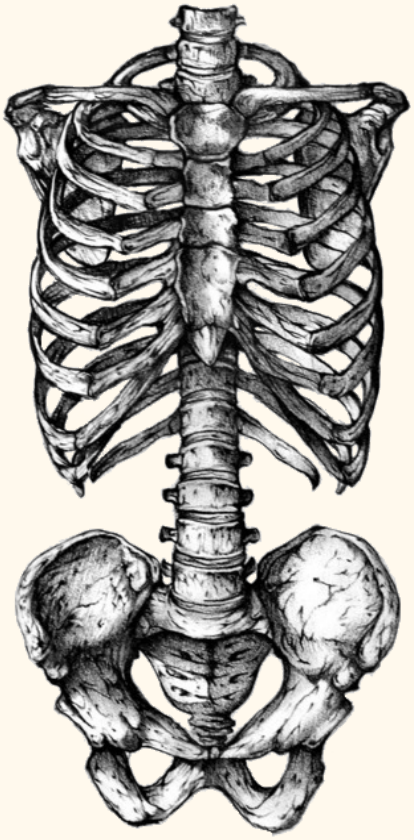
جامعة الملك سعود
King Saud University

434 Orthopedics Team

Lecture 5

Principles of Fractures



Objectives

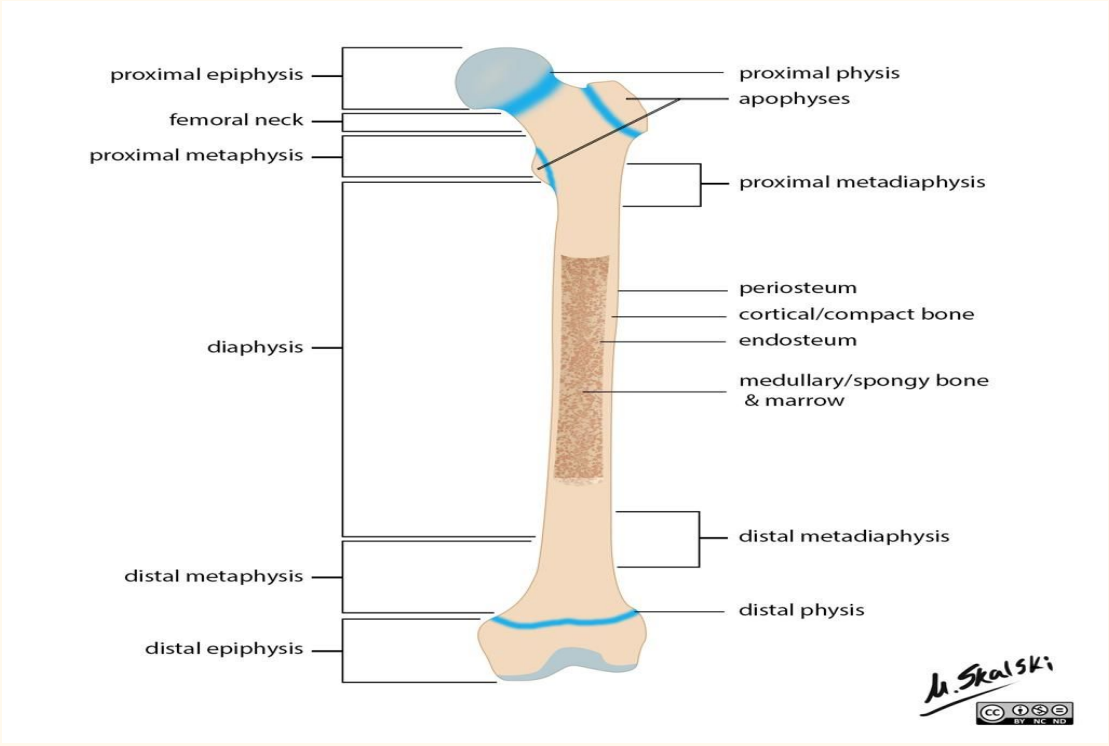
1- Introduction

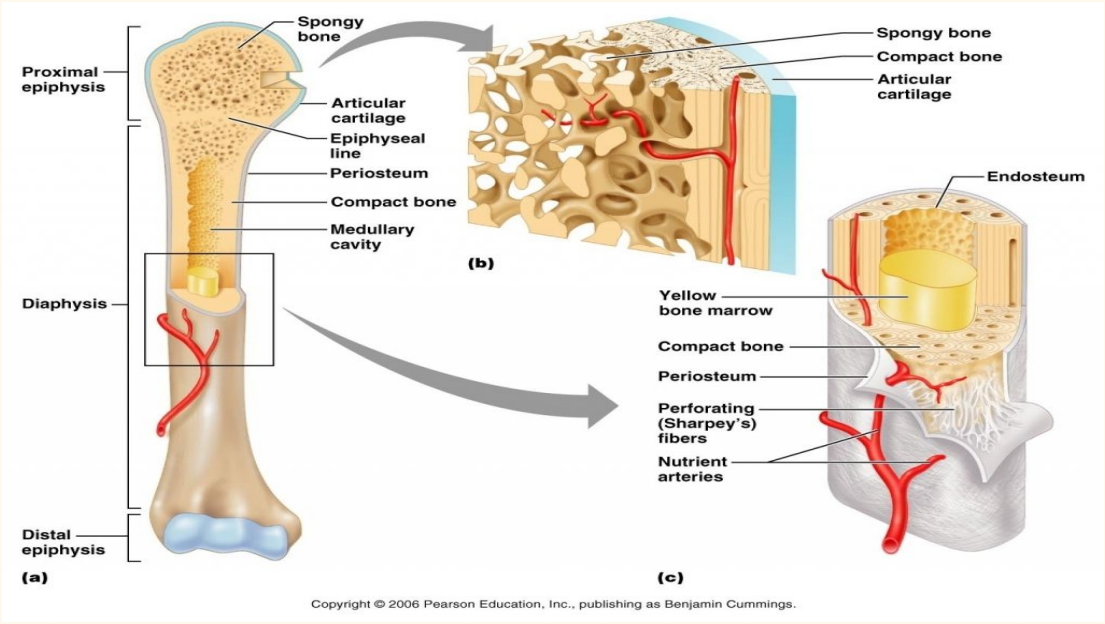
2- Basic science of fracture healing

3- Principles of evaluating patients with fractures

4- Principles of management

