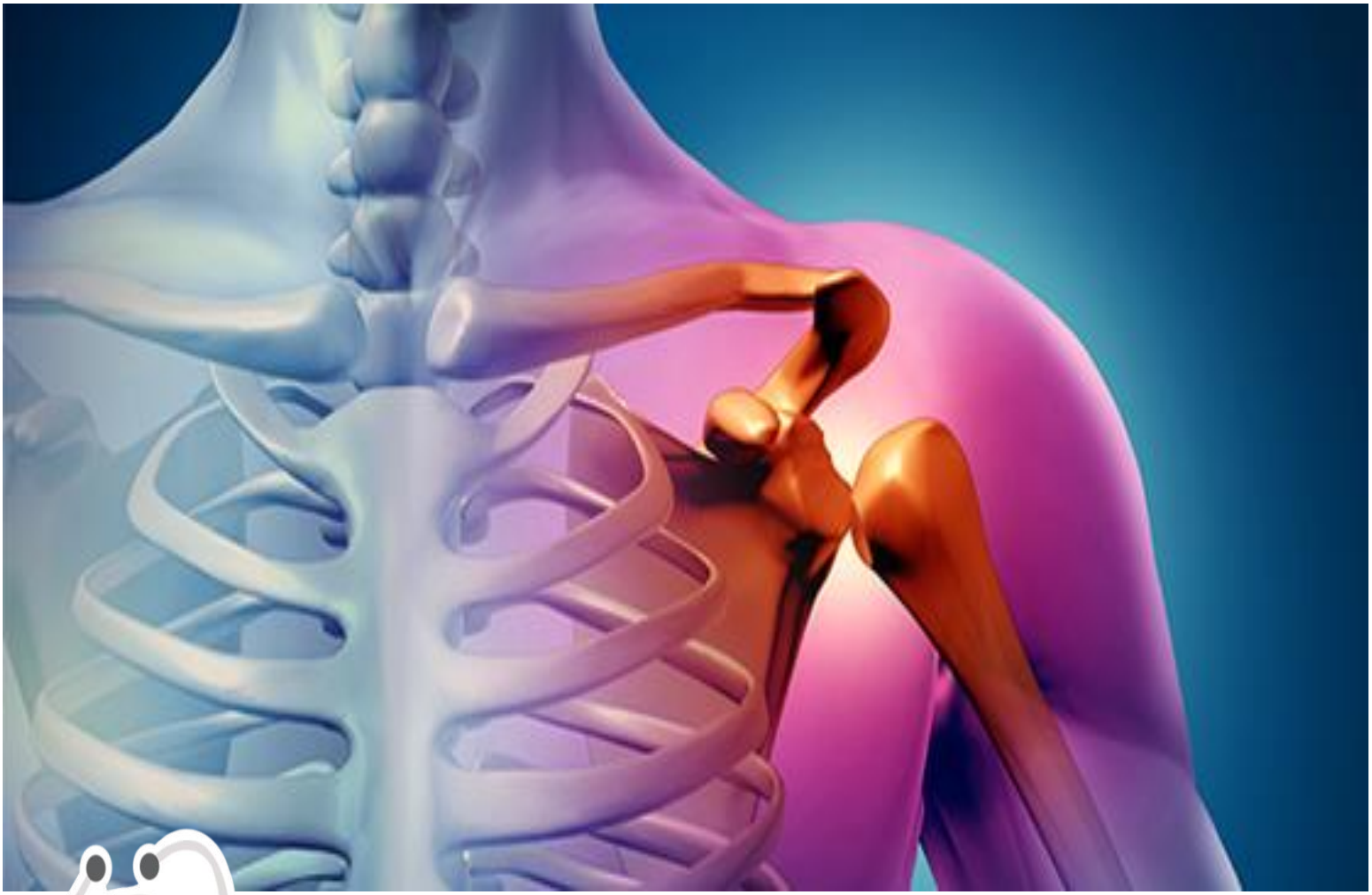
Orthopedics

432 Team

4 Principles of Fractures



1st Edition:

Done By: Abdulmohsen Almeshari (A1)

Revised by: Fahad Alotaibi (A1)

2nd Edition: Shroog AlHarbi (F1)

