Hardware in fractures: the orthopedic issues we have with fragile bone

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Problems that Haunt

- Very thin cortices
- Very little trabecular bone
- Crack propagation during fixation
- Severe osteoarthritis adjacent to a comminuted fracture
- Periprosthetic fracture

Problems that Haunt…

- Nonunions and delayed fracture healing
- Severe comminution or segmental loss at fracture sites
- Fractures in radiated bone
- Bad bone and big surgery
  - Spine
  - Joint replacements, especially revisions

So how do you think about these problems?
and
Why do you do those things you do?

Problems with Fracture Healing

- Older patients with a lifetime of other issues
  - Diabetes
  - Medications
  - Prior injuries
  - Radiated bone
  - Prior surgeries with hardware/joints
- Nonunions
  - Tibia
  - Femur
  - Humerus
- Trauma patients with significant soft tissue damage

Bone regeneration possible through a lifetime

- One of the few tissues constantly regenerated and repaired
  - Bone remodeling
  - Fracture healing
- Complex, well orchestrated process
- Heals without scar
  - Indistinguishable histologically from adjacent bone
  - Restoration of mechanical properties
  - Restoration of architecture

Bone regeneration possible through a lifetime

- Regenerative process can be compromised
  - **Trauma**
  - **Infection**
  - **Physical state :** Old age, Cachexia/malnutrition, ObesityBurns/Radiation
  - **Medications/Habits:** Steroids, NSAIDs?, Opioids?, chemotherapy agents, Cigarette Smoking

Bone changes everywhere with osteoporosis

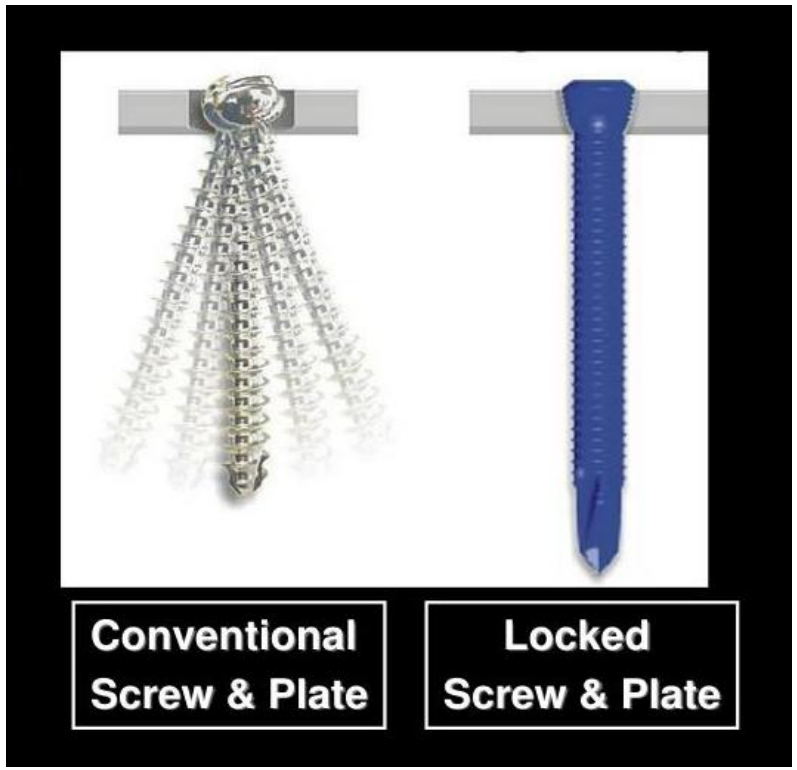
- Trabecular bone
  - Fewer
  - Rod like instead of plate like
  - Architectural gaps
- Cortical bone
  - Increased porosity
  - Slower periosteal bone formation
    - aging
  - Endosteal bone resorption results in thinner cortices
    - menopause

Grab on and hold tight…

- Traditional plates-screw constructs rely on friction between plate and bone
- Screw purchase and resistance to pullout are essential to maintain fracture reduction
- Failure point in osteoporotic bone often at the bone/implant interface
  - Decreased mineralized tissue per unit volume
  - Lower resistance to screw pullout

Conventional plates vs Locking plates

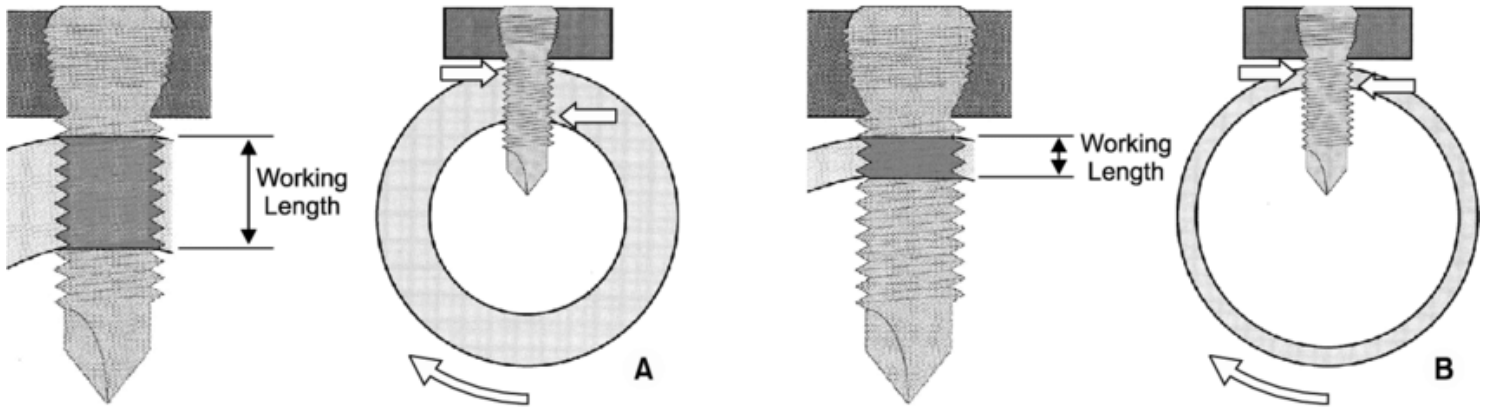
- Conventional plates and screws
  - friction between the thread and the bone to be stable
  - Wiggle stimulates fracture callus
- Locking plates create more rigid fixed angle construct
  - Not rely on screw purchase
  - Increased construct stiffness
  - Careful balance to prevent stress shielding and slow bone formation



