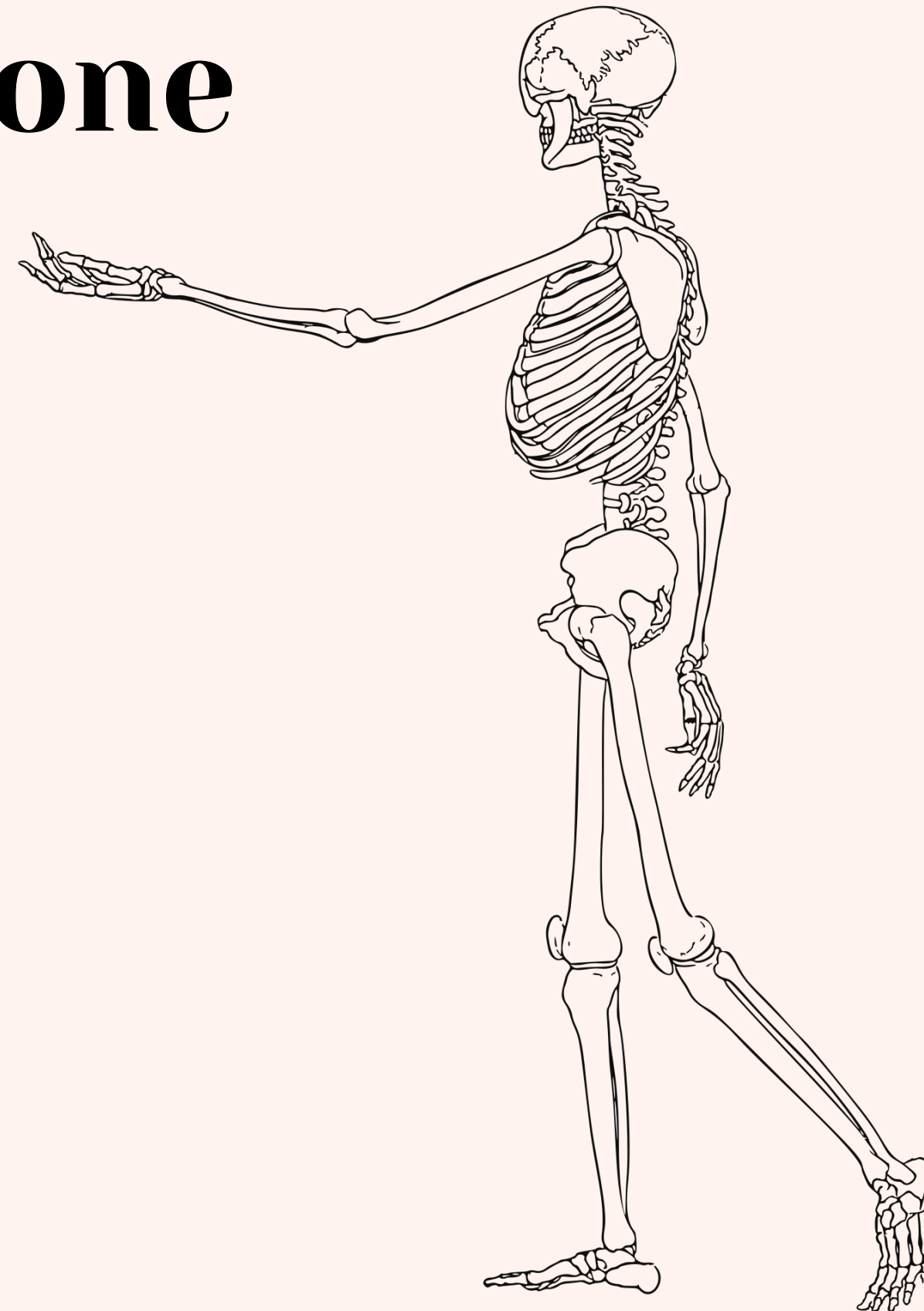


Fracture and bone healing



Editing File



Color index:

Main text (black)

Important (Red)

Dr.Notes (green)

Male slides only (blue)

Female slides only (pink)

Extra info(gray)

Objectives



Know basic anatomy and histology



Understand the mechanism and stages of fracture healing process



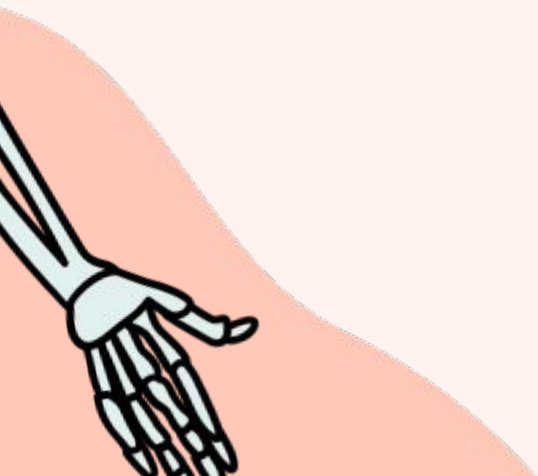
Know the factors affecting healing process and the possible complications of healing process



Appreciate the importance of road traffic accidents as a major cause of disability in Saudi Arabia



Know the different types of fractures



Basic anatomy

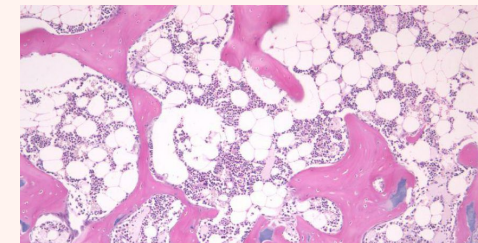
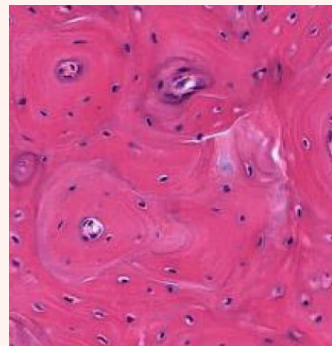
There are two types of mature bone:

Cortical

Trabecular
(cancellous bone)

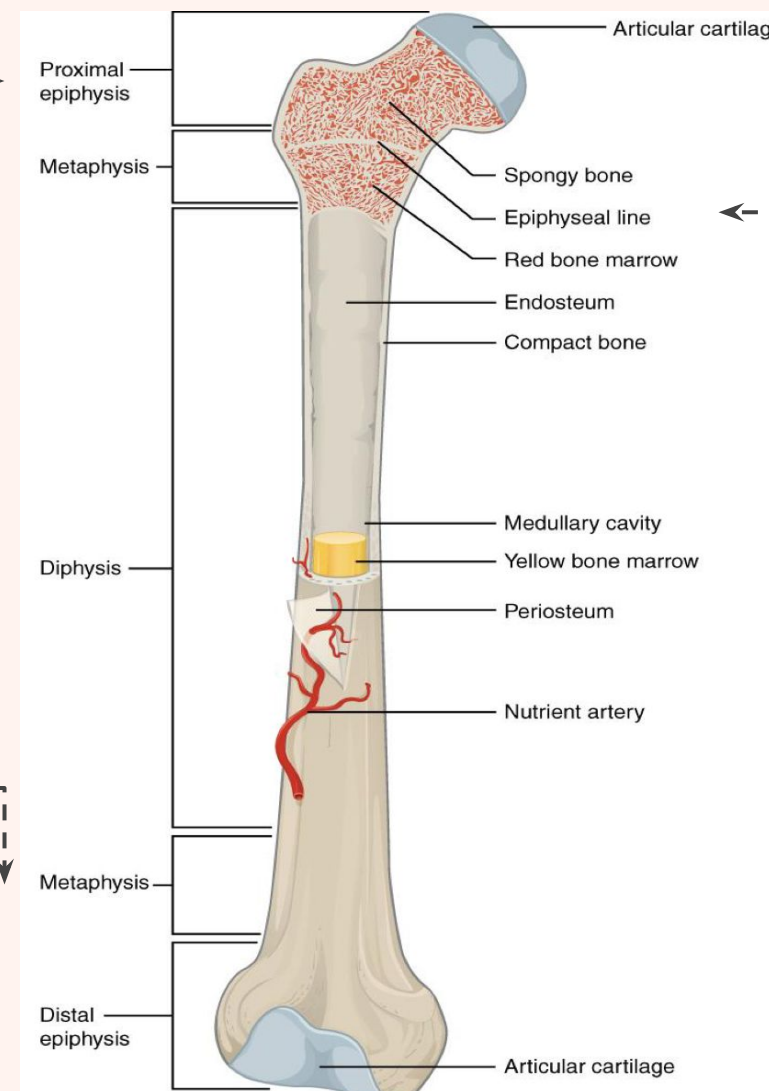
- Structural load-bearing function
- Thick and dense
- This is the area of bone to which ligaments and tendons attach
- Present in diaphyses (shafts) of long bones such as the femur and the outer surfaces of predominantly trabecular bones such as the vertebral bodies

- Some structural function
- Contributes to the metabolic functions of bone far more than cortical bone
- More prone to diseases involving or resulting from increased bone remodelling than cortical bone (osteoporosis)



Normal Anatomy

Parts of a long bones:



Epiphysis

ends of bone, partially covered by articular cartilage.

Diaphysis

shaft.

Metaphysis

junction of diaphysis and epiphysis. most common site of primary bone tumors

growth plate, cartilage plate in the metaphysis at each end of a long bone.

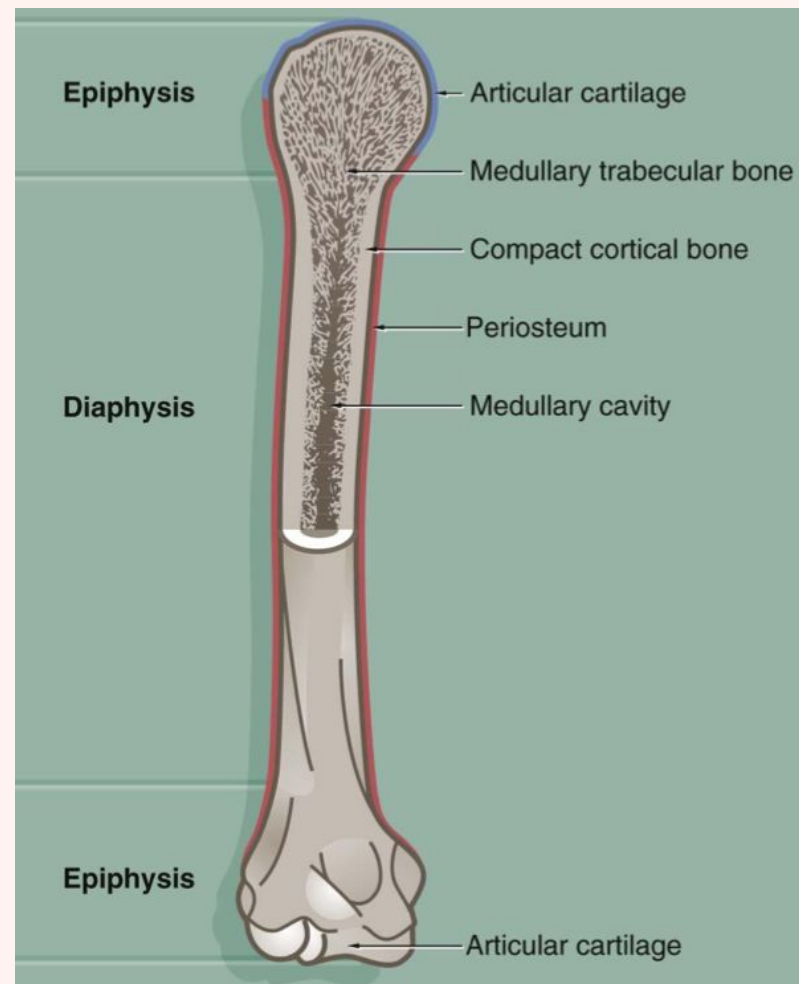
Epiphyseal plate

epiphyseal plate that has become ossified.

