Software 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, Obesity/Burns/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 dictates 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
    - Controlled 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

A

Construct Strength
in torsion

Torsional Strength [Nm]

LP
bicortical

LP
unicortical

FCL

B

Uni-Cortical:
torsion → toggle

FCL:
near cortex support
controls toggle
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 PGE2
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 100 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