syndrome

1. Drooping of the upper lid.
2. Narrowing of the palpebral fissure.
3. Retrogression of the eyeball (enophthalmos).
4. Contraction of the pupil.
5. Loss of the ciliospinal reflex; normally the pupil dilates when the sympathetic is paralysed this reflex is lost.
6. Anhydrosis.

Management of brachial plexus injuries

It is important to perform a detailed evaluation of the injury at the outset for prognostic purposes. This includes taking an adequate history in order to get some idea of the circumstances, velocities and violences which pertained at the moment of trauma. On examination the face and lower exremities must be included, and the cervical spine should be examined for local bony tenderness and range of motion. The supraclavicular fossa must be palpated to exclude a concomitant vascular injury. A detailed muscle and sensory chart should be documented as a baseline for any future change.

Electrophysiological assessment is of no value in dealing with a fresh injury. This period is too early for loss of nerve conduction and too soon to notice any denervation potentials on electromyography.

X-ray evaluation is important, anteroposterior and lateral views of the cervical spine should be taken on arrival. These serve to exclude a concomitant cervical spine fracture dislocation but, more importantly, may reveal a scoliosis away from the side of the lesion, indicating that the ipsilateral cervical musculature has been torn by the traction violence. Ipsilateral avulsion of cervical transverse processes by the levator scapulae muscle indicates a severe local violence.

Myelography is particularly useful in delineating proximal lesions. If a nerve root has been avulsed from the cervical spinal cord, there is no restraint to the passage of contrast medium outside the axial skeleton and a pouch of contrast medium at the exit of the nerve root is diagnostic of root avulsion.

Axon reflex tests are useful in differentiating pre- and postganglionic lesions and are based upon the physiological principles of the axon reflex. If histamine is applied to the skin, a triple response is evoked a red reaction, flare and weal. The red reaction and weal are local responses of the skin to applied histamine but the flare is mediated by an axon reflex which stops short of the spinal cord at the posterior ganglion. Thus, if histamine is applied to the insensitive dermatomes of the brachial plexus lesion, and all three modalities of the triple response are present, then the lesion is preganglionic.

Bad prognostic features

1. A history of severe violence.
2. Horner's syndrome.
3. A pulsatile swelling in the supraclavicular fossa.
4. A cervical scoliosis.
5. Avulsion fractures of the transverse processes of the cervical spine.
6. Myelographic evidence of root avulsion.
7. A positive axon reflex test.

Upper root (C5 to C6) palsy – Erb's palsy

(Erb, 1840-1921. Professor of medicine first at Leipzig then Heidelberg)

With this lesion, the patient presents with an adducted, medially rotated humerus. There is paralysis of the deltoid, lateral rotators of the humerus, and the clavicular portion of the pectoralis major, as well as partial involvement of the biceps muscle. The forearm and hand are otherwise unaffected, except for an inconstant sensory deficit which proceeds along the radial aspect of the arm from the thumb and index finger to the apex of the shoulder. Paralysis of the extensors at the elbow, wrist, and fingers implies involvement of the C7 root as well.

Lower root (C8 to T1) palsy – Klumpke's palsy

(Klumpke, Augusta. 1859-1927, Neurologist Paris).

This injury is far more common at birth than in adults. The arm is normal proximally, but there is weakness of intrinsic hand muscle function and loss of sensation on the palm.

Treatment of brachial plexus injuries

Most brachial plexus injuries caused by stretch or contusion will recover spontaneously within six months. Such injuries rarely require surgical treatment. Rest and relief of tension of the brachial plexus are of help during initial treatment. All flail joints should be splinted in a functional position and put through a full range of motion each day. Failure to improve over a period of several months may indicate laceration of one or more brachial plexus components, the repair of which may be complex and will require grafting.

For the Erb's palsy secondary reconstructive procedures offer a much greater chance of functional restoration than do attempts at nerve repair.

Median Nerve Injuries

Anatomy

The median nerve arises from the brachial plexus and carries fibres from the 6th, 7th, 8th cervical and 1st thoracic roots. It is the motor nerve to the wrist flexors, long flexors to the fingers and some of the intrinsic muscles of the hand (the lumbricals to the index and middle fingers and the thenar muscles with the exception of adductor pollicis). The sensory distribution of the median nerve in the hand is to the radial half of the hand.

Mechanism of injury

The median nerve is most frequently injured in wounds of the forearm, especially penetrating injuries, such as those caused by broken glass. It may also be injured in fractures of the lower end of the humerus.

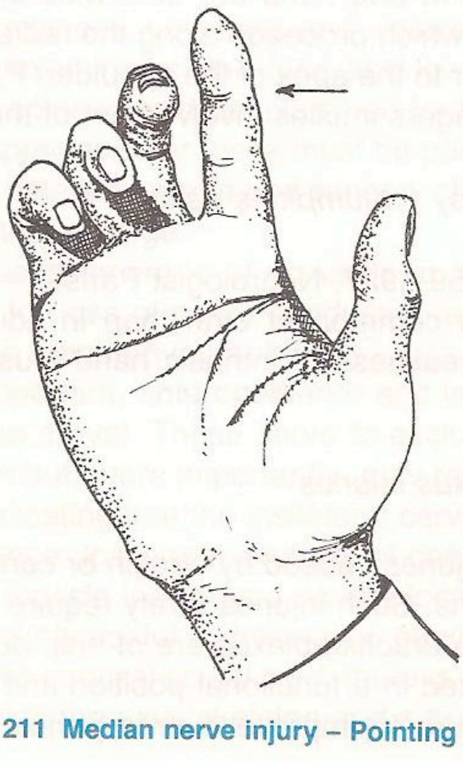


Fig. 211 Median nerve injury – Pointing index

Diagnosis

1. Loss of motor function

A complete division of the median nerve above the elbow involves the flexors of the wrist, fingers and thumb, the pronator teres and the pronator quadratus, as well as the opponens pollicis, abductor pollicis and the superficial head of the flexor pollicis brevis.

The characteristic attitude: The thenar eminence is wasted and the thumb rolled laterally.

When the patient is asked to close the fist, the thumb and the index finger remain extended (pointing index), Fig. 211.

2. Sensory

The sensory loss involves the thumb, index and middle fingers and half the ring finger, Fig. 212. The functional incapacity of the hand is severe, as the median nerve is the 'eye' of the hand.

Treatment

Surgery is indicated in open injuries, exploration and primary repair of the damaged nerve is carried out if at all possible and the wound is clean, secondary repair two to three weeks later is indicated if the wound is ragged and contused.

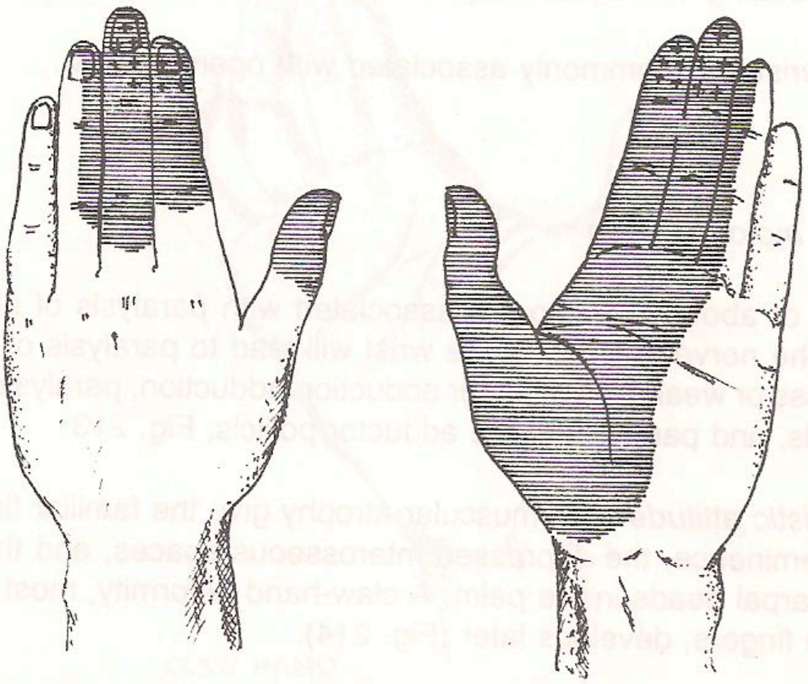


Fig. 212 Median nerve injury – sensory loss

If there is no recovery of motor function the main disability is loss of opposition. This can be overcome by muscle transfer operation.

Prognosis

After suture the thenar muscles rarely make a satisfactory recovery. Recovery of crude sensation to pain and temperature is usual but that to light touch is less common.