Epiphyseal line

Normal Anatomy cont.

Cross section:



Periosteum

dense fibrous layer.

Endosteum

layer of vascular connective tissue lining the medullary cavities of bone.

dense outer surface of bone composed of cortical/ compact bone.

Cortex

composed of cancellous (spongy bone).

Medullary space

Types of Bone Cells

Osteoblasts

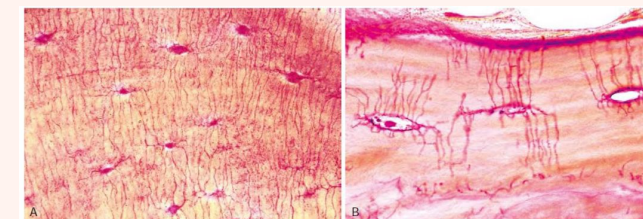
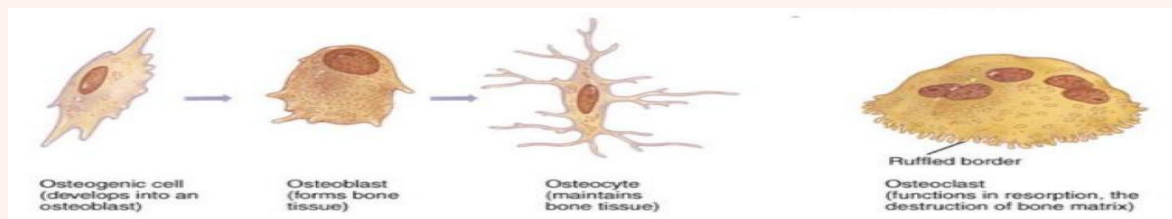
- Located on the surface of the matrix
- Synthesize, transport and assemble the matrix and regulate its mineralization
- Over time, may become inactive and remain on the surface of trabecula.
- Or they may become embedded within the matrix (osteocytes).

Osteocytes

- Located within matrix
- Interconnected by an intricate network of dendritic cytoplasmic processes through tunnels known as canaliculi
- Osteocytes help to control calcium and phosphate levels in the microenvironment, and mechanotransduction.

Osteoclasts

- Located on the surface of the matrix
- Specialized multinucleated macrophages derived from circulating monocytes that are responsible for bone resorption.
- Attach to bone matrix and create a sealed extracellular trench (resorption pit).



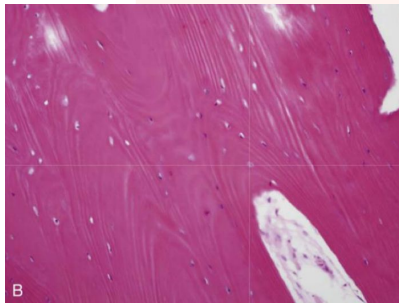
Matrix

- Bone matrix is the extracellular component of bone
- It is composed of an organic component known as osteoid (35%) and a mineral component (65%)
- Osteoid is made up of predominantly type I collagen with smaller amounts of glycosaminoglycans and other proteins
- Mineral component is composed of mainly inorganic moiety hydroxyapatite
[Ca₁₀(PO₄)₆(OH)₂]
- Serves as a repository for 99% of the body's calcium and 85% of its phosphorus
- **Bone:** mineralized osteoid; either lamellar bone or woven bone

Types of Matrix

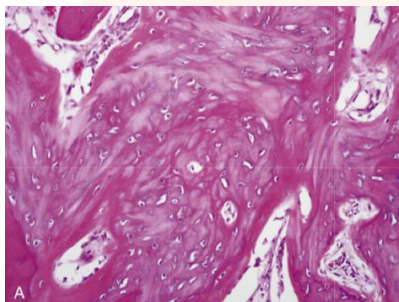
Lamellar

- Main type in adult
- Characterized by an orderly arrangement of collagen bundles and their cells
- layered bone with concentric parallel lamellae
- gradually replaces woven bone
- normal type of bone found in adult skeleton
- stronger than woven bon



Woven

- Produced rapidly, such as during fetal development or fracture repair, but the haphazard arrangement of collagen fibers imparts less structural integrity.
- In an adult, the presence of woven bone is always abnormal, but it is **not specific** for any particular bone disease since it can be found in a variety of pathologic settings.



Function of Bones



Constitute of 12% of body weight



Mechanical support



Transmission of forces generated by muscles



Protection of viscera



Mineral homeostasis



Providing a niche for production of blood cells

Special Thx to 443

Definition & Classification of Fractures

Fractures

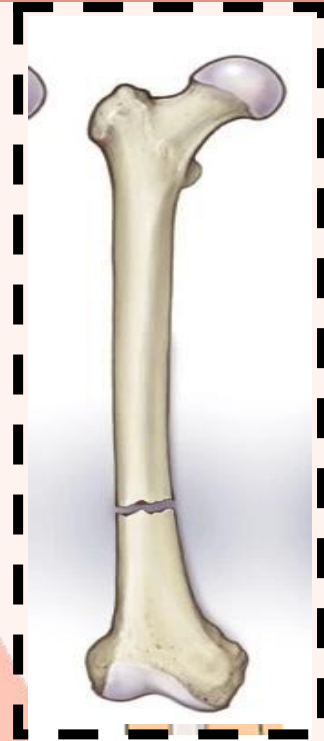
Defined as loss of bone integrity due to mechanical injury and/or diminished bone strength

