

PRINCIPLES OF FRACTURES (ADULTS)

SULTAN ALDOSARI; MD; FRCSC.



OBJECTIVES

- Introduction.
- Basic science of fracture healing.
- Principles of evaluating patients with fractures.
- Principles of management.

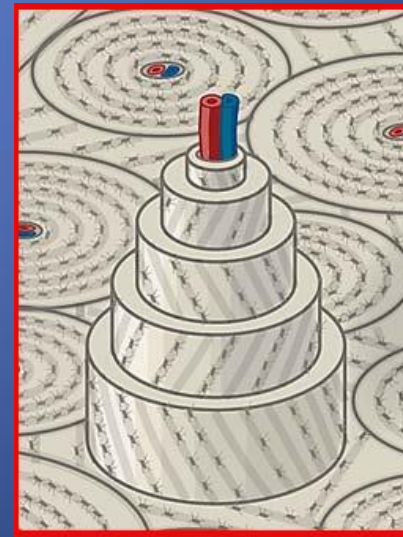
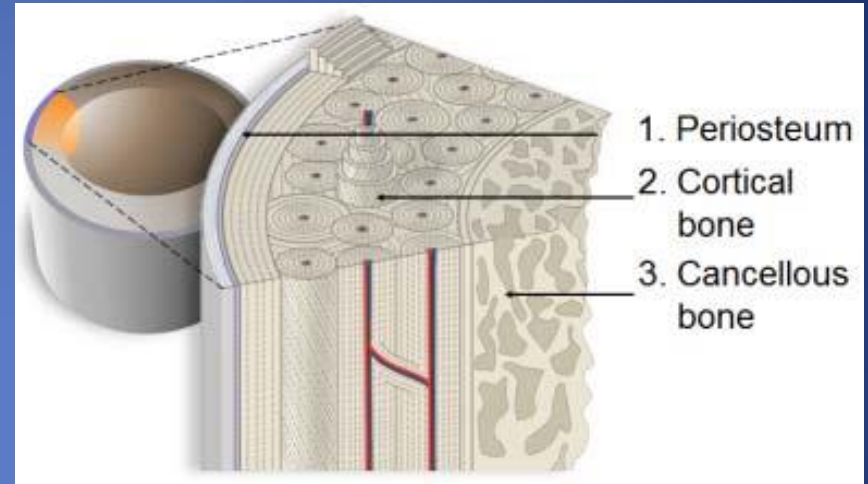
Types of Bone

- Lamellar bone
- Cancellous bone
- Woven bone



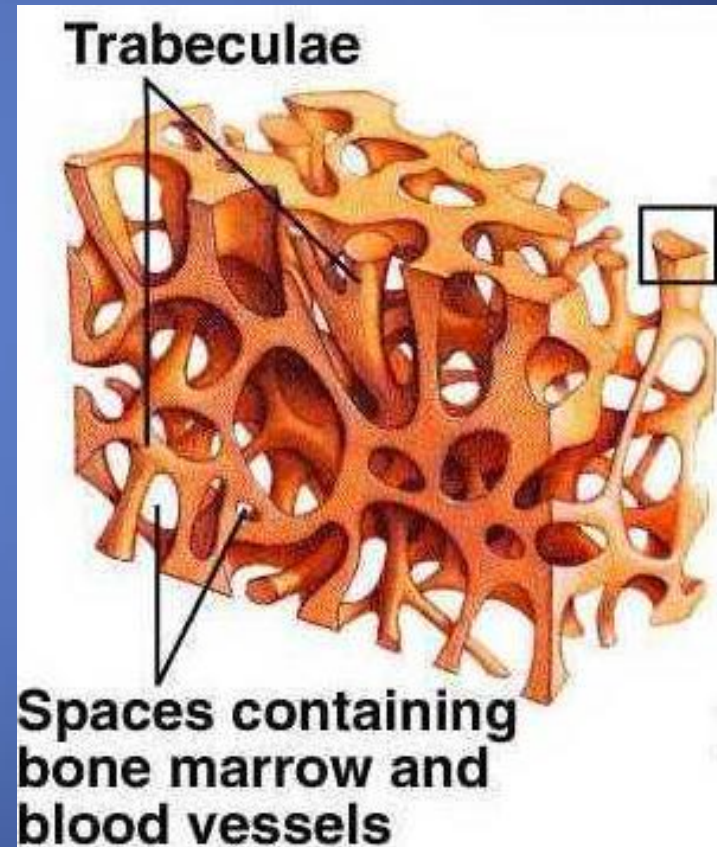
Types of Bone

- Lamellar Bone
 - Collagen fibers arranged in parallel layers
 - Normal adult long bone
 - Basic unit: Osteon
“Haversian systems”



