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Essentials of ORTHOPEDICS *for Physiotherapists*

As Per The Competency Based Curriculum For "Physiotherapy"-NCAHP Act -2021

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10 CHAPTER

General Principles of Fractures, Dislocations and their Treatment

CHAPTER OUTLINE

- Introduction to Orthopedic Injuries
- Definitions
  - Fracture
  - Dislocation
  - Subluxation
  - Sprain
  - Strain
- Types of Fractures
  - Closed and Open Fractures
  - Incomplete and Complete Fractures
  - Fracture Patterns (OTA Classification)
  - Atypical Fractures
- Displacement of Fractures
- Approach to Orthopedic Injury
  - History, Age, Sex, Mechanism of Injury
- Clinical Features of Fractures
- Deformities in Orthopedics
  - Bone, Joint, and Soft Tissue Causes
- Investigations in Orthotrauma
  - X-ray, CT, MRI
- Pathological Fractures
- Stress (Fatigue) Fractures
- Dislocations
  - Types, Clinical Features, Treatment
- Rehabilitation in Dislocations
- Complications of Fractures and Dislocations
- Fracture Healing
  - Indirect Healing
  - Primary (Direct) Healing
  - Distraction Histogenesis
- Factors Affecting Fracture Healing
- Physiotherapy Perspective in Fracture Management

COMPETENCY

OR1.2: Traumatology. Fracture—definition, types, signs and symptoms, fracture healing, complications of fractures, conservative and surgical approaches. Principles of management—reduction (open/closed, immobilization, etc.). Subluxation/dislocations—definition, signs and symptoms, management (conservative and operative).

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

DEFINITIONS

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

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

Subluxation: It is a partial dislocation of a joint.

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

Strain: It is a tear in the muscle.

TYPES OF FRACTURE

The bone can break within its soft tissue envelope and may not communicate to the exterior (simple or closed fractures) **(Fig. 10.1)** or it may rip through its soft tissues or the soft tissue itself may be damaged by the external forces, exposing the bone to the external atmosphere (compound or open fractures) **(Figs. 10.2 and 10.3)**. If the former event

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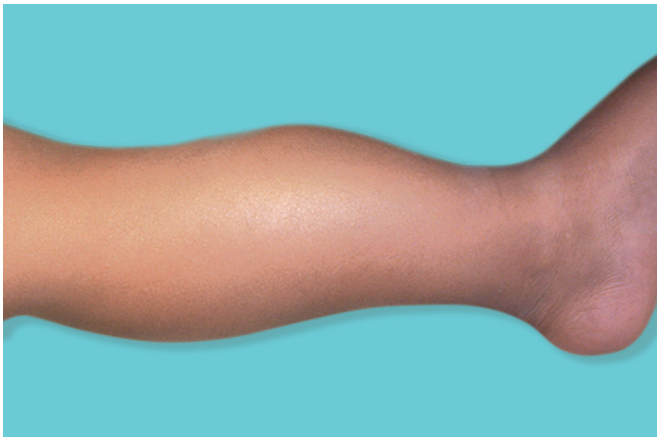


Fig. 10.1: Clinical photograph showing deformity in closed fracture.



Figs. 10.2A and B: Showing pinpoint compound fracture of the forearm (Type 1).



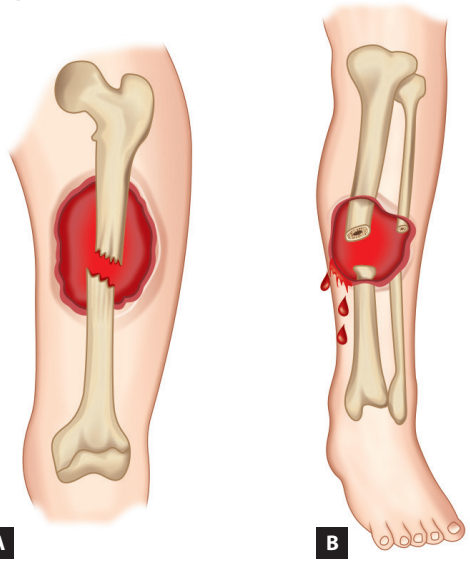
Fig. 10.3: Clinical photograph showing type 2 compound fracture of the femur.

is bad, the latter event is catastrophic. In both the situations depending on whether the force is direct (as in direct impact in RTA) or indirect (e.g., through the muscle action), and depending on the amount of force applied, the direction of force, age and other factors, different fracture patterns are produced and each one poses a problem peculiar to its own:

Remember

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

- *Simple or compound* **(Figs. 10.4A and B)**: These have been already explained.
- *Based on the extent of fracture line:*
  - *Incomplete fractures*: It involves only one surface or cortex of the bone.
  - *Complete fracture*: Here the fracture involves the entire bone. A complete fracture could be undisplaced or displaced **(Box 10.1)**.



Figs. 10.4A and B: Types of fracture. (A) Simple; (B) Compound.

BOX 10.1: Traumatic points.
- Causes for displacement
- Muscle forces
- Gravity
- Obliquity of the fracture line
- Improper handling of the fracture.