5- Common fractures in adults





Review Bone structure

Types of Bone :

1- Lamellar bone (Dense)

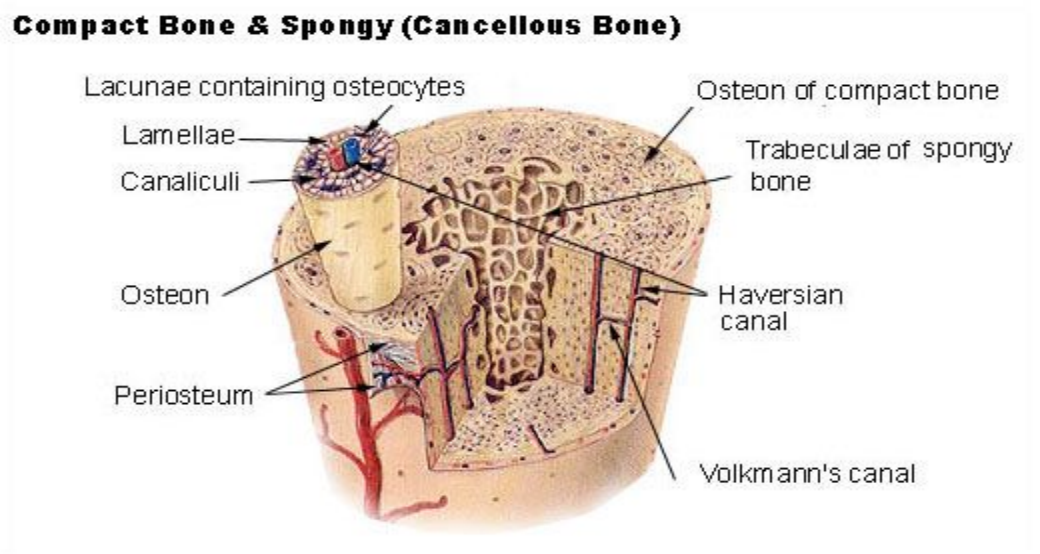
They're composed of collagen fibers arranged in parallel layers and they're found in the **diaphysis** part of normal adult long bones. The basic functional unit of lamellar bones is called an **Osteon** or **"Haversian System"**.