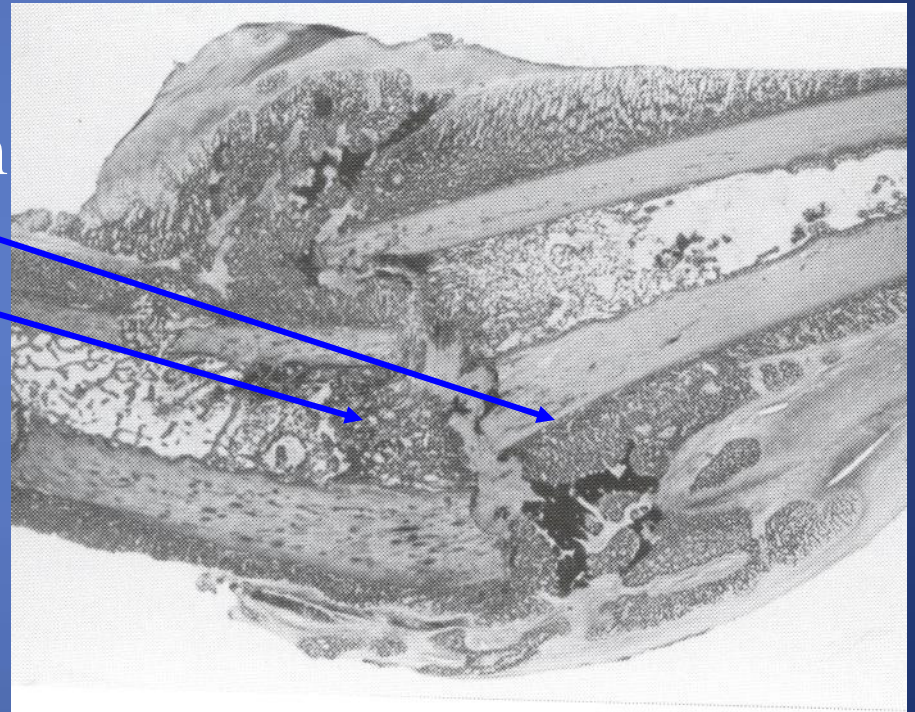
Types of Bone

- Cancellous bone (trabecular or spongy bone)
 - Less dense and more elastic bone
 - Small bones
 - Metaphysis



Types of Bone

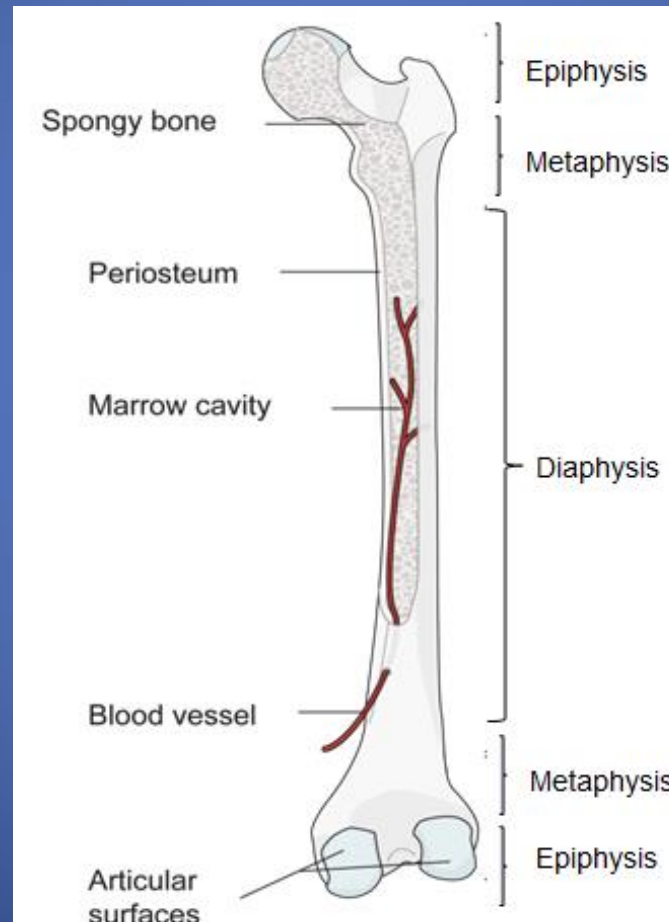
- Woven Bone
 - Coarse with random orientation
 - Weaker than lamellar bone
 - Normally remodeled to lamellar bone



Bone Composition

- Cells
 - Osteocytes
 - Osteoblasts
 - Osteoclasts
- Extracellular Matrix
 - Organic (35%)
 - Collagen (type I) 90%
 - Osteocalcin, osteonectin, proteoglycans, glycosaminoglycans, lipids (ground substance)
 - Inorganic (65%)
 - Primarily hydroxyapatite $\text{Ca}_5(\text{PO}_4)_3(\text{OH})_2$

Gross Anatomy

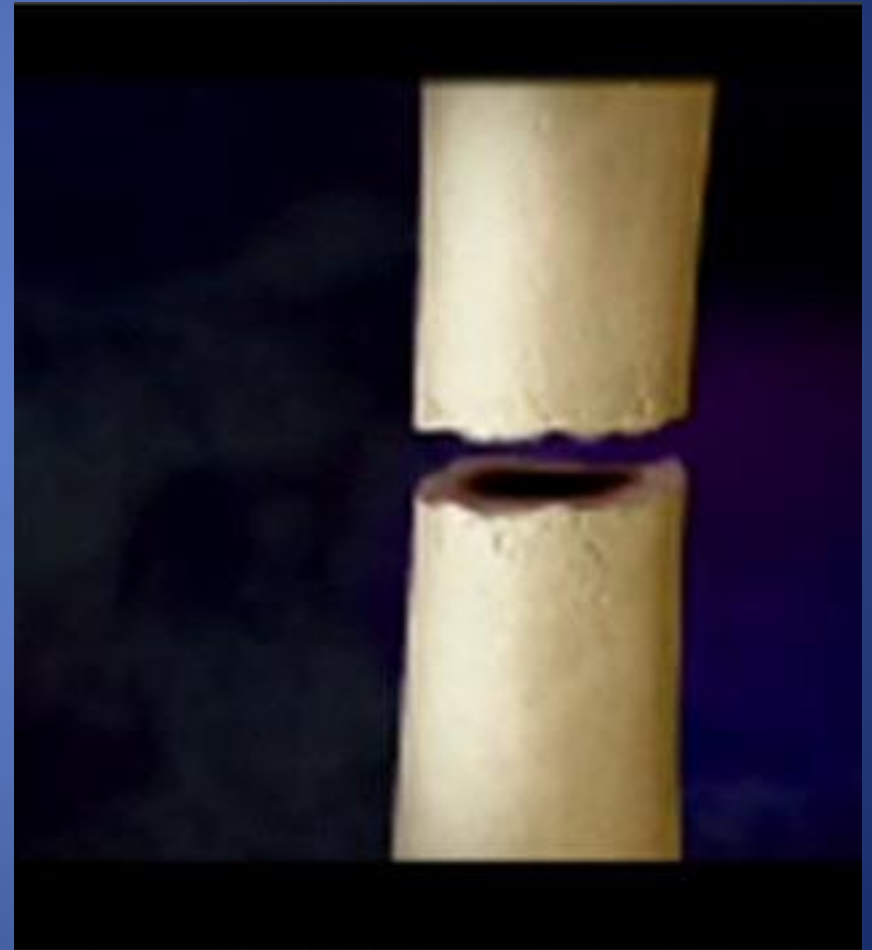


What does “Fracture” mean?

