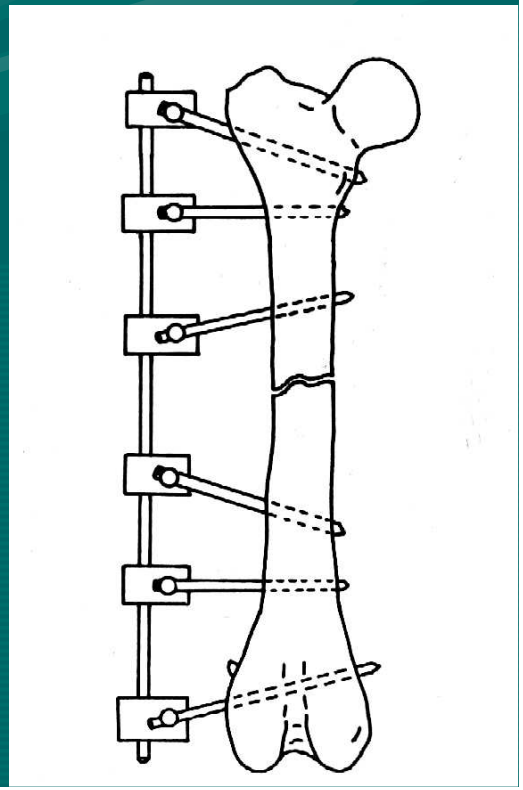
Surgical fracture treatment, fixation types

III. External Skeletal Fixation



History of External Fixation

- Already used at the end of the 19th century
- Gained popularity during/after II WW
- Widespread use delayed (missing standards)
- Widely used at present (biological osteosynthesis)

Advantages

- **Minimally invasive**
- **Robust** mechanical environment
- Effective in **infected** areas as well
- **Dynamization** at a later stage of healing
- Highly **customizable** (PMMA/APEF)

Disadvantages

- Outside of weight bearing axis
- Pin tracts are infection risks
- Some systems are not „flexible” in use (K-E)
- Somewhat limited range of orthopedic situations
- Can injure patient/owner

Indications

- **TIBIA**
- **RADIUS & ULNA**
- **HUMERUS & FEMUR** (with restrictions)
- Shearing injury, Gunshot trauma
- Some mandibular fractures
- Very small patients
- Mature patients/ Immature patients (growth plate!!)

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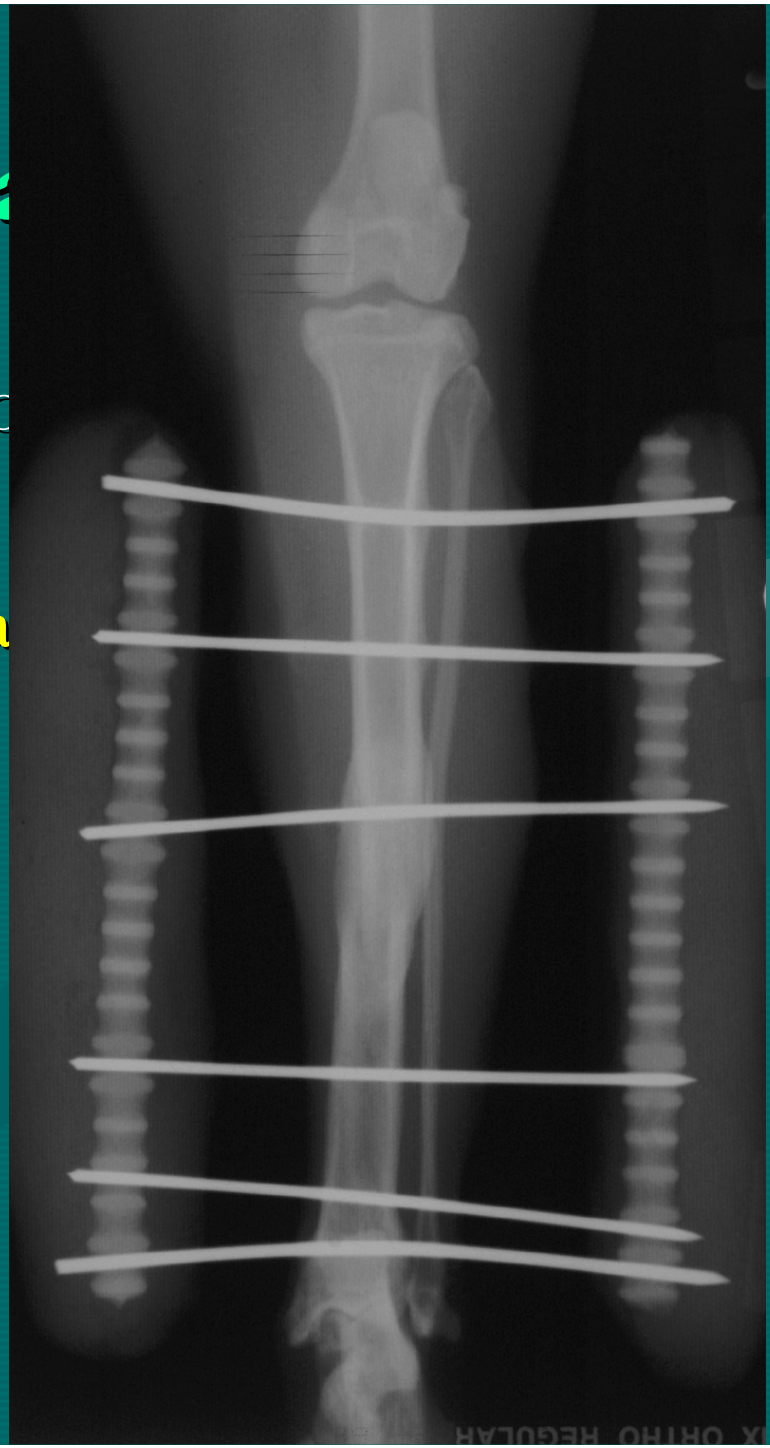

