PLEASE CLICK ON THE FOLLOWING LINK TO WATHC THE LECTURE ONLINE:-

https://www.youtube.com/watch?v=TlUOKn96yY4&list=PLuBRb5B7fa_eyBVgz4xb_AqlGcXLIEyRA&index=3

EXTERNAL FIXATOR

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12/7/2021

Learning objectives

- Describe the types of external fixators
- Describe the indications for external fixation
- Explain the “spectrum of stability” that can be achieved
- Describe how to determine the stability of the frame by the method of construction
- Describe how a modular frame is constructed and used to reduce and stabilize a fracture
- Explain how to place anatomically safe and stable pins in the tibia

Definitions

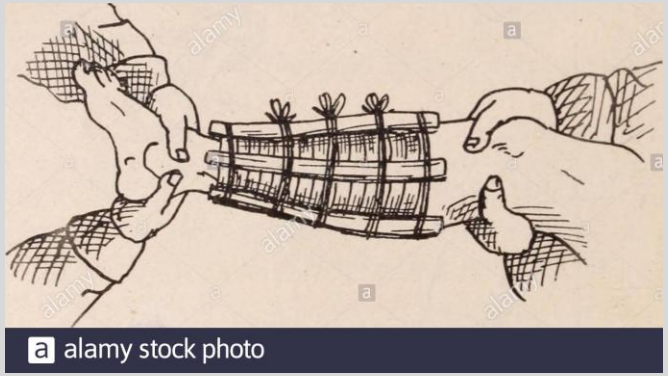
- **External Fixation** :

  Fixation of fractured bones by splints, plastic dressings, or transfixation pins.

- **External Fixator Device :**

  is a device placed outside the skin which stabilizes the bone fragment through wire or pins connected to one or more longitudinal bar/tube.

History



- Physicians have been using external fixation to treat fractures for more than 2000 years.
- Being first described by Hippocrates as a way to immobilize the fracture while preserving soft tissue integrity (external "shackle" device).
- The fixator design and biomechanics have changed dramatically over the years, but the principles remain the same.

Advantages of external fixation

- Minimally invasive—protects the local biology
- Damage control—can be quick to apply
- “Easy”
- Anywhere, any time.
- Wide range of indications
- Very successful outcome for management of fractures and soft-tissue handling
- Good results if done properly

Disadvantages of external fixation

- Risk of pin infection.
- Neurovascular injury.
- Tethering of the skin and muscles.
- Uncomfortable for the patient.
- Managing the patient in an external fixator can be challenging (compliance , bulky ,ugly appearance…).

INDICATIONS

1.Open Fracture

- Particular those with severe soft tissue injury
- Can be applied with minimal trauma, avoiding additional damage to soft tissues and bone vascularity

2. Closed Fracture

- Temporary bridging in severe polytrauma and severe closed soft-tissue contusions or degloving

3. Polytrauma

- For damage-control surgery in polytrauma
- The safest way to achieve initial stabilization of fractures in the severly injured
- Can be performed rapidly, minimally invasive technique, minimize any additional surgical insult to the patient

4. Articular Fractures

- Recommended in cases of open or closed articular fracture with severe soft-tissue compromise, when it can be applied in a joint-bridging fashion

5. Bone or soft-tissue loss

6. External fixator as a tool for indirect reduction

- One way to achieve minimally invasive intraoperative reduction is to apply the modular external fixator as an external reduction device

- 7. distraction osteogenesis , *Corrections , Limb lengthening , Segment transport.*

SO …

Temporary – fracture healing not intended:

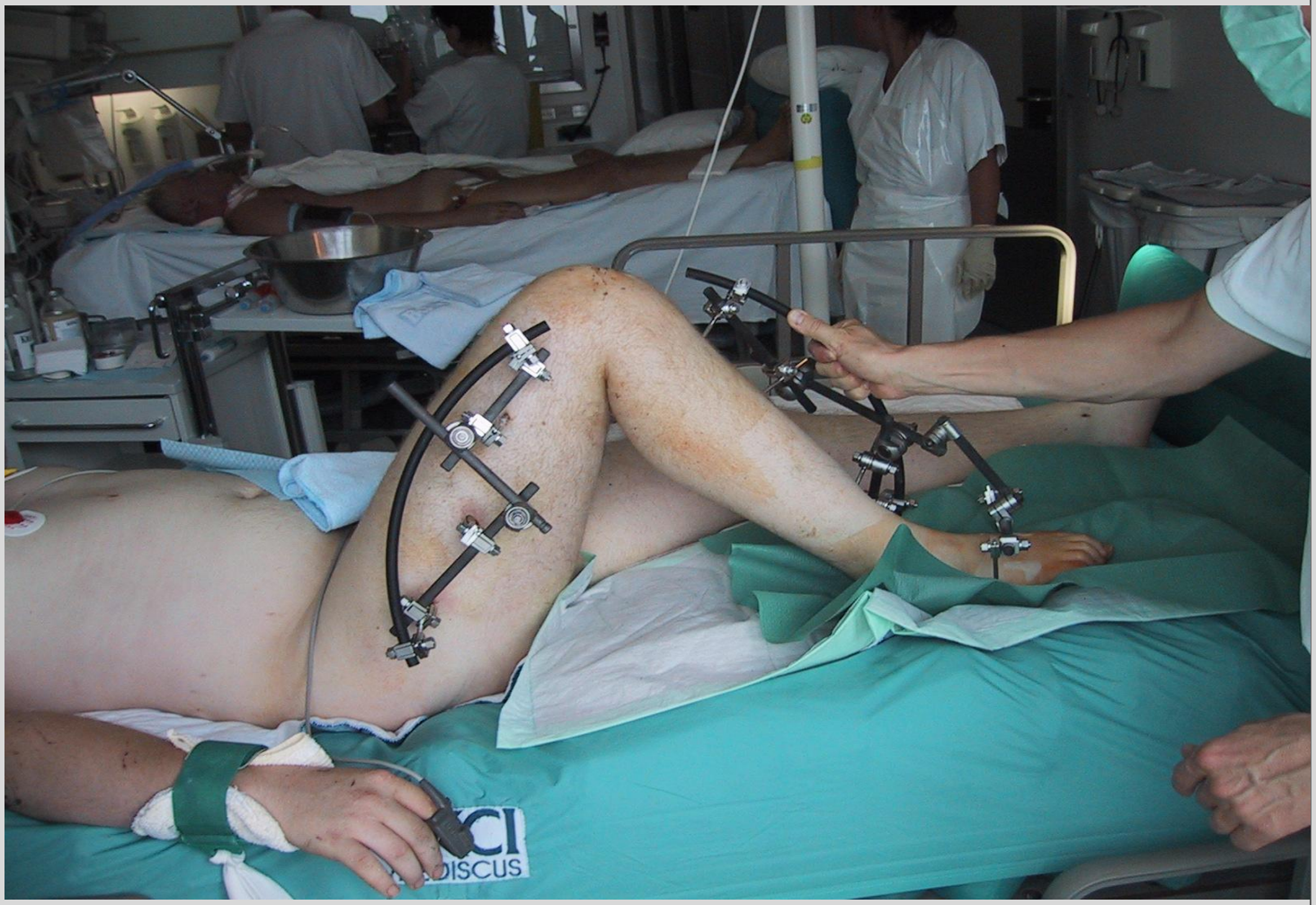
- DCO: within a bone segment and across joints.

Definitive application for fracture union:

- Achieve relative stability in a fracture setting – secondary bone healing.
- Achieve primary bone healing via compression.
- Create bone via distraction osteogenesis.

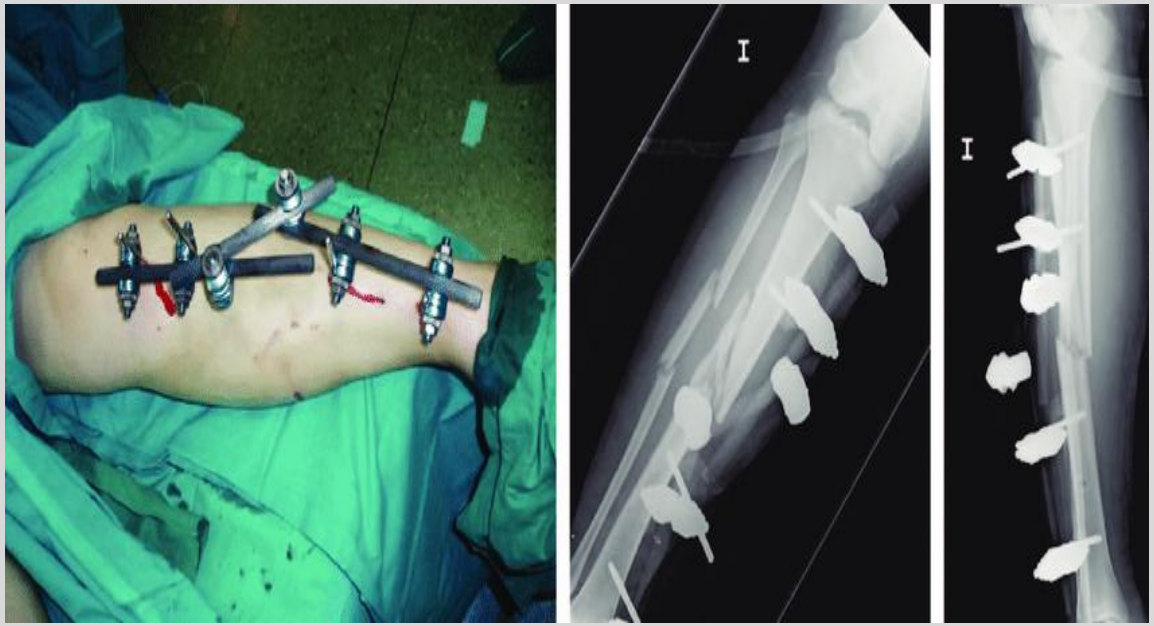
Polytrauma–damage control external fixation

