



Research Gaps in Care of Hip Fracture
(Organized by The Hip Society and ORS)

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Harry Rubash, MD

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Hip Fracture Research Gaps: Basic & Translational Research in Hip Fx Healing & Biomechanics

William Macaulay, MD, Columbia University

Objectives:

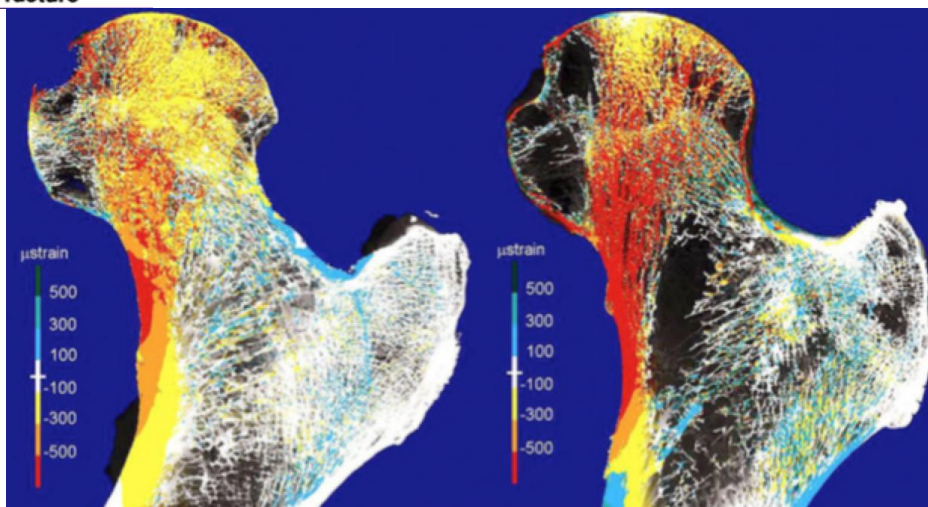
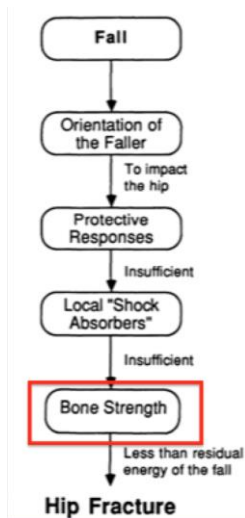
- Review current knowledge: Proximal femur biomechanics, osteoporotic bone loss and susceptibility to fracture, osteoporotic fracture healing & fixation options
- Identify gaps in knowledge and fertile avenues for further study

Proximal Femur Biomechanics

- Normal gait: peak compressive forces at calcar
- Sideways fall onto greater trochanter:
 - Peak compressive force at posterosuperior cortex
 - Peak tensile force at anteroinferior cortex
- Bone loaded normally in compression is half as strong when loaded in tension
- Insufficient trabeculae appropriately oriented to absorb force of fall → **hip fracture**

Osteoporotic Bone Loss and Susceptibility to Fracture

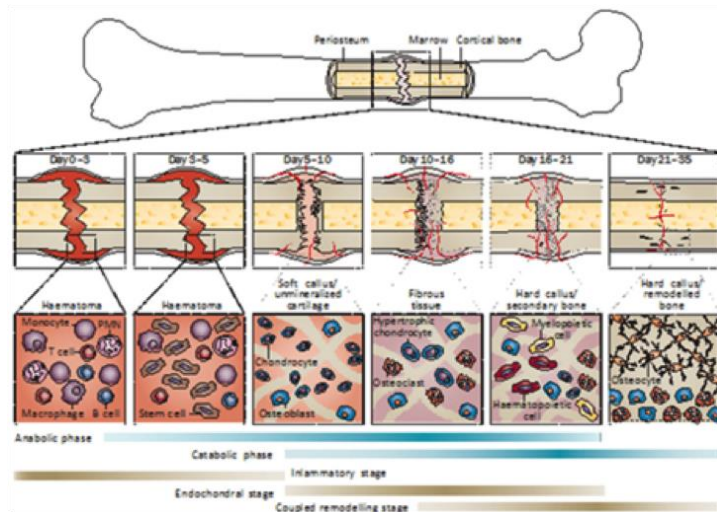
- Osteoporosis affects cortical and cancellous bone in proximal femur
 - Cortex bears 50% of load
 - Anisotropic and brittle, strongest in compression
 - Fracture occurs when applied load > ultimate tensile strength