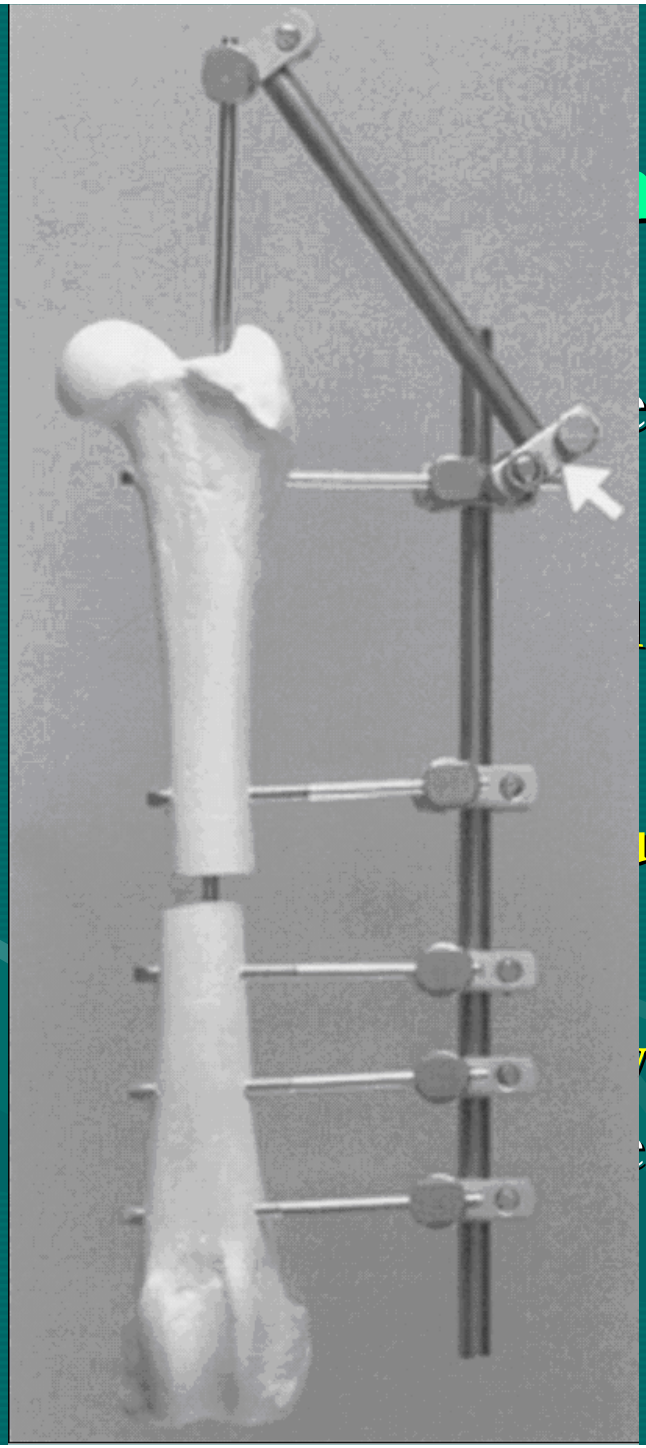

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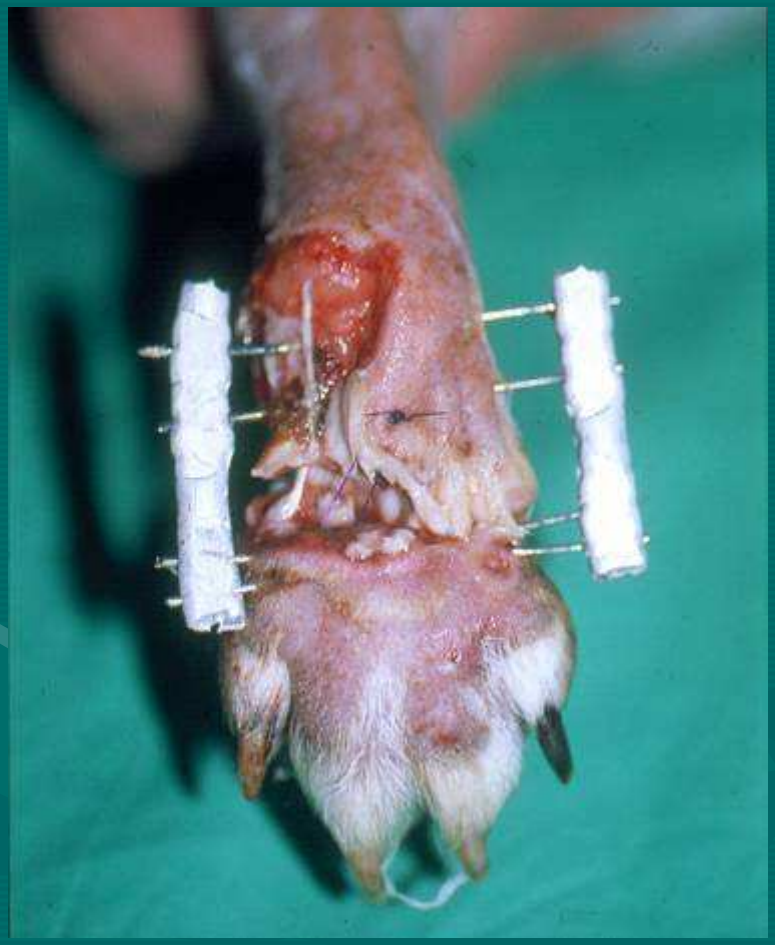
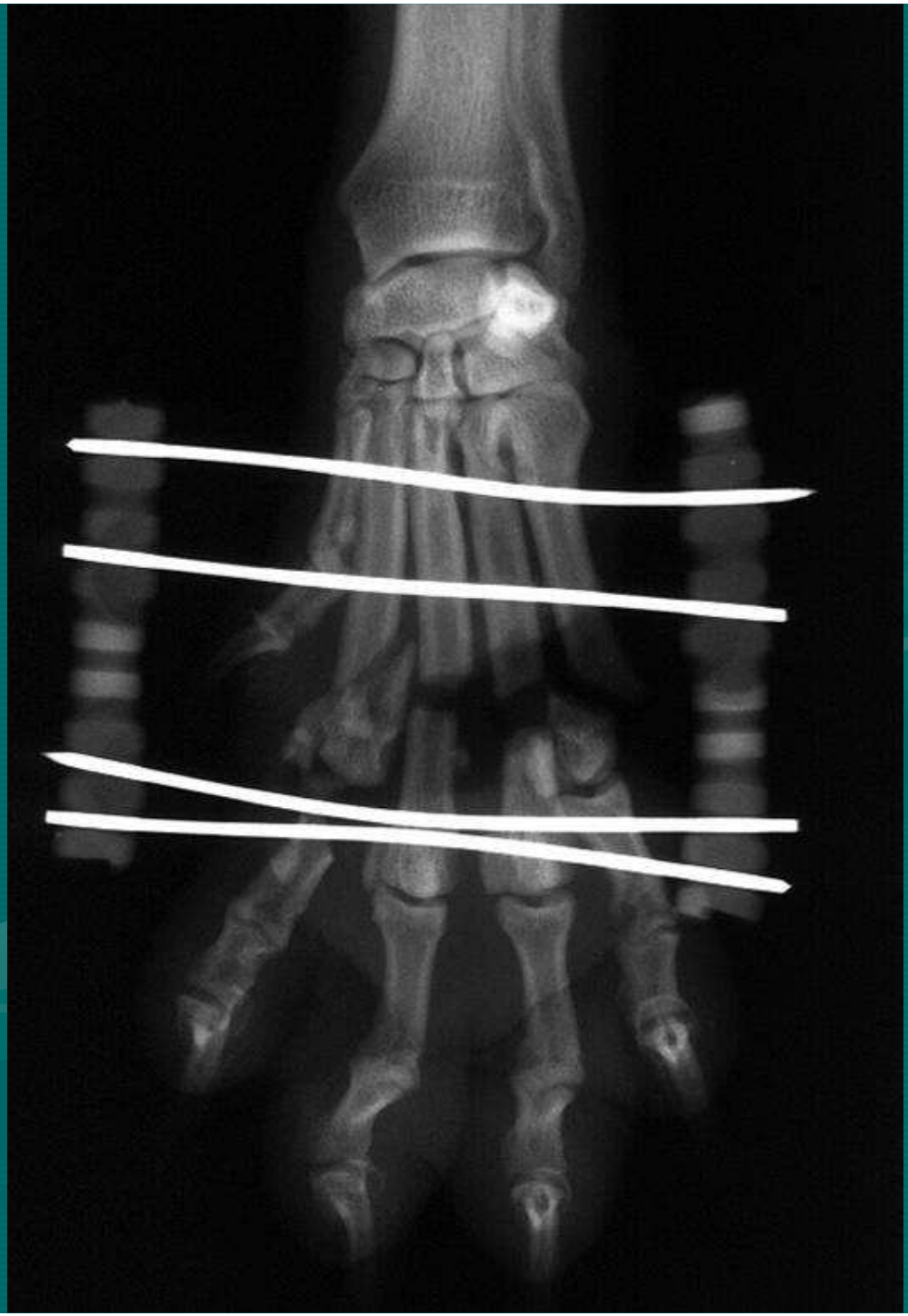
Shearing injuries

- ESF provides **easy access** to the wound thus facilitates daily management
- **Rigid** fixation a major advantage in the case of articular injuries

Shearing injuries

Shearing injuries





Shearing injuries

Gunshot trauma

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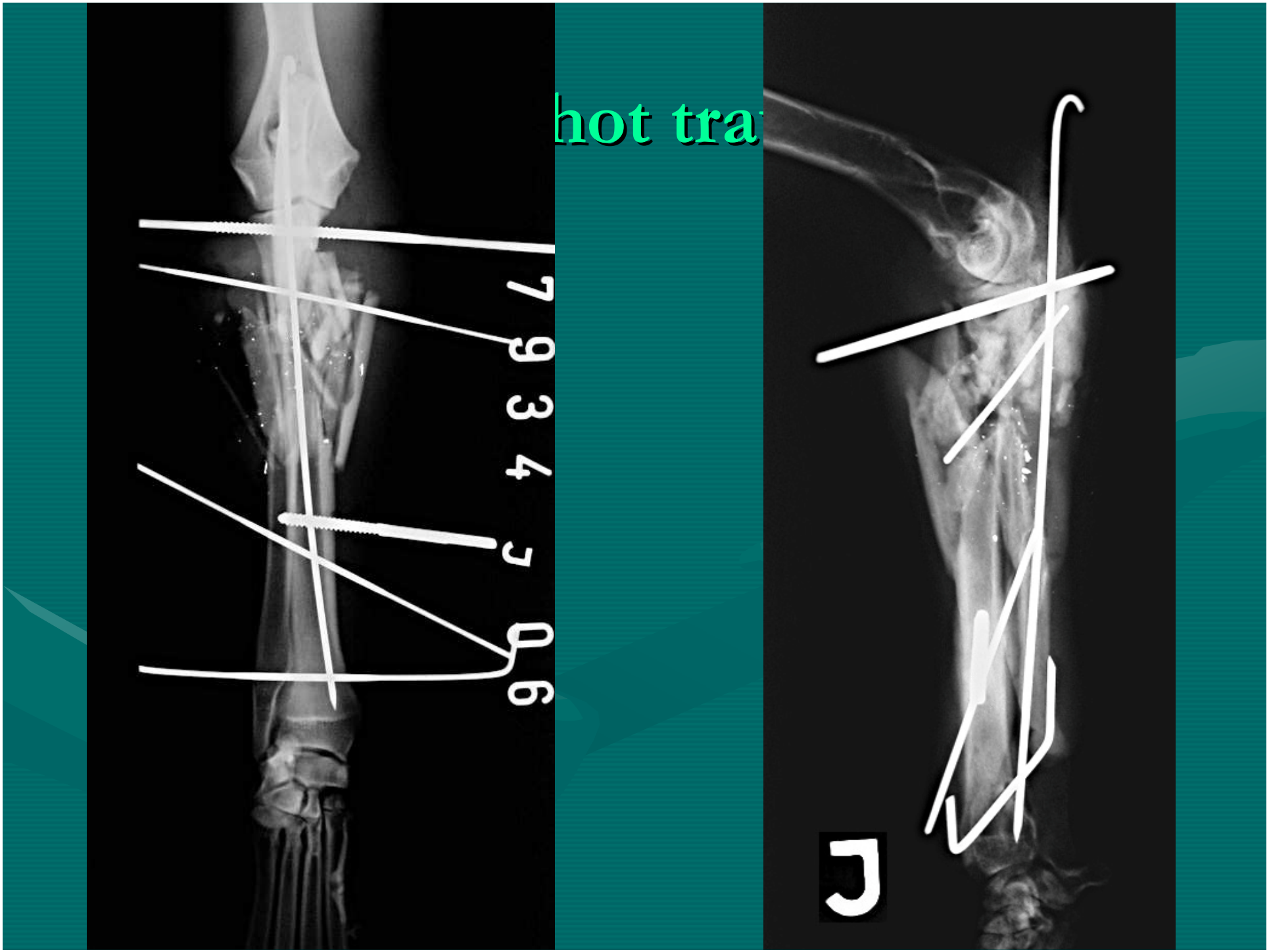
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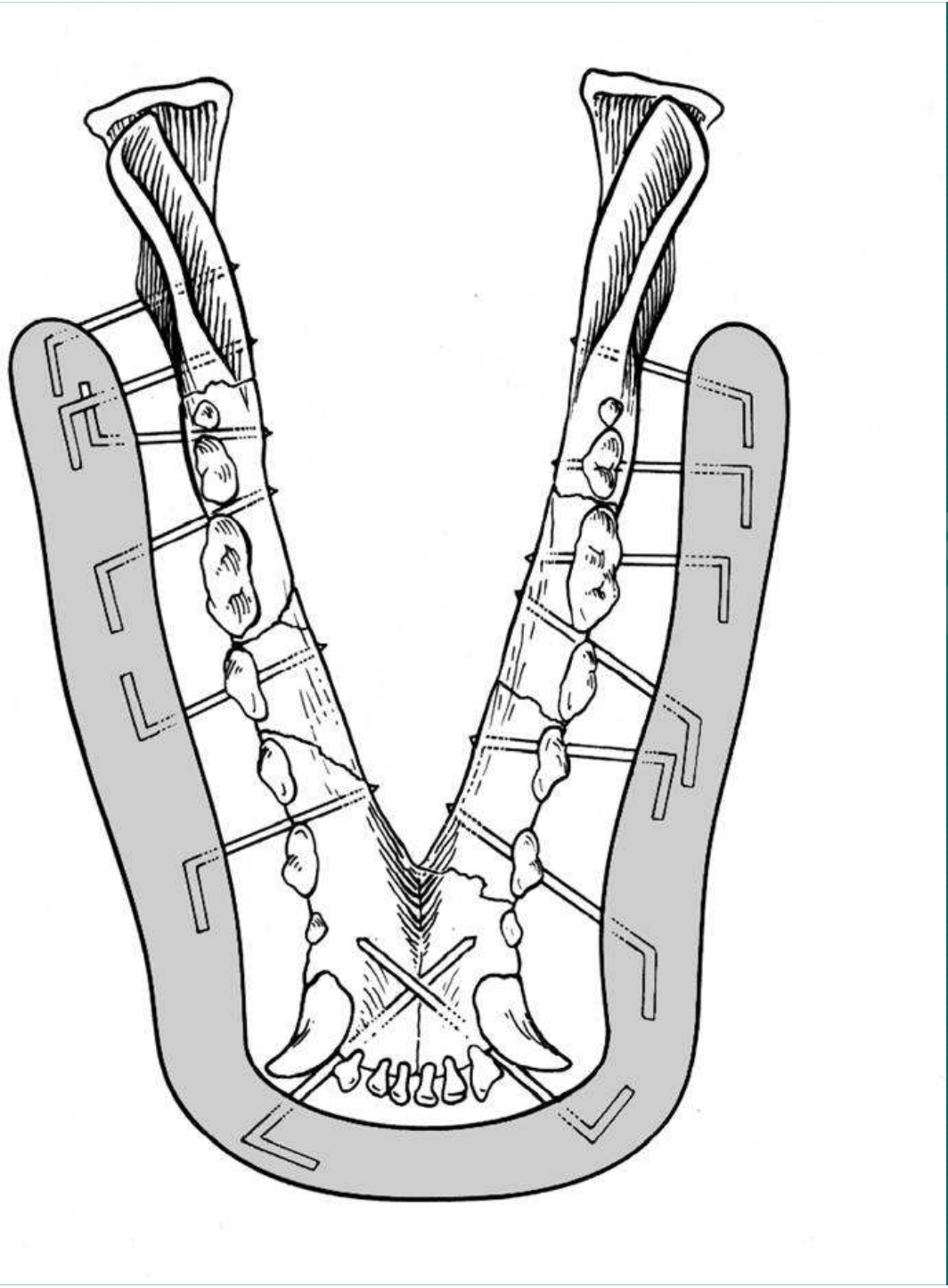