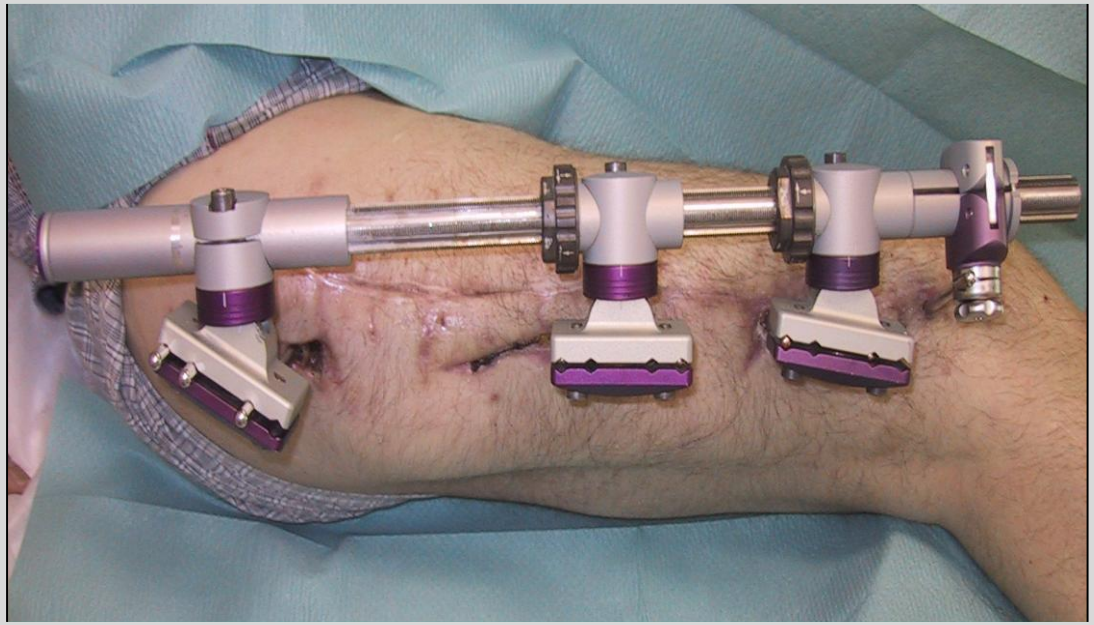
- Developed to focus on initial hemorrhage control, followed by definitive care.
- Minimize 2nd hit .
- Avoid fixation pins crossing surgical approach paths.



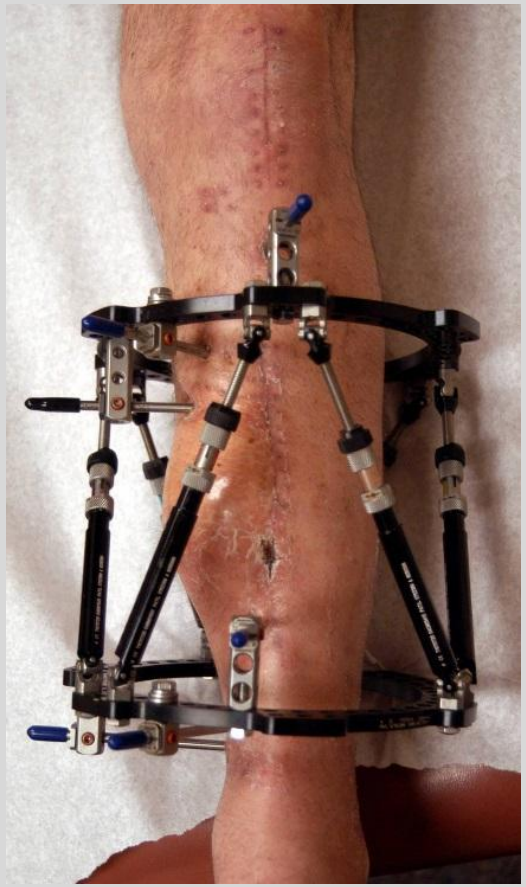
Types of external fixation

Monolateral Ex-Fix :



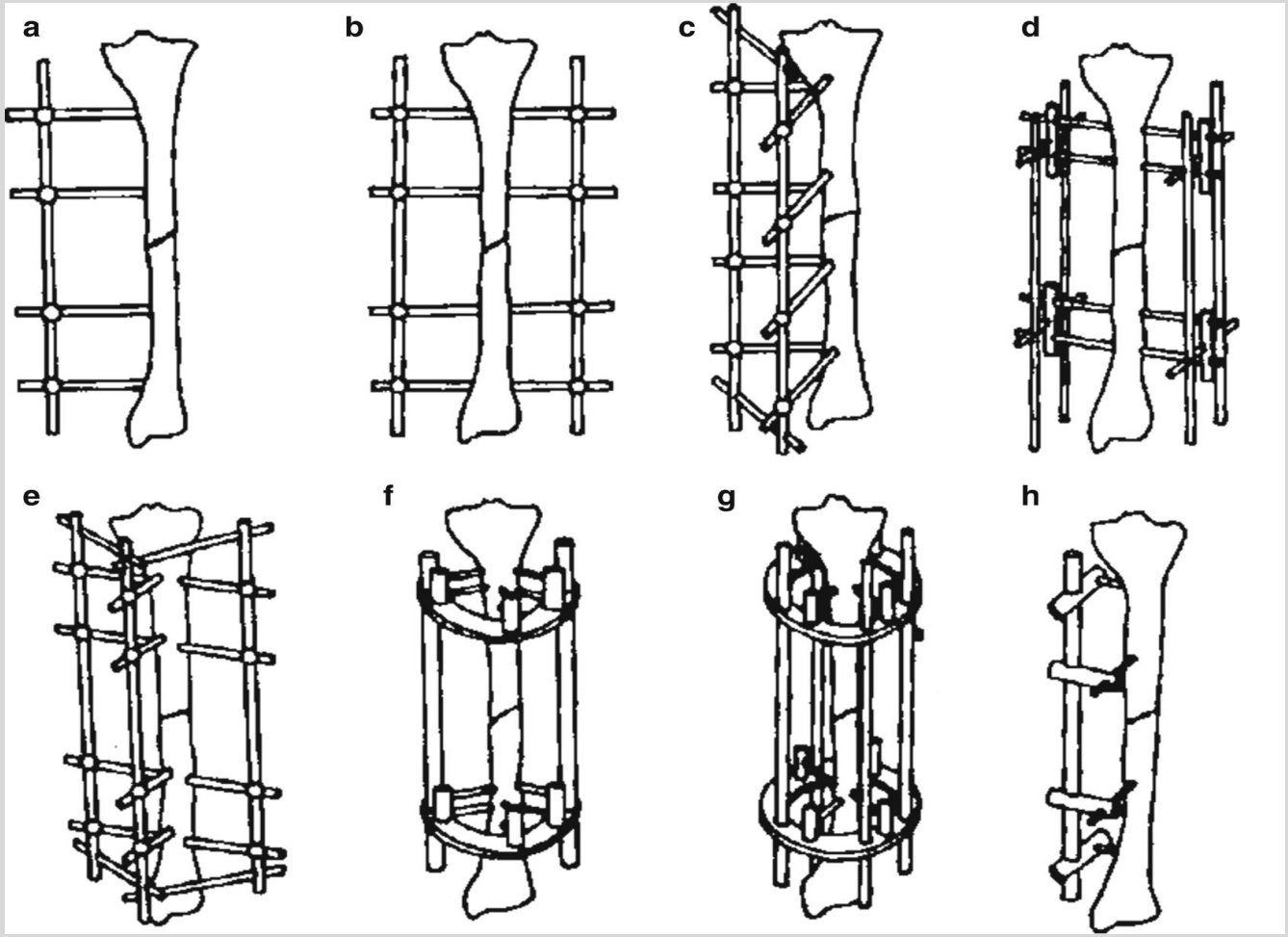


Ring Ex-Fix :