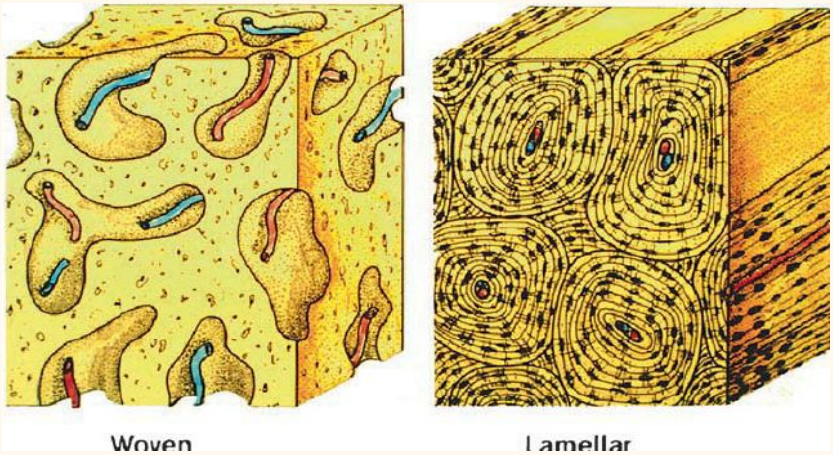
2- Cancellous bone (trabecular or spongy bone)

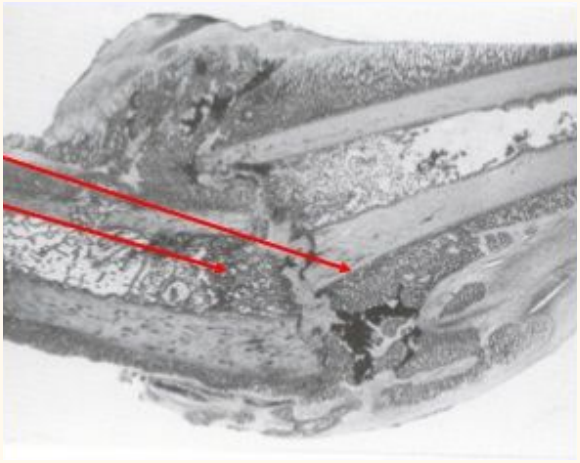
They're less dense and more elastic than lamellar bones. They're found in the **metaphysis** part of small bones.

3- Woven bone

They're coarse bones with random orientation. They're also weaker than lamellar bones. In bone healing, they're eventually **remodeled** to lamellar bones.







Bone composition :

1- Cells

a. Osteocytes (Mature bone cells)
b. Osteoblasts (Cells that create the matrix of the bone, bone builders)
c. Osteoclasts (Bone eaters)

2- Extracellular matrix

a.Organic (35%)
- Collagen (type I) 90%
- Osteocalcin, osteonectin, proteoglycans, glycosaminoglycans, lipids (ground substance)
b.Inorganic (65%)
Primarily hydroxyapatite $Ca_5(PO_4)_3(OH)$

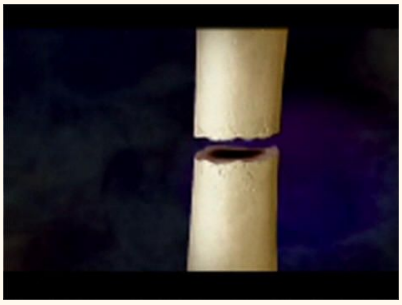
Description of Fracture :

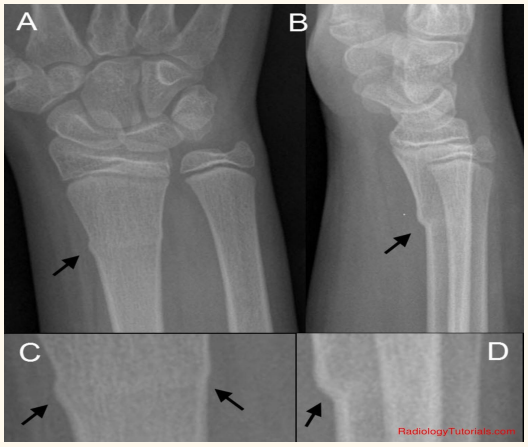
Fracture literally means broken bone. This can be described in different ways

(E L M M A):
Extent, **L**ocation, **M**orphology, **M**echanism, and **A**ssociated soft tissue injuries.