جامعة الملك سعود
King Saud University

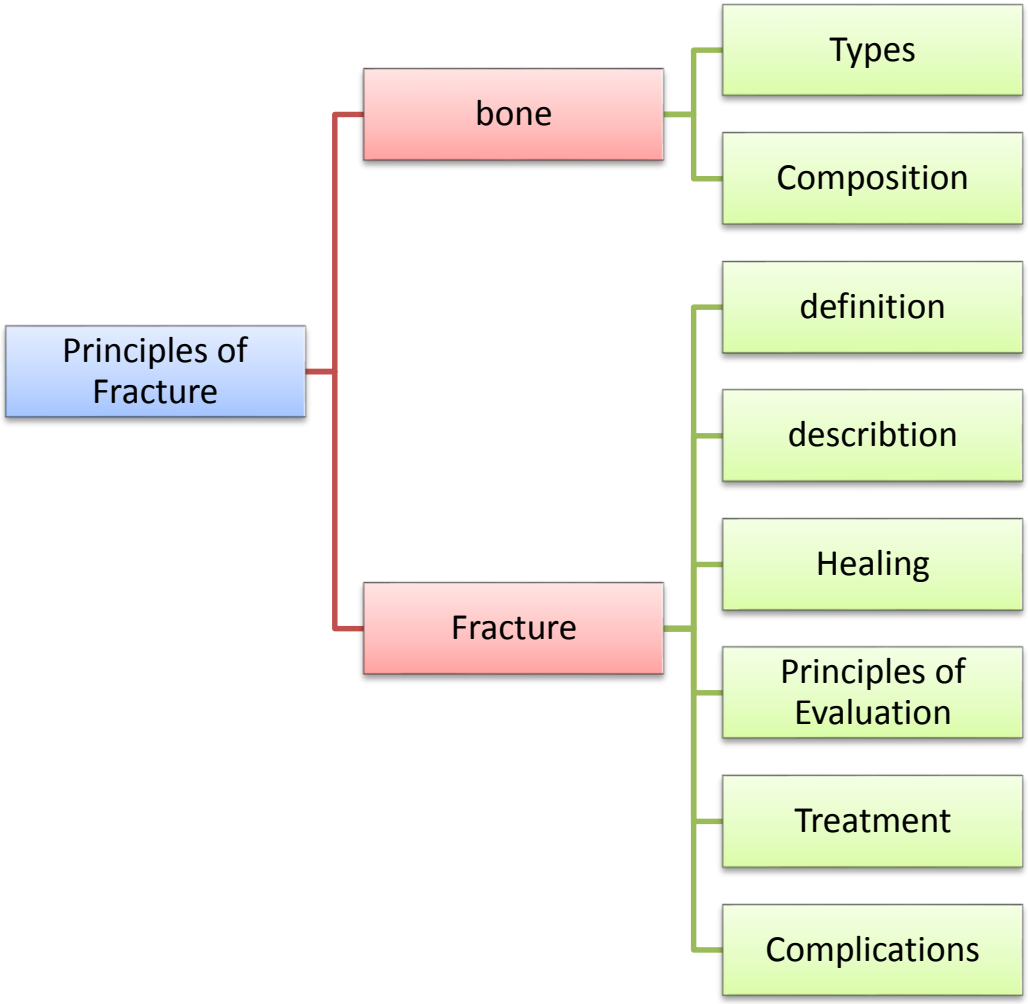
Color Code:

Slides	Doctor's Notes	Team Notes	Important
431 team work	Arabic Words	Books' notes	Other Sources