- Fracture means literally broken bone.
- This can be described in different ways:
 - Extent
 - Location
 - Morphology
 - Mechanism
 - Associated soft tissue injuries

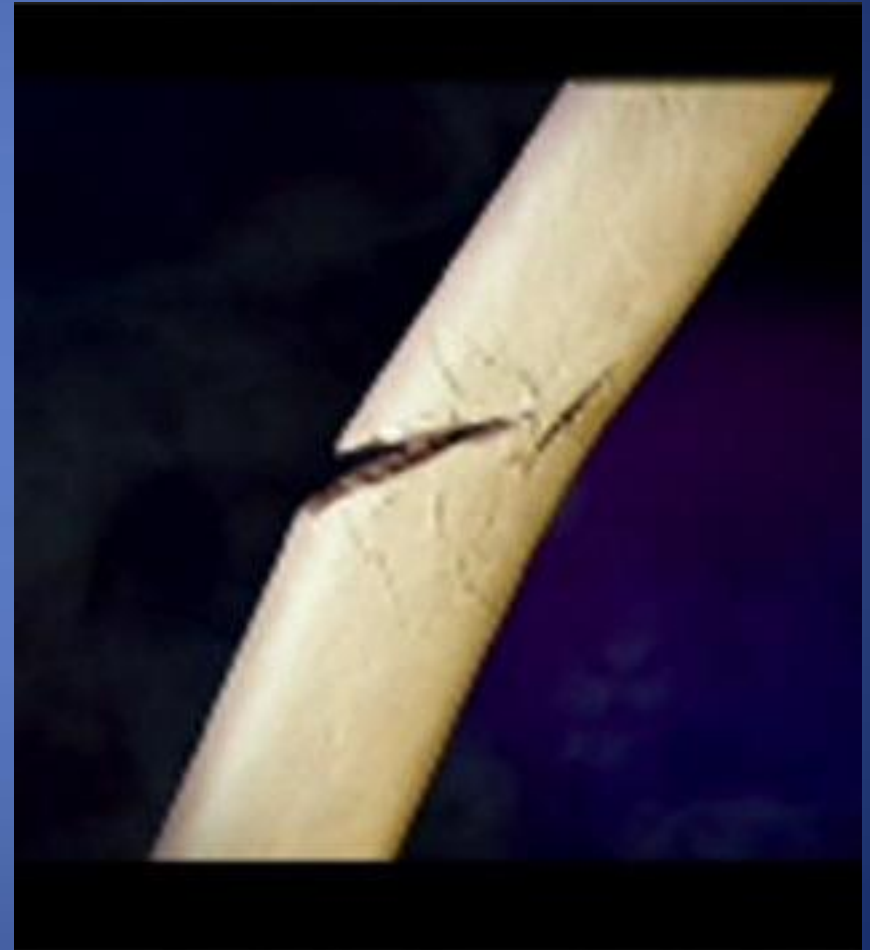
Description

- **Extent:**
 - **Complete:** fracture extends 360° of bone circumference (all around)



Description

- **Extent:**
 - Complete: fracture extends 360° of bone circumference (all around).
 - Incomplete: seen almost only in children:
 - Greensick



Description

- **Extent:**
 - Complete: fracture extends 360° of bone circumference (all around).
 - Incomplete: seen almost only in children:
 - Greensick
 - **Buckle fracture**

