

Non Union & Bone Grafting

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Definition

- Non union- When the fracture is not united, its non union.
- USFDA- 9 months post injury and no visible signs of union for last 3 months
→
- Non union – The fracture has not united in expected period of time for that particular bone and is unlikely to get union without intervention.
- Delayed Union- multiple (Retrospect) When there are some signs of union, but signs are not progressing adequately. There is delay in healing process.

Fracture Healing

Skin → fibrous.
Organ — fibrous.

- Primary

Bone → Bone.

- Secondary

✓ ↓
Callus (+)

Primary

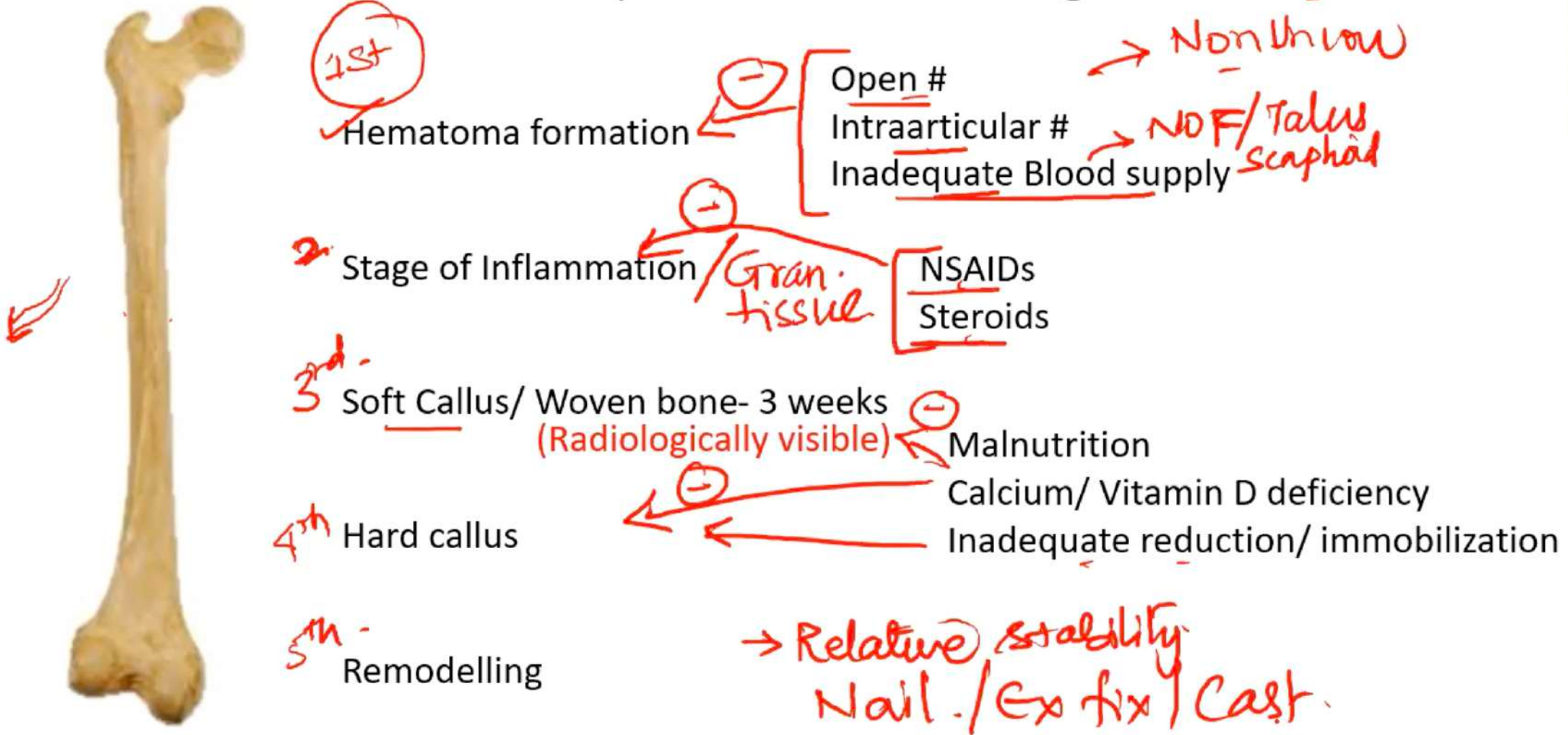
- Direct bone union
- Callus absent
- ☒ Absolute stability
- ☒ Plate fixation



Osteoclasts forms Cutting cones which resorb bone and osteoblasts forms new bone in gap.

