HOW FRACTURES HEAL?

Done by : Alaa khreisat
• 2 Types of Bone Formation

—— ENDOCHONDRAral

>Bone formation replaces a cartilage model.
>Bone (osteoprogenitor) cells arrive via Vascular buds.
>Examples: Long Bone (physeal) growth & Fracture repair

—— INTRAMEMBRANOUS

>Bone formation without a cartilage model (“flat bones”)
>Bone cells differentiate directly into Osteoblasts.
>Examples: clavicle, pelvis, skull
Fracture healing is characterized by a process of new bone formation with fusion of the bone fragments. The bone either heals by primary (without callus formation) or secondary (with callus formation) fracture healing.
A wide variety of factors can slow down the healing process. These include:

- Movement of the bone fragments_ excessive motion may lead to delayed or non-union. Weight bearing too soon
- Smoking, which constricts the blood vessels and decreases circulation
- Medical conditions, such as diabetes, hormone-related problems or vascular disease
- Some medications, such as corticosteroids and other immunosuppressants
- Fractures that are severe, complicated or become infected
- Advanced age
- Poor nutrition or impaired metabolism
- Low levels of calcium and vitamin D
- Type of bone involved
The mechanical strain applied across the fracture gap plays a major role in directing the healing response. Absolute stability and compression leads to direct healing (primary bone healing), while relative stability leads to indirect healing (secondary bone healing).

Clinical and experimental studies have shown that callus formation occurs in response to movement at the fracture site. It serves to stabilize the fragments as rapidly as possible – a necessary precondition for bridging by new bone formation. Therefore, most fractures are splinted in order to:

1. alleviate pain
2. ensure that union takes place in good position
3. permit early movement of the limb and a return of function.
HEALING BY DIRECT UNION(PRIMARY BONE HEALING)

If the fracture site is absolutely stable there is no stimulus for callus. Instead, osteoblastic new bone formation occurs directly between the fragments.

**Contact healing** where the exposed fracture surfaces are in intimate contact and held from the outset with absolute stability, internal bridging may occasionally occur without any intermediate stages.

**Gap healing** gaps between the fracture surfaces are invaded by new capillaries and osteoprogenitor cells growing in from the edges, and new bone is laid down on the exposed surface.

Where the crevices are very narrow (less than 200 μm), osteogenesis produces lamellar bone; wider gaps are filled first by woven bone, which is then remodelled to lamellar bone.

By 3–4 weeks the fracture is solid enough to allow penetration and bridging of the area by bone remodelling units, i.e. osteoclastic ‘cutting cones’ followed by osteoblasts.
absence of callus means that there is a long period during which the bone depends entirely upon the metal implant for its integrity, increasing the risk of implant failure. Moreover, the implant diverts stress away from the bone, which may become osteoporotic and may not recover fully until the metal is removed.
(a) by direct penetration of the fracture gap by a cutting cone

(b) by bridging callus.
Healing by callus, though less direct (indirect healing)
Has distinct advantages:
It ensures mechanical strength while the bone ends heal,
and with increasing stress the callus grows stronger and stronger (according to Wolff’s law states that bone grows and remodels in response to the forces that are placed upon it in a healthy person. After an injury to bone, placing specific stress in specific directions to the bone can help it remodel and become normal healthy bone again)
Surgical stabilization is not always necessary but it can prevent malunion.
Is the most common form of healing in tubular bones; in the absence of rigid fixation
FIG. 51-2 The stages of bone healing.
(From Ignatavicius DD, Workman LM: Medical-surgical nursing, ed 8, Philadelphia, 2016, Elsevier.)
Five stages of healing:

1-Haematoma formation – At the time of injury, bleeding occurs from the bone and soft tissues.

2-Inflammation – The inflammatory process starts rapidly when the fracture haematoma forms and cytokines are released, and lasts until fibrous tissue, cartilage, or bone formation begins (*1–7 days postfracture*). Osteoclasts are formed to remove the necrotic ends of bony fragments.

3-Soft callus formation – *After 2–3 weeks*, the first soft callus is formed. This is about the time when the fragments can no longer move freely. The strain applied to the cells in the fracture gap modifies their growth factor expression and progenitor cells are stimulated to become osteoblasts. The cells form a cuff of woven bone periosteally. The fracture can now still angulate but is stable in length.
4-Hard callus formation – When the fracture ends are linked together, the hard callus starts and lasts until the fragments are firmly united (3–4 months). Bone callus forms at the periphery of the fracture and progressively moves centrally.

5-Remodelling – The woven bone is slowly replaced by lamellar bone. This process can last from a few months to several years.
The periosteum is an excellent source of local mesenchymal stem cells that can enhance bone repair. For this reason it is imperative that, as much as it is possible, the periosteum is left in place and remains viable. This should be taken into account when considering direct contact plates that press against the periosteum, potentially damaging the vascular supply and leading to periosteal necrosis.
How long does a fracture take to unite?

No precise answer is possible because age, constitution, blood supply, type of fracture and other factors all influence the time taken. A spiral fracture in the upper limb takes 6–8 weeks to unite; in the lower limb it needs twice as long. Add 25% if the fracture is not spiral or if it involves the femur. Children’s fractures, of course, join more quickly. These figures are only a rough guide; there must be clinical and radiological evidence of consolidation before full stress is permitted without splintage.
Union is incomplete repair; the ensheathing callus is calcified. Clinically, the fracture site is painless on palpation and weight-bearing. X-rays show bridging callus. The fracture line is completely or almost obliterated and crossed by bone trabeculae. Repair is complete and further protection is unnecessary.
Delayed union is that fracture healing is not taking place at the expected rate and time but healing is still possible. Additional effort should be aimed at achieving fracture healing as fast as possible. Clinically, the fractured limb has local swelling and movement or partial weight-bearing is painful.

The rate of repair depends upon

- The type of bone involved (cancellous bone heals faster than cortical bone).
- The type of fracture (a transverse fracture takes longer than a spiral fracture).
- The state of the blood supply (poor circulation means slow healing), the patient’s general constitution (healthy bone heals faster)
- The patient’s age (healing is almost twice as fast in children as in adults).
Non-union is when a fracture fails altogether to unite. Unless there is bone loss, non-union is usually defined as fracture that has not healed 9 months post operation and there is no visible progress of healing during the last 3 months.

Causes are:

- Severe damage to soft tissues, rendering them non-viable (or nearly so).
- Distraction and separation of the fragments.
- Interposition of soft tissues between the fragments.
- Excessive movement at the fracture site.
- Poor local blood supply.
- Abnormal bone.
- Infection.
On X-rays, non-unions are typified by a lucent line still present between the bone fragments; sometimes there is exuberant callus trying – but failing – to bridge the gap (hypertrophic nonunion) or at times none at all (atrophic non-union) with a withered appearance to the fracture ends.