Debridement

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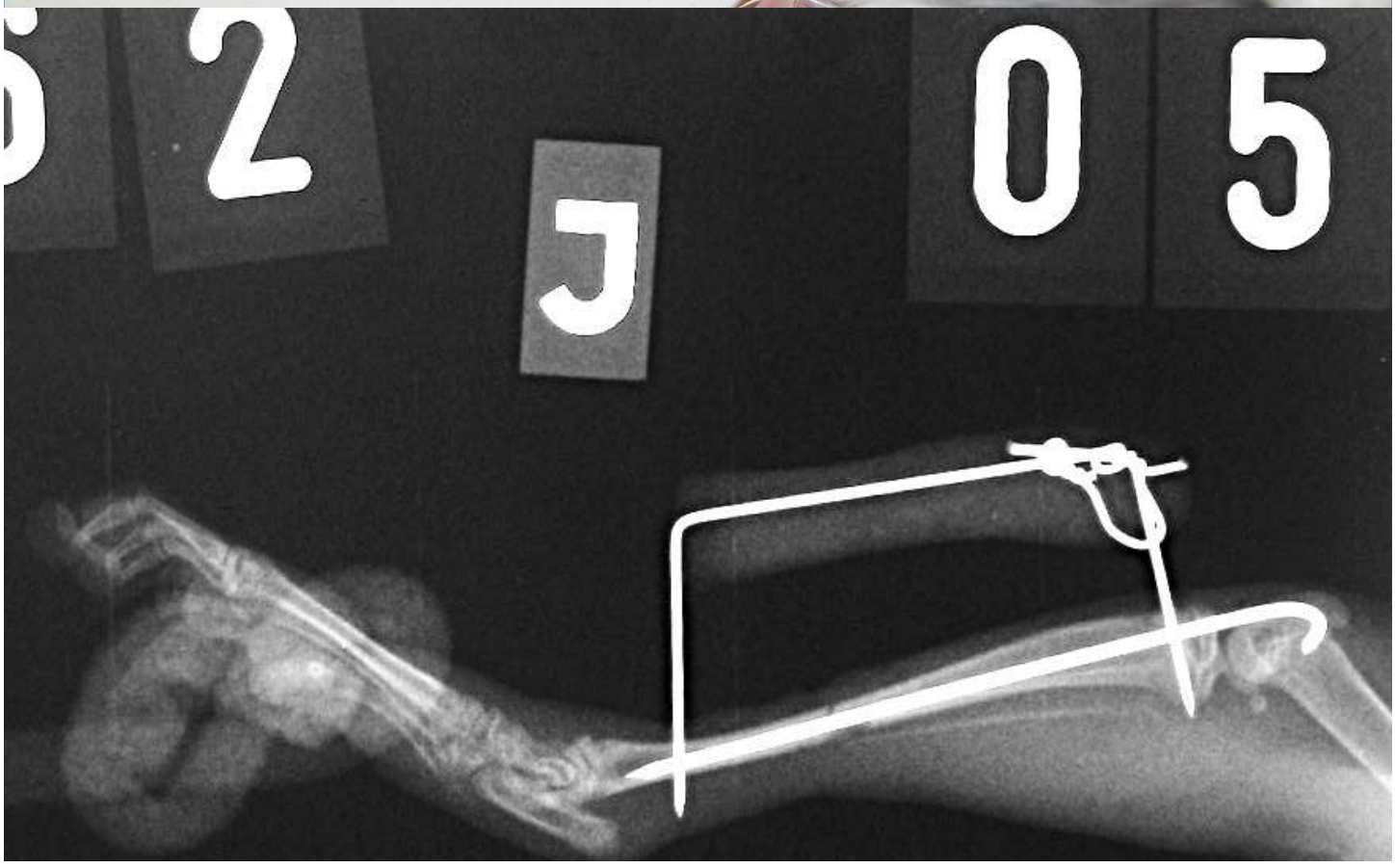
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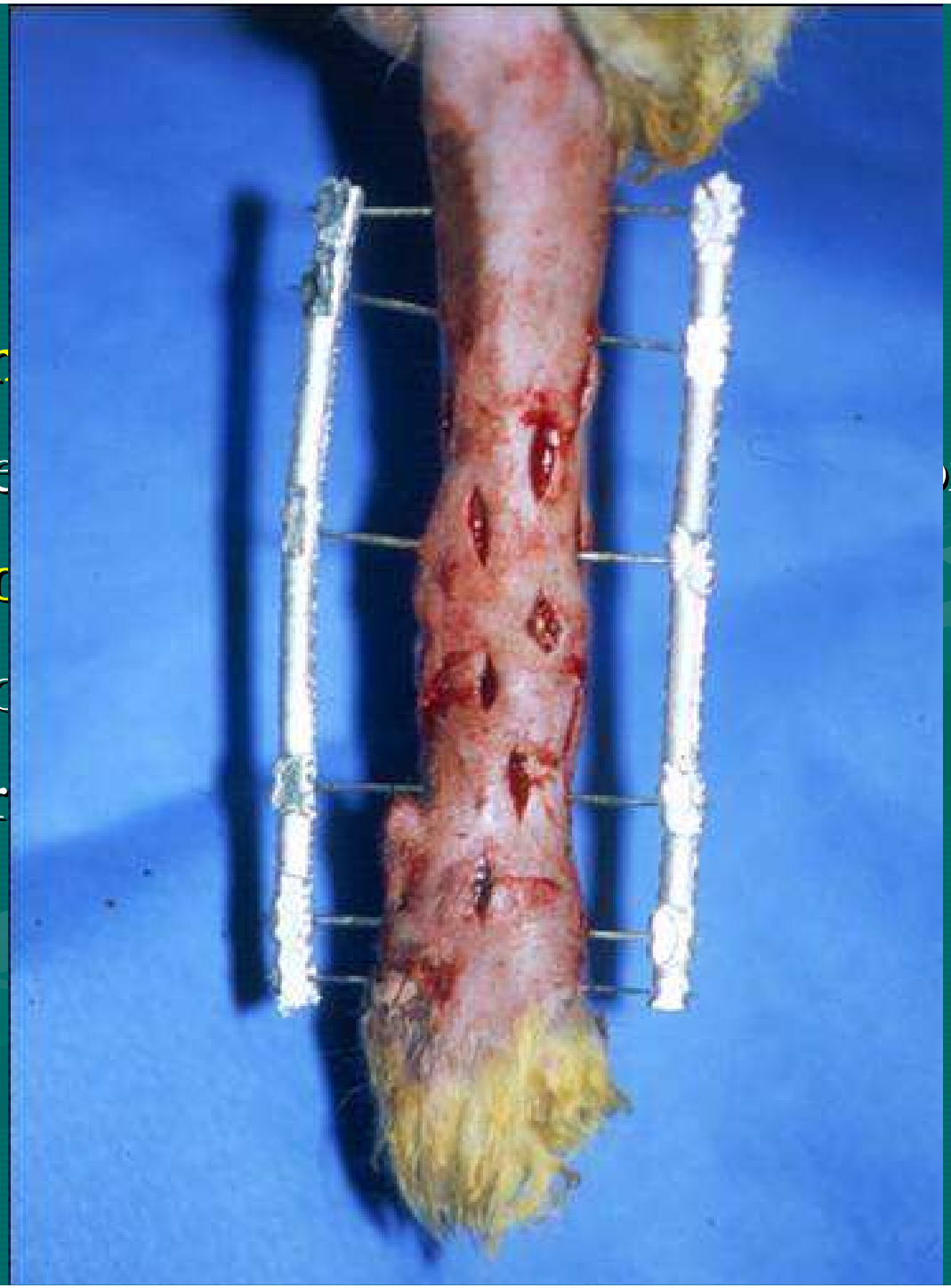

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Elements of an ESF system

- **Fixation pins**
- **Fixation column** (connecting column/rod)

The different systems

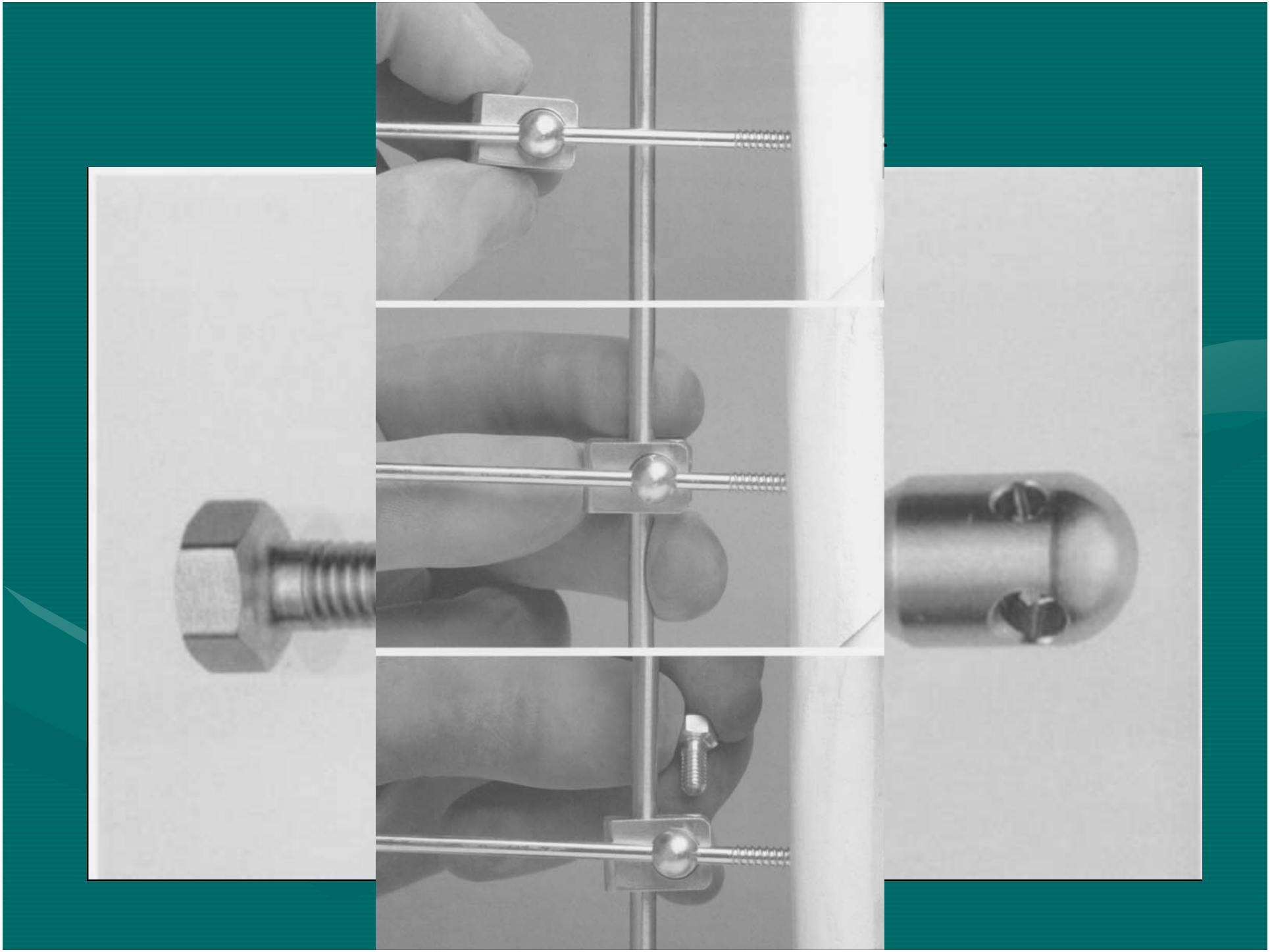
- K-E system
- Securos, Imex-SK
- Synthes-Aesculap
- PMMA/APEF
- Manuflex

