INTRODUCTION

Word Orthopedics was coined by Dr. Nicholas Andrey in 1741. This word comprises of 2 Greek words—orthos (straight) and padion (child). Speciality of orthopaedics is divided into sub-branches as follows:

- Sports Medicine
- Traumatology (Accidental services)
- Cold Orthopaedics
- Hand and foot surgery
- Joint replacement surgery
- Spinal injuries unit
- Rehabilitation Medicine.

TYPES OF FRACTURES

Fractures have been classified on the basis of their etiology, clinical picture, displacement and on radiological features.

1. Aetiological
   a. Traumatic
   b. Pathological

2. Clinical
   a. Simple
   b. Compound

3. Displacement
   a. Displaced
   b. Undisplaced

4. Radiological
   a. Transverse
   b. Oblique
   c. Spiral
   d. Segmental
e. Comminuted
f. Greenstick

**Traumatic Fracture**

It can occur due to assault, road traffic accidents or hanging.

**Pathological Fracture**

Patient may have pathology in the bone, e.g. Tumor, cyst or secondaries. Usually this fracture occurs due to trivial trauma.

**Simple Fracture**

Patient does not have wound over fracture site i.e. fracture is not communicating to exterior.

**Compound Fracture**

When fracture communicates to exterior, it is called as compound fracture. It can be from within, (internal compound) where sharp fracture end protrudes out through skin. It can be from outside (external compound) where object striking over bone, pierces skin and soft tissue overlying it.

**Displaced Fracture**

Fractured bone looses its anatomical alignment. It may be shifted or angulated. It may undergo rotation or over-riding. It is respectively known as shift angulations and rotation or overriding. (See Fig. 1.1 (a), (b), 1.2 and 1.3)
**INTRODUCTION**

**CHAPTER 1**

**Transverse Fracture**
Fracture line is perpendicular to long axis of bone.
(See Fig. 1.4)

![Fig. 1.4 Transverse fracture](image)

**Oblique Fracture**
Fracture line runs obliquely. (See Fig. 1.5 and 1.6)

![Fig. 1.5 Oblique fracture](image)

**Spiral Fracture**
Fracture exists in more than one plane.
(See Fig. 1.7 and 1.8)

![Fig. 1.6 Oblique fracture of shaft tibia](image)

![Fig. 1.7 Spiral fracture](image)
Segmental Fracture

Two or more fractures are present in a bone at different level. (See Fig. 1.9)

Comminuted Fracture

This type of fracture has more than two fragments in number. (See Fig. 1.10 and 1.11)

Pathological Fracture

Osteogenesis imperfecta is an important cause of pathological fracture up to five years of age. (Fig. 1.12)

Osteoporosis is commonest cause of pathological fracture in old age. Bone cyst or chronic osteomyelitis are a common cause of pathological fracture in children. Secondaries can also cause fracture in old age persons. Osteopetrosis (Marble bone disease or Albers Shonberg disease) starts during gestation and progresses till growth stops. It presents with frequent fractures which heal slowly. Rickets, Scurvy, Osteomalacia, Multiple
myeloma, Fibrous dysplasia, Eosinophillic granuloma, Paget disease, Histiocytosis X and Gaucher’s disease are other causes of pathological fracture. (See Fig. 1.12)

Dislocation
When the articular surface of a joint are completely displaced from each other, joint is said to be dislocated. Joints that commonly undergo dislocation are hip, shoulder, elbow, knee and patella. Other joint may also dislocate depending on mode of trauma. Chopart (intertarsal) dislocation and Lisfranc (tarsometatarsal) dislocation are uncommon. (See Fig. 1.13 (a), (b) and 1.14)

Subluxation
When the articular surface of a joint are partially displaced, it is said to be subluxated. (See Fig. 1.15)
SPRAIN

A tear in ligament is called as sprain and can be diagnosed by clinical examination and stress test. It has been classified into three degree as follows:

First Degree Sprain
Patient presents with mild swelling, local tenderness and no functional impairment. Only a few fibres of ligament are torn in first degree sprain. In this condition symptomatic treatment is given.

Second Degree Sprain
Patient presents with pain, swelling and inability to use limb. Joint movements are within normal limit. Most of the fibres of ligament are torn sparing only few fibres. Treatment is given by immobilizing the joint by plaster application.

Third Degree Sprain
Patient presents with gross swelling. Pain is less. Joint movements may show talar tilt in ankle. All fibres are torn. It is treated by surgical repair of ligament.

Strain
Strain means tear in muscle and is commonly seen in young athletes.

