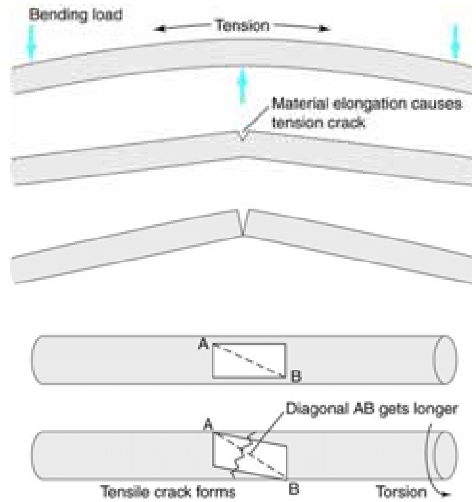
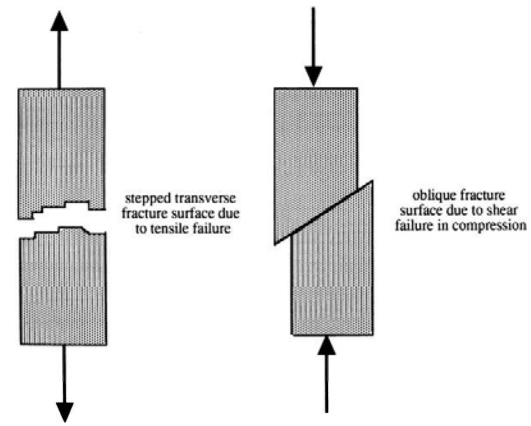
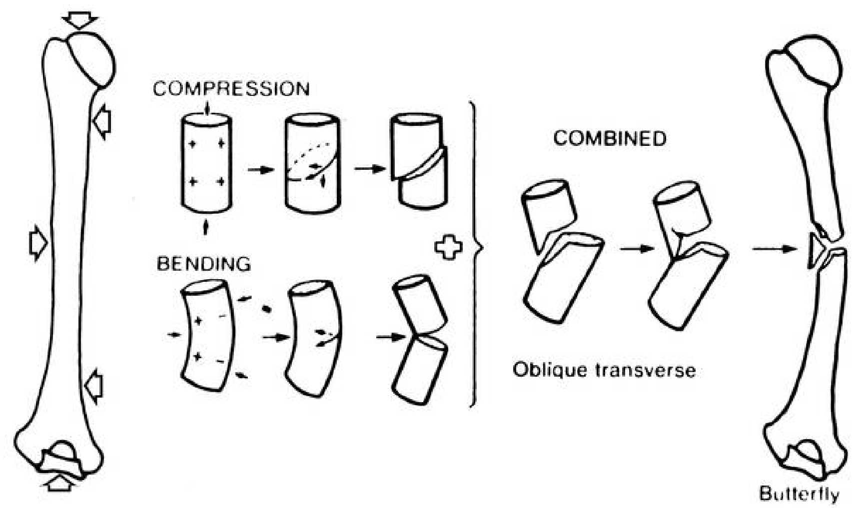
Section 28: Bone Plate Analysis and Design

Biomechanics of Bone Fx

- Weakest in Tension, Strongest in Compression
- Pure **Bending → Transverse** Fx
- **Torsion → Spiral** Fx
- **Shear → Oblique** Fx
- **Butterfly** due to **Bend + Shear**







From: Justice

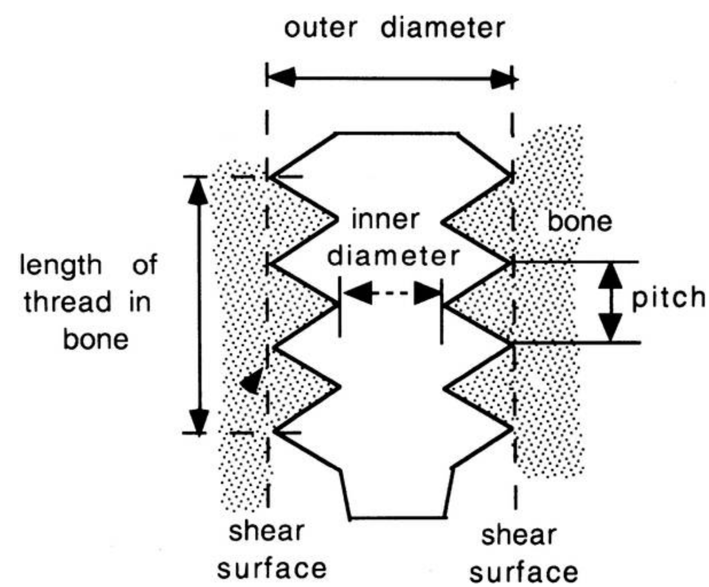
Screw fixation

- Rotary forces → compression between objects (inclined plane on spiral pulls object toward head)
- Four part construction: ***head, shaft, thread, tip***
- Thread defined by ***root diameter, thread diameter, pitch***

