Bone Plate Sizing and Factors for Long-Bone Stabilization

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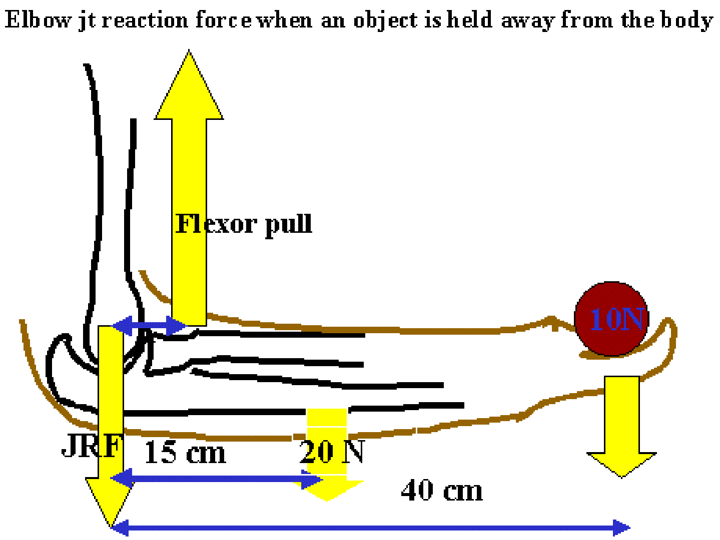
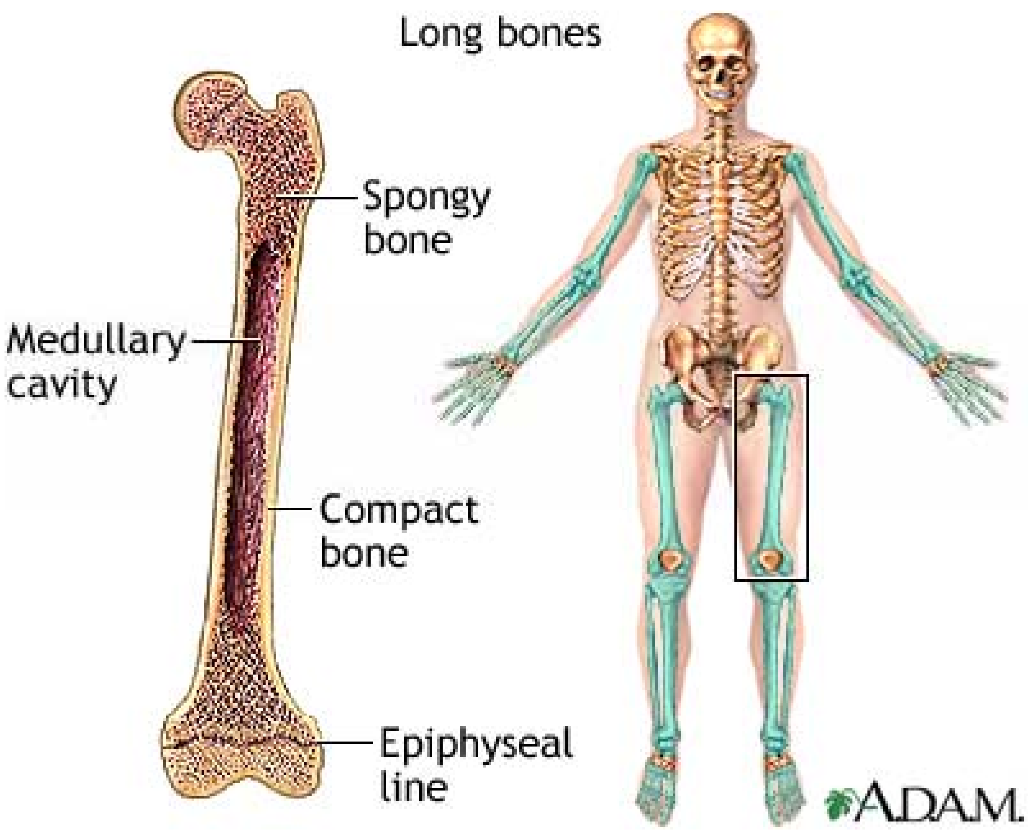
Human Body Components