Ulnar Nerve Injuries

Anatomy

The ulnar nerve arises from the brachial plexus and carries fibres of the 8th cervical and 1st thoracic roots. In the forearm it supplies the flexor carpi ulnaris and the ulnar half of the flexor digitorum profundus. In the hand it supplies all the muscles except the 1st and 2nd lumbrical and the thenar muscles although it does supply adductor pollicis. The sensory distribution is to the ulnar part of the hand, the little finger and the medial half of the ring finger.

Mechanism of injury

The ulnar is commonly injured:

1. At the elbow in fractures of the lower end of the humerus specially those affecting the medial epicondyle.

Malunion leading to cubitus valgus may sometimes cause late ulnar nerve lesion.

2 At the wrist, it is commonly associated with open injuries.

Diagnosis

1. Loss of motor function

Injuries at or above the elbow is associated with paralysis of all the muscles supplied by the nerve. Injuries at the wrist will lead to paralysis of the interossei resulting in loss or weakness of finger abduction/adduction, paralysis of the medial two lumbricals, and paralysis of the adductor pollicis, Fig. 213.

Characteristic attitude: The muscular atrophy give the familiar flattening of the hypothenar eminence, the depressed interosseous spaces, and the prominence of the metacarpal heads in the palm. A claw-hand deformity, most marked in the ring and little fingers, develops later (Fig. 214).

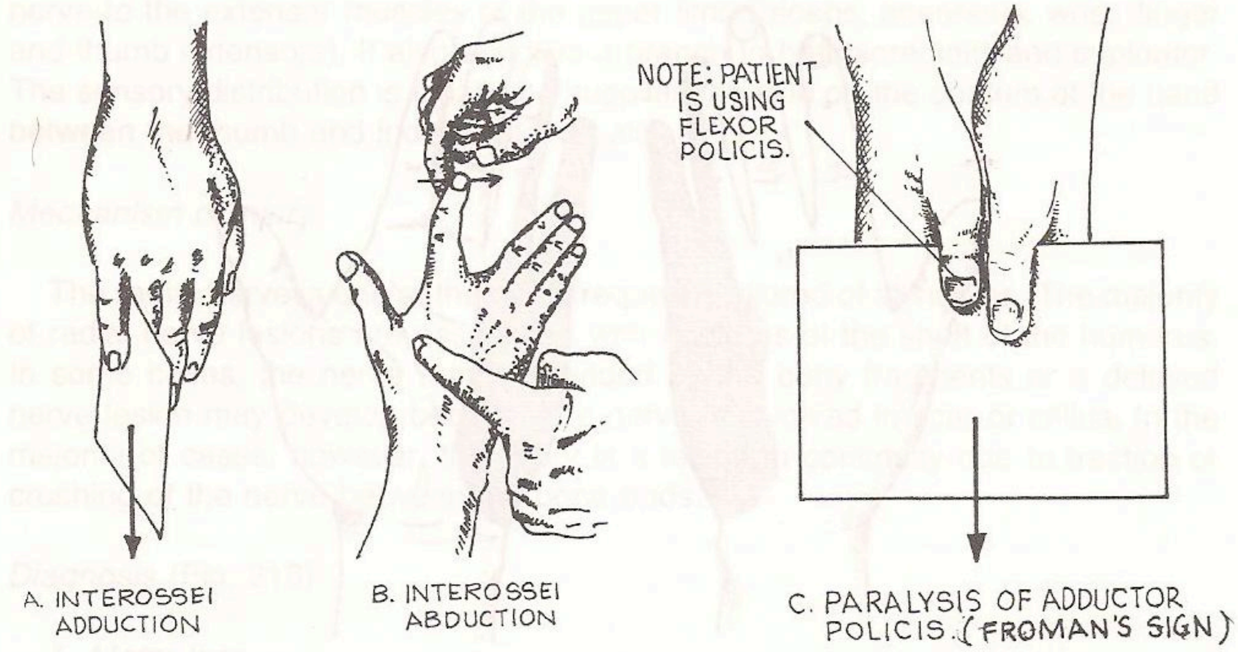


Fig. 213 Ulnar nerve – motor loss

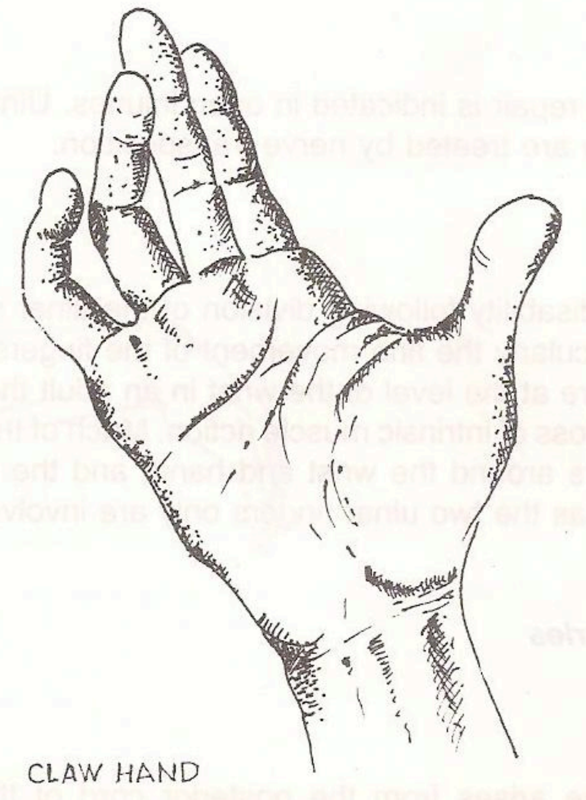


Fig. 214 Ulnar nerve injury – Characteristic attitude

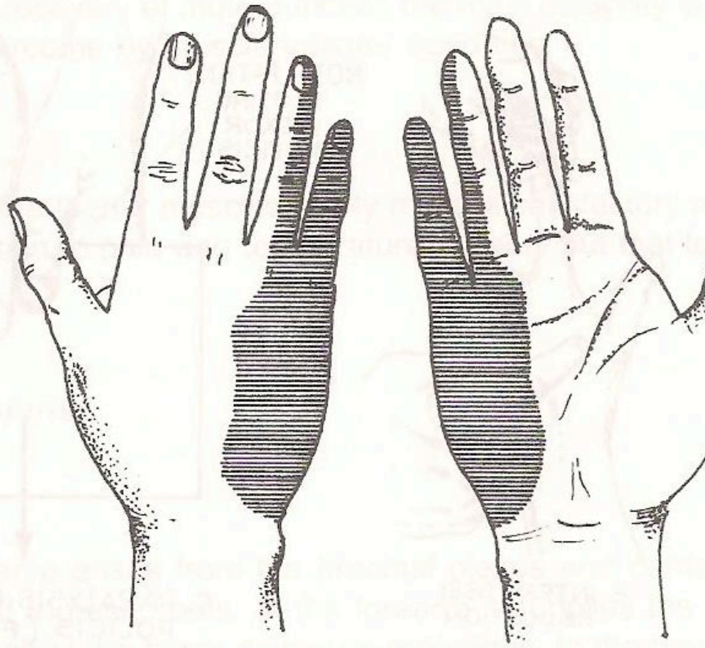


Fig. 215 Ulnar nerve – sensory loss

2. Sensory loss

Sensation is lost over the ulnar border of the hand, the entire little finger and ulnar half of the ring finger, on both extensor and flexor surfaces (Fig. 215).

Treatment

Exploration and repair is indicated in open injuries. Ulnar lesions due to deformities at the elbow are treated by nerve transposition.

Prognosis

The functional disability following division of the ulnar nerve is slight. The disability affects particularly the fine movement of the fingers, and even after a successful nerve suture at the level of the wrist in an adult there is generally considerable permanent loss of intrinsic muscle action. Much of this loss can be improved by tendon transfers around the wrist and hand, and the sensory deficit is not a serious handicap, as the two ulnar fingers only are involved.

Radial nerve injuries

Anatomy

The radial nerve arises from the posterior cord of the brachial plexus and carries fibres from the fifth to the eighth cervical roots inclusive. It is the motor nerve to the extensor muscles of the upper limb (triceps, anconeus, wrist, finger and thumb extensors). It also supplies a branch to brachioradialis and supinator. The sensory distribution is small and supplies the skin on the dorsum of the hand between the thumb and index metacarpals.

Mechanism of injury

The radial nerve is one of the most frequently injured of all nerves. The majority of radial nerve lesions are associated with fractures of the shaft of the humerus. In some cases, the nerve may be divided by the bony fragments or a delayed nerve lesion may develop because the nerve is involved in scar or callus. In the majority of cases, however, the injury is a lesion in continuity due to traction or crushing of the nerve between the bone ends.

Diagnosis (Fig. 216)

1. Motor loss

The paralysis affects the extensor group of muscles, the brachioradialis, the radial and ulnar carpal extensors, and the extensors of the thumb and fingers.