From: Justice

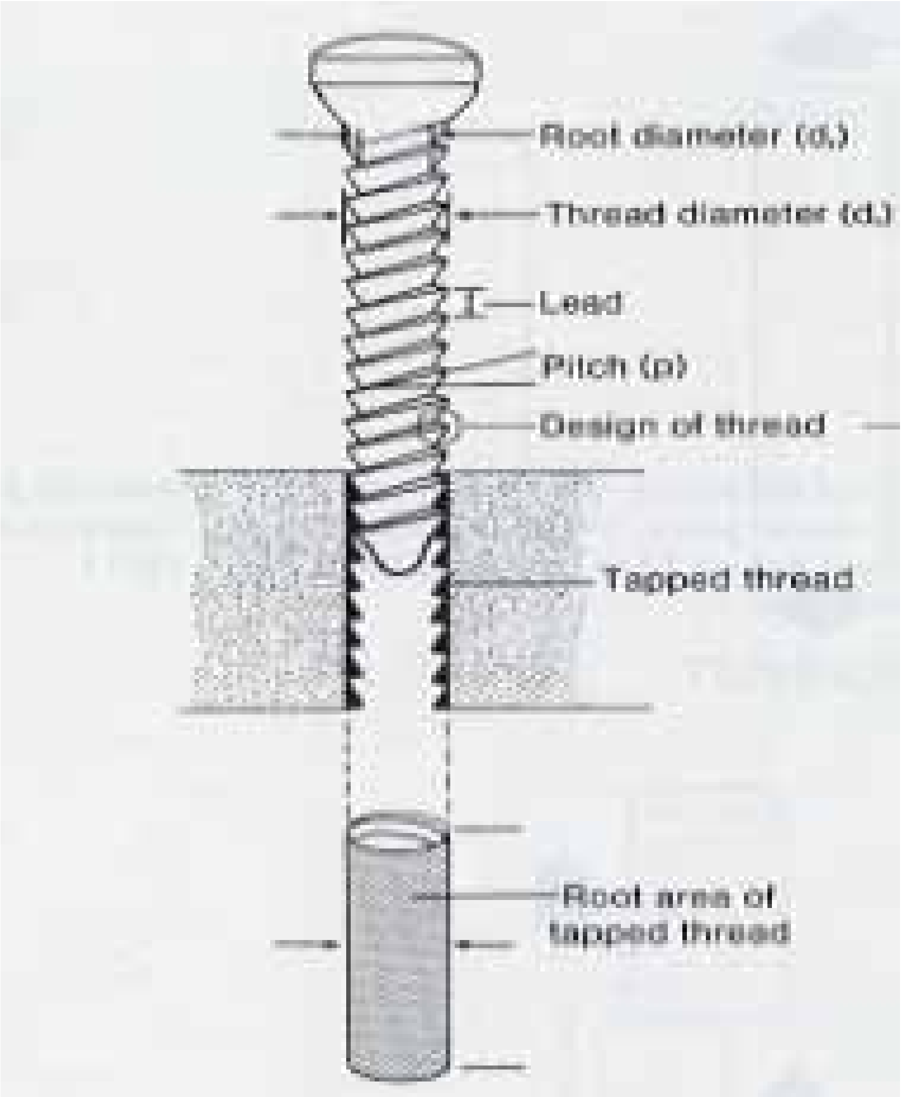
Screws

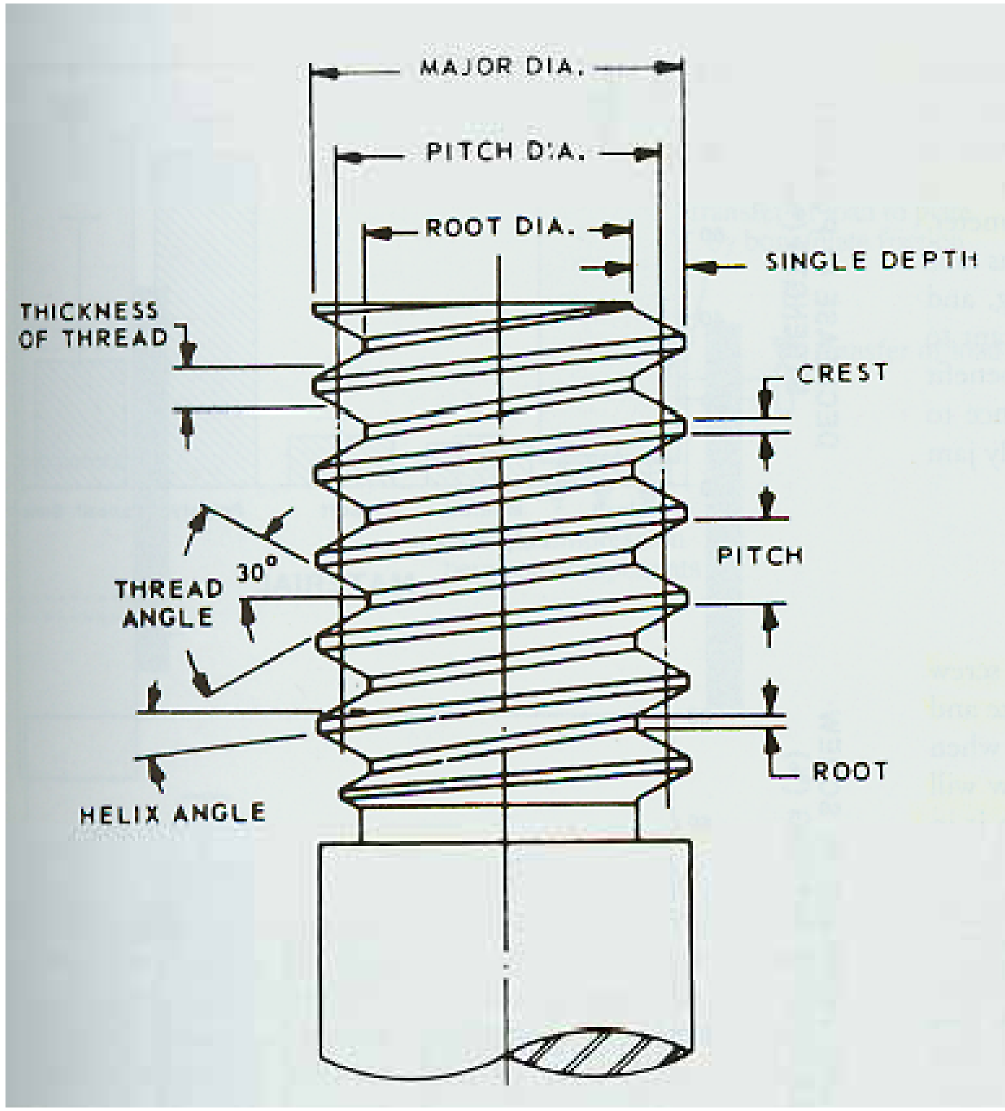
- ***Larger core*** diameter has ***higher resistance to fatigue & shear failure***
  - 4th power of the diameter
- **Pullout strength** (maximum force screw can support along its axis)
  - outer diameter, length of engagement, shear strength/density of bone



