PATHOLOGY OF FRACTURES AND FRACTURE HEALING

P. J. OKOTH

CLASSIFICATION OF FRACTURES

P. J. Okoth

Definition of fracture

- A bone fracture (#) is a **break in the continuity** of the bone.
- It may be a **complete** break or an **incomplete** break of the bone.
- A bone fracture can be the result of:
  - high force impact or stress, or
  - trivial injury as a result of certain medical conditions that weaken the bones, where the fracture is then properly termed a **pathological fracture**.

Classification of fractures

- Fractures can be classified according to:

1. Aetiology
2. Whether open or closed
3. Fracture pattern

CLASSIFICATION

- Fractures may be classified, according to their **aetiology**, into four groups:

1. **Traumatic fractures**
2. **Fragility fractures**
3. **Fatigue or stress fractures**
4. **Pathological fractures**

Classification…

1. **Traumatic fracture** - This is a fracture due to sudden injury or trauma. e.g.- Fractures caused by a fall, road traffic accident, fight etc.
   - They occur through bone that was previously free from disease.
   - May occur by direct violence or by indirect violence

Classification…

2. **Fragility fractures** – these are fractures associated with generalized bone weakness due to osteoporosis.
   - Seen most commonly in elderly patients

Classification…

3. **Fatigue or stress fractures** – occur from oft-repeated stress and not from a single violent injury.
   - Commonly occur in athletes or new military recruits
   - They occur when the rate of microdamage exceeds the rate of repair. The microdamage accumulates and progresses to a complete fracture across the full width of the bone.
   - Mostly occur in the metatarsals (mostly 2^{nd} and 3^{rd}).
   - May also occur in the shaft of fibula, tibia and neck of femur

Classification…

4. **Pathological fractures** – fractures through bone already weakened by disease.
   - Occurs following trivial violence, or even spontaneously.
   - Usually occur in conditions that weaken the bones, such as bone cancer, osteogenesis imperfecta, bone cysts, chronic bone infection.

CLOSED AND OPEN FRACTURES

- All fractures can be broadly described as:

1. **Closed (simple) fractures:**
   - Are those in which the skin is intact.
   - There is no communication between the site of fracture and the exterior of the body.
2. **Open (compound) fractures:**
   - There is a wound on the skin surface that communicates with the fracture.
   - may thus expose bone to contamination.
   - Open injuries carry a higher risk of infection.

PATTERNS OF FRACTURE

- Fractures can be designated by descriptive terms denoting the shape or **pattern** of the fracture.
- The following are the terms in common use:

1. **Transverse fracture**: A fracture that is at a right angle to the bone's long axis.
2. **Oblique fracture**: A fracture that is diagonal to a bone's long axis.

Patterns of fracture…

3. **Spiral fracture:** A fracture where at least one part of the bone has been twisted.
4. **Comminuted fracture:** A fracture in which the bone has broken into several pieces (more than 2).
5. **Compression or crush fracture:** usually occurs in the vertebrae, for example when the front portion of a vertebra in the spine collapses due to osteoporosis

Patterns of fractures…

6. **Greenstick fractures** – A greenstick fracture occurs when a bone bends and cracks, instead of breaking completely into separate pieces. They are peculiar to children below 10 years. Their bones are springy and resilient like branches of a young tree (a green stick)
7. **Impacted fractures** – the bone fragments are driven so firmly together that they become interlocked and there is no movement between them.