1. Extent

Complete: fracture that extends 360° of bone circumference (all around)
Incomplete: seen almost only in children:
- Greenstick fracture
- Buckle (torus)fracture (buckling of the cortex)





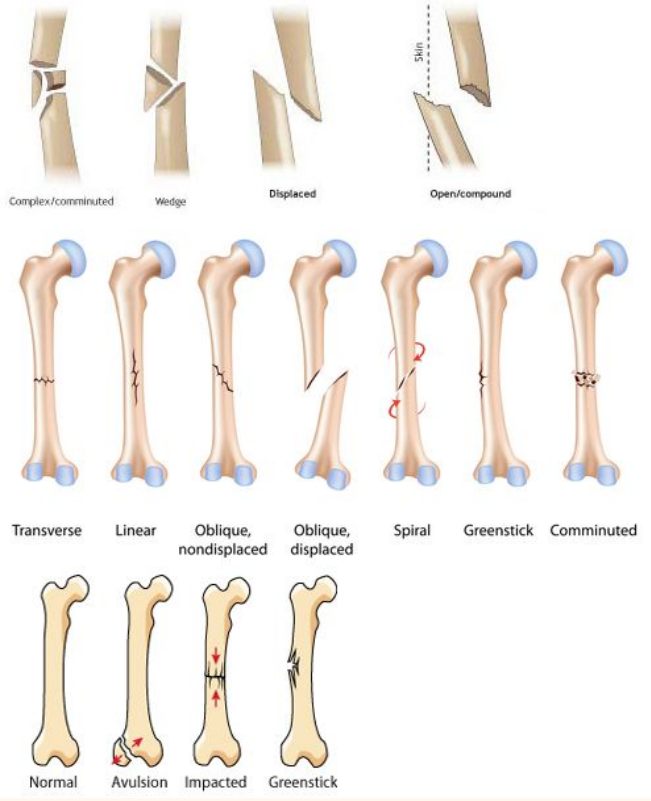
A buckle fracture also called a torus fracture, is an extremely common injury seen in children. Because children have softer, more flexible bones, one side of the bone may buckle upon itself without disrupting the other side of the bone—also known as an incomplete fracture.

2. Location

-Name of bone -Side -Diaphysis, metaphysis or epiphysis
-In long bones (diaphysis): divide them in thirds (proximal, middle or distal third)
-If the fracture is in the metaphysis part, mention if it's intraarticular or extra-articular (reaching the joint near it or not)

3. Morphology

Transverse: loading mode resulting if fracture is tension.
Oblique: loading mode is compression (one level fracture)
Spiral: loading mode is torsion, usually low energy. (Usually occurs in sports & pediatric age group) (multiple levels of fractures by low energy trauma)
Wedge (fracture with butterfly fragment): loading mode is bending. (1 piece)
Comminuted: 3 or more fragments, usually result from high energy. (high energy trauma)
Segmental: a fracture in two parts of the same bone.



4. Mechanism

- High energy vs. Low energy (In high energy accidents, soft tissue injuries are expected e.g. RTA. In low energy: sport injuries)
- Multiple injuries (associated with soft tissue damage) vs. isolated injury (Multiple injuries include: pneumothorax,liver laceration, total abdominal injury
- Pathological fracture: normal load in presence of weakened bone (abnormal bone) (tumor, osteoporosis, infection)
- Stress fracture: normal bone subjected to repeated load (military recruits/athletes) usually it will be incomplete small fractures.

• Associated soft tissue injury

- Closed 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) important to role out open fractures

Note: "In proximity" doesn't necessarily mean above the fractured bone. It can be anywhere close to it.

Fracture healing

There are 2 kinds of bone healing, either Indirect or Direct.