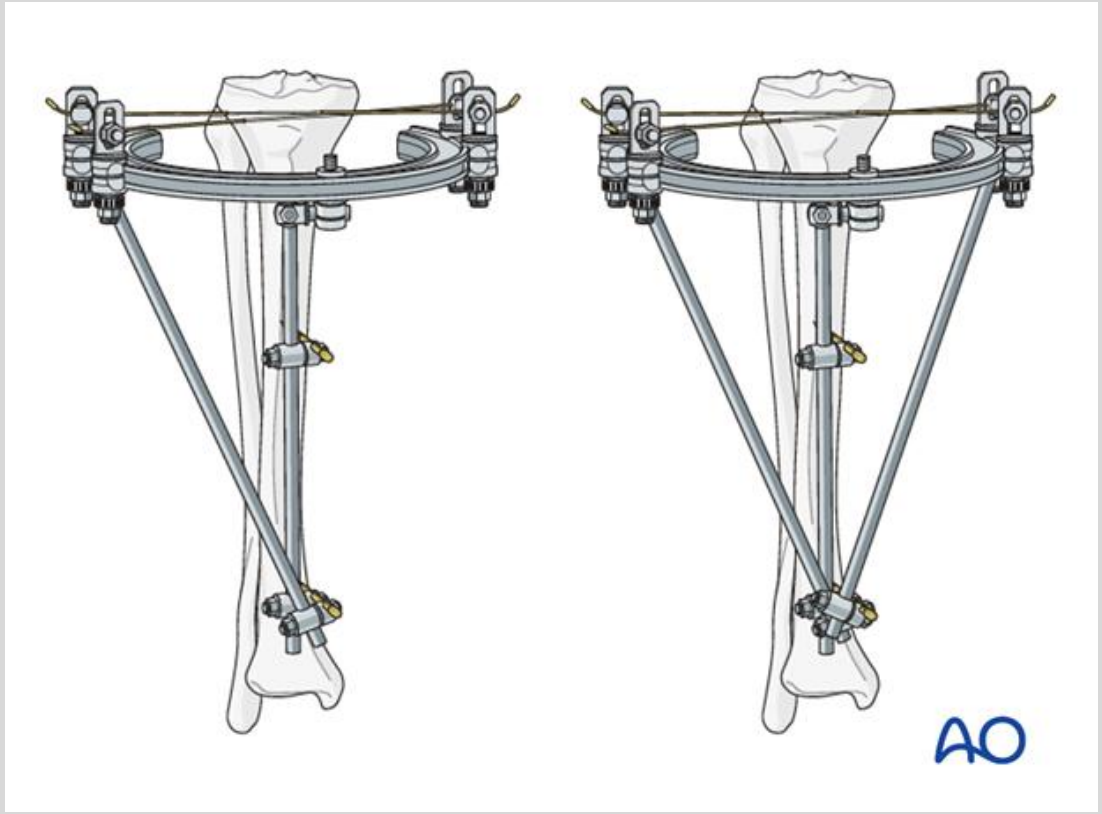


Construct Design

- ❑Uniplanar :
  - Unilateral (a)
  - Bilateral (b+d)
- ❑Biplanar :
  - Unilateral (c + h)
  - Bilateral (e)
  - Triangular –multiplanar (c + e)
- ❑Circular :(iliozarov , TSF) (f+g)
- ❑Hybrid fixators (wire and pin)
- ❑Pinless external fixator



Hybrid Ex-Fix



Pinless Ex-Fix

Spanning Ex-Fix

Articulated Ex-Fix

Mini EX - FIX

FRAME COMPONENTS

❖Uniplanar/Biplanar

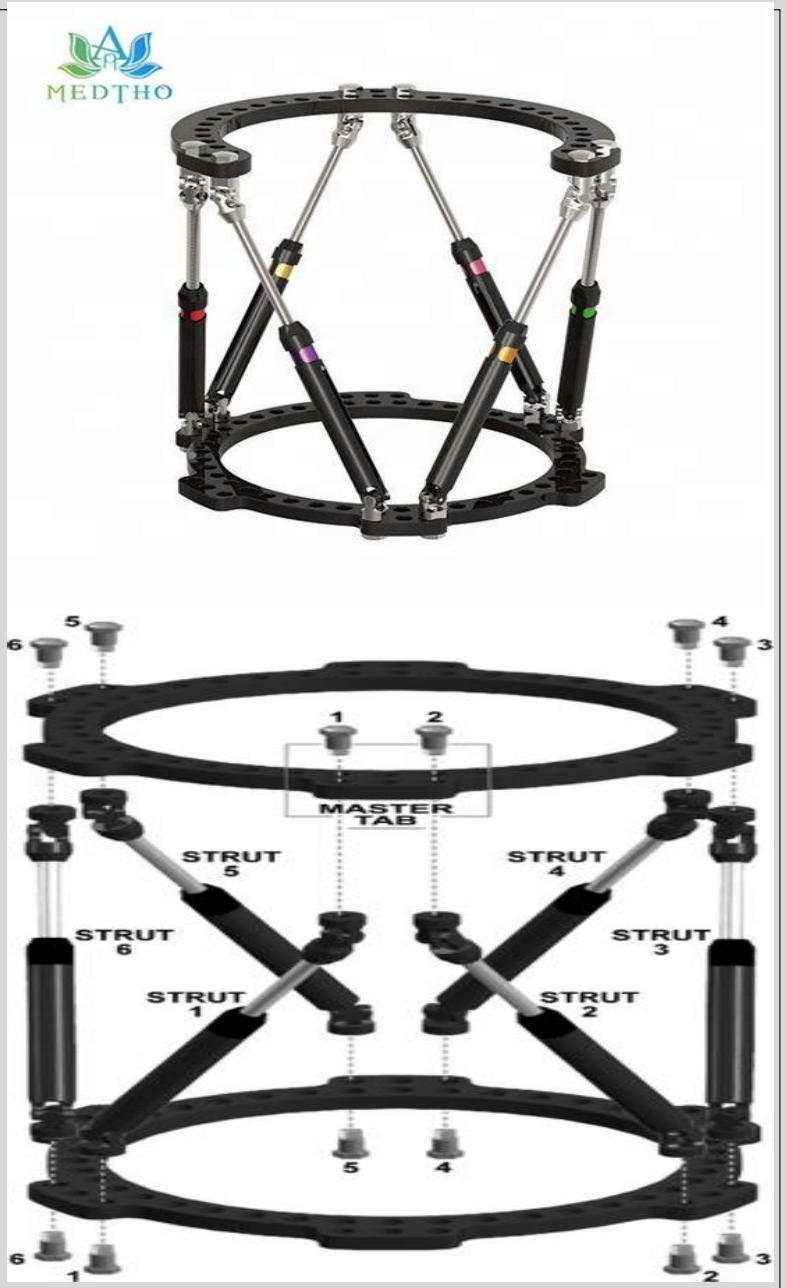
(Traditional Frame)

- Pins
- Clamps
- Connecting rods

❖ Ring/Hybrid/Hexapod

- Rings
- Transfixion wires
- Half pins
- Struts
- Misc small parts


A8067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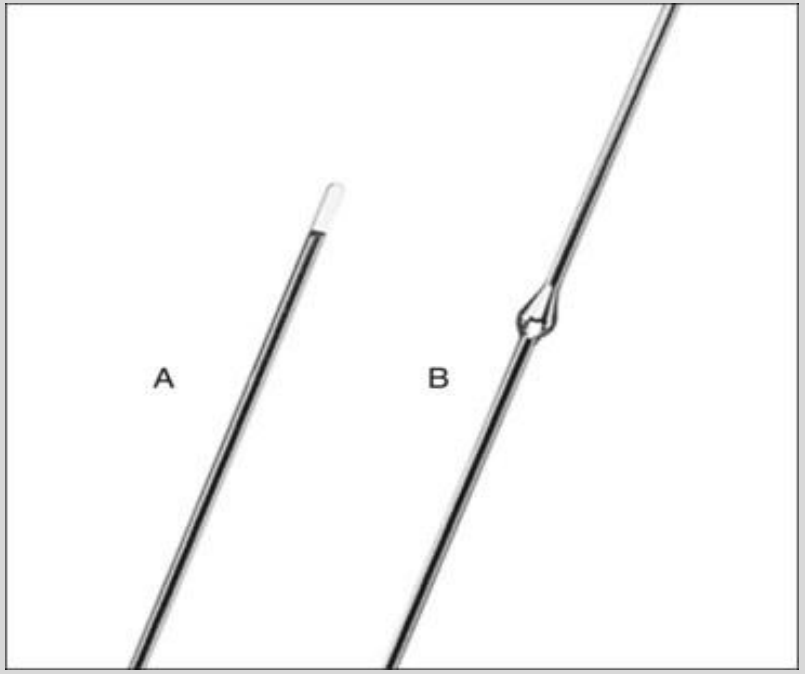

A
B

PIN

- it is a link between the bone and the frame.
- Schanz screws are partially threaded pins.
- Available in different diameters and lengths.

❑Many options

- 2-6mm sizes
- Self drilling/tapping
- Blunt tip
- Conical
- Fine thread
- Course thread (Cancellous bone)

❑Material

- Titanium
- Stainless

❑Coatings

- Non-coated
- Titanium
- Hydroxyapatite

- The single most important factor with frame strength is increasing pin size /Pin stability is dependent on radial preload .

- PIN bending stiffness proportional to radius^4.

