External Fixation

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ASO Surgery St Nikolaus Eupen

5 november 2012

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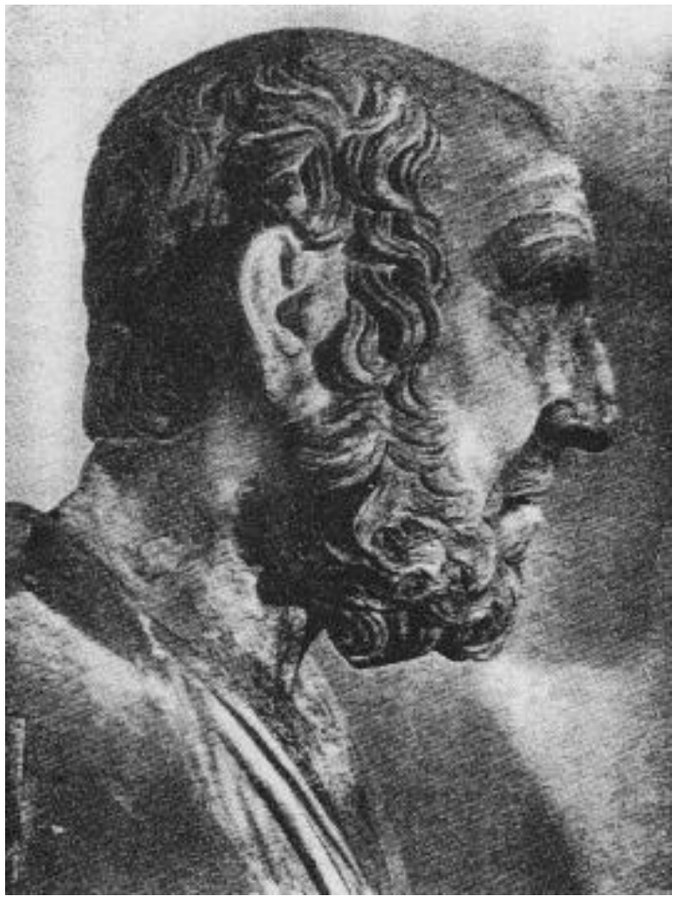
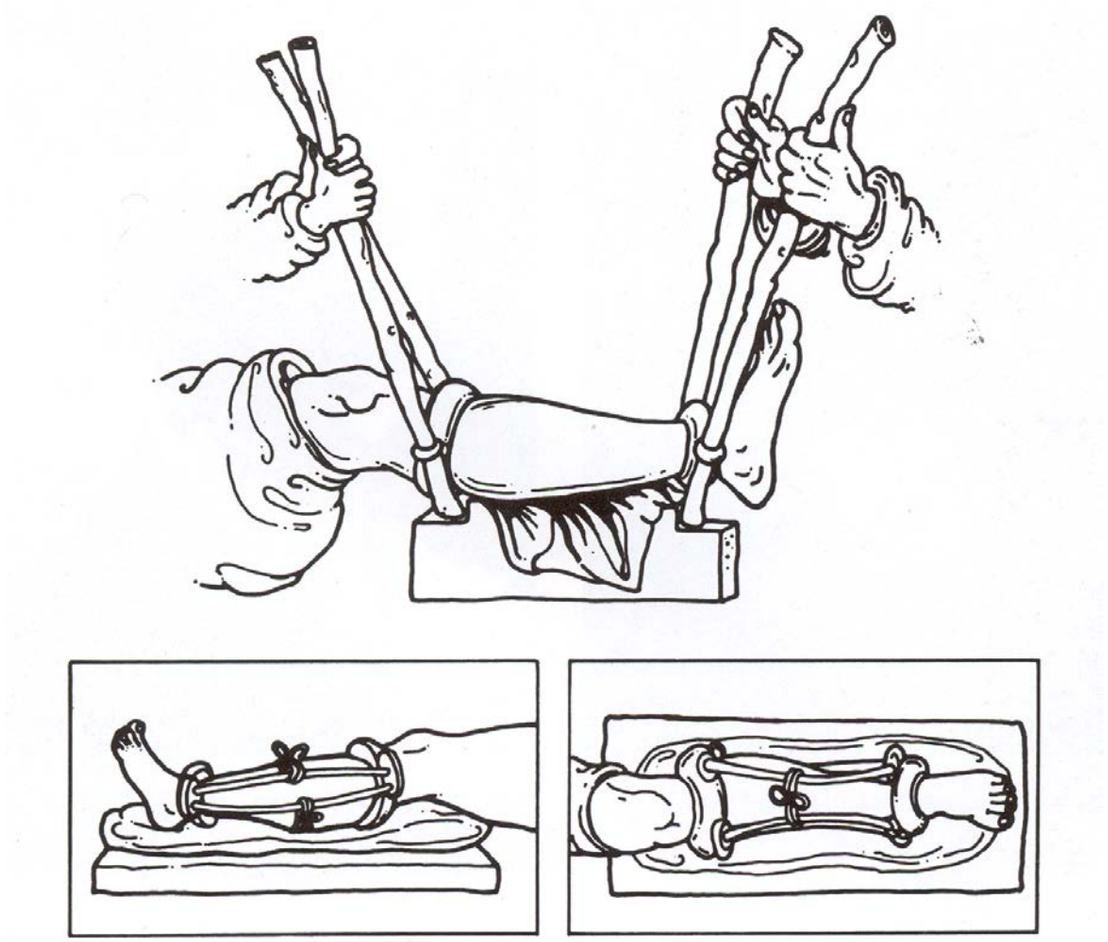
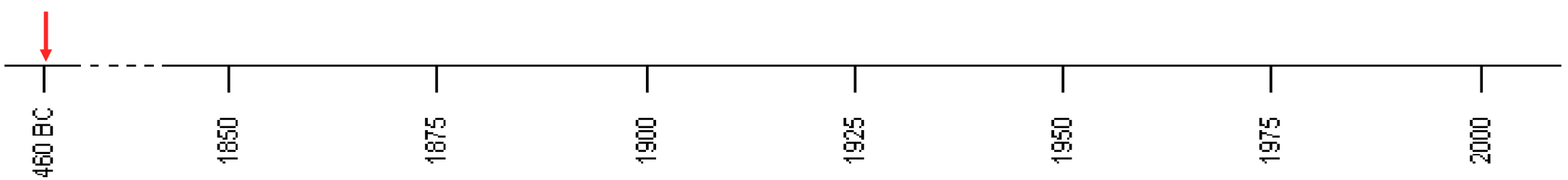
- History
- Indications
- Principles and Biomechanics
- Complications and contra-indications

History

420 BC Hippocrates







History

1840 Malgaigne, France

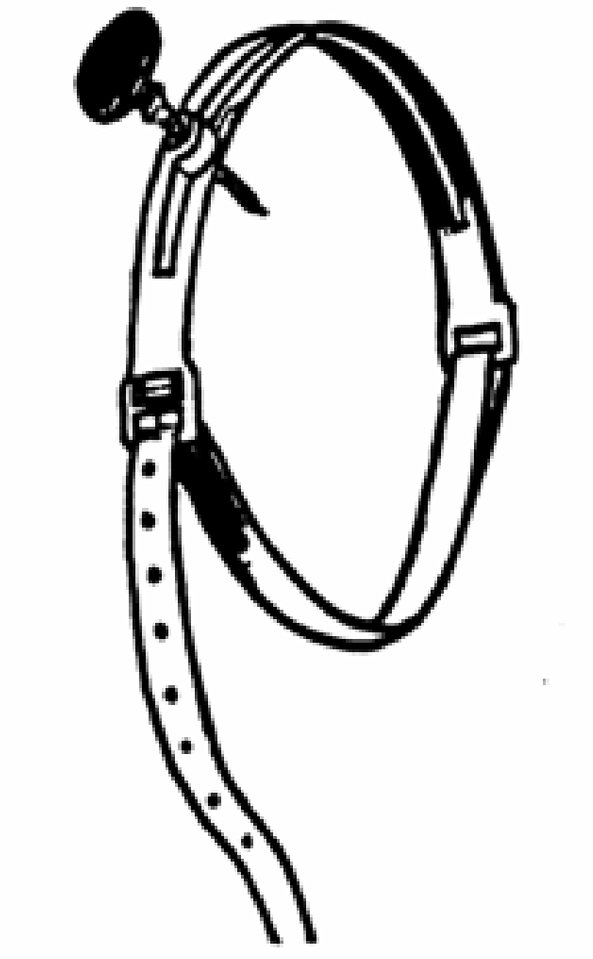
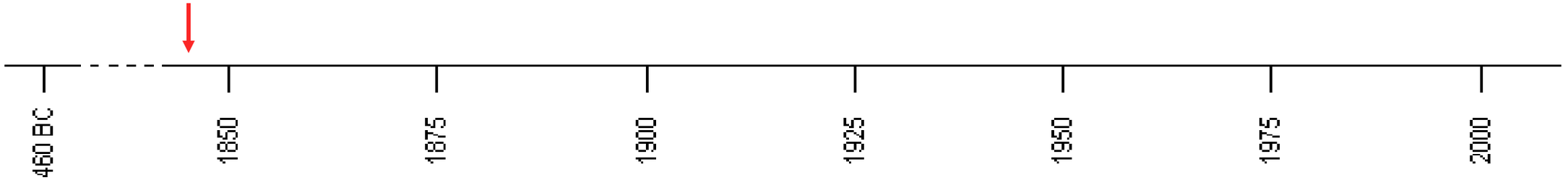
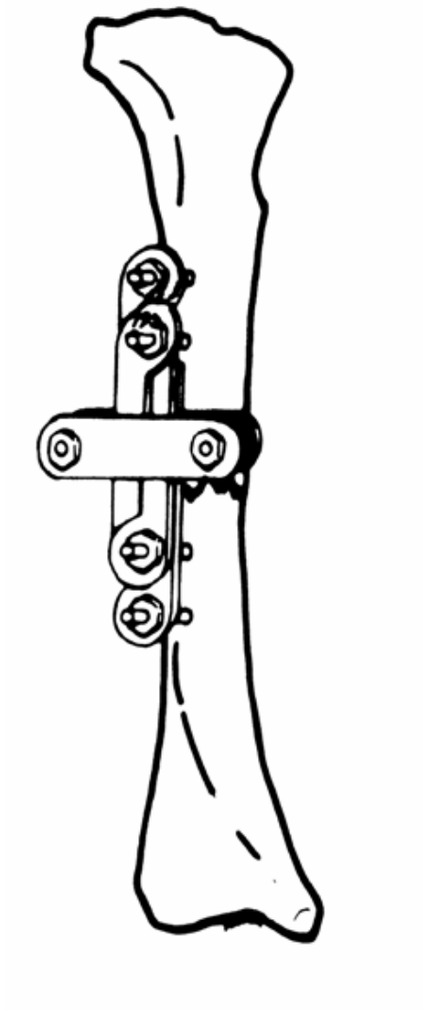