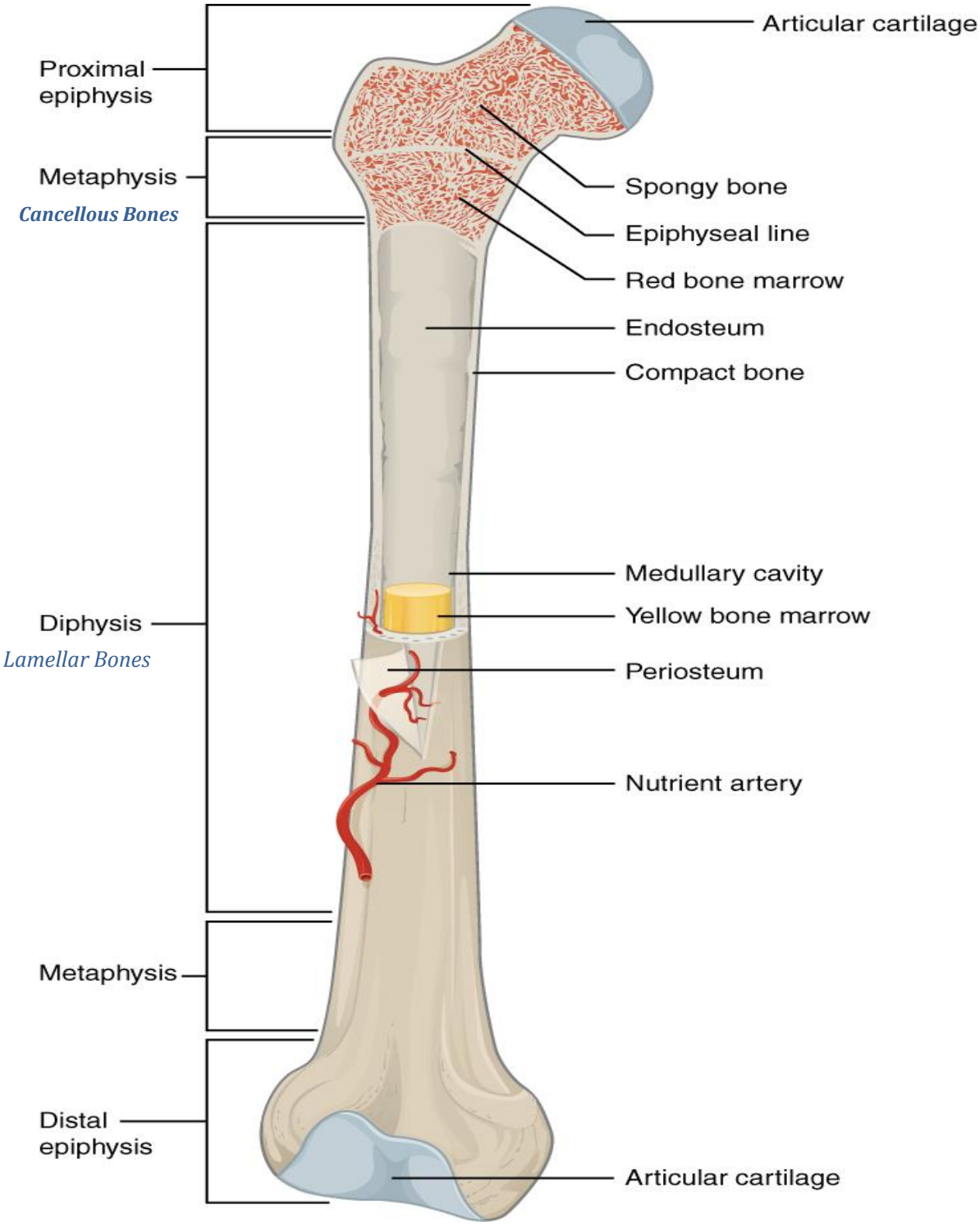
Objectives

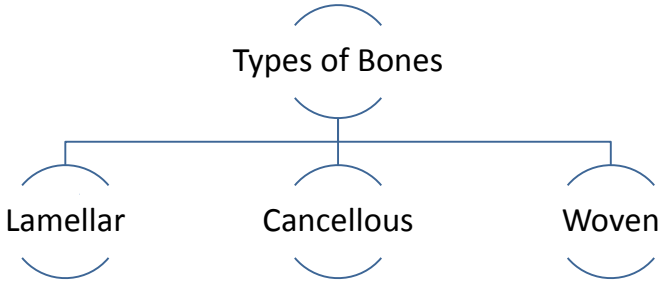
1. Basic science of fracture healing.
2. Principles of evaluating patients with fractures.
3. Principles of management.

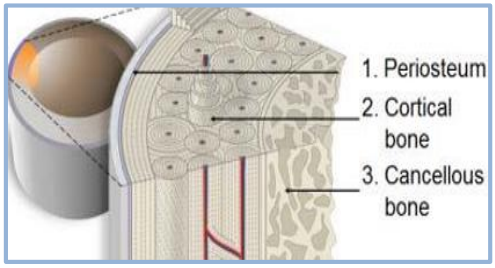
Mind Map



Let's review some basics!

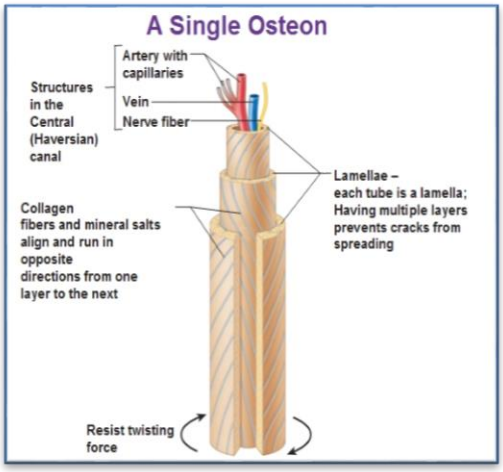






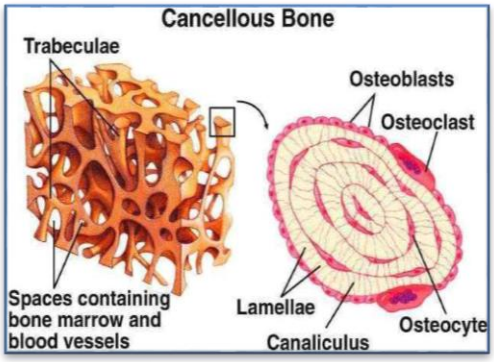
1. Lamellar Bones: (Dense):

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**".