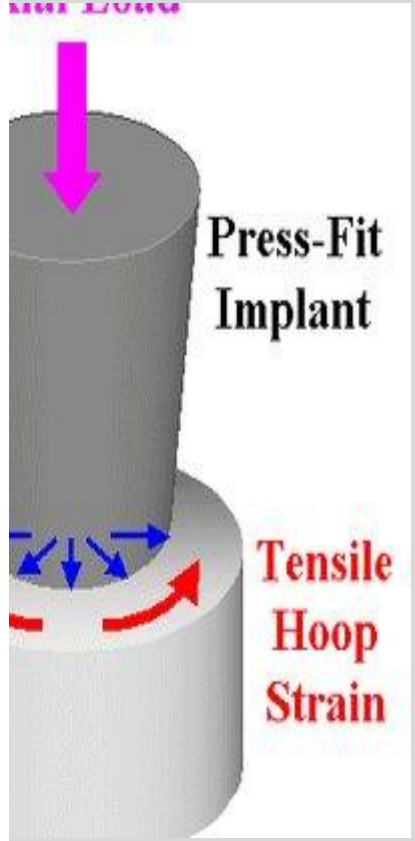
- The pin should not exceed one-third diameter of the bone .

- Avoid unicortical pin.

DON`T EXCEED 1/3RD OF THE BONE DIAMETER

Radia

- A force be
- Implant – B
- Larger dia
  force.

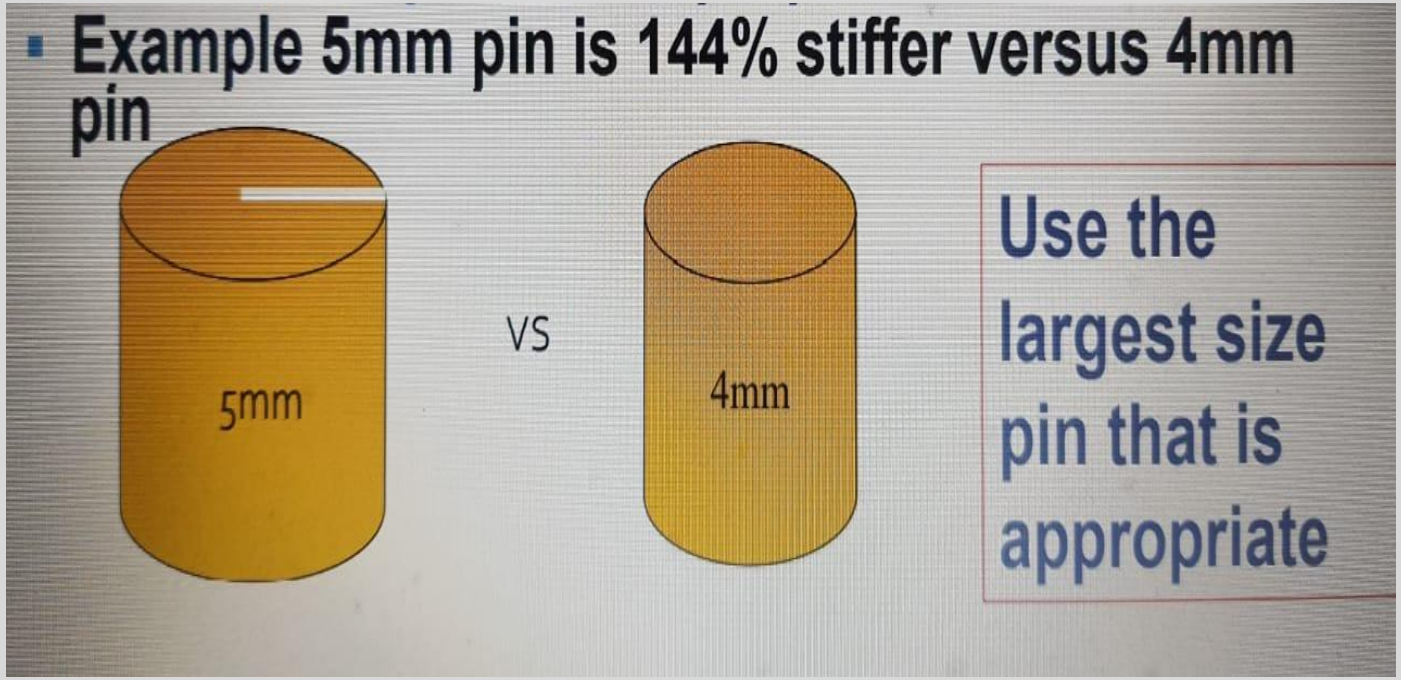


Example ….. BENDING STIFFNESS

- 5 mm pin(R=2.5) is 144 % stiffer than 4 mm pin (R=2).

- 2.5 * 2.5 * 2.5 * 2.5 = 39.0625
- 2 * 2 * 2 * 2 = 16

- 39.1 – 16 = 23.1
- 23.1 / 16 = 1.44 (144%)



GENERAL GUIDELINES

- Femur – 5 or 6 mm
- Tibia – 5 or 6 mm
- Humerus – 5 mm
- Forearm – 4 mm
- Hand, Foot – 2.5-3 mm

SELF DRILLING/SELF TAPPING

- ❑ Advantages

– Single stage insertion

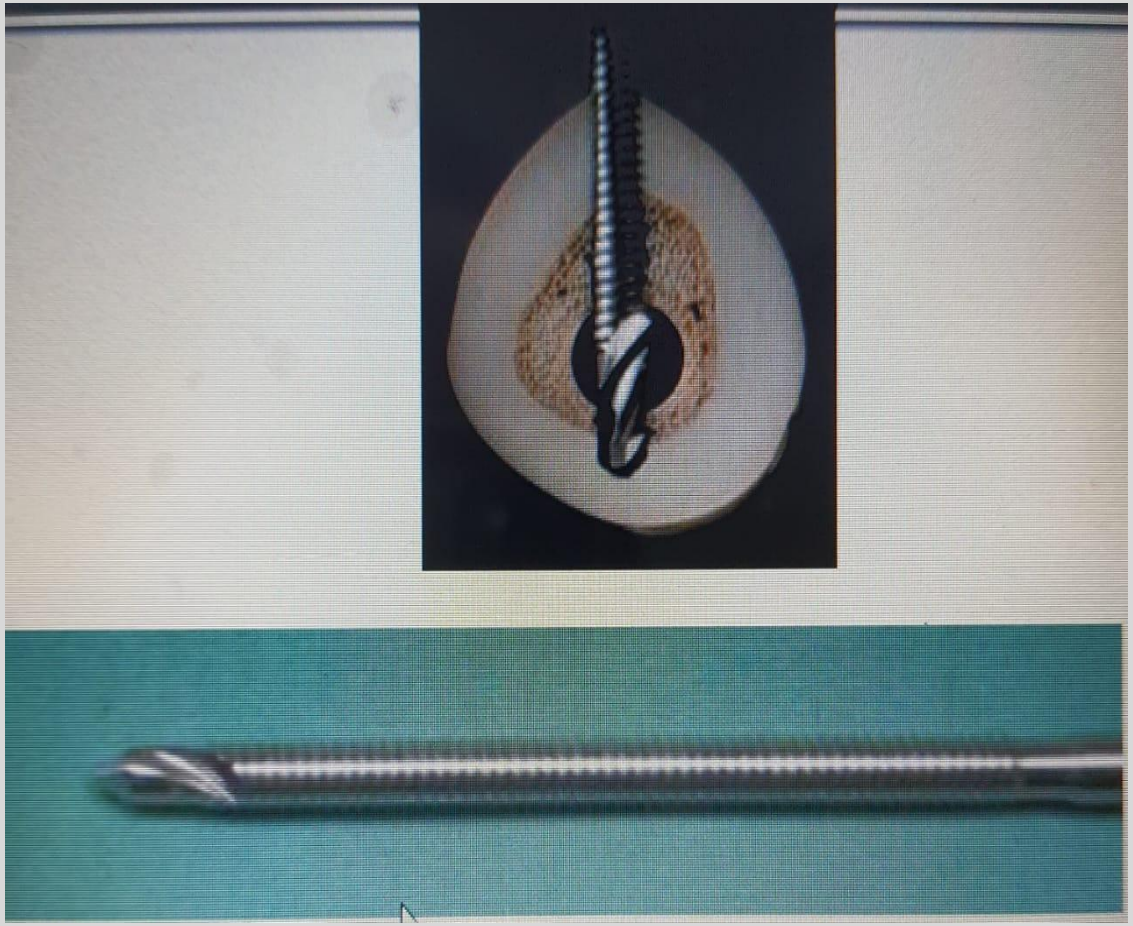
– Fast

- ❑ Disadvantages

- Short drill flutes resulting in possible:

- ◦ Thermal necrosis
- ◦ Stripping near cortex
- ◦ Loss of radial pre-load
- ◦ Decreased torque to
- ◦ pull out over time

(loosening).