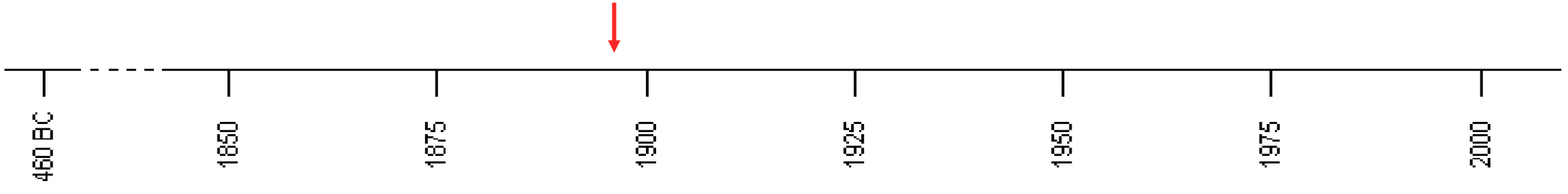
Fig. 3



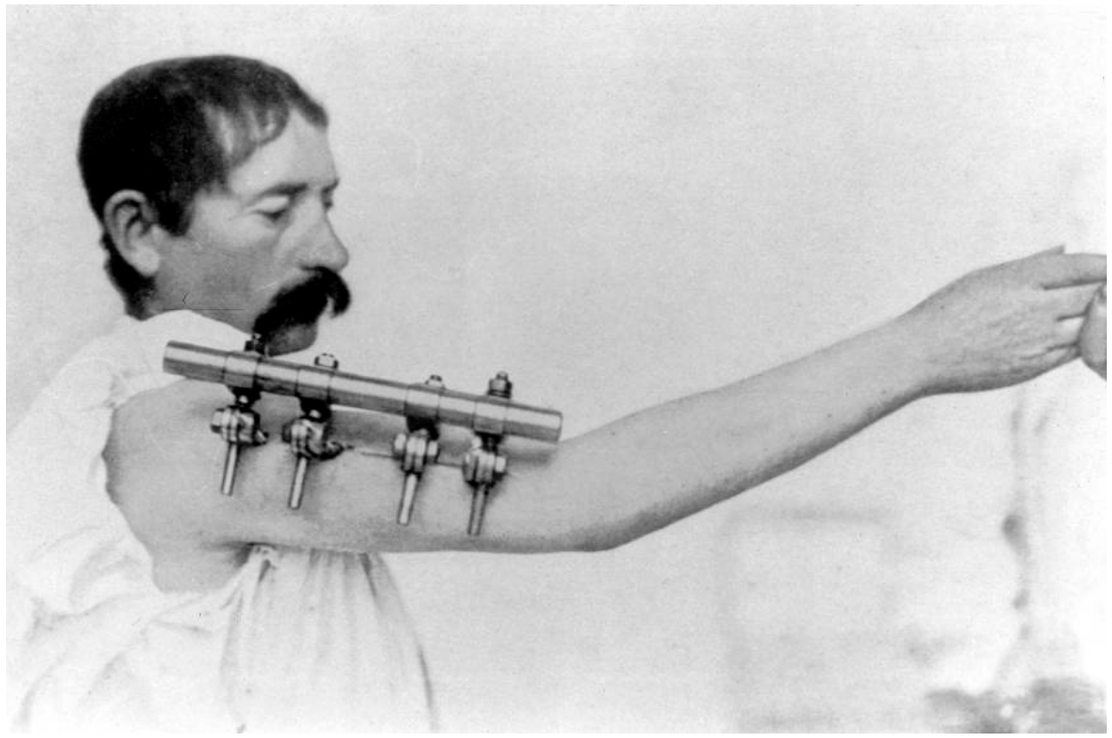
1897 Clayton Parkhill, USA

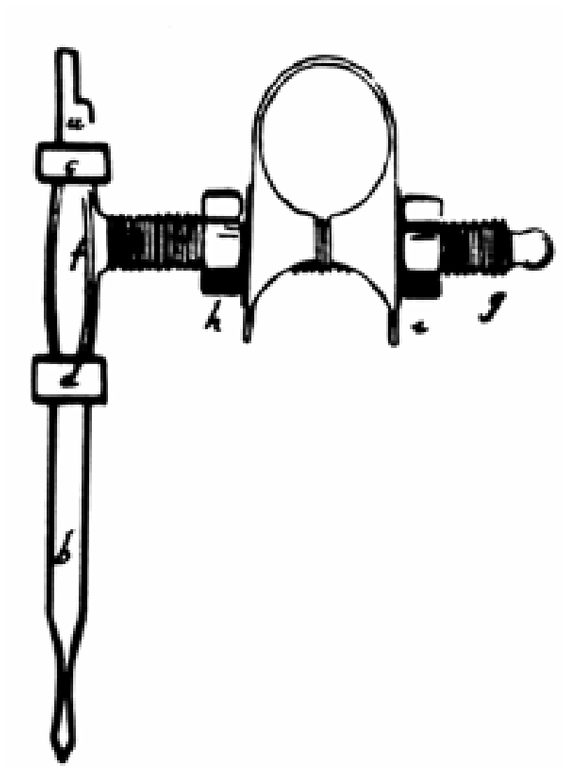


– monolateral fixator
with bone clamp system

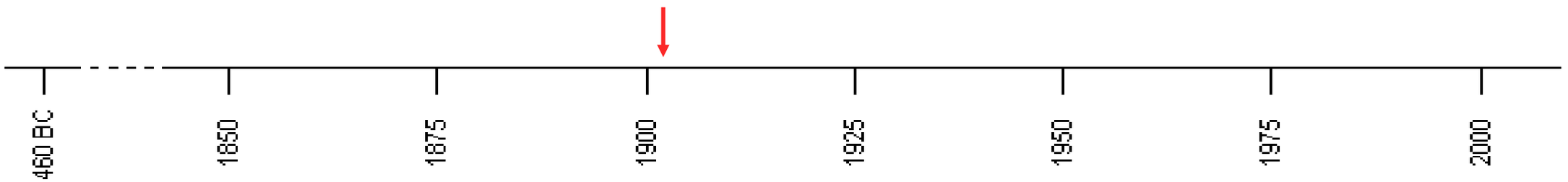


1910 Lambotte, Belgium

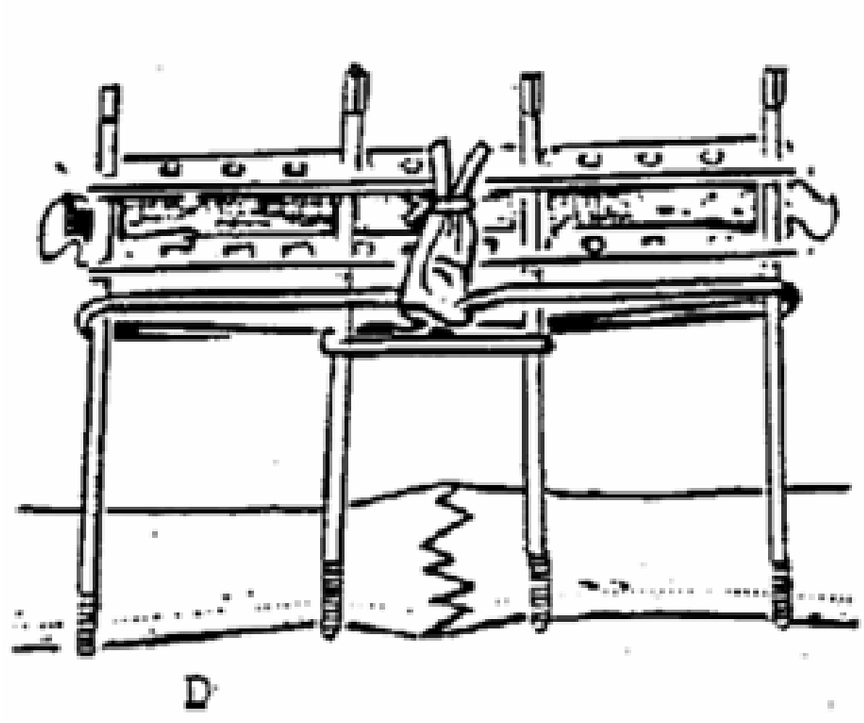




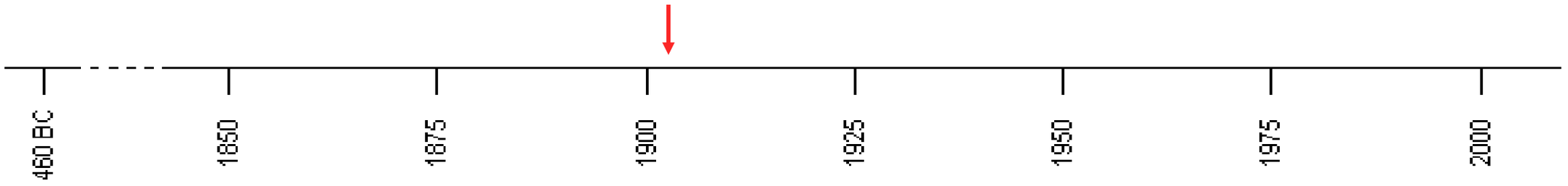