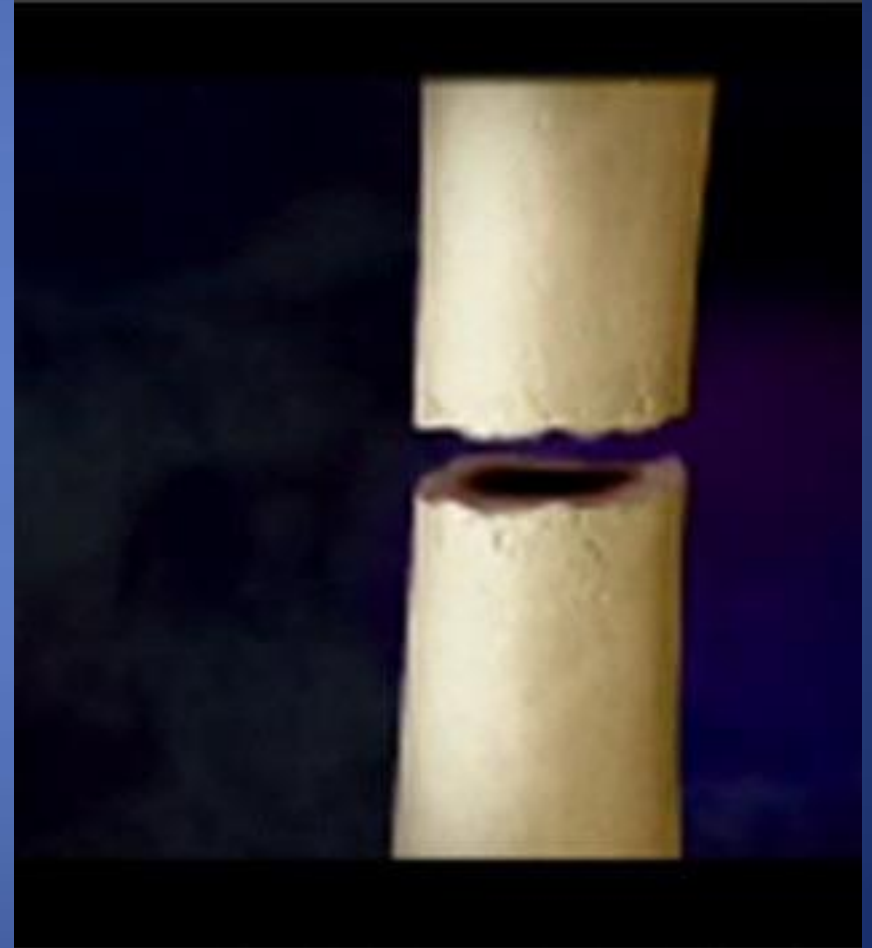


Description

- **Location:**
 - Name of bone
 - Side
 - Diaphysis, metaphysis or epiphysis
 - Long bones (diaphysis): divide them in thirds (proximal, middle or distal third)
 - Metaphysis: intra-articular v.s extra-articular

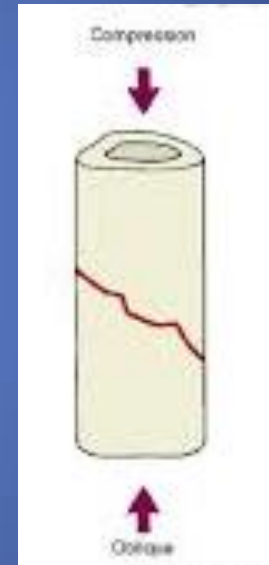
Description

- Morphology:
 - Transverse: loading mode resulting in fracture is tension



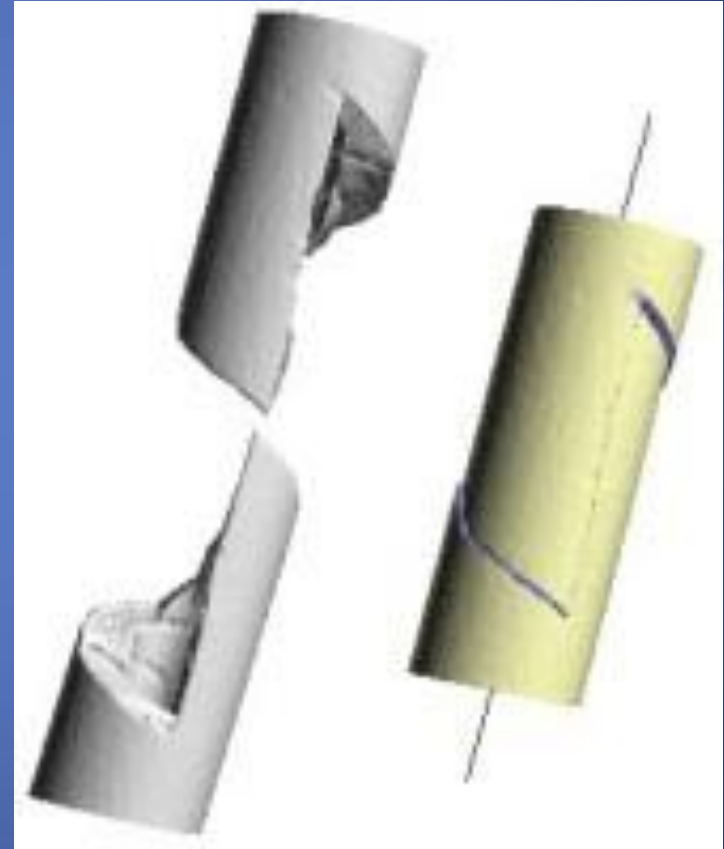
Description

- **Morphology:**
 - **Oblique:** loading mode is compression.



Description

- Morphology:
 - Spiral: loading mode is torsion.



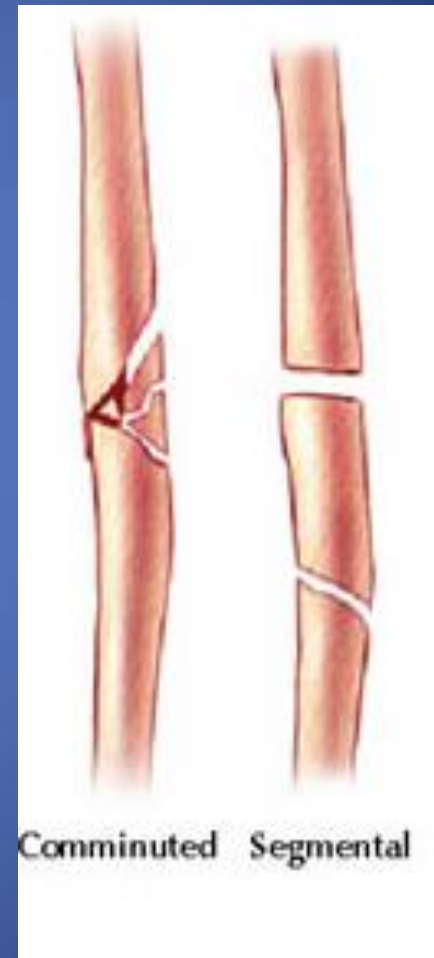
Description

- **Morphology:**
 - Fracture with Butterfly fragment: loading mode is bending.
 - It also called a wedge fracture.