Remember the principles of geriatric fracture care

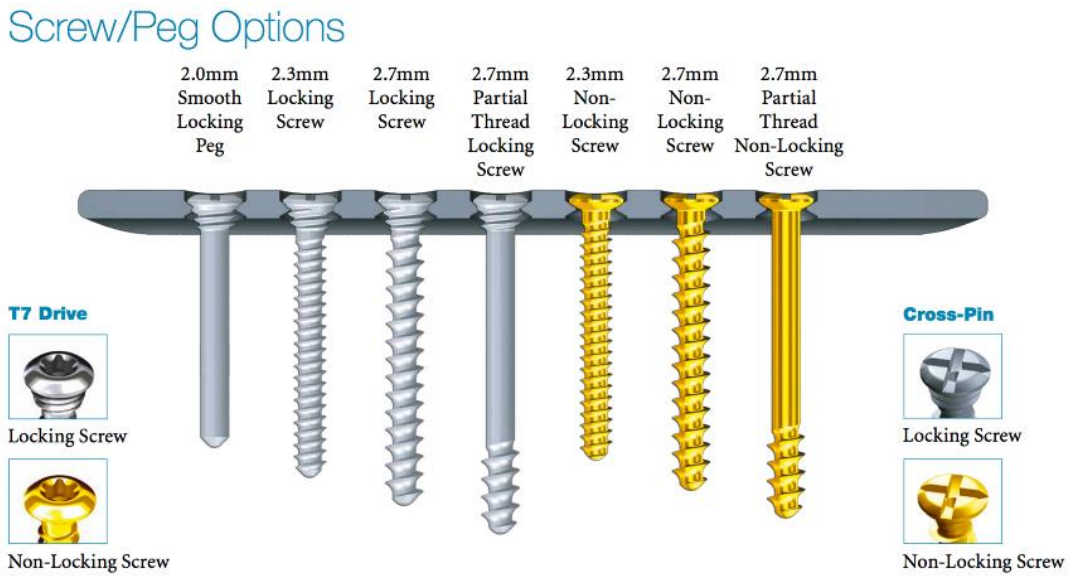
- Intend for early weightbearing and full weightbearing
- Do what will return to function as quickly as possible
- Think “long” to distribute mechanical force across the entire bone
- Choose your hardware wisely

Very thin cortices



- Screws hold onto bone by contact along the threads
- Working length is the number of threads gaining contact
  - Extend working length by going bicortical

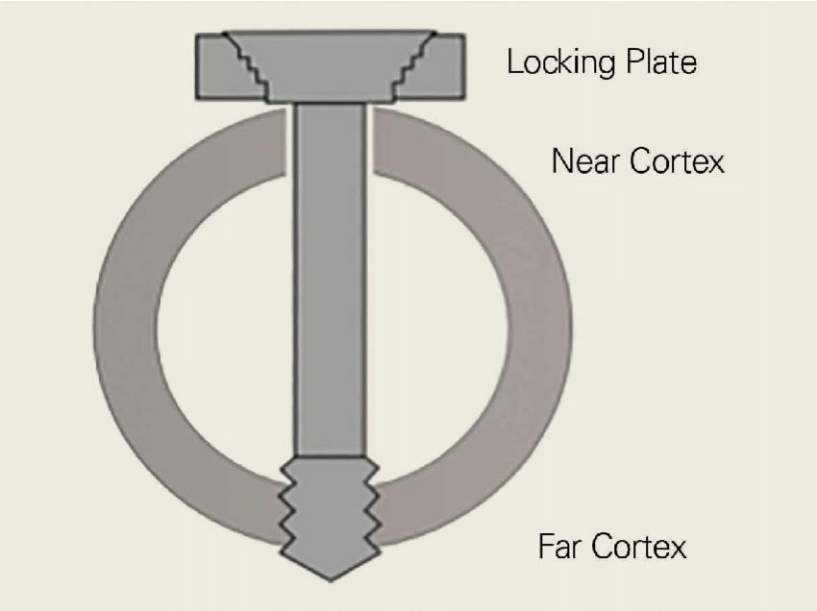
Choosing your screws wisely



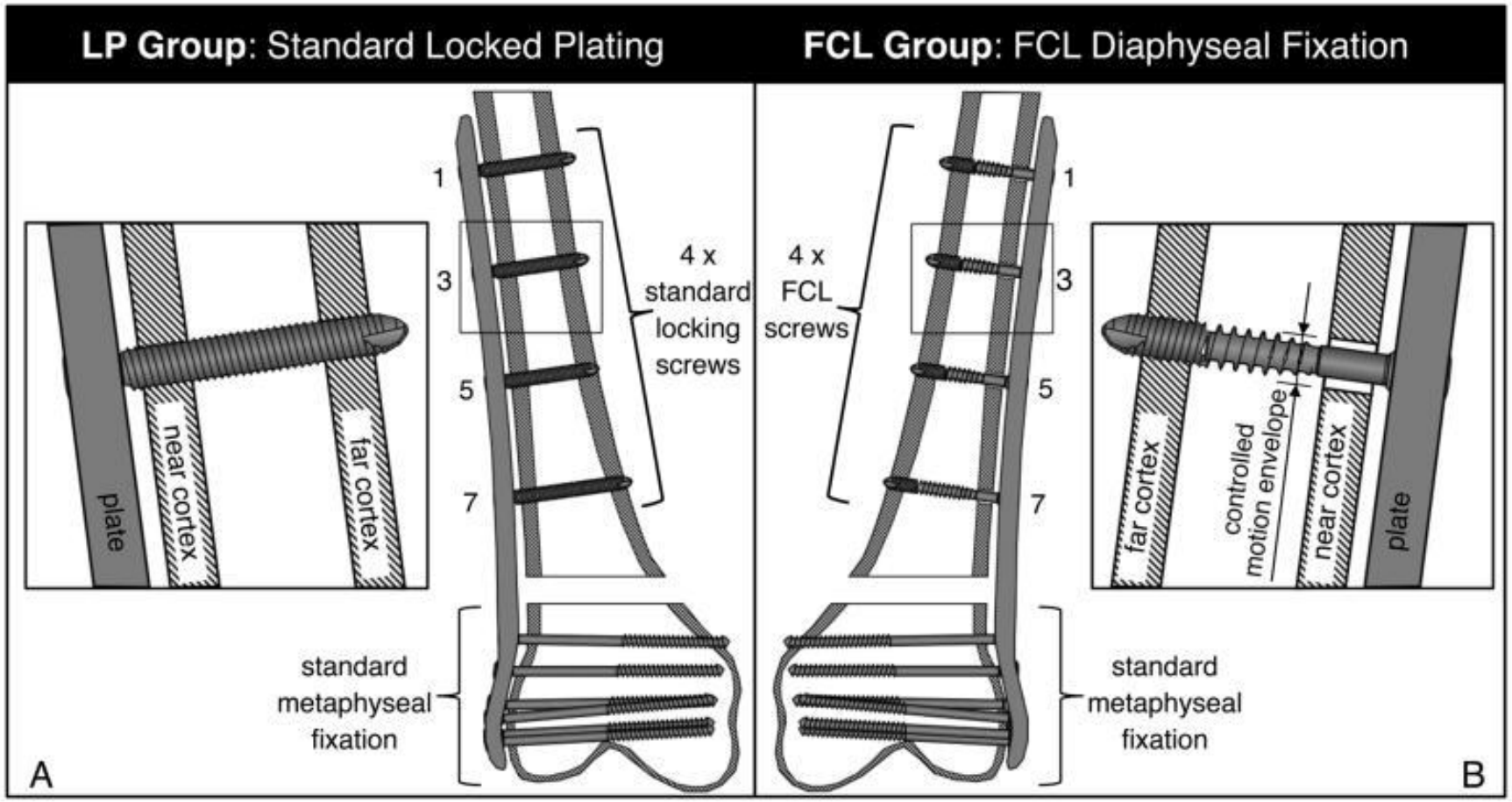
- Diameter matters
  - Inner dicates bending strength
  - Outer dictates screw pullout strength
- Adjustments effect stiffness
  - screw pitch
  - screw shaft diameter
  - contact with far cortex