BLOOD SUPPLY OF LONG BONES

Long bones are mainly supplied by following vessels:
1. Nutrient artery
2. Epiphyseal vessels
3. Metaphyseal vessels
4. Periosteal vessels

ASSEMBLY OF BONE

Human body has been assembled into axial skeleton and appendicular skeleton. Axial skeleton has got 80 bones forming upright axis of body. Whereas appendicular skeleton has got 126 bones forming appendages and girdles that connect them to axial skeleton.

Sesamoid Bone
These are the bones that develop within the substance of a tendon or fascia. This type of bone is small, rounded and triangular in shape.

TYPES OF JOINTS

Joints have been classified into three types as follows:
1. Fibrous Joint (Synorthosis)
2. Cartilaginous Joint (Amphorthosis)
3. Synovial Joint (Diarthrosis)

Fig. 1.16 Different types of joint

1. Fibrous Joint
Fibrous joints are immovable joints and further divided into three subtypes as follows:
   a. Syndesmosis
   b. Sutures
   c. Gomphosis

a. Syndesmosis
This kind of joint has got dense fibrous membrane which holds the articular surface close and tight to
each other. Distal tibiofibular joint is an example of such kind of joint.

b. Sutural joint
Sagittal, coronal and lambdoid sutures of skull come under this type of joint. Bone margins are united by jagged interlocking process.

c. Gomphosis
This kind of joint has one socket into which conical part of bone fits itself e.g., teeth and socket of jaw bones.

2. Cartilaginous Joint
This kind of joint is made up of either hyaline cartilage (synchondrosis) or fibrous cartilage (symphysis). This joint provides slight movement. Symphysis pubis is an example of fibrocartilaginous joint whereas articulation between ribs and sternum is an example of synchondrosis.

3. Synovial Joint
Synovial joints are lined by synovial membrane which secretes synovial fluid that keeps the joint lubricated and provides nourishment to articular cartilage. Synovial joints has fibrous capsule outside, holding the articulating bones together. These joints are most mobile joint in body.

Synovial fluid
Synovial fluid has two main functions in a joint. It provides lubrication to the joint and nutrition to avascular cartilage. Synovial fluid is nothing but an ultrafiltrate of plasma containing locally secreted hyaluronan and lubricin. Hyaluronan provides viscoelastic properties, while lubricin provides lubrication to the joint.

Synovial fluid has following features:
1. This is viscous fluid which is pale yellow in colour.
2. Intra-articular pressure is minus 8 cm to minus 12 cm $H_2O$.
3. Its specific gravity is 1.008–1.015.
4. Synovial fluid contains 2 g of protein (albumin, globulin and mucin).
5. $A : G$ ratio in synovial fluid is 20 : 1.
6. Albumin is present in larger quantity in synovial fluid in comparison to senum.
7. Fibrinogen is not present in synovial fluid.
8. This also contains certain enzymes e.g., amylase, lipase and protease.

Articular cartilage
This cartilage is present at the joint line of long bones and consists of chondrocytes. Articular cartilage is avascular structure which even does not have nerves. Tensile strength of articular cartilage is provided mainly by type-II collagen. Aggrecan is main proteoglycan in articular cartilage and consists of a protein core with side chains of chondroitin and keratin sulphate. Certain degradative enzymes are also found in articular cartilage e.g. collagenase, gelatinase, aggrecanase and stromelysin. Tissue inhibitor of metalloprotienses (TIMP) is also found.

Types of Synovial Joint
Synovial joints are divided into three types as follows:

a. Uniaxial
b. Biaxial

c. Multiaxial

\textbf{a. Uniaxial joint}

It provides movement in one axis; either in horizontal (elbow joint) or vertical axis (atlantoaxial joint) known as Hinge and Pivotal joints respectively.

\textbf{b. Biaxial joint}

It provides movements in two axes and two plains at 90 degree. These joints have two subtypes as follows:

i. \textbf{Saddle joint}: Articular surface of saddle joint is concave in one direction and convex in other direction whereas the articulating surface of opposite bone is exactly opposite. Carpophalangeal joint of thumb, joints between C1 and C2, the atlantoaxial joint are this kind of joint.

ii. \textbf{Condyloid joint}: It has one condyle that fits into a socket e.g., Radiocarpal joint.

\textbf{Knee joint}

Knee joint is a compound synovial joint which has 2 condylar joint between femoral and tibial condyles and another saddle joint between femur and patella.

\textbf{c. Multiaxial joint}

These joints provide movement in more than two axis. It is subdivided into two types as follows:

i. \textbf{Ball and socket joint}: For example, Hip, knee and shoulder joint.