Break in the continuity of bone due to mechanical injury and/or diminished bone strength

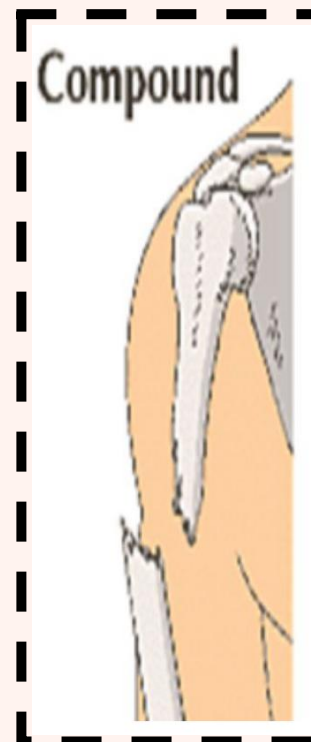
a way that might help u memorize it

SCCD GPS
Simple
Compound
Comminuted
Displaced
Greenstick
Pathologic
Stress

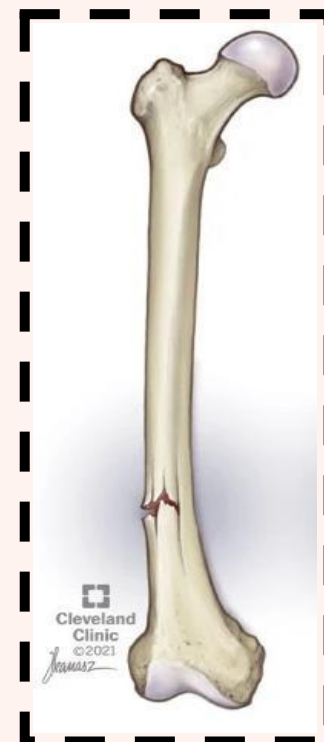
Simple



Compound



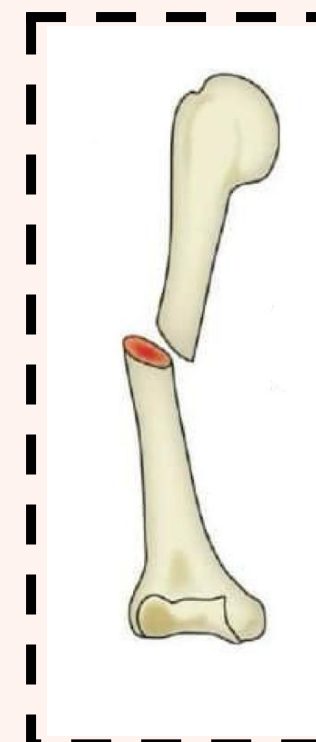
Greenstick



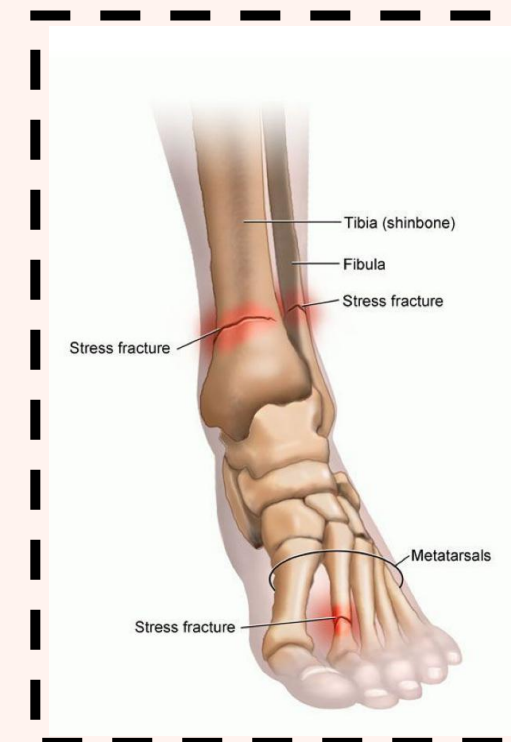
Comminuted



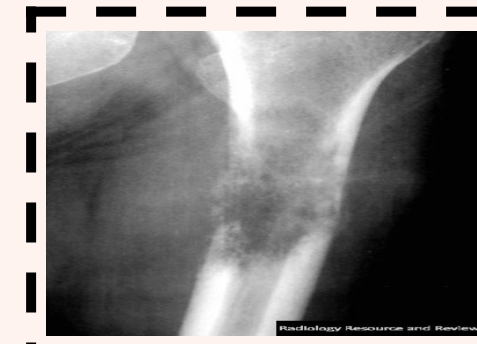
Displaced



Stress



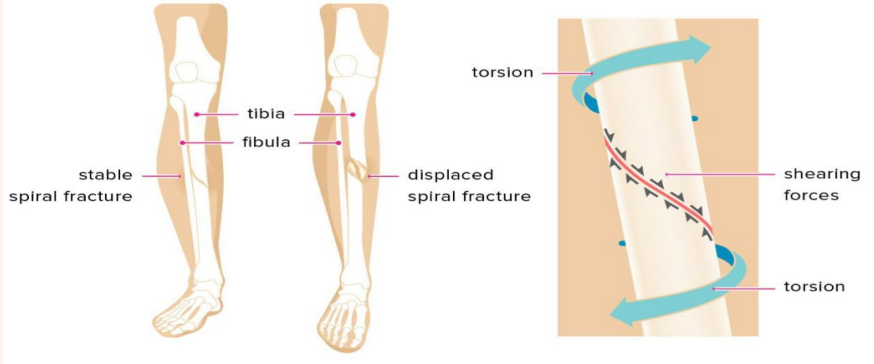

Pathologic



Type of Fractures

Type	Definition
Closed (Simple)	The overlying skin is intact. Does NOT communicate with external environment. "غير مهشم وما اخترق الجلد"
Open (Compound)	The bone communicates with the skin surface (infection) (Infection) العظمة طلعت برة الجلد مع جرح فيصاحبها مرض
Greenstick	Extending only partially through the bone, common in infants when bones are soft العظمة انكسرت جزئيا بس ما انفصلت عن بعض وصارت قطعتين مثل ال simple مثل ما هو موضح بالصورة
Comminuted	The bone is fragmented (segments) A bone that is broken in at least two places. Comminuted fractures are caused by severe traumas like car accidents. "مهشم و يكون على شكل قِطَع"
Displaced	The ends of the bone at the fracture site are not aligned "نهايات الكسر بعيدة عن بعض"
Stress	Slowly developing fracture that follows a period of increased physical activity in which the bone is subjected to repetitive loads (يجي نتيجة الضغط لفترات طويلة على العظمة)
Pathologic	Involving bone weakened by an underlying disease process, such as a tumor

Type of Fractures cont.

Type	Definition
Complicated	Associated with damage to nerves, vessels or internal organs I think it's pretty clear 🐶
Spiral fracture- Twisting force	<p>They happen when one of your bones is broken with a twisting motion. They create a fracture line that wraps around your bone and looks like a corkscrew</p> <p>الكسر على شكل لولبي 🌀</p> 
Complete	A complete fracture breaks the bone into separate pieces.
Incomplete	<p>Incomplete fracture is a partial fracture in the bone</p> 

Causes of Fractures

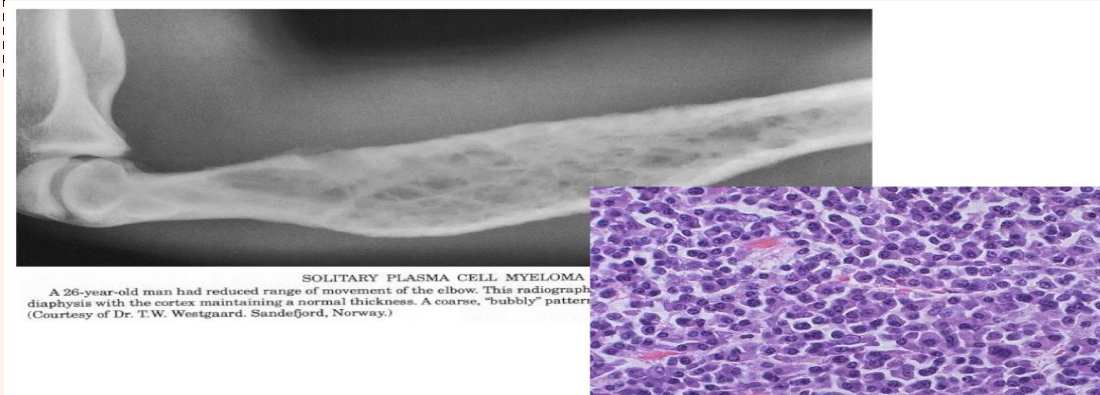