Creative combos to balance stiffness

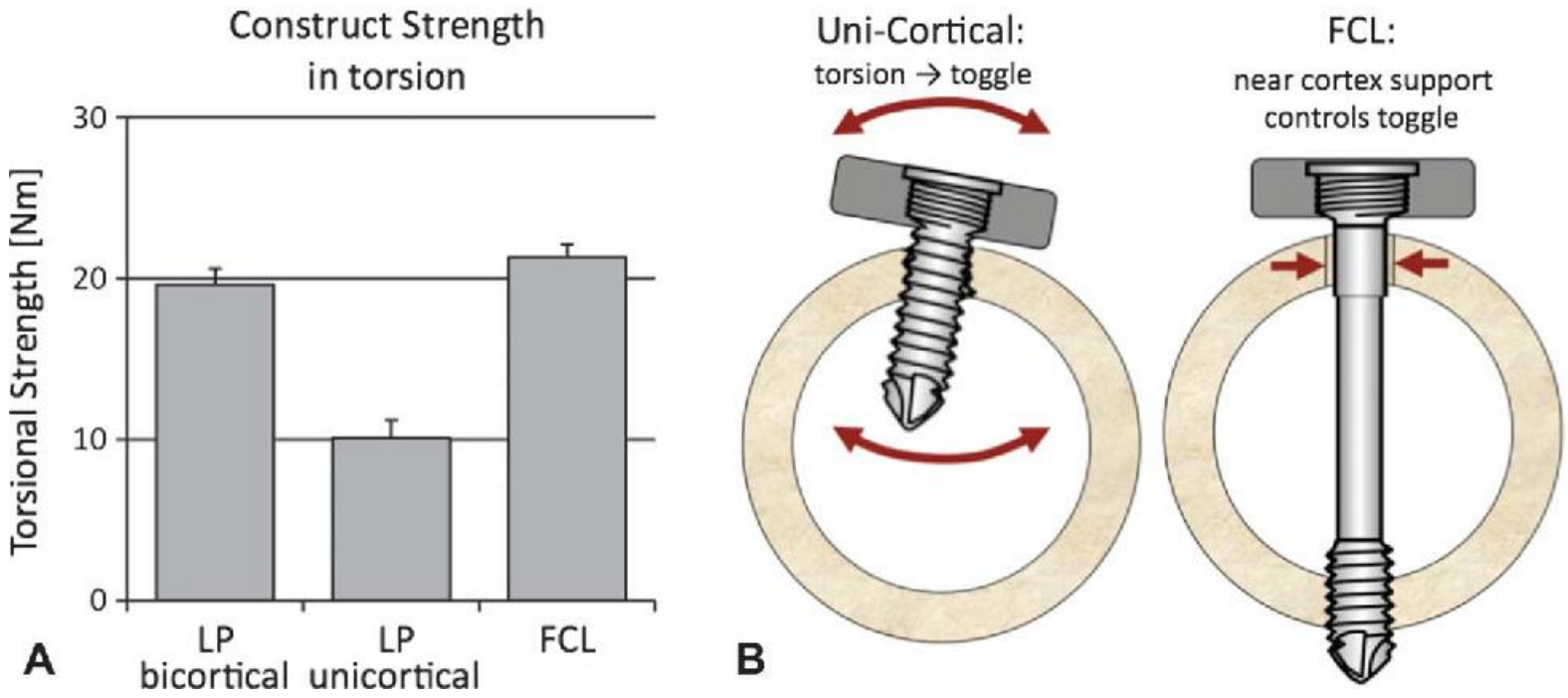
- Far cortical lock screws
  - Promote construct stiffness
  - Allows screw flexion in a controlled range
    - Contolled toggle near the collar
  - Controlled micromotion at the near cortex helps to promote bone formation
    - 36% more callus volume
    - 54% stronger in torsion



Far cortical locking plates



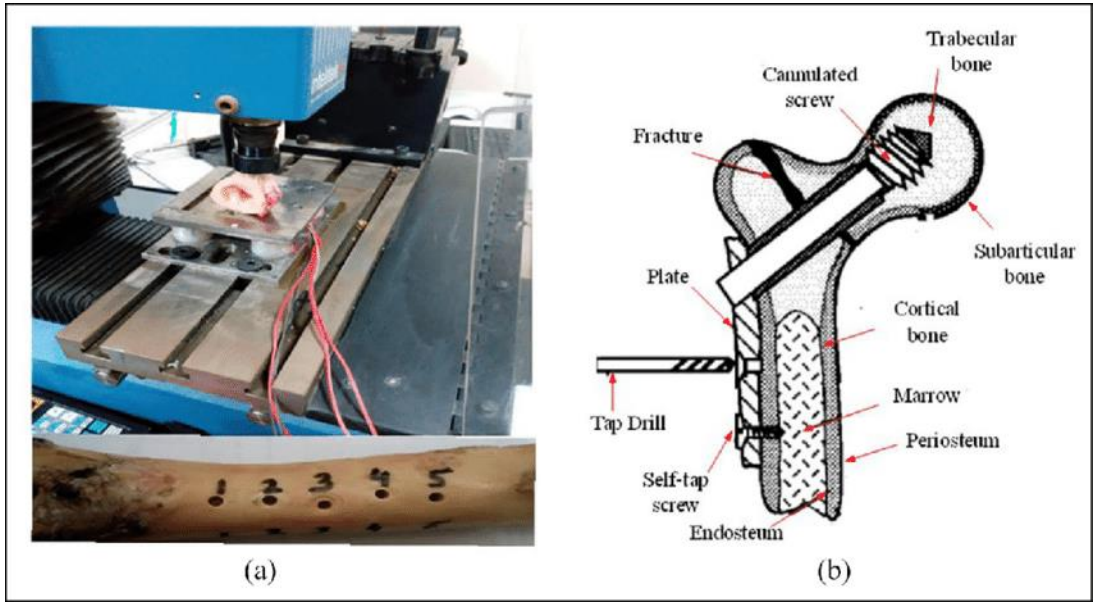
Balancing strength and motion



Unicortical vs bicortical

- Working length of the screw increased with bicortical contact
  - Improves pullout strength
- Bone location matters
  - A unicortical screw in diaphysis still has better pullout strength than a bicortical screw in the metaphysis