Kirschner-Ehmer system

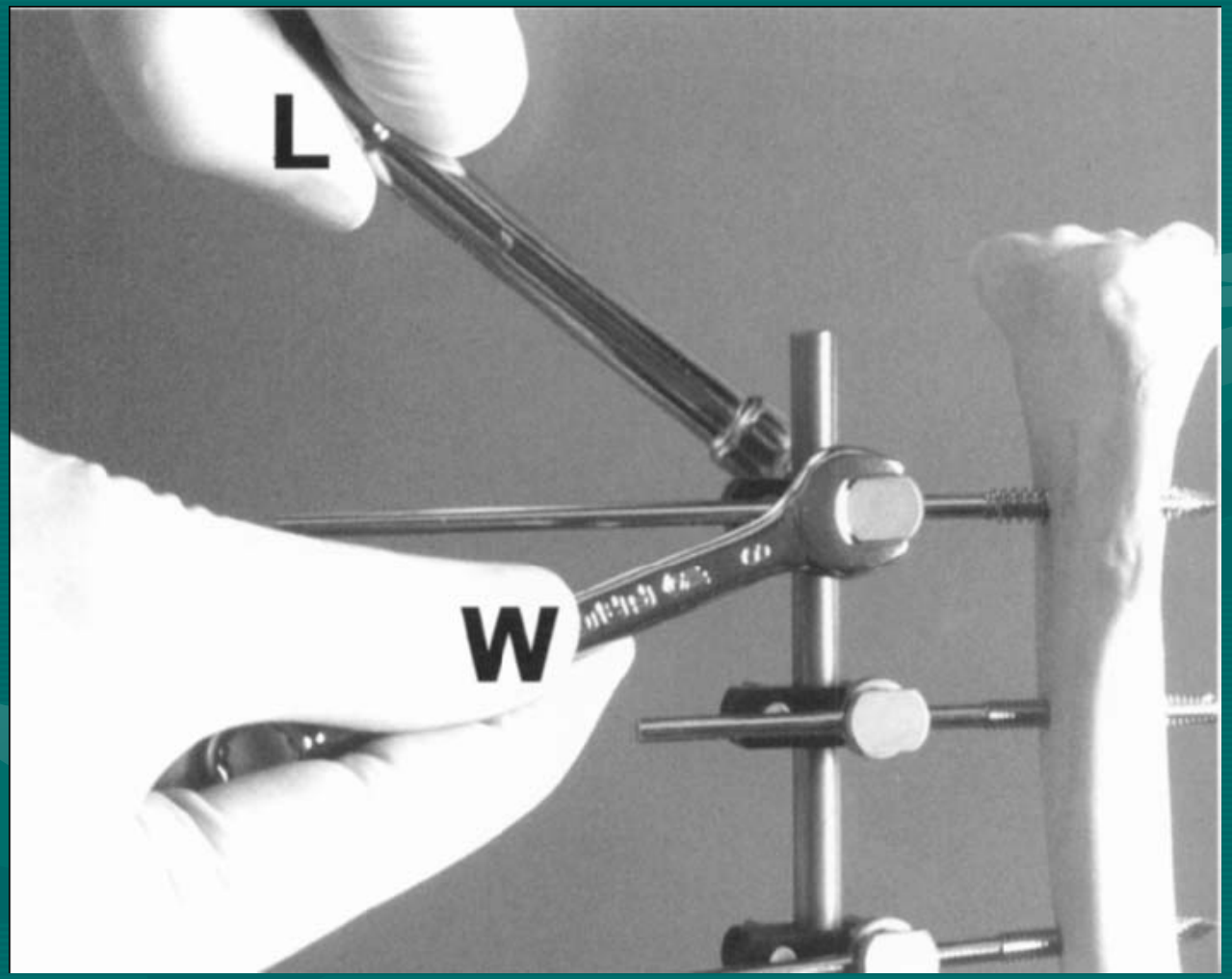
- **Elements**
- **Disadvantages**
  - no potential for using **smaller/larger** pins
  - difficulty to use **positive** profile pins
  - frequent **failure**/loosening of clamps
  - **overcomplex** frames to protect weak frame components
  - Straight connecting bar makes ideal **pin placement** difficult

Securos system/ IMEX-SK system

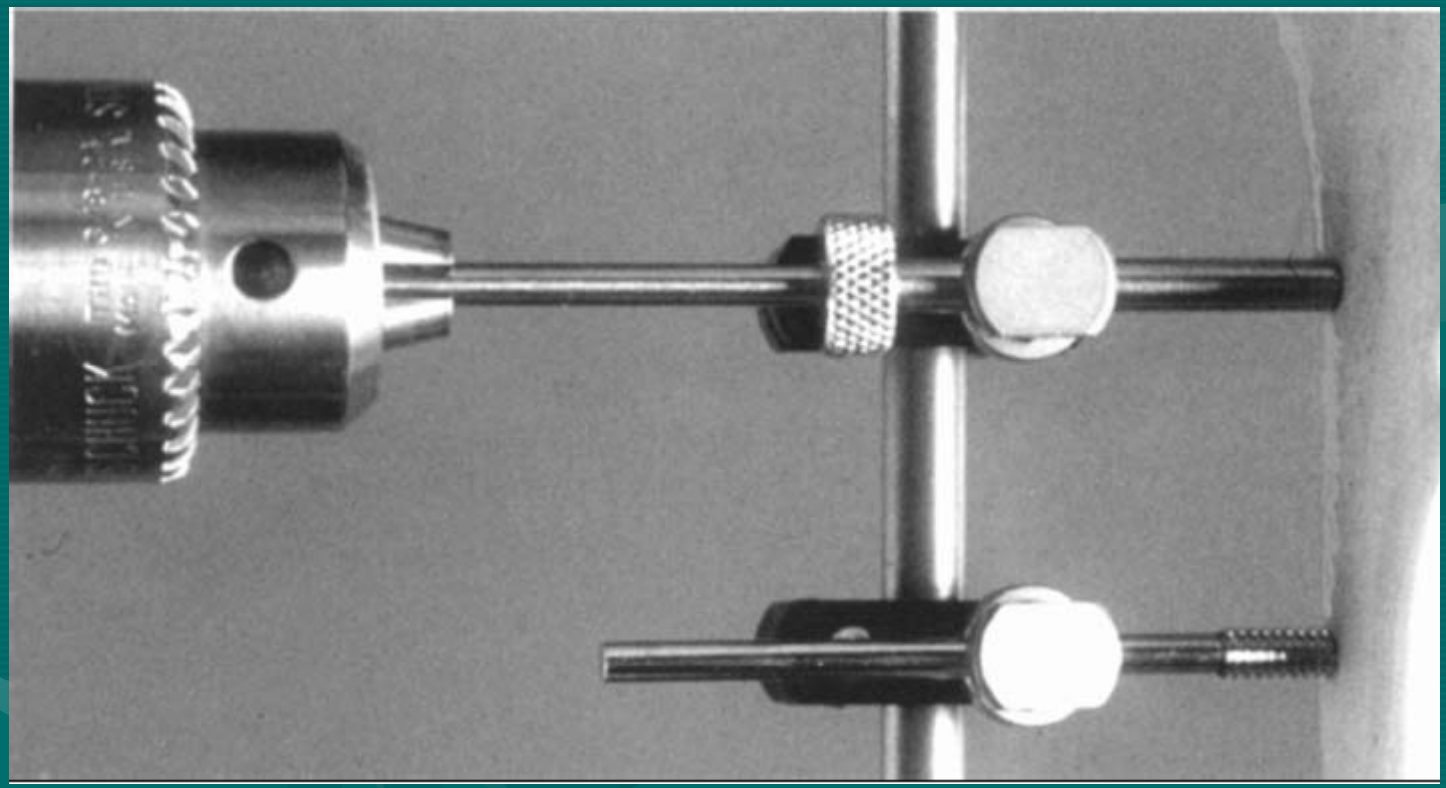
- **Elements**
- **Advantages to K-E system**
  - Better strength and versatility
  - Positive profile pins



IMEX-SK system



IMEX-SK system



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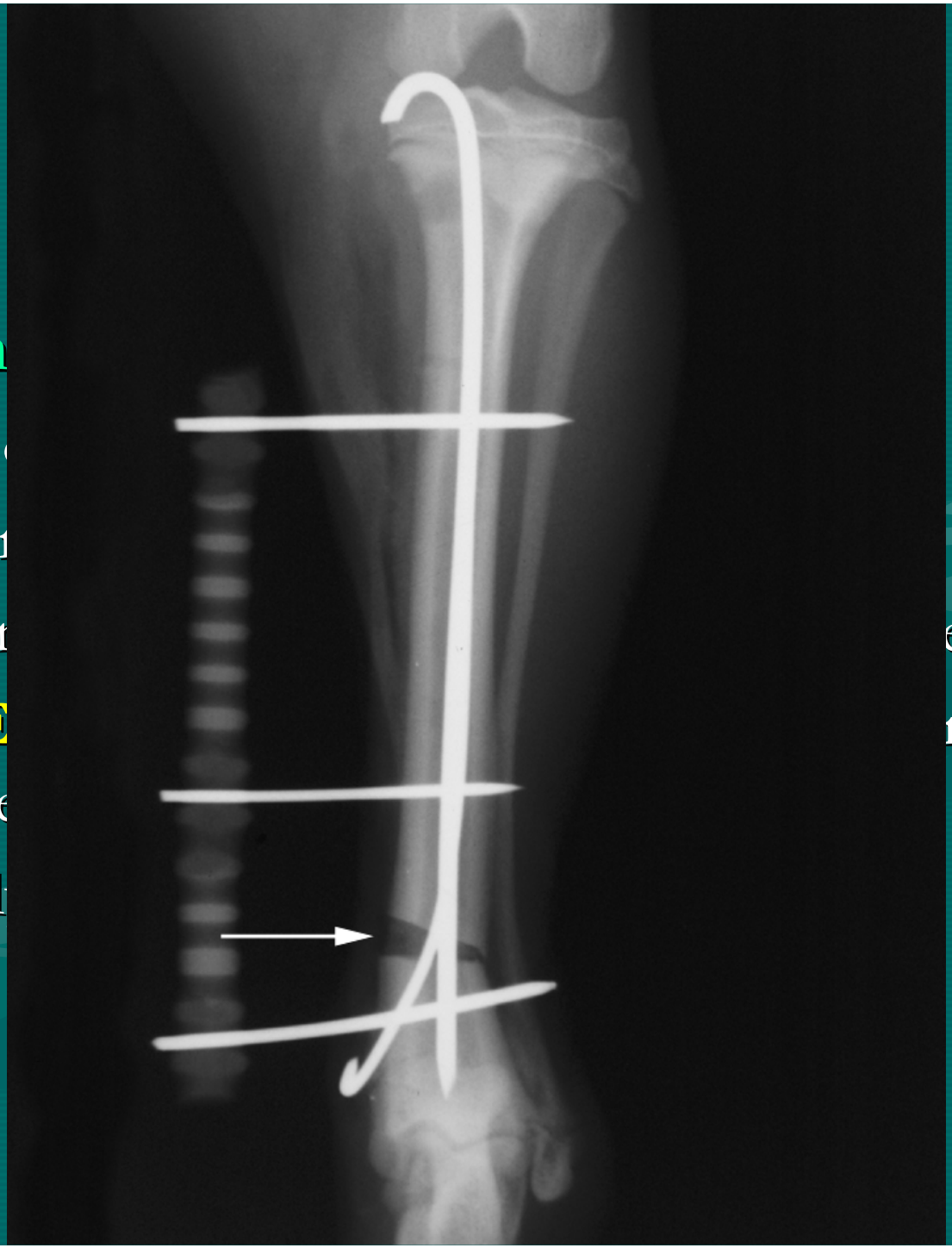