From: Justice

Screw fixation



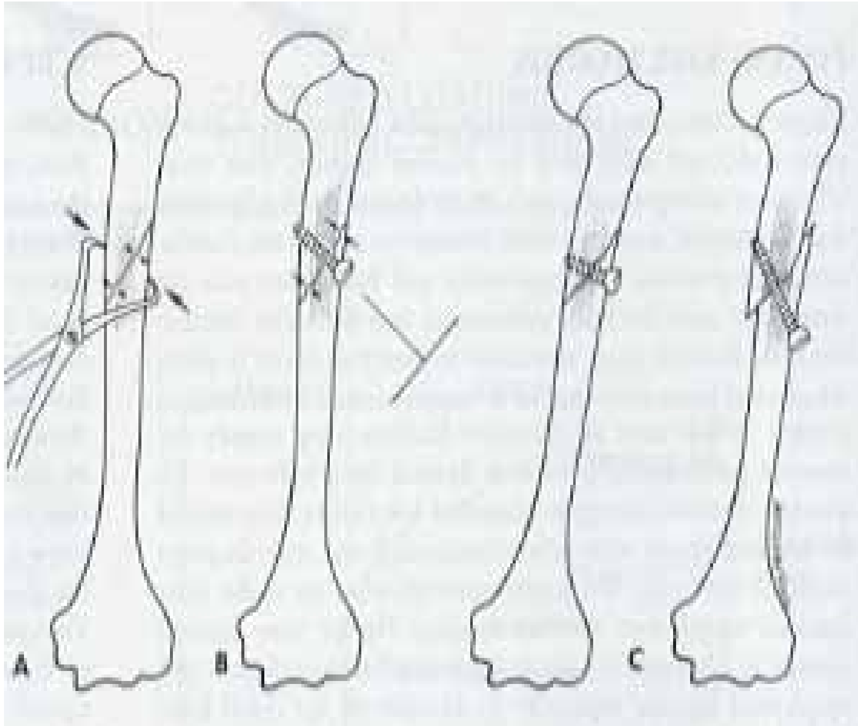


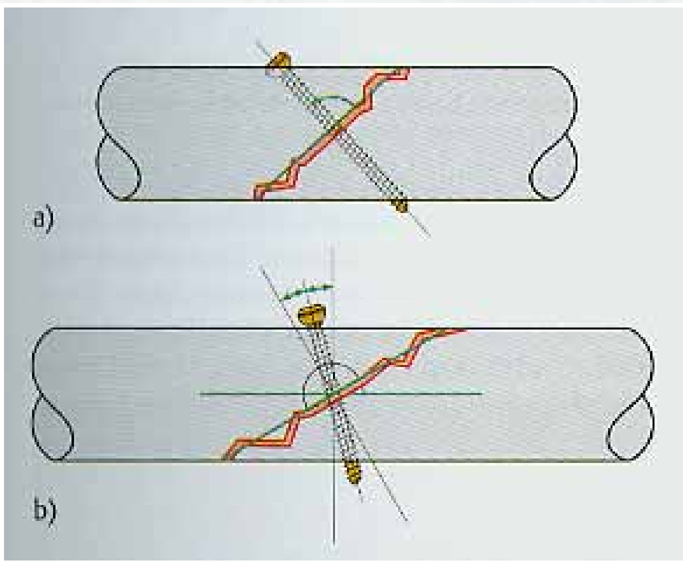
From: Justice

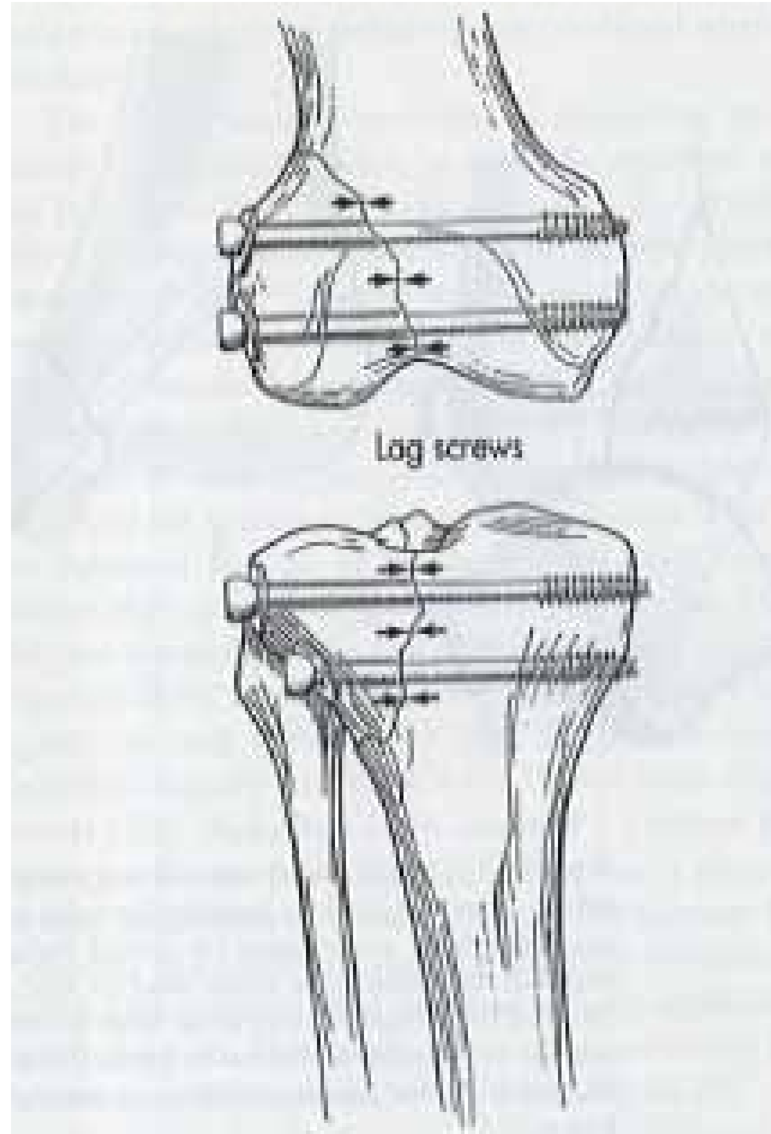
Interfragmentary compression screw

- Lag screw can convert ***torque forces*** to a ***compressive force***
- Screw should be ***perpendicular*** to fracture preventing sliding of fragments when compressed
- ***Gliding hole*** => cortex under screw head drilled to thread diameter
- ***Thread hole*** => opposite glide hole; drilled to the core diameter of screw