Very little trabecular bone



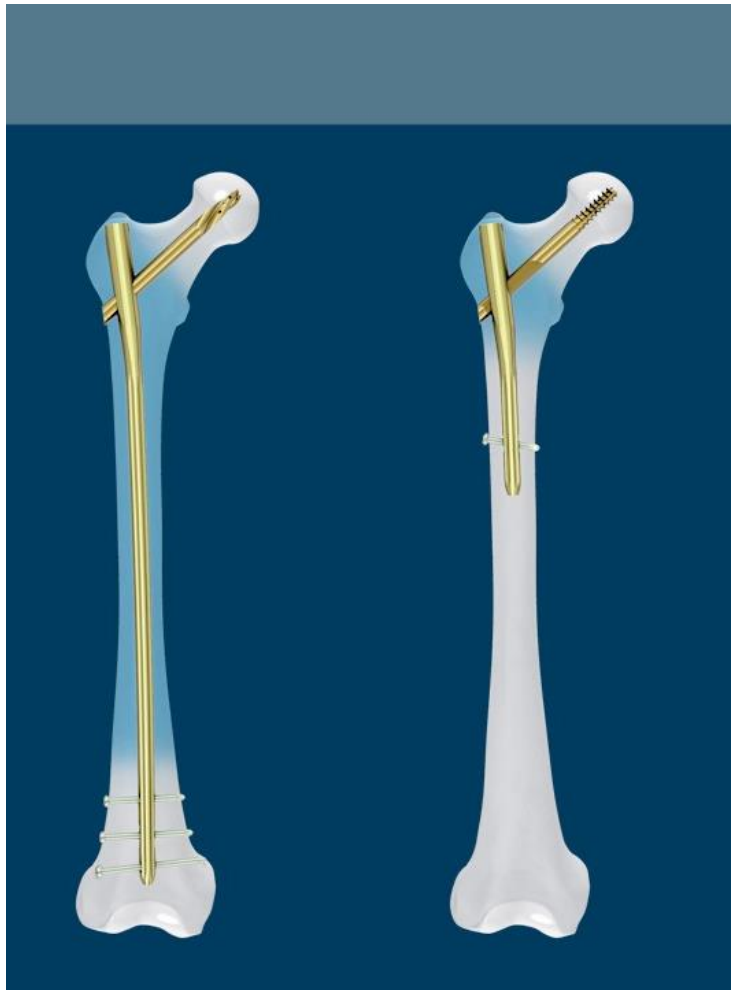
- Periarticular we rely upon trabecular contact
- Linkage to the subchondral bone can be helpful
- Not possible in all fractures
- IM rod tip-to-apex distance 25 mm goal

Creating a stable construct

- High failure rate of unstable intertroch fractures (50% with DHS)
- IM rod devices provide load sharing
- Load to failure significantly greater with IM nail

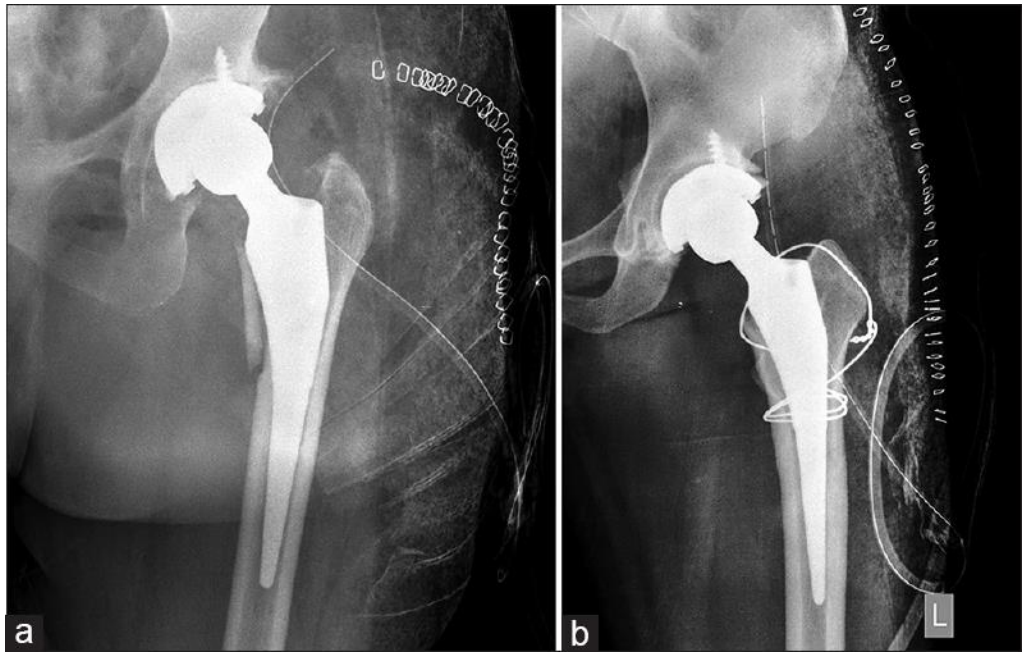
Short nail vs long nail

- Long nails possible to protect the entire bone
  - Similar principle to prophylactic nailing
  - Data not robust enough to show a significant difference in diaphyseal fracture rates
- Lower blood loss with short nail
- Similar healing and hardware failure rates