Description

- Morphology:
 - Comminuted fracture: 3 or more fragments
 - Segmental fracture



Description

- **Mechanism:**
 - High energy vs. low energy.
 - Multiple injuries vs. isolated injury.
 - Pathological fracture: normal load in presences of weakened bone (tumor, osteoporosis, infection)
 - Stress fracture: normal bone subjected to repeated load (military recruits/athletes).

Description

- **Associated soft tissue injuries:**
 - Close fracture: skin integrity is maintained.
 - Open fracture: fracture is exposed to external environment .

Any skin breach in proximity of a fracture is an open fracture until proven otherwise.



QUESTIONS ?

FRACTURE HEALING

Bone Healing

- Indirect bone healing (endochondral ossification) occurs in nature with untreated fracture.
- It is called indirect because of formation of cartilage at intermediate stage.
- It runs in 4 stages:
 - Hematoma formation
 - Soft callus formation
 - Hard Callus formation
 - Remodeling

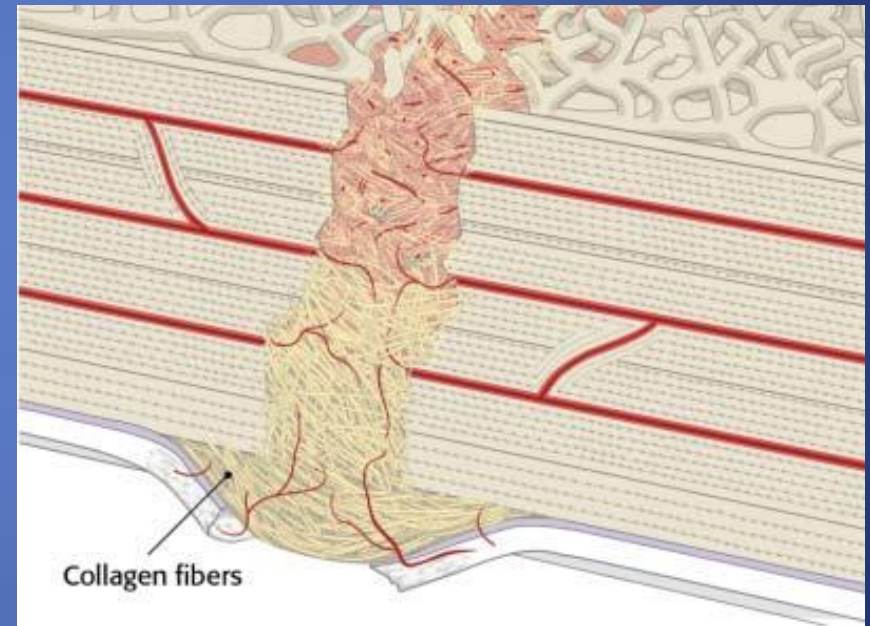
Indirect Bone Healing

- Inflammation phase (1-2 weeks):
 - Disruption of B.V
 - Cells migrates
 - Coagulation starts



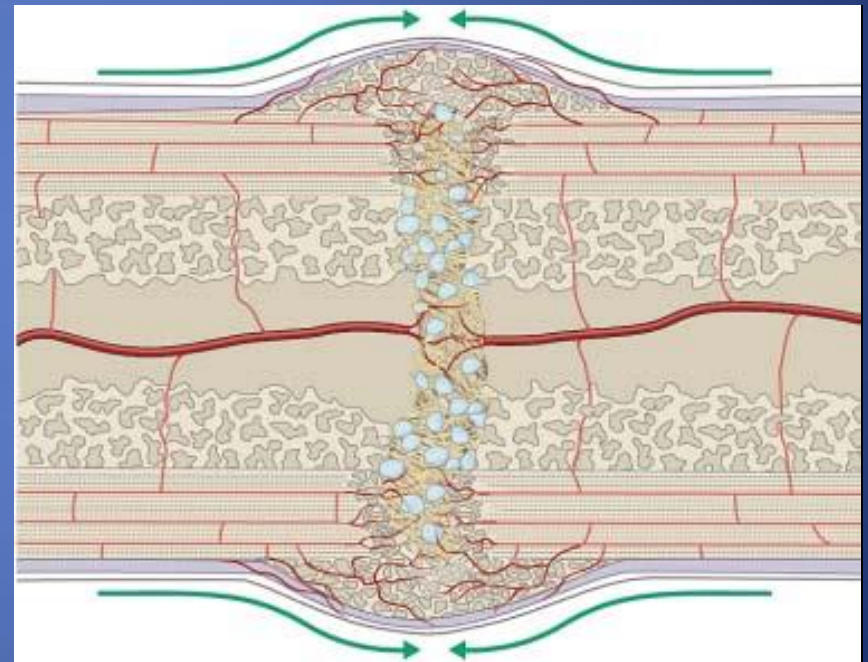
Indirect Bone Healing

- Soft callus (2-3 weeks)
 - Cascade of cellular differentiation occurs
 - New B.V
 - Fibroblasts produce granulation tissue
 - This evolves into fibrocartilage