– first monolateral fixator with pins



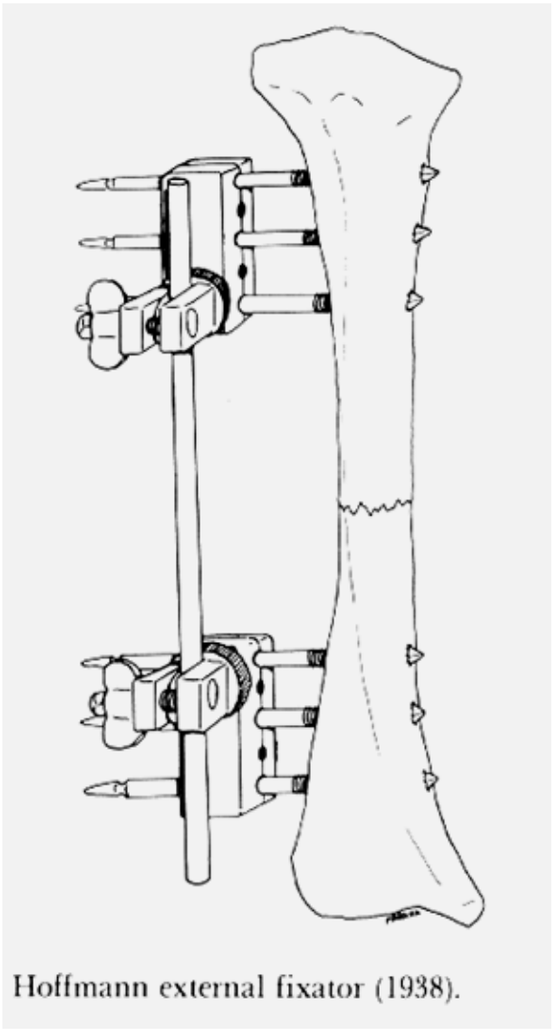
1945 Judet, France



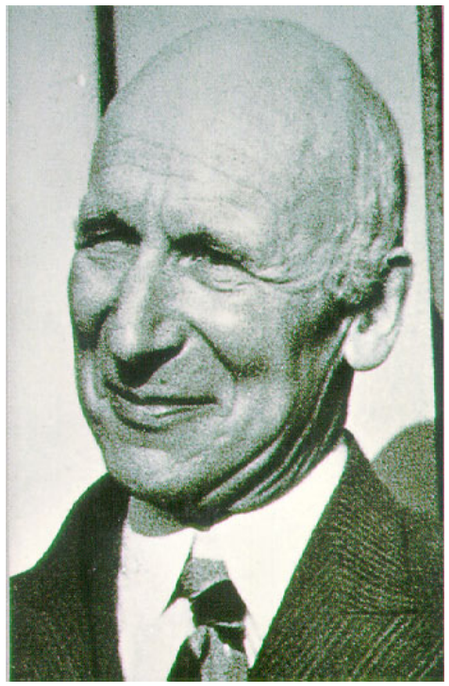
- Stab incision, bicortical pins
- Jean and Robert Judet : preloading with rubber band



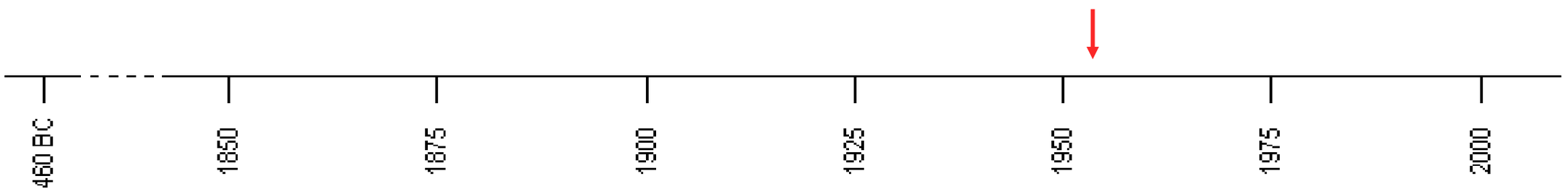
1954 Hoffmann, Switzerland



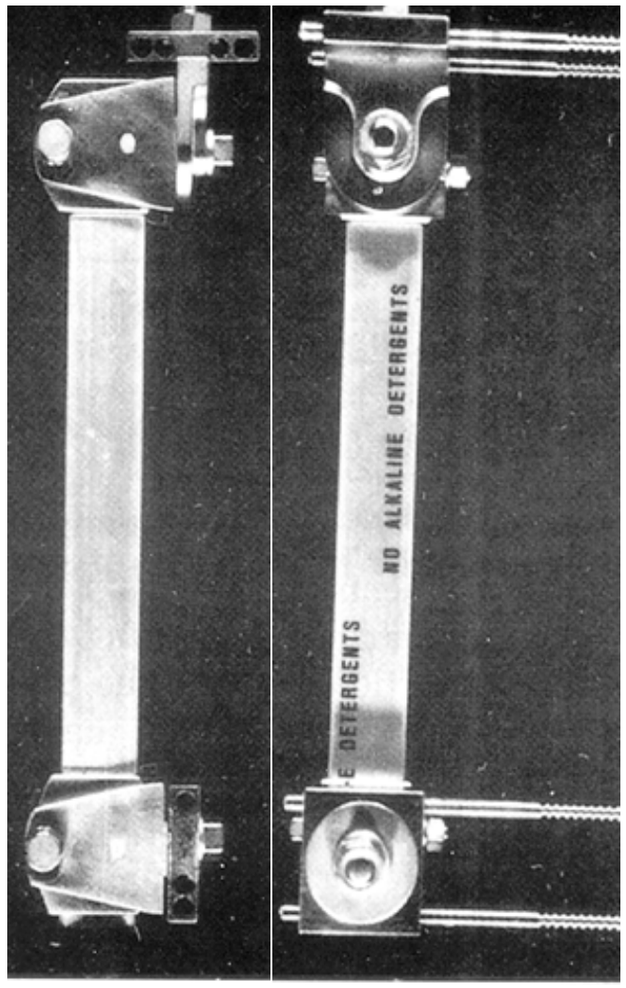
Hoffmann external fixator (1938).