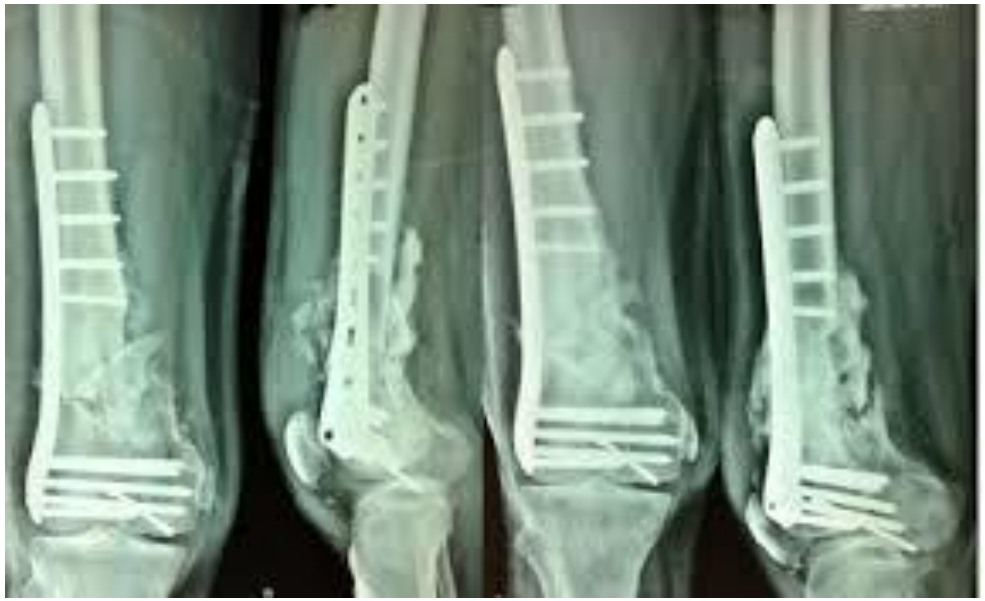
Crack propagation during fixation

- Any drill hole up to 20% of the bone's diameter can weaken bone by 40%
- Never forget about hoop stress while passing implants



Challenges of metaphyseal fractures

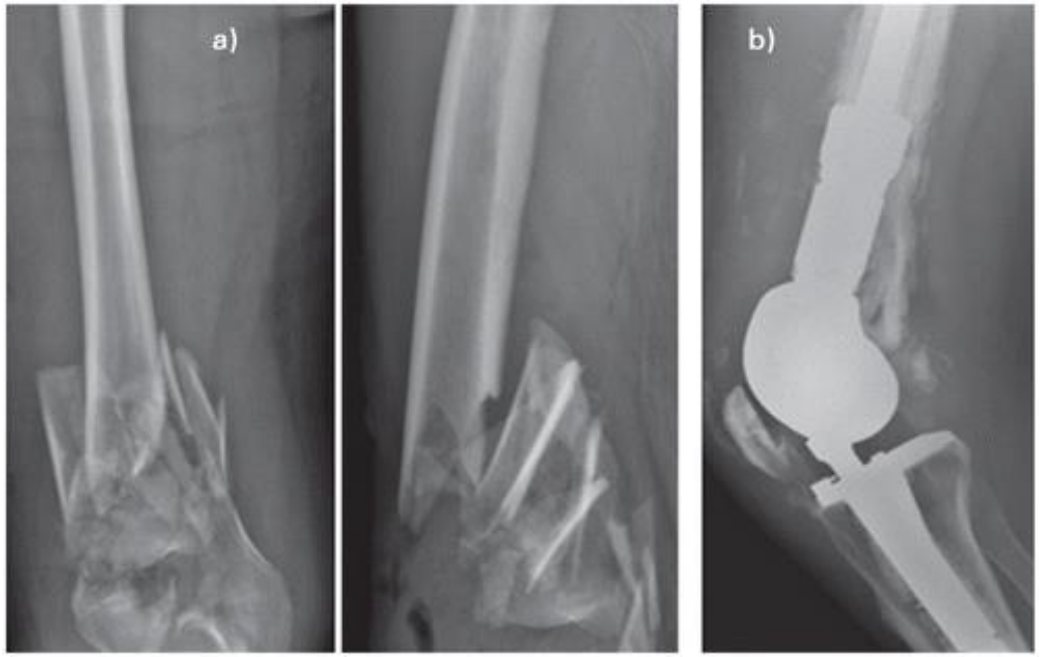
- Stable well reduced construct is important
- Minimally invasive plating can avoid blood supply loss to bone fragments
- Consider polyaxial locking plates



Severe osteoarthritis next to a comminuted fracture

- May need to address the arthritis and the fracture at the same time

Periarticular fractures



- Consider complex arthroplasty for severe comminution
- Use stems for stability
- Judicious use of cement
- Tibial plates that extend to the rim

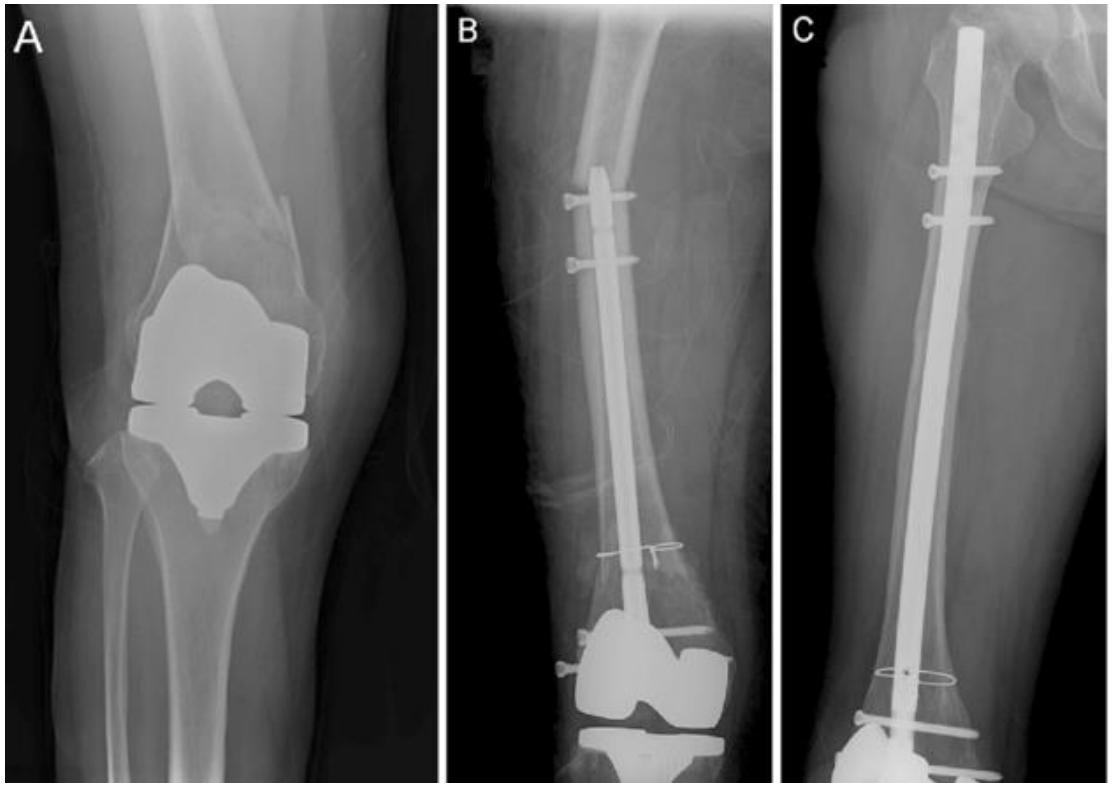
Hemiarthroplasty vs Total hip

- Early 2000's data suggested total hip for physiologic younger hip fractures
- Meta-analysis from end of 2019 show no difference
  - Function
  - Quality of life
  - Reoperation
- May need to think differently if known preop significant arthritic symptoms