Trauma

- Healthy bones are extremely resilient and can withstand strong impacts.
- Examples: Sporting injuries, vehicle accidents and falls.
- Road accident are the second leading cause of death and main cause of premature death in KSA.
- Death rate in 2016 estimated to be 28.8 per 100,000 population.

سوقوا زين

Pathologic

- Minimal trauma.
- The underlying bone is abnormal **e.g:**
- Osteoporosis (هشاشة العظام)
- Osteomalacia (تليين العظام يعني تصير لينية)
- Paget's disease of bone
- Tumor (primary or metastasis)
- Congenital bone diseases (e.g. Osteogenesis Imperfecta).



Stress

- Slowly over time.
- Collection of microfractures associated with increased physical activity (new repetitive mechanical loads on bone).
- Most common in the weight-bearing bones of the lower leg and foot.
- Athletes and military recruits who carry heavy packs over long distances are particularly susceptible

Healing of fracture



Reactive phase

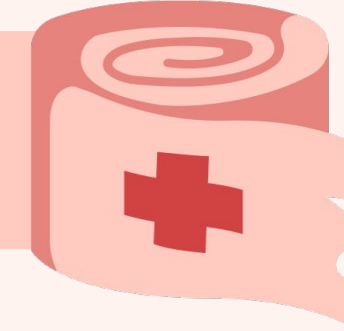
- 1- Fracture Hematoma And Inflammatory Phase
- 2- Granulation Tissue Formation

Reparative phase

- 3- Callus Formation (Soft And Bony)
- 4- Lamellar bone deposition

Remodeling phase

- 5- Remodeling To Original Bone Contour



Bleeding causes swelling due to inflammation induced by chemical mediators produced from macrophages and other inflammatory cells with granulation tissue formation.

1) Hematoma And Inflammatory Phase:

Due to tearing of blood vessels in the medullary cavity, cortex and periosteum, a hematoma forms at the site of fracture hematoma: (تجمع دم ويتخثر جوا الكسر عند الأوعية الدموية وحوليتها بشوي في منطقة النزيف بسبب الكسر)

- Inflammation Bleeding from the fractured bone and surrounding tissue causes the fractured area to **swell** due to inflammation induced by chemical mediator produced from macrophages and other inflammatory cells

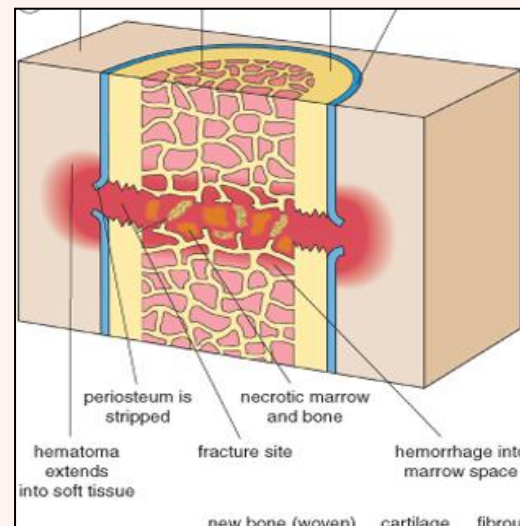
2) Granulation tissue formation

Organization of the hematoma is associated with the migration of neutrophils and macrophages into the fracture hematoma; these cells phagocytose the hematoma and necrotic debris.