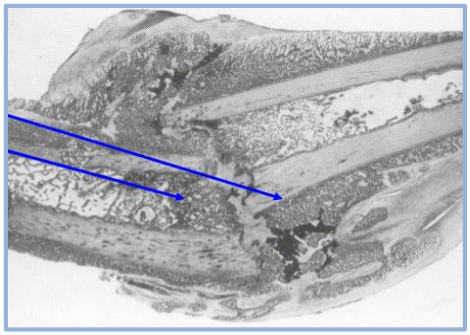
2. Cancellous Bones (trabecular or spongy bone):

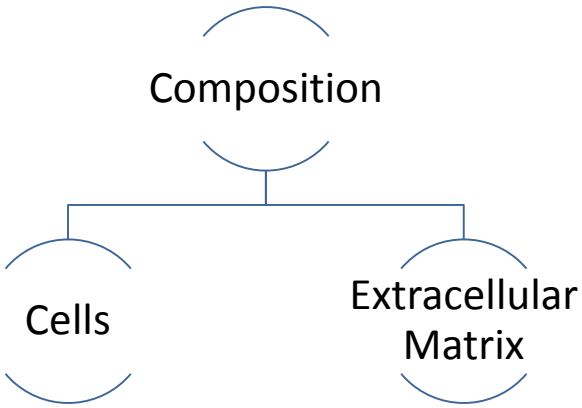
They're less dense and more elastic than lamellar bones. They're found in the **metaphysis** part of small bones.



3. Woven Bones

They're coarse bones with random orientation. They're also weaker than lamellar bones. In bone healing, they're eventually remodeled to lamellar bones (will be explained later).





- ***Cells***

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

- ***Extracellular Matrix***

  a. **Organic (35%)**
     - **Collagen (type I) 90%**
     - Osteocalcin, osteonectin, proteoglycans, glycosaminoglycans, lipids (ground substance)

  b. **Inorganic (65%)**
     - Primarily hydroxyapatite $Ca_5(PO_4)_3(OH)_2$

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

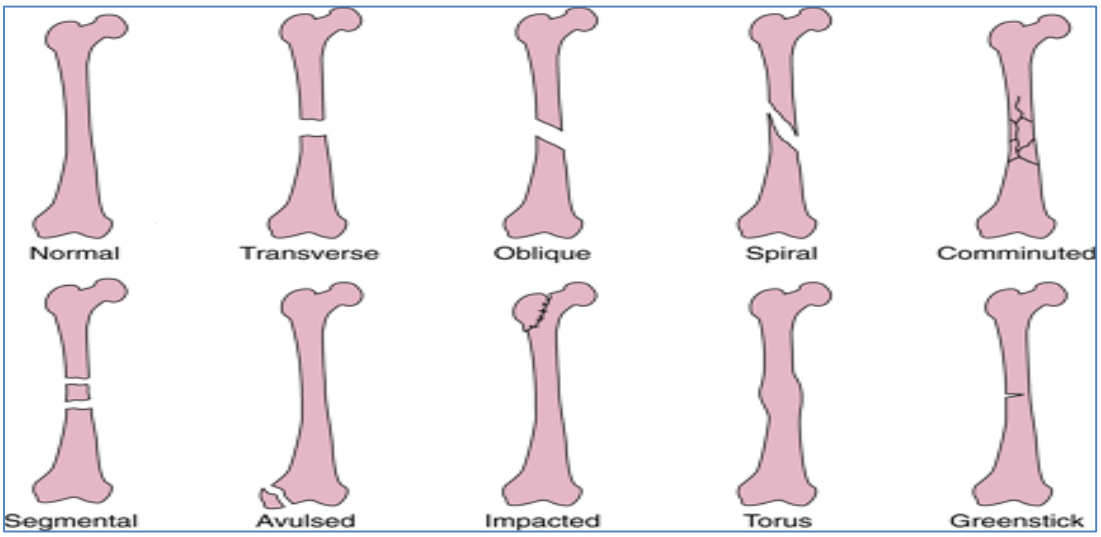
- **Complete**: fracture that extends 360^0 of bone circumference (all around)
- **Incomplete**: seen almost only in children:
  - *Greenstick fracture*
  - *Buckle (torus) fracture*

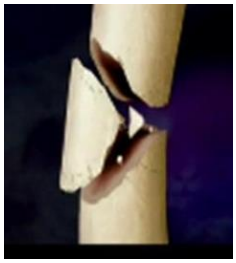
2. Location

- 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 intra-articular or extra-articular (reaching the joint near it or not)

3. Morphology

a. Transverse: loading mode resulting if fracture is tension???
b. Oblique: loading mode is compression
c. Spiral: loading mode is torsion. (Usually occurs in sports)
d. Wedge (fracture with butterfly fragment): loading mode is bending. (3 pieces)
e. Comminuted: 3 or more segments
f. Segmental: a fracture in two parts of the same bone.