1. Indirect bone healing "no orthopedic surgeon touch the patient"

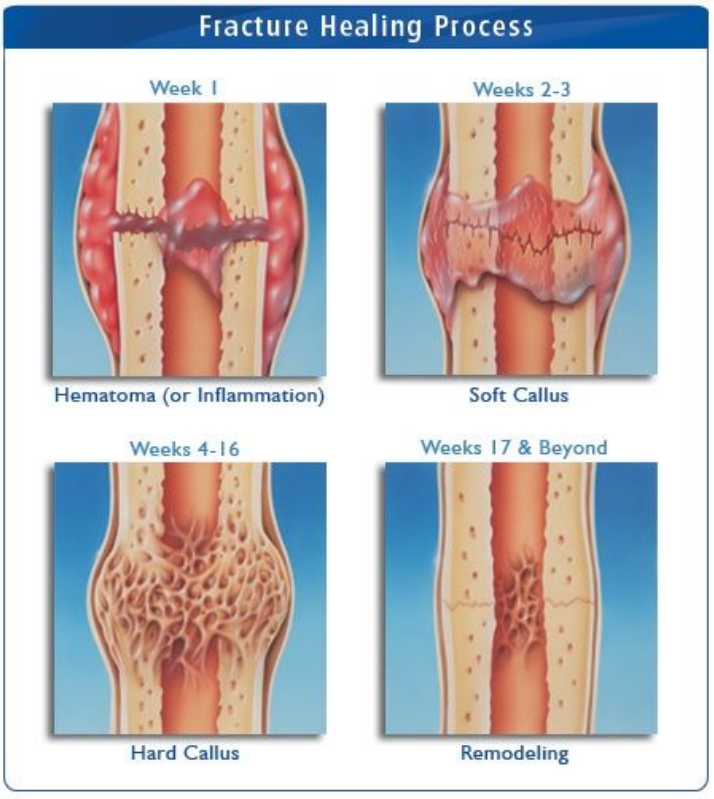
In indirect bone healing, the process occurs in nature with untreated fracture through endochondral ossification (occurs in fractures with gap). It is called indirect because of formation of cartilage at an intermediate stage. It runs in 4 phases: hematoma formation, soft callus formation, hard callus formation, and finally, remodeling.

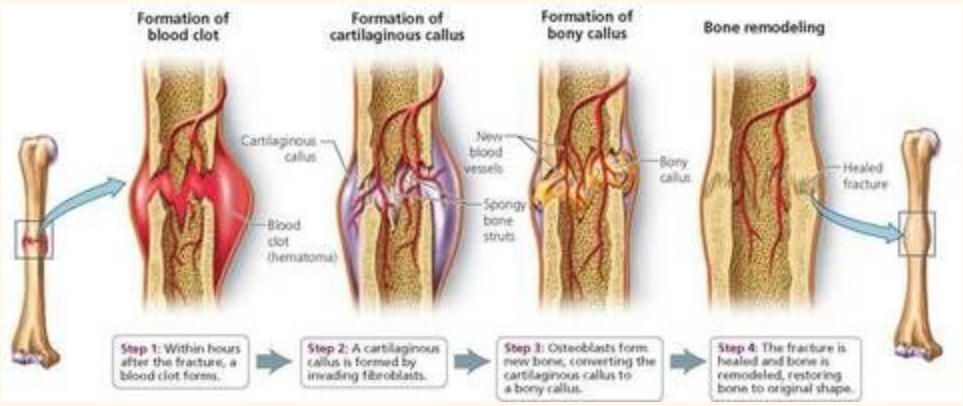
a. Hematoma formation (Inflammation phase) (1-2 weeks) In this phase, there is disruption of the blood vessels, migration of cells occurs, and coagulation begins.
b. Soft Callus(2-3 weeks) In this phase, cascade of cellular differentiation occurs, angiogenesis (new blood vessel formation) takes place, and

fibroblasts produce granulation tissue that eventually evolves into fibrocartilage.

c. Hard Callus (3-12 weeks) In this phase, endochondral ossification converts soft callus into woven bone. The process starts at the periphery and then moves centrally. It continues until there is no more movement. This phase can be seen on x-ray unlike the 2 previous ones.

d. Remodeling(Years) In this phase, the woven bone that was formed is converted into lamellar bone.