- Articulating long bones
- Passive ligaments
- Active muscles
- Forces
- Broader and complex systems to make every-thing work together

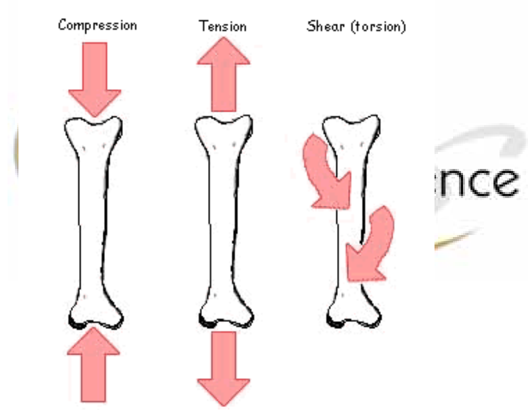


Bone Properties

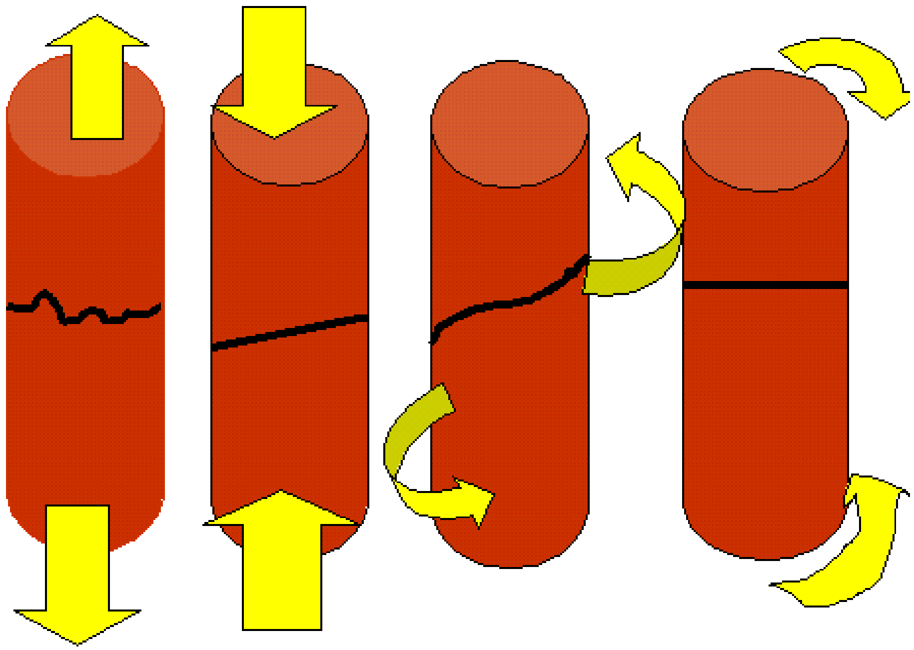
- Non-deformable
- Long
- Load bearing
- Round
- Hollow
- Linear elastic