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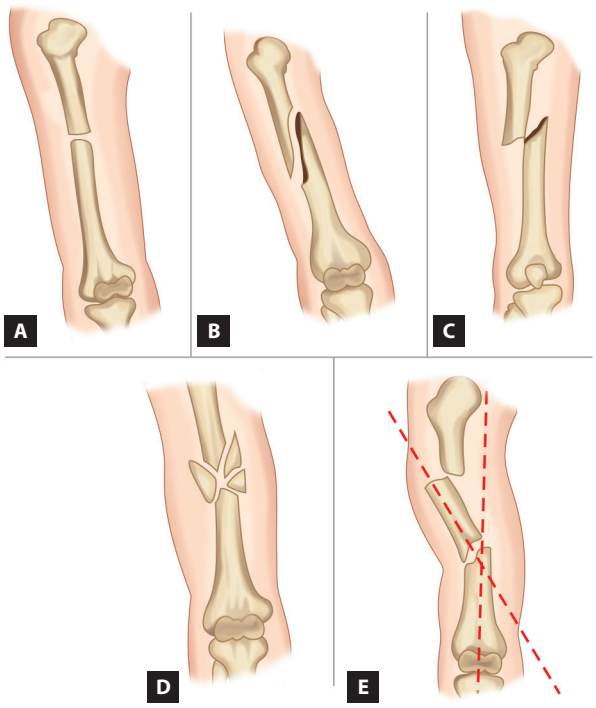
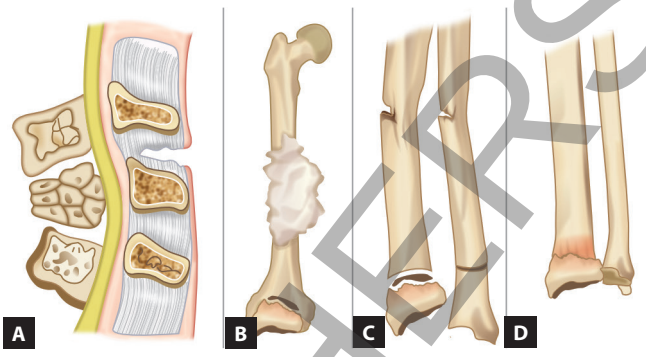


Figs. 10.5A to E: Types of fracture based on fracture patterns. (A) Transverse; (B) Spiral; (C) Oblique; (D) Comminuted; (E) Segmental.

- Based on fracture patterns [orthopedic trauma association classification **(Figs. 10.5A to E)**]:
  - *Linear fractures:* These could be transverse, oblique or spiral. Any fracture which forms an angle less than 30° with the horizontal line is called transverse. Angle equal to or more than 30° is termed oblique.
  - *Comminuted fractures:* Here the fracture fragments are more than two in number. They are further subclassified into <50% comminution or more than 50% comminution. Butterfly-shaped fractures are also included in this group.
  - *Segmental fractures:* A fracture can break into segments and the segment could be two levels, three levels, and a longitudinal split or comminuted.
  - *Bone loss:* This could be a less than 50% bone loss or more than 50% bone loss or a complete bone loss.

Atypical Fractures (Figs. 10.6A to D)

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



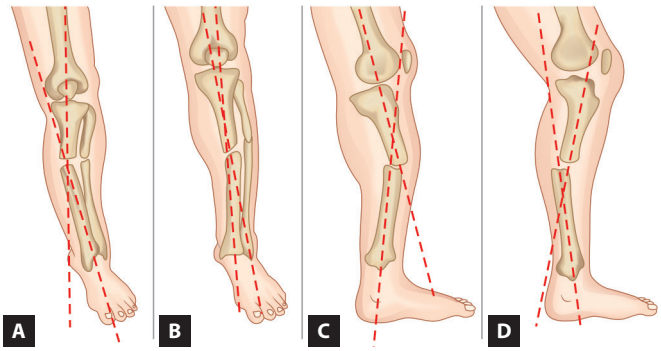
Figs. 10.6A to D: Atypical fractures. (A) Compression; (B) Pathological; (C) Greenstick; (D) Torus fracture.

Remember

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

Displacement of Fractures

A complete fracture usually gets displaced due to various factors already mentioned. Depending on the direction of force, mode of injury, pull of the muscles, a fracture can show any one of the following displacements or angulations **(Figs. 10.7A to D)**:



Figs. 10.7A to D: Types of angulation in fractures. (A) Medial; (B) Lateral; (C) Anterior; (D) Posterior.

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

APPROACH TO ORTHOPEDIC INJURY

Orthopedic injuries encompass a wide range of problems starting from bone and joint injuries, strains, sprains and damage to associated neurovascular structures. The value of a systematic clinical approach to unravel the myth and mysteries of orthotrauma cannot be less emphasized. Time-honored and time-tested clinical formulae applied so successfully in the diagnosis of various system disorders can be applied for orthotrauma also and consists of the following:

- *History:* Contrary to popular beliefs, a proper history gives vital clues and goes a long way in arriving at a proper diagnosis.
- *Age:* Certain fractures have predilections for certain age groups **(Table 10.1)**. Hence the practice of first enquiring about the age of the patient is a step in the right direction.
- *Sex:* Colles' fracture is more common in females and supracondylar fracture humerus, posterior dislocations of elbow are more common in males.

Mechanism of Injury

This could be different in different age groups as mentioned in **Table 10.2**.

Clinical Features

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

TABLE 10.1: Fractures and dislocations in different age groups.

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

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

TABLE 10.2: Modes of injury in different age groups.

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

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

- *Pain*: This is very subjective symptom and is invariably the first and the most important complaint. It may be mild, moderate and severe and may be due to tearing of periosteum (which contains the nerve endings), soft tissue injury, nerve injury, etc.
- *Swelling*: It is due to soft tissue injury, medullary, bleeding and reactionary hemorrhage. Swelling is usually more in fractures and less in dislocations.
- *Deformity*: Patients with displaced fractures and dislocations usually present with some deformity.
- *Inability:* To use the affected part is another frequent complaint. Having made a note of the history and presenting complaints, effort is now directed towards eliciting the signs, some of which are general and some are injury specific.
- *Tenderness:* This is an important clinical sign in bone and joint injuries and is usually seen after trauma. Importance of tenderness, methods of elicitation and grading is mentioned in the box.
- *Swelling:* The swelling is examined for shape, size, consistency, tenderness, fluctuation, etc.
- *Deformity* **(Table 10.3)**: This is usually seen in displaced fractures and dislocations. Undisplaced fractures, mild strains and sprains usually show no deformities. Some of the deformities are very characteristic **(Figs. 10.8A to D)** and specific, and help in making a spot diagnosis.
- *Abnormal mobility:* Between fracture fragments is a sure sign of fracture.
- *Loss of transmitted movements:* When one end of the limb is rotated, it automatically gets transmitted to the

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TABLE 10.3: Famous orthopedic deformities due to fractures.

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

other end. Due to the break in the continuity this is no longer possible in displaced fractures.