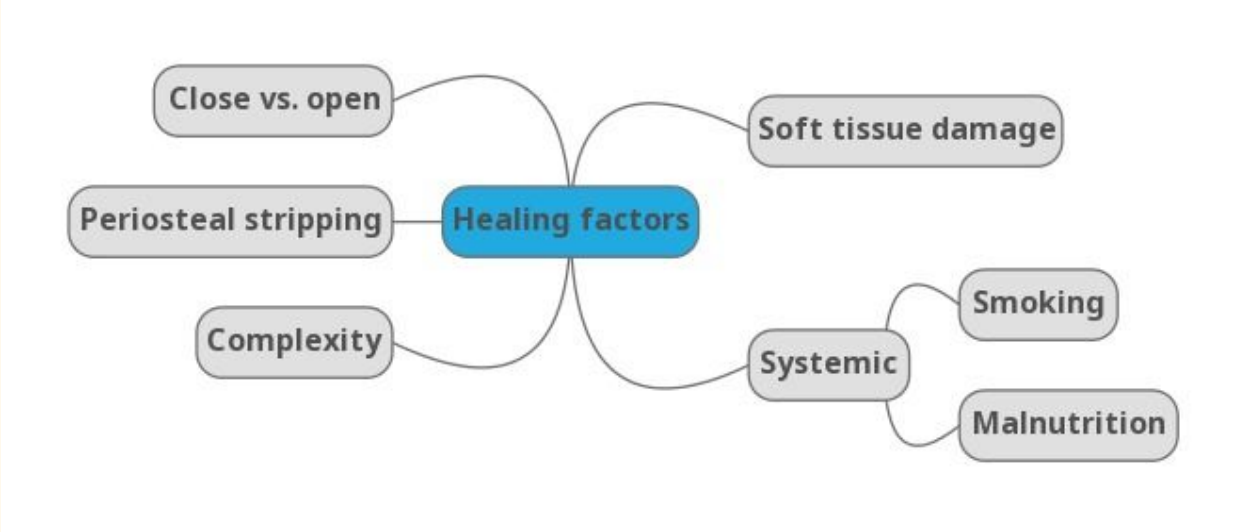


2. Direct bone healing (Contact healing)

It can happen if no motion takes place. Bone is formed without intermediate stage through the "Cutting cone mechanism". This mechanism works only if the fracture is < 1mm. (No gap must be in fracture site)

In cortical bone remodeling proceeds in tunnels with osteoclasts forming "cutting cones" removing damaged bone followed by refilling by osteoblasts in the "closing cone" occurring behind the osteoclasts.

"Direct bone healing happens after surgery. It is called direct because there will be no cartilage formation. When we put plate and screws, there will be no movement so it will heal in a direct way."
Direct contact between the fracture ends allows healing to be with lamellar bone immediately.



Principles of Evaluation

1. History

Patients complain of pain and inability to use the limb (if they are conscious and able to communicate)
What information can help you make the diagnosis?

Onset:
When and how did the symptoms begin?
Specific traumatic incident vs. gradual onset?

If there was a specific trauma, the details of the event are essential information:
Mechanism of injury?
Circumstances of the event? Work-related?
Severity of symptoms at the time of injury and progression after?

•Pain (SOCRATES) : very severe one.

•Previous pain at the site of injury
•Constitutional symptoms
•Ask the main questions (What?, How?, (Mechanism of injury) When?, Where?

Trauma history.
o What is the Mechanism? (RTA – Syncope – Falling – Slipping – Or minor trauma)
o If RTA: Speed – Seatbelt – Ejection – Site in the car – Driver - What happened to Others? - Deployed air bag - dead at the scene
o If Falling: Height? Position of the falling?.

•Inability to use the affected limb.
•Inability to ambulate.
•Deformity.
•History of other previous fracture.
•Medical history
• Surgical history
• Family history
• Social history (Smoking – Allergy – Occupation)

•If it is a major trauma: Patient might not be able to communicate.

If you suspect a pathological fracture, you must: 1. Ask about prior pain before event happened. 2. Ask about constitutional symptoms. 3. Ask about history of cancer.

If you suspect stress fracture, ask about recent increment of activities.