Stress & Loading

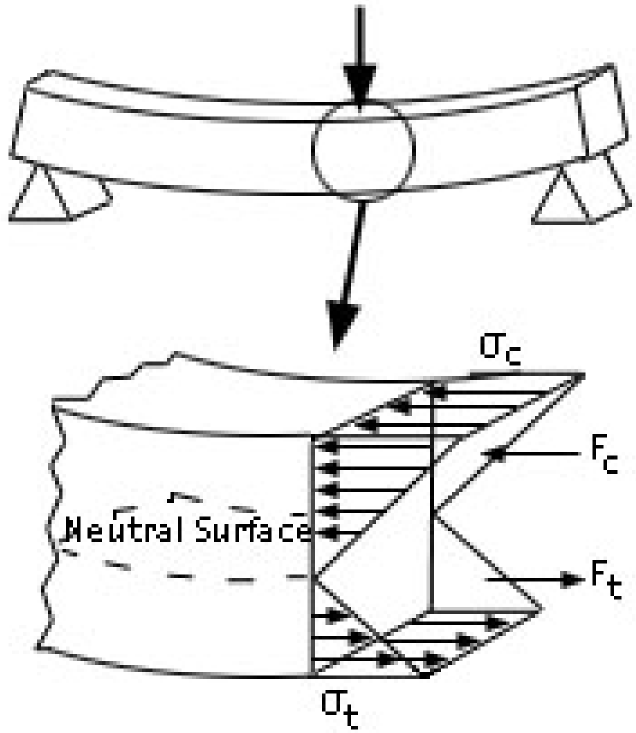


- **Longitudinal**
  - $\sigma = F/A$
- **Torsion**
  - $\tau = Tr/I_p$
- **Bending**
  - $\sigma = My/I$



Bending Stress Distribution

- $$\sigma = \frac{M \cdot y}{I}$$
  - M= bending moment
  - y= distance from neutral axis
  - I= (second) moment of inertia



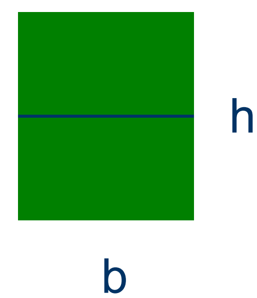
- $$I_x = \int y^2 dA$$
  $$I_p = \int r^2 dA$$