BLUNT PINS

- ❑Multi stage insertion
- ❑ Preservation of near cortex
- ❑ Tapered pins
  - ◦ Improved radial pre-load
  - ◦ Beware of advancing and

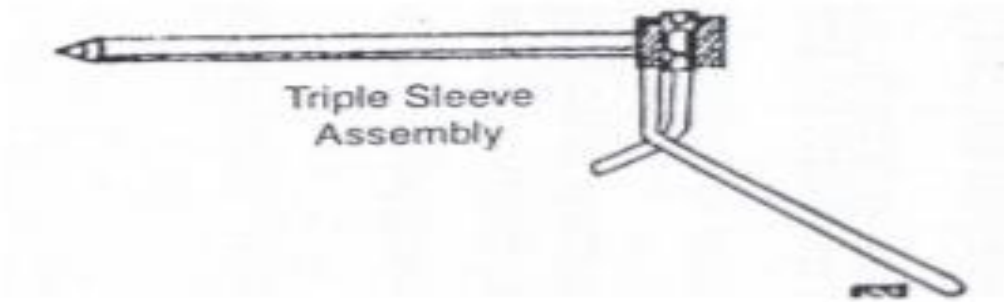
then backing up= loss of

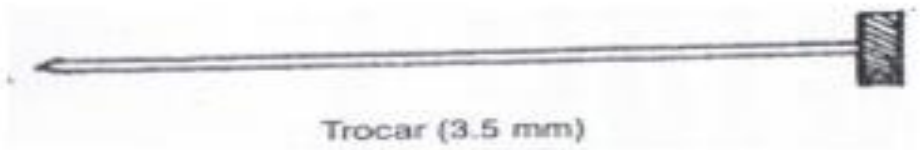
radial pre-load with early loosening.

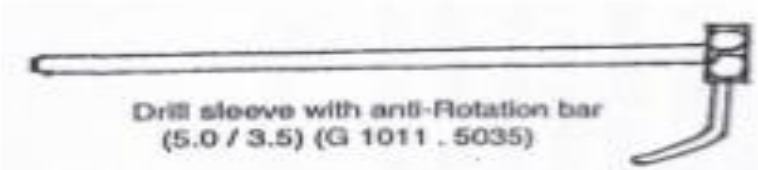
Hydroxyapatite (HA) vs titanium vs uncoated

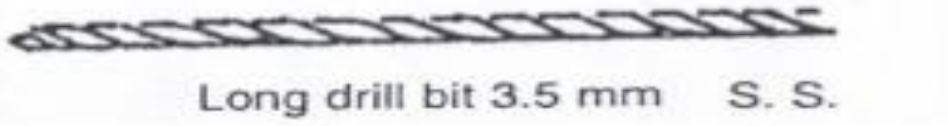
- HA with superior of extraction torque (13x higher).
- 2x higher extraction torque vs titanium.
- Decreased infection :
- Highly consider HA pins for extended use and or definitive fracture care.

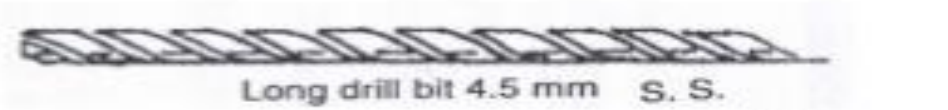
Required instruments

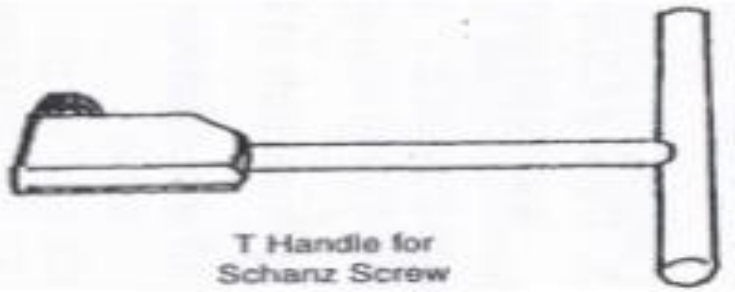












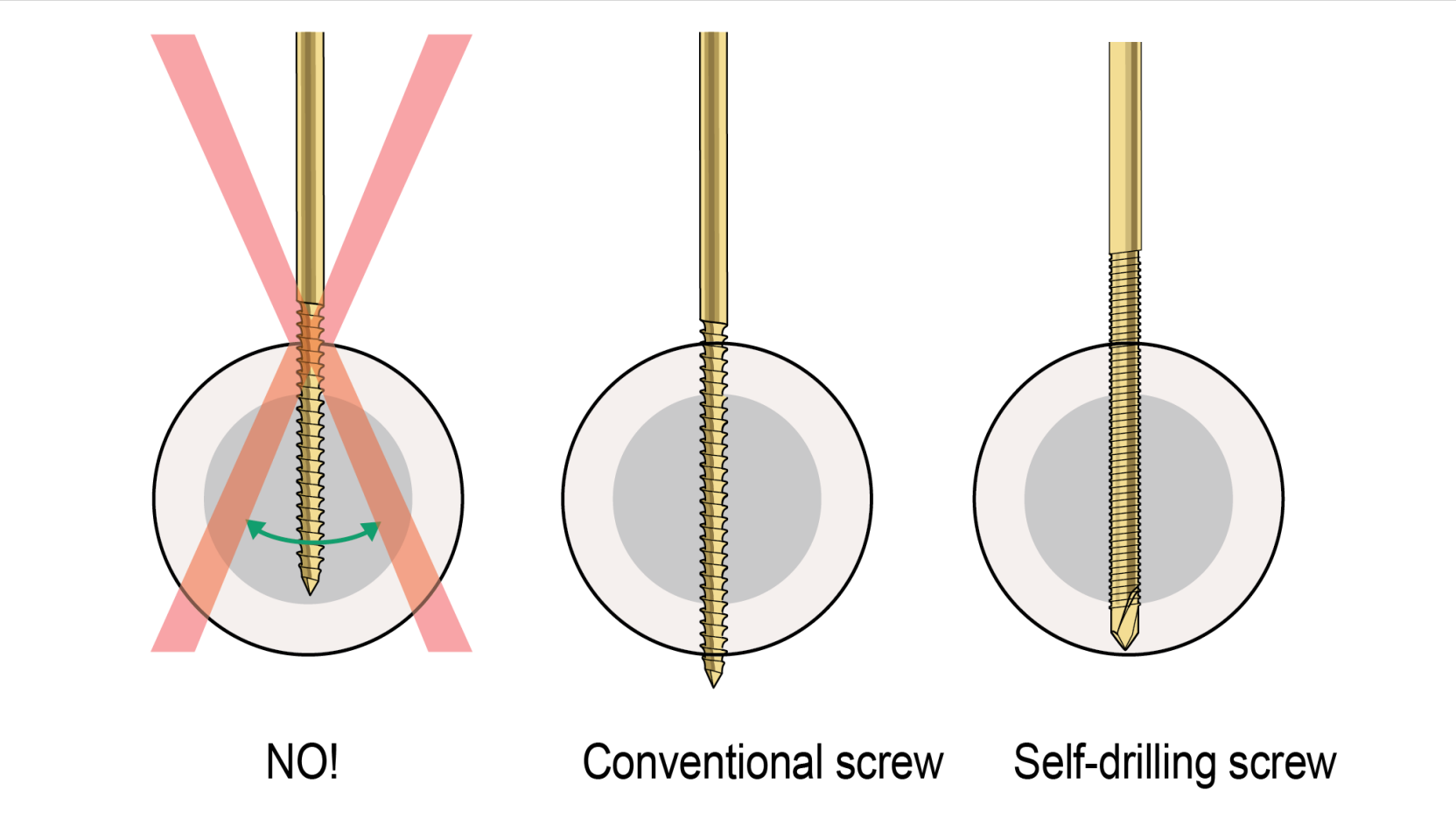
PIN INSERTION TECHNIQUE

1. Incise skin
2. Spread soft tissues to bone
3. Triple sleeve first in and last out
4. Irrigate while drilling
5. Place appropriate pin using sleeve
6. Place pin bi-cortical

