

Fracture Union

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Aims

- Discuss the types of fracture healing and the pathophysiology of this
- Discuss the types of failure of healing
- Discuss the factors affecting healing
- Discuss the treatment principles

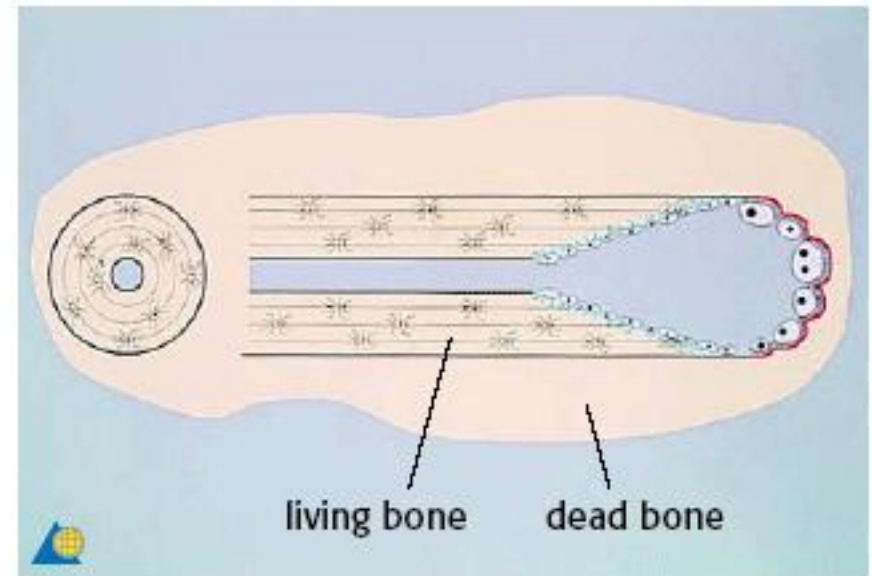
- Fracture
 - Bone absorbs greater amount of energy under mechanical loading than it can withstand, resulting in cortical discontinuity.
- Fracture healing
 - To completely restore the prior micro and macroscopic appearance of the bone without scarring.

Types of fracture healing

- Primary fracture healing
 - Direct
 - Anatomic reduction and absolute stability
 - Rigid fixation
 - Compression plating, lag screws
- Secondary fracture healing
 - Indirect
 - Non absolute stability
 - Semi rigid/ non rigid fixation
 - Ex Fix, IM nail, bridging plate

Primary fracture healing

- Absolute stability ensured
- Minimal action at fracture site
- Haematoma resorbed and swelling subsides
- Haversian remodelling occurs
- Osteons
 - Tip – osteoclasts
 - Remove dead bone
 - Behind – osteoblasts
 - Form new bone
 - Connected to capillaries behind
- Bridge the fracture gap



Secondary fracture healing

Haematoma formation



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graph TD; A[Haematoma formation] --> B[Inflammation]; B --> C[Proliferation and Differentiation]; C --> D[Ossification]; D --> E[Remodelling];
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The diagram illustrates the five stages of secondary fracture healing as a vertical sequence of five dark blue rectangular boxes. Each box is slightly offset to the right from the one above it, creating a descending staircase effect. The text inside each box is white. Small, light grey downward-pointing arrows are positioned between the boxes, indicating the flow from one stage to the next.

Inflammation

Proliferation and Differentiation

Ossification

Remodelling

Haematoma formation

- Rupture of periosteal and endosteal vessels and soft tissue trauma
- Blood fills fracture site
- Regional hypoperfusion
- Bone necrosis at fracture site
 - Unless adequate collateral circulation
- Triggers coagulation cascade
- Haematoma forms
 - Platelets
 - Macrophages
 - Release cytokines (PDGF, Interleukins, prostaglandins)

Inflammation

- Inflammatory mediators released from haematoma and necrotic/injured cells
- Dilates blood vessels
- Increased vascular permeability
 - Migration of inflammatory cells
 - Further cytokine release
- Activation of osteoclasts
 - Resorption of necrotic bone and debris
- Migration of fibroblasts
 - Haematoma → granulation tissue
 - New fibrin matrix
 - New capillary network forms

Proliferation and Differentiation

- Migration of osteoblasts
 - Primitive mesenchymal cells
 - Proliferate
 - Differentiate into cells with osteogenic potential
 - Forming callus to bridge the fracture site

Ossification

- Endochondral ossification (soft callus)
 - Differentiation to form cartilage
 - Type II collagen
 - Increase of osteocalcin
 - Chondrocytes undergo atypical apoptosis
 - New extracellular matrix (type I collagen – osteoid)
 - Calcification of the matrix
 - Bone replaces the soft callus
- Intramembranous ossification (hard callus)
 - Early synthesis of osteocalcin
 - Direct synthesis of type I collagen
 - New extracellular matrix
 - Calcification of matrix
 - Bone replaces the hard callus