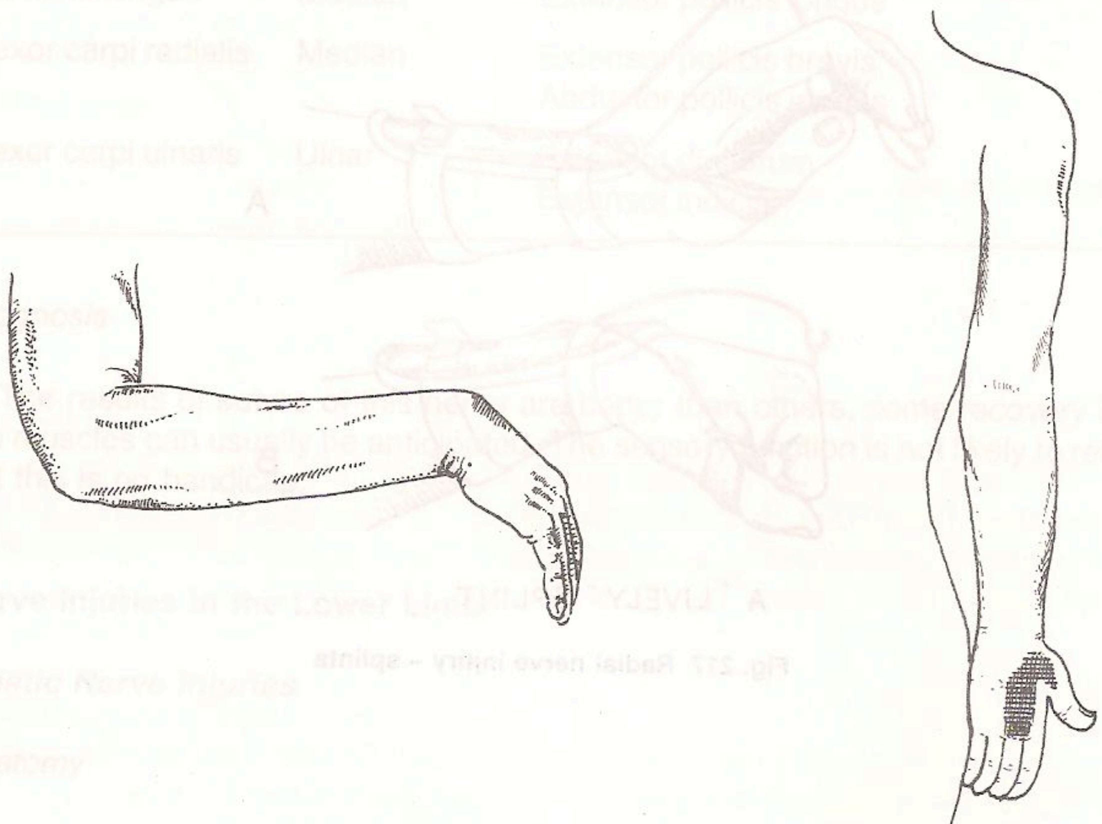


Fig. 216 Radial nerve injury – diagnosis

Paralysis of the triceps muscle is very rare, as all the branches supplying it arise before or just as the main trunk enters the radial groove.

Characteristic attitude: Drop wrist.

2. Sensory loss

The sensory signs are trivial, a small ill-defined, triangular zone of anaesthesia on the dorsum of the hand over the first interosseous space is lost.

Treatment

1. Conservative treatment

With closed injuries of the radial nerve the condition is usually one of axonotmesis or neurapraxia, and only rarely neurotmesis. The nerve lesion is treated conservatively by splinting the wrist in extension to avoid over-stretching of the paralysed muscles. The paralysed metacarpophalangeal joints and thumb are extended by splints (Fig. 217). Massage, electrical stimulation of paralysed muscles and passive joint exercises are also instituted as in any other peripheral nerve lesion.

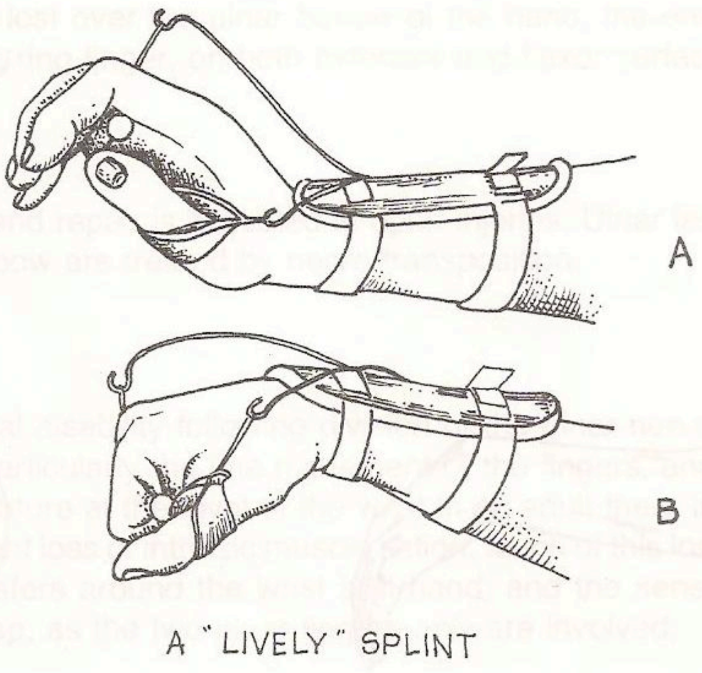


Fig. 217 Radial nerve injury – splints

2. *Operative treatment*

a) Nerve repair

This is indicated in open injuries. Since the nerve is almost wholly a motor one, and the amount of sensory recovery unimportant, the results of suture should be good.

b) Nerve exploration

This is indicated if the nerve fails to recover within six months of conservative treatment. If the nerve is involved in scar and callus it should be freed (neurolysis).

c) Reconstructive surgery

This is indicated to improve function if other methods of treatment have failed. The following table summarises the commonly used muscles for transfer.

Muscles	Nerve supply	To replace
Pronator teres	Median	Extensor carpi radialis longus and brevis
Palmaris longus	Median	Extensor pollicis longus
Flexor carpi radialis	Median	Extensor pollicis brevis Abductor pollicis longus
Flexor carpi ulnaris	Ulnar	Extensor digitorum Extensor indicis

Prognosis

The results of suture of this nerve are better than others, some recovery in all the muscles can usually be anticipated. The sensory function is not likely to return, but this is no handicap.

Nerve Injuries in the Lower Limb

Sciatic Nerve Injuries

Anatomy

The sciatic nerve arises from the lumbo-sacral plexus and carries fibres from the fourth and fifth lumbar roots and the first, second and third sacral roots. It is the motor nerve to the lower limb supplying all the muscles, except those on the anterior, and medial aspect of the thigh, which are supplied by the femoral and obturator nerves.

Its sensory distribution is extensive; it supplies the skin of the posterior aspect of the thigh and leg, the lateral aspect of the leg and skin of the foot. Below the knee it supplies both muscle and skin through the agency of its two terminal branches; the medial and lateral popliteal nerves.

Mechanism of injury

Lesions of the sciatic nerve are infrequent, stretching of the nerve may occur with posterior dislocation of the hip, and laceration may occur with deep wounds of the thigh, especially gunshot wounds.

Diagnosis

1. Motor loss

In a complete injury of the sciatic nerve there is usually paralysis of all the muscles below the knee. In partial injuries the lateral popliteal division is the one usually damaged.

Characteristic attitude: Drop foot. (Fig. 218)

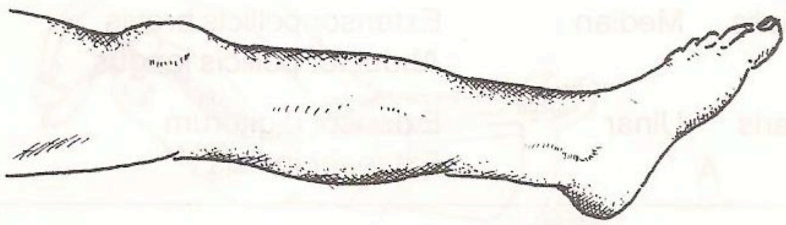


Fig. 218 Drop foot

2. *Sensory loss* (Fig. 219)

In complete lesions, the sensation is abolished in the foot over a zone conveniently termed the slipper area. In partial lesions, there is usually sensory disturbance on the lateral aspect of the leg, and the lateral aspect and dorsum of the foot.

Treatment

Exploration of the sciatic nerve is indicated especially with open injuries. Nerve repair should be carried out if possible.