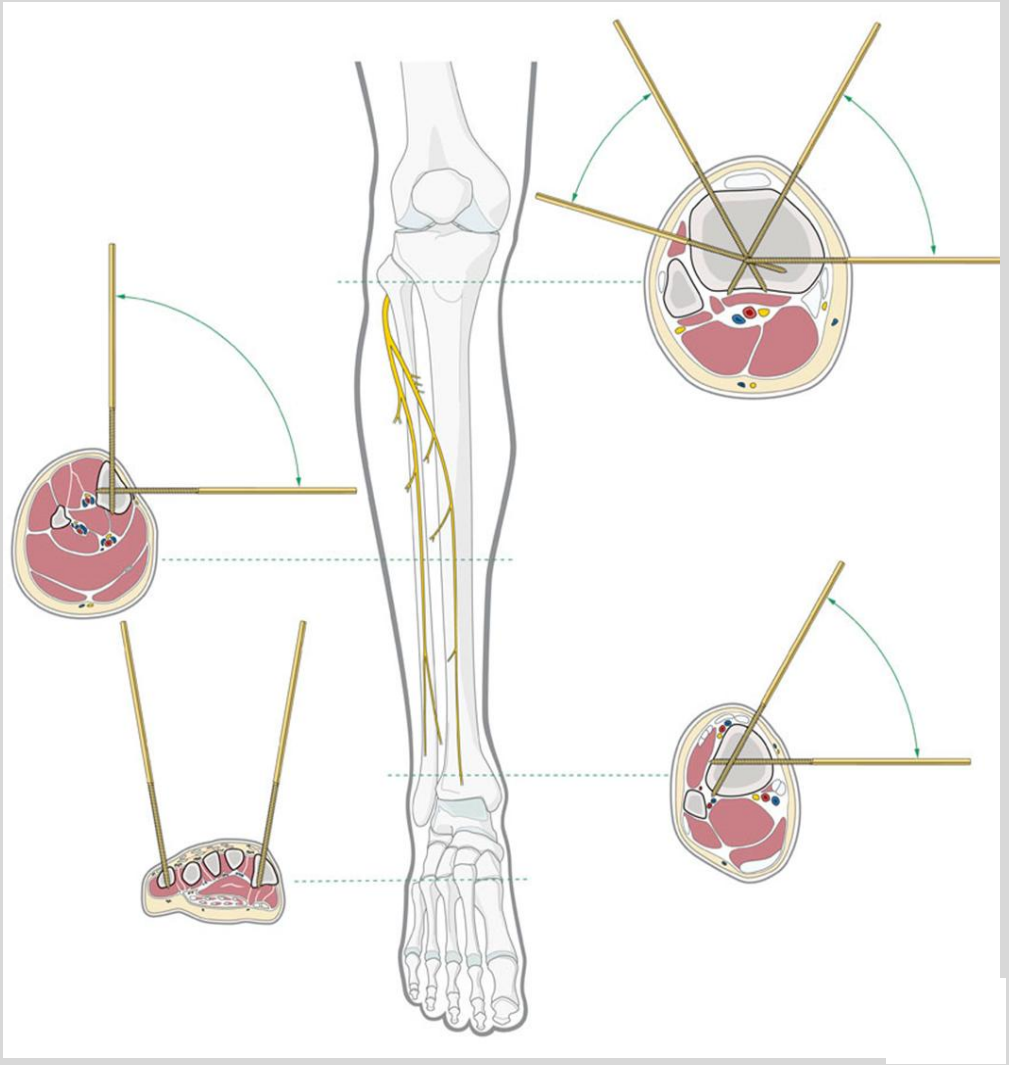
Avoid soft tissue damage and bone thermal necrosis

Principles of External Fixation. Kemper. OTA. Oct. 2014

Schanz screws placement in diaphyseal bone



- Must avoid anatomical structures
- Avoid tethering soft tissue
- Less pain
- Fewer pin-track infections



Tibia safe zones **

CLAMP


D31


Rod to Rod Coupling
Pin to rod Coupling
Inverted Pin to rod Coupling
Double Pin to Rod Coupling
Inverted Double Pin to rod Coupling
Inverted Pin to rod Coupling
Multi-Pin Clamp
30°Angled Post
Straight Post
Semi-Circlar Rod

Connecting Rods

- materials:
  - titanium
  - Steel
  - Aluminum
  - Carbon fiber
- Design
  - Simple rod
  - Articulated
  - Telescoping

Rods/Tubes

- The AO fixators consist of systems in four sizes, depending on the size of the rod :
  - **Large** : 11 mm tubes/rods + Schanz screws from 4 - 6 mm
  - **Medium** : 8 mm tubes/rods + Schanz screws from 3 - 6 mm
  - **Small** : 4 mm tubes/rods + Schanz screws from 1.8 - 4 mm
  - **Mini** : 2 mm system for fingers; it is presently available in the conventional design and includes multi pin clamps for K-wires and 2 mm longitudinal rods

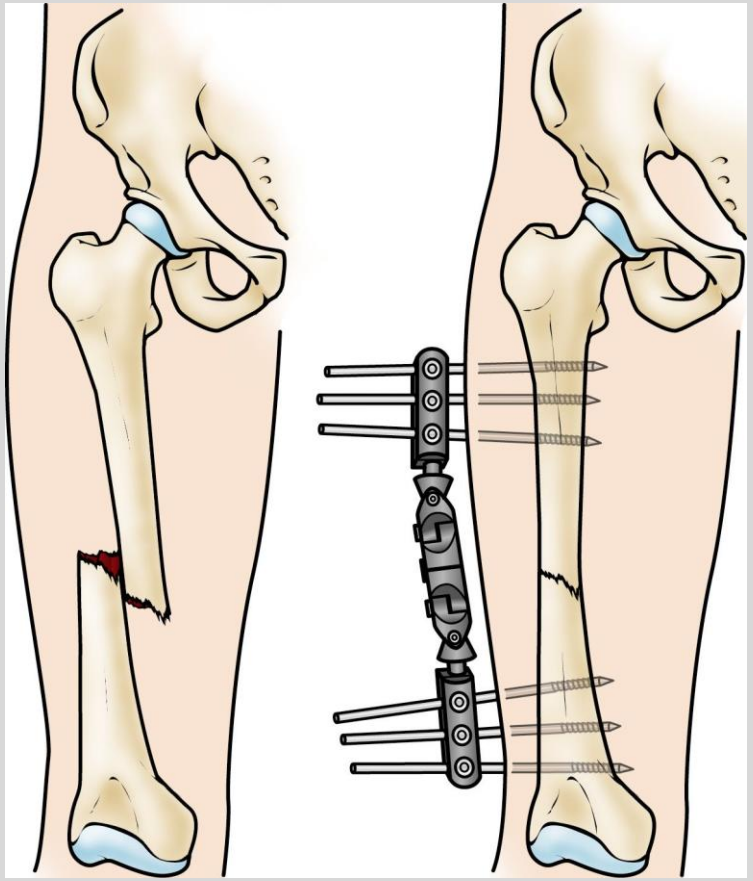
- Stainless steel, aluminum alloy, carbon fiber

AO Principles of Fracture Management. 2000

BIOMECHANICS : ↑ STABILITY

❑FRACTURE FACTOR :

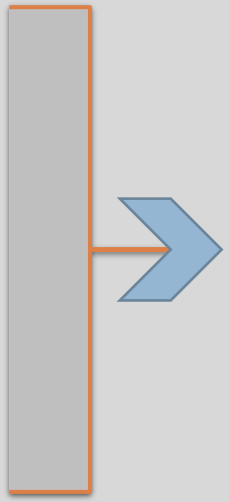
- Fracture ends abutment (end to end alignment)



BIOMECHANICS : ↑ STABILITY

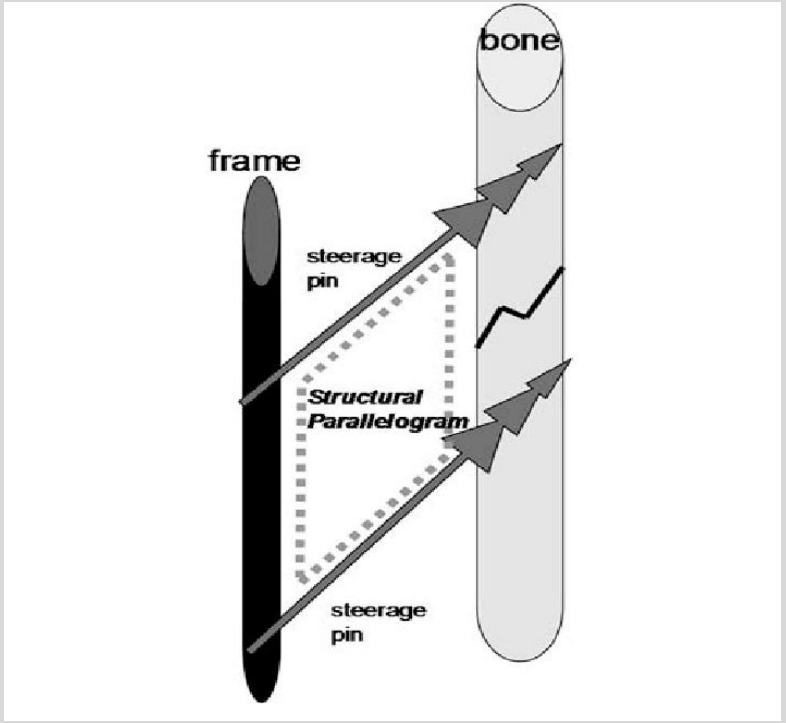
❑PIN FACTOR:

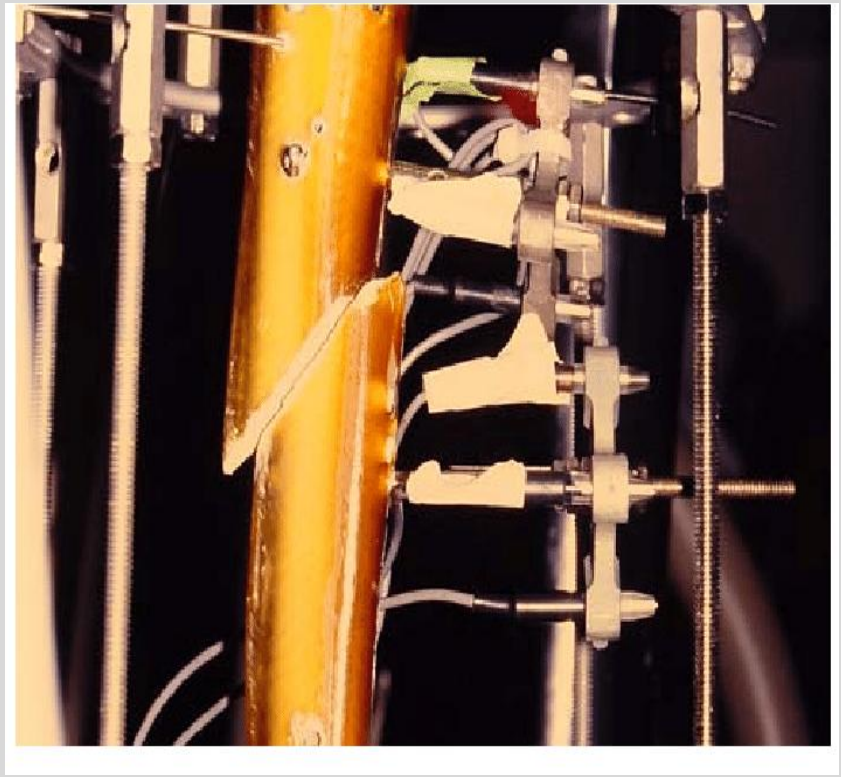
- Increasing pin diameter
- Increasing pin spread
- Increasing number of pins
- Decreasing distance from pin to fracture



Minimize cantilever bending and shear at fracture

Oblique Fractures





BIOMECHANICS: ↑ STABILITY

❑ ROD FACTOR :

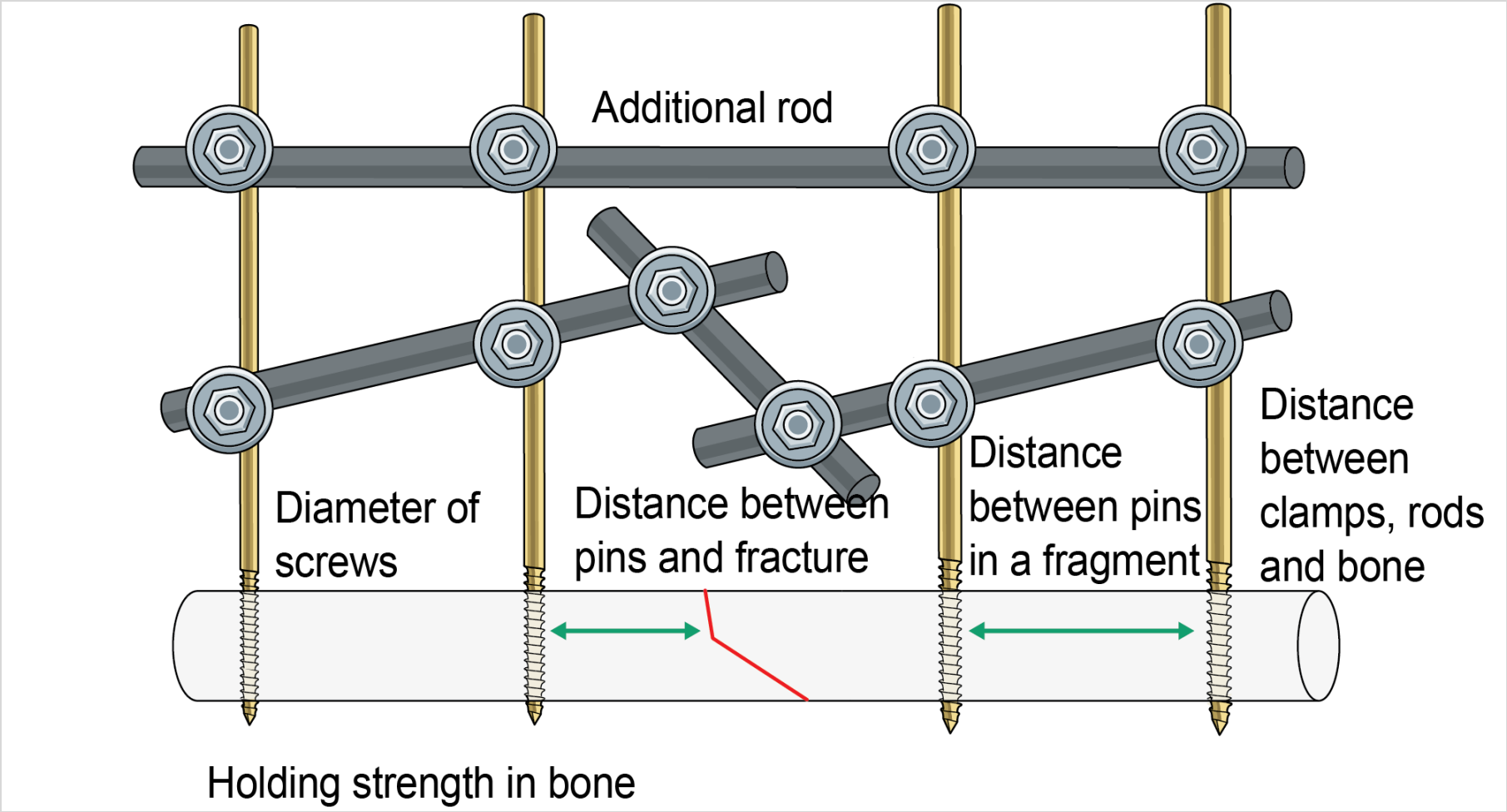
- Decreasing distance from bar to bone.
- Increasing number of rods.
- Increasing diameter of rod.
- Allowing sufficient space for soft tissue swelling.

BIOMECHANICS: ↑ STABILITY

❑RING FACTOR :

- Decreasing ring size .
- Increasing number of rings.
- Separation of (rings) from each other.
- Increasing wire tension and size.

Factors influencing stiffness of construct



Modular variety of External Fixator

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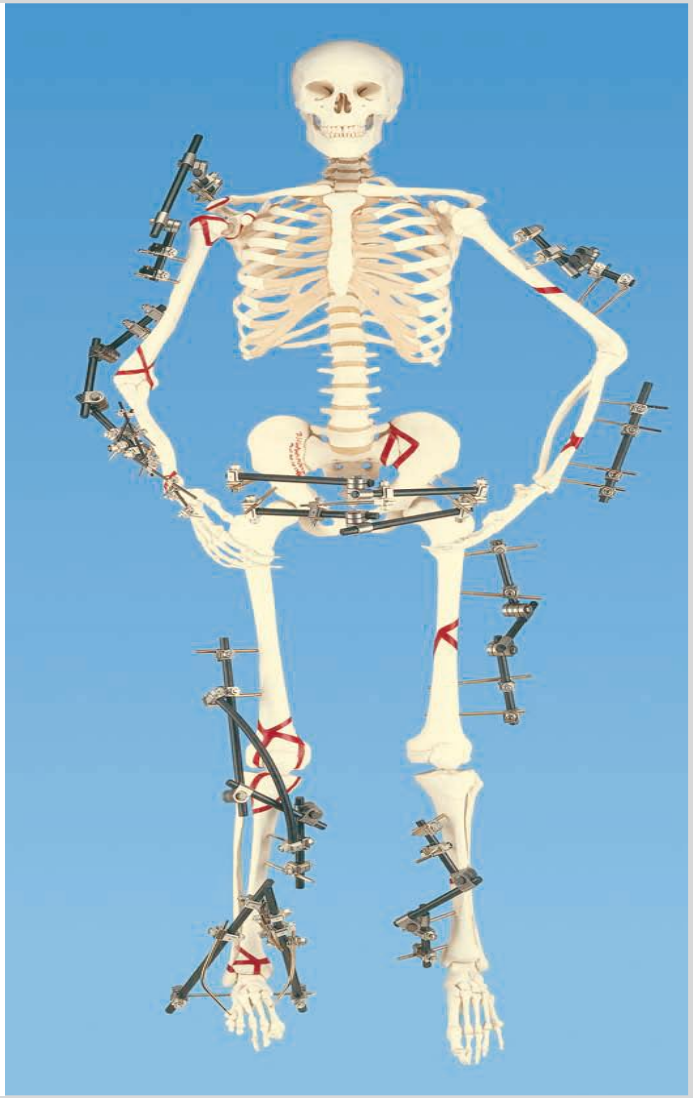
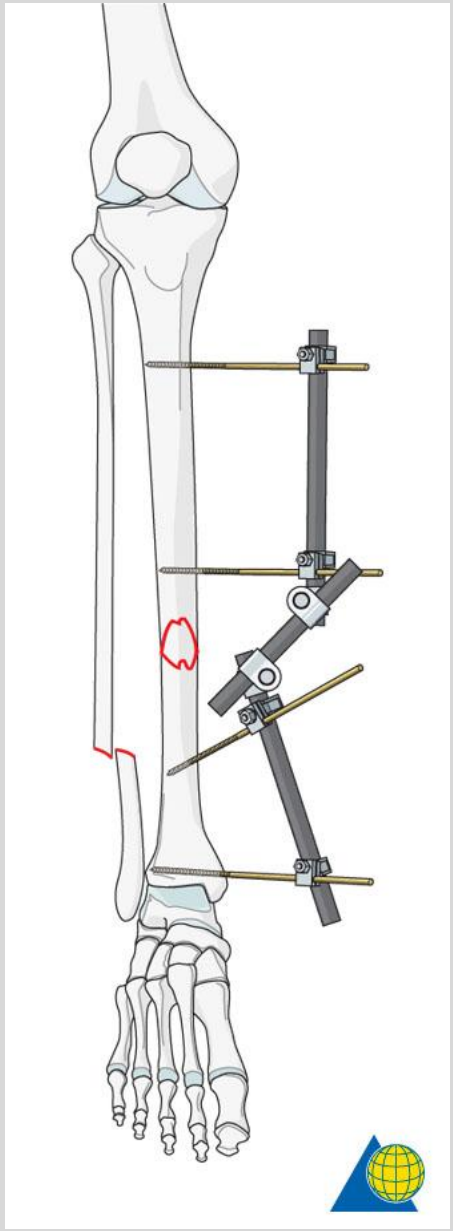


- The modular external fixation technique is recommended by the AO for reduction and stabilization.