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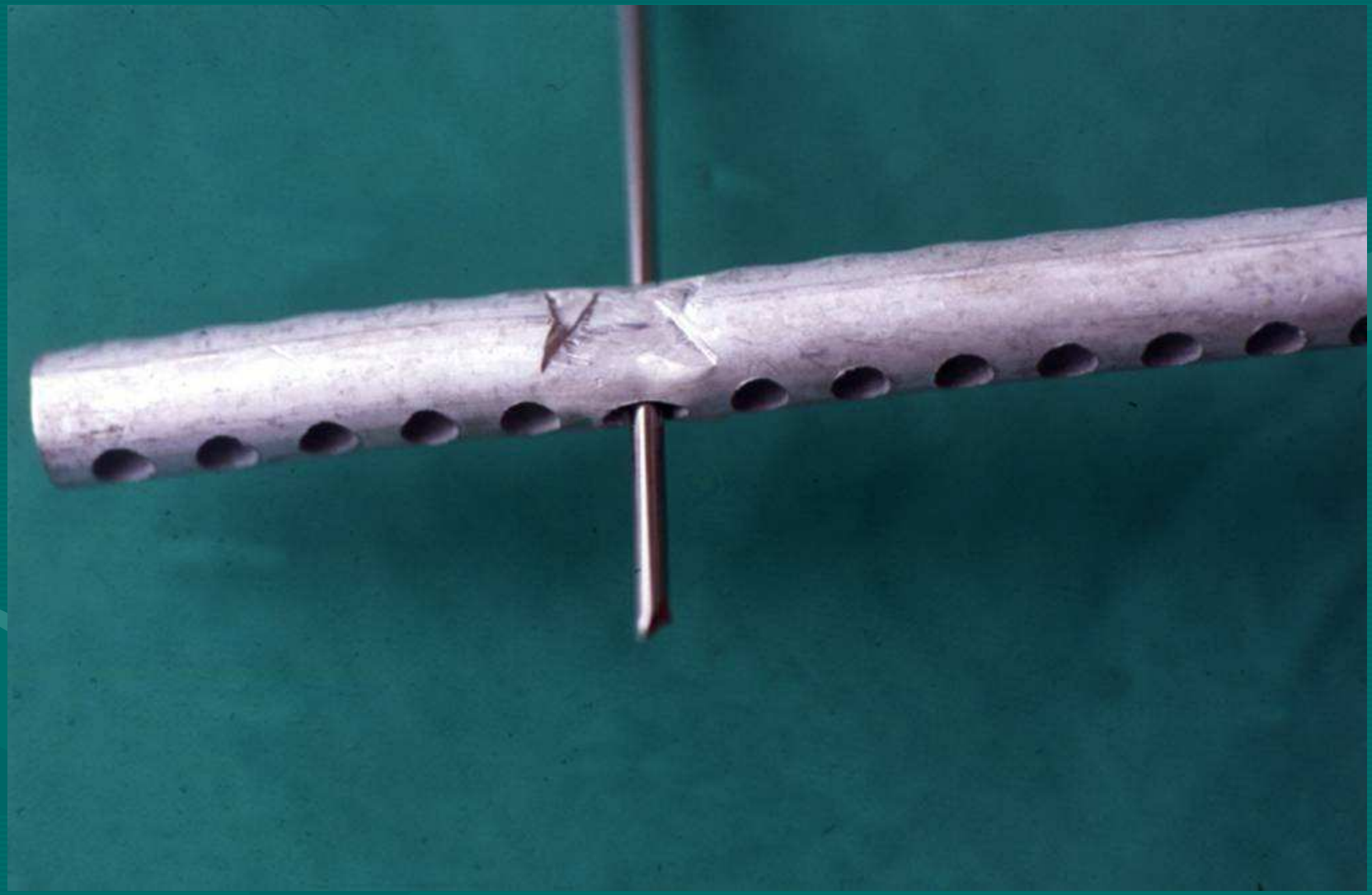
PMMA/APEF

- **Disadvantages**
  - Single use
  - Postop adjustment not easy
  - Dynamising not easy↔K-E

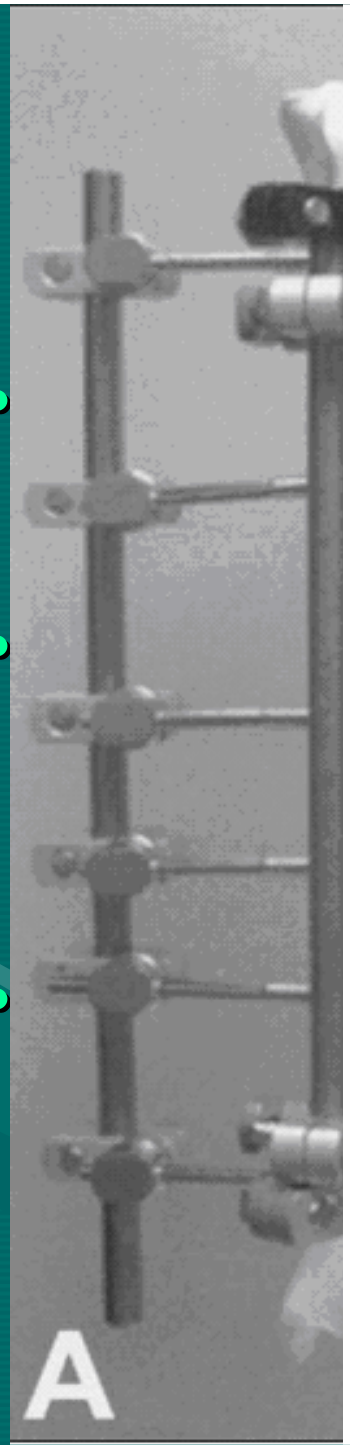
Manuflex

- 

Classification of frames

- **Unilateral (type I)**
  - type Ia
  - type Ib
  - type I tie-in config (IM pin)
- **Bilateral (type II)**
- **Multiplanar (type III)**