From: Justice







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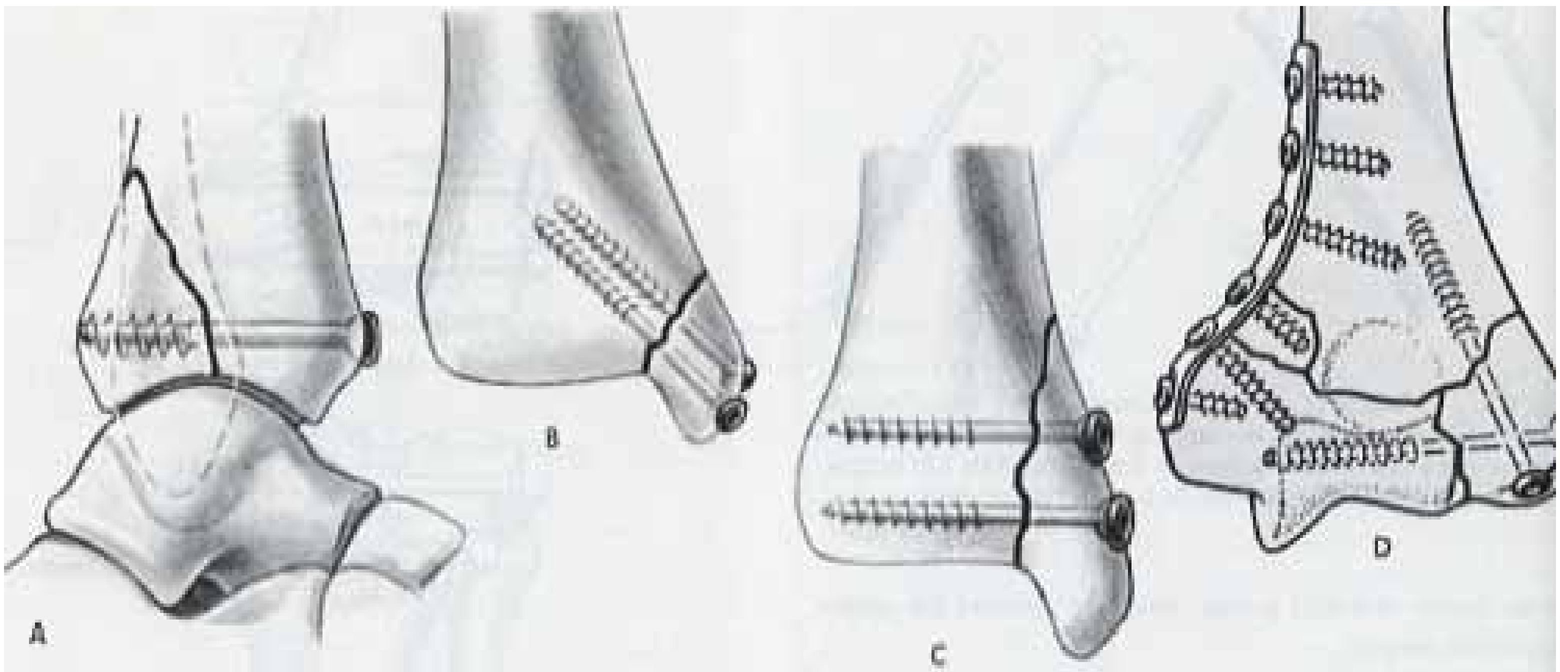
From: Justice

Interfragmentary compression screw

- This alone is well suited for avulsion, epiphyseal, metaphyseal and intraarticular fractures- absolute stability, no callus

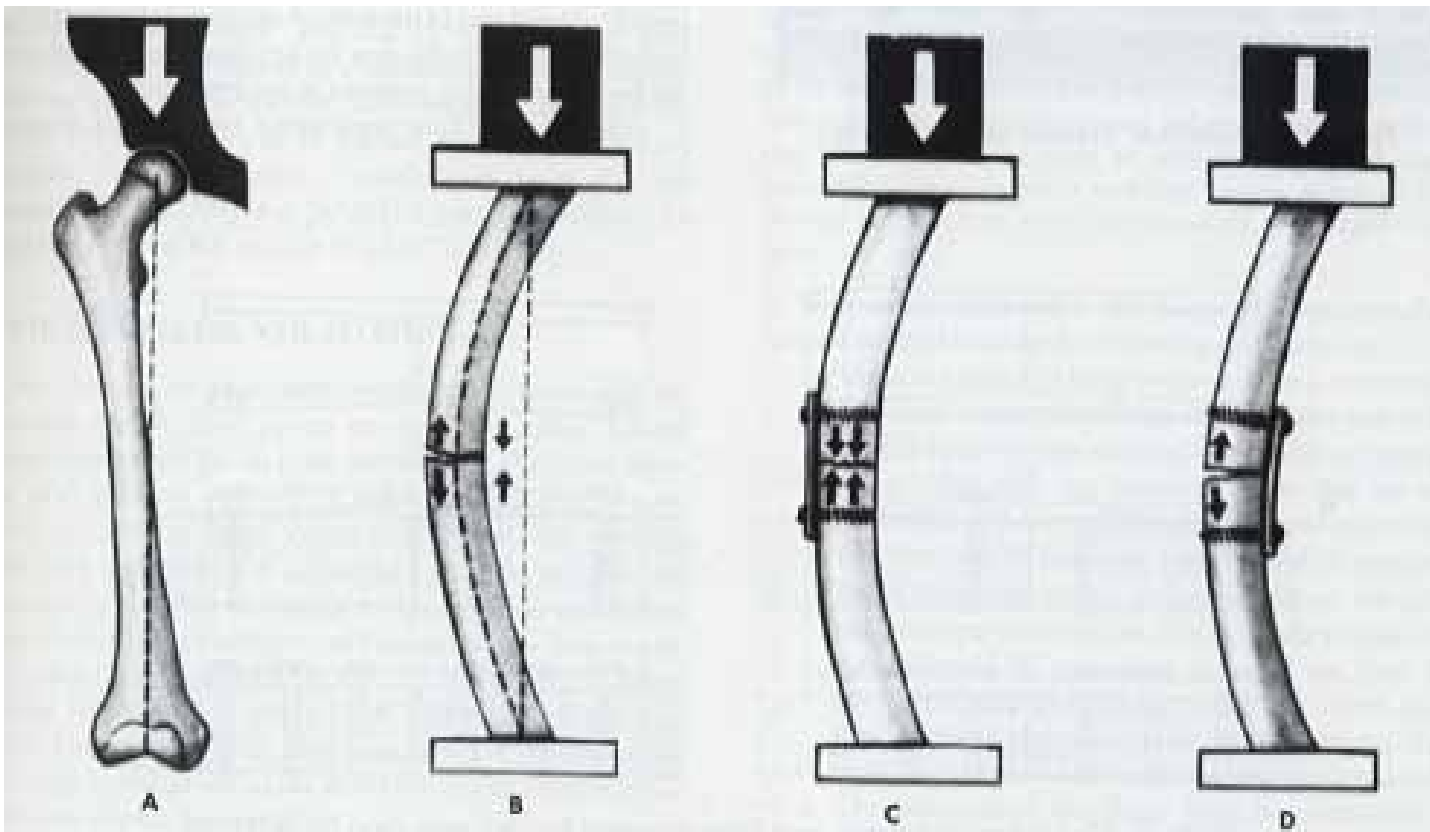


From: Justice

Plate and screw fixation

- For transverse or short oblique fx, screws must be combined with other internal fixation
- Principle based on converting *tension force* to ***compression force***
- Accomplished by placing plate on ***tension*** or ***convex*** side of bone