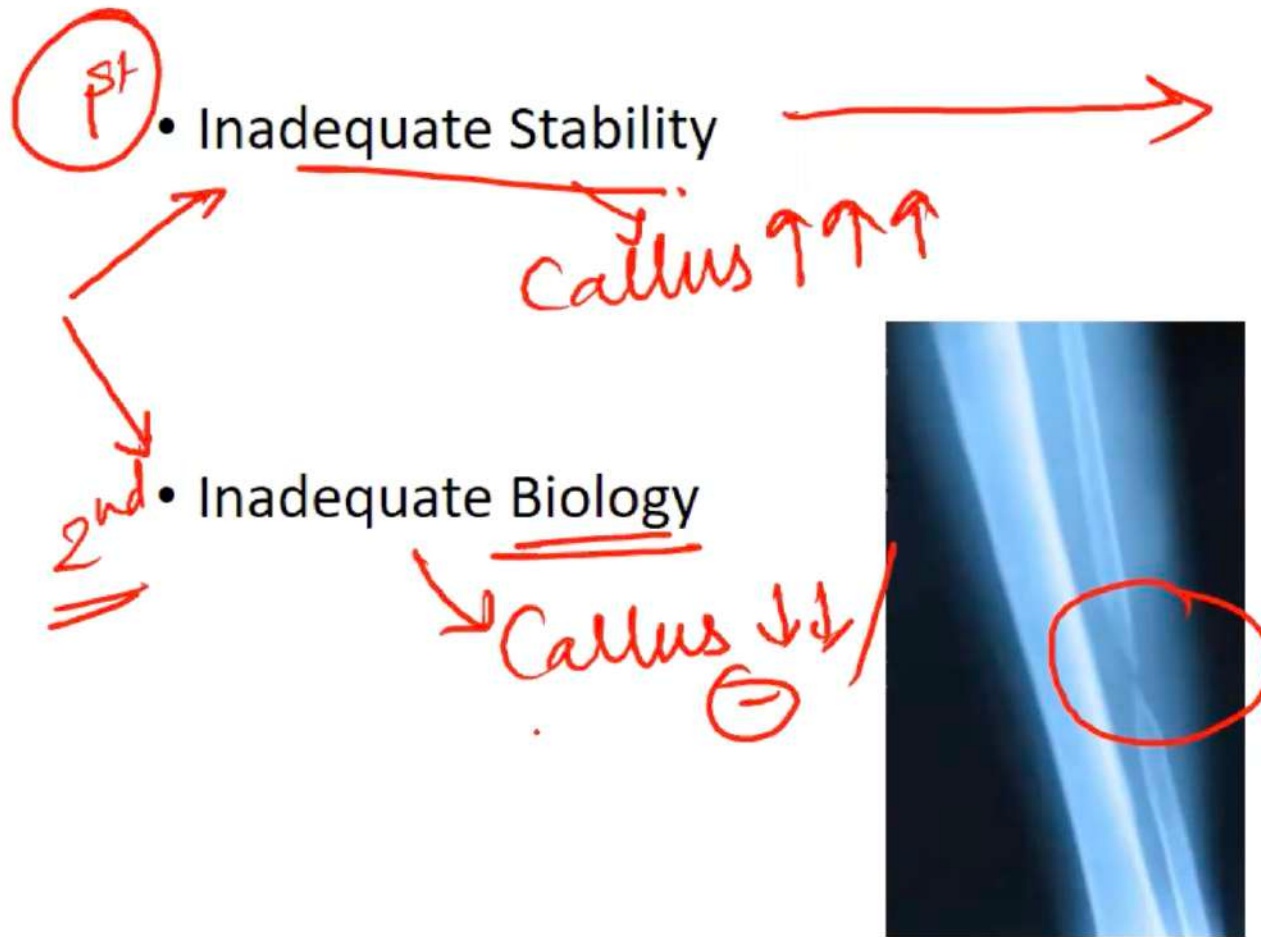
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Secondary Fracture Healing



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Mechanism of Non union



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Open #



Intra-articular #



Reduced Vascular supply
(NOF, Talus scaphoid)



Fracture factors



Bone loss

Segmental/ Comminuted #

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Age



Smoking (Nicotine)