L: Cummings, Steven R. and Nevitt, Michael C. A hypothesis: the causes of hip fractures. *J Gerontology* 44.5 (1989): M107-M111. R: Morgan, Elise F and Bouxsein, Mary L. Use of finite element analysis to assess bone strength. *Nature BoneKEY- Osteovision* 2.12 (2005): 8-19.

- Osteoporotic patients lose bone cortical and cancellous bone mass
 - If bone density < 0.5 g/cc, multiple trabecular fractures may occur
 - Increased susceptibility to fracture with fall
 - Hip fracture patients have significantly reduced cortical area and density, especially in anteroinferior region of femoral neck
- Mechanism of fall determines fracture location
 - Peritrochanteric fractures involve rotational component to direct blow of fall, more likely to occur if bone quality is very poor

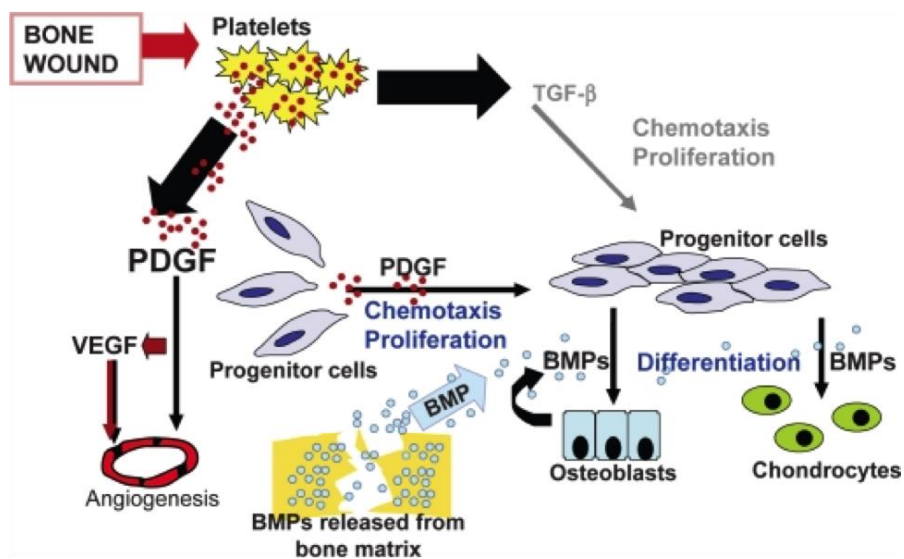
Fracture healing: impaired in osteoporotic bone



Einhorn, Thomas A., and Louis C. Gerstenfeld. "Fracture healing: mechanisms and interventions." *Nature Reviews Rheumatology* 11.1 (2015): 45-54.

- Mesenchymal cell differentiation
- Inflammatory cell activity
- Local revascularization
- Remodeling

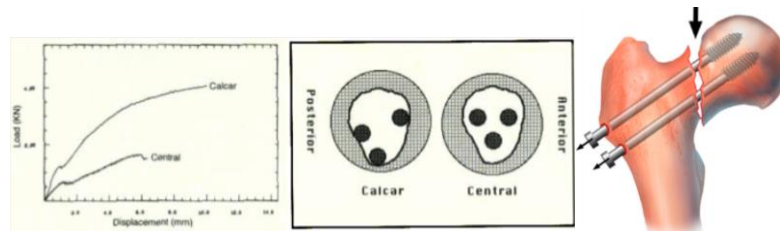
Mediators of fracture healing



Hollinger JO, et al 2008. Recombinant human platelet derived growth factor: biology and clinical applications. *J Bone Joint Surg Am*, 90:48-54.