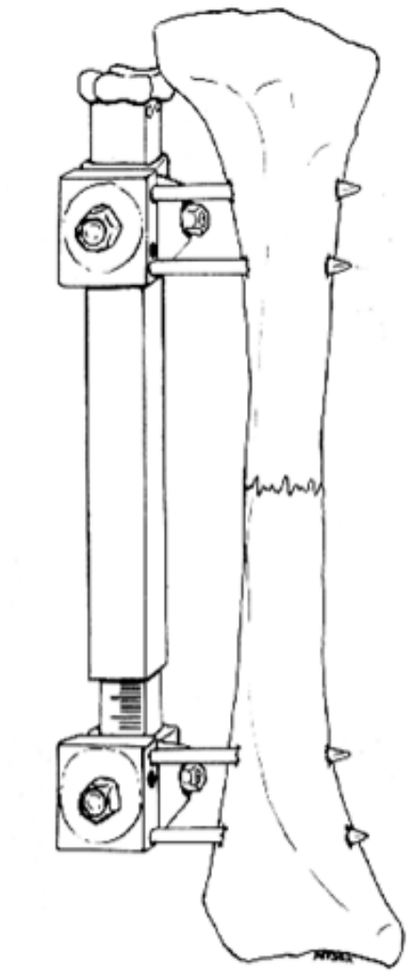


Hoffmann I → Hoffmann II

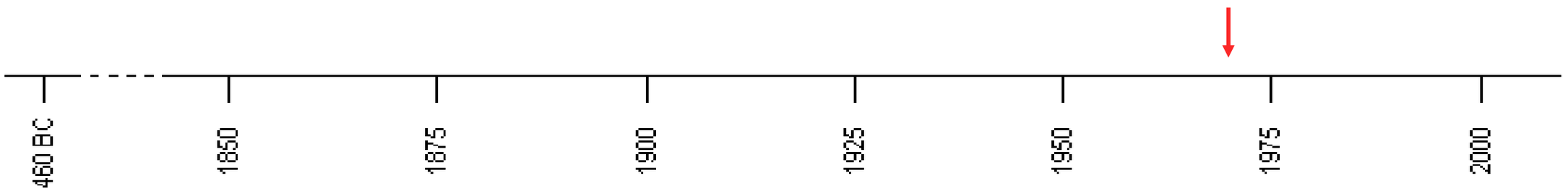


1972 Wagner, Austria

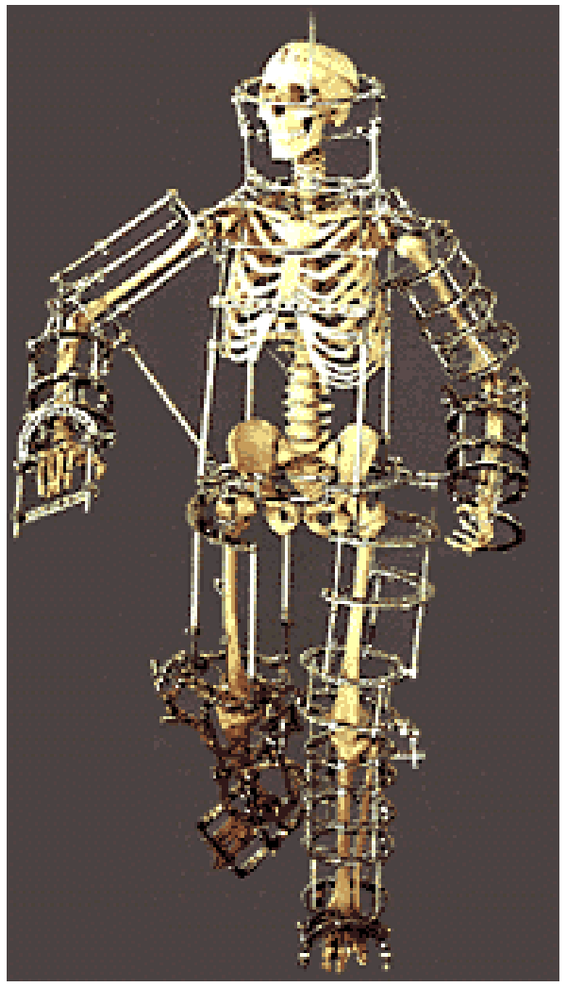




– Apparatus for bone lengthening



1972 Illizarov, Russia

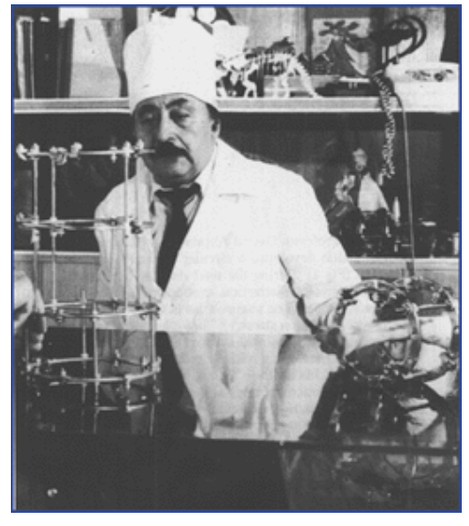


– highly complex, but versatile, ring fixators

– correction of limb

– length discrepancies

– segmental transport



460 BC
1850
1875
1900
1925
1950
1975
2000

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Indications

- Definitive fx care:
  - Open fractures
  - Peri-articular fractures
  - Pediatric fractures
- Temporary fx care
  - "Damage control"
    - Long bone fracture temporization
  - Pelvic ring injury
  - Periarticular fractures
    - Pilon fracture
  - Malunion/nonunion
  - Arthrodesis
  - Osteomyelitis
  - Limb deformity/length inequality
    - Congenital
    - Acquired

Advantages

- Minimally invasive
- Flexibility (build to fit)
- Quick application
- Useful both as a temporizing or definitive stabilization device
- Reconstructive and salvage applications

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Principles of external fixation

- Pin placement
- Frame stability

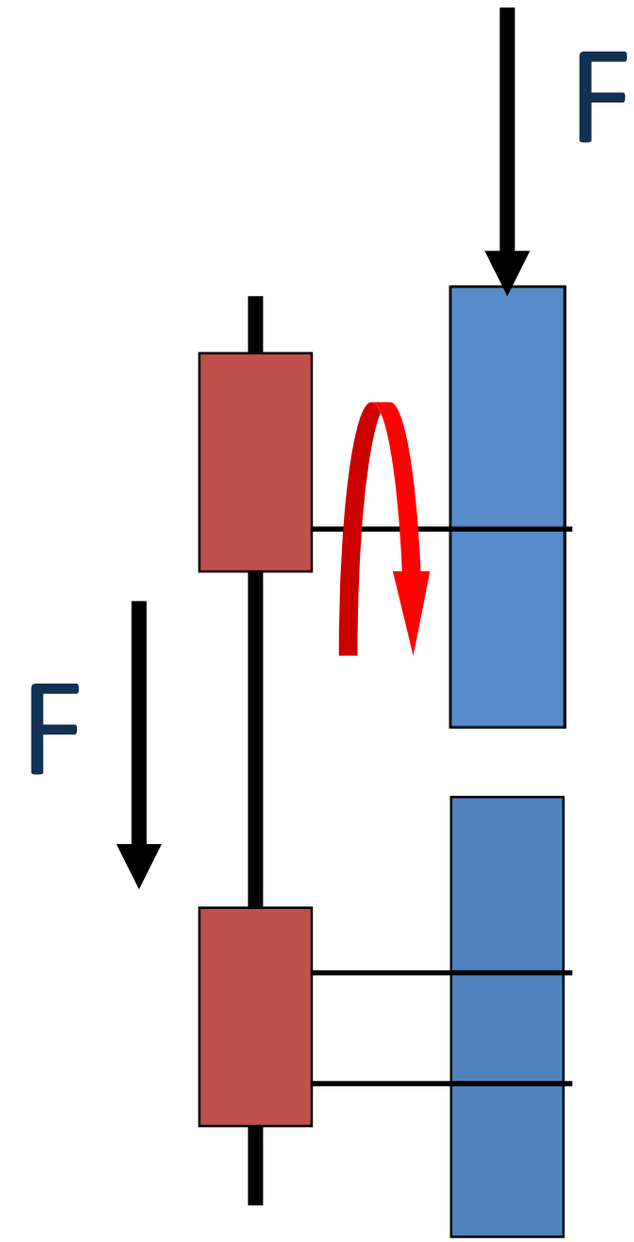
Pin Placement

The ultimate frame stability is influenced more by the position and geometry of the pins than by the number of pins

Pin Placement

At least 2 pins per segment

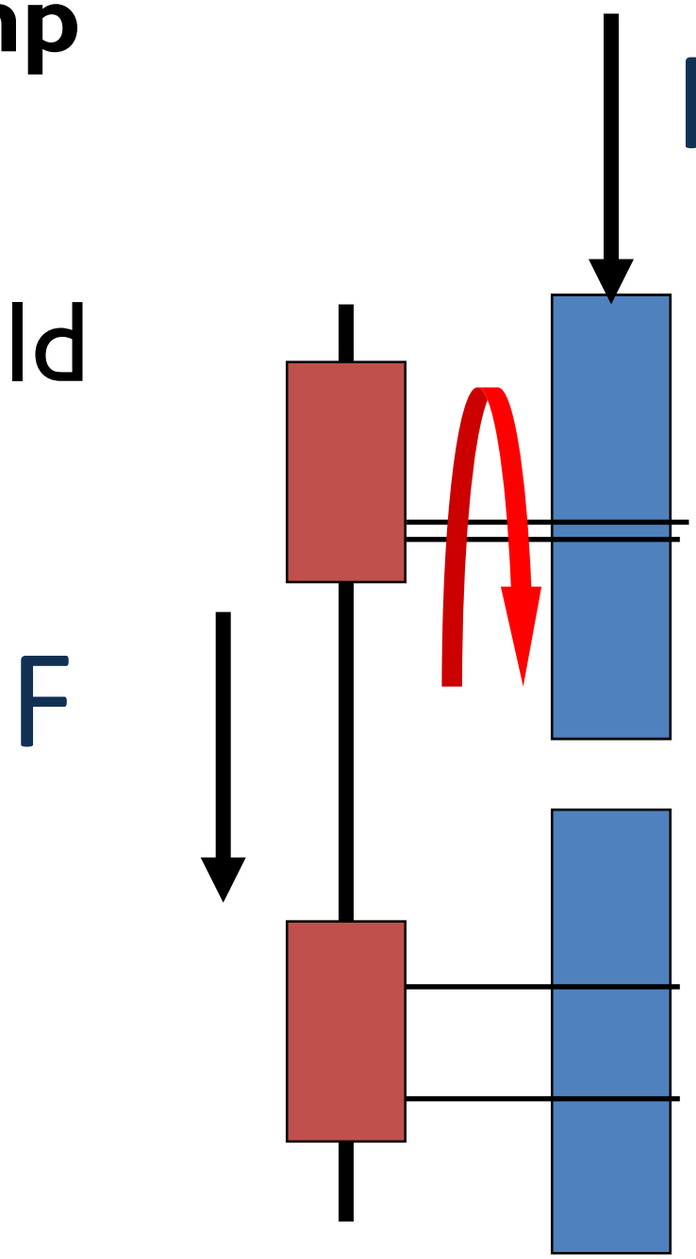
Only one pin allows bone movement around the pin