$$\sigma = \frac{M \cdot y}{I}$$

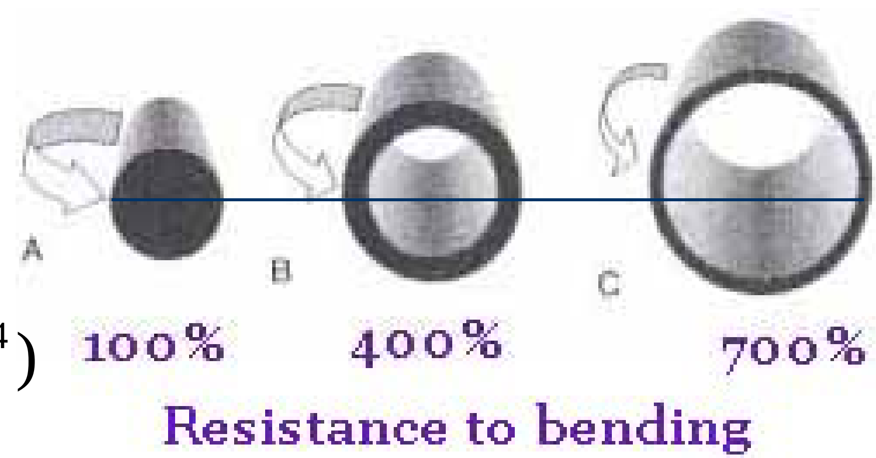
Moments of Inertia

About the centroidal or neutral axis

- **For a rectangle**
  - $$I_X = \int y^2 dA = \frac{bh^3}{12}$$

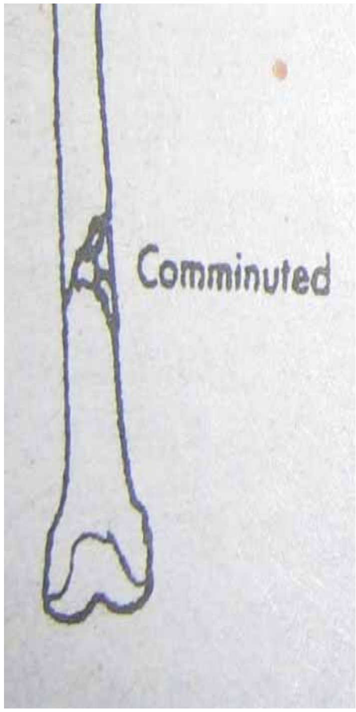


- **For an annulus**
  - $$I_p = \int r^2 dA = \frac{\pi}{2}(R_2^4 - R_1^4)$$



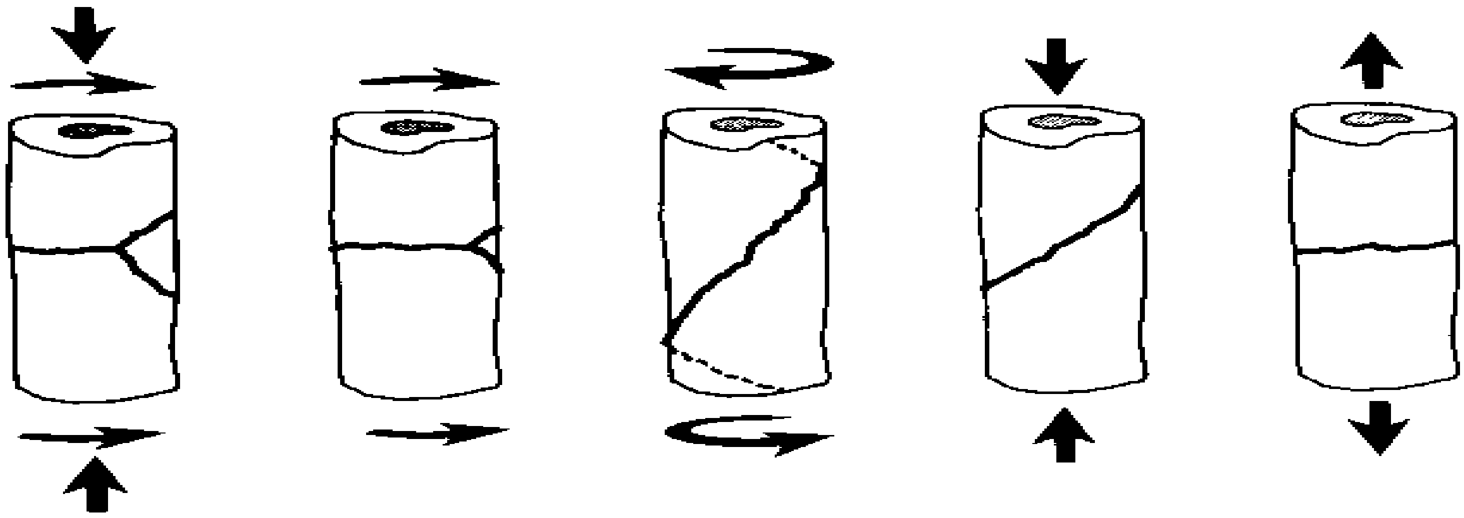
Long Bone Fractures

- Bending moment probably involved
- Compression probably involved
- Probably near the middle
- Fracture indicates break vs. crack
- Result is a butterfly fracture
- Now how do we repair or "plate it"?
- Use a "compression" bone plate