  -ex. a unilateral/type Ia added to a bilateral
- **Circular/Ilizarov**
- **Strength & stiffness:** type Ia < type Ib < type I tie-in < type II < type III)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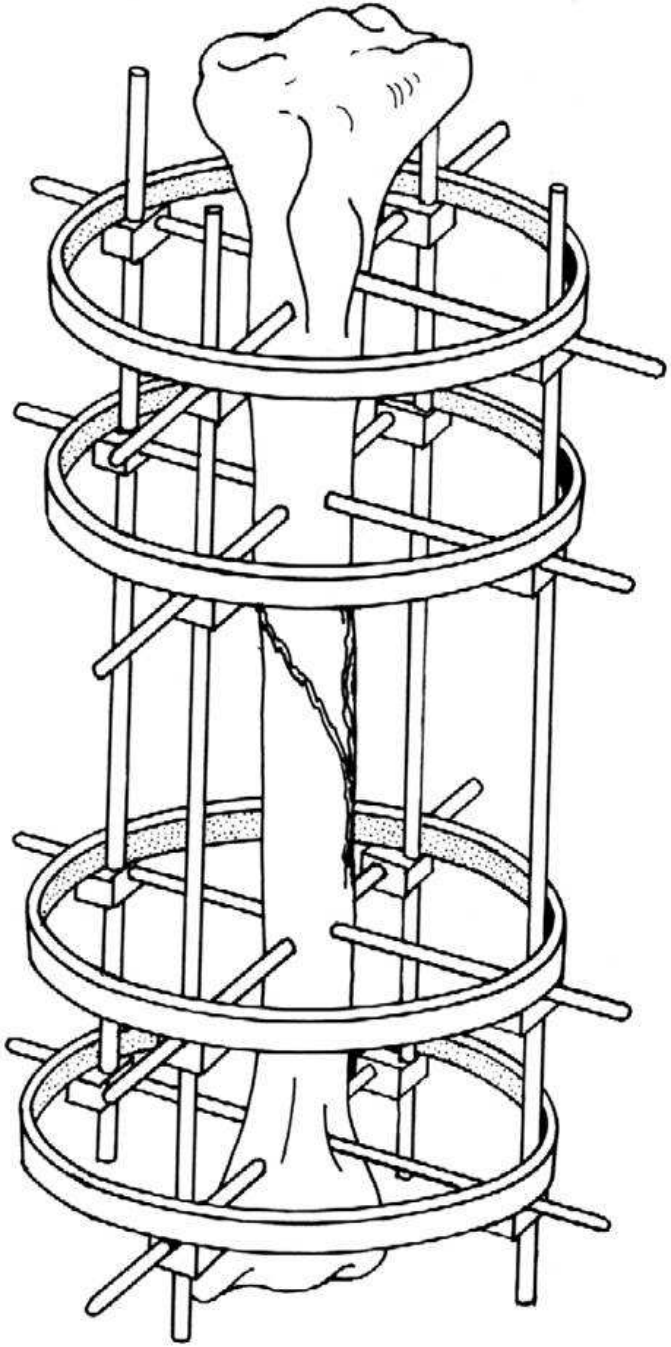
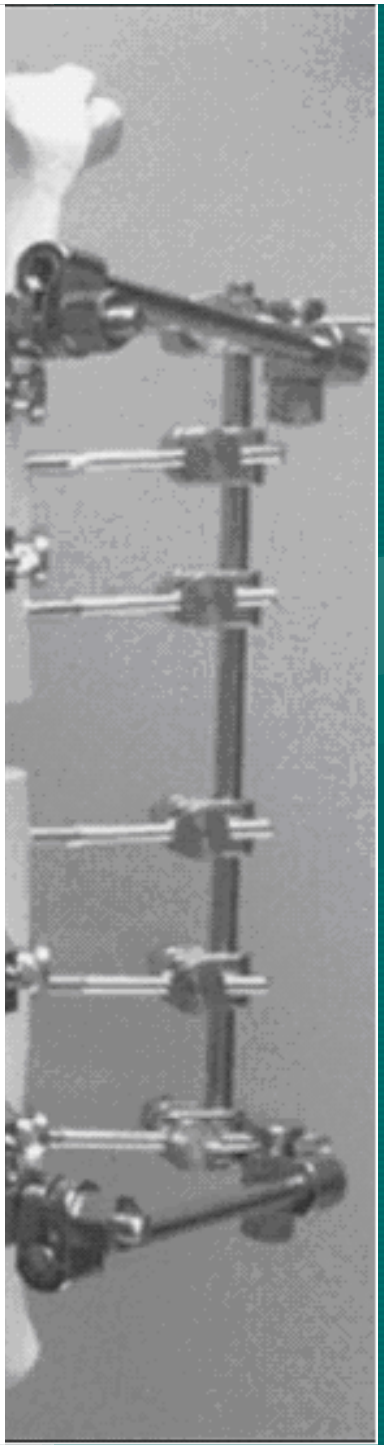
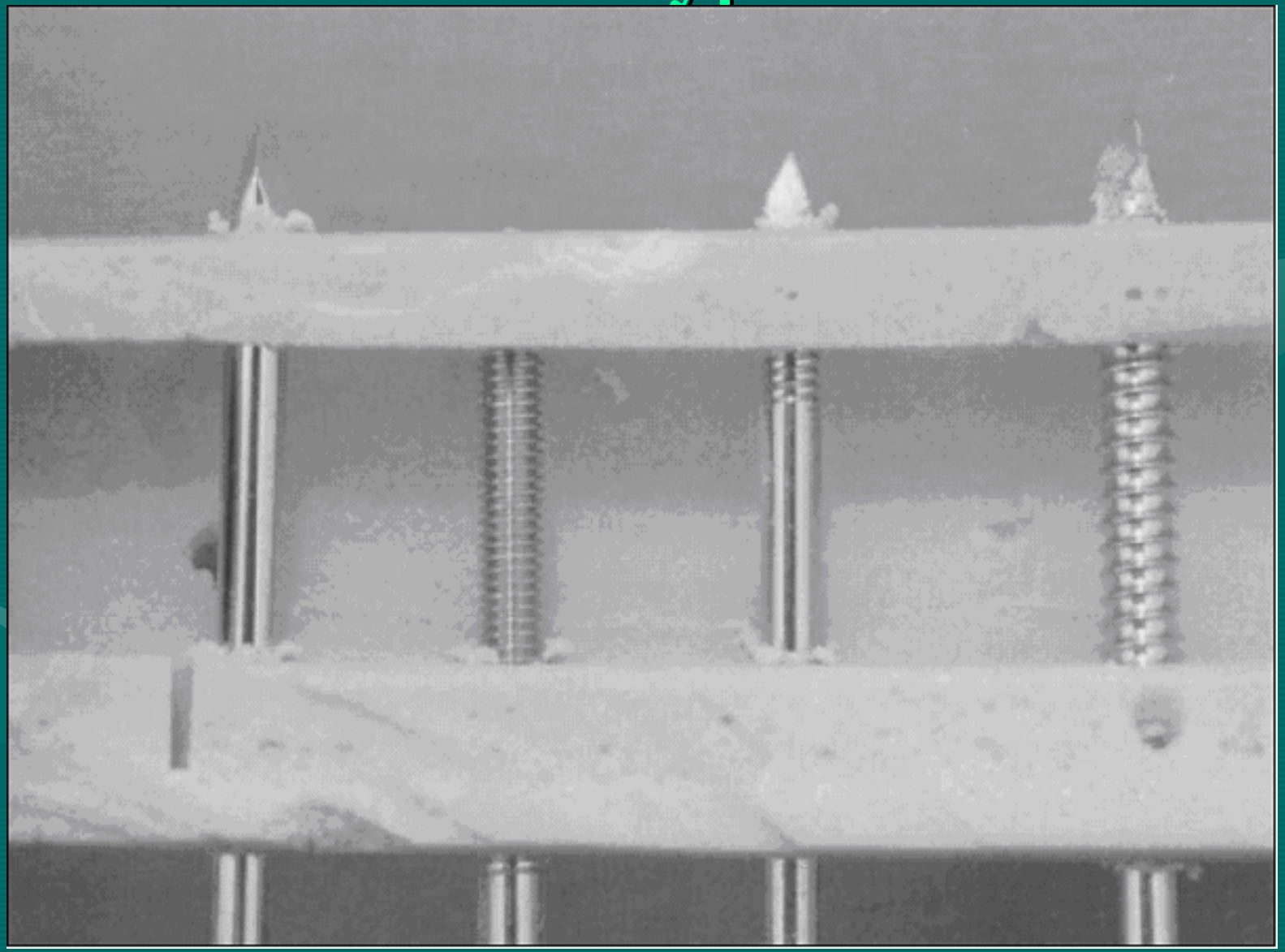




Pin Types

- **Smooth pins** (K-wire, Steinmann pins)
  - Cheap but minimal resistance to pullout
  - Inserted in an angle (70 degrees)
- **Positive profile threaded pins**
  - More expensive
  - Increased pin-bone interface (⇓ pin-loosening)
  - No need for angulation
  - Preserves core diameter
  - Less prone to pin breakage

Pin Types



Pin Insertion

- **MOST IMPORTANT**: correct limb alignment
- **M-L** alignment and torsion!!(valgus/varus, abnormal stresses on adjacent joints)
- Some **CRAN-CAUD** malalignment can be tolerated (elbow/carpus,stifle/tarsus can accomodate)

Pin Insertion

- **Releasing** soft tissues (prevent windup)
- **Pre-drilling** pin holes(decrease heat necrosis)
- Pins should be min 0,5-1 cm from **joint surface** and min 2 cm from **fracture line** (fissures!)
- **Two cortices** engaged
- Begin with prox/dist ones→**alignment**

Pin Insertion
-controlling heat-

- **Adverse reactions:** local thermal bone injury+excessive local stress
- **Pin-bone interface** affected→necrosis→fibrous connective tissue→micromovement of pin→bone resorption→pin-loosening
- **Trocar points** of pins dont facilitate egress of bone shards→impaction→HEAT
- **>50rpm**→ thermal necrosis minimized

Pin Insertion

- **Larger** pins → greater pin-bone interface (don't exceed 30%)
- **More** pins → increase strength (max 3-4 per segment)
- **Stiffer** pins → more even load sharing
- **Softer** pins → exerts more stress on near cortex →stress →resorption

Pin Insertion Summary

- At least **3 pins** per fragment
- **Near/far** from fracture site
- **Largest** possible pins (dont exceed 30%)
- **Stiff** pins
- **Positive** profile threaded pins
- If using smooth pins **70 degrees**!

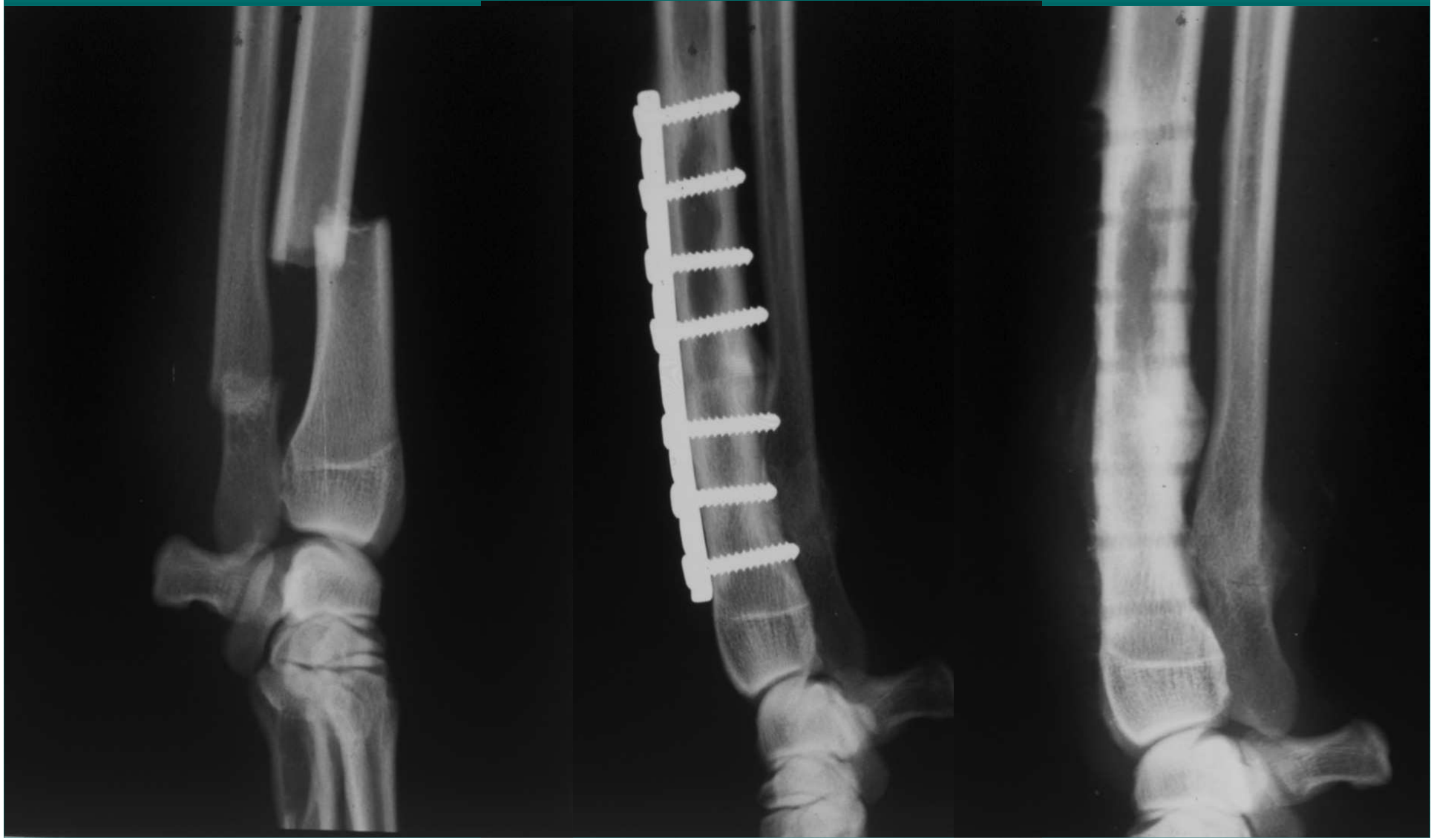
Bone healing

- **Factors affecting bone healing**
  - Age & general health
  - Location & type of fracture
  - Surrounding soft tissue damage
  - Obtained degree of fragment apposition
  - Mechanical environment provided by ESF
- **Primary bony union**
  - Rigid internal fixation + close contact of fragments

Bone healing

- **Secondary bone healing**
  - Fracture gaps + some interfragmentary motion
  - ESF is good example as interfragmentay compr. usually is not applied (ESF preserves blood supply, important for 2ndary union)

