FRACTURE HEALING

DEFINITON OF FRACTURE

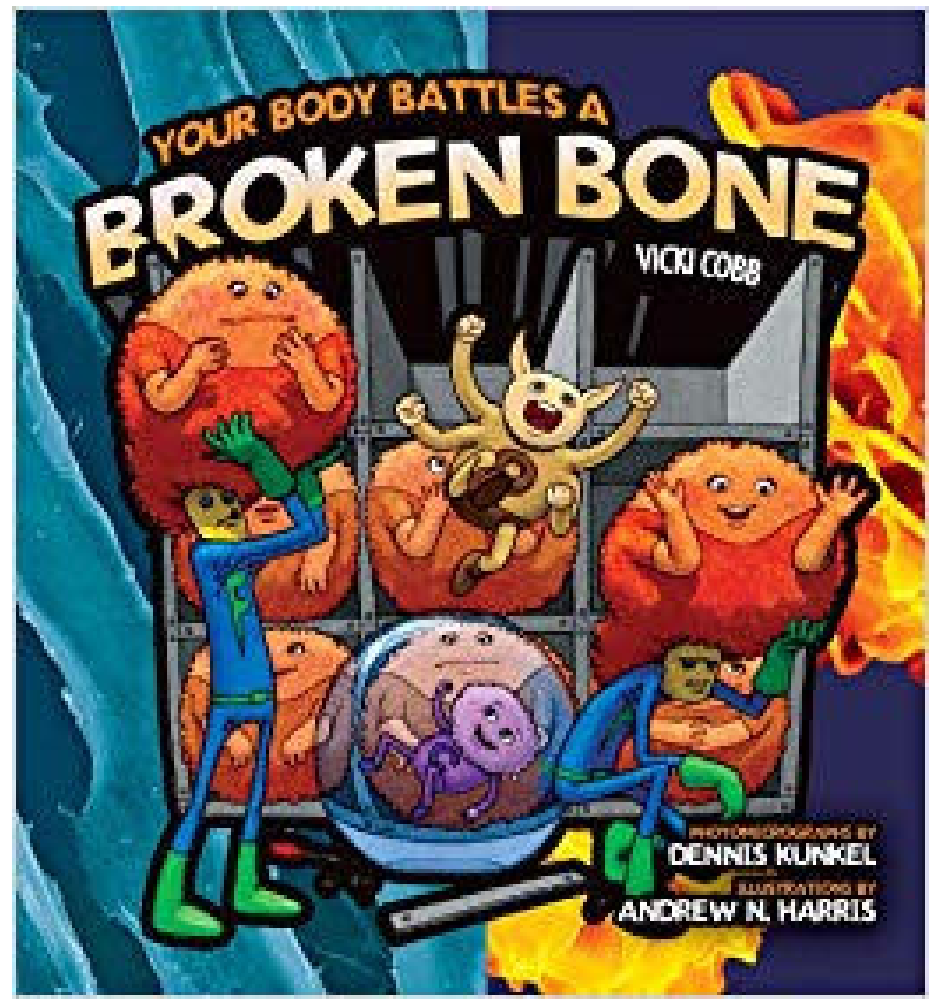
It’s a break in the continuity of bone

With partial or total disruption of blood supply to the region of bone

Seen radiologically as uni or bicortical break.

DEFINITION OF FRACTURE REPAIR

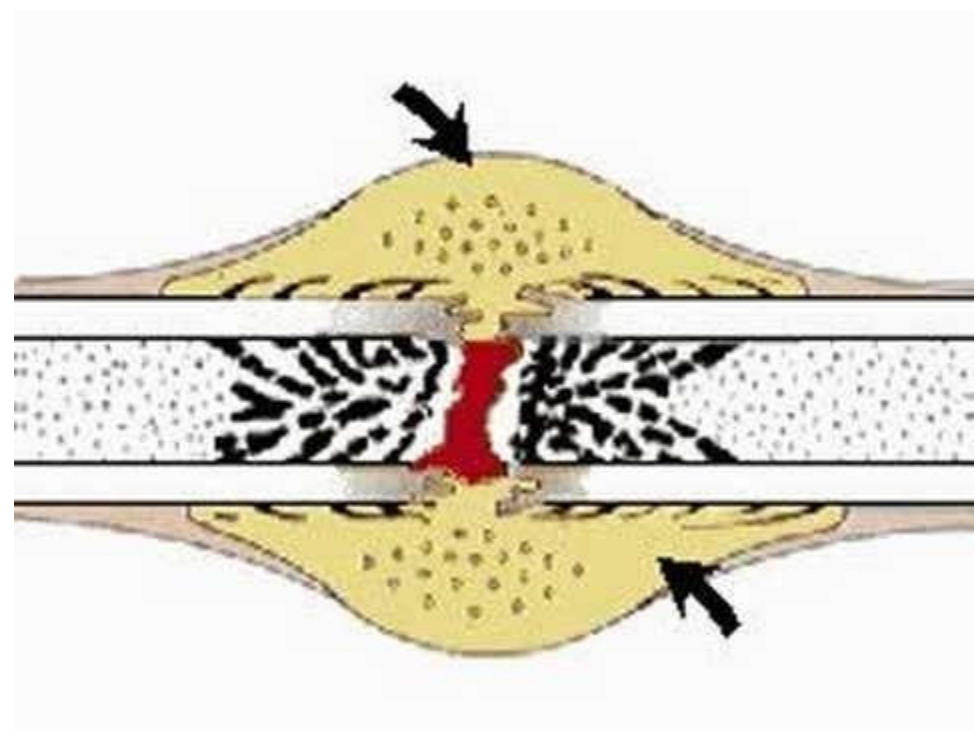
Is a systematic and organized cascade of events for the regeneration of tissue with influence of local and systematic factors