While recovery is awaited, below knee irons and a toe raising spring are worn. Great care should be taken with socks, shoes and foot toilet to try to avoid trophic

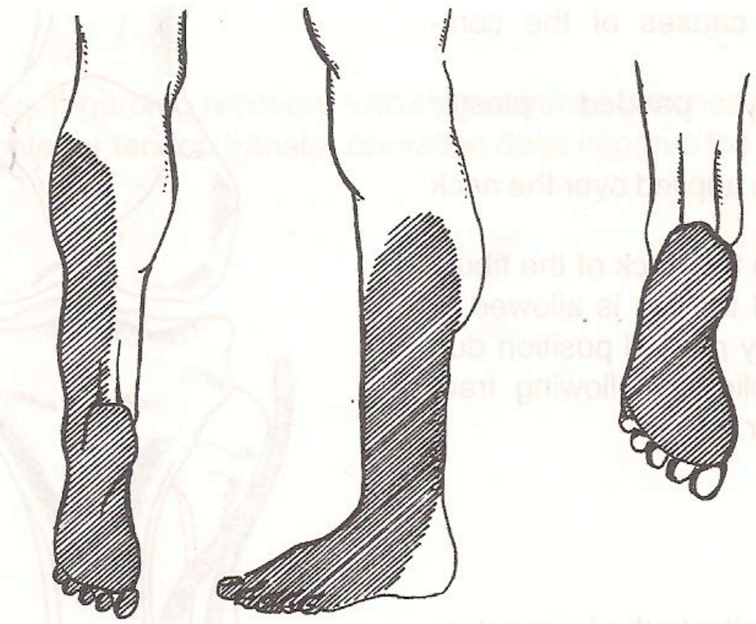


Fig. 219 Sciatic nerve injury – sensory loss

ulcers. If recovery fails, correction of the foot drop will be required. In partial lesions of the nerve, the tibialis posterior is usually functioning strongly and anterior transfer of this muscle gives satisfactory results. In complete lesions, the tibialis posterior muscle is likely to be paralysed in these circumstances, a toe raising device or caliper is necessary.

Prognosis

Although neurological recovery is never complete following nerve repair, good function of the limb can be obtained.

Common Peroneal Nerve Injuries

Anatomy

The common peroneal nerve arises from fourth and fifth lumbar, first and second sacral roots. It supplies the tibialis anterior, the extensor digitorum longus, the extensor hallucis longus, the extensor digitorum brevis, and the long and short peroneal muscles.

Mechanism of injury

The nerve is frequently compressed at the knee where it winds laterally around the neck of the fibula (Fig. 220).

The common causes of the compression are:

1. Inadequately padded plaster casts.
2. Skin traction applied over the neck of the fibula.
3. Pressure on the neck of the fibula may also occur if the leg is allowed to lie in an externally rotated position due to inadequate splinting following fractures of the femur.

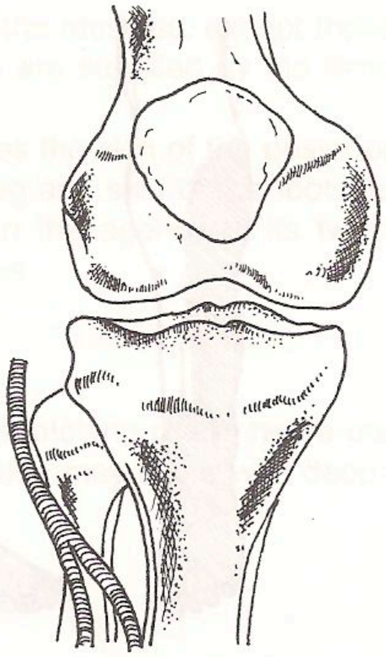


Fig. 220 Common peroneal nerve

Diagnosis

1. Motor loss

The paralysis affects the long extensors and the evertors of the ankle and foot.

Characteristic attitude: Plantar flexion and inversion of the foot. (drop foot).

2. Sensory loss

Anaesthesia is noted only over a small triangular area opposite the first metatarsal space.

Treatment

In closed injuries, active exercises and wearing of drop foot appliance (Fig. 221) is necessary. If recovery fails, tendon transfers operation (anterior transfer of tibialis posterior) will improve function and gait.

In open injuries, nerve repair should be attempted.

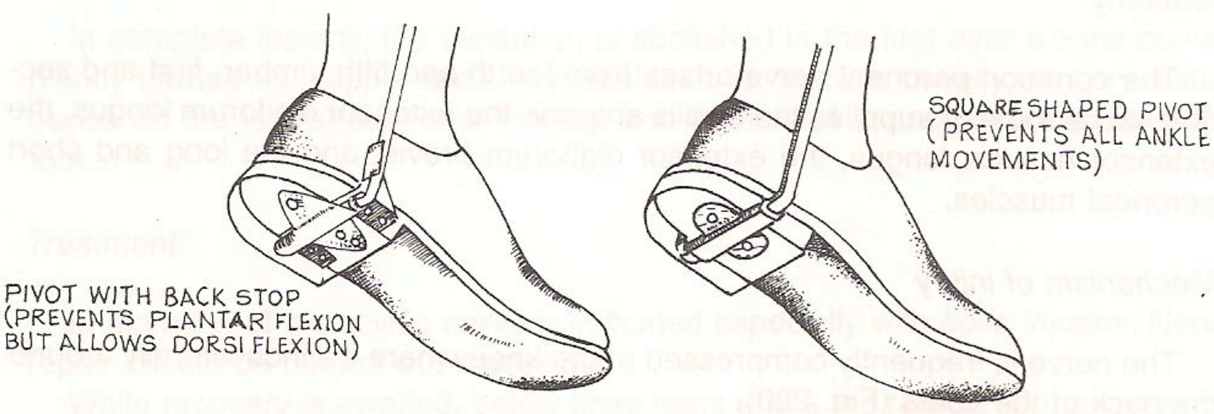


Fig. 221 Appliances for drop foot

Prognosis

The prognosis regarding recovery following common peroneal nerve injuries is bad. Tibialis posterior tendon transfer operation does improve the function and the gait.

VASCULAR INJURIES ASSOCIATED WITH FRACTURES AND DISLOCATIONS

Vascular injuries are uncommon complication of long bone fractures. These injuries are often multifactorial with arterial venous, lymphatic, and micro-vascular components.

Skeletal trauma can easily conceal vascular injuries because attention is given only to the obvious bone deformity. Consequently, recognition of these injuries is too late, and the likelihood of a successful repair is greatly decreased.

Arterial Injuries

Interruption of the arterial supply may be due to:

1. Swelling
2. Division of the vessel
3. Occlusion

Diagnosis

The diagnosis is not usually difficult, providing the possibility is borne in mind. The following features should arose suspicion:

1. Certain fractures where the artery passes close to bone (Fig. 222).

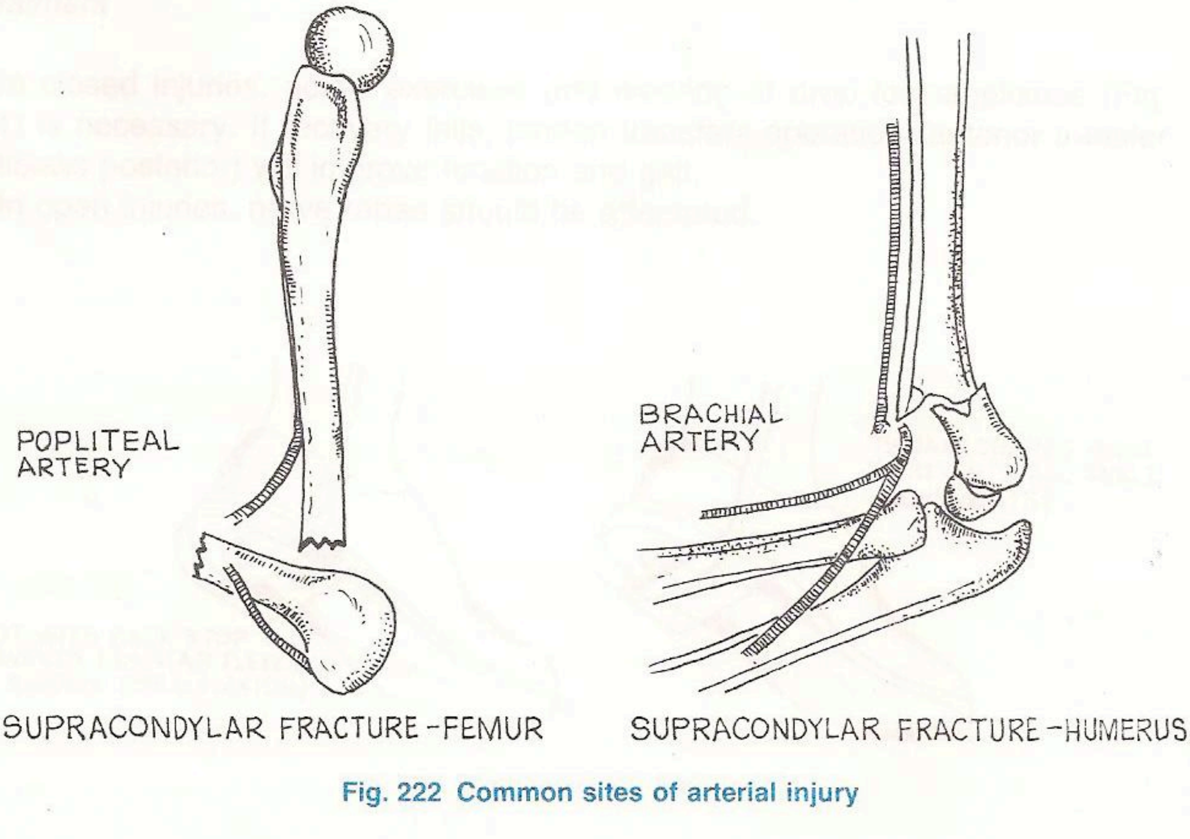


Fig. 222 Common sites of arterial injury

a) Supracondylar fracture of the humerus may cause brachial artery injury.
b) Supracondylar fracture of the femur may cause popliteal artery injury.

2. Run-over injuries
Occasionally, these injuries produce arterial occlusion from intimal damage.
3. The development of severe pain which increases on passive stretching of the infarcted muscles. The most commonly affected are the flexors of the fingers and the toes.

Signs of Acute Ischaemia

The following table summarises the cardinal signs of acute ischaemia: (Pnemonic – Please press and see how colour fades)

Signs of acute ischaemia

1. Pain	Intensity increase on passive extension of finger and toes.
2. Pulsation	Obliteration of peripheral pulses. Loss of capillary circulation.
3. Sensation	Paraesthesia or anaesthesia in the territory of the ischaemic nerve.
4. Heat	The skin is cold.
5. Colour	The skin may be completely white or congested and cynosed.
6. Force	Active movements are weak or absent.

Investigations

The clinical diagnosis of arterial injury may be difficult in some cases in which the signs of ischaemia are not clear. One or more of the following investigations may be needed to confirm the diagnosis.

1. Ultrasound (Doppler)

This device can be useful in localizing patent arteries and veins that are not palpable distal to a fracture or dislocation.

2. Arteriography

Although arteriography is an invasive procedure, it has a high diagnostic yield and low complication rate. Arteriography is recommended early in the evaluation of patients who demonstrate any sign of arterial insufficiency.

3. Venography

This should be performed when there is suspicion of either isolated or concomitant venous injury.

Treatment

1. Ischaemia due to swelling

If ischaemia is due to swelling all tight dressings, splints, plaster of Paris, should first be split down to skin or removed and the limb elevated. Unless this produces a rapid improvement in the circulation, surgical treatment is indicated.

Basically, surgical treatment is directed towards relieving the pressure caused by the swollen soft tissues contained within an unyielding fascial envelope (compartment syndrome). The deep fascia is incised throughout the injured area and the incision should be so placed that the vessels can be inspected. Any damage to the vessels is dealt with accordingly.

2. Division of the vessel

If the main arterial supply is transected it must be repaired. Repair is technically feasible as far distally as the popliteal artery in the popliteal fossa and the brachial artery in the antecubital fossa. Recent advances in microsurgical techniques have made arterial repair of smaller diameter vessels possible. Any vascular repair must be protected from abnormal movement at the fracture site and internal fixation or external fixator is necessary to achieve this.

3. Occlusion

Occlusion of an artery is the common vascular injury seen in association with fractures and dislocations. The injury may result from direct trauma by the bone ends or it may be the result of traction on the vessel. In either event, the intima is damaged with occlusion of the lumen and reflex vasospasm which usually extends for a considerable distance both proximally and distal from the site of the injury. A closed injury of this nature is treated by opening the vessel and removing clot and damaged intima from the lumen until a good blood flow is established both proximally and distally. The vessel is repaired by suturing a patch of vein wall on to the site of the incision to avoid stenosis and thrombus formation.

Venous Injuries

Isolated venous injuries associated with osseous trauma are rare except in the pelvis. However, the combination of venous and arterial disruption following skeletal trauma is common and occurs more frequently than is appreciated. In general, these injuries are lacerations, often multiple, producing hematomas. Thrombosis may follow as a delayed event. When this occurs, the hemodynamic and hydrostatic effects may be significant, particularly after attempted arterial repair, since improved arterial inflow may then only contribute to hematoma formation, distal edema, and progressive tissue destruction.

Venous reconstruction decreases hydrostatic pressure and resistance across the arterial repair. Most venous lacerations can be repaired by lateral suture. More severe venous disruption may require excision and primary anastomosis or interposition venous grafting. These venous repairs are vulnerable to thrombosis, but even if they remain open for only 24 to 72 hours, relaxation of vasospasm and development of venous collaterals may occur. Furthermore, thrombosed venous grafts may later recanalize.

FRACTURES IN CHILDREN

Fractures in children demand separate consideration for the following reasons:

1. Healing is rapid as long as there is bone contact.
2. Open reduction is rarely indicated except in cases of fractures into joints.
3. Power of remolding is great and some degrees of angular deformity will correct spontaneously.
4. Epiphyseal injuries in the growing child may lead to growth disturbance.
5. Fractures in children are often missed because the history of trauma is either concealed or the child is not old enough to communicate.
6. The diagnosis may not be obvious radiologically. X-rays of both limbs for comparison are occasionally required.

Fractures in children will be discussed under the following headings:

A. Birth fractures. B. Epiphyseal injuries.
C. Shaft fractures of long bones. D. Pathological fractures.

Birth Fractures

These may occur in a normal bone as a result of a difficult labour or in a congenitally diseased bone.

1. Fractures in normal bone

Fracture of humerus, clavicle, femur and displacement of epiphyses of the humerus or femur are the most commonly encountered. These types of fractures are usually associated with considerable displacement, so deformity is obvious, healing is rapid and large masses of callus usually develop, nonunion is practically unknown, and angular deformity is corrected by remodelling during the first few years of life.

General lines of treatment are the same as those in adults:

a) *Reduction*: Anatomical reduction of long bone shaft fractures is not necessary since by the power of remolding the alignment will be restored, but it must be remembered that the remolding process can correct angular deformity but not rotational deformity.

b) *Immobilization*: Once reasonable alignment of the fracture is achieved, immobilization is carried out according to the site of injury.

c) Soft tissue treatment.

d) Rehabilitation is not usually needed in children.

2. Fractures in a congenitally diseased bone

a) Congenital pseudoarthrosis of the clavicle

This condition usually presents as a painless swelling mostly on the right side situated just lateral to the midshaft of the bone.

Treatment is operative, the cartilaginous pseudoarthrosis is excised, a bone graft is used and the clavicle is fixed internally.

b) Congenital pseudoarthrosis of the tibia

This condition is very difficult to treat. It usually presents with an anterior angulation of the tibia, which if fractured by trauma or by an osteotomy to correct the deformity, will lead to pseudoarthrosis.

Treatment of the established case depends basically on applying a series of bone grafts. Electric stimulation and Ilizarov method have been used with some success.

Epiphyseal Injuries

The epiphysis can be divided into two main groups, the pressure epiphysis at the end of long bones, and the traction epiphyses associated with muscle attachments (Fig. 223).

