Healing of Bone Fractures

Lecture One

432 Pathology Team

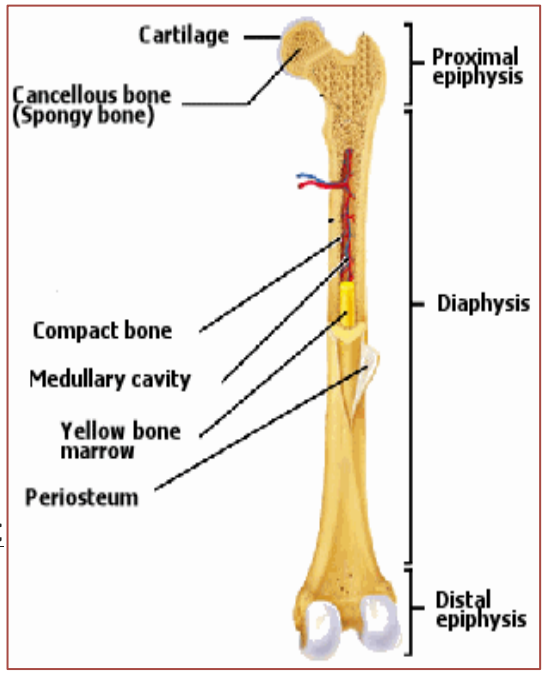
Healing of Bone Fractures

Lecture Objectives:

- *Know the importance of road traffic accidents with resultant trauma as a major cause of death and disability in the Kingdom.*
- *Know the mechanisms and stages of fracture healing.*
- *Differentiate between trauma induced and pathological fractures.*
- *Know the factors contributing to delayed-fracture healing.*

There are topics in Anatomy and Histology that are essential to understand the bone

Structure of The Bone:



1- Epiphyses

2- Epiphyseal line (growth plate): present in children and classes (ossifies) in puberty, it is responsible of growth of the bone.

a- *In long bone* (Endochondral ossification)

b- *In flat bones* (Intremembranous ossification)

3- Metaphysis; between *diaphysis* and *epiphysis* – there are some diseases that only effect Metaphysis. Ex: (Osteomillitis)

4- **Diaphysis:** Shaft of bone

you need to know these sites and the diseases that affect them

5- The bone is covered by each end with **articular cartilage**. *It helps bone to form joints.*

6- Periosteum.

Classification of Bones:

1- **(Compact \ Lamellar \ Cortical) bone**

Beneath the periosteum. It is formed of parallel calcified osteoid.

We see:

1-Lamely.

2-Osteoid.

3-Mineral (calcium mainly).

4- Haversian System and Haversian Canal

2- Spongy-form \ trabecular \ woven

a- Interconnecting irregular trabeculae with spaces in between.

b- Trabeculae spaces are filled with bone marrow

Bone cells:

1- **Osteo-progenitor** Cells are the mother Of bone

2- **Osteoblasts** → Form osteoid.

3- **Osteocytes** inside the lacunae

4- **Osteoclasts** ناحتة : resolve the bone

Appearance of bone under polarized light:

Compact: Parallel lines of lamely.

Spongy: Lines are not parallel.

Bone Fractures

Caused by physical trauma, bone fracture is one of the most common abnormalities of bone. The degree of fracture can very widely, from a simple crack in the cortical bone to a complex multiple fracture with fragmentation and displacement of the bone pieces, associated with severe damage to the surrounding soft tissues and sometimes exposure of the bone fragments to the exterior through a large gaping wound (open "compound" fracture).

Bone Fractures are BONE DISRUPTIONS usually due to ***trauma***.

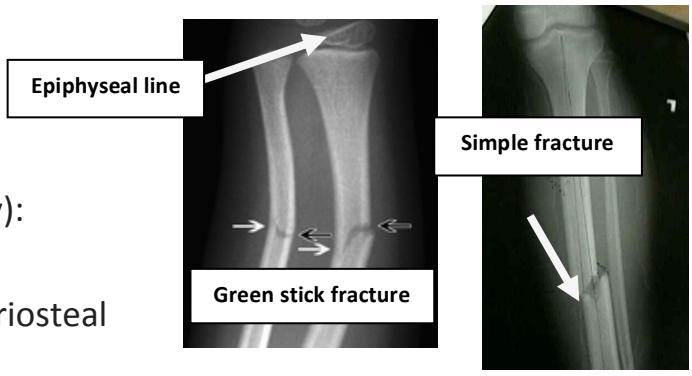
Bone fractures are either:

- Physical

- Pathological

First signs of bone fractures: ***Swelling & Pain***.