FRACTURE REPAIR

It’s a regenerative process rather than healing

As the defect is replaced by new bone rather than scar tissue.



FRACTURE REPAIR

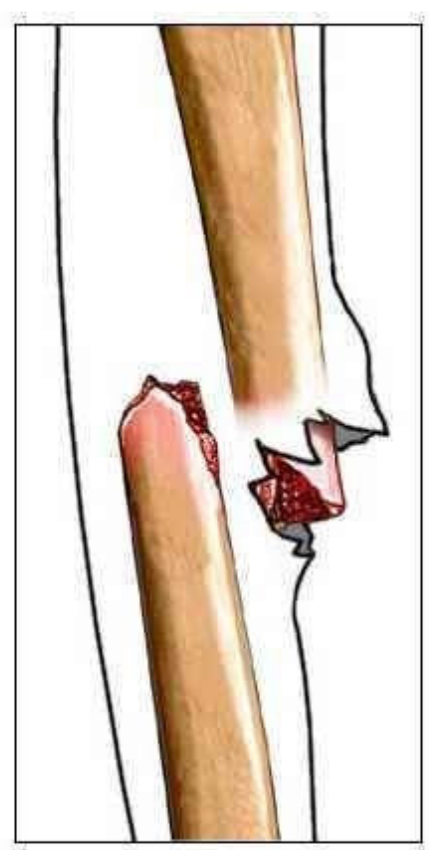
It’s a continuous process in which bone is

Formed
↓
Replaced
↓
Remodeled

FACTORS AFFECTING FRACTURE REPAIR

Local factors

1. Type of bone (normal or pathological)
2. Type of fracture (open or closed)
3. Intra articular fracture
4. Surrounding soft tissue injury
5. Single or both bone fracture
6. Local bone pathology like cyst
7. Infection
8. Venous stasis
9. Type of treatment and fixation



FACTORS AFFECTING FRACTURE REPAIR

Systemic factors

1. Age
2. Activity level
3. Nutritional status
4. Hormonal factors
5. Vitamin and mineral deficiency
6. Diabetes mellitus
7. Patient on drugs like chemotherapy, steroids
8. Smoking
9. Alcohol abuse
10. Head injury

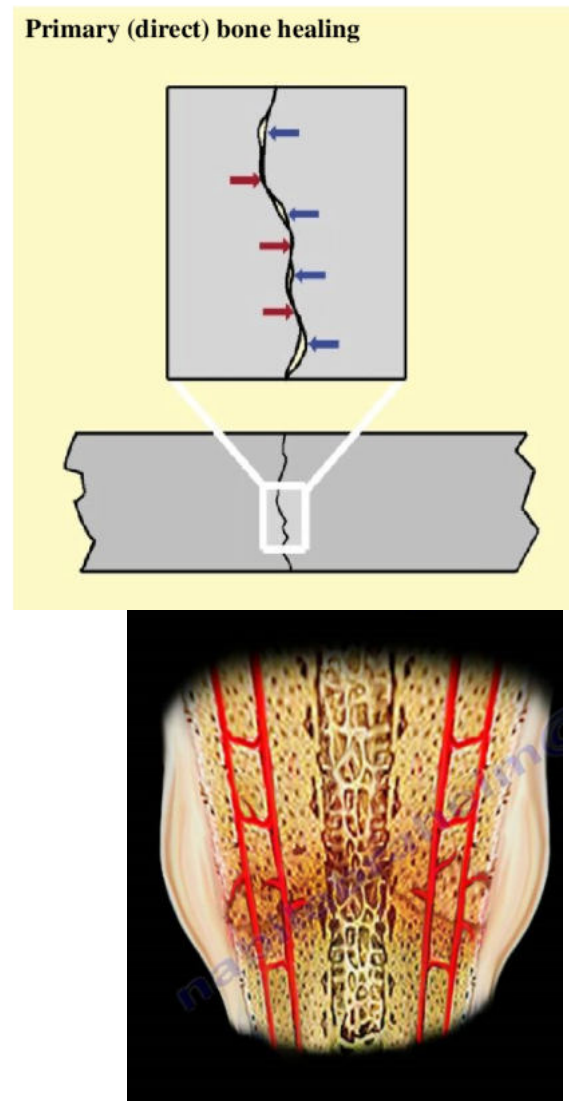
TYPES OF FRACTURE REPAIR

3 types

1. Intramembranous repair (direct bone healing)
2. Creeping substitution
3. Repair with bone callus formation (indirect bone healing)