- *Crepitus:* This is an abnormal grating sensation produced by the friction between two ragged surfaces of the fracture fragments. Obviously it is elicitable only in displaced fractures. It should be elicited very gently and in the end.
- *Shortening:* Limb shortening of various degrees is fairly common in bone and joint injuries **(Fig. 10.9)**.

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

REMEMBER

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

REMEMBER

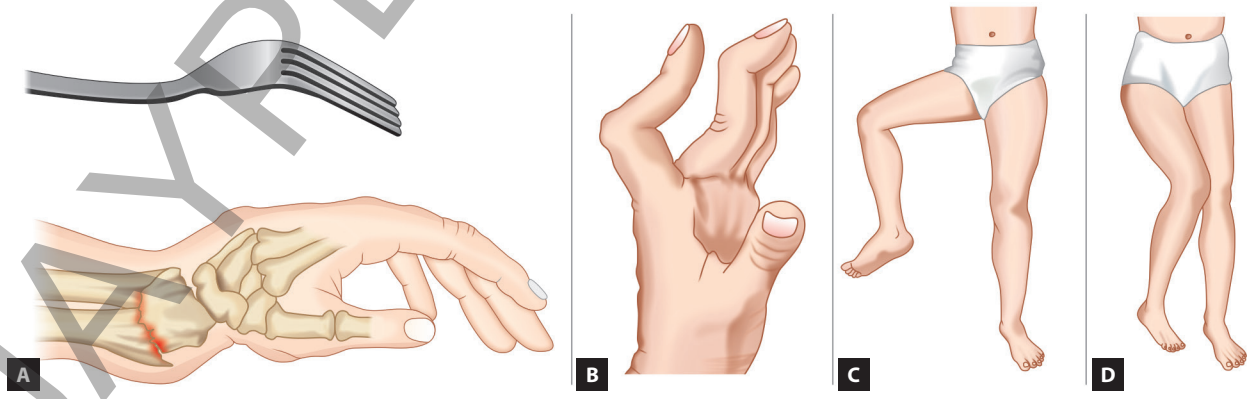
'D' in fracture:
- Deformity is seen often in displaced fractures
- Displacement could be anterior, posterior, medial or lateral
- Distal fragment is the reference point to suggest the type of displacement
- Dislocation of joints usually presents a deformity.

Clinical Signs

Various clinical signs are described in fractures. They can be best represented as follows in order of their importance **(Table 10.4)**.



Fig. 10.9: Clinical photograph showing limb shortening and rotation (posterior dislocation of hip).



Figs. 10.8A to D: Some important deformities in orthopedics. (A) Dinner fork deformity; (B) Swan neck deformity; (C) Anterior dislocation of hip; (D) Posterior dislocation of hip.

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TABLE 10.4: Clinical signs in fracture.

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

About Crepitus

It is defined as an abnormal grating sensation either felt or heard. It could be:

- ❖ Fine, e.g., osteoarthritis
- ❖ Coarse, e.g., fractures
- ❖ Snap, e.g., snapping tendons.

About Tenderness

REMEMBER

Tenderness may be the only evidence of fracture in:

- Crack fracture
- Hairline fracture
- Stress fracture
- Fatigue fracture
- Torus fracture
- Pathological fracture.

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

- Grading:
  - Grade I: Just a suspect
  - Grade II: Patient winces on pressure
  - Grade III: Patient winces and withdraws
  - Grade IV: Patient will not allow to touch.
- This grading of tenderness is superior to the conventional mild, moderate and severe grading.

Clinical Manifestations due to Neurovascular Injuries

Certain fractures are known to cause neurovascular damage quite frequently, e.g., supracondylar fracture of humerus in children. Impending vascular damage is detected by the familiar five **Ps (Box 10.2)** and nerve injuries are detected by the classical deformities and screening tests (as described in peripheral nerve injuries).

BOX 10.2: About five Ps.

In detecting impending vascular damage:

- **P**ain
- **P**allor
- **P**aresthesia
- **P**ulselessness
- **P**aralysis.

DEFORMITIES

Definition

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

Classification

The deformities can be classified as shown in **Flowchart 10.1**. Acquired deformities are more commonly encountered than the congenital variety.

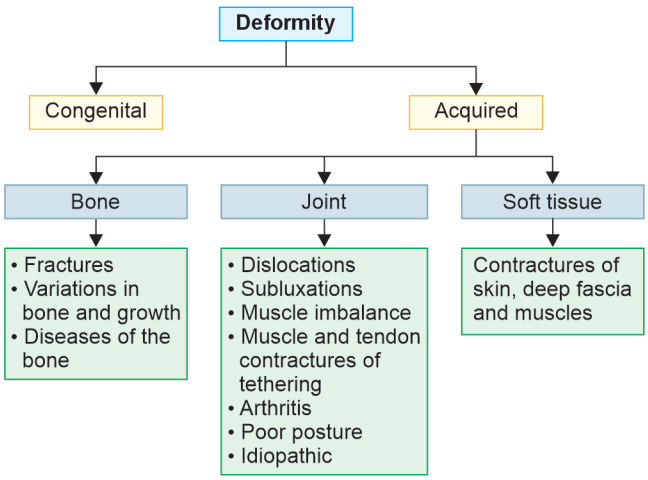
Congenital Deformities (Since Birth)

These are due to some genetic abnormalities or environmental variations or both. They may be obvious at birth or may be seen few years later. Incidence is around 2–3%. They may be so severe that the child is still born or may be so minor that it is not noticeable (for more details refer section on 'congenital deformities').

Acquired Deformities

These could be due to problems in the bone, joint or soft tissues **(Figs. 10.10A to G)**.

Flowchart 10.1: Showing different types of orthopedic deformities.