Diabetes



Vascular disease

Host factors

Immunosuppression



Vitamin D deficiency

Treatment Factors

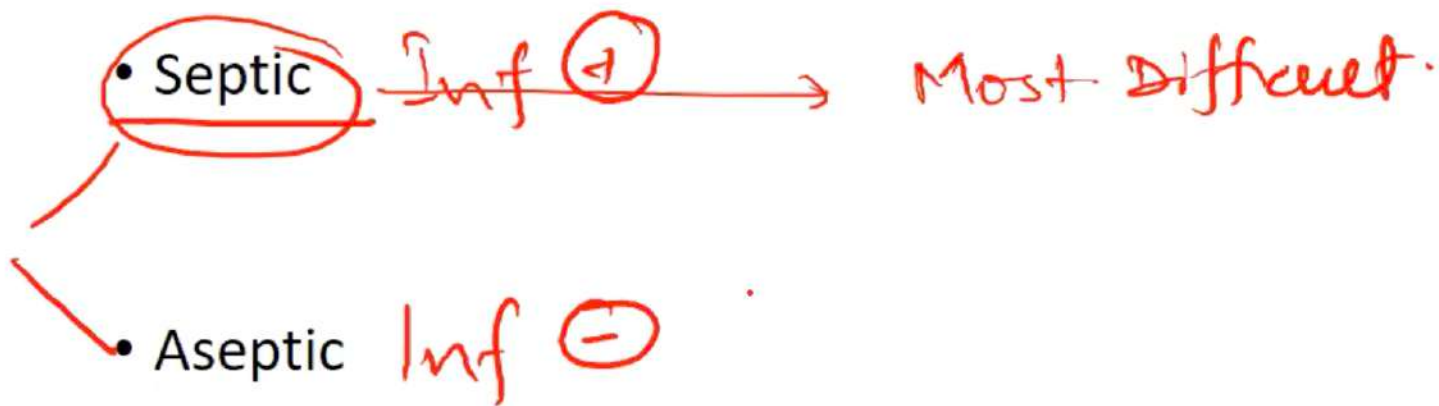
- Inadequate Reduction
- Inadequate Stability/
Immobilization
- Soft tissue interposition
- Soft tissue stripping



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Classification of Non union

- ✓ Based on Infection-



Based on viability of ends (Weber and Cech)

- Based on Strontium 85 uptake → vascularity
- Hypervascular (Hypertrophic)
- Avascular (Atrophic)

Hypervascular/ Hypertrophic



Elephant Foot

vase. ↑
 callus ↑ -
 Stability lacking.



Horse Hoof

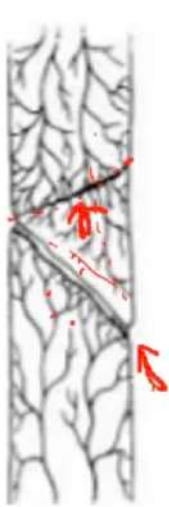
vascularity ↑
 Callus mod.
 St. ↓



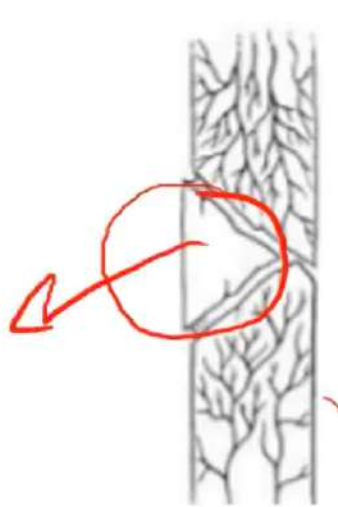
Oligotrophic

↓
 No
 callus
 Vase ↑

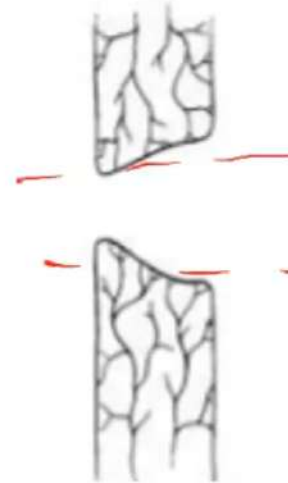
Avascular / Atrophic



Torsion Wedge



Comminuted



Defect/ Gap



atrophic



→ vasc. ↓
callus ↓
Biology lacking → Bone Grafting

Pseudoarthrosis

Hypertrophic non union with synovial pseudocapsule
due to excessive chronic motion at # site