2. Physical examination

1- Inspection:
Swelling
Deformity
Ecchymosis
Skin integrity:
* Bleeding
* Protruding bone
For any abrasions or bleeding its most likely an open fracture or wound.
2- Palpation:
Bony tenderness
Examine joint above and below.
3- ROM :
Can not be assessed in acute fracture.
4- Vascular exam:
5- color.
6- Temperature-
7- Capillary refill (within 2 second as compared to other side)
8- Pulses
Always compare contralateral side.
5- Peripheral nerve exam of injured limb
6- Always check compartment tightness: Wood like vs.soft
7- examine joint above and below for any Associated MSK injuries

At the end of your exam, you must comment on: (imp)
- Skin is intact or not
- Neurovascular status is intact or not
- Compartments of limbs are soft or not

3. Investigations

Start with basics and proceed to more specific tests:
a) Basic blood works (because he may go for surgery)
b) X-rays of interest
c) Advanced radiological exams if needed
X-rays should be adequate and this means them containing:
At least 2 orthogonal (perpendicular) views: **AP** and **lateral**

Joint above and below the area should be visible
Special views: specific for the region of interest
If fracture does hurt, **splint** the patient's injured limb before you send him to x-ray and if there is gross deformity, re-align, splint and then send for images.**to relief the pain**

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

X-rays are 2D: get minimum two orthogonal views!
Include joint above and below injury

NB: Fractures hurt, immobilization helps. Immobilizing a patient in a backslab is the most effective way to relieve pain from a fracture and may be done BEFORE getting X-rays

- Secondary signs of fracture on x-ray:

Soft tissue swelling	Fat pad signs (Capsule filled with blood)	Periosteal reaction
		

Joint effusion	Cortical buckle
	

Advanced radiological images should be considered:
If fracture extends to joint ---> obtain CT scan
If fracture is suspected but not seen on x-ray ---> MRI

How to describe a fracture ?

1. Clinical parametres

- Open vs. closed
- ANY break in the skin in proximity to the fracture site is OPEN until proven otherwise
- Neurovascular status
- Presence of clinical deformity

2. Radiological parametres

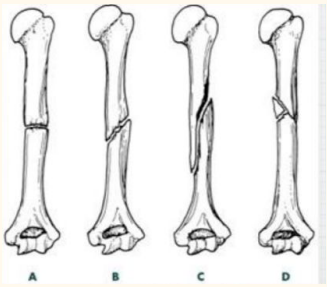
1-Location :

Which bone? Which part of the bone? Epiphysis –intrarticular?
Metaphysis–intraarticular?
- Dipahysis – divide it into 1/3 (upper, lower and mid thirds)

- use anatomic landmarks when possible.
(e.g. medial malleolus, ulnar styloid, etc...)

2-Pattern:

Simple vs. comminuted, complete vs. incomplete,
orientation of fracture line (transverse, oblique, or spiral)



3-Displacement :

(translation/angulation/shortening/rotation)

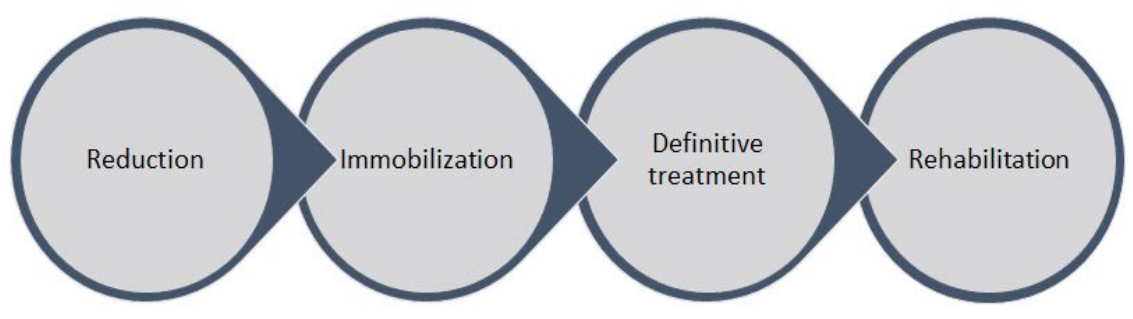
Displacement is the opposite of apposition. We call the displacement of the fragment that is distal in relative to the proximal. It's expressed as a Percentage.

4- Angulation :

Angulation is the deviation from normal alignment.

The apex of both fragments defines direction of angulation. It's expressed in degrees.