1

Fracture and inflammatory

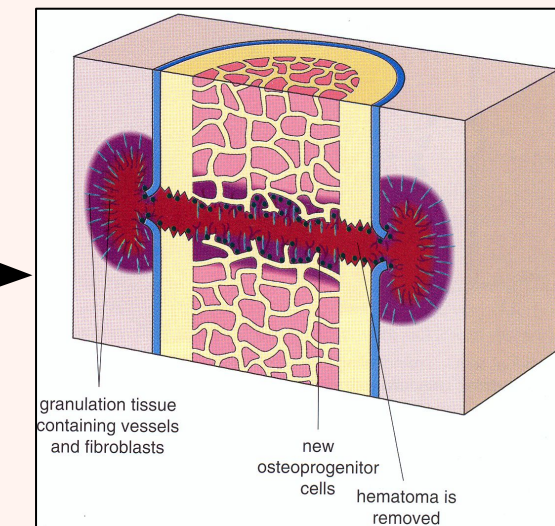
This stage begins day one of bone fracture and lasts about 2 to 3 weeks.



2

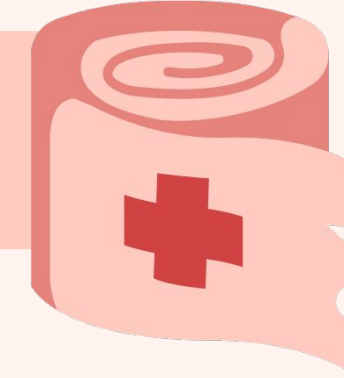
Granulation tissue formation

Between 2 and 3 weeks after the injury



Reparative Phase

Healing of fracture

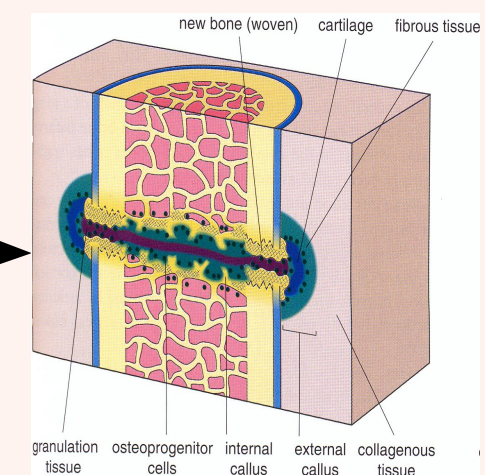


- Degranulated platelets and migrating inflammatory cells release PDGF, TGF- β , FGF, and other factors, activate osteoprogenitor cells in the periosteum, medullary cavity, and surrounding soft tissues and stimulate chondroblastic and osteoblastic activity
- Cytokines activate bone progenitor cells, and within a week, the involved tissue is primed for new matrix synthesis.
- Chondroblasts and osteoblasts derived from osteoprogenitor cells migrate into the granulation tissue, which proceed to deposition of cartilage with endochondral ossification and then deposition of bone osteoid in a haphazard way, producing a woven bone pattern. Forming soft callus.

3

Callus formation

This stage usually lasts until 4 to 8 weeks after the injury





1: soft callus/procallus

Between 2 and 3 weeks after the injury, the pain and swelling will decrease. At this point, the site of the fracture stiffens and new bone begins to form. The new bone cannot be seen on x-rays. This stage usually lasts until 4 to 8 weeks after the injury.

This soft callus can hold the ends of the fractured bone in apposition but is noncalcified and cannot support weight bearing (end of first week).

after 2 weeks ..

2: HARD (BONY) CALLUS (the cast can be removed)

Between 4 and 8 weeks, the new bone begins to bridge the fracture. This bony bridge can be seen on X-rays. By 8 to 12 weeks after the injury, new bone has filled the fracture.

- Activated osteoprogenitor cells deposit woven bone.

Osteoblasts arise from pluripotent progenitor cells in the periosteum and granulation tissue. They produce woven bone, resulting in a bony callus that stabilizes the fracture site .

- In some cases, the activated mesenchymal cells in the soft tissues and bone surrounding.

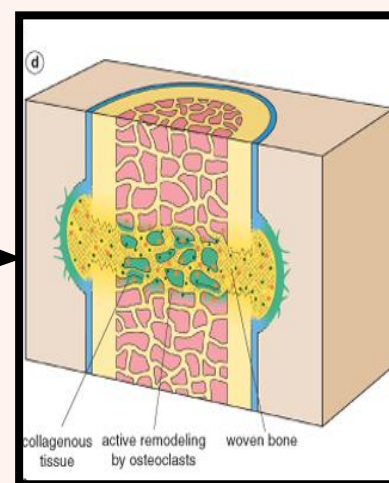
the fracture line also differentiate into chondrocytes that make fibrocartilage and hyaline cartilage.