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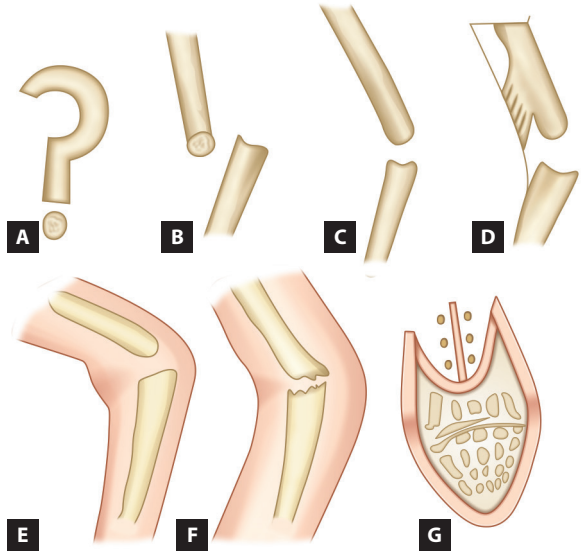

Figs. 10.10A to G: Causes for deformity. (A) Idiopathic; (B) Dislocation; (C) Muscle imbalance; (D) Muscle tethering; (E) Soft tissue contractures; (F) Fractures; (G) Postural.

Clinical Facts (Table 10.5)

Bone Causes

The following causes are responsible for deformities in the bone:

- *Growth disturbances:* Tumor, infections or trauma near the growth epiphysis can cause unequal stimulus, suppressions or stimulation of growth. This results in bending, shortening or lengthening of a bone respectively, e.g., osteomyelitis, epiphyseal injuries, tumor, etc.
- *Bone disorders:* Endocrine disorders, metabolic disorders, developmental disorders are some of the examples with bone deformities.
- *Fractures:* This is by far the most important cause for a bone deformity. All displaced and fresh fractures cause temporary deformity, while malunion or nonunion of fractures lead to deformities at a later date **(Fig. 10.11)**.

TABLE 10.5: Deformity facts.

Classical deformities	*Possible diagnosis*
Wryneck	Cervical spine injuries
Drooping of shoulder	Clavicle fracture
Flat shoulder	Anterior dislocation of shoulder
S-shaped deformity of humerus	Supracondylar fracture humerus
Dinner fork deformity	Colles' fracture
Boutonnière deformity	Rupture of central extensor Slip of finger
Mallet finger	Rupture of distal end of index extensor
Jersey finger	Rupture of distal end of flexor digitorum profundus of index finger
Flexion, adduction and internal rotation	Posterior dislocation of hip
Flexion, abduction and external rotation of lower limb	Anterior dislocation of hip
Incomplete external rotation of lower limbs	Fracture neck femur (intracapsular)
Complete external rotation of lower limbs	Trochanteric fractures, shaft femur, leg bones fractures
S-shaped ankle	Ankle dislocations

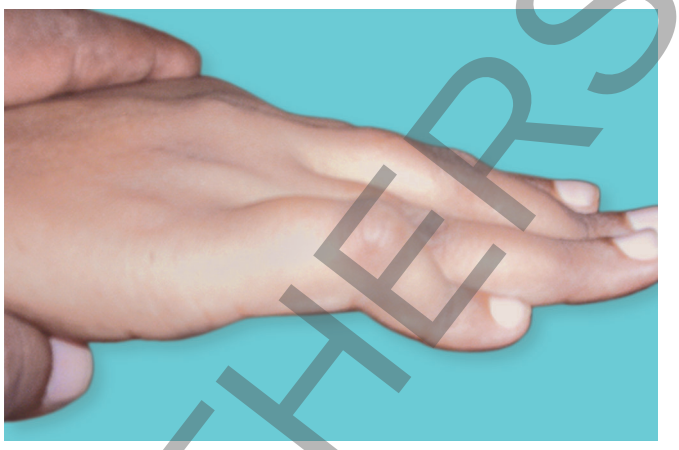

Fig. 10.11: Clinical photograph showing deformity following fracture.

Joint Causes

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

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

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Deformity due to Soft Tissue Contractures

Soft tissue contractures (skin and deep fascia) other than the muscle contractures can also cause joint deformities, e.g., Dupuytren's contracture, post burn contracture, etc. **(Figs. 10.12A and B)**.

Treatment Options

Conservative Measures

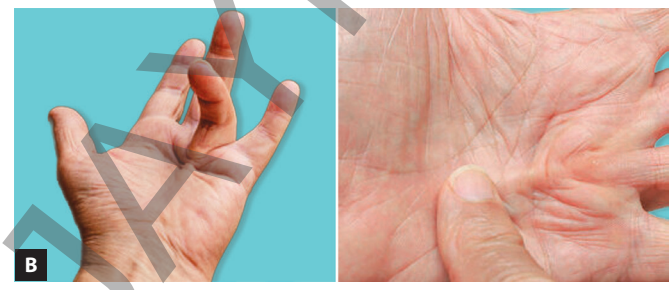
These includes manipulative correction under anesthesia and retention by splints or casts, gradual correction by traction or splints, etc., (e.g., turn buckle splints). Correction by plaster wedging is hazardous.

Surgical Measures

There are various surgical options available:

- *Ilizarov:* This is the gold standard for deformity correction in recent times **(Fig. 10.13A)**.
- Soft tissue release.
- *Tenolysis*: Tendon lengthening or tendon transfers are successfully employed in polio, cerebral palsy, etc.
- *Arthroplasty:* Can be crude as a salvage procedure (e.g., girdle stone excision in TB hip) or sophisticated as is total hip replacement or total knee replacement in rheumatoid and other disorders **(Fig. 10.13B)**.
- *Corrective osteotomy:* This is a simple, but effective procedure to correct joint deformities, e.g., French osteotomy in cubitus varus deformity, etc. **(Fig. 10.13C)**.
- *Arthrodesis:* Fusion of the joints in functional positions in badly damaged joints, e.g., TB knee, rheumatoid arthritis, etc. **(Fig. 10.13D)**.





Figs. 10.12A and B: Clinical photograph showing: (A) Soft tissue contracture; (B) Dupuytren's contracture.



Fig. 10.13A: Clinical photograph showing ilizarov procedure.