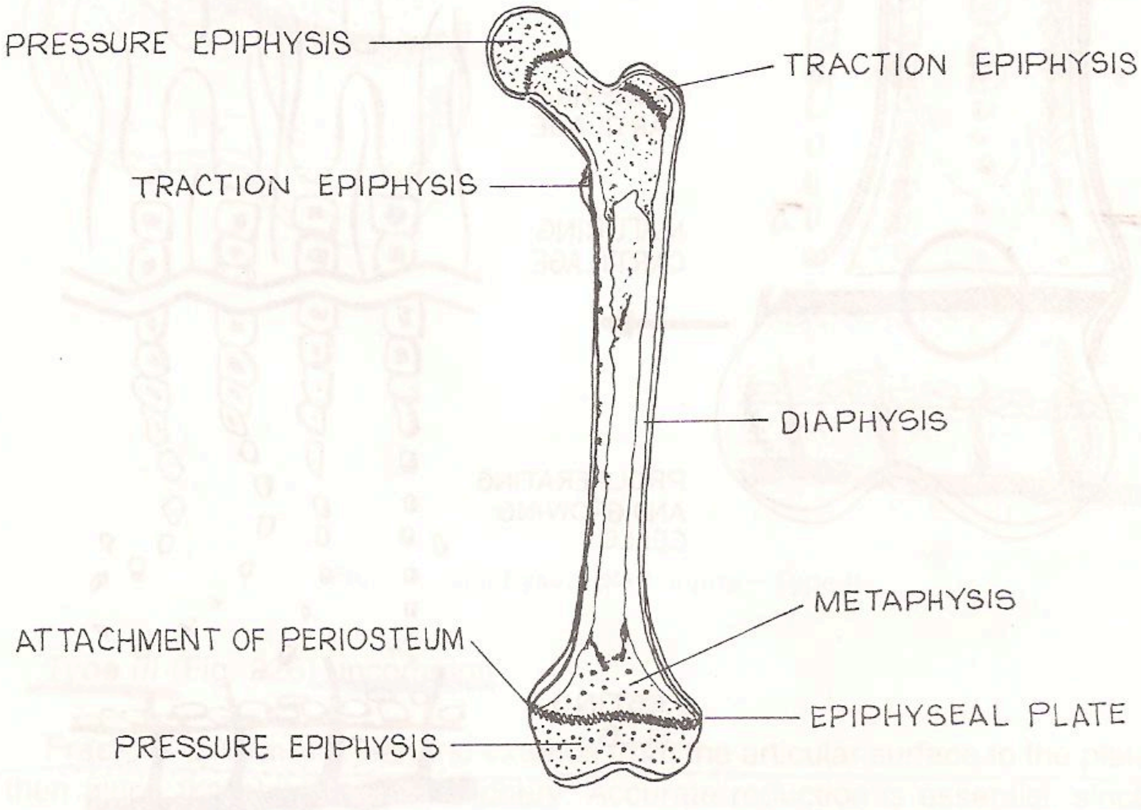


Fig. 223 Types of epiphysis

Injuries to traction epiphysis are always produced by overaction of the associated muscles, these injuries are of no more than nuisance value and require only palliative treatment.

Injuries of the pressure epiphysis on the other hand can have serious consequences varying between retardation of growth, gross angular deformity and avascular necrosis, the outcome depends upon few features the most important of which is the type of injury.

Classification of epiphyseal plate injuries

The following classification is based on the mechanism of injury as well as on the relationship of the fracture line to the growing cells of the epiphyseal plate.

Type I (Fig. 224)

There is complete separation of the epiphysis without any fracture through bone; the growing cells of the epiphyseal plate remain with the epiphysis.

Closed reduction is easy to achieve and maintain.

Prognosis: Excellent with no growth disturbance.

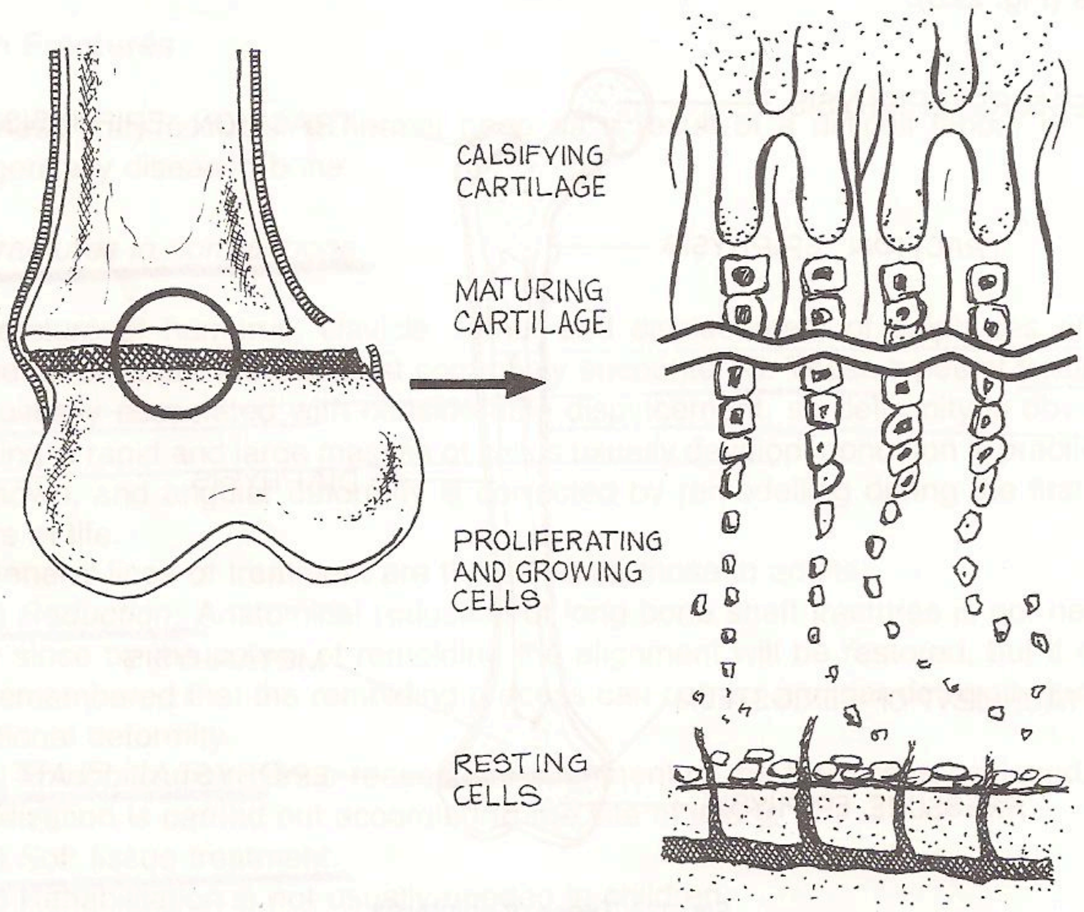


Fig. 224 Epiphyseal plate injury – Tpe I

Type II (Fig. 225)

This is the commonest type accounting for 70% of all injuries.

The line of fracture – separation extends along the epiphyseal plate to a variable distance and then breaks out through the metaphysis producing the familiar triangular shaped fragment.

Closed reduction is relatively easy to obtain as well as to maintain.

Prognosis: Excellent, with no growth disturbance.

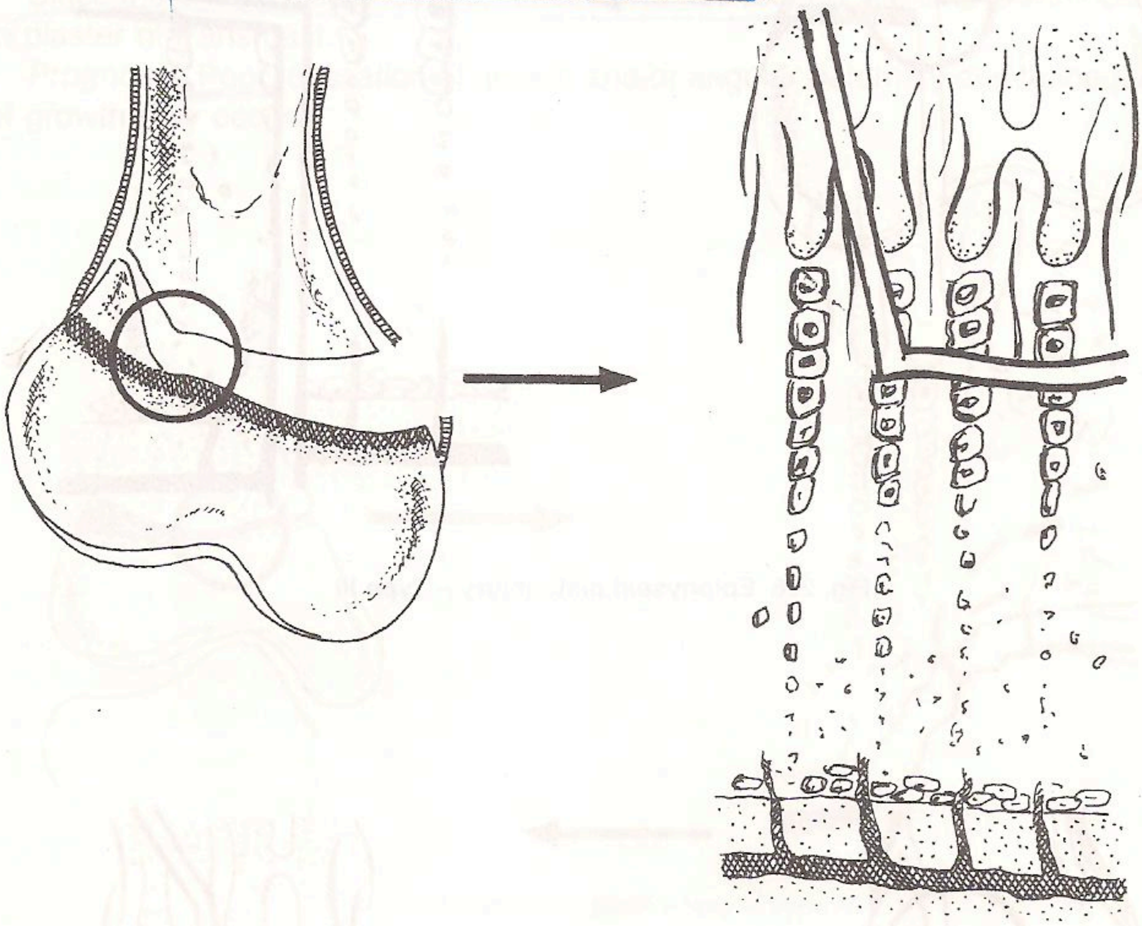


Fig. 225 Epiphyseal plate injury – Type II

Type III (Fig. 226) uncommon

Fracture is intra-articular and extends from the articular surface to the plate and then along the plate to the periphery. Accurate reduction is essential, since it is an intra-articular fracture. Open reduction may be necessary.