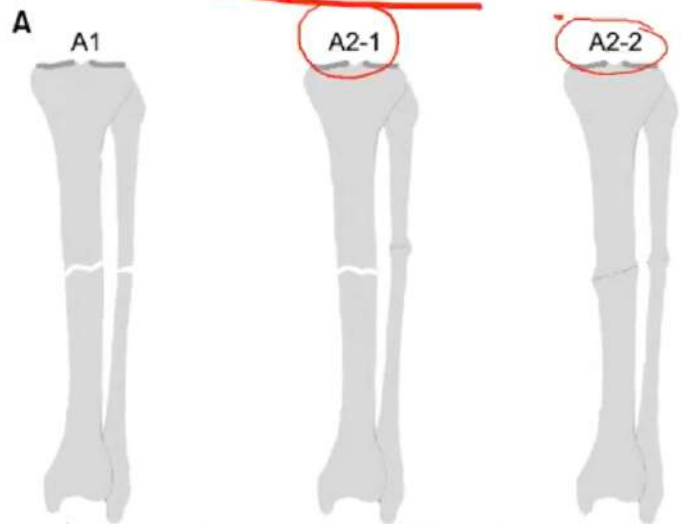
Rx- Debridement with IF with BG



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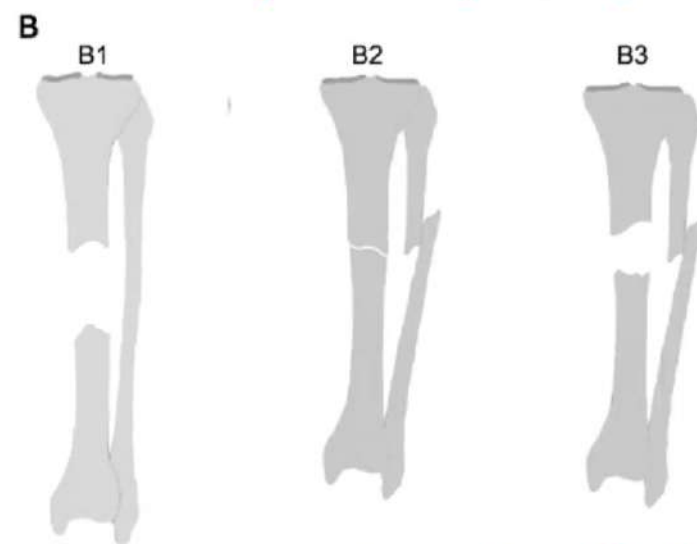
Paley Classification

<1cm Bone loss.



~~loss/~~
mobile - contd. → BG (+)
stiff - i def - → BG (-)

>1cm loss.



Defect. Shortening Both

Diagnosis

- History And examination
- History of Open #
- Mechanism of injury
- History of prior Infection
- H/O previous surgery- Autologous Bone grafting – Site
- Risk factors- Smoking, Tobacco, radiation etc



Xray

- Gap Gap Torso
- T - Tapering
- O obliterated
- R - Rounder
- S - Sclerosis
- O blurred / Deformity



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Xray



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CT

- More accurate
- Disadvantage – low specificity, False positive high –

unnecessary
Sx.



Treatment

- Decide what is lacking and what you want-

- Mechanical stability

- Plate
- Nail
- External Fixator

BG ⊖

Hypervascular

- Biological stimulus

- Bone Graft
- Bone Graft Substitutes

Avascular

Non operative

Delayed union Vs Non union

Ideal case for non operative therapy-
Bone alignment maintained,

Hypertrophic non union

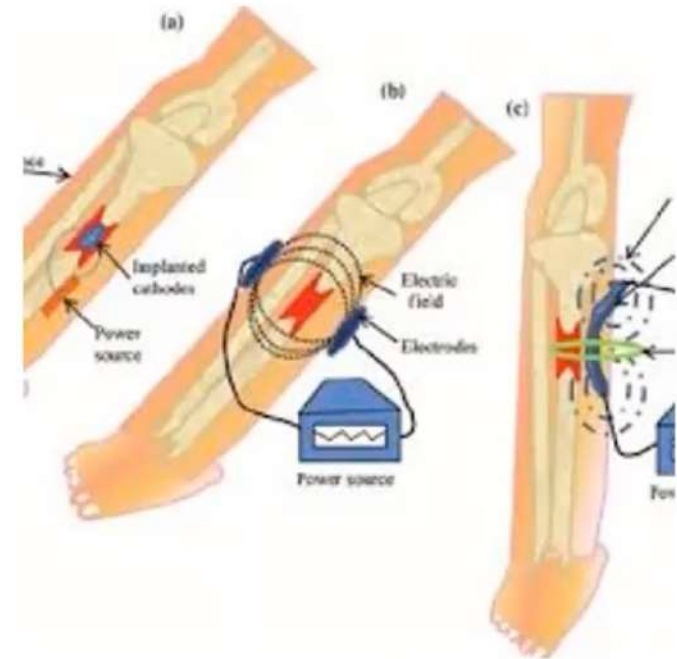
Time to union will not have significant morbidity.