\textbf{BONE PHYSIOLOGY}

Bone is a kind of connective tissue with a collagen framework impregnated with calcium and phosphate salts particularly hydroxyapatite which have general formula of $\text{Ca}_{10} (\text{PO}_4)_6 (\text{OH})_2$.

Total blood flow in bone is $200–400 \text{ ml/min}$ in adults.

Calcium turnover rate is 100% in infant and 18% in adults.

\textbf{Bone Types I}

Human bone structure is compared of the following two types:

1. Compact bone (cortical bone)
2. Trabecular bone (spongy bone)

\textbf{Compact bone}

This bone is predominantly found in diaphyseal area of long bones.

This bone has following characteristic features:

a. It accounts for 80% of bone in body.

b. It makes outer layer of bone in body.
c. Bone cells lie in lacunae.

d. Collagen is arranged in concentric layers around the Haversian canal known as Osteon or Haversian system.
e. Surface to volume ratio is low.

Trabecular bone
This bone is predominantly seen at the ends of long bones (epiphysis) and vertebral bodies. This bone has following characteristic features:
a. It accounts for 20% of bone in the body.
b. It lies inside cortical bone.
c. It is made up of spicules or plates. Many cells are sitting on surface of plates.
d. Nutrition is provided via bone ECF into trabeculae.
e. Surface to volume ratio’s high.
f. This bone is more quickly remodelled than cortical bone due to having greater surface area.

90% of protein in bone matrix is type 1 collagen. This collagen is as strong as steel and is made up of helix of three polypeptides bound tightly together. Two of these are alpha-1, polypeptide encoded by one gene and other is alpha-2 polypeptide encoded by different gene.

Structure of Bone
Basic structural unit of compact bone is Haversian system also known as Osteon. This system consists of lamellae which are arranged concentrically about the haversian canal. Haversian system is present along the long axis of bone. Haversian canals connect with each other and with Volkman’s canal. Volkman’s canals run horizontally from endosteal to periosteal surface.

Sharpey’s fibres are very important structure as they fix the periosteum to outer surface of bone specially at the attachment site of muscle and tendon.

Growth of Bone
First appearance of bone is seen after 7th embryonic week. Bone grows by enchondral and intramembranous ossification. In enchondral ossification (cartilaginous bone) bones are modelled in cartilage and transformed into bone. When mesenchymal cells form bone directly, it is called as intramembranous ossification (membranous bone) e.g. clavicle, mandible and certain bones of skull.

Cartilage first appears at 5th embryonic week. It is of three types. (hyaline, elastic and fibrous)
Bone increases in length by epiphyseal plate which lays down new bone on the end of shaft of bone. Width of bone is markedly affected by pituitary growth hormone and IGF-1.

Types of Bone
Our human body has 3 types of bone: long, flat and small bone.

Long bone
Middle portion (shaft) of long bone is known as diaphysis. This has medullary cavity inside. Diaphysis is made up of compact bone. Ends of long bone is known as epiphysis, are madeup of spongy bone which is covered by thin layer of compact bone.
Area of spongy bone just beneath the epiphyseal plate is known as metaphysis.
10  FUNDAMENTALS OF ORTHOPAEDICS

Fig. 1.19 Structure of long bone prior to epiphyseal closure

Flat bone
Outer and inner table of skull are example of flat bone.

Small bone
Carpals and metacarpals are small bones.

COMPONENTS OF BONE

Bone is composed of periosteum and osteogenic cells.

Periosteum
This is a tough membrane which covers outer surface of bone. This is made up of 2 layers. Outer layer is thin fibrous layer which contains fibroblasts. Inner layer is osteogenic layer which contains osteogenic cells. These osteogenic cells differentiate into osteoblast, chondroblast and perhaps osteoclast and osteocyte.

Osteoblast
This is an osteogenic cell and has following features:

a. Osteoblasts are modified fibroblast.
b. Bone formation is done by osteoblast.
c. Osteoblast lay down type-1 collagen and form new bone.

d. Osteoblast regulates the process of osteoclast formation via RANKL-RANK and M-CSF-OPG mechanism.
e. Osteoblast contains following enzymes e.g. alkaline phosphatase, phosphorylase and glycolate.

Osteoclast
This is also an osteogenic cell and has following features:

a. Osteoclasts are member of monocyte family.
b. Osteoclasts are attached to bone via integrins in sealing zone.
c. Osteoclasts erode and absorb previously formed bone.
d. Pyridinoline is a breakdown product of collagen, which is used to measure in urine as an index of rate of bone resorption.
e. Parathyroid hormone accelerates bone resorption whereas estrogen hampers bone resorption.
f. First osteoclast resorbs bone, then osteoclast lay down new bone. This cycle takes 100 days.