Plate and screw fixation



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From: Justice

Plate and screw fixation

- Plates offer benefits of ***anatomic reduction*** and stability for early motion, but must be ***protected from early weight bearing.***
- Ideally ***3-4 screws*** on each side of fracture
- ***Prebending*** the plate to increase compression

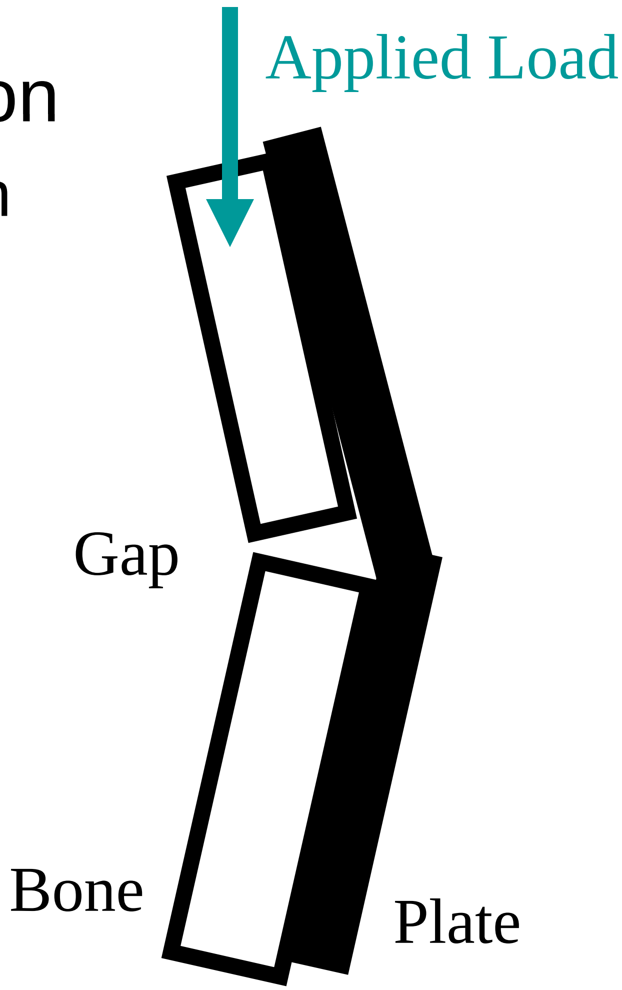
Biomechanics of Plate Fixation

- Function of the plate
  - Internal splint
  - Compression
- “The bone protects the plate”

From: Le

Biomechanics of Plate Fixation

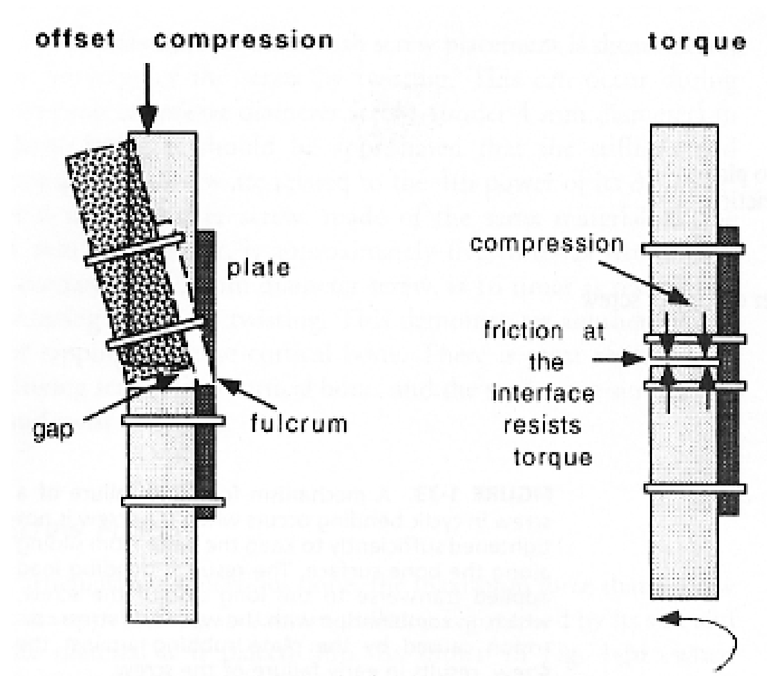
- Fracture Gap /Comminution
  - Allows bending of plate with applied loads
  - Fatigue failure

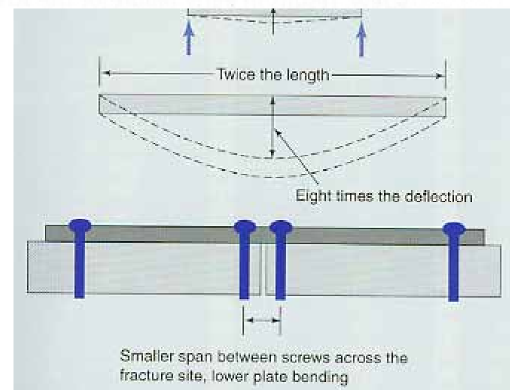


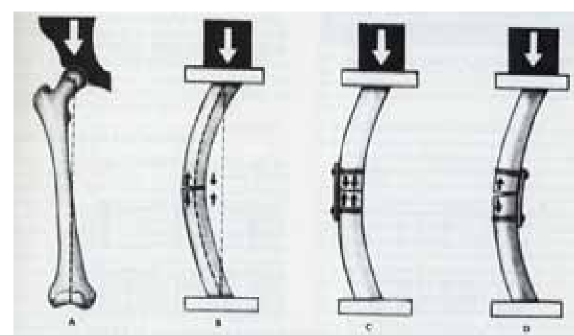
From: Le

Plates & Bending failure

- Leaving gap opposite plate makes it a fulcrum
- increased stress at holes
- avoid holes over fracture sites
- greater the span between screws
  - less stiff
  - more bending