Pin Placement

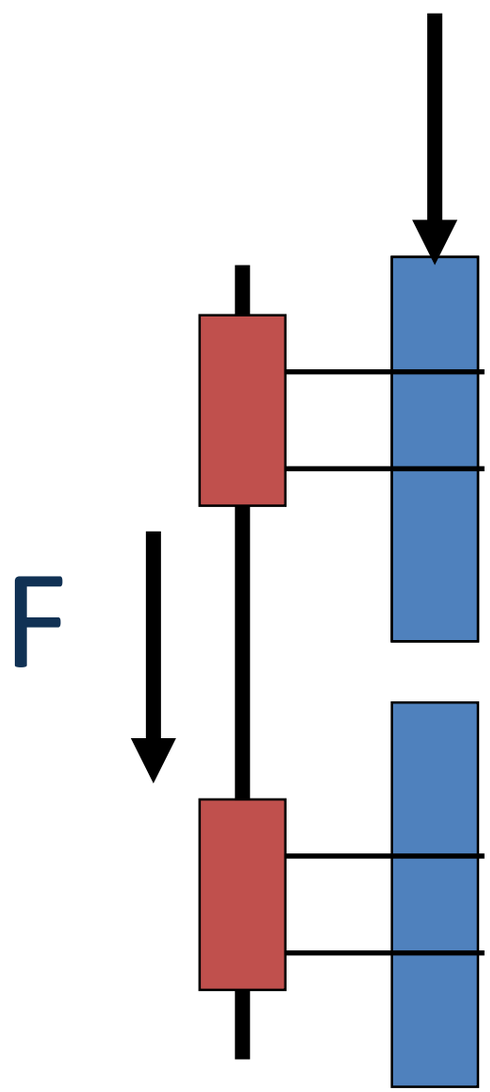
Spread the pins in a clamp

Close together, pins would behave like one single pin



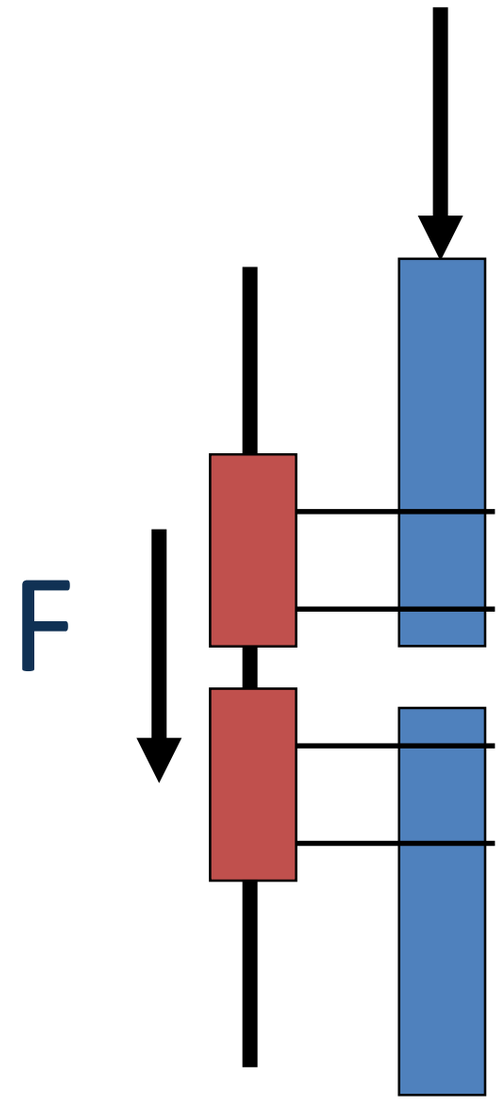
Pin Placement

Pin groups close together



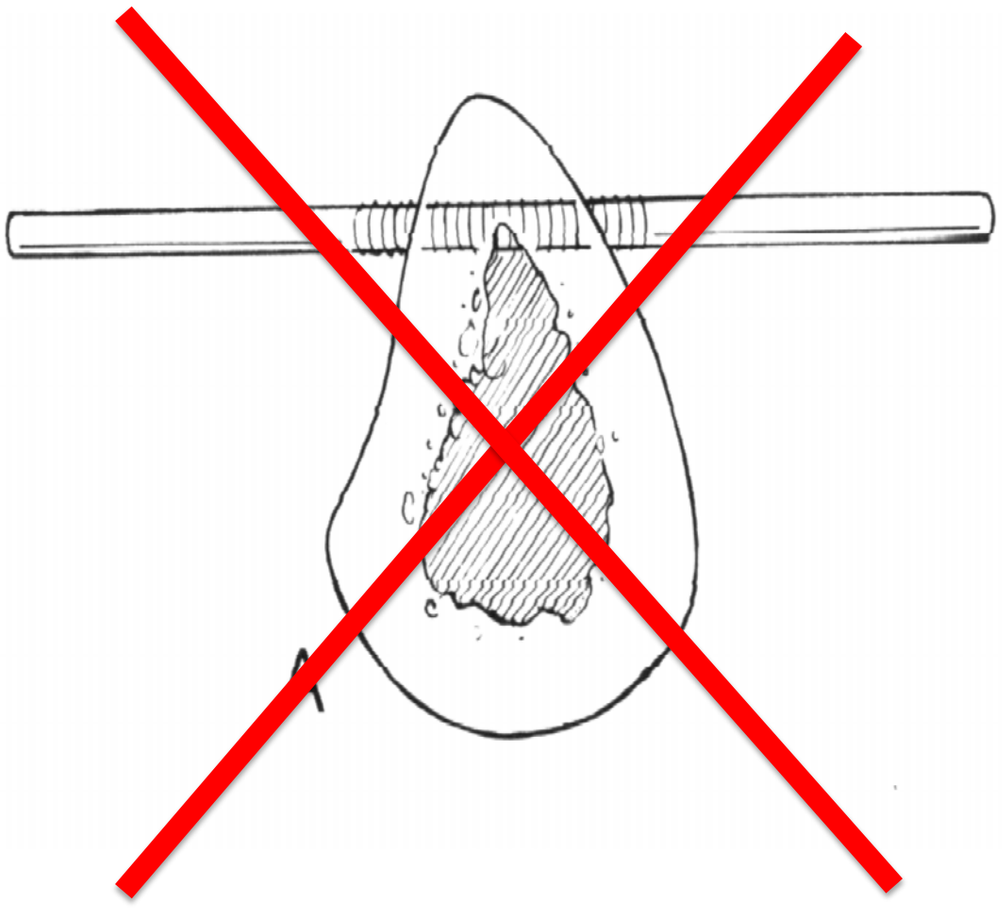
- A shorter lever arm reduces the momentum across the fracture site

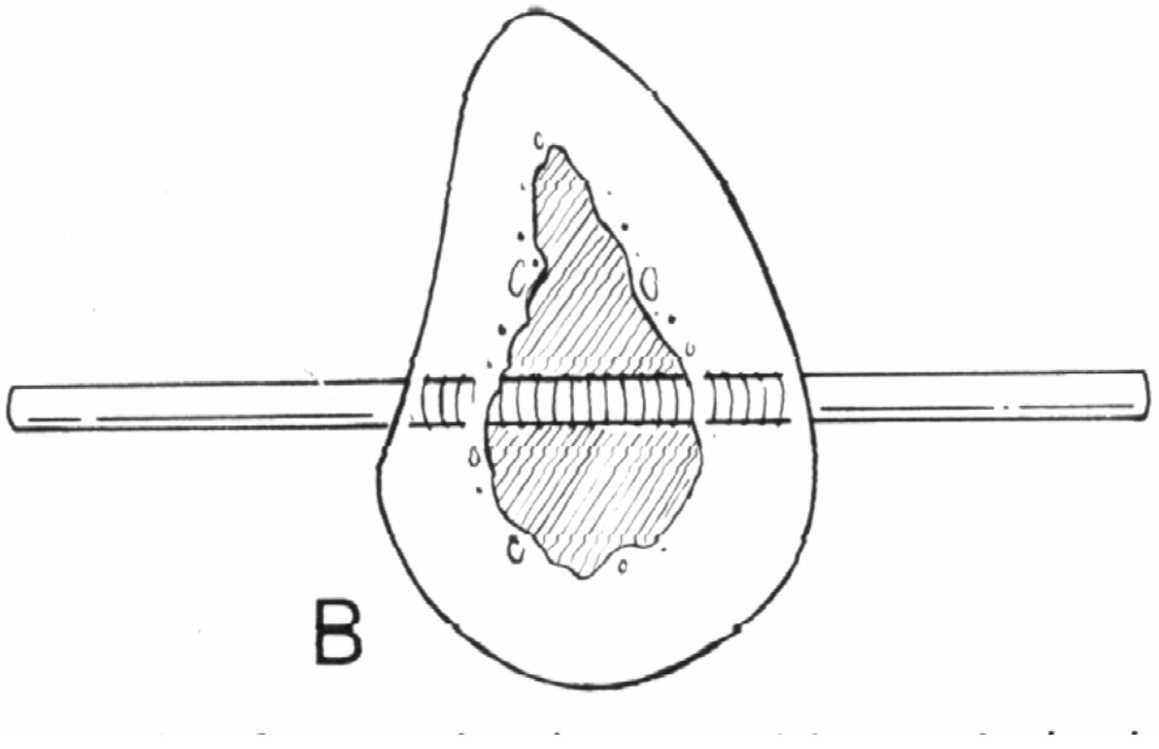
- At least 2 cm between pins and fracture site



Pin Placement

Penetrate the bone in the middle





Best grip in the bone

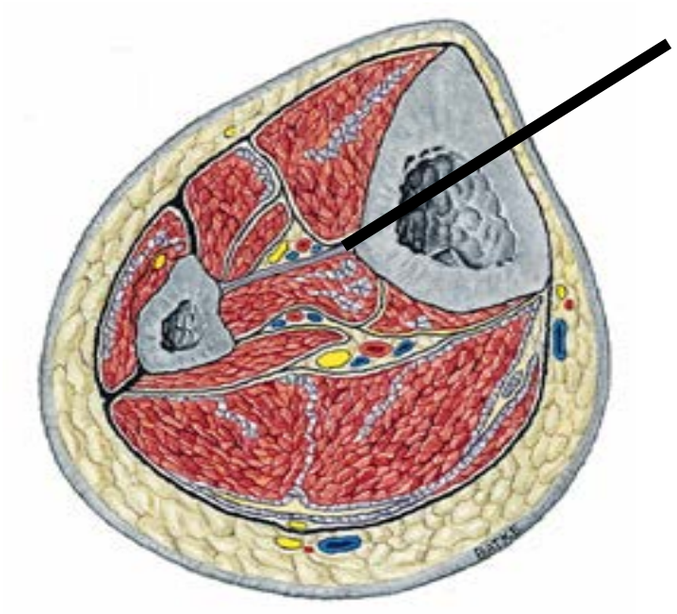
Pin Placement

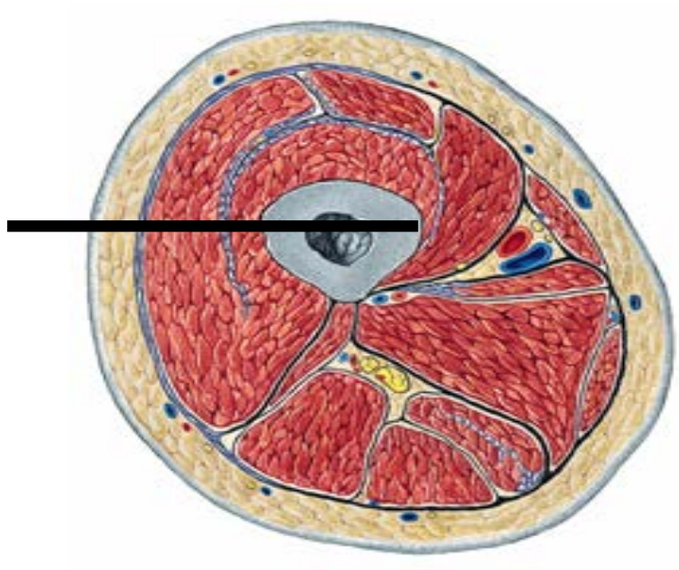
- Since stiffness of a pin is proportional to r^4, a small increase in diameter will result in a large increase in stiffness.