Types of fracture:



1- Green stick fracture

This type occurs in children (usually):

- No clear separation.
- You only see a small line and periosteal reaction.
- They heal very well.
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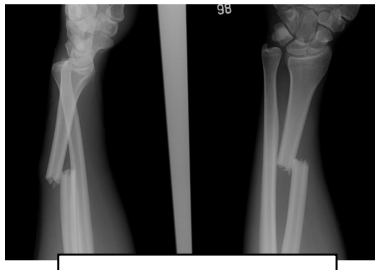


2- Closed fracture:

a. Simple fracture:
   There is a linear fracture with no displacement.
b. Displaced fracture:
   The bone changed its place; it's also called (SPIRAL fracture).
c. Comminuted fracture:
   A closed fracture, displacement and separated bone fragments.

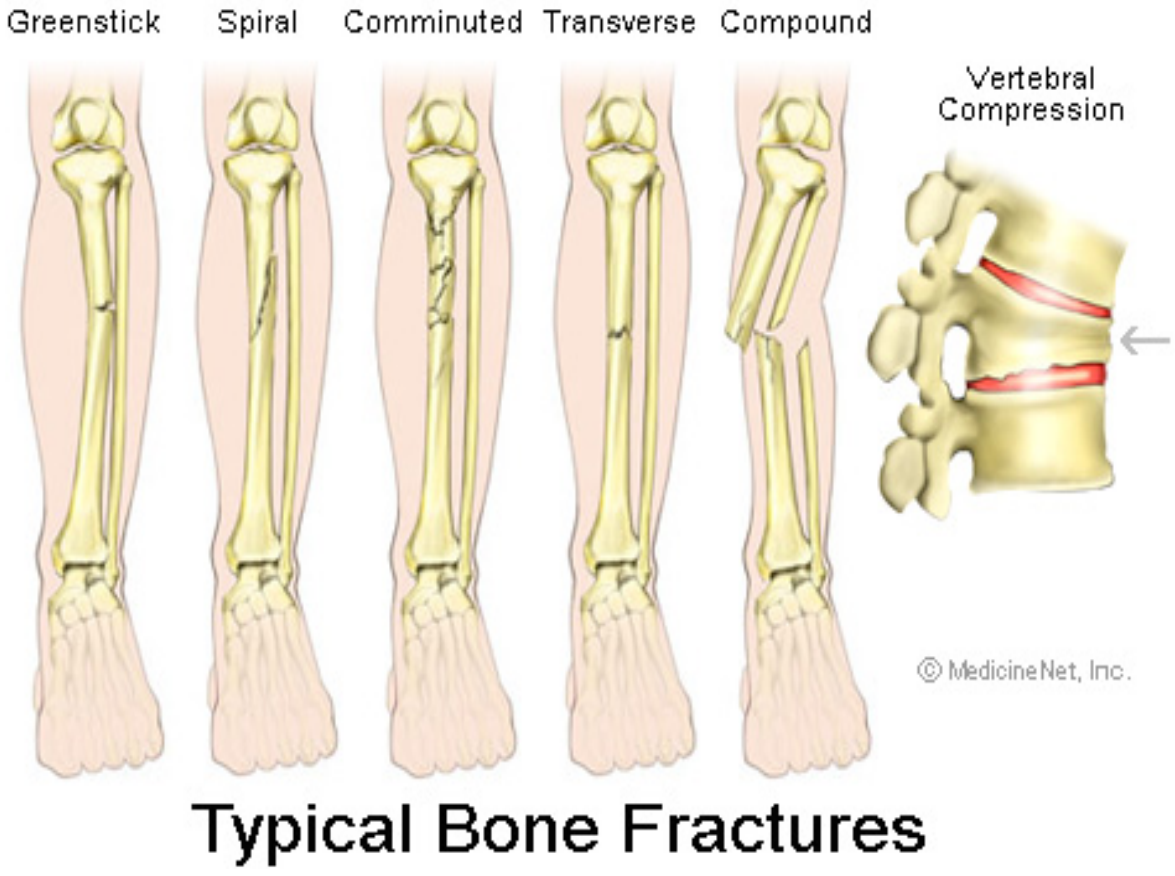
3- Compound (open) fracture:

Displaced and fragmented bone fracture where fragments are separated and exposed to the exterior.

Comminuted fracture

4- Stress fracture :

Small fracture, mostly in the leg (calcaneum), usually happens after long walks, vigorous exercise and in the army.



Typical Bone Fractures

A. Pathological fractures:

The bone has to be diseased before the fracture: tumor, infection, malformation…etc.

Disease → minor injury → fraction

Ex:

1- **Osteogenic Imperfecta** or Brittle bone disease (congenital – dominant) : Abnormal collagen → deformed bone → susceptible **معرض** for multiple fractures + deformities in the bone.
Fractures may happen in the early few months of post-natal **بعد الولادة** life or even in fetal **قبل الولادة** life.

2- **Osteoporosis** (particularly in the femur and vertebral column in the elderly).

3- **Osteomalacia** (the fractures are often small micro-fractures without displacement).

4- **Paget's disease of bone** مرض تكثف العظام (the pagetic bone being structurally weak despite the increase in bulk) العظم ضعيف عمليا بالرغم من أنه أسمك من الطبيعي.

5- **Primary or metastatic tumor** carcinoma in bone is an important cause of pathological fracture. Bone metastases from carcinoma of the breast, bronchus, thyroid and kidney produce bone destruction (osteolytic metastases), which predisposes to fracture. Primary tumors of bone or bone marrow, such as giant-cell tumor of bone and melanoma, also play a role, as do some non-neoplastic bone lesions such as bone cyst.

Healing of bone fractures:

Hematoma → Inflammation → **Granulation Tissue Formation** →**Callus** → Bony union → replacement by lamellar bone → **Remodeling**

Healing of fractures goes through series of steps. These steps aim to ossify تلحم the parts of the broken bone together and remodel the bone **so that the anatomy can return to close to normal**.

1- **Hematoma** → Inflammation → **Granulation Tissue Formation** →**Callus** → Bony union → replacement by lamellar bone → **Remodeling**

When a bone breaks, **hematoma** (blood clot) forms around the broken ends of the bone. This hematoma causes the swelling of the surrounding tissue.

2- **Hematoma** → **Inflammation** → **Granulation Tissue Formation** →**Callus** → **Bony union** → **replacement by lamellar bone** → **Remodeling**

a. The hematoma is directly followed by acute inflammation, the neutrophils and macrophages try to remove the blood and clean up the hematoma.
b. Then the acute inflammation is followed by chronic inflammation and granulation tissue.

3- **Hematoma** → Inflammation → **Granulation Tissue Formation** →**Callus** → Bony union → replacement by lamellar bone → **Remodeling**

The transformation of hematoma into granulation tissue is called **"ORGANIZATION of the hematoma"**

Granulation tissue is formed of:

a. Fibrous tissue and fibroblasts.
b. New blood vessel formation.
c. Chronic inflammatory cells and macrophages.

4- **Hematoma** → Inflammation → **Granulation Tissue Formation** →**Callus** → Bony union → replacement by lamellar bone → **Remodeling**

Formation of callus:

Granulation tissue contains proliferating cells derived from the periosteum and endosteum (Osteoprogenator cells) which differentiate into chondroblasts and osteoblasts that lay down new cartilage and immature (woven) bone forming osteoid and chondroid arranged haphazard, then calcium deposits on the osteoid. The result is hard tissue called **callus** surrounding and joining the broken ends of the bone. (2-3 weeks)

5- **Hematoma** → Inflammation → **Granulation Tissue Formation** →**Callus** → Bony union → replacement by lamellar bone → **Remodeling**

Bony union occurs when new bone produced in the callus links the bone fragments together.