INTRA MEMBERANEOUS REPAIR

- No callus formation
- Bone heals directly
- Seen in rigid fixation such as plating
- This occurs when the gap after fixation is below 500 microns
- Cutting cones crosses from one side to another



INTRA MEMBERANEOUS REPAIR

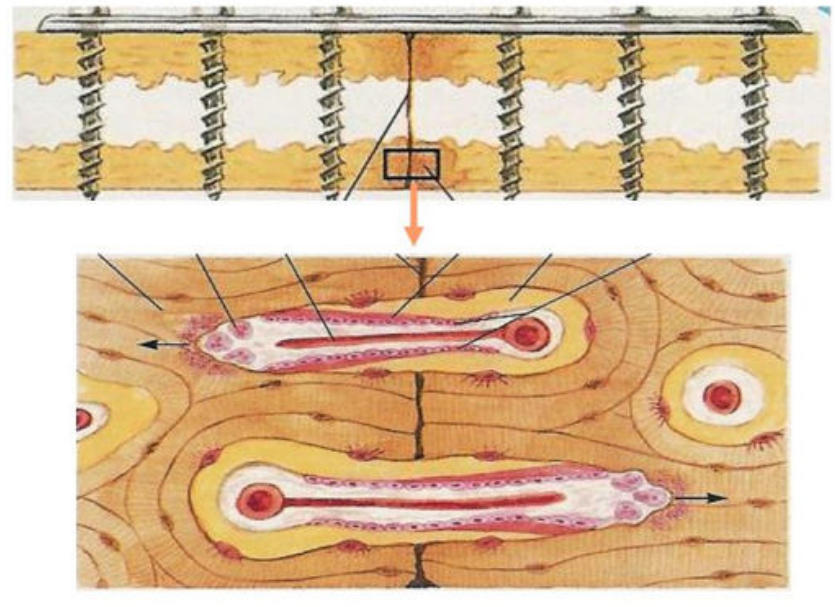
Healing passes through following stages

1. **Resorption of bone ends-** due to compression at fracture site
2. **Fibrous tissue formation-** formed from healing hematoma

   composed of collagen

3. **Maturation to lamellar bone-**

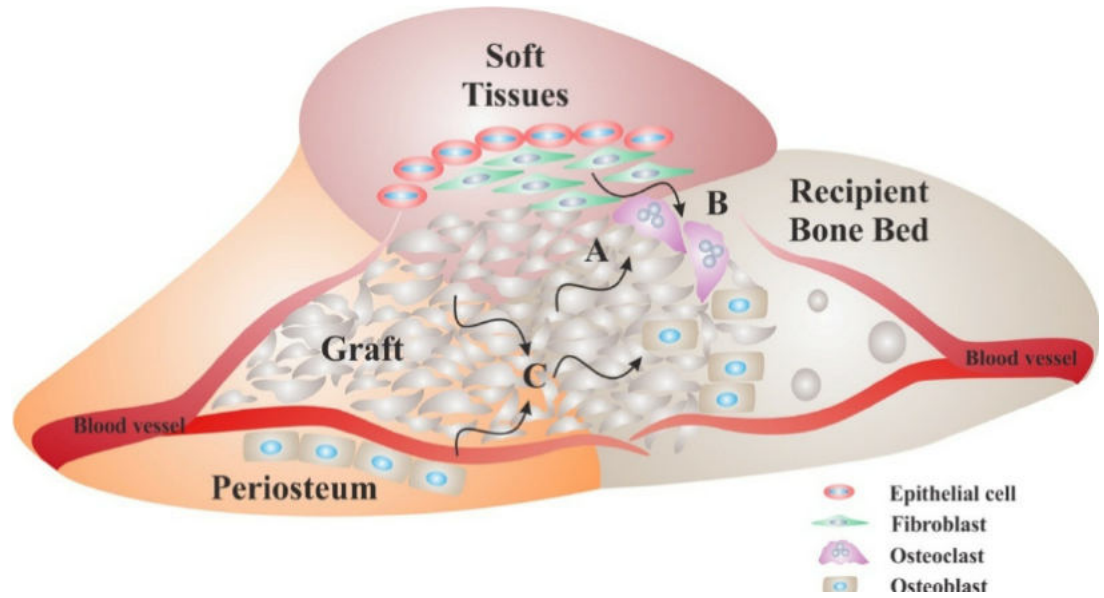
Haversian remodeling occurs across fracture site. Osteoclastic front is followed by osteoblastic ossification and laying of thin capillaries.