Primary and secondary bony union



Bone healing

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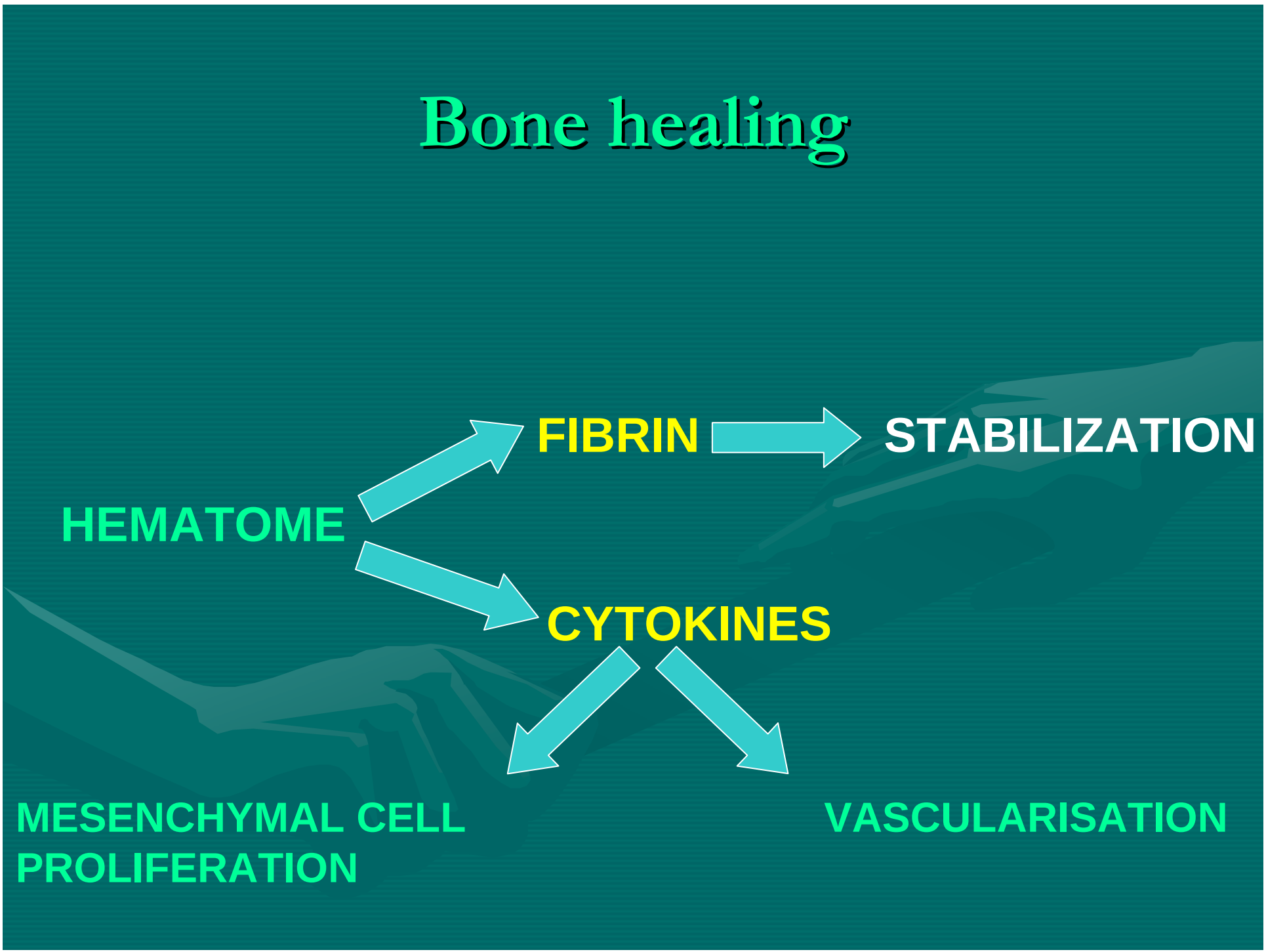
Soft tissue and bone damage

HEMATOME

Bone healing



Differentiation of mesenchymal cells

Small amount of interfragmentary strain

And **high O_2** environment

→ **Osteoblasts**

More strain

And **lower O_2** environment

→ **Chondroblasts**

Large amount of strain

And **low O_2** environment

→ **Fibroblasts**

Callus Formation

- **Outside of callus** has best mechanical & biological environment
  - most resistant to bending forces (less strain)
  - periosteal blood supply maintains high O2 environment
- **Fracture ends** under high strain + low O2 tension (more chondro/fibroblasts)
- **Outer edge** of callus gives most info on secondary callus formation!

Callus Formation

- Limited amount of **strain** helps bony union (max 2% of fracture area)
- **Excess strain** leads to chondro/fibroblast formation + low O2 env →NONUNION!
- **Axial forces** promote ←→bending/twisting forces hinder bony union

Postop Xray

- **AAAA=alignment, apposition, apparatus, activity**
- Are there adequate **number** of pins/segments?
- Pin **size** correct?
- Are pins **properly centered**, safe distance away from skin/fracture lines?
- Does **frame config** match fracture type/patient size?

Postop Xray

- Amount of external callus is inversely proportional to the rigidity of the frame
- **Osteomyelitis:** rough/irregular callus margins
- **Pin-loosening:** 1mm radiolucent area around pin

Postop Xray

- Resorption/lack of bridging callus indicates **delayed/non-union**

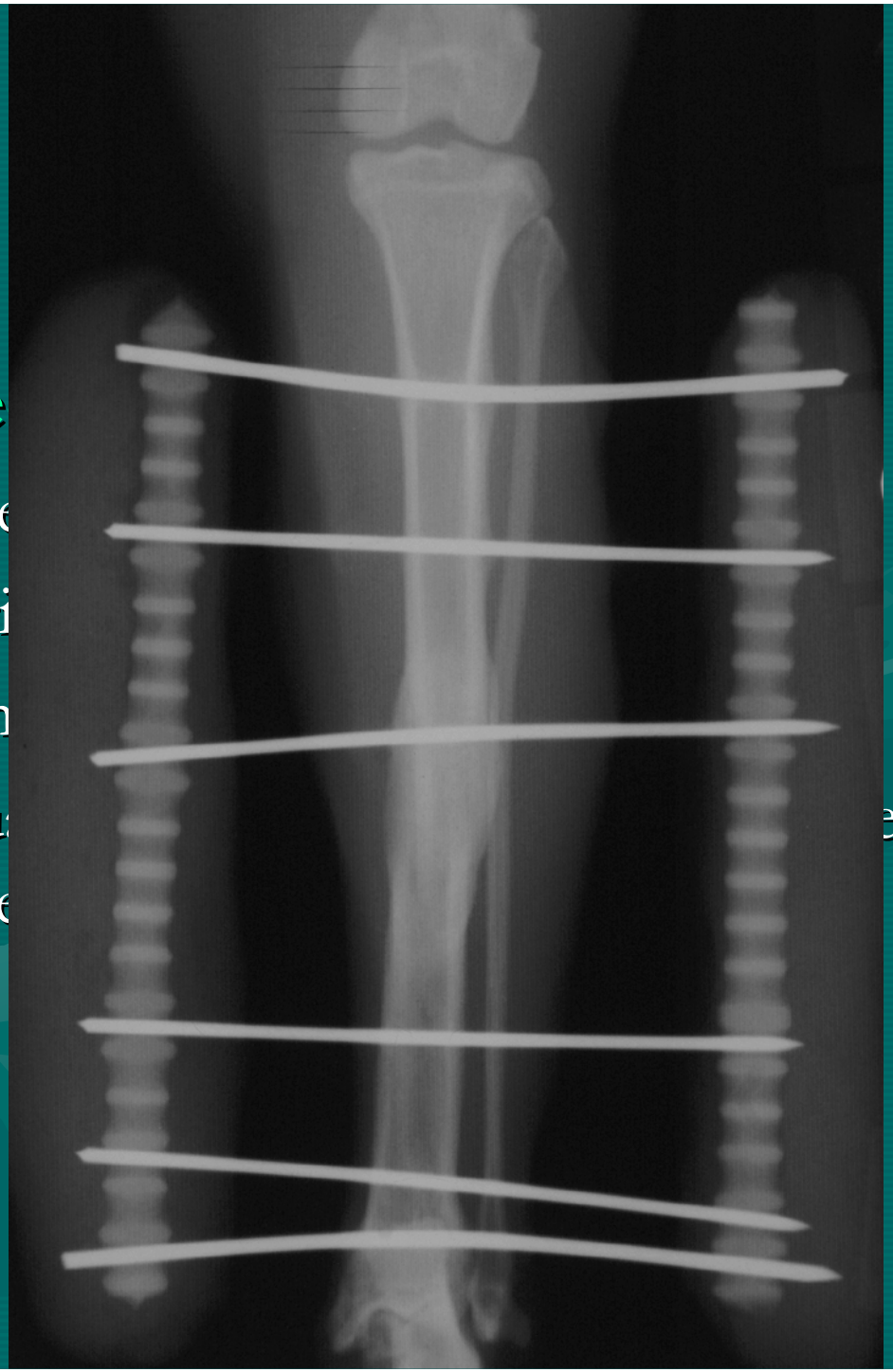
  →reexploration→bone grafting→new fixation

- Generalized loss of bone density indicates **stress protection** →staged dynamization

Postop Xray

- Ideally fractures fill up with bone density material after **6-8 weeks**
- Rechecks at **7-10 days**, 6-8 weeks then every **3-4 weeks**
- **7-10 days recheck**
  - Partially weight bearing
  - Some edema
  - Mild pain on pin site

- **6-8 weeks re**
  - Usually heale
  - Weight beari
  - Pain free pin
  - Xrays (evalu e time, removal, inte



ESF can be removed

- Animal is **weight bearing**
- Sufficient bony **callus bridging** the fracture gap (density→ adjacent bone)
- If severe lameness but good callus→ find reason (often loose pin!)