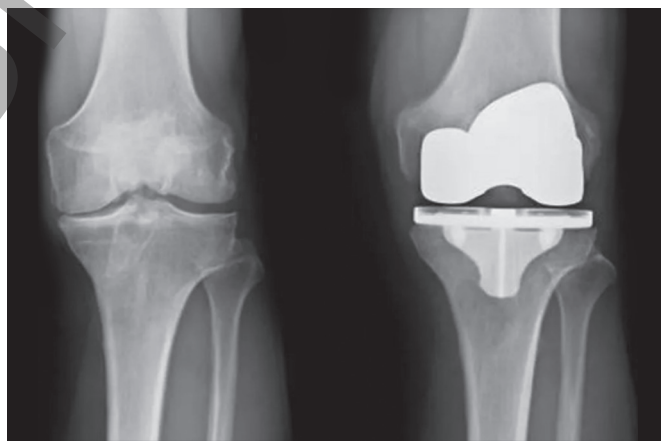


Fig. 10.13B: Clinical photograph showing total knee arthroplasty.

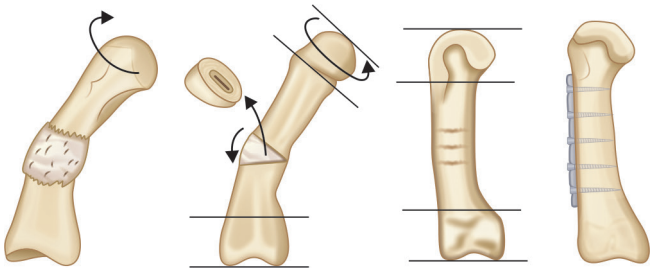


Fig. 10.13C: Photograph showing Corrective Osteotomy. (*Courtesy:* JP E-book reader)

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Fig. 10.13D: Photograph showing arthrodesis.



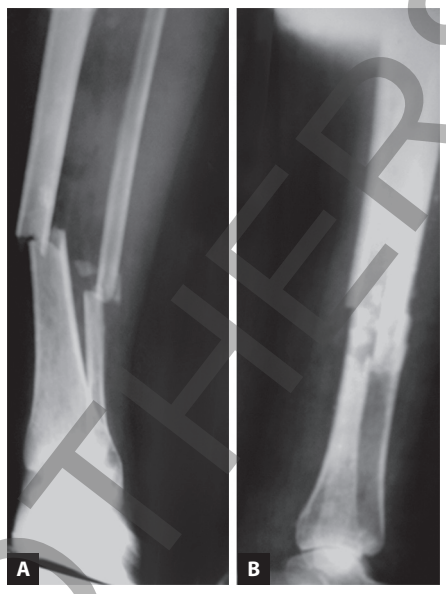
Fig 10.13E: Photograph showing epiphyseal growth arrest.

❖ *Epiphyseal growth arrests:* When potential for growth is still left, stapling of the epiphysis can be attempted on one side to correct the bending deformity, e.g., in genu varum or valgum **(Fig. 10.13E)**.

INVESTIGATIONS IN ORTHOTRAUMA

Radiography

Radiography is an important diagnostic tool for fractures. Minimum two views, anteroposterior and lateral are required as bone is a cylinder **(Figs. 10.14A and B)**. Sometimes an oblique view and other special view are required depending upon the clinical situations and bone under study **(Box 10.3)**.



Figs. 10.14A and B: Plain X-ray showing fracture of both bones—tibia and fibula.

BOX 10.3: Role of X-ray.

- Helps confirm the clinical diagnosis
- Helps study the fracture anatomy
- Helps study the fracture displacement
- Helps to detect crack and stress fractures
- Helps to plan the treatment
- Helps to detect fracture dislocation combinations, e.g., Monteggia
- Helps to ascertain post-reduction status of fractures
- Helps in medicolegal study

REMEMBER

The rules in X-rays

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

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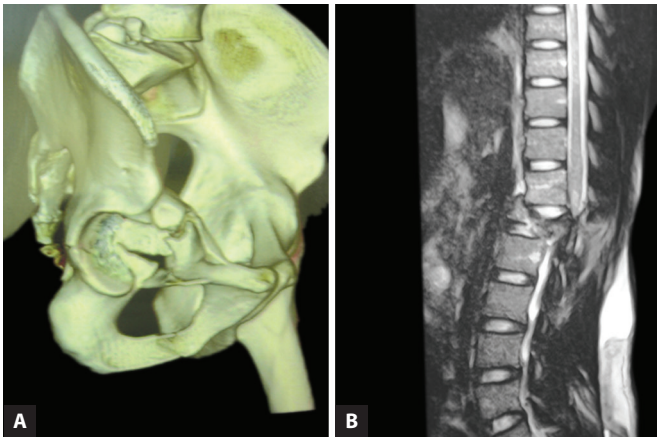

Figs. 10.15A and B: Role of CT scan and MRI. CT scan showing acetabular fractures and MRI of the spine showing compressed fracture of the vertebra.

CT Scan and MRI

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

Notes:

- *Computed tomography (CT) scan:* This is helpful in detecting fracture of skull, pelvis, spine and identifying loose bodies in the joint **(Fig. 10.15A)**.
- *Magnetic resonance imaging (MRI):* This is useful to diagnose any fracture. In addition, it helps to identify soft tissue and ligament injuries. It is certainly the 'Gold Standard' but has its Achilles heel in being expensive **(Fig. 10.15B)**.

PATHOLOGICAL FRACTURES (BOX 10.4)

When a fracture occurs through a bone, which has already been weakened by a generalized or localized skeletal disorder it is called pathological fracture. Unlike traumatic fractures, these fractures take place either spontaneously or due to trivial trauma **(Box 10.5)**.

Clinical Features

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

Investigation

Plain X-ray help to make a diagnosis. However for more accurate diagnosis CT Scan, MRI are indicated.

BOX 10.4: Causes of pathological fractures.

Localized diseases:

- Infective disorders:
  - Chronic pyogenic osteomyelitis
  - Tubercular or syphilitic osteomyelitis
- Neoplasms

  Benign:
  - Chondroma
  - Giant cell tumor
  - Hemangioma spine (lung, breast, prostate, kidney, etc.)
  - Bone atrophy (e.g., polio, etc.)
  - Tabes dorsalis, etc.