CREEPING SUBSTITUTION

Primarily seen in cancellous bone

Seen around intra and peri articular fractures



It’s a process of resorption of trabecular network

Lying of new bone by appositional ossification on the surface of scaffold

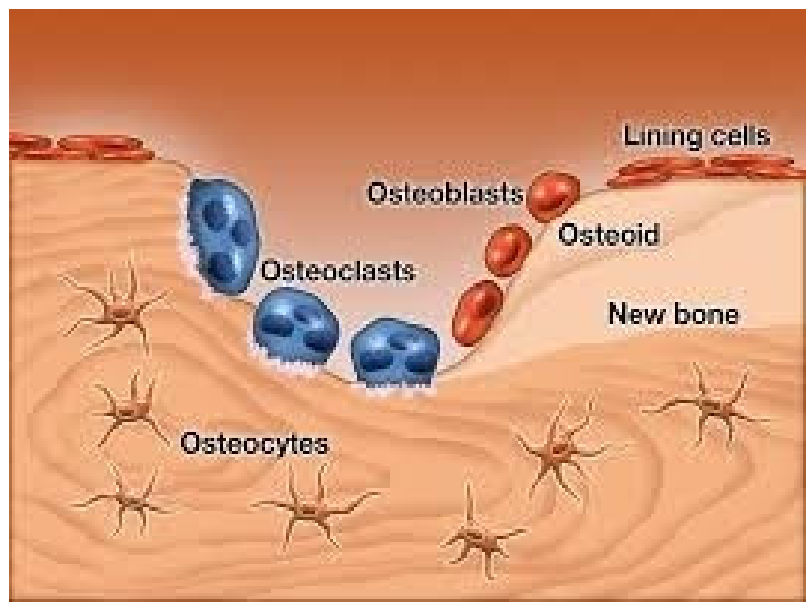
The inflammatory cells and granulation tissue creeps and new bone is thus formed

CREEPING SUBSTITUTION

This sandwich of necrotic bone surrounded by viable new bone is remodeled

Gross architecture of the bone is maintained

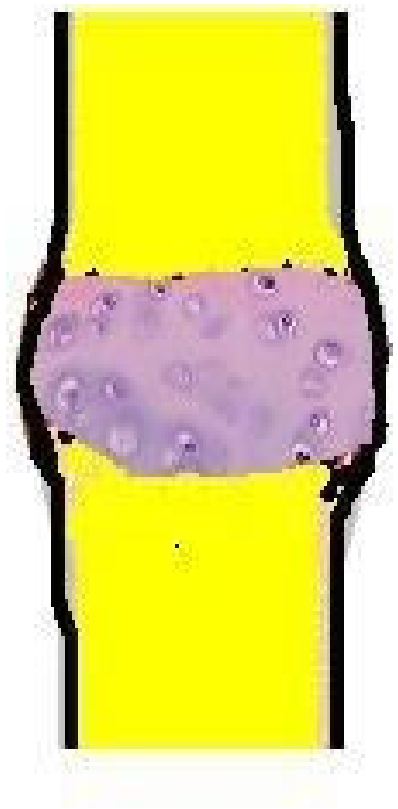
Scaffold is copy pasted by new living bone



SECONDARY BONE HEALING

This refers to passing through the stage of callus formation

Callus is pre-ossification cartilage tissue which is formed in response to controlled motion over fracture site



SECONDARY BONE HEALING

Three stages

1. **Reactive (Inflammatory) stage**

a) Hematoma formation

b) Granulation tissue formation

2. **Reparative stage**

a) Callus formation → soft callus
→ hard callus

a) Consolidation

3. **Remodelling stage**

INFLAMATORY STAGE

Hematoma formation

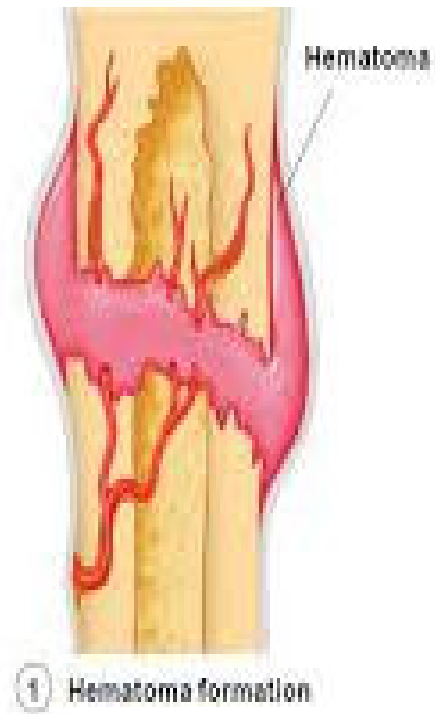
Blood leaks into the surrounding tissue due to disruption of vessels, periosteum and endosteum

↓

Induces local inflammatory response

↓

Starts regional acceleratory phenomenon



INFLAMATORY STAGE

Stage of hematoma formation

Osteoblast comes from bone marrow and mesenchymal cells from cambium layer of periosteum