- In uncomplicated fractures, this early repair process peaks within 2 to 3 weeks.
- The newly formed cartilage acts as a nidus for endochondral ossification, recapitulating the process of bone formation in epiphyseal growth plates
 - This connects the cortices and trabeculae in the juxtaposed bones
 - With ossification, the fractured ends are bridged by a bony callus and then lamellar bone is formed

With time, remodeling creates new lamellar trabecular bone, which is oriented in a direction determined by the stresses to which the bone is exposed with mobilization

4

Lamellar bone deposition



Healing of fracture



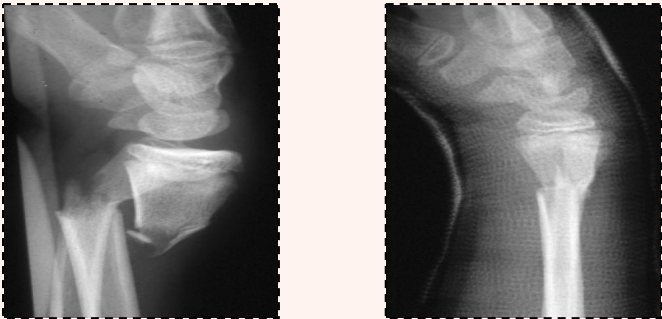
Remodeling Phase

Beginning about 8 to 12 weeks after the injury, the fracture site remodels itself, correcting any deformities that may remain as a result of the injury.

- This final stage of fracture healing can last up to several years.
- Although excess fibrous tissue, cartilage, and bone are produced in the early callus, subsequent weight bearing leads to remodeling of the callus, lamellar bone and restoration of medullary cavity.



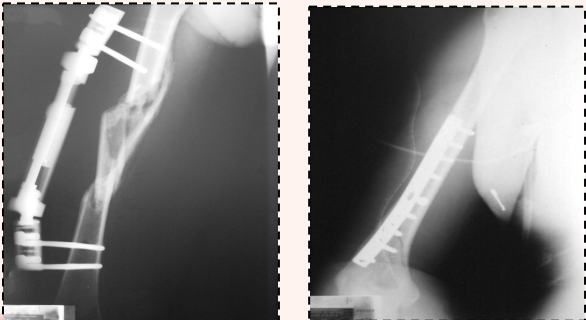
Excellent Reduction with Well Molded Cast



Immobilization promotes bone fracture healing



External and internal fixation



Bone involved upper limb
less time than lower limb

adequate immobilization

Healing of fracture



[CLICK HERE!!!](#)

1

Reactive Phase

1. **Hematoma and inflammatory phase :**
 - due to tearing of blood vessels in the cortex **hematoma is formed** to prevent blood loss.
 - Inflammatory cell influx to the hematoma .
1. **Granulation tissue formation**

2

Reparative Phase

3. **Callus formation:**
 - Inflammatory cells release PDGF, TGF- β , FGF and other factors, activate osteoprogenitor cells and within a week, the involved tissue is primed for **new matrix synthesis**.
 - This **soft callus/procallus** apposition but can hold the ends of the fractured bone in noncalcified (end of first week).
 - After 2 weeks **Hard callus formed**.
 - Activated osteoprogenitor cells deposit woven bone, activated mesenchymal cells differentiate into chondrocytes that make fibrocartilage and hyaline cartilage.
 - With **ossification**, the fractured ends are bridged by a bony callus :
4. **Lamellar bone deposition:**
 - With time, remodeling creates new lamellar trabecular bone

3

Remodelling Phase

- **After 8 to 12 Weeks The fracture site remodels itself**, correcting any deformities that may remain as a result of the injury (final stages can last for years)

BF
www.bonfixator.com
Stage 1 : Impact

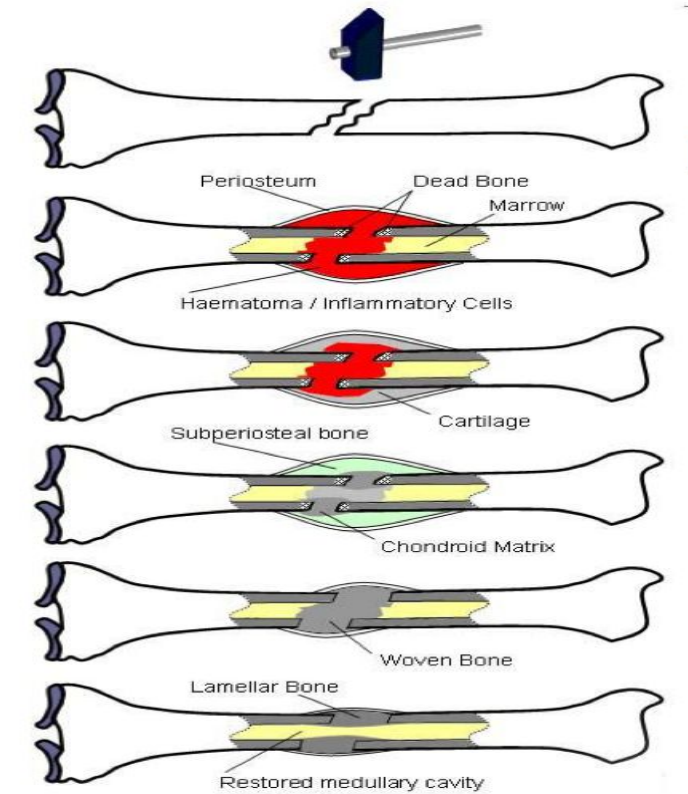
Stage 2 : Induction

Stage 3 : Inflammation

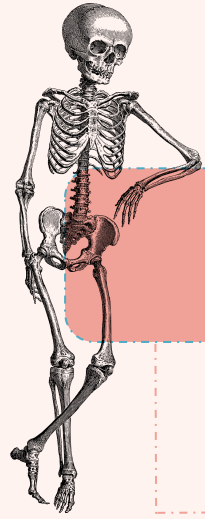
Stage 4 : Soft Callus

Stage 5 : Ossification

Stage 6 : Remodelling



Healing of fracture



Factors disrupting healing process


Displaced and comminuted fractures

Infection

Inadequate minerals and vitamins

Inadequate immobilization (Nutritional):
movement of the callus and prevents its normal maturation, resulting in delayed union or Nonunion

Vascular insufficiency:
This is particularly important in certain areas such as the **scaphoid bone in the wrist** and **the neck of the femur**, both of which can be associated with vascular necrosis of fracture fragments.