  Malignant:
  - Osteogenic sarcoma
  - Ewing's sarcoma
  - Solitary myeloma
  - Metastatic carcinoma
  - Metastatic sarcoma
- Miscellaneous cause:
  - Simple bone cyst
  - Monostotic fibrous dysplasia
  - Eosinophilic granuloma

General affections of bone:

- Congenital disorders:
  - Osteogenesis imperfecta
  - Fibrous dysplasia
  - Gaucher's disease, etc.
- Generalized rarefaction of bones:
  - Senile osteoporosis
  - Hyperparathyroidism
  - Osteomalacia
  - Nutritional rickets
  - Scurvy
- Miscellaneous:
  - Multiple myeloma
  - Diffuse metastatic carcinoma
- Disseminated tumors:
  - Paget's disease
  - Fibrous dysplasia
  - Gaucher's disease, etc.

Treatment

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

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BOX 10.5: Common causes for pathological fractures.

Local disorders (Figs. 10.16A to E)

Metastatic carcinoma

- The primary could be in the lungs, breast, prostate, thyroid or kidney
- Common sites:
  - Vertebral bodies (thoracic/lumbar)
  - Proximal half of femoral shaft
  - Proximal half of humerus

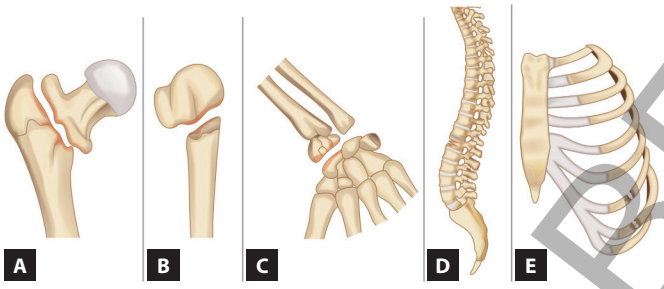
Bone cyst of a long bone

Generalized disorders (Figs. 10.17A and B)

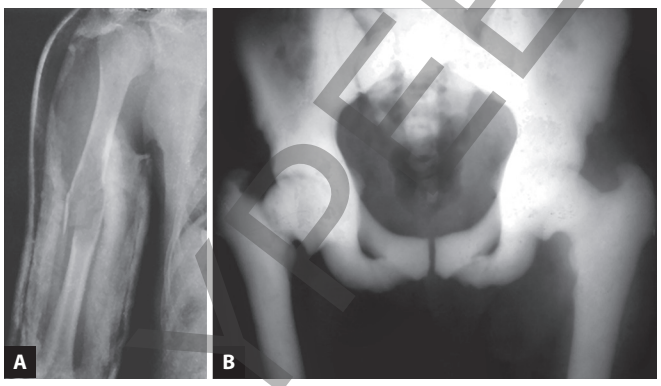
Senile osteoporosis

- Common sites affected are:
  - Lower end of radius
  - Thoracic or lumbar vertebral body
  - Neck or trochanteric region of femur
  - Ribs

Paget's disease of bone: Shaft of tibia or femur



Figs. 10.16A to E: Showing common sites of pathological fractures. (A) Neck femur; (B) Neck humerus; (C) Lower end of radius; (D) Spine; (E) Ribs.



Figs. 10.17A and B: Pathological fracture. (A) Humerus due to lytic lesion; (B) Intracapsular pathological fracture of neck femur.

Fatigue or Stress Fractures

Fatigue or stress fractures occur due to repeated stress or minor trauma to a particular bone usually of the lower limbs **(Fig. 10.18)**. Here there is no single specific causative injury as in a traumatic fracture. The onset of pain is gradual or insidious. Activity increases the pain and rest relieves it. On examination, there is significant local tenderness, thickening of bone, local swelling, etc.

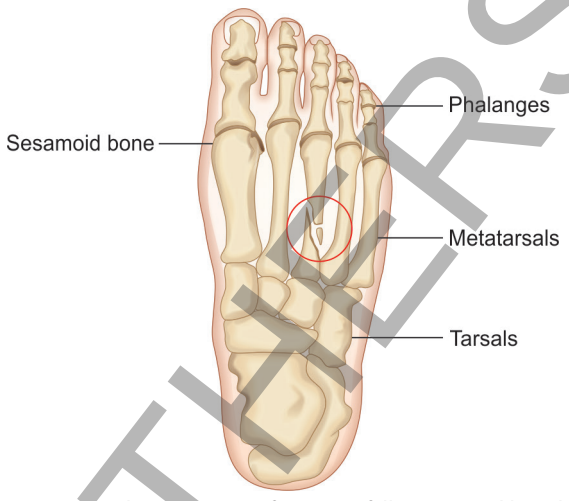


Fig. 10.18: Showing stress fracture of ill metatarsal bond.

BOX 10.6: Practical points.

- **Common sites:**
  - Second metatarsal bone, e.g., march fracture (due to repeated marching as in soldiers)
  - Tibia or fibula—repeated running or dancing
  - Femur—occasionally
- **Radiology:**
  - 1st week—usually no fracture is detected
  - 2nd/3rd week—faint hairline fracture, transverse/undisplaced
  - Zone of callus that surrounds the fracture is more significant than the fracture itself
- Treatment is by rest

Radiograph

Radiograph of the part at first may not reveal any fractures, but may be seen after 3–4 weeks **(Box 10.6)**. The fracture itself will be hairline, transverse and undisplaced. More striking than the fracture is a zone of callus that surrounds it **(Fig. 10.19)**.