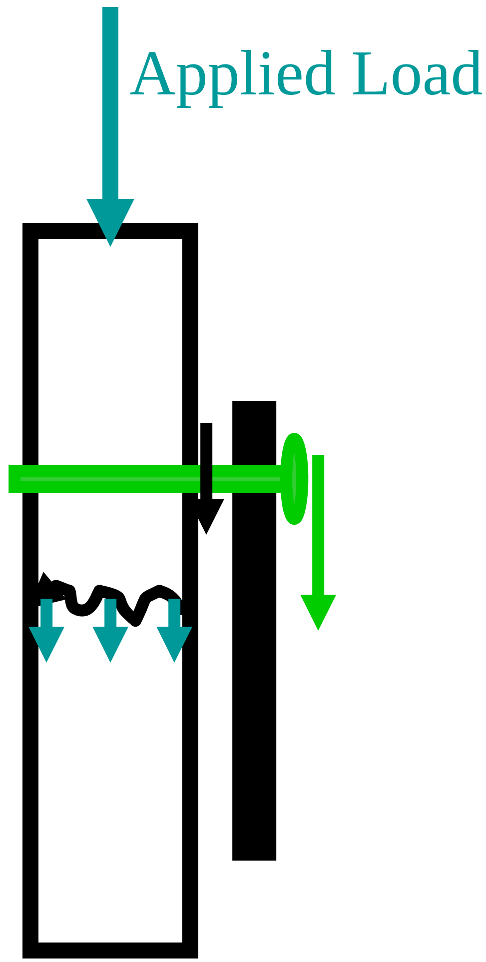




From: Justice

Biomechanics of Plate Fixation

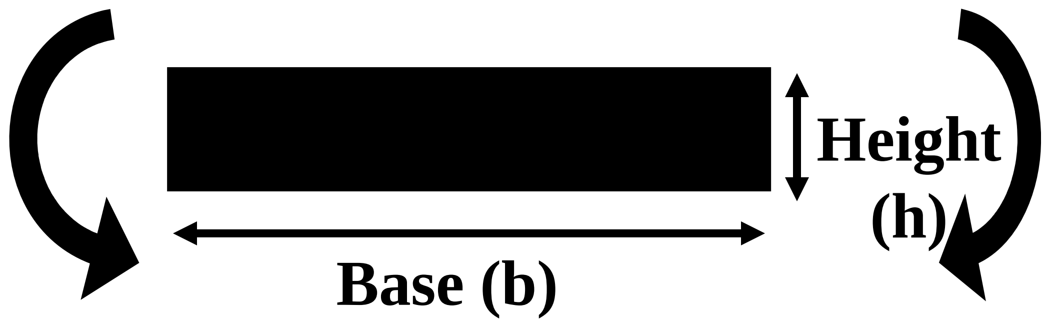
- Bone-Screw-Plate Relationship
  - Bone via compression
  - Plate via bone-plate friction
  - Screw via resistance to bending and pull out.



From: Le

Biomechanics of Plate Fixation

- Plates:
  - Bending stiffness proportional to the thickness (h) of the plate to the 3rd power.

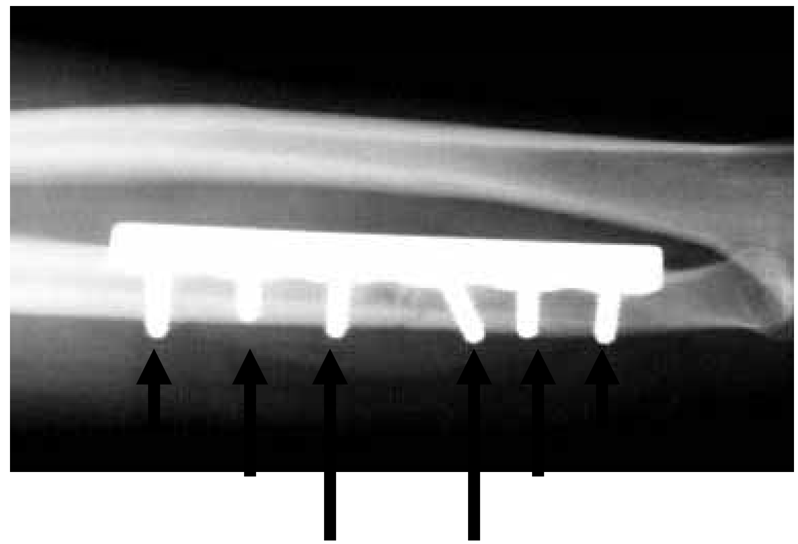


$$I = bh^3/12$$

From: Le

Biomechanics of Plate Fixation

- The screws closest to the fracture see the most forces.
- The construct rigidity decreases as the distance between the innermost screws increases.