Wedge fracture

4. Mechanism

- High energy vs. Low energy (In high energy accidents, soft tissue injuries are expected e.g. RTA)
- 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.

5. Associated soft tissue injuries

- **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 roll out open fractures

Note!

"In proximity" doesn't necessarily mean above the fractured bone. It can be any where close to it.

Fracture Healing:

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

1. *Indirect bone healing*

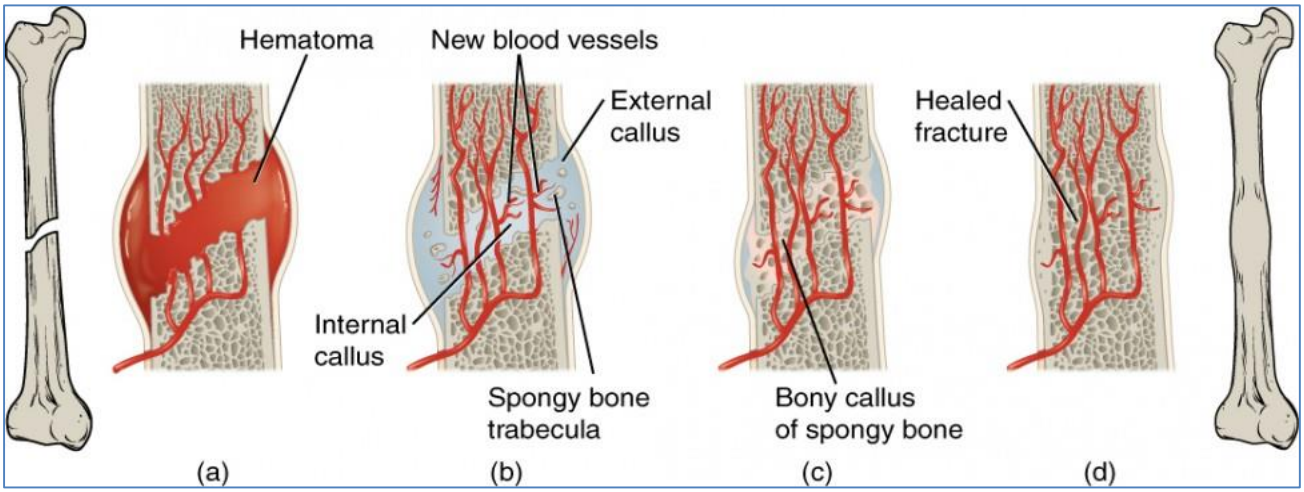
In indirect bone healing, the process occurs in nature with untreated fracture through **endochondral ossification**. It is called indirect because of formation of cartilage at an intermediate stage. It runs in 4 phases: hematoma formation, soft callus formation, hard callus formation, and finally, remodeling.

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*.

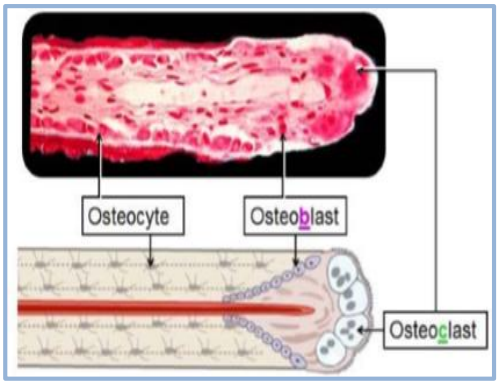
c. **Hard Callus** (3-12 weeks)
In this phase, endochondral ossification converts soft callus into woven bone. The process starts at the periphery and then moves centrally. It continues until there is no more movement.

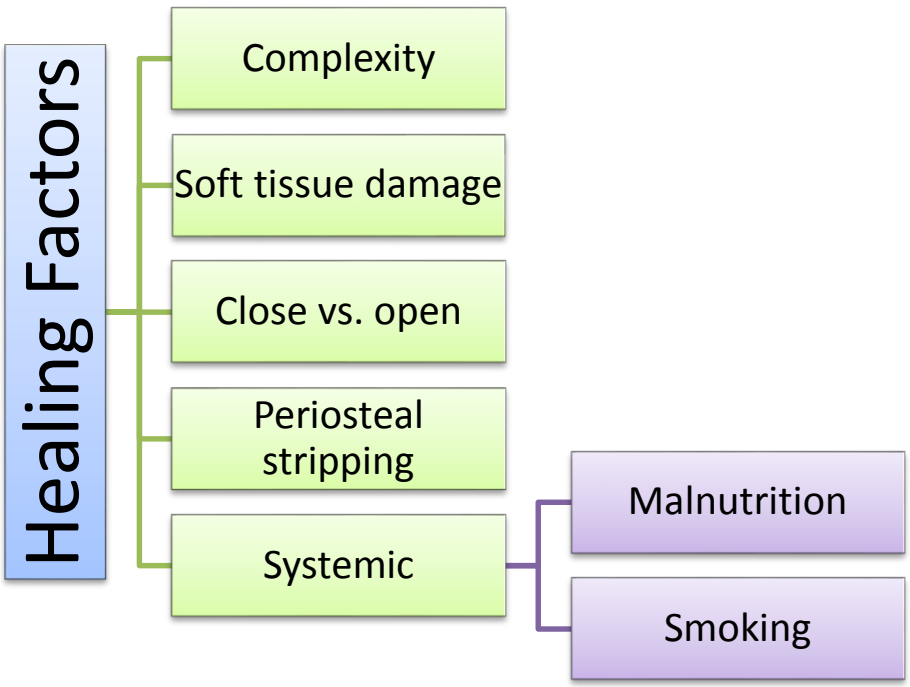
d. **Remodeling** (Years)
In this phase, the woven bone that was formed is converted into lamellar bone.