↓ BMP

Osteoclast come from hematopoietic cells of bone marrow

↓ BMP

Migrate to the fracture focus

↓ TGF-beta and platelet derived growth factor

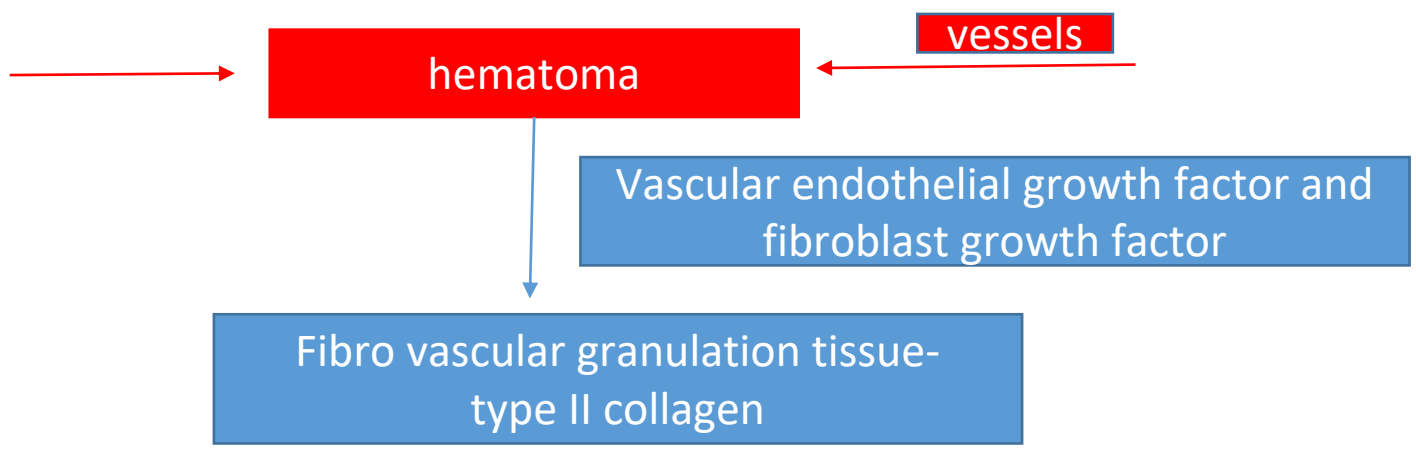
Colony forming unit fibroblast

↓

Granulation tissue

INFLAMATORY STAGE

Granulation tissue formation



This stage last for 2 weeks

REPARATIVE STAGE

It comprises of two stages-

Callus formation stage → soft callus (primary callus)
→ hard callus

Consolidation (lamellar bone deposition)

REPARATIVE STAGE

Callus formation-

It’s a regenerative tissue formed in response to micro motion at the injury site.

The formation is combined effect of four distinct healing responses

- Bone marrow
- Bone cortex
- Periosteum
- External soft tissue

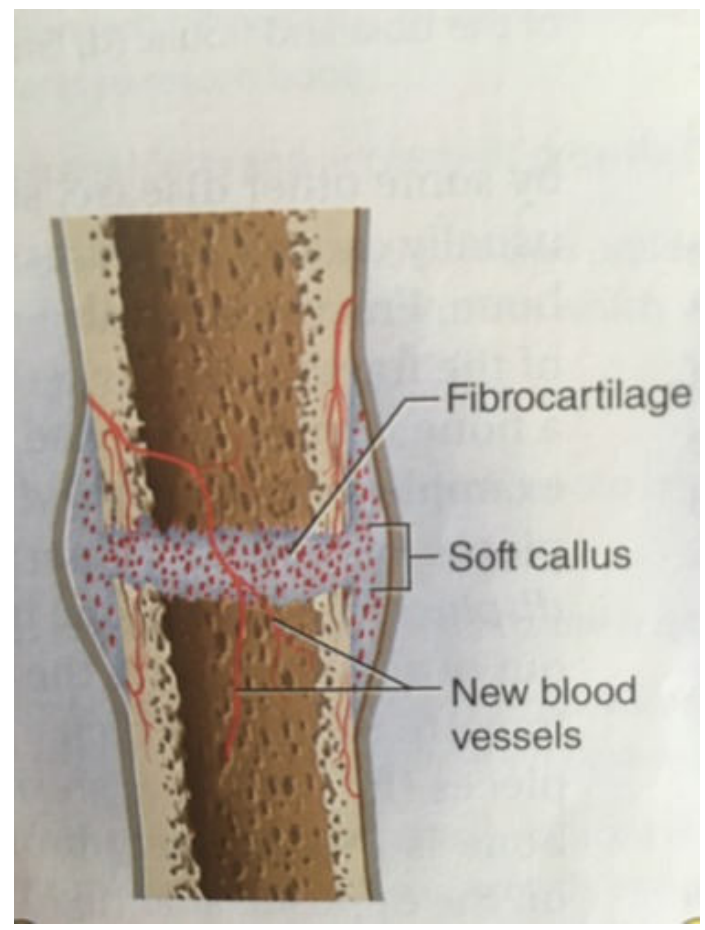
REPARATIVE STAGE

Soft callus-

Starts forming after 2 weeks

4 types-

1. Periosteal bridging callus
2. Intramedullary callus
3. Intercortical uniting callus
4. External soft tissue callus



REPARATIVE STAGE

Periosteal bridging callus

Cells from cambium layer develop into osteoblast and deposit the organic matrix

Intramedullary callus

Laid down from inside the bone
It's a double concave shape
Predominant response during gap repair