Cement vs Press fit femoral component

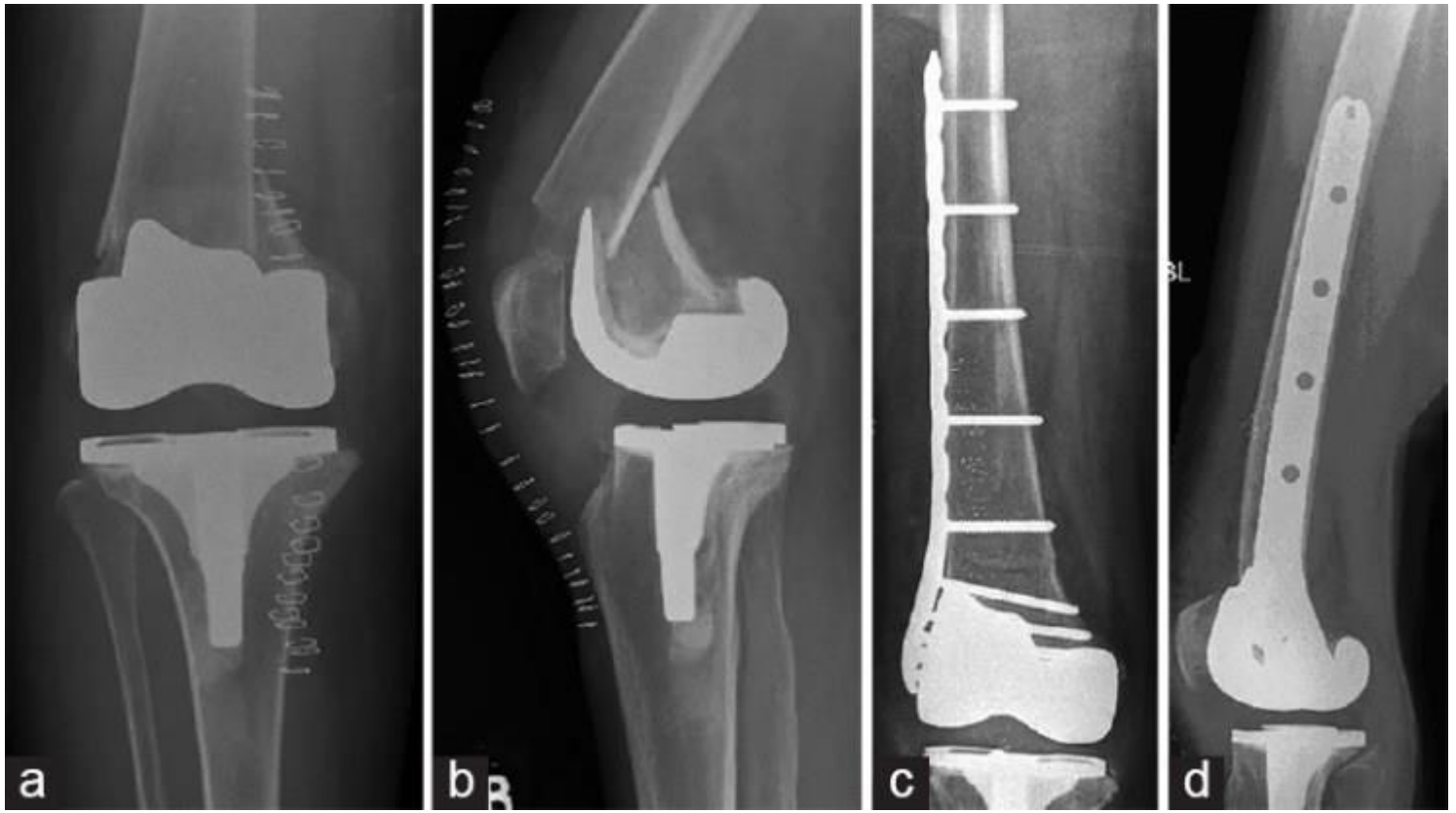
- Increased risk of implant loosening in supraelderly (>age 80)
- Consider cementing for older patients and with significant osteoporosis
- Careful cementing techniques
  - Mortality and complications some increase with cement

Periprosthetic fracture



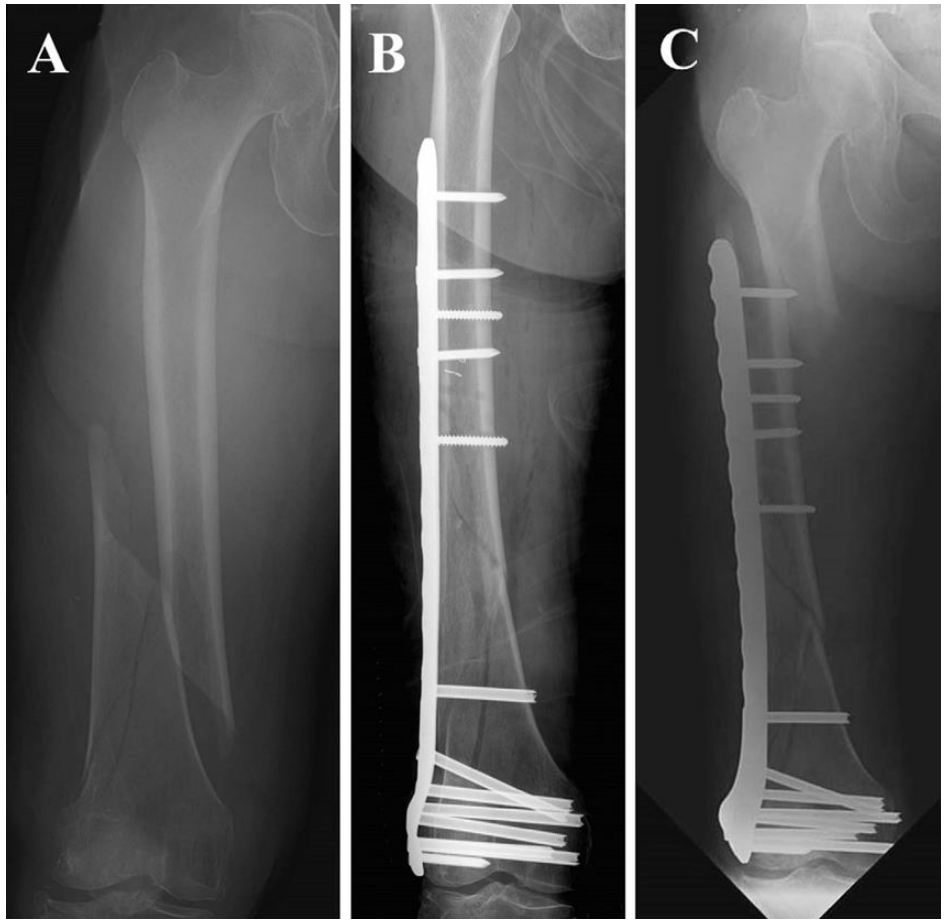
- Working around implants
- Creating new stress risers