Patterns of fracture…

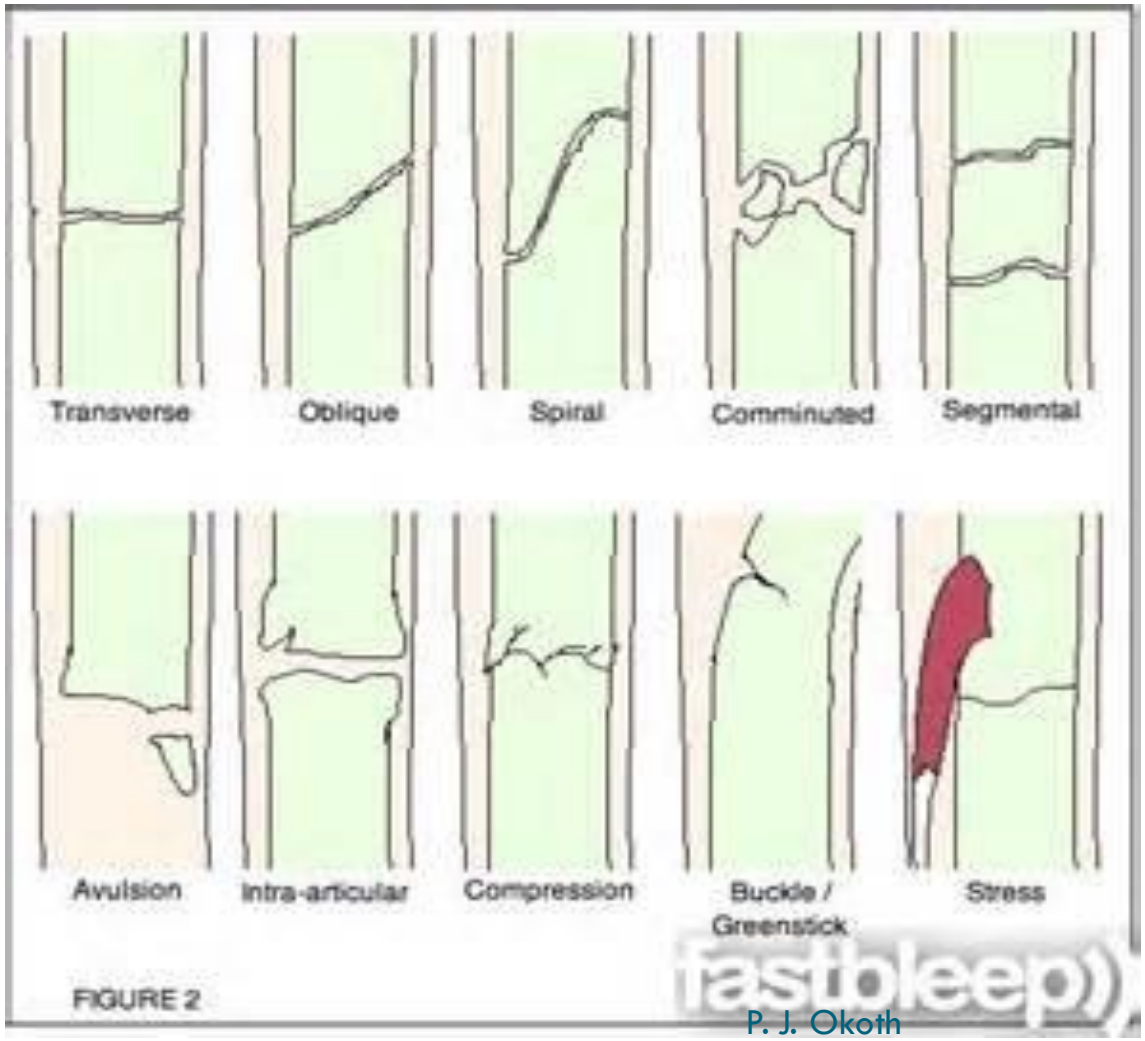
8. **Segmental fracture**

- **Segmental fracture** is a **fracture** composed of at least two **fracture** lines that together isolate a **segment** of bone, usually a portion of the diaphysis of a long bone.
- It is a comminuted fracture with middle fragment having the full circumference intact.

Fracture patterns…

9. **Avulsion fracture:** A fracture where a fragment of bone is separated from the main mass as a result of a tendon or ligament pulling off a piece of the bone.
10. **Linear fracture:** A fracture that is parallel to the bone's long axis.