Weight Bearing

PTB Cast

Direct Intervention



Electrical stimulation

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ULTRASOUND



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Stop Smoking



Nutrition

Indirect Interventions



Stop Drugs



Multivitamin

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Providing the Mechanical stability

- Fixation choice –
- Nail
- Plate
- Ex Fix
- Nail + Plate

Nailing

- Preferred in Diaphysis non union

- Primary nailing
- Exchange nailing
- Dynamization

Exchange nailing

- Indications -
 - Bone defect,
 - rotationally unstable (# screws)
 - undersize nail

Angulation shouldn't be there. It will remain as it is

- Tips -
 - 1/ 2 mm overreaming
 - Different company nail
 - Static locking

Dynamization

- Removal of interlocking screws at one end of nail
- Indications - When there is a gap at # site –
due to resorption
distraction in index surgery

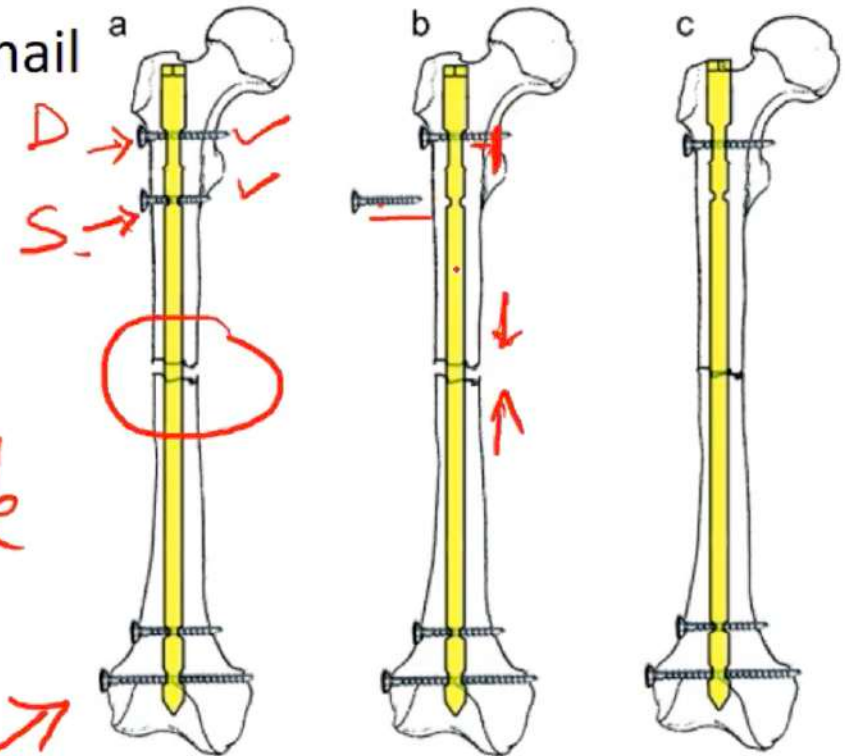
Two ways –

1. Removal of only static screw-

rotationally stable
min. comp.

2. Removal of all screws

max. comp.
not unstable -
penetrate



- When to do?? → 3-6 months -
- Which end to do? –
→ long bone fragment

Plate and screw construct

- Preferred in Metaphysis non union
- Limitations-
- Invasive
- Soft tissue compromise
- Load bearing – protected weight bearing in post op
- Eccentric extramedullary – chance of implant failure is high
- Inability to correct limb shortening from bone loss



Nail + Plate (Augmentation plating)



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External fixation

- Ilizarov Ring Fixator-
- Gold standard for DDD- Defects, Decrease bone length, Deformity
- Immediate weight bearing
- Multiplanar deformities can be corrected
- Shortening can be treated.
- Soft tissues are protected