- Recommended pin diameter is never greater than 1/3 the diameter of the bone at the site of pin placement.

Pin Insertion

- Insert the most difficult pins first
- Pay attention to where you can place pins
  - Joints
  - Fracture
  - Soft tissues
- Travel the longest distance possible through the bone
- Bi-cortical purchase
- Think of patient comfort





Frame Stability

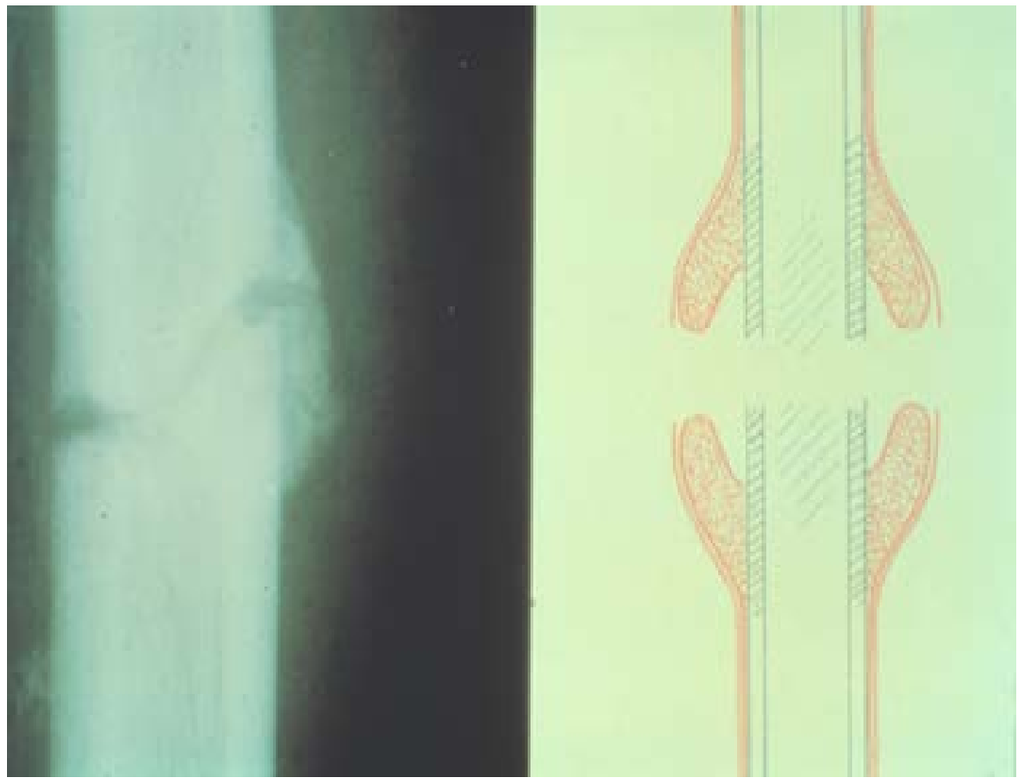
frame should be stable and elastic

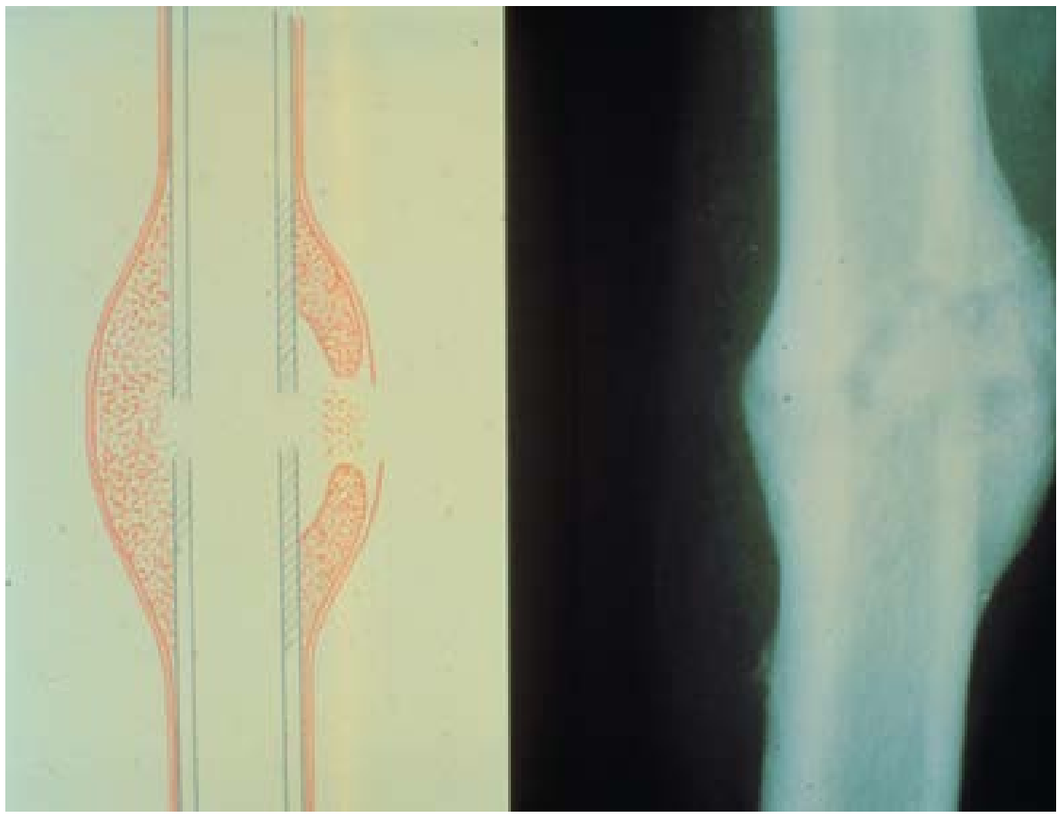
- Stability avoids loss of reduction
- Elasticity generates micro-movements thus callus

A. G. Apley:
"Callus is like Sex"

Callus is like sex

"It joins two things Together"

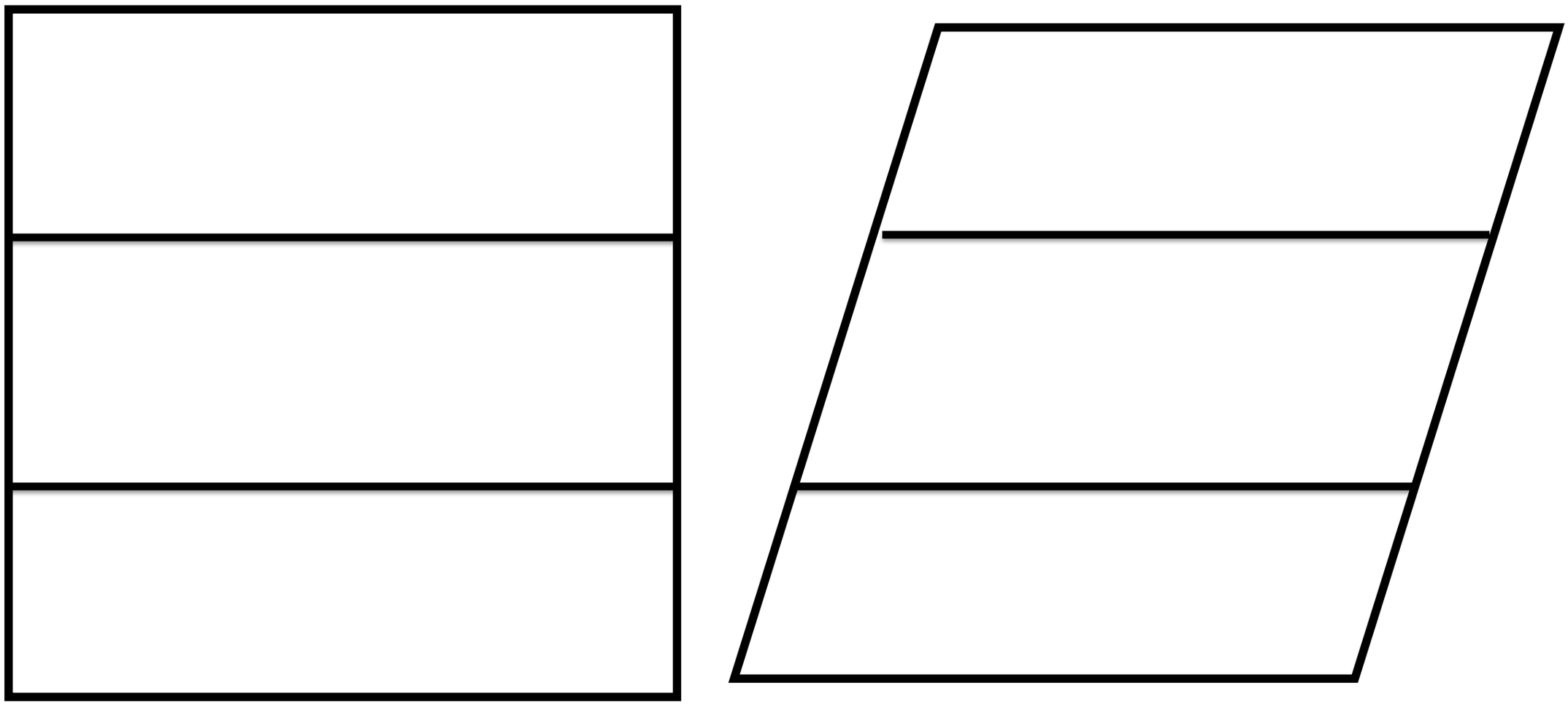




"And it needs a little movement"