Patterns of fractures …



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Fracture patterns

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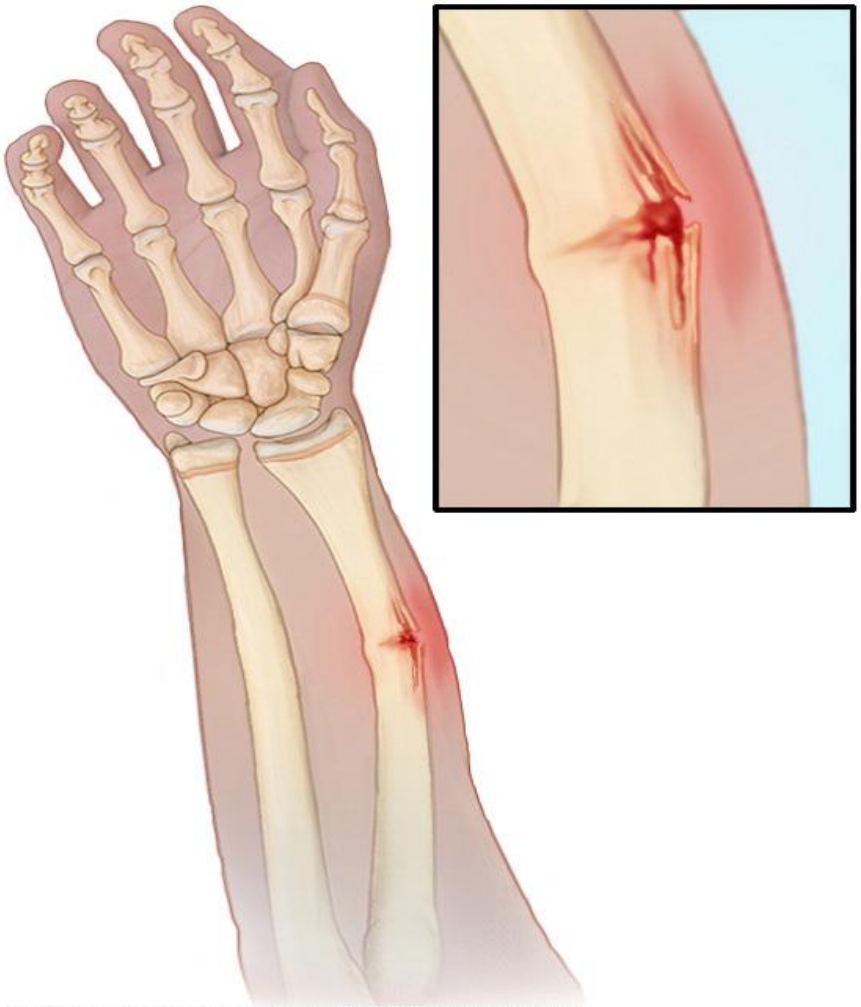
Greenstick fracture



Greenstick

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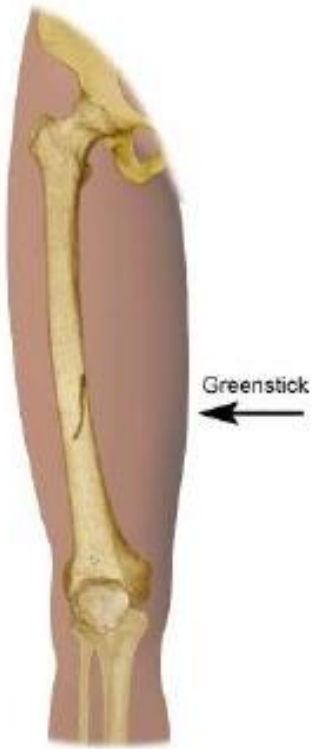
Greenstick Fracture



- Incomplete break where one side of bone is broken and the other side is bent
  - Results in a “bowing” appearance