Treatment principles



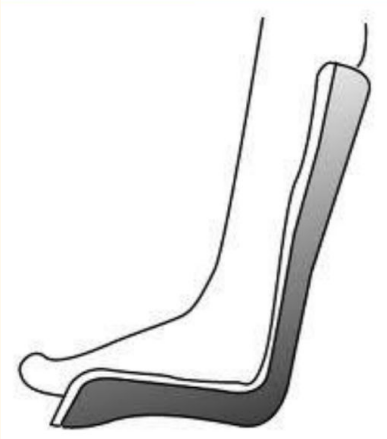
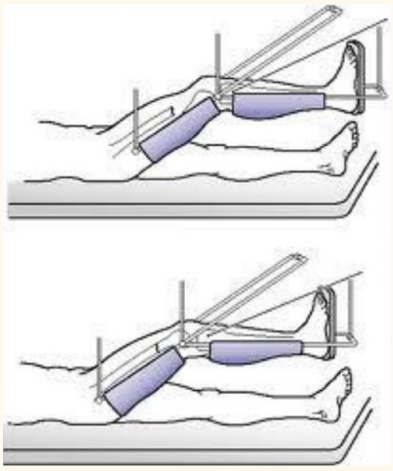
Note!
If the injured limb is grossly deformed, simple re-alignment and splinting should be initially

A. Reduction Reduction is indicated when a fracture is displaced. It's meant to re-align fracture fragments and to minimize soft tissue injury. It can be considered definitive if fragments' position is accepted. An open reduction takes place at OR.

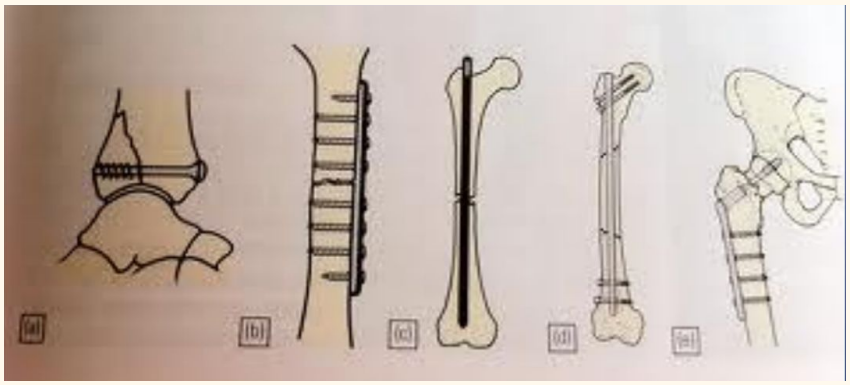
Important points to remember:
1-Take consent from patient prior to reduction (1st & most imp step)
2- Patient must receive adequate analgesic prior to reduction
3- Most reductions occur under conscious sedation at emergency
4- Reduction must be followed by immobilization
5-Nerve/Vascular status must be documented before and after reduction and immobilization (before and after reduction)

B. Immobilization Immobilization is done to hold reduction in position, to provide support to broken limb, to prevent further damage, and most importantly, control the pain.
Most fractures require an immobilization of joint above and below.

Examples of immobilization methods:

Back Slap 	Brace 	Sling 
Complete cast 	Skin traction 	Skeletal traction (used mostly in femur fracture) 

C. Definitive treatment It's indicated when reduction cannot be achieved or held at initial stage. Reduction can be attempted closed or open (surgery). Immobilization can be achieved with: plate and screws, IM nail, EX-fix.



D. Rehabilitation
Initiating motion should be attempted as early as possible without jeopardizing maintenance of reduction. Weight bearing restriction for short period (6-8 weeks). Move unaffected areas immediately.

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.
Save the patient's life ---> save the patient's limb ---> save the limb's function.

Complications

If fracture extends into joint or close:
OA (osteoarthritis)
Stiffness
Fracture healing:
Nonunion: doesn't heal after double the expect time
Mal-union: healed with mal-alignment

Fracture specific: AVN (a vascular venous thrombosis) after femur neck fracture.
Medical complications: lower limb's fractures may be associated with venous thrombus event (VTE).
Surgical related: infection, hardware failure.

Summary

Treatment summary

- Reduce (if necessary)
  to maximize healing potential
  to insure good function after healing
- Immobilize
  to relieve pain
  to prevent motion that may interfere with union
  to prevent displacement or angulation of fracture
- Definitive treatment
  With surgery using (plate and screws, IM nail, EX-fix)
- Rehabilitate
  to insure return to function

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