Prognosis: Good providing the blood supply to the separated portion has been preserved.

Type IV (Fig. 227), uncommon

The fracture which is intra-articular, extends from the articular surface through the epiphysis across the plate and towards the periphery through the metaphysis.

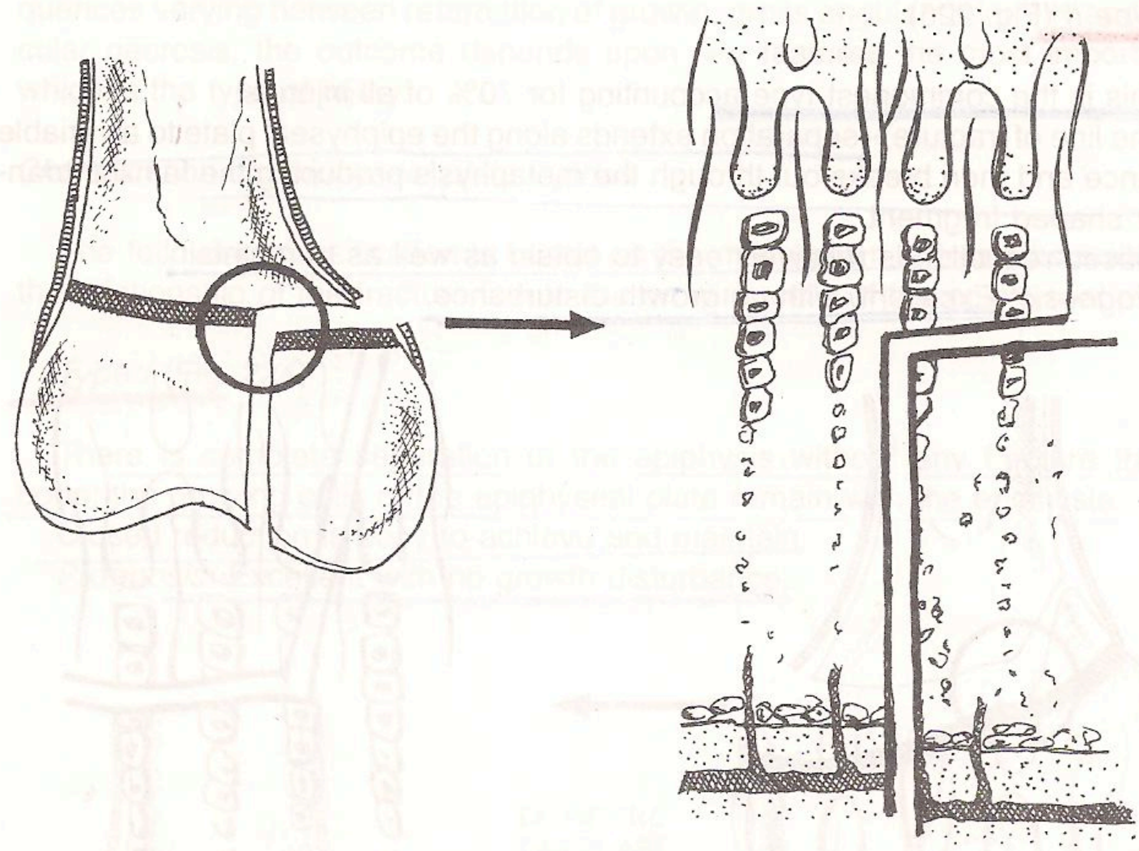


Fig. 226 Epiphyseal plate injury – Type III

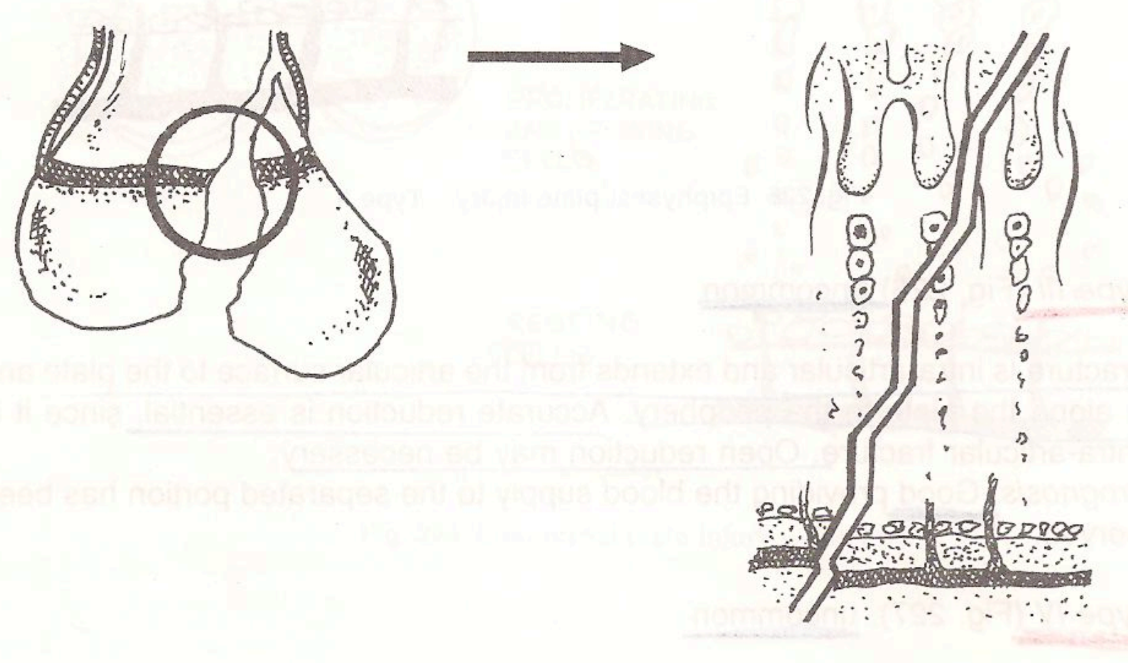


Fig. 227 Epiphyseal plate injury – Type IV

Accurate reduction is essential for the sake not only of the plate but for the restoration of the articular surface. Open reduction is almost always necessary.

Prognosis: Can be favourable if anatomical reduction has been achieved.

Type V (Fig. 228), uncommon

This injury results from severe crushing force. Displacement of the epiphysis is unusual.

Since there is no displacement, reduction is not needed, the limb is immobilized in plaster of Paris cast.

Prognosis: Poor, cessation of growth and/or angular deformity due to inequality of growth may occur.