Remodelling

- Disorganized mineralized woven bone must be remodelled to withstand appropriate force
- Woven bone is replaced by lamellar bone
 - Ordered micro-architecture
 - Destruction of excess bone
 - Strength along stress lines

Fracture union

- Clinical union
 - Pain free
 - Stability of fracture site
- Radiological union
 - Plain radiographs
 - Trabeculae or cortical bone crossing fracture site

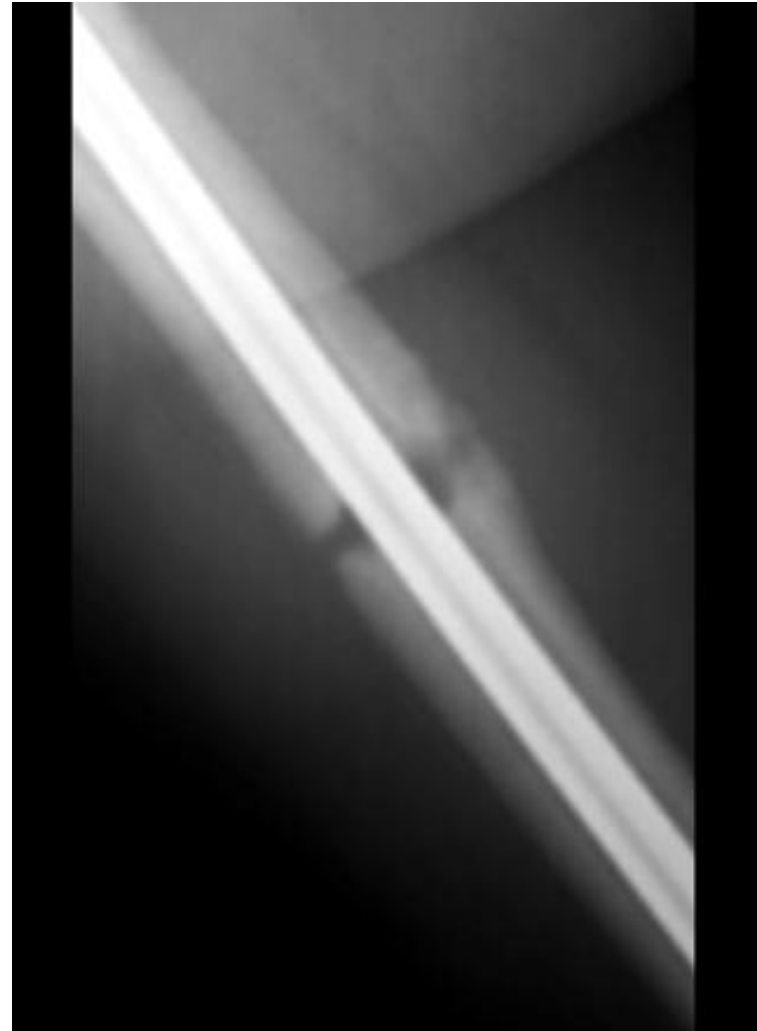
Failure of fracture healing

- Non union
 - Symptomatic fracture with no apparent potential to heal without intervention
 - Hypertrophic
 - Atrophic
- Delayed union
 - A fracture in which healing hasn't occurred in the expected time and the outcome remains uncertain
- Pseudoarthrosis
 - Painless fracture that has failed to unite and has no potential to do so

- Hypertrophic non union



- Atrophic non union



Factors Affecting union

SYSTEMIC

- Age
- Nutritional status
- Vitamin deficiencies
- Systemic diseases
 - Diabetes
- Drugs
- Smoking
- Alcohol
- Obesity
- Poor functional level

LOCAL

- High energy impact
 - Soft tissue damage
 - Bone loss
 - Open fractures
- Infection
- Fracture location
- Fracture type
- Poor local blood supply
- Soft tissue interposition
- Loading of fracture
- Stability
- Fixation/surgical methods
- Pathological fractures

Diagnosis

- **History**
 - Pain at fracture site
 - Functional requirements
 - Questioning related to potential cause
- **Examination**
 - Mobility of the fracture + ROM
 - Warmth
 - Scars
 - Sinuses
 - Shortening/lengthening
- **Investigations**
 - **Blood tests**
 - Infection
 - Systemic disease
 - **Plain radiographs**
 - Union
 - Malalignment
 - Further displacement
 - Adequacy of fixation
 - Loosening / failure
 - **CT**
 - **MRI**
 - Implants can degrade image quality

Treatment principles

- Restore pain free function
- Improve systemic features where possible

- Straighten
- Stabilize
- Stimulate
- Sterilize

- Complex or recurrent failures
 - Early referral to specialist

Summary

- 2 types of fracture healing depending on fixation methods and stability
- Multiple factors affecting fracture healing
- Best treatment for non union is prevention



Any Questions?

References

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