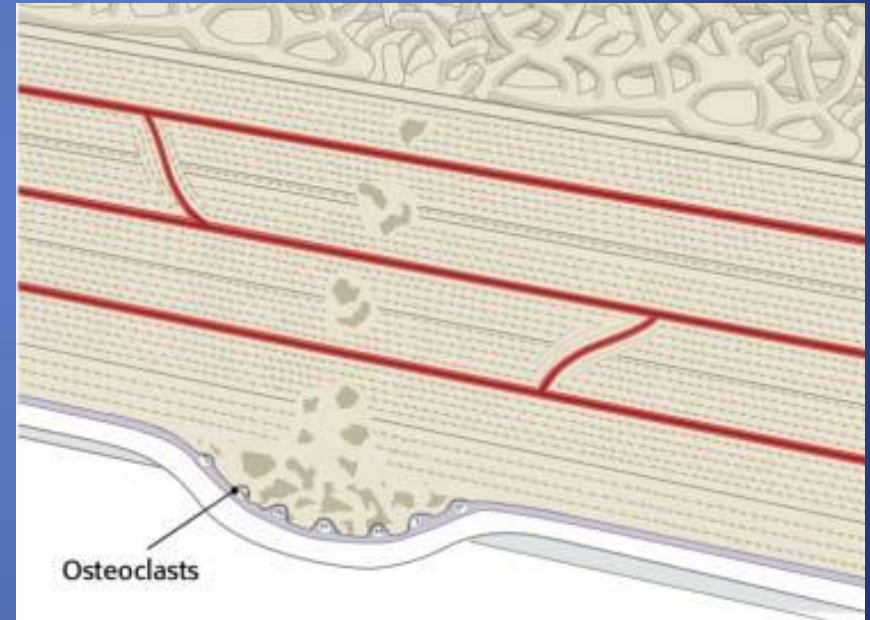
Indirect Bone Healing

- Hard callus (3-12 weeks)
 - Endochondral ossification converts soft callus into woven bone
 - Starts at periphery
 - Continues till no more movement



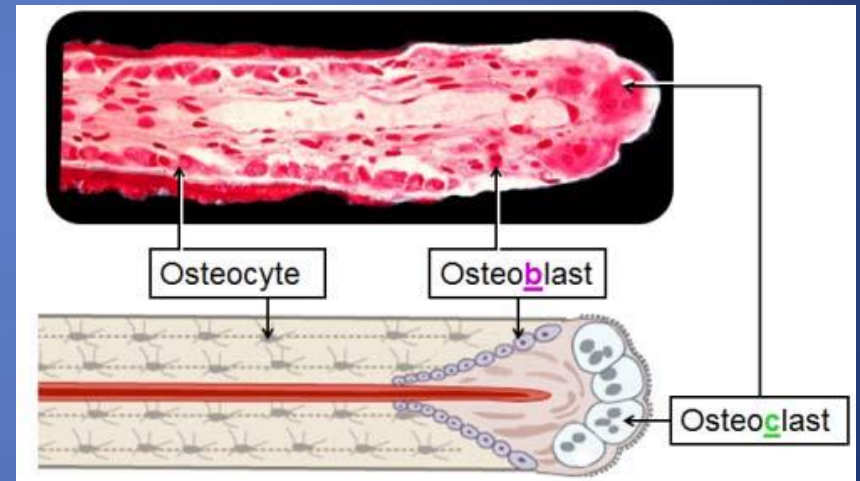
Indirect Bone Healing

- Remodeling (years)
 - conversion of woven bone into lamellar bone.



Direct bone healing

- It can happen if no motion takes place
- Bone is formed without intermediate stage
- “Cutting cone mechanism”





Is it direct or indirect bone healing mechanism?

Healing Factors

- Complexity of fracture
- Soft tissue damage
- Close v.s Open
- Periosteal stripping
- Systemic :
 - Malnutrition
 - smoking



PRINCIPLES OF EVALUATION

HISTORY

- Pain: very severe one. Get complete pain history components
- Inability to use the affected limb.
- Inability to ambulate.
- Deformity.
- If it is a major trauma: Patient might not be able to communicate.
- Ask about mechanism of injury.

HISTORY

- Major Trauma (MVC):
 - ① Speed.
 - ② Front or back seated.
 - ③ Driver.
 - ④ Seat belted.
 - ⑤ Ejection.
 - ⑥ Deployed air bag.
 - ⑦ Death at scene.



HISTORY

- If you suspect pathological fracture:
 - Ask about prior pain before event happened.
 - Ask about constitutional symptoms.
 - Ask about history of cancer.
- If you suspect stress fracture:
 - Ask about recent increment of activities.

PHYSICAL EXAM

- Inspection:
 - Swelling
 - Deformity
 - Ecchymosis
 - Skin integrity:
 - Bleeding
 - Protruding bone



PHYSICAL EXAM

- Palpation:
 - Bony tenderness.
 - Examine joint above and below.
- ROM:
 - Can not be assessed in acute fracture.

PHYSICAL EXAM

- Vascular exam:
 - color.
 - Temperature.
 - Capillary refill (within 2 sec as compared to other side)
 - Pulses
 - Always compare contralateral side.
- Peripheral nerve exam of injured limb.
- Always check compartment tightness:
 - Wood like vs. soft

PHYSICAL EXAM

- *At the End of your exam, you must comment on:*

- ① Skin is intact or not
- ② N/V status is intact or not
- ③ Compartments of limb are soft or not.

INVESTIGATIONS

- Start with basic and proceed to more specific tests.
 - ① Basic blood works.
 - ② X-rays of interest.
 - ③ advance radiological exams if needed.

INVESTIGATIONS

- X-rays:
 - 2 orthogonal (perpendicular) views: AP and lateral.
 - Joint above and below.
 - Special views: specific for the region of interest.
- Fracture does hurt:
 - Splint patient's injured limb before you send him to X-rays.
 - If there is gross deformity, re-align, splint then send for images.