REPARATIVE STAGE

Intercortical uniting callus

Occupy the space between opposed cortices of fracture ends

External soft tissue response

Develop from vascular mesenchymal tissue like muscles and is important in fracture repair

REPARATIVE STAGE

Hard callus

Transformation of woven bone into primary lamellar bone

Commences in 4th week and finishes around 16th week.

The amount of callus formed depends on the oxygen tension and strain pattern (treatment)

REPARATIVE STAGE

Consolidation

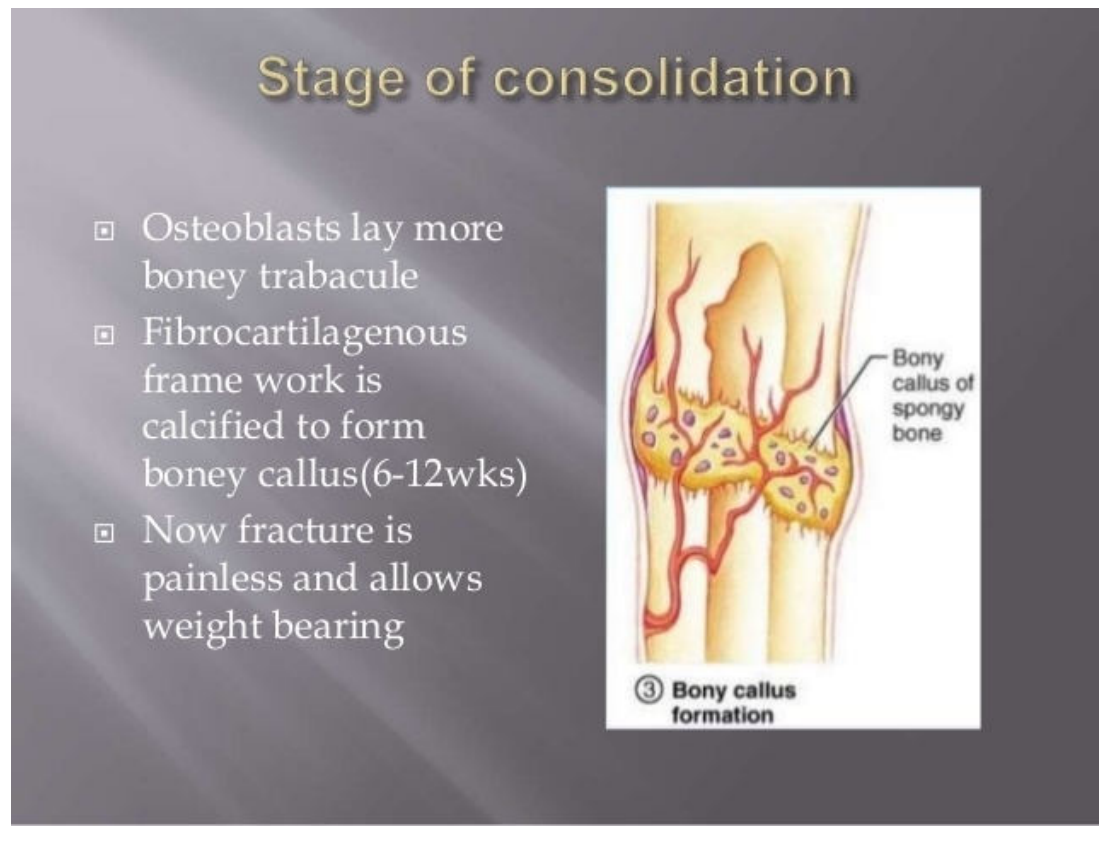
(lamellar bone deposition)

Type II collagen is replaced by type I collagen.

Followed by mineralization of the collagen. **(osteoid)**

Enchondral ossification- formation of lamellar bone over hyaline cartilage

Bone substitution- formation of lamellar bone over woven bone.