2. Direct bone 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. "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." – 431 team work.





Principles of Evaluation: (very important)

History:

History is always the most important thing to do when evaluating a patient. The case here is not any different. Patients with fracture usually suffer from **extremely severe pain**. Ask the main questions (What?, How?, (Mechanism of injury) When?, Where?). Patients may also tell you that they're unable to use the affected limb and if the fracture is in the lower limbs they won't be able to ambulate. Patients also may notice a deformity.

If the trauma was major, the patient might not be able to communicate. But it's still important to know several information in this case, and these include: speed of the vehicle, front or back seated, if the patient was the driver, if he was wearing his seat belt, if there was any form of ejection, if the air bag was deployed or not and if there was any death at the scene.

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.

Physical Exam:

Physical exam is as important as the history. Begin your examination with **inspection**. Sometimes it's pretty obvious! Look for any swelling, deformity, ecchymosis (a discoloration of the skin resulting from bleeding underneath), Skin integrity (bleeding, and/or protruding bone). Next, **palpate** the suspected area to check for any bony tenderness. Don't forget to examine the joint above & below. In acute fracture, range of motion cannot be assessed (you may ask the patient to move his limb but never do passive movement). After that, do the **vascular exam**. Check the **color** & **temperature** of the suspected area. Check for the **capillary refill** (within 2 sec as compared to the other side) & **pulses**. *Always compare contralateral side to make sure it's not systemic*.

Then, do a **peripheral nerve exam** if it was an injured limb. Last but not least, always check the **compartment tightness** (wood like vs. soft) to exclude compartment syndrome.

At the end of your exam, you must comment on: (imp)

1. Skin is intact or not
2. Neuro/Vascular status is intact or not
3. Compartments of limbs are soft are not

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

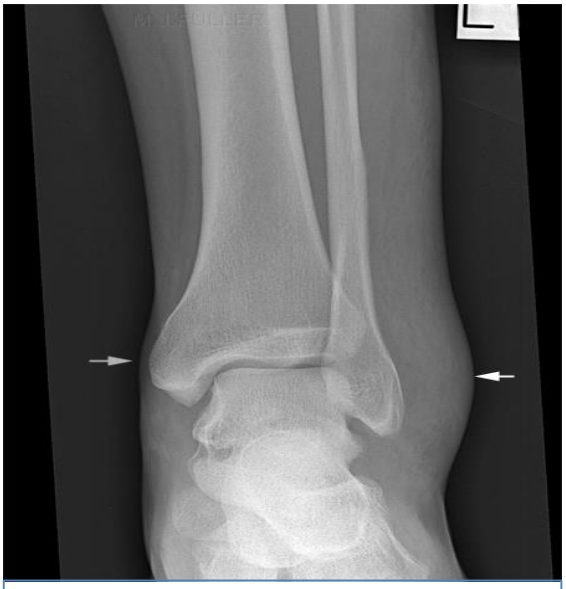
- At least 2 orthogonal (perpendicular) views: AP and lateral
- Joint above and below the area should be visible
- Special views: specific for the region of interest

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)

Secondary signs of fracture on X-ray: (see next page)

a) Soft tissue swelling
b) Fat pad signs (Capsule filled with blood)
c) Periosteal reaction
d) Joint effusion
e) Cortical buckle