Screw Axial Force

From: Le

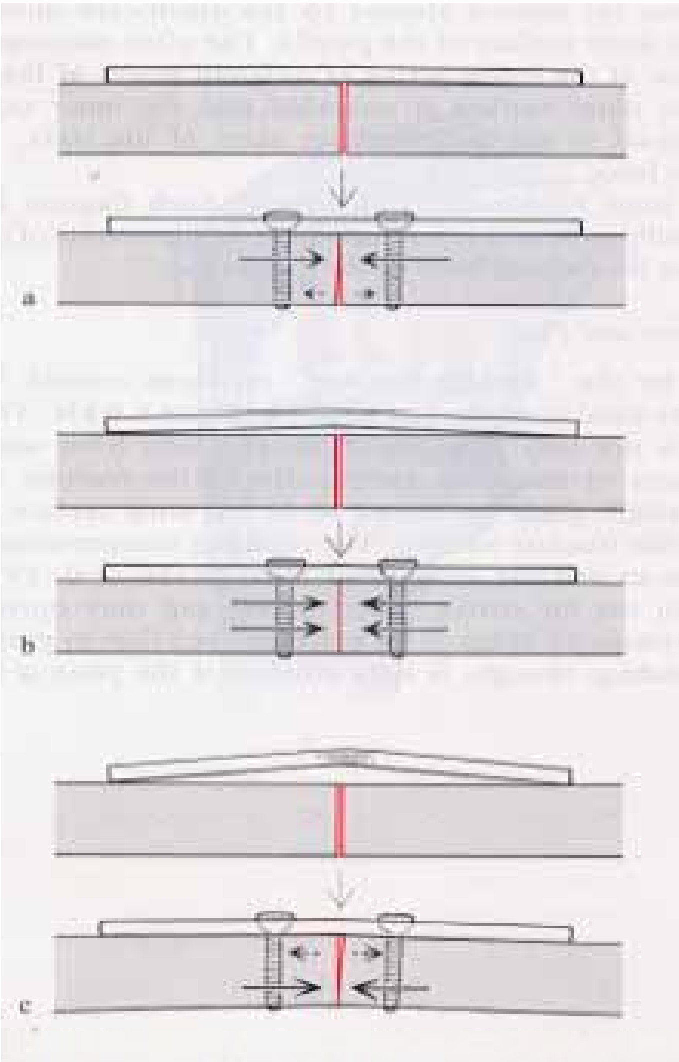
Biomechanics of Plate Fixation

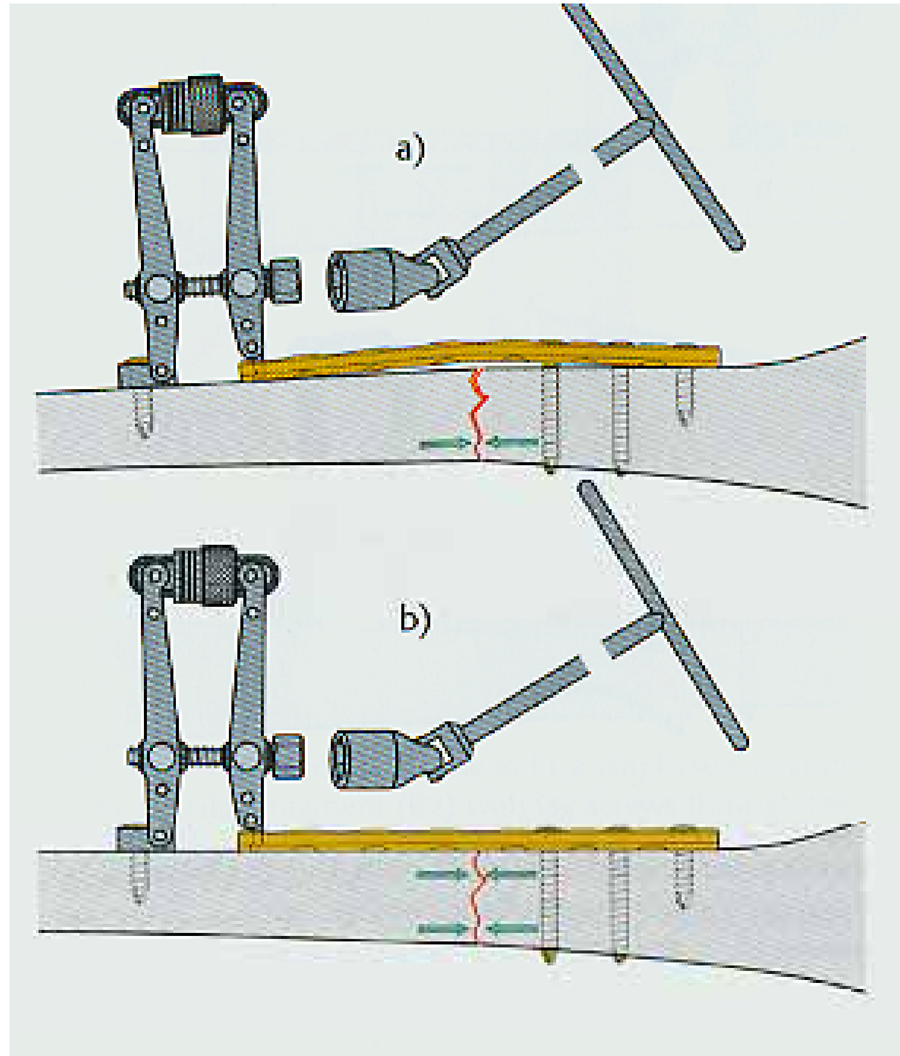
- Number of screws (cortices) recommended on each side of the fracture:

Forearm	3	(5-6)
Humerus	3-4	(6-8)
Tibia	4	(7-8)
Femur	4-5	(8)