REMODELLING

Recycling of minerals (calcium and phosphate)

Conversion of primary lamellar bone

Secondary lamellar bone

May last upto 7 years

Osteoclast with their cutting cones

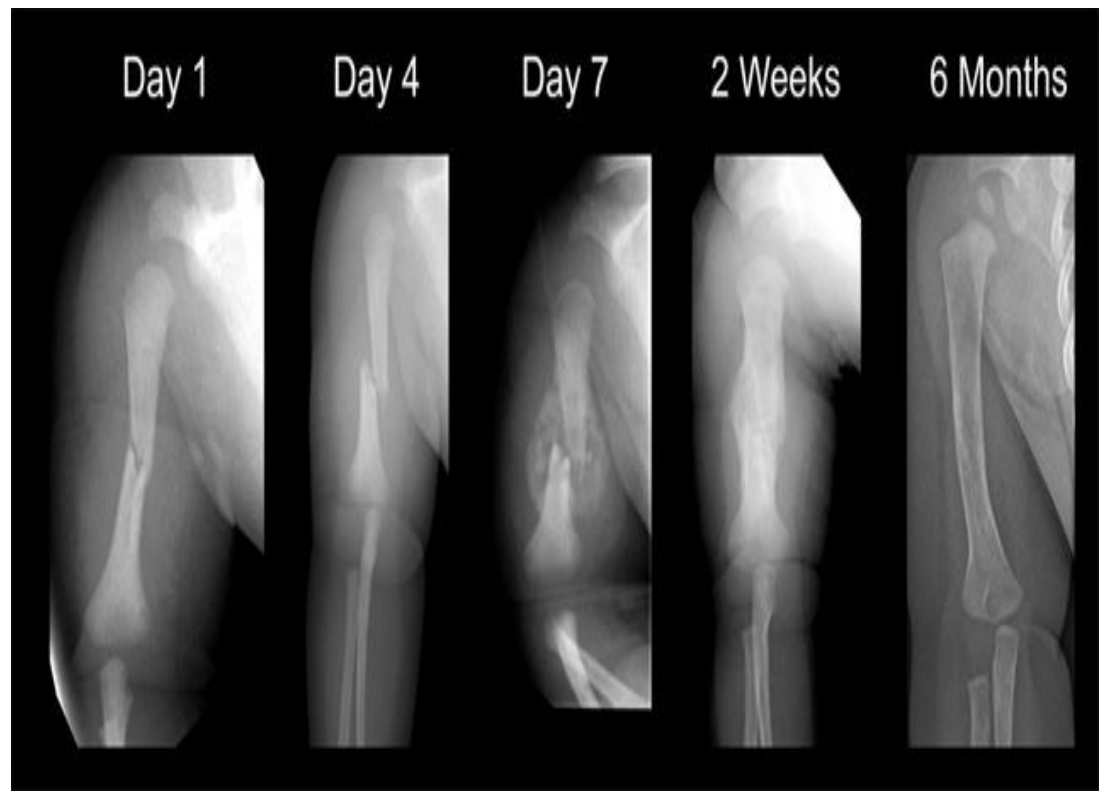
Resorbs the bone and form howship lacunae

According to the functional load and stress(wolff's law)

Osteoblast then grows and lay down the lamellar bone

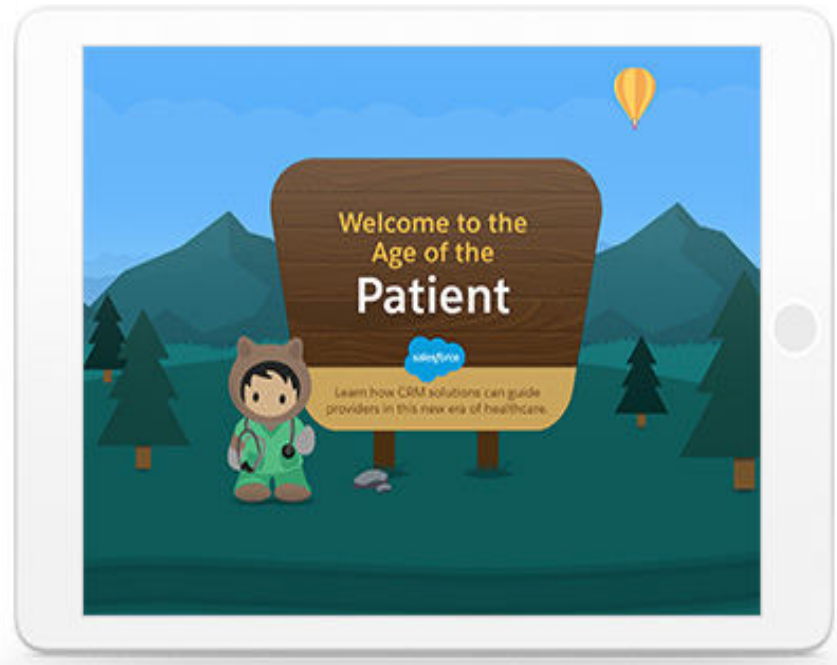
FACTORS AFFECTING REMODELLING

- Proximity to appendicular skeleton
- Juxta physeal deformity (more bone deposition on concave side and bone resorption at convex side). So any deformity near the physis have more chances of remodeling
- Presence of deformity near the particular physis. Remodeling is more when present near proximal humerus than distal humerus.