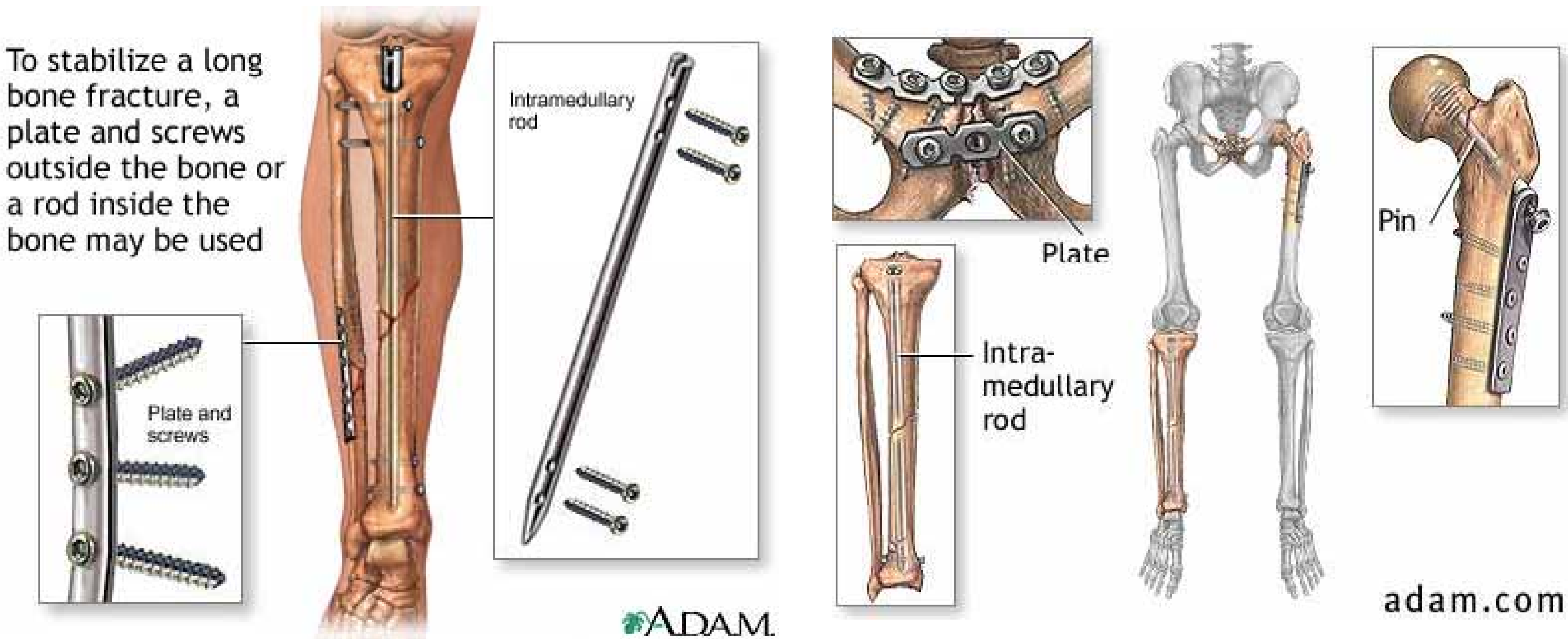


Fracture Anatomy

- Bone weaker in tension so tension fails first
- Crack propagates, bearing area reduced, and eventually opposite side fails in compression
- Result is butterfly fracture