Treatment

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

DISLOCATIONS

Dislocation is defined as a total loss of contact between the two ends of bones. All dislocations are emergencies unlike

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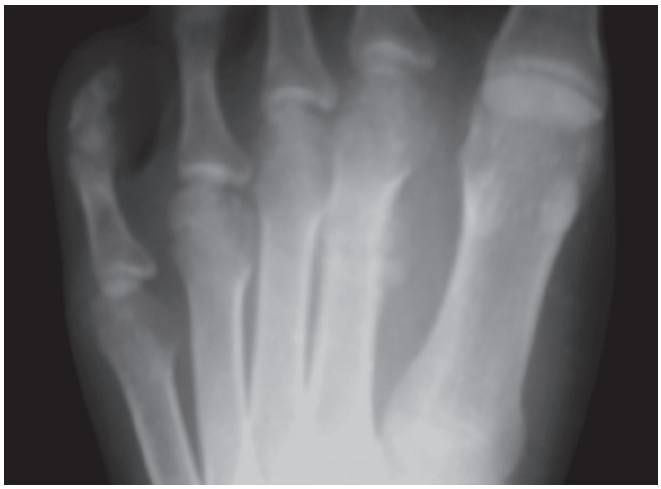


Fig. 10.19: Plain X-ray showing stress fracture (periosteal reaction).

fractures, for delay in reduction may damage the articular surface, which is deprived of nutrition by the synovial fluid. Unlike fractures all dislocations need prompt reduction and early treatment because the patient will not be relieved of pain due to the persistent capsular stretch. The capsule contains nerve endings, which give rise to pain.

Pathology

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

Types

Congenital or Acquired

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

- Traumatic common in young adults due to high-velocity trauma **(Table 10.6)**
- Pathological, e.g., TB hip, septic arthritis, etc.
- Infective, e.g., Tom Smith arthritis in infants
- Paralytic, e.g., Poliomyelitis, cerebral palsy, etc.
- Inflammatory disorders, rheumatoid arthritis, etc.

Clinical Features

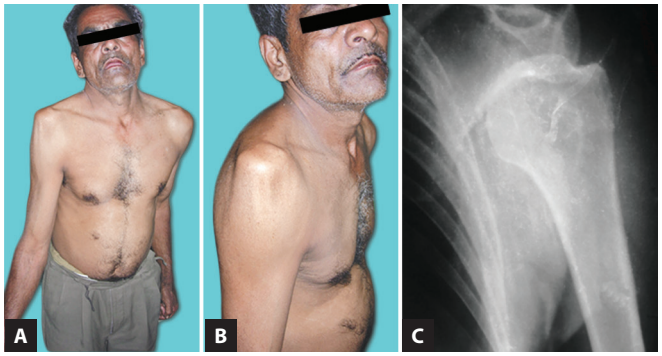
Traumatic variety is the most common type of dislocations one encounters in clinical practice. Patient gives history of trauma usually a road traffic accident (RTA) following which there is pain, swelling, deformity and loss of movements. In dislocations **(Box 10.7)** of other varieties, clinical symptoms and signs pertaining to that particular dislocation are seen **(Figs. 10.20A to C)**.

TABLE 10.6: Common traumatic dislocations.

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

BOX 10.7: Typical deformities in dislocations.

- Shoulder—abduction deformity
- Elbow—flexion deformity
- Hip—anterior flexion abduction and external rotation deformity, posterior flexion abduction and internal rotation deformity
- Knee—flexion deformity
- Ankle—varus deformity



Figs. 10.20A to C: Clinical photograph showing anterior shoulder dislocation. (A) Deformity; (B) Flat shoulder; (C) Plain X-ray of the dislocation.

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Investigations

Radiograph of the affected part should include anteroposterior and lateral views of the joints.

Treatment

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

Rehabilitation in Dislocations

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

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

Complications

- *Acute:* Injury to peripheral nerves and vessels can occur, e.g., sciatic nerve palsy in posterior dislocation of hip.
- *Chronic:*
  - *Unreduced dislocation:* Which is common in Asian countries due to ignorance, delay in seeking treatment, etc?
  - *Recurrent dislocations:* Due to inadequate and improper healing of soft tissues following initial trauma.
  - *Traumatic osteoarthritis:* Due to damage to the articular cartilage following impaired nutrition by the synovial fluid.
  - *Joint stiffness:* Due to capsular and other soft tissue damage.
  - *Avascular necrosis:* Due to injury to the vessels.
  - *Myositis ossificans*: More commonly seen than in fractures due to greater periosteal strip.

Remember

Remember in dislocation:

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

Subluxation

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

Sprain

Sprain is a tear in the ligaments. The severity varies from grade I to III. Mild sprains are more common and heal by conservative treatment, whereas grade III sprains cause joint instabilities and need to be repaired surgically. Sprains are commonly encountered in knee joints and ankle joints **(Fig. 10.21)**.

Strain

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



Fig. 10.21: Clinical photograph showing ankle sprain.

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FRACTURE HEALING

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

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

During the first 2 days at the fracture sites and away from the fracture site, in the deep layer of periosteum the osteogenic cells proliferate and lift the fibrous layer of the periosteum away from the bone. Marrow cells also proliferate, but to a lesser degree. These osteogenic cells differentiate into osteoblasts, which form the bone trabeculae resembling the embryonic tissue. The osteogenic cells lying away from the fracture site due to inadequate vascularity differentiate into chondroblasts and chondrocytes, which form the cartilage. The cartilage is finally converted into bone by endochondral ossification.

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

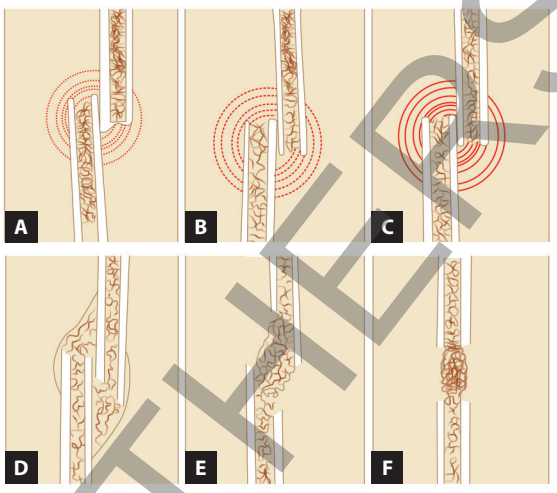
Methods of Fracture Healing

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

Indirect Fracture Healing

Indirect fracture healing is the common method of fracture healing where both external and internal callus are formed. Hunter has described six stages in this method of healing **(Figs. 10.22A to F)**:

1. *Stage of impact:* This stage extends from the moment of impact till the complete dissipation of energy causing fractures.
2. *Stage of induction:* Following fracture cells possessing osteogenic potential are activated. Other inducing factors are bone morphogenic protein (BMP), fall in oxygen tension and bioelectric effects.
3. *Stage of inflammation:* In this stage the disruption of blood supply results in necrosis of the bone ends. There is hemorrhage, cellular proliferation and vascular ingrowths.