FACTORS AFFECTING REMODELLING

- Fracture location- fracture near the metaphysis remodels faster.
- Age of the patient
- Pathological bone



FACTORS AFFECTING FRACTURE REPAIR

Method of treatment

Absolute stability, rigid fixation, low strain environment

↓

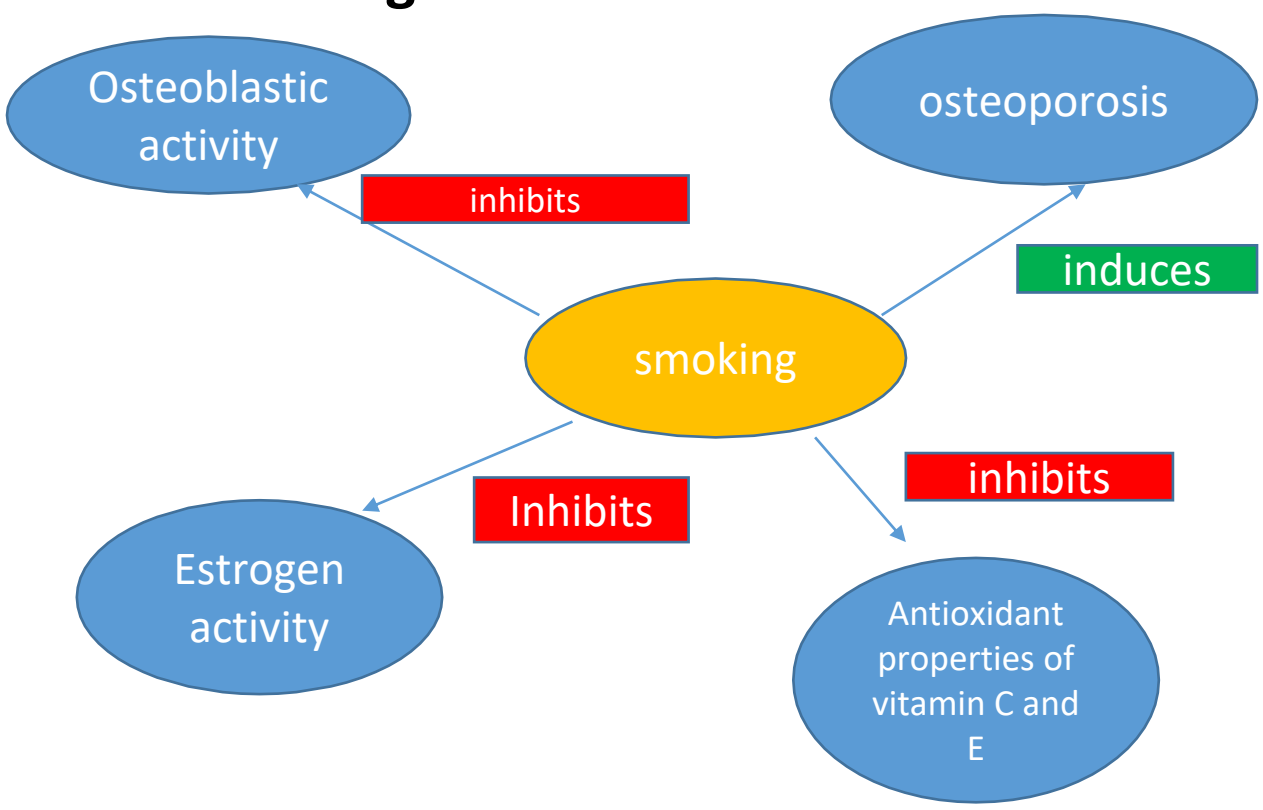
Primary fracture repair

Affect of age and site of fracture

Fracture heals faster in children by 1.5 to 2 times than in old age

FACTORS AFFECTING FRACTURE REPAIR

Smoking



Radiation

can cause

1. Osteoradionecrosis
2. Fractures
3. Bone growth changes
4. Radiation induced cancers

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Indications-

- Skeletal defects after tumor resection
- Reconstruction of bone defects after failed joint arthroplasty
- Reconstruction of congenital bone defects
- Obliteration of cystic cavity of bone
- Repair of fresh fractures with bone loss.
- Treatment of non union
- Arthrodesis of joints.

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Provide

Latticework for ingrowth of host bone- **osteoconductive**

Supply living osteogenic cells- **osteogenic property**

Growth factors to induce bone formation- **osteoinduction**

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Types of graft-

1. Cancellous graft
2. Cortical graft
3. Cortico- cancellous graft
4. Auto graft
5. Syngraft
6. Allograft
7. Xenograft
8. Synthetic graft

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Sites of obtaining cancellous bone auto graft

1. Iliac crest
2. Proximal tibia
3. Trochanteric region of femur
4. Distal condyle of femur
5. Olecranon process of ulna
6. Distal radius styloid process.

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Sites for obtaining cortical bone auto graft

1. Fibula
2. Tibia proximal half

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Types of allograft-

1. Fresh
2. Fresh frozen
3. Freeze dried (lyophilized)
4. Osteochondral allograft
5. Large composite graft