6- **Hematoma** → Inflammation → **Granulation Tissue Formation** →**Callus** → Bony union → replacement by lamellar bone → **Remodeling**

The cartilage and woven bone are gradually replaced by **lamellar bone** (the type found in mature bone).

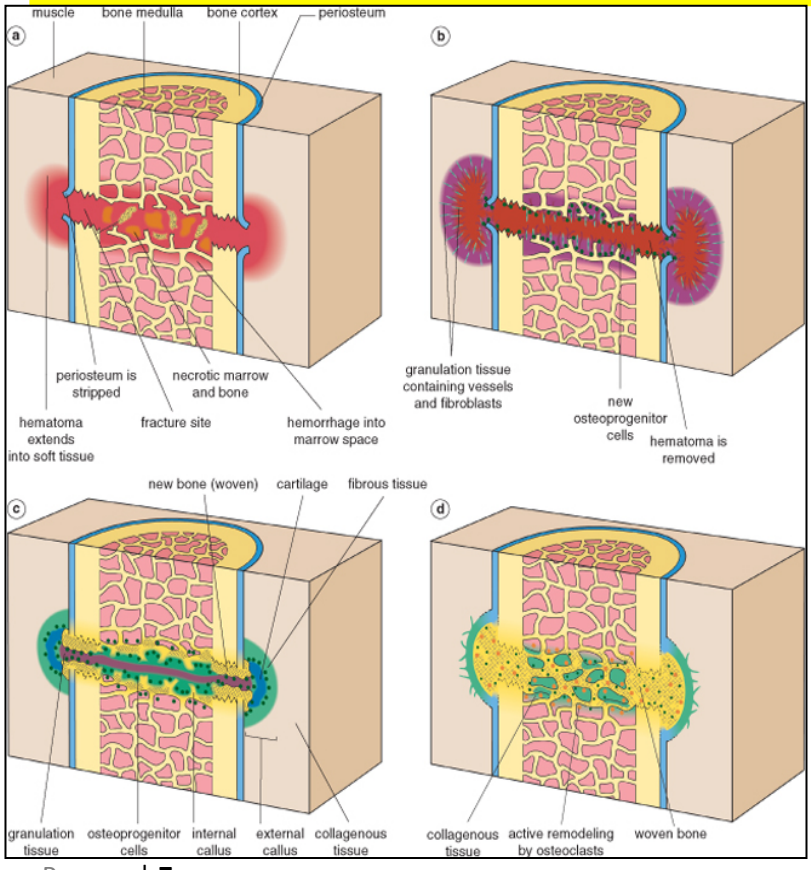
7- **Hematoma** → Inflammation → **Granulation Tissue Formation** →**Callus** → Bony union → replacement by lamellar bone → **Remodeling**

This new bone can be **remodeled** so that the anatomy can return to close to normal. This stage starts after the third week (after formation of callus), the remodeling is done by the osteoclasts. Also, in this stage the bone layers are formed (collagenous tissue, trabecular bone, lamellar bone) .

SUMMARY:

The healing steps in general are:

1-Hematoma formation → **2-**Inflammation and granulation tissue formation → **3-** Callus formation → **4-** Remodeling



Delayed Healing:

Delayed or abnormal healing of fractures can lead to **non-union** in which the fractured bone ends do not join by bone.

For **proper** fracture healing to take place, it is essential that the fractured bone ends be in:

1- ***Close Apposition.***
2- ***The fracture is immobilized.***
3- ***That the patient's healing capacity is adequate.***