Surgical Fixation

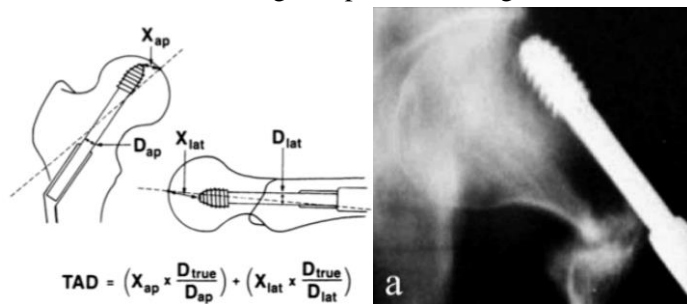
- Cannulated Screws
 - Calcaneus purchase of inferior screw necessary to withstand physiologic axial loading
 - Pauwels III fractures and basicervical fractures - failure more likely due to orientation of fracture line



L: Booth, Kevin C, Donaldson, Thomas K, Dai, Qiang G. Femoral neck fracture fixation: A biomechanical study of two cannulated screw placement techniques. *Orthopedics* 21.11 (1998): 1173-1176.

R: Liporace, Frank, Gaines, Robert, Collinge, Cory, Haidukewych, George J. Results of internal fixation of Pauwels type-3 vertical femoral neck fractures. *Journal of Bone and Joint Surgery* 90.8 (2008): 1654-1659.

- Sliding Hip Screw
 - Stable intertrochanteric (IT) fractures
 - Sliding allows “controlled collapse” of fracture with healing
 - Most devastating complication = lag screw cutout



$$TAD = \left(X_{ap} \times \frac{D_{true}}{D_{ap}} \right) + \left(X_{lat} \times \frac{D_{true}}{D_{lat}} \right)$$

- Tip-apex distance
- Rotational failure
- Lateral wall integrity

L: Baumgaertner, Michael R, Curtin, Stephen L, Lindskog, Dieter M, Keggi, John M. The value of the tip-apex distance in predicting failure of fixation of peritrochanteric fractures of the hip. *Journal of Bone and Joint Surgery* 77.7 (1995): 1058-1064.

R: Sommers, Mark B, Roth, Christoph, et al. A laboratory model to evaluate cutout resistance of implants for peritrochanteric fracture fixation. *Journal of Orthopaedic Trauma* 18.6 (2004): 361-368.

- Cephalomedullary Nail (CMN)
 - CMN transfers proximal femoral loads to more distal femoral regions
 - Decreased fracture stability → decreased compression on calcar and lateral cortex
 - Bone and nail form composite structure - each bears load proportionally per stiffness
 - May lock lag screw statically or dynamically - static locking is stiffer construct
 - With current generation nail, no benefit for use of long nail for most IT fractures
- Equivocal fixation with sliding hip screw and cephalomedullary nail

Gaps in Knowledge

- Osteoporotic fx's target long bone metaphyses; then why are femoral necks so at risk?
- There is a paucity of feasible metaphyseal fracture healing models
- Does the decrease in osteoprogenitor cells seen with aging translate to a slower/poorer fx healing?
- Age-related activity & role of the above mentioned fx healing mediators is not well understood
- Teriparatide improves fx healing in animal models; can this be shown for human hip fractures?
- Expanded application of extended finite element method (XFEM) to evaluate fracture healing, mechanics, and load transfer in fractured femur following fixation

Research Gaps in Clinical and Health Services Research- outline of talk

Stephen Kates, MD

Professor and Chairman, Virginia Commonwealth University

What is covered

- Research gaps in:
Clinical care

Health Services research
- Suggested ways to address them
- Recent review 2013-17
- Not every topic is studied

Timing of Surgery

- Shown to make a difference
- What is best?
- Literature:
 - No clear evidence
 - Lewis and Waddell review Bone & Joint Journal Dec 2016
 - ASA 1-2 safe for immediate surgery
 - ASA 3-4 should undergo optimization preop
 - Need better studies to inform policies