Osteocyte
Osteocytes are synthesized by osteoblast. Osteocyte has large oval nucleus with large chromatin granules. Its cytoplasm is faintly basophilic. Glycogen and PAS positive granules are abundantly found in osteocytes.

PHYSIOLOGY OF WALKING

Normal walking comprises of two phases: stance phase and swing phase. Both of these phases are further divided into 3 phases as follows:

Stance phase
1. Heel stroke (heel strikes the ground) [Fig. 1.20 (a)]
2. Mid stance (foot is kept flat on ground) [Fig. 1.20 (b)]
3. Push off (foot is off the ground) [Fig. 1.20 (c)]

**Swing phase**

1. Acceleration phase (leg comes in front of body) [Fig. 1.21 (a)]
2. Swing through (leg is swinging forward) [Fig. 1.21 (b)]
3. Deceleration phase (swinging becomes slow and heel becomes ready to strike the ground) [Fig. 1.21 (c)]
Fracture of necessity
This is Galeazzi fracture i.e. fracture of lower end of radius with subluxation or dislocation of inferior radioulnar joint. Galeazzi fracture is also known as reverse monteggia fracture.

Chauffer’s fracture
This is fracture of radial styloid process.

Bennet’s fracture
This is an intraarticular fracture of base of first metacarpal bone.

Monteggia fracture
This is fracture of upper 1/3rd of ulna with dislocation of head radius.

Colles’s fracture
This is a transverse fracture of lower end of radius within 3/4th of an inch from it’s distal articular margin at the corticocancellous junction occurring as a result of fall on outstretched hand leading to dinner fork deformity; commonly seen in postmenopausal elderly females.

Chopart fracture-dislocation
This is fracture-dislocation through inter-tarsal joint.

Burst fracture
This is comminuted fracture of vertebral body where its fragments burst out in different direction. This fracture manifests in 5 pattern (discussed in chapter of spinal injuries).

Straddle fracture
This is fracture of superior and inferior pubic rami on both sides.

Rolando fracture
This is an extraarticular fracture of base of first metacarpal bone.

Essex-Lopresti fracture
This is fracture head of radius with dislocation of inferior radioulnar joint.

Night stick fracture
This is fracture of shaft of ulna.

Smith fracture
This is reverse of colles’s fracture, i.e. fracture of lower end of radius with palmar displacement.

Volar Barton fracture
This is anterior marginal fracture of lower end radius.

Dorsal Barton fracture
This is posterior marginal fracture of lower end of radius.

Base ball finger
This is also known as Mallet finger. This is an avulsion of extensor tendon of distal interphalangeal joint from it’s insertion at the base of terminal phalanx.

Whiplash injury
This is a ligamentous injury of neck.

Malgaigne’s fracture
This is disruption of pelvic ring associated with injury to pubic symphysis and sacroiliac joint on same side.
Holstein-Lewis fracture
This is an oblique fracture of distal third of humerus associated with radial nerve injury. Radial nerve is entrapped between fracture ends.

Mallet thumb/finger
This is an avulsion of extensor pollicis longus insertion into base of disal phalanx, leading to flexion deformity of thumb/finger.

Jersey finger
This fracture is seen in adolescent and young adults. Instead of more common avulsion of FDP from its metaphyseal insertion on volar aspect of distal phalanx, a metaphyseal fragment with variable amount of physeus may accompany the tendon.

Gamekeeper’s thumb
This is also known as Skier thumb. This is partial or complete disruption of ulnar collateral ligament and volar plate, is caused by valgus stress applied to metacarpophalangeal joint of thumb.

Boxer’s fracture
This is a fracture neck of 5th metacarpal that is ventrally displaced. It is commonly seen in boxers.

Jefferson’s fracture
This is a fracture of first cervical vertebra.

Hangman fracture
This is a fracture of second cervical vertebra that occurs through its pedicle. This is not associated with any neurological deficit.

Chance fracture
This is a type of seat belt injury. This is a horizontal avulsion fracture of vertebral body.

Clay shoveller’s fracture
This is a fracture of spinous process of first thoracic vertebra, caused by strong muscular action. It is commonly seen in shovelling by labourers.

Bumper’s fracture
This is fracture of lateral condyle of tibia, occurs as a result of hit by bumper of a car or truck.

Dash board fracture
This is a fracture of patella that occurs as a result of knee striking to dash board of a car due to sudden application of brake.

Pott’s fracture
This is a fracture of medial and lateral malleoli and also known as bimalleolar fracture.