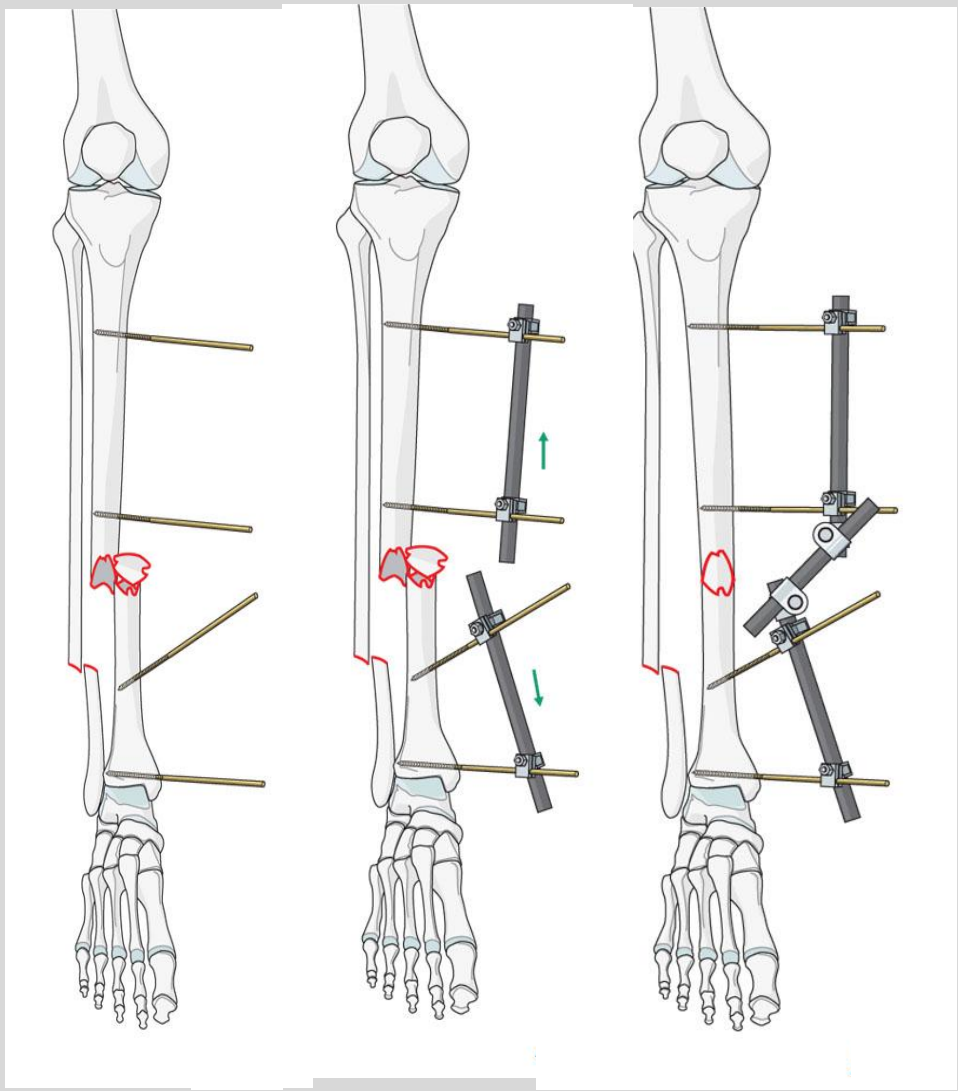
Modular technique

- The **modular method** allows the external fixator to become a **reduction tool**



Modular technique

- Pin insertion
- Fix rods/tubes to pins
  - Create a “partial” frame for each main fragment
  - Tighten all clamps very well
- Apply third rod using two rod-to-rod clamps, yet loosely
  - Reduce fracture
  - Tighten clamps



PIN SITE INFECTION

- RISK FACTORS:
  - Age
  - Medical comorbidities , Immune system status , smoking
  - Increased duration of pin fixation
  - periarticular pin placement > diaphyseal..???
  - Surgical technique…..???
  - Hygene…

Levels of Skin Reaction to Percutaneous Pins

1. Pin site reaction : Represents normal/physiologic changes in skin colour, skin warmth, and pin site drainage and resolves within 72 h.

2. Pin site colonization: Includes Erythema, warmth, drainage, possible pain, and positive culture.

3. Pin site infection: Includes all of the above, possibly with the addition of pus, pin loosening, or increased microbial growth on cultures.

PIN site infection

Grades	Clinical findings	Treatment
1	Slight discharge and redness around the pin	Local pin and wound care
2	Redness and tenderness in soft tissues with or without discharge of pus	Local pin and wound care + oral antibiotics
3	As for grade 2 but with failure to improve with local care and antibiotics *after* 72 hours	Infected pins removed + oral antibiotics (IV antibiotics)
4	Severe soft tissue involvement affecting more than one pin. *Pin loosening*	Infected pin removed + oral antibiotics (IV antibiotics)
5	As for grade 4 but also with bone involvement visible on X-Ray	Pins removed + curettage of bone + (IV antibiotics)
6	A sequestrum has formed within the bone and a persistent sinus has developed.	Further surgery required to eradicate problem.

*checketts otterburn classification - CO (minor 1-3 , major 4-6).

- ORAL ANTIBIOTICS:
  - Dicloxacillin is a narrow-spectrum β-lactam antibiotic of the penicillin class.
  - used to treat mild-to-moderate staphylococcal infections.
  - similar in pharmacokinetics, antibacterial activity, and indications to flucloxacillin , BUT with lower incidence of severe hepatic toxicity.

- IV ANTIBIOTICS :
  - Culture based…

Prevention and Care :

- intravenous antibiotics are given prior to skin incision and continued for 24 post-operatively.
- Avoid Electrocautery at pin sites to prevent tissue necrosis.
- No- touch technique to the PIN tip and threads.
- Use drill sleeve , meticulous soft tissue handling , avoid skin tenting and release if presents .
- pre-drilling pin sites with a sharp dill bit with irrigation during drilling and insertion.
- inserting pins by hand.
- not using a tourniquet to reduce the risk of thermal necrosis to bone and skin (natural cooling).
- Pin design : titanium (low metal-skin irritation) ,HA coated PINS(osteointegration and prevent loosening).

- it is unclear whether cleansing pin sites is necessary to reduce the risk of infection.
- The ideal pin site cleansing solution is yet to be identified .
- but there is some evidence that chlorhexidine may be useful to decrease pin site colonization, antibiotic use, and pain.
- solution of 1:1 hydrogen peroxide and normal saline . (in case of dermatitis + 1:3 dilution can be used).
- Daily showering is encouraged on POD 4 - 5 .
- Patients are allowed to swim in a chlorinated pool after 4 weeks .

Complications of PIN site infection:

- pin loosening (with loss of fixation, loss of alignment, frame instability.
- osteomyelitis.
- joint or fracture site contamination (septic arthritis , infected nonunion).
- increasing pain which limits patient function .

MRI Compatibility

- Stainless steel components (pins, clamps, rings) most at risk for attraction and heating
- Titanium (pins), aluminum (rods, clamps, rings) and carbon fiber (rods, rings) demonstrate minimal heating and attraction
- Almost all are safe if the components are not directly within the scanner (subject to local policy)
- Consider use of MRI "safe" ex fix when area interest is spanned by the frame and use titanium pins

Kumar, JOR, 2006
Davison, JOT, 2004
Cannada, CORR, 1995

- The latest standard plates and screws used in orthopedic surgery do not pose an additional hazard or risk to patients undergoing MR imaging at 1.5-T or less.
- Migration-displacement, or RF induced heating, which is extremely low.
- Though artifacts caused by them cannot be ignored because of their relatively large size, it is possible to be minimized by choosing appropriate pulse sequences and optimizing scanning parameters.

Take-home messages

- External fixators have broad indications
- Many types of fixators are available with specific functions
- The stability of a fixator is surgeon-controlled
- The modular technique is the standard for damage control applications
- Technique and location of pin placement is important to minimize infection and pain