Torus fracture

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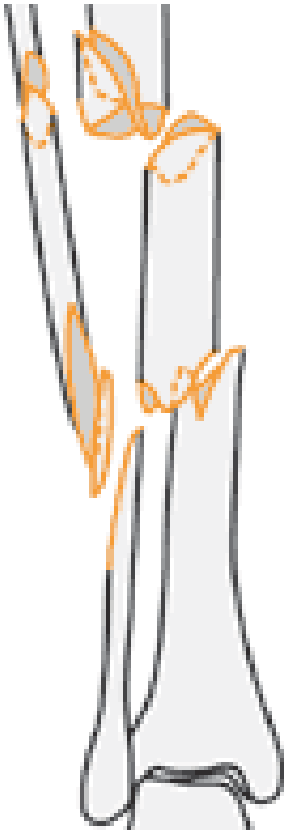
Segmental fracture



Segmental fracture

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Avulsion fracture

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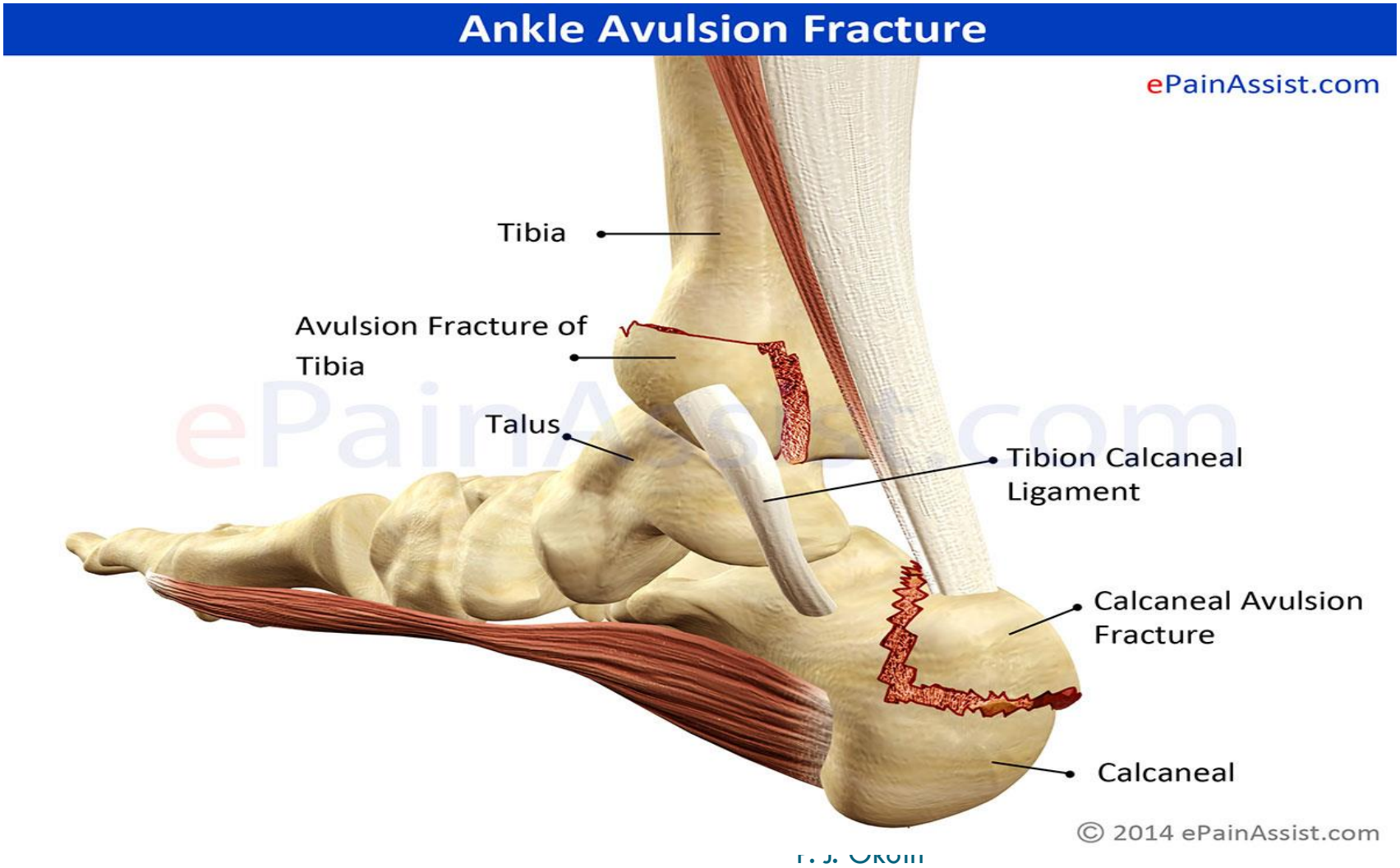
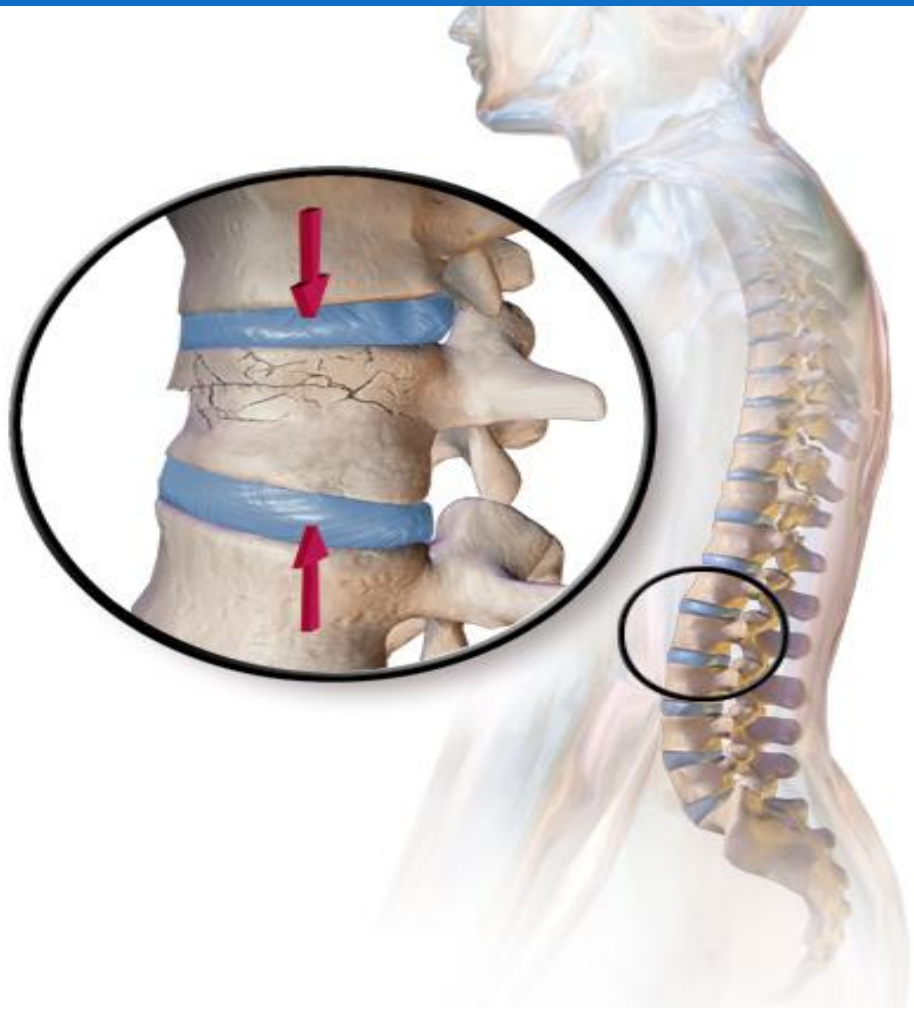
Avulsion fracture



Compression fracture



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HEALING OF FRACTURES

Mr. Okoth

Healing of fractures

A fracture begins to heal as soon as the bone is broken.

Healing proceeds through several stages until the bone is consolidated.

Fracture healing, is a proliferative physiological process in which the body facilitates the repair of a bone fracture.