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Arthroplasty

- Old age
- Periarticular / Intraarticular non union
- Joint arthrosis



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Amputation

- When amputation has more benefits than non union treatment



Fragment excision

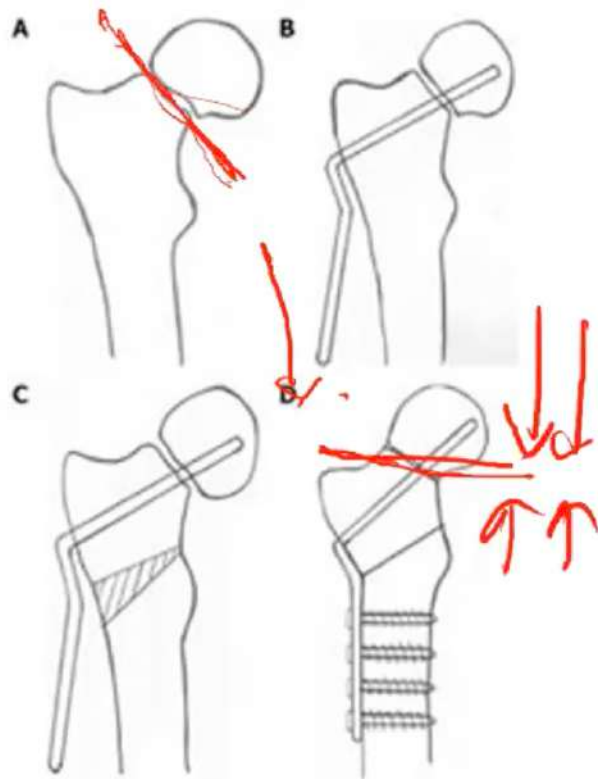


- Girdle stone excision arthroplasty for infected Non union neck femur



Radial head # not feasible for arthroplasty

Osteotomy



Valgus osteotomy for
neck femur non union

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→ Fibula osteotomy for tibial non union

Level ?? — Same — IF
diff — Cast

Tibialization of fibula

- Huntington's procedure



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Providing Biologic stimulus

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Bone Graft

• Autograft

(same individual)

- No disease risk
- Easily available
- Cost nil

- ☒ Donor site infection
- ☒ Another surgery

• Allograft

(diff. ind.)

- ☒ No donor site morbidity
- If high volume graft required

- ☒ Availability issues
- ☒ Risk of Infection
- Costly

• Xenograft

(diff. species)

Properties of Bone Graft

- ① • Osteoconduction - Surface / Scaffold.
- ② • Osteoinduction - Growth factors / Proteins
- ③ • Osteogenesis → Cells -

Suitable donor site

Autograft (C, DL, OG)

✓ Anterior crest - Iliac crest Bone Graft

• Posterior crest

✓ Femoral condyle

✓ Tibial condyle

✓ Olecranon

✓ Distal radius

• Bone marrow (RIA)

60-80ml



Reamer Irrigator Aspirator

Bone Graft Substitutes

autograft

- No donor site morbidity

- Unlimited supply $\rightarrow$ (OC/OI)

Collagen + Proteins A
(Ca/PO₄)_x

- ① • Demineralised Bone Matrix (Decalcified allograft)
(OC/OI)

- ② • Bone Morphogenic Protein (BMP) $\rightarrow$ recomb. BMP-2 & 7
(OI)

- ③ • Bone marrow aspirate (Mesenchymal Stem cells)
(OG)

- ④ • Ceramic $\rightarrow$ CaSO₄, CaPO₄ $\rightarrow$ (OC)

- ⑤ • Polymers $\rightarrow$ PGA/PLA $\rightarrow$ (OC)

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Ceramics

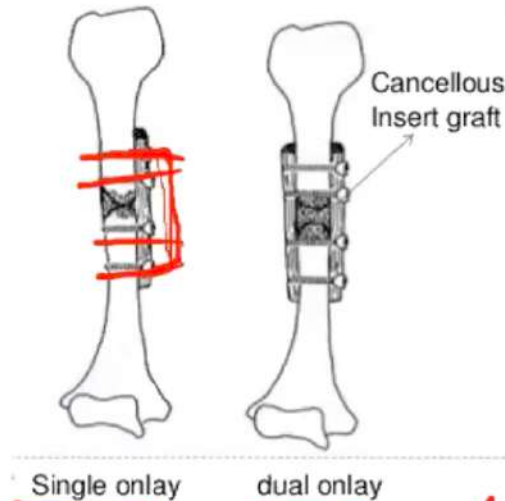
- Calcium Phosphate
- Calcium sulphate
- Beta tricalcium phosphate
- Hydroxyapatite