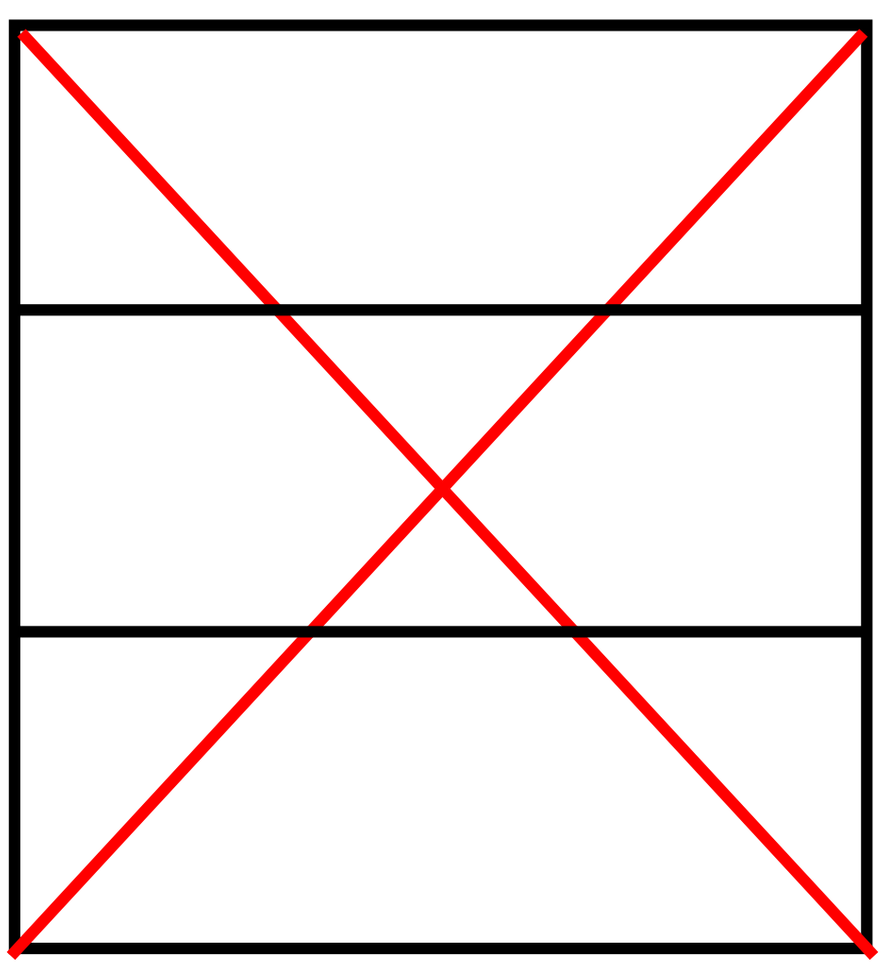
Frame stability

The IKEA bookshelf

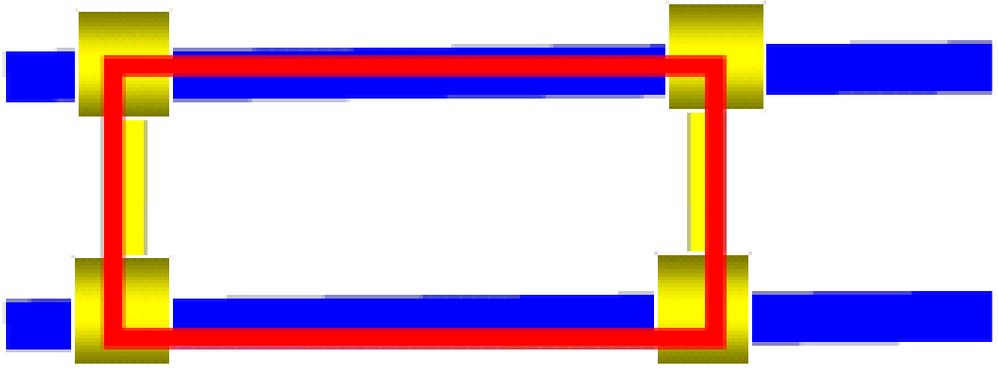


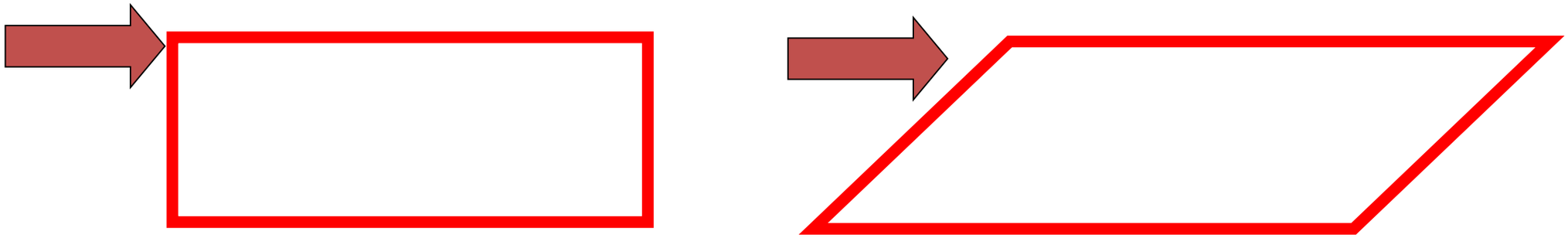
Frame stability

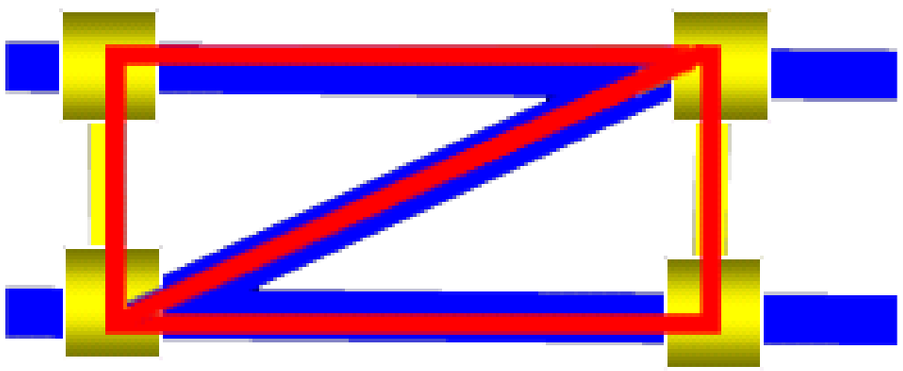
The IKEA bookshelf



Frame stability

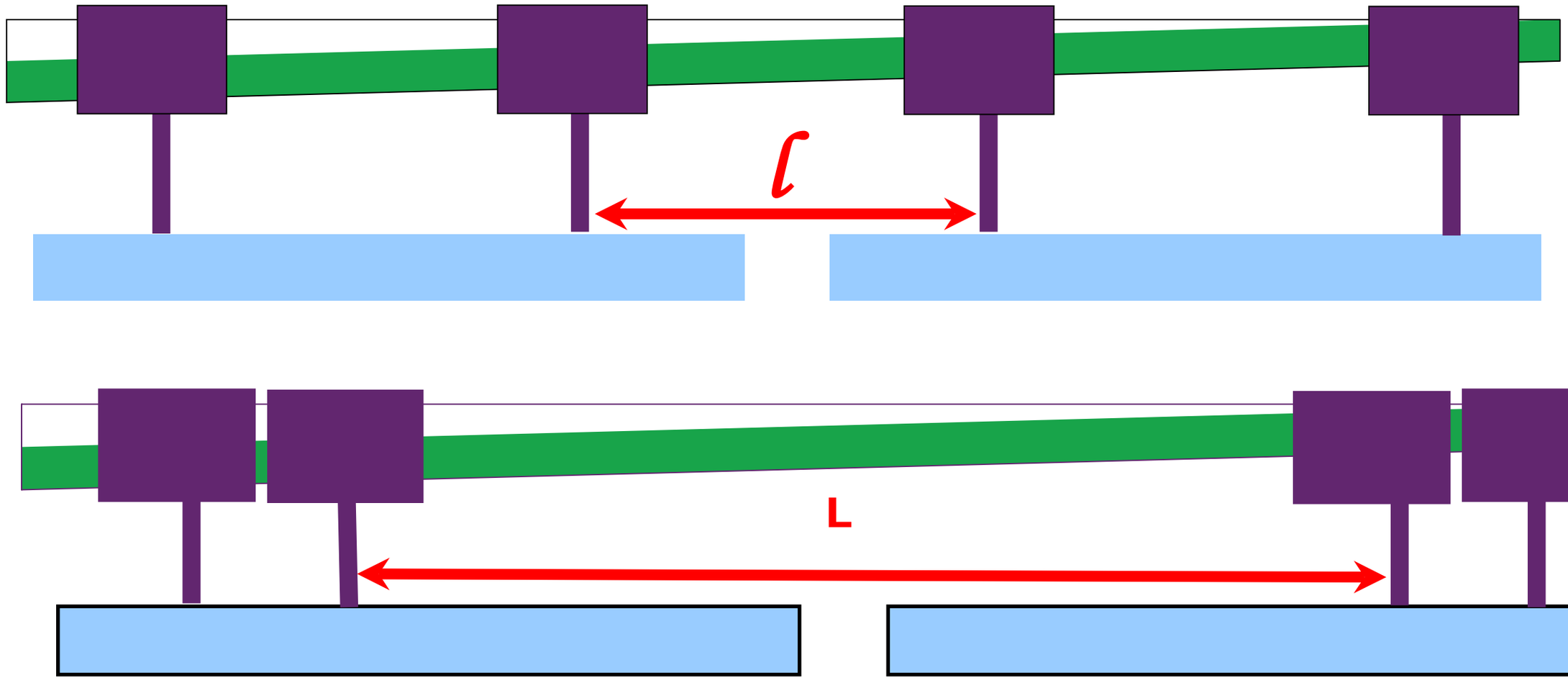




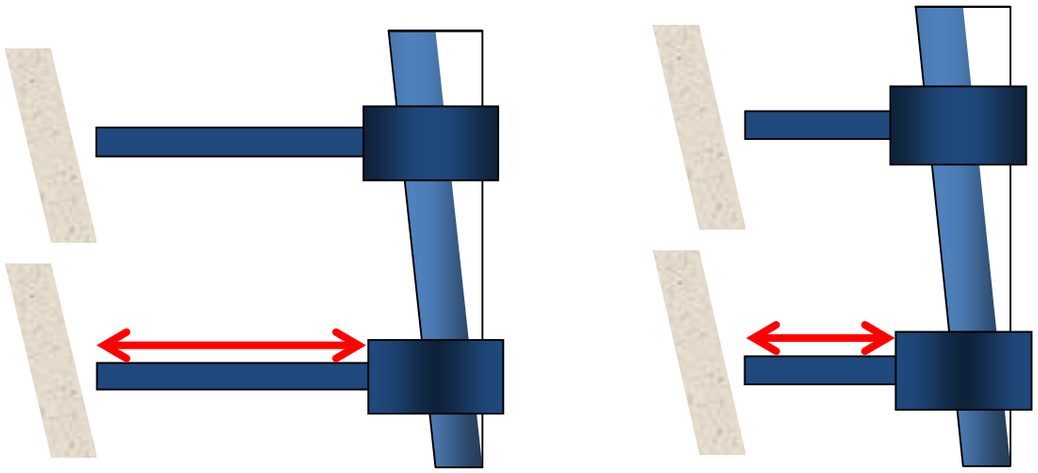


Frame stability

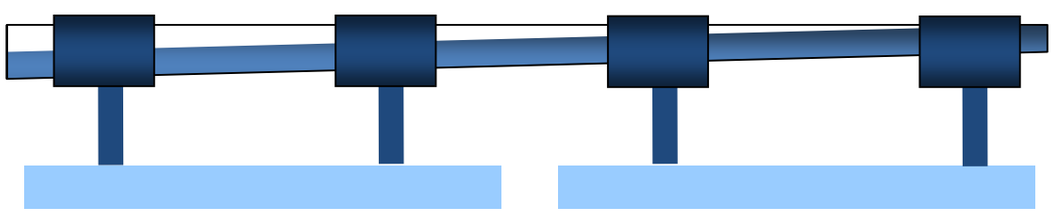
Reduce the “working length” of the Rods

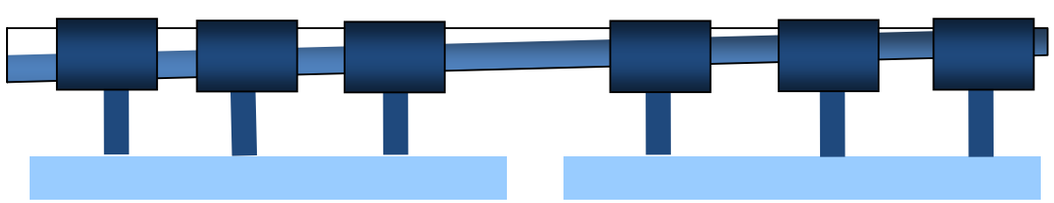


Frame stability



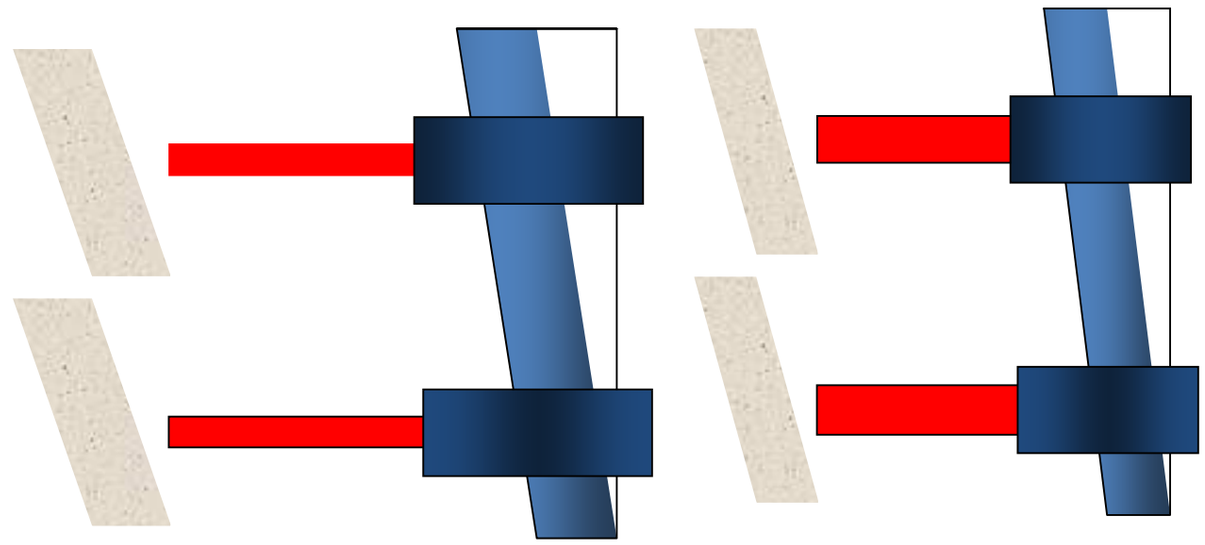
Reduce pin working length



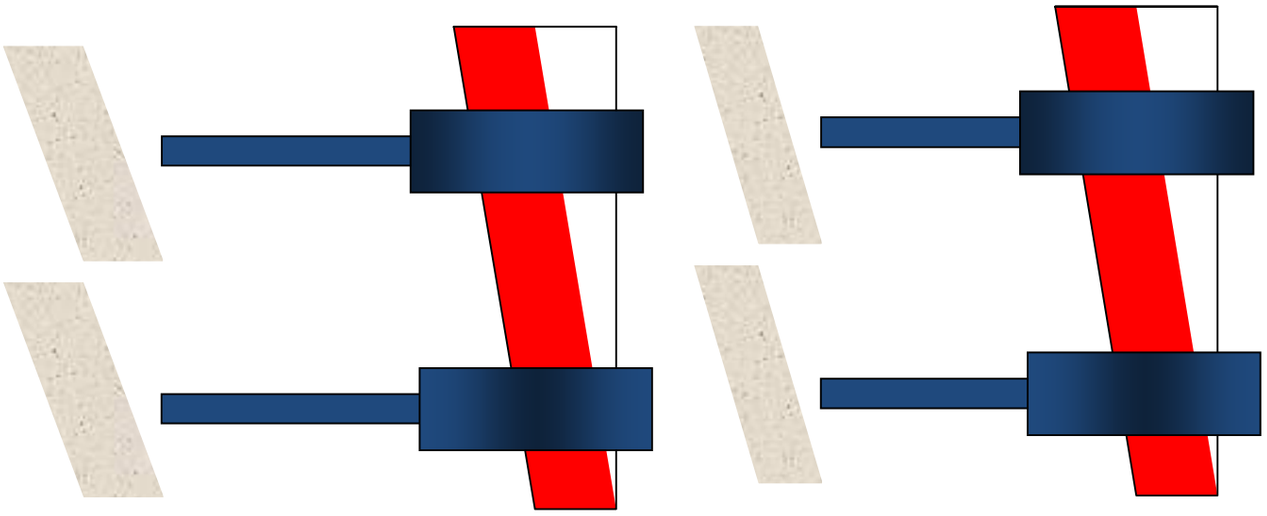


Increase the number of pins

Frame stability



Increase pin diameter



Increase rod diameter

To control overall frame stiffness:

- Increase/decrease the pin diameter
- Increase/decrease the number of pins used
- Place the frame close to/farther from the bone
- Pin spacing within a fragment
- Triangulation
- Increase/decrease the rod diameter
- Rod and pin material
- Pin configurations, positions and trajectories

Index

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Disadvantages

- Mechanical
  - Pin-bone interface failure
  - Inadequate immobilization
  - Weight/bulk

Disadvantages

- Biologic
  - Infection (pin track)
    - May preclude conversion to IM nailing or internal fixation
  - Neurovascular injury
  - Soft tissue contracture

May result in malunion/nonunion, loss of function

Complications

- Pin-track infection/loosening
- Frame or Pin/Wire Failure
- Malunion
- Non-union
- Soft-tissue impalement
- Compartment syndrome
- CRPS

Pin tract infection