REPAIR OF TUBULAR BONE

- Occurs in five stages:

1. Stage of haematoma
2. Stage of subperiosteal and endosteal cellular proliferation
3. Stage of callus
4. Stage of consolidation
5. Remodelling

Stage of haematoma

- Bleeding torn vessels form a haematoma between and around the fracture surfaces
- Haematoma is contained by the periosteum, which may be stripped up
- Where the periosteum is torn, the haematoma extravasates into soft tissues and is contained by muscles, fascia and skin.
- Deprived of blood supply, about 1or 2 millimeters of bone at the fracture surfaces dies.

Stage of subperiosteal and endosteal cellular proliferation

- Within 8 hours of the fracture there is an acute inflammatory reaction with migration of inflammatory cells and the initiation of proliferation and differentiation of mesenchymal stem cells.
- Cells proliferate from the deep surface of the periosteum and the breeched medullary canal [in the endosteum and marrow tissue].
- The cells are precursors of osteoblasts, which later lay down the intercellular substance.

Stage of subperiosteal and endosteal cellular proliferation …

- The cellular tissue form a collar of active tissue around each fragment, which grows out towards the other fragment and this creates a scaffold across the fracture site.
- The clotted haematoma is gradually absorbed and fine new capillaries grow into the area.

Stage of callus

- The differentiating stem cells give rise to osteoblasts and chondroblasts.
- The osteoblasts lay down an intercellular matrix of collagen and polysaccharide, which soon becomes impregnated with calcium salts to form the immature bone or osteoid of fracture callus.
- Osteoclasts also begin to mop up dead bone.

Stage of callus…

- As the immature fibre bone [woven bone] becomes more densely mineralized, movement at the fracture site decreases progressively and the fracture becomes rigid.
- At about 4 weeks after injury the fracture fragments unite and the fracture is said to be 'sticky'.
- The callus may be felt as a hard mass surrounding the fracture.
- The mass of callus is also visible in radiographs and gives the first indication of union.

Callus …

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Stage of consolidation

- With continuing osteoclastic and osteoblastic activity, the woven bone is transformed into lamellar bone [a more mature bone with a typical lamellar structure]

Stage of remodelling

- Newly formed bone often forms a bulbous collar which surrounds the bone and obliterates the medullary canal.
- The mass of callus tends to be large when:
  - There is marked periosteal stripping
  - When the fracture haematoma has been large
  - When there is marked displacement of the fragments.

Remodelling…

- The mass tends to be small when:
  - Bone fragments are in exact anatomical aposition
  - The fragments are rigidly fixed in close aposition by a metal plate with screws or by an intramedullary nail.
- Callus is usually profuse in children because the periosteum is easily stripped from the bone by extravasated blood, allowing bone to form beneath it.

Remodelling…

- In the months that follow, the bone is gradually strengthened along the lines of stress.
- Surplus bone outside the line of stress is slowly removed.
- The medullary cavity is gradually reformed.
- Eventually the bone assumes a shape as close to normal as possible.

Remodelling…

- In children, remodelling is usually so perfect that eventually the site of the fracture becomes indistinguishable on radiographs.
- In adults the site of fracture is usually permanently marked by an area of thickening or sclerosis.

REPAIR OF CANCELLOUS BONE

- Healing of cancellous bone follows a different pattern from that of tubular bone.
- Because the bone is of uniform spongy texture and has no medullary canal, there is a relatively much broader area of contact between the fragments, and the open meshwork of trabeculae allows easier penetration by bone forming tissue.
- Union can occur directly between the bone surfaces and it does not have to take place through the medium of external callus.

Repair of cancellous bone…

- The first stage of healing is the formation of a haematoma, into which new blood vessels and proliferating osteogenic cells from the fracture surfaces penetrate until they meet and fuse with similar tissue growing out from the opposing fragment.
- Osteoblasts then lay down the intercellular matrix, which becomes calcified to form woven bone.

Assignment

- Discuss the rate of union of fractures, outlining factors that influence the speed of union.
- Classify the common causes of pathological fractures.

- REFERENCES:
  - Adam's Outline of Fractures
  - Apley's System of Orthopaedics and Fractures
- **THE END!**