Soft tissue swelling

Fat pad signs

Periosteal reaction

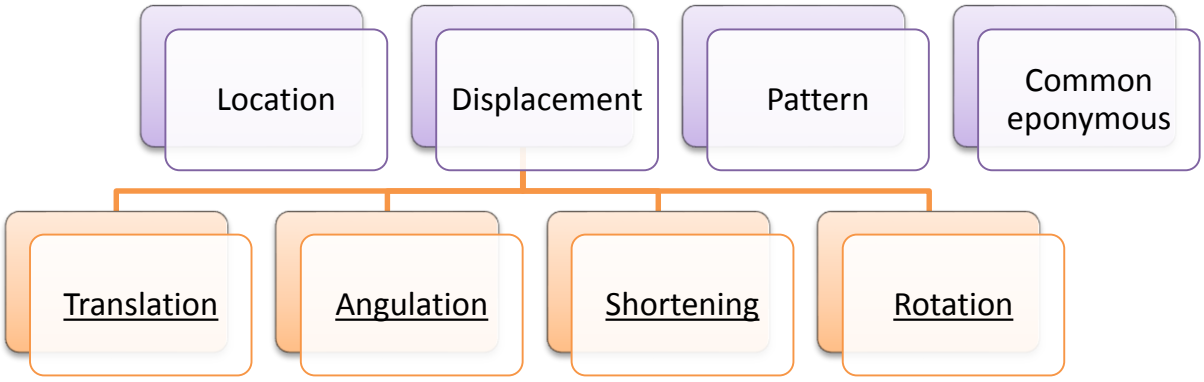
Joint effusion

Buckle cortical

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

Radiographic Description of fracture:



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…)

Pattern

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

Displacement

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.

Angulation

Angulation is the deviation from normal alignment. The apex of both fragments defines direction of angulation. It's expressed in degrees.

Fracture description: (Summary)

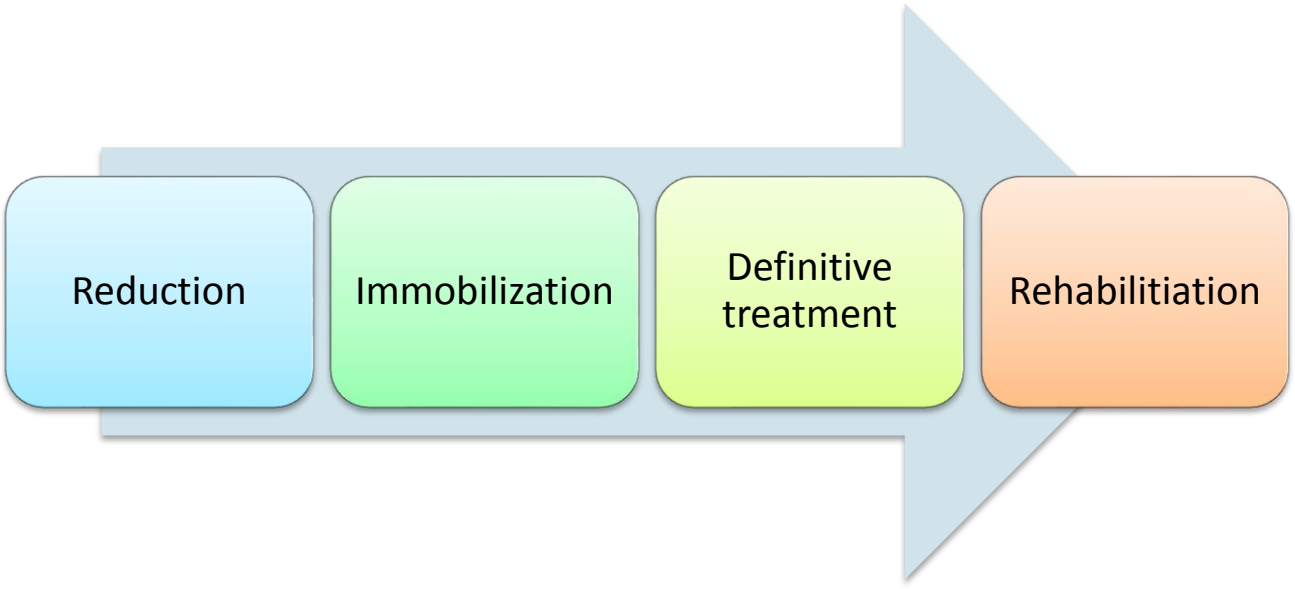
Clinical parameters:

- Open vs. closed (Any break in the skin in proximity of the fracture site is considered OPEN until proven otherwise)
- Neurovascular status
- Clinical deformity

Radiographic parameters:

- Location
- Pattern
- Displacement
- Common eponymous

Treatment Pathway:



Note!

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

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.