- Osteoconduction



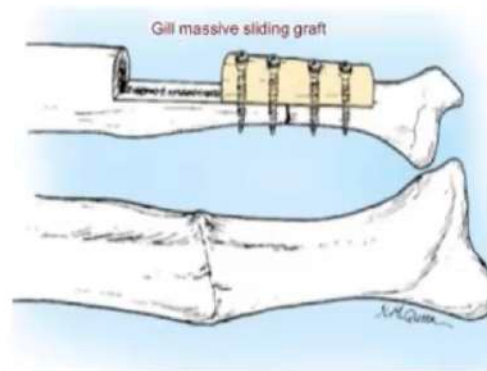
Techniques of Bone Grafting

- Onlay (Phemister)
(Boyd)



- Cancellous Insert
(Nicoll) (Block)

- Sliding (Gill)



Blair

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Articular non union

- Arthritis and/or Joint Instability

Yes

No

Age

Old Age

Young Age

- Arthroplasty

- Arthrodesis/
Excisional arthroplasty

- Non union treatment

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Defect Non union

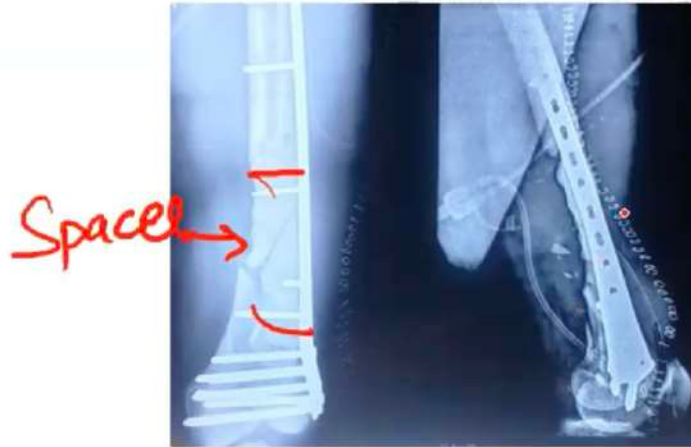
- Causes-
- Post traumatic bone loss
- Bone resorption at # site
- Post Tumor resection
- Post sequestrectomy



Masquelet technique

- 2 stage –
- 1st stage - Fixation + cement Spacer for 4-6 weeks
- 2nd stage – Spacer removal and Bone graft inside membrane

Induced membrane



- Spacer role ?
 - Why membrane is formed ?
- fibrosis = infection*
Not known



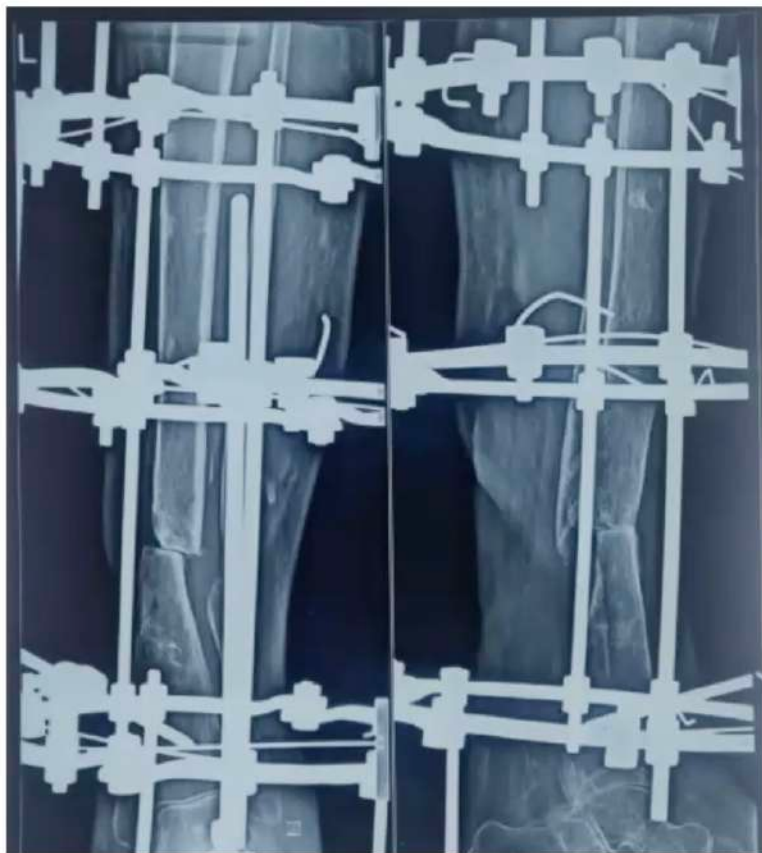
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Fibula Graft for Bone defect