More time needed

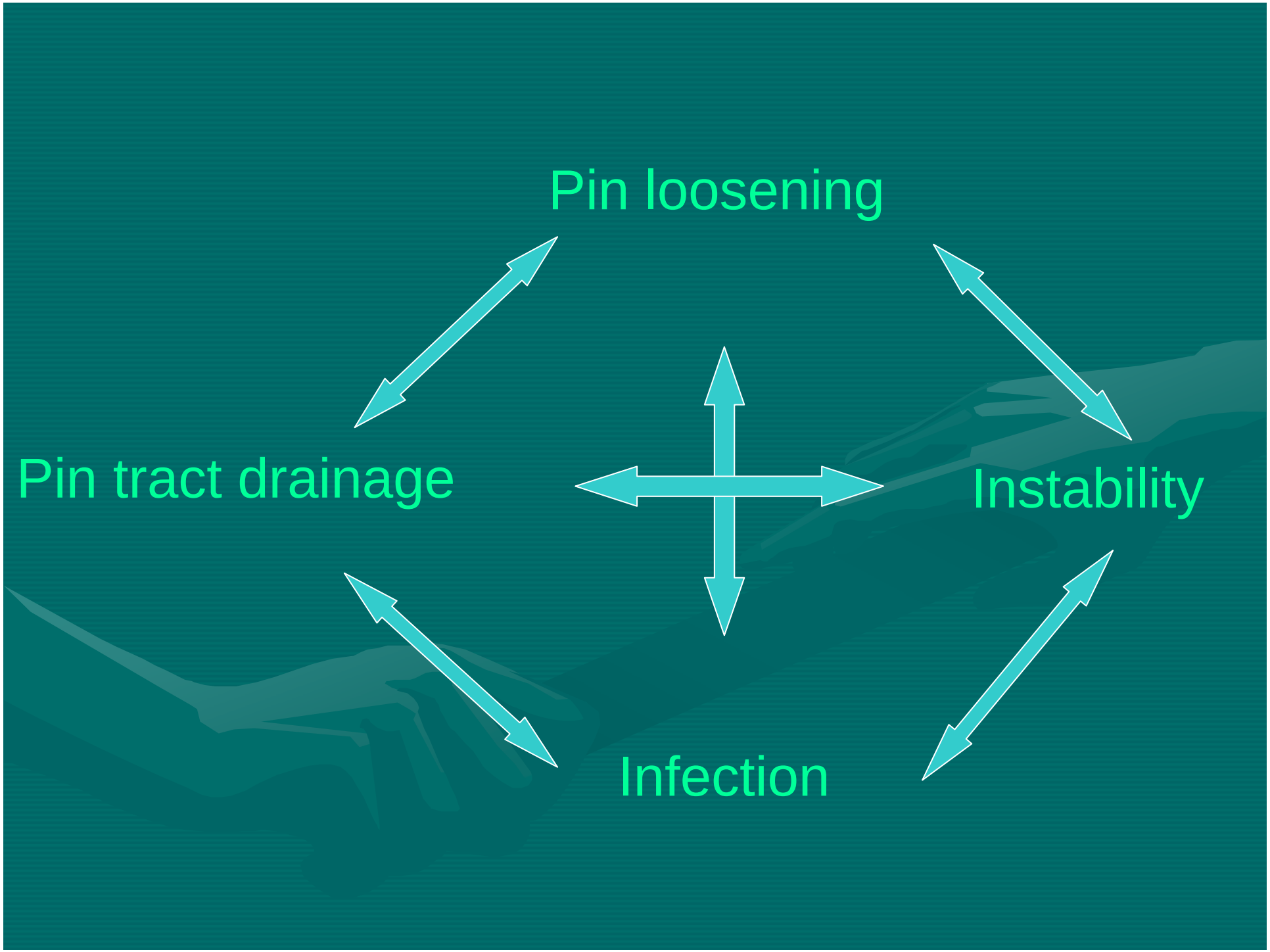
- Weight bearing but callus not completely bridged
- Bridging callus of insufficient radiodensity (too stiff frame?)

Complications

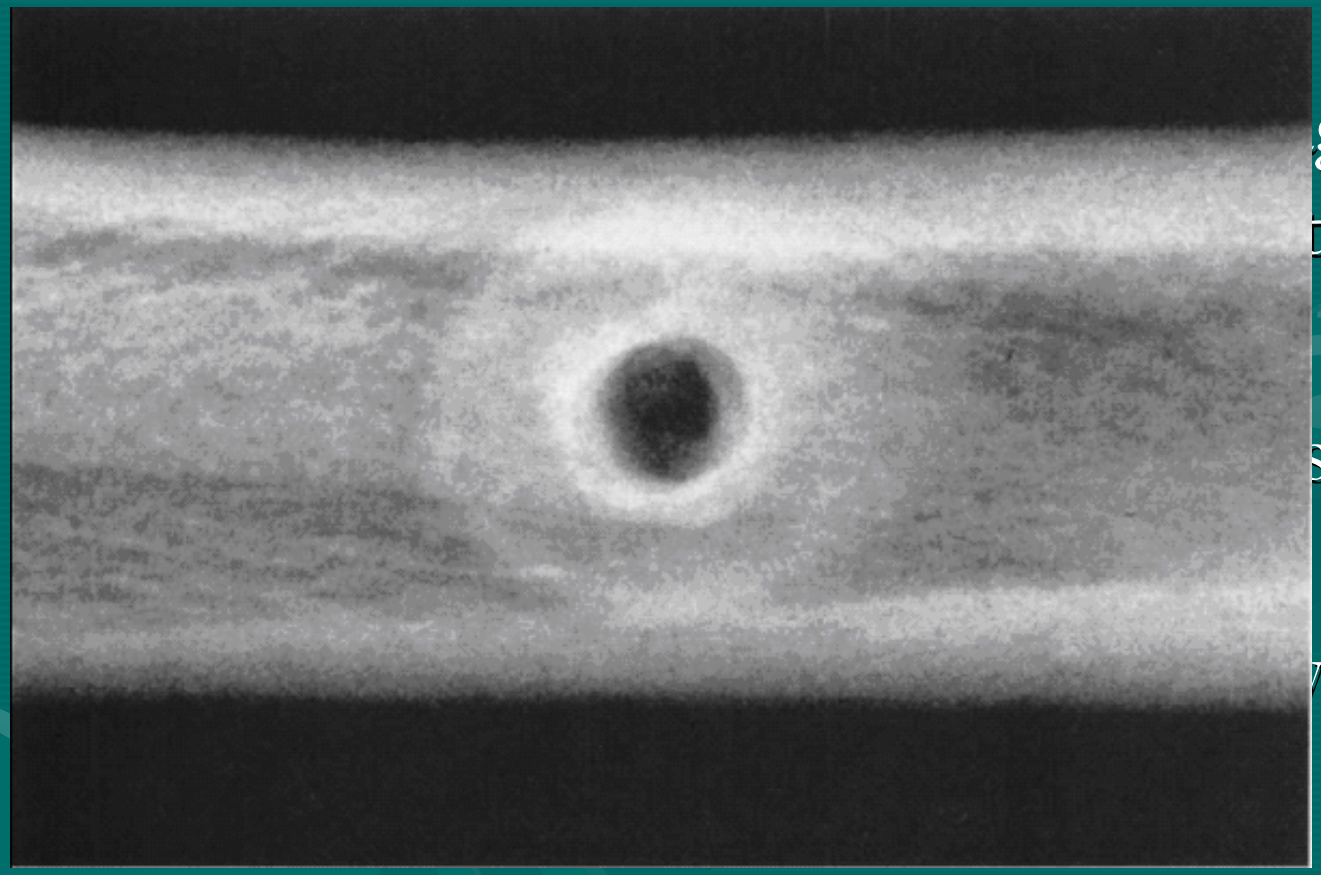
- **Soft tissue impalement:** muscles, nerves (can be severe, „wind-up”) tendons, vessels
- **ESF faliure:** frame faliure, pin breakage, pin loosening
- **Infection:** osteomyelitis, sequestration, major/minor pin tract infections

Pin breakage and loosening

- **Pin breakage:** negative threaded pin?, reassess frame strength/rigidity
- **Pin pullout:** smooth pins inserted parallel
- **Pramature pin loosening:** very common complication, often poor placement!
  - If good bone union process→ remove loose pin(s) = dynamization
  - If frame is not stabile anymore→ review ESF


Pin loosening
Pin tract drainage
Instability
Infection

Osteomyelitis and sequestrum



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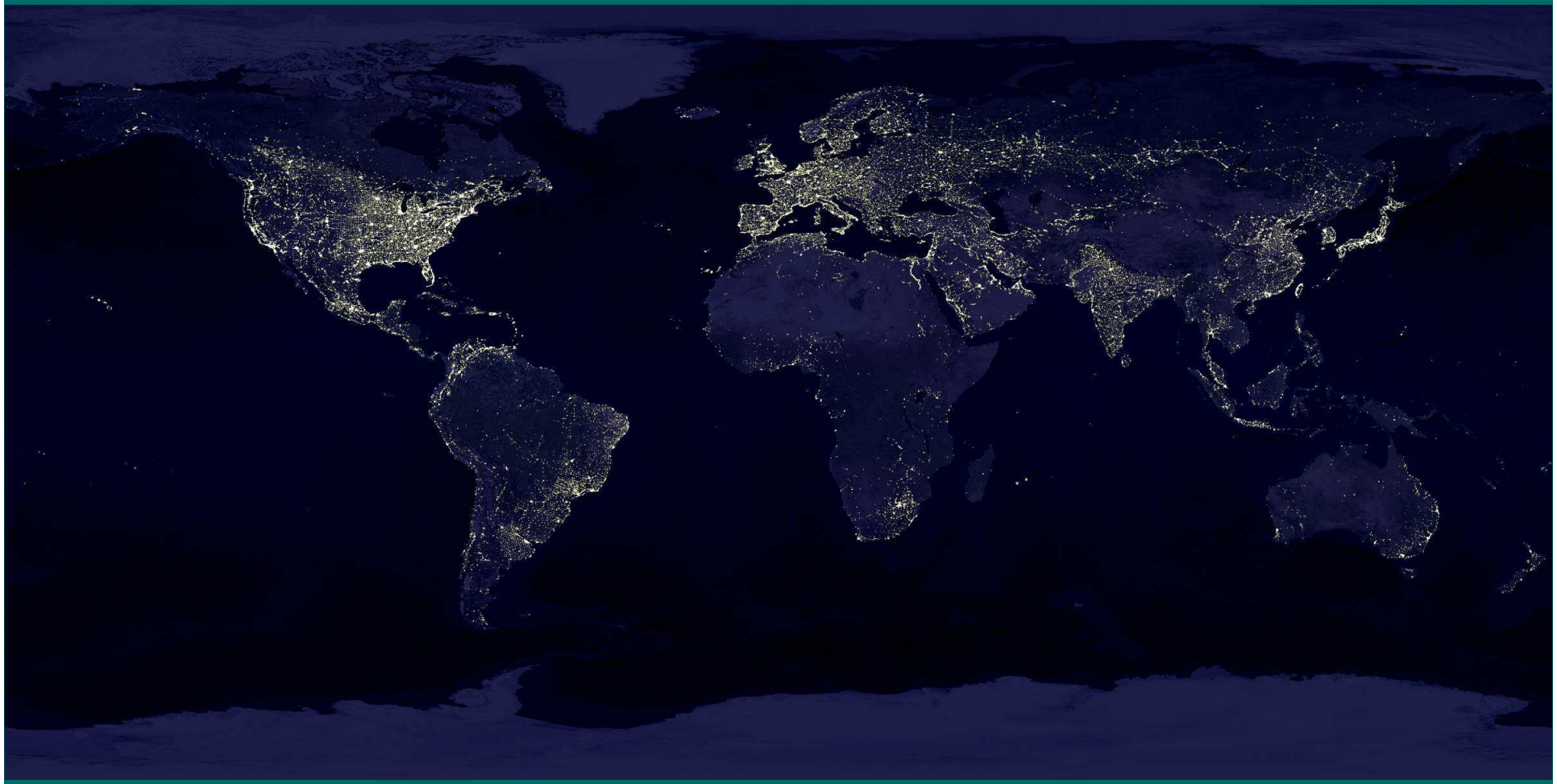
Minor pin tract infection

- To some degree its normal (where thick soft tissue)
- Bacterial contamination of the pin-skin surface
- Limited granulation tissue formation
- Light serous discharge
- Lack of pain
- No pin loosening

Thank You!



Practical training