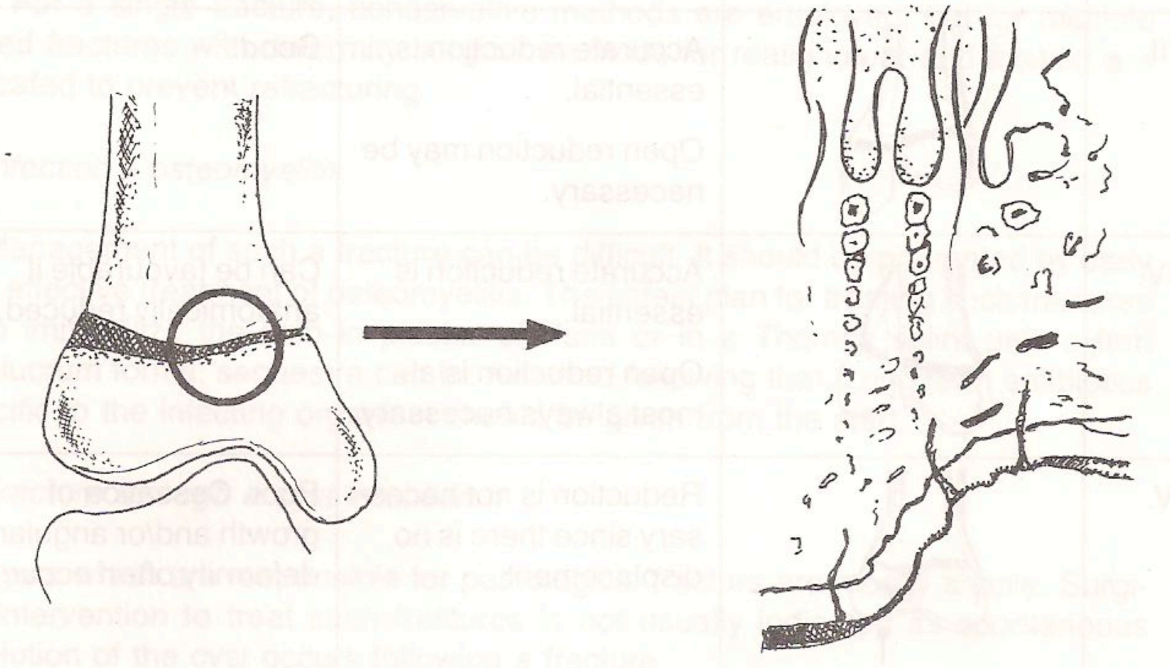


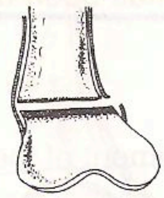
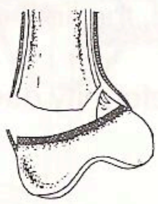
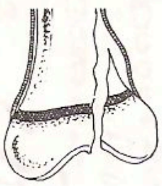
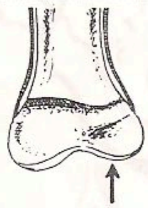
Fig. 228 Epiphyseal plate injury – Type V

The following table summarizes the types, treatment and prognosis of epiphyseal plate injuries.

Fractures of the shafts of long bones

Fracture shafts of long bones in children pose different problems to those in adults for the following reasons.

1. Union always occurs providing that there is bone contact.
2. Discrepancies of axis and length tend to correct spontaneously.
3. Healing is rapid.
4. Growth stimulation and compensatory overgrowth will occur.

Type		Treatment	Prognosis
I.		Closed reduction is easy. Immobilize in plaster cast.	Excellent, no growth disturbance.
II.		Closed reduction is easy to achieve and maintain.	Excellent, no growth disturbance.
III.		Accurate reduction is essential. Open reduction may be necessary.	Good.
IV.		Accurate reduction is essential. Open reduction is almost always necessary.	Can be favourable if anatomically reduced.
V.		Reduction is not necessary since there is no displacement.	Poor. Cessation of growth and/or angular deformity often occur.

For these reasons anatomical reduction is neither indicated nor desirable and operative treatment is rarely indicated except in certain cases of forearm fractures if closed manipulation fails to achieve alignment compatible with perfect function.

PATHOLOGICAL FRACTURES

Pathological fracture could be simply defined as a break in the continuity of bone within an abnormal bone structure. This abnormal bone structure could be due to:

1. Congenital diseases such as osteogenesis imperfecta 'brittle bone disease'

Osteogenesis imperfecta is a congenital disorder, in which there is a genetically induced abnormality in bone structure. The bone is fragile and breaks easily, but fractures always unite promptly and soundly with large amount of callus. The aim of treatment is to obtain union of every fracture in as good an alignment as possible. For a single fracture, conservative methods are employed, but for multiple united fractures with deformity surgical methods for realignment and fixation are indicated to prevent refracturing.

2. Infection – osteomyelitis

Management of such a fracture can be difficult. It should be prevented by early and effective treatment of osteomyelitis. The safest plan for treating such fractures is to immobilize the limb in plaster of Paris or in a Thomas splint until a firm involucrum forms; sequestra can be removed following that. Long term antibiotics specific to the infecting organism should be given from the start.

3. Fracture through a cyst in children

Cysts which are responsible for pathological fracture are mostly simple. Surgical intervention to treat such fractures is not usually indicated as spontaneous resolution of the cyst occurs following a fracture.

4. Metabolic diseases

a) Osteoporosis which is less mass per volume unit of bone
b) Osteomalacia which is failure of mineralization of osteoid.
c) Pagets disease (osteitis deformans)

In addition to the management of the fracture the disease itself should be treated when possible.

5. Primary bone tumours

In this type of pathological fractures, the management depends on treating the primary tumour itself.

6. Metastatic bone tumours

Metastases to the skeleton are relatively common in cancer patients. Following the first pathological fracture due to a metastasis, it is estimated that 30% of patients survive for 1 year or longer. For that reason, an aggressive surgical approach is favoured for the treatment of these fractures, in order to make the patient more mobile and pain free for the remaining life span. The most common primaries giving rise to bony metastases are carcinomas of the breast, prostate, lung and kidney. Multiple myeloma and lymphoma also give a similar clinical picture.

Diagnosis

A pathological fracture due to a metastasis should be highly suspected on clinical grounds if:

1. The history reveals

a) An insignificant amount of trauma.
b) General symptoms of weight loss, malaise and tiredness.
c) Previously diagnosed malignancy.
d) Symptoms suggestive of malignancy in various organs.

2. Examination reveals

a) General examination: Signs suggestive of malignancy *e.g.* weight loss.
b) Local examination shows:
i) Tenderness, pain and swelling at the fracture site is much less than expected.
ii) Muscle spasm and deformity is minimal.

To confirm the diagnosis the following investigations are needed:

1. Radiology

a) Routine X-ray of the affected bone is helpful to determine:
i) The site of the lesion
ii) The osseous response of the lesion, *e.g.* osteolytic as in carcinoma breast metastasis, osteoblastic as in carcinoma prostate metastasis.
b) A chest X-ray is always necessary to detect pulmonary metastasis.
c) An isotope bone scan may be needed to detect an early lesion undemonstrable by routine radiology.

2. Laboratory investigations

a) Specific tests are abnormal with certain tumours, *e.g.* raised acid phosphatase in prostatic cancer and positive Bence Jones protein in multiple myeloma.

b) Nonspecific tests: The serum alkaline phosphatase and the erythrocyte sedimentation rate are always raised.

Management

The aim is to make the patient more functional and pain free for the remaining life span.

Early operative intervention, adequate stability obtained by internal fixation or a prosthesis supplemented with bone cement, should be carried out if indicated whenever possible.

Other methods of treatment of advanced cancer therapy such as radiotherapy, chemotherapy, hormonal and immunotherapy may be needed depending on the primary cause.

Prophylactic internal fixation

Although this procedure is still debatable, the following high risk characteristics are considered indications for prophylactic internal fixation of a long bone with metastasis:

1. Involvement of cortex.
2. Increasing pain.
3. Pure lysis as evidenced on X-ray.
4. Development of a malignant lesion not previously demonstrable in the bone.

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INDEX

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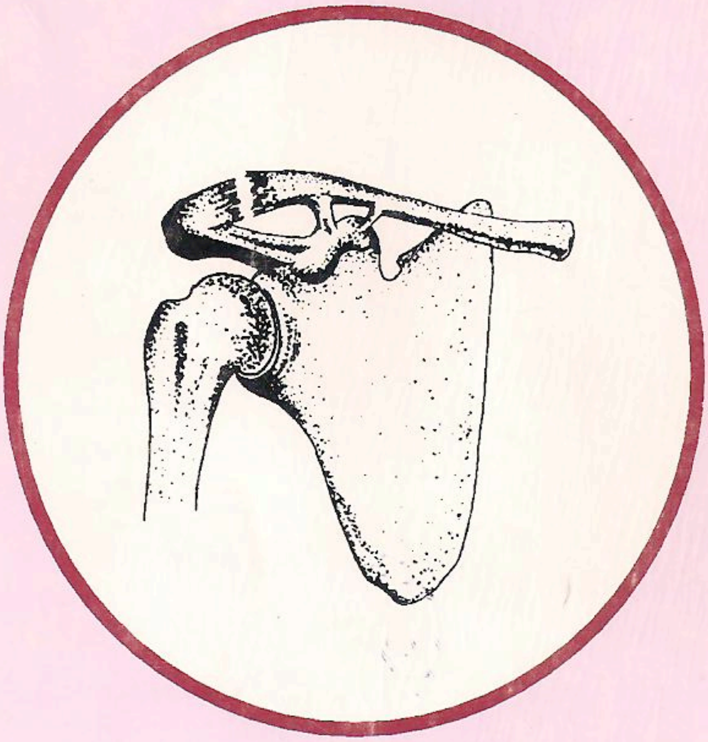

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