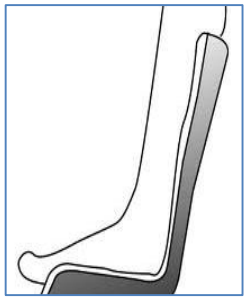
Important points to remember:

- Take *consent* from patient prior to reduction (1st & most imp step)
- Patient must receive adequate *analgesic* prior to reduction
- Most reductions occur under *conscious sedation* at emergency
- Reduction must be followed by immobilization
- 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:



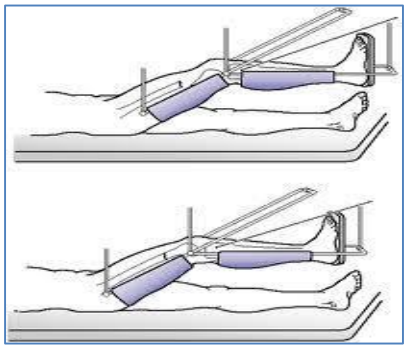
BACK SLAB

BRACE

SKIN TRACTION

SLING

COMPLETE CAST

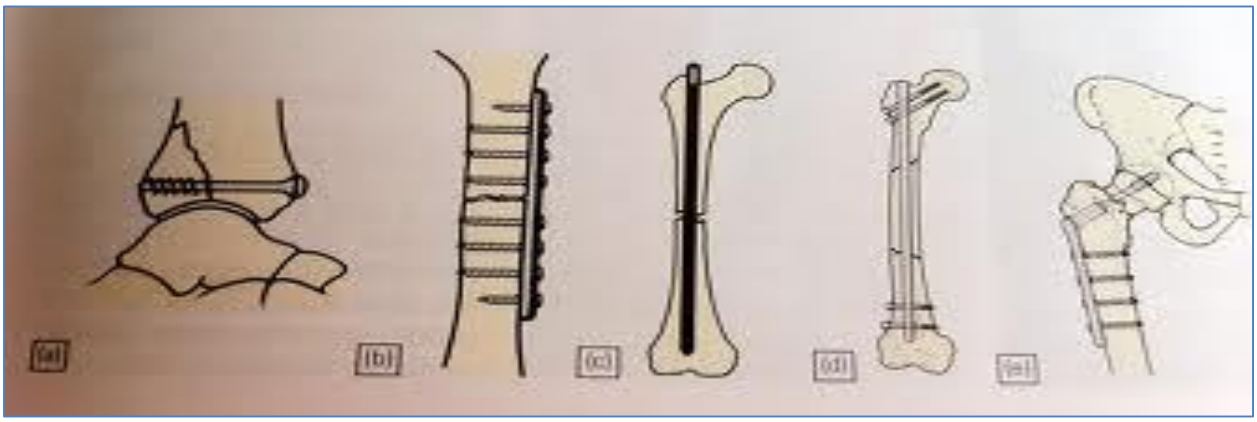


SKELETAL TRACTION

* 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 of course, jeopardizing maintenance of reduction. Weight bearing restriction for short period (6-8 weeks). Move unaffected areas *immediately.*

Treatment Principles:

Reduce:

- 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 ensure return to function

Multiple Trauma

It's a multi-disciplinary approach. Trauma Team Leader (TTL) at the ER runs it. Orthopedic is part of the team. Each institute or hospital has their own trauma protocol, so follow it based on the hospital you're in. 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 associated with venous thrombus event (VTE).

Surgical related: infection, hardware failure.

Summary

- **Bones Types:** 1) Lamellar Bones 2) Cancellous Bones 3) Woven Bones,
- **Bones Composition:**
  - **Cells** (osteocytes, osteoblasts, osteoclasts)
  - **Extracellular Matrix** (Organic (35%) Inorganic (65%))
- **Fracture** can be described in different ways: Extent – Location – Morphology - Mechanism - Associated soft tissue injuries.
- **Fracture Healing:**
  1) Indirect bone healing:
     - A- Hematoma formation (Inflammation phase) (1-2 weeks)
     - B- Soft Callus (2-3 weeks)
     - C- Hard Callus (3-12 weeks) D- Remodeling (Years)
  2) Direct bone healing

Summary (Cont.)

- **Healing Factors:** Complexity, Soft tissue damage, Close vs. open, Periosteal stripping, Malnutrition, Smoking.
- **Principles of Evaluation:**
  - **History** (What? How? (Mechanism of injury) When? Where?)
  - **Physical Exam** (inspection, palpate, range of motion cannot be assessed, vascular exam, peripheral nerve, check the compartment tightness), R/O open fracture, compartment syndrome and N/V injuries
  - **Investigations** (Basic blood works, X-rays of interest, Advanced radiological exams if needed).
- **Treatment Pathway:**
  - **Reduction** (re-align)
  - **Immobilization** (Fractures hurt, immobilization relieves pain),
  - **Definitive treatment** (indicated when reduction cannot be achieved or held at initial stage)
  - **Rehabilitation** (to restore the limb's function)

Questions:

1- Is it direct or indirect bone healing?

2- A vascular venous thrombosis may happen in which of the following fracture:

A- Vertebral body fracture

B- Femur neck fracture

C- Tibial bone fracture

Q1= indirect

Q2= B

432 ORTHOPEDICS TEAM LEADERS

Khalid AlOsaimi (A1)
Orthopedicteam432@gmail.com

Khulood AlRaddadi (F1)
Khulood.AlRaddadi@gmail.com