 **Bones are important**

Time Factor- Perkin's formula

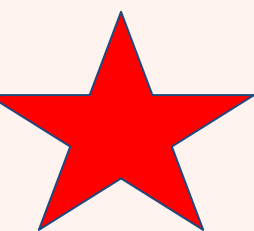
	Union	Consolidation
Upper limb	Spiral → 3 week Transverse → 6 week	Spiral → 6 week Transverse → 12 week
Lower limb	Spiral → 6 week Transverse → 12 week	Spiral → 12 week Transverse → 24 week

Children need half the time to heal compared to adults

Ex: adult needed 4 months to heal how much time needed for a child to heal?

Answer: 2 months

Number of weeks in table isn't needed



Healing of fracture



Complications

Delayed union

A fracture that takes longer to heal than expected is a delayed union

Nonunion

A fracture that fails to heal in a reasonable amount of time is called a nonunion

(No to healing same as Nonunion)

Malunion

A fracture that does not heal in a normal alignment is called a malunion

(Malunion as مالِك دخل بأتعافى بكيفي)

Delayed Union & Non union causes

1

Soft tissue interposition

2

Nutrition

3

Bone Disease

4

Infection

5

Position of reduction

6

old age

7

Poor blood supply

Other complications

Neurovascular injury

Osteonecrosis (vascular necrosis)

Infection: Open fractures can become infected

Post-traumatic arthritis: Fractures that extend into the joints (intra-articular fractures) or fractures that cause the bones to meet at an abnormal angle in the joint can cause premature arthritis of a joint.

Growth abnormalities: A fracture in the open physis, or growth plate, in a child, can cause many problems)
- e.g premature partial or complete closure of the physis. This means that one side of a bone or the whole bone stops growing before it naturally would

Compartment syndrome:

-Severe swelling after a fracture can put so much pressure on the blood vessels that not enough blood can get to the muscles around the fracture.
-The decreased blood supply can cause the muscles around the fracture to die, which can lead to long-term disability.
-Compartment syndrome usually occurs only after a severe injury.

DEFINITION

Osteonecrosis (vascular necrosis):

-Infarction (ischemic necrosis) of bone and marrow cells, peak 30-50 years
-10% of hip replacement due to osteonecrosis.

Causes:

- Vascular injury (trauma, vasculitis)
- Drugs (corticosteroids)
- Systemic disease (sickle cell disease)
- Radiation
- Unknown (25%)

Mechanism:

- Mechanical disruption of vessel
 - Thrombotic occlusion
 - Extravascular compression
-
- Medullary infarcts, are geographic and involve the trabecular bone and marrow
 - Cortex not affected due to Collateral blood flow
 - In subchondral infarcts, a triangular or wedge-shaped segment of tissue that has the subchondral bone plate as its base undergoes necrosis
 - Overlying cartilage is viable.. Synovial fluid
 - Can lead to secondary osteoarthritis

Keywords



Word (disease)	The word that leads to the disease (symptoms, features or a word)	Word (disease)	The word that leads to the disease (symptoms, features or a word)
Simple fracture	Overlying Skin is intact	Delayed union	Long time to heal
Compound fracture	Bone is in contact with skin with bleeding and causes infection	Nunion	The bone fails to heal
Greenstick fracture	Partial fracture not fully	Malunion	abnormal heal of bone
Comminuted fracture	Bone is fragmented (segments)	Osteonecrosis	Infarction cause of: Vascular injury, radiation, sickle cell disease,unknown 🧐
Displaced fracture	Bone ends away from each other		
Stress fracture	Fracture after period of time from physical activity		
Pathologic	Fracture by disease		



Resources to understand better

[CLICK HERE!!!](#)

[Small gift for u from batch leader](#) 🦴



Anki Flashcards

[CLICK HERE!!!](#)

Special thx to Abdulaziz Alanazi 🦴



MCQs



Q1/ The second stage of Fracture healing is..... where active phagocytosis absorbs the products of local necrosis?

A- Ossification

B- Hematoma

C- Granulation tissue

D- Callus Formation

Q2/ A type of fracture where the bone is fragmented?

A- Greenstick

B- Complete

C- Comminuted

D- Stress

Q3/ The first step of fracture healing is?

A- soft callus formation

B- remodeling

C- hard callus formation

D- hematoma formation

MCQs



Q4/ Which of the following is not a cause of bone fracture?

A- Pathologic

B- Trauma

C- Stress

D- Burns

Q5/ fracture has only one side damaged and only occurs in children?

A- Simple

B- greenstick

C- Comminuted

B & C

Q6/ Osteoblast deposit the osteoid collagen in Haphazard pattern and random arrangement?

A- Lamellar bone

B- Woven bone

C- Compact bone

D- Trabecular

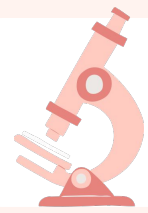
Pathology Team

leaders:

Layal alkhalfah

Abdulaziz Nasser

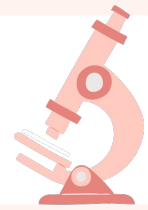
Members:



Ghida Alkahtani



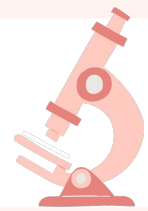
Abdulaziz Alanazi



Aram Alzahrani



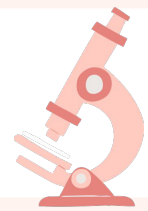
Waleed Alanazi



Sahar Alfallaj



Faisal alghamdi



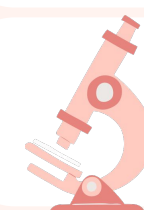
Norah Alnoشان



Faisal Alamoud



Raseel Aldajany



Mouath al abdussalam