INVESTIGATIONS

- Fracture can be obvious on images.
- Sometimes, careful assessment of radiographs is needed (i.e. stress fracture or non displaced fracture)



- * Secondary signs of fracture on x-ray:

- * **Soft tissue swelling**

- * Fat pad signs

- * Periosteal reaction

- * Joint effusion

- * Cortical buckle



- * Secondary signs of fracture on x-ray:
 - * Soft tissue swelling
 - * **Fat pad signs**
 - * Periosteal reaction
 - * Joint effusion
 - * Cortical buckle



- * Secondary signs of fracture on x-ray:
 - * Soft tissue swelling
 - * Fat pad signs
 - * **Periosteal reaction**
 - * Joint effusion
 - * Cortical buckle



- * Secondary signs of fracture on x-ray:
 - * Soft tissue swelling
 - * Fat pad signs
 - * Periosteal reaction
 - * **Joint effusion**
 - * Cortical buckle



- * Secondary signs of fracture on x-ray:

- * Soft tissue swelling
- * Fat pad signs
- * Periosteal reaction
- * Joint effusion
- * **Cortical buckle**



INVESTIGATIONS

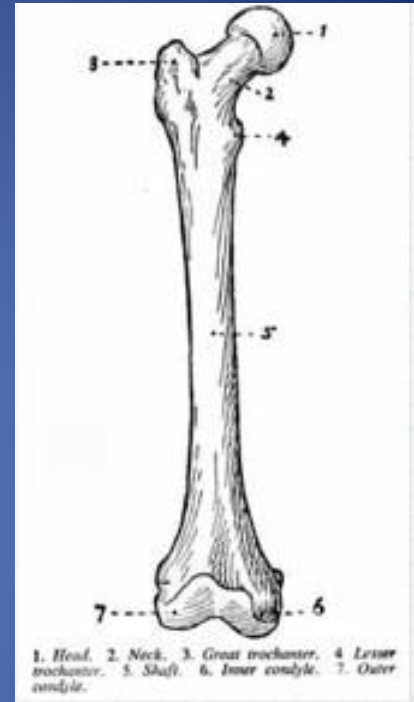
- Advanced radiological images:
 - If fracture extends to joint: obtain CT scan
 - If fracture is suspected but not seen on X-rays: consider doing MRI.

RADIOGRAPHIC DESCRIPTION OF FRACTURE

- Location
- Displacement:
 - Translation
 - Angulation
 - Shortening
 - Rotation
- Pattern.
- common eponymous

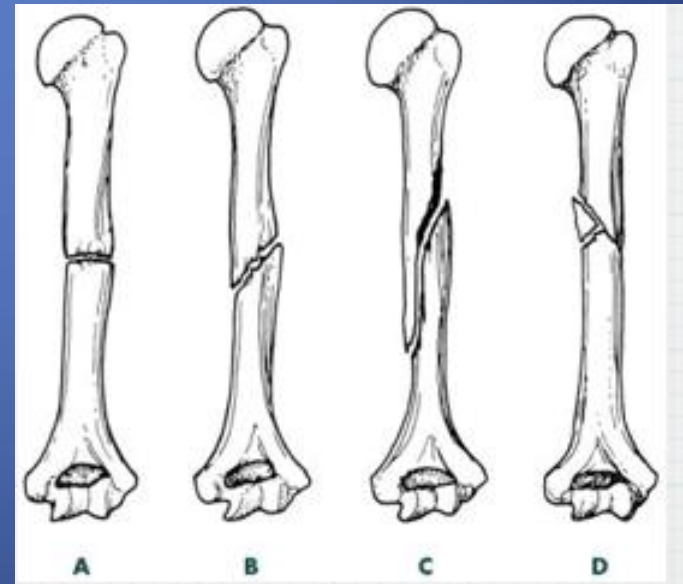
Location

- * Which bone?
- * Which part of the bone?
 - * Epiphysis -intraarticular?
 - * Metaphysis
 - * Diaphysis -divide into 1/3s
- * Use anatomic landmarks when possible
 - * e.g. medial malleolus, ulnar styloid, etc



Pattern

- * Simple vs. comminuted
- * Complete vs. incomplete
- * Orientation of fracture line
 - * Transverse
 - * Oblique
 - * Spiral



Displacement

- * Displacement is the opposite of apposition
- * Position of distal fragment relative to proximal
- * Expressed as a percentage



Angulation

- * Deviation from normal alignment
- * Direction of angulation defined by apex of
- * Expressed in degrees



FRACTURE DESCRIPTION: SUMMARY

Clinical parameters

Open vs. Closed

Neurovascular status

Clinical deformity

Radiographic parameters

Location.

Pattern.

Displacement.

Common eponymous

TREATMENT PATHWAY

- ① Reduction.
 - ② Immobilization
 - ③ Definitive treatment
 - ④ Rehabilitation.
- *If the Injured limb is grossly deformed, simple re-alignment and splinting should be initially undertaken*

REDUCTION

- If fracture is displaced.
- Meant to re-align fracture fragments.
- To minimize soft tissue injury.
- Can be consider definitive if fragments' position is accepted.
- Open reduction: take place at OR.