Plating can work



Rods can work

Osteoporosis care is still essential



Proximal humerus can be challenging

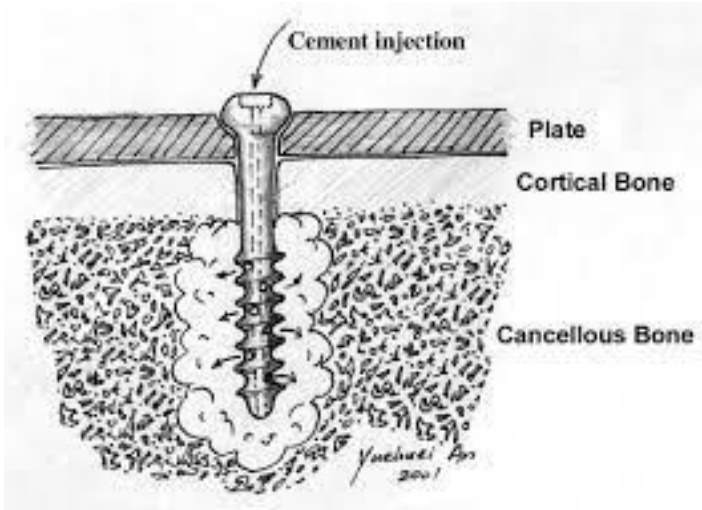
- High rate of construct failure in metaphyseal fractures
- Increased stability with fixed angled locking plates
- Still close to 35% failure rate
- Arthroplasty options may be needed

Distal Radius Fractures

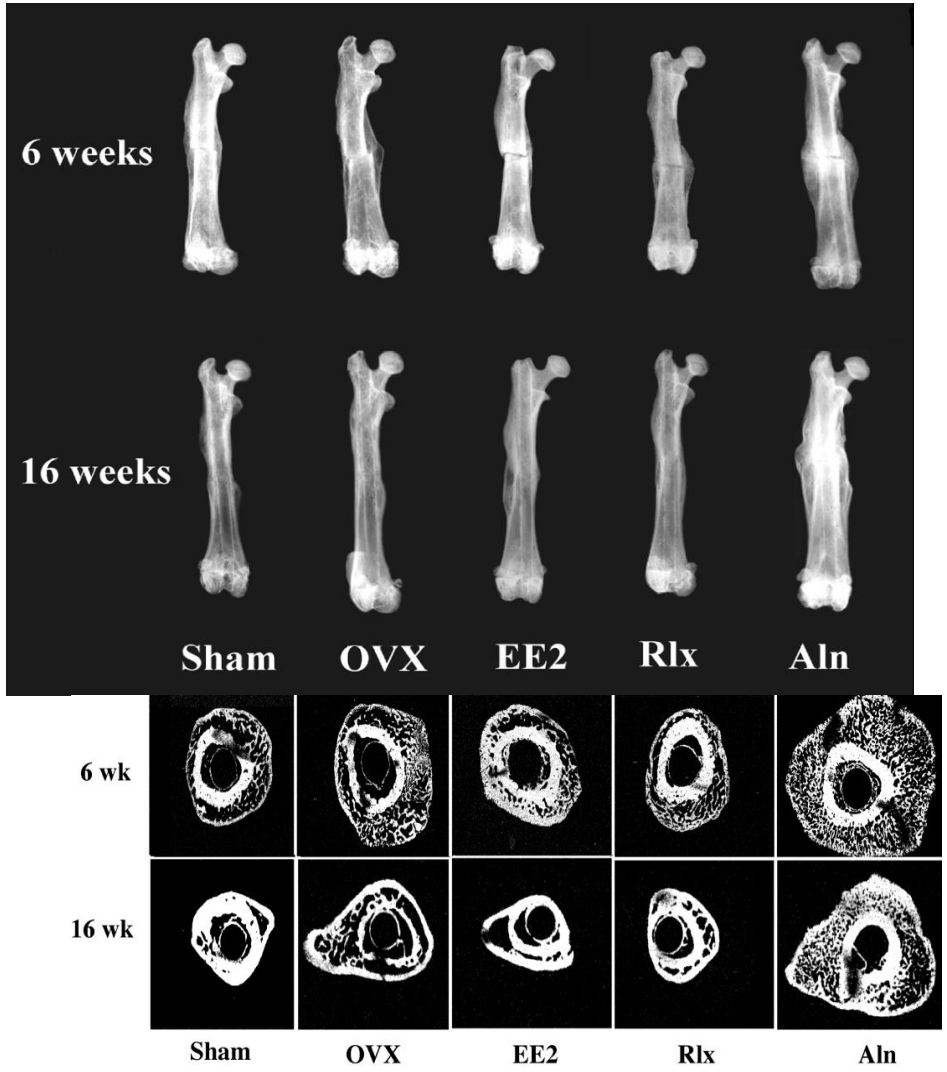
- Most common fragility fracture after vertebral fracture
- Volar locked plating shows better short term outcomes

Screw augmentation

- PMMA
  - Interdigitates with surrounding bone and screw threads
  - Concern over thermal necrosis and screw loosening
- Hydroxyapatite coating
  - Stimulate bone remodeling
  - Increase screw holding strength