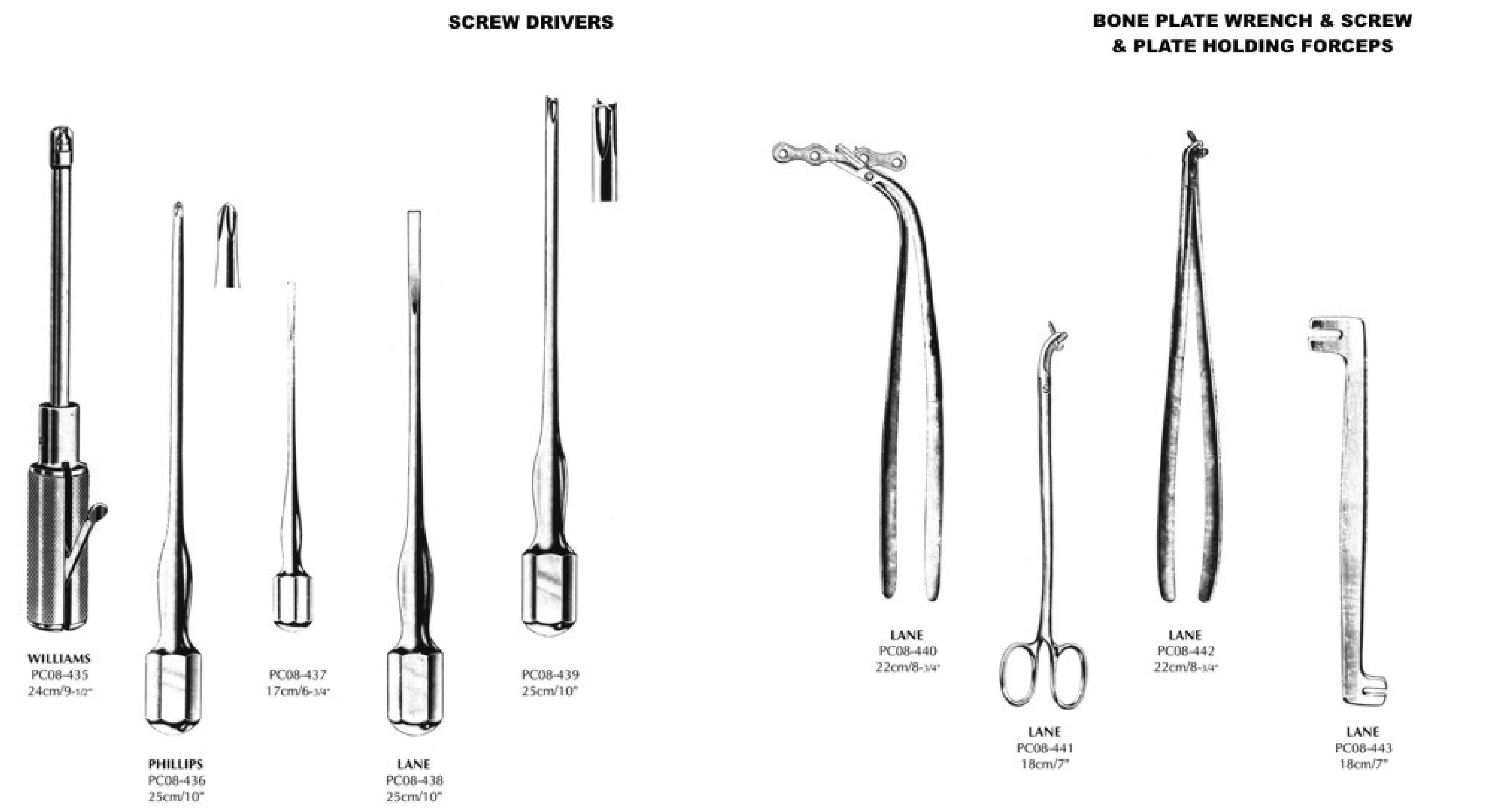
Bone Plate Uses



Bone Plate Examples

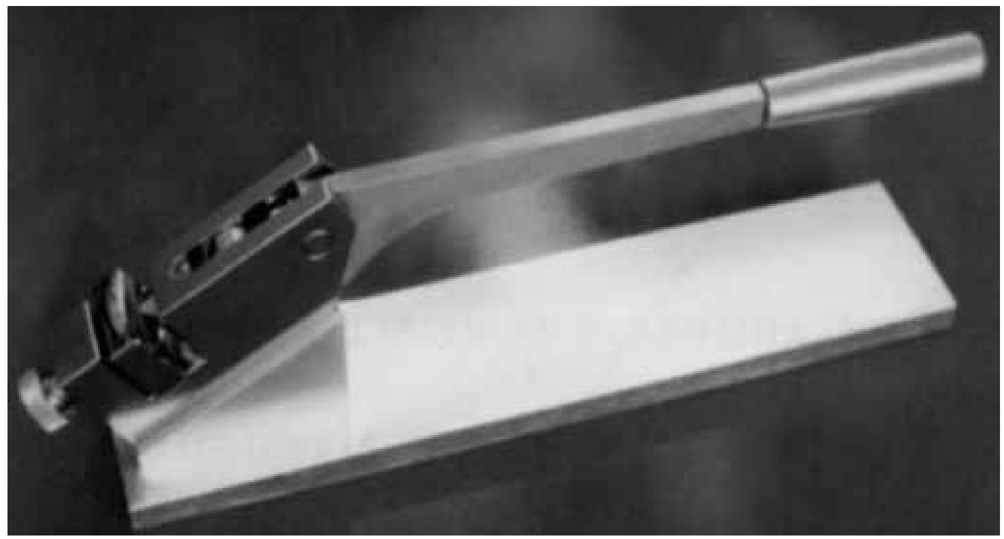
Bone Plate Xrays

Bone Plate Tools



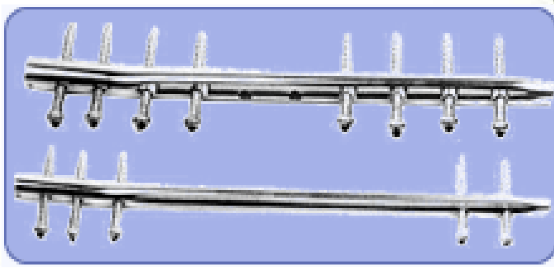
Bone Plate Modifications

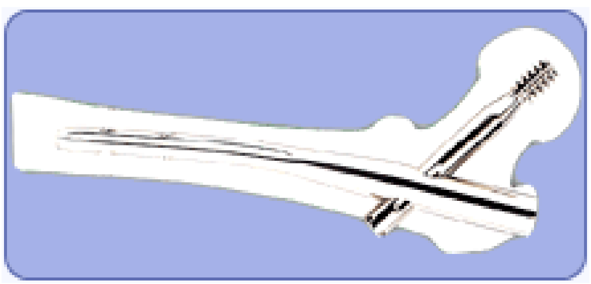
Contouring Tower



Bending Press

Bone Plates



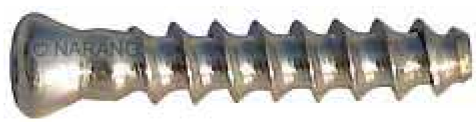


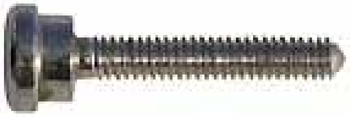
Orthopedic-Implants.com

Bone Screws

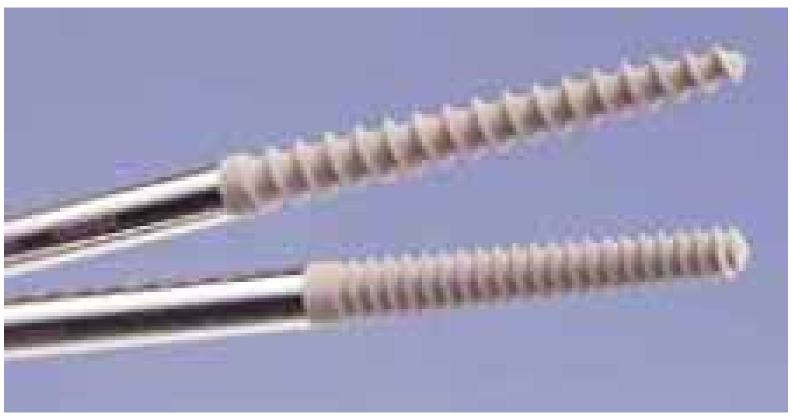




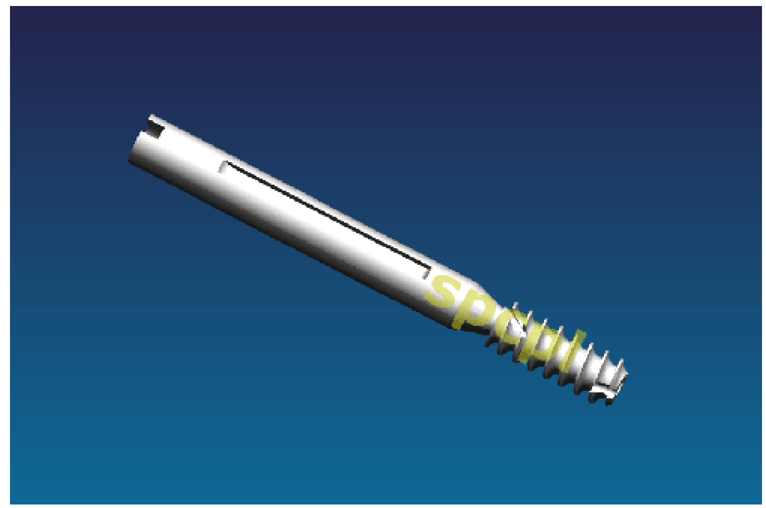


Specialized Bone Screws



DynaFix® Hydroxyapatite Bone Screws



10-mm locking bolt (Sharma)

Bone Healing

- **Secondary- Callus formation (natural)**
  - Inflammation & interfragmentary stabilization
  - Bony bridge if proper immobilization
  - Remodeling- Wolff’s Law
- **Primary- Contact (Haversian remodeling)**
  - Revascularization
  - Reconstitution of intercortical union
  - Must be aligned, stable, and adequate blood supply
  - Longer period, but immediate stabilization (if plated)

