Fracture Healing

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A fracture occurs as a consequence of either a single event of mechanical overload or multiple smaller episodes as in stress fracture. Adult bone is brittle which means it undergoes very little plastic deformation before it breaks. Bone in children is more elastic and so can bend to a greater degree before a fracture occurs.

Fractures heal using one of two patterns depending on the rigidity of the stabilisation. Examples of non-rigid stabilisation would be a plaster cast or an intramedullary nail. One example of rigid fixation would be compression plating with an interfragmentary lag screw.

Healing in Unstable Conditions

In unstable situations, bone healing occurs with callus formation. One example of healing in this manner is long bone fractures treated in plaster. The process is divided into four stages:

1. **Inflammation**: Initially the fracture ends bleed, sometimes impressively. This quickly goes on to form a haematoma around the fracture site. The subsequent inflammatory response causes release of vasoactive factors which over the next 1-7 days produce a capillary network. A fibrin network begins to form.

2. **Soft Callus**: As movement at the fracture ends is reduced over the following 1-3 weeks the vascular network increases and fibrous tissue replaces the haematoma. Subperiosteal new bone formation begins.

3. **Hard Callus**: Calcification of the soft callus takes place over the 1- 4 months forming rigid calcified tissue.

4. **Remodelling**: Once the fracture is solidly united remodelling takes place over the following months to years with the new woven bone being replaced by lamellar bone and the medullary canal being restored.

The following x-rays show a tibial fracture healing by callus formation at 0, 2 and 9 months and then again at 10 years.

Stage 1 is not radiologically visible as the haematoma is not of sufficient density to be distinguishable from other soft tissues on x-ray.

Stage 2 is the earliest you will see evidence of callus formation on an x-ray. The two month x-ray is an example of a fracture late in this stage. Subperiosteal new bone can clearly be seen. This is the early formation of callus.

Stage 3 is clearly evident on x-rays and the 9 month x-ray demonstrates this. There is copious callus formation seen around the fracture site.

The remodelling of Stage 4 is seen to occur over many years but there is usually permanent evidence of a fracture seen on x-ray no matter how long ago it occurred. Comparing the 9 month x-ray with the one taken 10 years later, the extent of the remodelling can be seen and the medullary canal has re-formed.

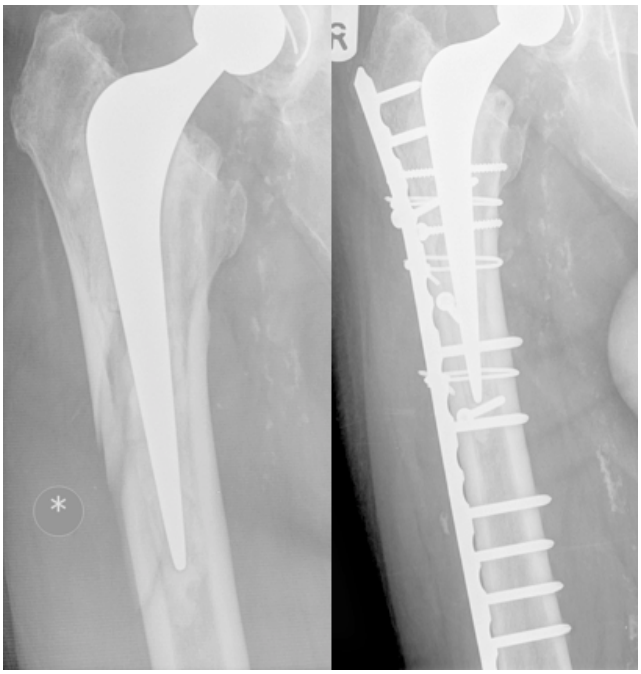
Healing in Stable Conditions

This situation exists in the presence of a surgical intervention which gives absolute stability to the fracture site. In practice the fixation should give interfragmentary compression which reduces the strain on the fracture site allowing for direct bone healing. It also obliterates any fracture gap as direct bone healing cannot occur if a gap is present.

Radiologically only minor changes are observed with a virtual absence of callus being one of the prominent features. The main radiological sign of healing is the gradual disappearance of the fracture itself on X-ray although in a perfectly reduced fracture even this may not be visible.

The following x-ray shows a patient who sustained a periprosthetic fracture of his total hip replacement. The fracture itself has some comminution. This was fixed very rigidly using compression from lag screws and cables, then neutralised with a locking plate.

Because all the fracture ends were compressed and the whole construct was very rigid it went on to heal by direct bone healing. The x-ray on the right is the same patient at 12 weeks. No callus can be seen but he was pain free and went on to mobilise normally. The fracture is healed.



In the first few days the haematoma is resorbed and over the following few weeks the Haversian system internally remodels the bone. Direct healing involves 'cutter cones' which traverse the fracture site. Behind these cones come new blood vessels and osteoblasts which allow new bone to be laid down.

This process takes significantly longer than healing with callus and does not give as biologically strong an outcome. However, what it does do is allow for much more accurate apposition of the healing fracture and prevents the formation of callus. This is important in fractures involving joints as incongruity of the two joint surfaces will quickly lead to a post traumatic arthritis.