REDUCTION



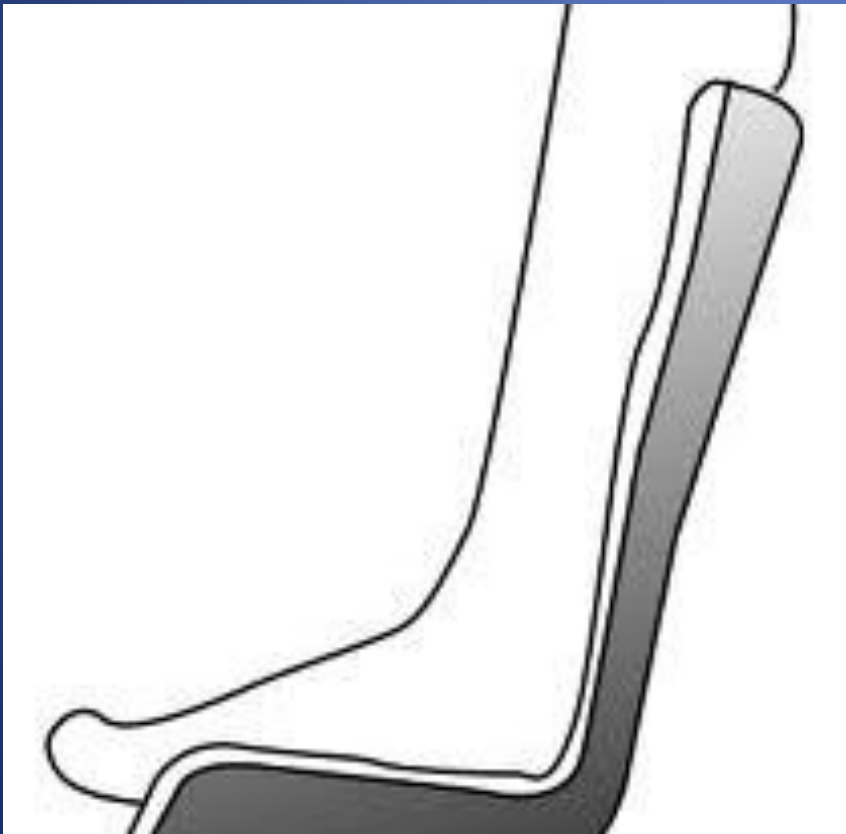
- ✓ Patient must receive adequate analgesic prior to reduction.
- ✓ Most occur under conscious sedation at Emerg.
 - ✓ Reduction must be followed by immobilization.
- ✓ N/V status must be documented before and after reduction and immobilization

IMMOBILIZATION

- To hold reduction in position.
- To provide support to broken limb
- To prevent further damage.
- **Control the Pain**
- Most fractures require an immobilization of joint above and below

IMMOBILIZATION

BACK SLAB



BRACE



IMMOBILIZATION

SLING

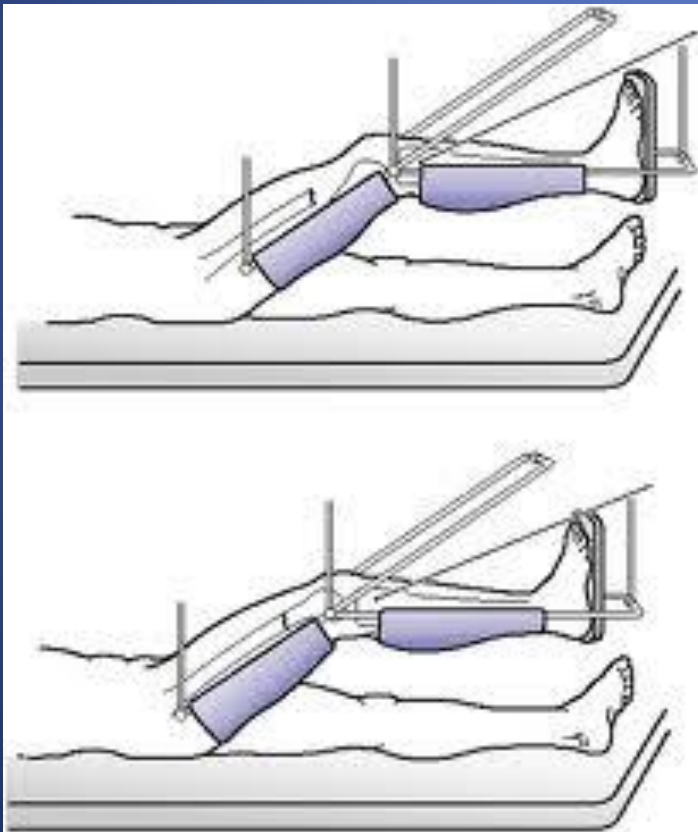


COMPLETE CAST



IMMOBILIZATION

SKELETAL TRACTION



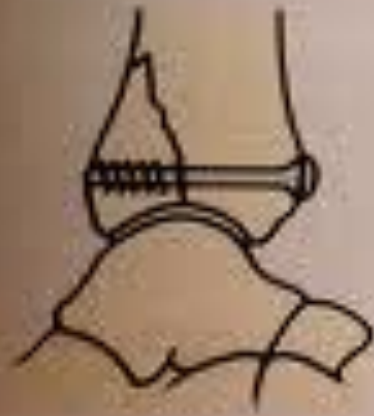
SKIN TRACTION



DEFINITIVE

- If satisfactory reduction can not be achieved or held at initial stage.
- Reduction can be attempted close or open (surgery)
- Immobilization can be achieved with:
 - Plate and screws.
 - IM nail
 - EX-fix

(a)



(b)



(c)



(d)



(e)



Rehabilitation

- Motion as early as possible without jeopardizing maintenance of reduction.
- Wt bearing restriction for short period (6-8 weeks).
- Move unaffected areas immediately

Treatment: Principles

- * Reduce (if necessary)
 - * to maximize healing potential
 - * To ensure good function after healing
- * Immobilize
 - * to relieve pain
 - * to prevent motion that may interfere with union
 - * to prevent displacement or angulation of fracture
- * Rehabilitate
 - * to insure return to function

MULTIPLE TRAUMA

- Multi-disciplinary approach.
- Run by Trauma Team Leader (TTL) at ER. Orthopedic is part of the team.
- Follow trauma Protocol as per your institution.
- Treatment is prioritized toward life threatening conditions then to limb threatening conditions.

COMPLICATIONS

- If fracture extends into joint or close:
 - O.A
 - Stiffness
- Fracture healing:
 - Nonunion: doesn't heal after double the expect time.
 - Malunion: healed with mal-alignment.
- Fracture specific: AVN after femur neck fracture.
- Medical complications: LL fractures, VTE
- Surgical related: infection, hardware failure.

Take home points

- * Fractures hurt –immobilization relieves pain.
- * R/o open fracture, Compartment syndrome and N/V injuries.
- * Principles of fracture treatment:
 - * Reduce
 - * Immobilize
 - * Rehabilitate

QUESTIONS?