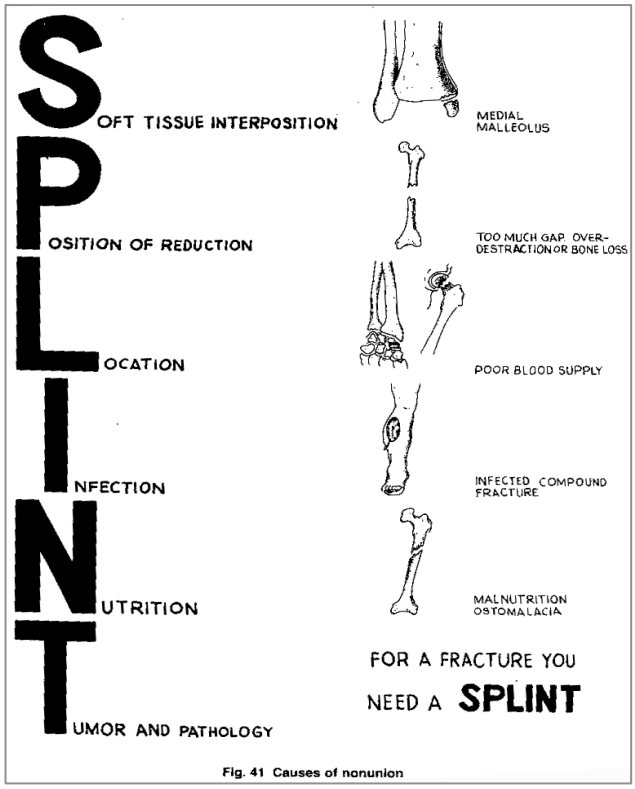


Fig. 41 Causes of nonunion

There are some factors that delay healing:

1- ***Infection:***
Infection is a major factor that could affect healing of **compound fractures**.

2- ***Poor apposition*** جزئا العظم المكسور يكونان في وضع غير مناسب للالتحام :
Ex:
   a. Interposed fibrous tissue, muscle tissue or other soft tissue between the fracture ends.
   b. Wide displacement.

3- ***Poor blood supply to the affected area.*** 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 **avascular necrosis** of fracture fragments.

4- ***Diseases of the bone.***

5- ***Bad nutrition particularly*** (where there is protein malnutrition or vitamin deficiencies especially vit.D & vit.C)

6- ***If the patient is taking corticosteroids.***

7- ***If the patient is diabetic.***

In general, any factor that can delay **WOUND** healing can also delay **BONE FRACTURE** healing.

Fixation of Bone fractures:

The aim of treatment in fractures is to ensure closure apposition of the bone ends, followed by firm immobilization منع من الحركة so that the fractured ends cannot move during the formation of granulation tissue and callus. This can be done in two ways:

1- ***Applying external pressure.***
2- ***Surgical :*** **wire, screw, plate…etc.**

Complications of healing:

When fractured bone ends are not closely apposed, or if any of the above local complicating factors are present, ossification of the callus does not occur and the two bone ends are joined by **fibrous tissue** (fibrous ankylosis) which is unstable forming what is called PSEUDO ARTHROSIS مفصل وهمي.

REMEMBER: ***Fracture may occur with minimal trauma if the underlying bone is abnormal.***

VEHICLE ACCIDENTS (RTA)

Trauma due to motor vehicle accidents is of major clinical and social importance. Damage inflicted is related to several factors, the most important of which are speed of travel, restraint, and protection from impact. There are three main types of injury caused by RTA:

1) **Injuries caused by sudden deceleration**. التوقف المفاجئ When a body is accelerated and then suddenly brought to a stop, the resulting internal stresses may cause severe damage.

   - *The aorta may be transected, leading to severe internal bleeding.*
   - *The brain may sustain internal tearing of white matter tracts.*

2) **Injuries caused by direct trauma**. These occur when a body impacts on parts of a vehicle or with road surfaces. There may be:

   - *Lacerations to face and hands from windshield glass.*
   - *Fracture of sternum and ribs from impact with steering column.*
   - *Fracture of legs from collapse of car frame, or from impact of car on a pedestrian.*
   - *Contusional damage and laceration of liver, spleen and lungs.*
   - *Contusions of brain and fracture of neck from impact damage to head.*

3) **Injury secondary to impaired cardiorespiratory function**. Blood loss, unconsciousness and interruption of the airway are common in victims of trauma and lead to secondary damage.

   - *Brain is extremely vulnerable to hypoxia, developing neuronal death.*
   - *Kidneys may develop tubular necrosis.*

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*Good Luck ^_^*