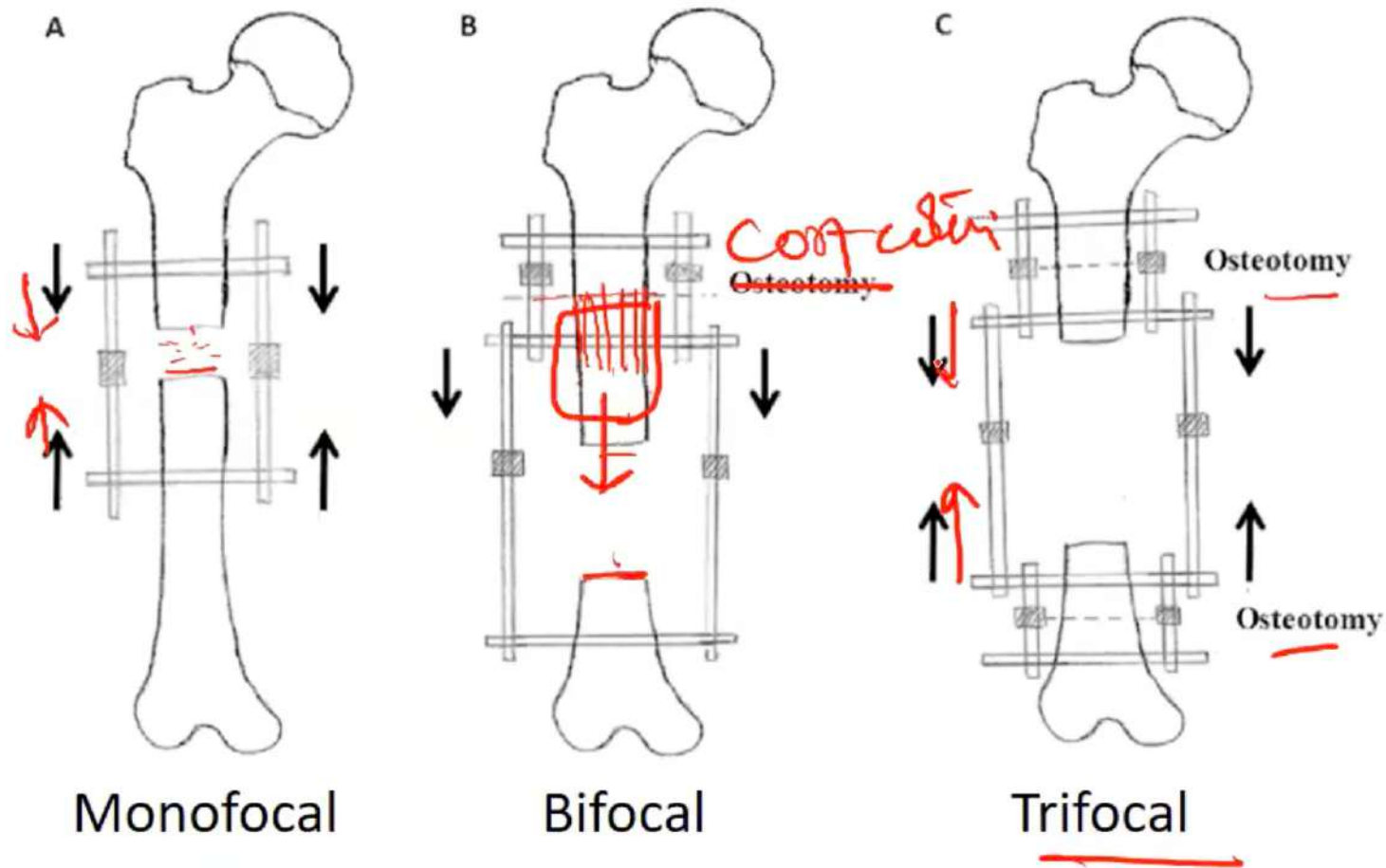
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Ilizarov Bone transport



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Ilizarov: Methods for filling Bone defect



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Infected Non union

- Conventional treatment

Infection control followed by union

1st

- Active / Aggressive treatment

Focus on bony union

Infected Non union

- Conventional management-
- 1st stage- Radical Debridement
- 2nd stage- Wound coverage – Skin graft/ flap
- 3rd stage- Bone grafting



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Conventional treatment

- Implant removal –
- Debridement
- Soft tissue coverage
- Antibiotics – Local delivery –
Beads / Nail / Spacer
- Antibiotics Parenteral
- Stabilization



Antibiotic

Active management

Focus on bony union

1st stage – Debridement + Stabilization +/- Bone grafting

2nd stage – Sequestrectomy and Wound coverage.