- Proper pin/wire insertion technique:
  - Subcutaneous bone borders
  - Away from zone of injury
  - Adequate skin incision
  - Cannulae to prevent soft tissue injury during insertion
  - Sharp drill bits and irrigation to prevent thermal necrosis
  - Manual pin insertion
- Proper postoperative care

Pin loosening

- Prevention
  - Proper pin/wire insertion techniques
  - Thermonecrosis prevention: Pre-drilling (new drill!)
  - Adequate soft-tissue release
  - Bone graft early

Malunion

Intra-operative causes: poor technique

- Prevention:
  - Clear pre-operative planning
  - Prep contralateral limb for comparison
  - Use fluoroscopic and/or intra-operative films
  - Adequate construct

Malunion

Post-operative causes: frame failure

- Prevention:
  - Proper follow-up with both clinical and radiographic check-ups
  - Adherence to appropriate weight-bearing restrictions
  - Check and re-tighten frame at periodic intervals

Soft-tissue Impalement

- Tethering of soft tissues can result in:
  - Loss of motion
  - Scarring
  - Vessel injury
- Prevention:
  - Check ROM intra-operatively
  - Avoid piercing muscle or tendons
  - Position joint in NEUTRAL
  - Early stretching and ROM exercises

Compartment syndrome

- Rare
- Cause:
  - Injury related
  - pin or wire causing intracompartmental bleeding
- Prevention:
  - Clear understanding of the anatomy
  - Good technique
  - Post-operative vigilance

Algoneurodystrophy

- Controverse

Relative contra-indications

- Soft tissue destruction with uncertainty about anatomy
- Extensive internal osteosynthesis/prosthesis
- Bone disease

Questions