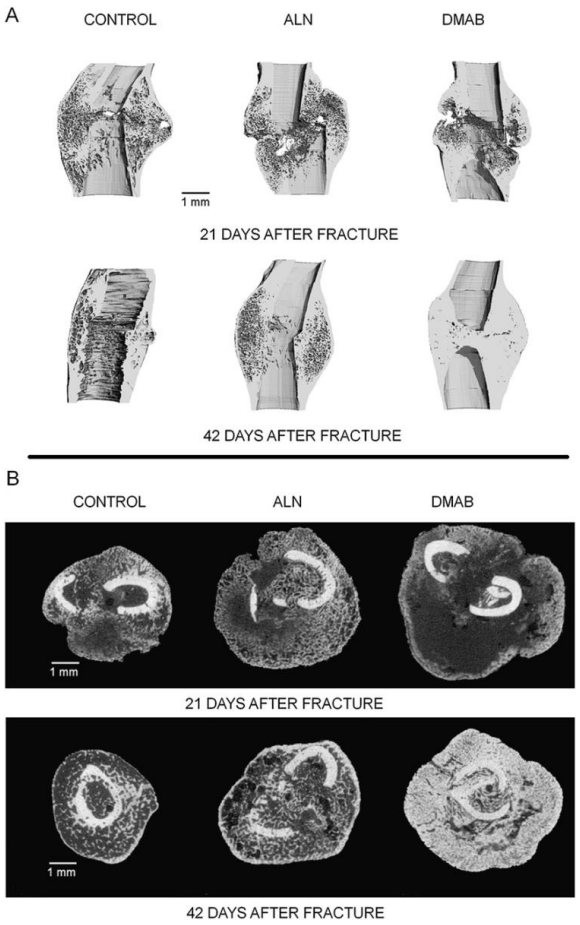
Do not fear starting osteoporosis meds



Cao Y, et al., JBMR 2002 17(12): 2237-2246

Callus formation comparisons in rat femur fracture model

Denosumab



- Mouse femur fracture model
  - Increased callus volume
  - Delayed callus remodeling
  - Increased BMD in callus tissue
- Bisphosphonates show only increased BMC in callus
- No compromise in mechanical properties
- Antiresorptive meds do not stop cartilage formation that creates the callus

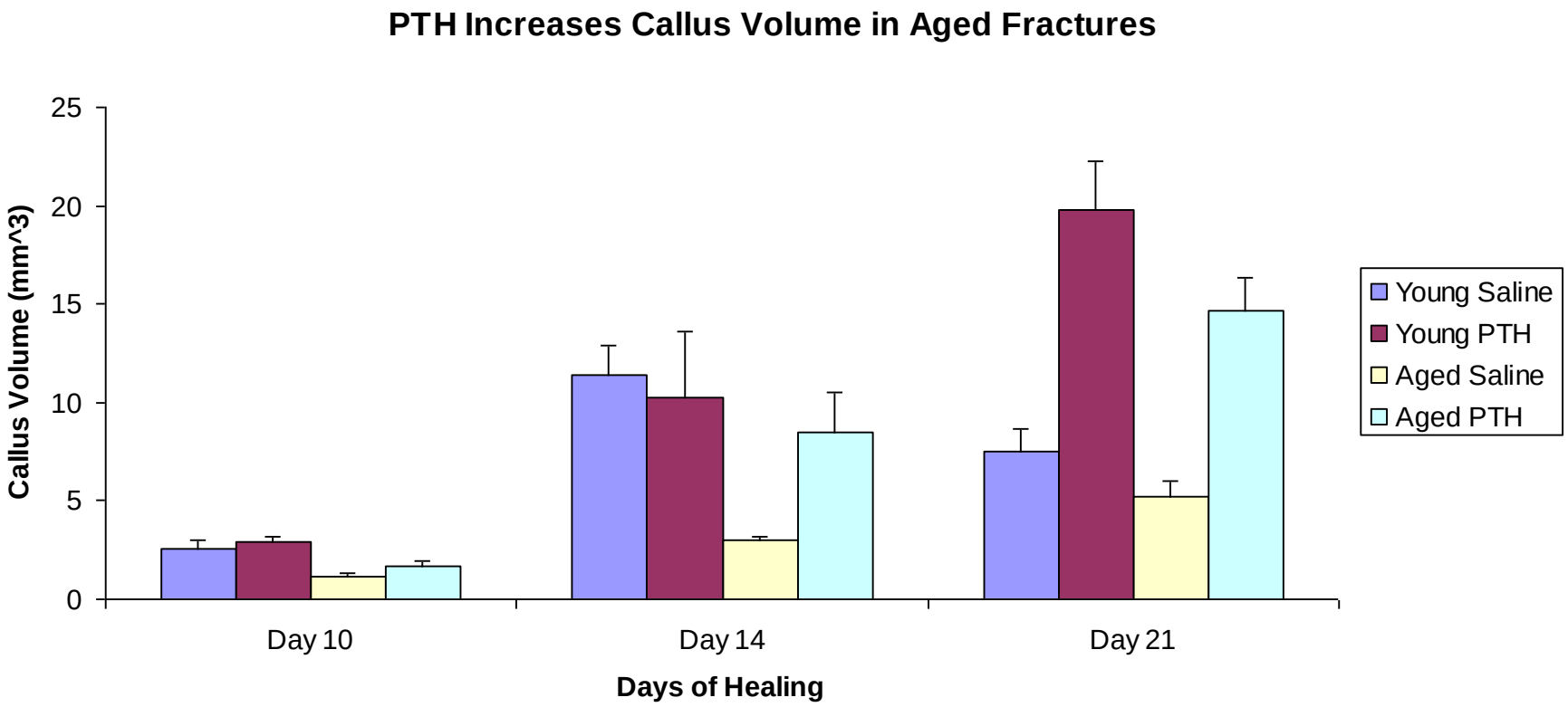
Remember the Importance of Vitamin D

- Required for mineralization of newly formed bone
- Up to 60 % trauma patients Vitamin D deficient
- Treatment with Vitamin D can lead to union in cases of severe deficiency

PTH and fracture healing applications?

- Anabolic therapy for osteoporosis
- Stimulates mesenchymal stem cell recruitment and osteoblastic differentiation
- Stimulates VEGF expression
- Works through signals similar to PGE_2

Effect of PTH on Fracture Healing in Aged Mice



1-34 PTH dose of 10 mcg/kg/day

PTH and fracture healing: wrist fractures

- Aspenberg P, et al (JBMR 2010; 25(2))
  - 102 postmenopausal women treated nonoperatively
    - 3 groups (control, 20mcg/day, 40 mcg/day)
    - Placebo controlled, double blinded, randomized
  - Time to bridging 3 or 4 cortices
    - No difference in 40mcg and control group
    - Improved in 20mcg group compared to control (p=.006)
    - Study powered for the 40 mcg group
- Aspenberg P, et al (Acta Orthop 2010; 81(2))
  - Early callus formation improved with treatment of distal radius fracture with PTH

PTH and pelvis fractures

- 1-84 PTH I00 mcg daily start day 2 after fracture
- 21 treated patients, 44 control
- By 8 weeks all PTH patients healed, only 4 of control
  - Also improved pain and return to function with PTH
  - Not a randomized or blinded trial for physician or patient

So what do I do?

- Evaluate patients for overall bone health
- Evaluate prior medication history, fracture history, extent of surgery, possible risks with hardware failure
- Optimize Vitamin D
- Consider preoperative anabolic agent
  - May not be covered by insurance
  - Recommend 2 months of use preop (previously had done 6, not noticing any difference with shorter course)
  - Continue anabolic for the full course or at least until fusion healed

Thank you