Side-swipe fracture
This fracture is seen in elbow, while projecting out of a car and side swept by other vehicle. This injury involves fracture of distal humerus, proximal end of radius and or ulna.

Cotton’s fracture
This is a fracture of medial, lateral and posterior malleoli also known as trimalleolar fracture.

Aviator’s fracture
This is a fracture of neck of talus, caused by forced dorsiflexion of ankle and commonly seen in air craft crash.

Jone’s fracture
This is a fracture of base of 5th metatarsal.

March fracture
This is fatigue fracture of second metatarsal caused by repeated stress and commonly seen in soldiers.

Hoffa’s fracture
This is a fracture of femoral condyle in coronal plane.

Massonaise’s fracture
This is an ankle injury associated with fracture neck of fibula.

IMPORTANT SIGNS

Reisser’s sign
This sign is seen in scoliosis. Iliac apophysis fuses with the iliac bone at maturity, i.e., growth is completed and there is no chance of worsening of spinal curve. This is called as Reisser’s sign and seen on X-ray.
Trethowan sign
This is seen in slipped capital femoral epiphysis. If we draw a line along the superior surface of neck, it remains superior to head of femur.

Hawkin’s sign
This sign is seen in avascular necrosis of talus. This is best radiographic indication of viability of talus. Avascular necrosis can be seen radiologically 6–8 weeks after fracture-dislocation. Disuse atrophy can be seen in bones of foot and lower end of tibia. Subchondral atrophy of talus rules out avascular necrosis.

Scottish dog sign
This is seen in spondylolisthesis. In oblique view of spine, pars interarticularis area looks like a Scottish dog. If it looks like a Scottish dog wearing a collar it means that defect is in the pars interarticularis (isthmus) of vertebra and patient has spondylolysis (without slipping of vertebra). If dog’s head is separated from neck it means there is slip of vertebra and called as spondylolisthesis.

Aneurysmal sign
This is seen in anterior type of spinal tuberculosis.

## MOVEMENTS AT THE JOINTS

Movements at various joints in degrees are as follows:

<table>
<thead>
<tr>
<th>JOINT</th>
<th>MOVEMENTS</th>
<th>RANGE</th>
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<tbody>
<tr>
<td>HIP</td>
<td>Flexion (with knee extended)</td>
<td>0–90</td>
</tr>
<tr>
<td></td>
<td>Flexion (with knee flexed)</td>
<td>0–120</td>
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<tr>
<td></td>
<td>Extension</td>
<td>0–20</td>
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<tr>
<td></td>
<td>Abduction</td>
<td>0–45</td>
</tr>
<tr>
<td></td>
<td>Adduction</td>
<td>0–30</td>
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<tr>
<td></td>
<td>External rotation</td>
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<tr>
<td></td>
<td>Internal rotation</td>
<td>0–30</td>
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<tr>
<td>KNEE</td>
<td>Flexion</td>
<td>0–135</td>
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<tr>
<td></td>
<td>Extension</td>
<td>135–0</td>
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<tr>
<td>ANKLE</td>
<td>Dorsiflexion</td>
<td>0–25</td>
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<td></td>
<td>Plantarflexion</td>
<td>0–45</td>
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<tr>
<td>SHOULDER</td>
<td>Flexion</td>
<td>0–90</td>
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<tr>
<td></td>
<td>Extension</td>
<td>0–45</td>
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<tr>
<td></td>
<td>Adduction</td>
<td>0–45</td>
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<tr>
<td></td>
<td>Abduction</td>
<td>0–180</td>
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<tr>
<td></td>
<td>External and Internal rotation (with arm in neutral position, hanging by the side of chest)</td>
<td>0–70</td>
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<tr>
<td>ELBOW</td>
<td>Flexion</td>
<td>0–145</td>
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<tr>
<td></td>
<td>Extension</td>
<td>145–0</td>
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<tr>
<td>RADIOULNAR JOINT</td>
<td>Supination</td>
<td>0–90</td>
</tr>
<tr>
<td></td>
<td>Pronation</td>
<td>0–80</td>
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<tr>
<td>WRIST</td>
<td>Dorsiflexion</td>
<td>0–70</td>
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<tr>
<td></td>
<td>Palmar flexion</td>
<td>0–90</td>
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<td></td>
<td>Radial deviation</td>
<td>0–20</td>
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<tr>
<td></td>
<td>Ulnar deviation</td>
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<tr>
<td>MP JOINT</td>
<td>Flexion</td>
<td>0–90</td>
</tr>
<tr>
<td></td>
<td>Extension</td>
<td>0–40</td>
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