Figs. 10.22A to F: Hunter's stages of fracture healing. (A) Stage of induction; (B) Stage of inflammation; (C) Stage of soft callus; (D) Stage of hard callus; (E) Stage of remodeling; (F) Normal.

4. *Stage of soft callus:* Here the hematoma is organized with fibrous tissue, cartilage and woven bone. Fragments are united with fibrous or cartilaginous tissue or both.
5. *Stage of hard callus:* Bone fragments are firmly united with bone. If immobilization is complete, membranous bone healing takes place. If incomplete bone heals by endochondral ossification.
6. *Stage of remodeling:* Here fiber bone is converted to lamellar bone. Medullary canal is reconstituted and callus diameter begins to decrease in size, which takes few months to several years. However, there will be no remodeling of rotational misalignment.

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

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

Factors affecting fracture repair are shown in **Box 10.8**.

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- Numerous new clinical photographs have been added throughout the text to help students understand orthopedic conditions better.
- A separate chapter on Orthopedic Surgical Techniques has been added, while retaining the useful surgical photographs from the earlier edition. This should be particularly valuable to physiotherapy students, who seldom get an opportunity to witness live orthopedic surgeries during their training or career. An insight into operative procedures through photographs can help them understand the underlying pathology and treatment of orthopedic conditions better and, ultimately, make them better physiotherapists.
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John Ebnezar is an internationally acclaimed orthopedic and spine surgeon, pioneering researcher, academician, author, and the founder of the subspecialty of Geriatric Orthopedics in India. A distinguished clinician with a unique integration of modern orthopedics and evidence-based holistic medicine, he is widely regarded as one of the foremost proponents of WHOlistic Orthopedics globally. He is the recipient of some of India's highest medical and civilian honors, including the prestigious Padma Shri, becoming the first and only orthopedic surgeon from Karnataka and among the very few orthopedic surgeons in India to receive this national distinction. He is also a recipient of the coveted Dr B.C. Roy National Award, India's highest medical honor, and uniquely became the only doctor in the country to receive both the Padma Shri and Dr B.C. Roy National Award in the same calendar year (2016). Dr John Ebnezar has made extraordinary contributions to orthopedic education and medical literature. He has authored more than 200 books in Orthopedics, a world record achievement by an individual orthopedic surgeon, covering the entire spectrum from undergraduate and postgraduate education to subspecialty reference works for orthopedic surgeons, physiotherapists, nurses, lawyers, and the general public. His renowned A to Z Orthopedics Series and public health orthopedic books have earned global recognition, with several international editions published in the United States, United Kingdom, Italy, and Spain. A visionary researcher, he became the first orthopedic surgeon in the world to obtain a PhD in Yoga, establishing scientific evidence for the role of yoga in orthopedic rehabilitation and musculoskeletal disorders. His pioneering research in osteoarthritis, spinal disorders, fracture healing, and spinal cord injuries has been published extensively in peer-reviewed indexed journals, and his work has contributed to internationally accepted orthopedic guidelines, including recommendations by the American Academy of Orthopedic Surgeons (AAOS). Dr Ebnezar has received over 400 international, national, and state awards, including multiple Lifetime Achievement Awards, Karnataka Rajyotsava Award, Kempegowda Award, and several prestigious research honors. He also holds multiple Guinness World Records in academics, community service, and health awareness initiatives. An inspiring teacher and speaker, Dr John Ebnezar has delivered more than 400 scientific presentations and is notably the first orthopedic surgeon in India to become an international TED Speaker. He has served in several leadership roles, including Vice President of the Indian Orthopedic Association, Founder President of the Geriatric Orthopedic Society of India, and President of the Neurospinal Surgeons Association (Karnataka Chapter). Through decades of clinical excellence, academic innovation, social commitment, and relentless dedication to patient care, Professor Emeritus Dr John Ebnezar continues to inspire generations of medical professionals and remains a towering figure in contemporary Orthopedics.

Rakesh John is a highly accomplished orthopedic surgeon with extensive academic and clinical expertise in contemporary Orthopedics. He is currently serving as a Consultant Orthopedic Surgeon at Macclesfield District General Hospital and has been closely associated with academic orthopedics, contributing significantly to teaching, research, and postgraduate training. An academically distinguished surgeon, Dr Rakesh John graduated with top honors from Postgraduate Institute of Medical Education and Research and subsequently pursued advanced orthopedic training internationally. He holds the prestigious distinction of being a Double FRCS and has undergone specialized fellowships in Knee Surgery, Shoulder Surgery, and Trauma from reputed institutions in the United Kingdom, Canada, Hong Kong, and other internationally recognized centers. Dr Rakesh John has authored and coauthored more than 70 scientific articles published in peer-reviewed indexed journals, reflecting his strong commitment to evidence-based orthopedics and academic excellence. His areas of interest include orthopedic education, trauma care, joint reconstruction, and subspecialty surgical training. He has been actively involved in undergraduate and postgraduate teaching with a special emphasis on maintaining clarity, clinical relevance, conceptual understanding, and examination-oriented presentation in orthopedic education. His contribution to this edition has played a vital role in the thorough revision and updating of the text, ensuring that it remains aligned with current academic standards and the evolving needs of medical students and trainees. His continued dedication to academic orthopedics and high standards of medical education is clearly reflected throughout this edition.

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