From: Le

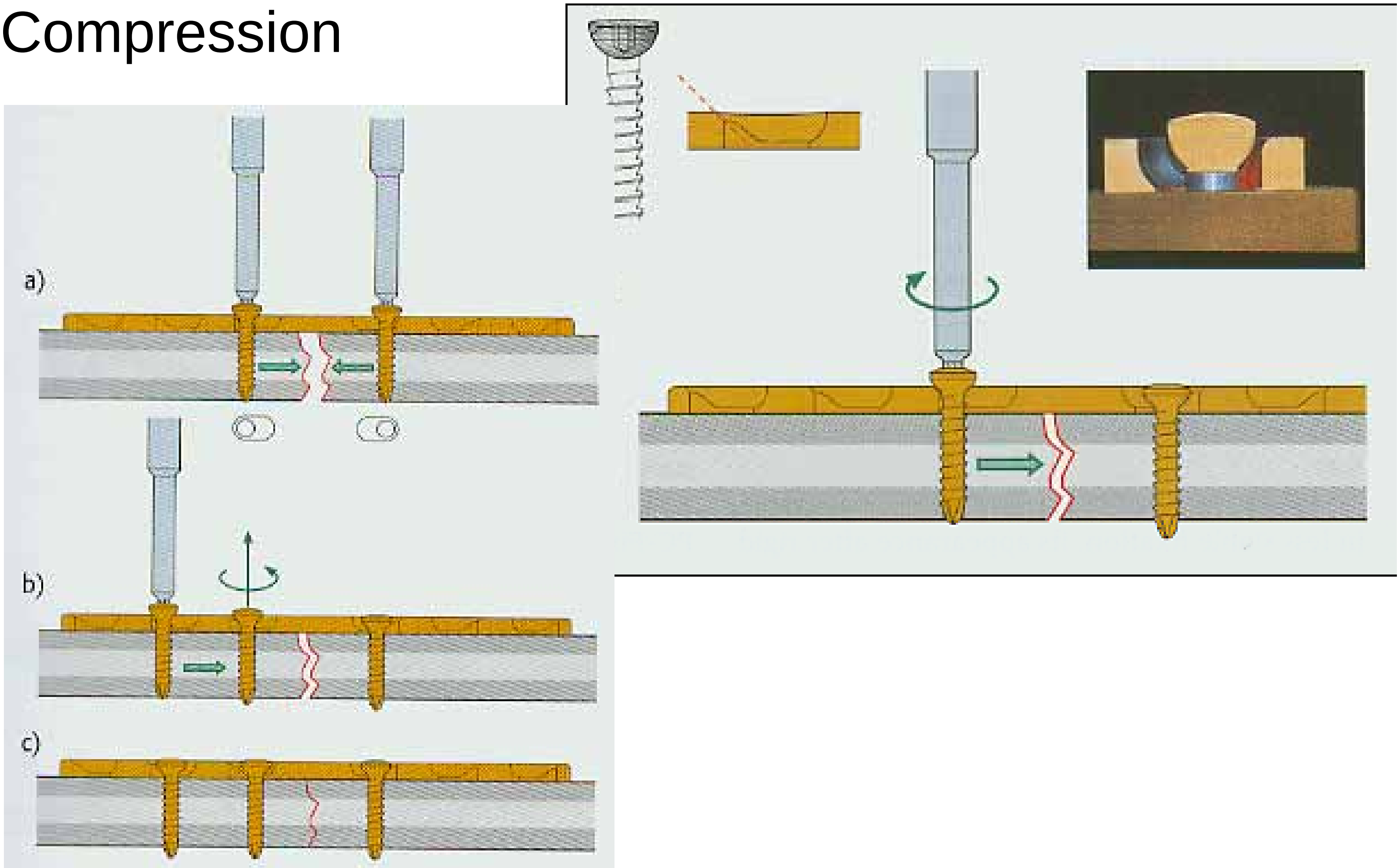
Prebending





From: Justice

- Dynamic Compression



From: Justice

- Tension Band Plate

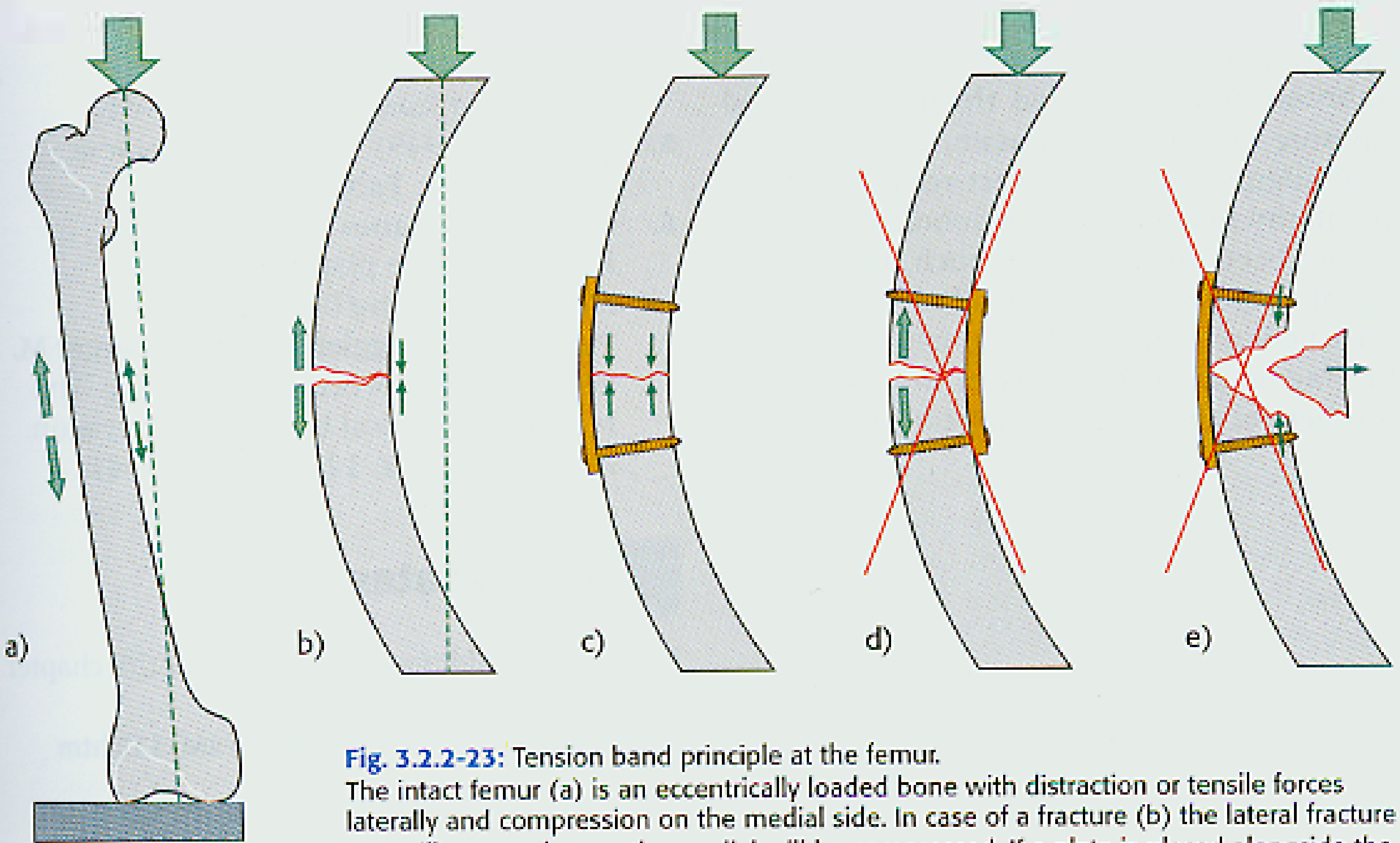


Fig. 3.2.2-23: Tension band principle at the femur.
The intact femur (a) is an eccentrically loaded bone with distraction or tensile forces laterally and compression on the medial side. In case of a fracture (b) the lateral fracture gap will open, whereas the medial will be compressed. If a plate is placed alongside the linea aspera of the femur (c), it will be under tension when loaded, thereby compressing the fracture gap, provided there is bony contact medially. If the plate is placed to the compression side (d), it is not able to prevent opening of the lateral gap (instability). If the medial cortex is not intact (e), the tension band principle cannot work, because of lack of buttress (see **chapter 3.2.3**).

From: Justice