Plate Purpose

- **Provide compression force/stress across the face of the fracture.**
  - Must preload plate through compression (tension) and curvature (bending)
  - Prevents fracture from opening
- **Provide stabilization/immobilization**
  - Stabilize fracture and other pieces
  - Immediate load-bearing capacity

Plate Location & Shaping

- Plate is located on the tension side
- Plate is pre-bent so to provide compression across fracture site
- Screw insertion causes plate to be in tension so fracture is under compression
- Plate is sized so that neutral axis is at the plate/bone interface

Neutral Axis Location

1. Where areas above/below are equal?
2. Center of mass?
3. Center of least potential energy?
4. Where stiffness above/below are equal?
5. Center of area?
6. Where (second) moment of inertia equal?

Stiffness & Neutral Axis

- **Neutral Axis experiences no elongation**
- **Mechanical stiffness on both sides equal**
- **Stiffness depends on geometry**
  - Area
  - Distance away
- **Stiffness depends on Young's Modulus**
  - Assume linear elastic
- **Stiffness equals: E•I**

Manipulating I & Properties

- **For Bone/Plate construct**
  - $E_p \cdot I_p = E_b \cdot I_b$
  - $E_p \approx 10 \cdot E_b$
- **For bone geometry**
  - $R_2 - R_1 \approx 1/5 \cdot R_2$
- **To adjust I, use Parallel Axis Theorem**
  - $I_{interface} = I_{centroid} + A \cdot d^2$
  - d = distance from centroid plane to interface plane

- **In setting E·I equal for the bone and for the plate**
  - Geometry of bone known (or assumed)
    - So I_{bone} can be calculated
  - Geometry of plate yet to be determined/selected
    - So I_{plate} can be determined, but not specifically b or t
  - Young's Modulus of plate and of bone known
    - $10 \cdot E_{bone} = E_{plate}$

Plate Properties

- **From the simple plates we've seen**
  - Rectangular cross section
  - About 3-7 times wider than thick
- **Other relevant assumptions**
  - $10 \cdot E_{bone} = E_{plate}$
  - $R_2 - R_1 \approx 1/5 \cdot R_2$ (for the bone)