Timing: what is known

- Delay Factors: Echocardiogram: not helpful

Luttrell and Nana, JAGS

Echocardiograms delay care without benefit

- Weekend surgery safe: Lim, AH AOTS 2015
- Surgical delay in hip fracture care contributes to patient morbidity and mortality. Ryan JOT 2015
- Surgery between 1-2 days is best 190k pts

Longer time increases mortality and pressure ulcers

Moja et al, PLoS One, 2012- older metanalysis

- Can delay surgery
- No consensus on safety
- Varies by drug
- Reversal agents are in development

- No clear evidence based guidelines!
- ASRA guidelines referenced
- “New oral anticoagulants and regional anesthesia” Benzon, HT Br J Anes, 2013

References half-lives- no –data

- Case reports of bad outcomes: Rasmussen LE, 2015 dibigatran
- Longer times to surgery Tran, T *Thomb Res* 2015

Warfarin

- Lawrence, JE Delays to theater- CORR 2017
- Diament, M 2015 GOSR- Algorithm for warfarin
- Gleason, L JAGS 2014 Warfarin reversal
- These are case series studies
- **Better quality research required**
- Ahmed et al, JOT 2014
- Implementation of a perioperative warfarin management protocol can expedite surgery in hip fracture patients, but did not reduce hospital stay

Decision to not operate

Medical consultation model vs true co-management

- Limited data
- Hard to study with RCT
- Important for system care
- Prestmo et al Lancet 2015 Best paper but small RCT

“Immediate admission of patients aged 70 years or more with a hip fracture to comprehensive geriatric care in a dedicated ward improved mobility at 4 months, compared with the usual orthopaedic care. The results suggest that the treatment of older patients with hip fractures should be organised as orthogeriatric care”

- Middleton, M. et al, Age Aging Dec 2016
- Changing hip fracture model from a geriatric consultation model of care to an integrated orthogeriatric model significantly improved mortality and performance indicators
- Neuberger et al Dec 2016 Age Aging Associations between increased orthogeriatrician hours / patient and reduced 30-day mortality (196,401 patients)
- Bracey et al, GOSR, Dec 2016 :OHC has improved efficiency of hip fracture management as judged by significant reductions in LOS with a trend toward reduced TTS (case series)
- Forni et al, 2016 Arch Geronol Geriatrics: A co-managed approach to hip fracture, with orthopaedic surgeons and geriatricians, offers a multidisciplinary pathway for the elderly and leads to a reduction in mortality after hip fracture surgery (**23,973 patients**)
- Gosch, M et al, AOTS 2016: Fragility fracture patients residing in long-term care facilities- orthogeriatric co-management appears to improve the outcome of high-risk fragility fracture patients

- Biber, R AOTS 2013
- A co-managed GFC offering an organized fracture program for the elderly can reduce hospital length-of-stay and time-to-operation in hip fracture patients. A significant effect can be observed within the first year after establishment of a GFC.
- Implants – what is best?
- Femoral neck fractures
- Screws vs. sliding hip screw vs. Arthroplasty
- Registry data available
- FAITH trial studied the screws vs. SHS only
- Literature: Miller, B and Cram, P JBJS A 2013
- “There has been little change in the trends of operative and non-operative treatment for proximal femoral fractures over the last two decades, and there was little evidence of regionalization of hip fracture treatment to higher-volume hospitals”
- Monopolar vs. Bipolar vs THR
for femoral neck fracture
- What type?
- Which patients some receive which treatment
- Literature: Most papers favor THR over monopolar/bipolar hips
- Not well defined on who is the right patient and right surgeon
- **Post-surgical physical therapy**
- When?
- Type?
- When to stop therapy?
- Literature: Unclear
- Pourabbas, B Ortho Trauma Rehab 2016
- By continuing rehabilitation of elderly patients with surgically-treated hip fractures for one year, improvement in activities of life and walking independence can be expected even if they have a poor result after the first 3 months of rehabilitation
- McGilton 2016 JAGS
- Although cognitive impairment and prefracture functional impairment contribute to poor outcomes, prefracture functional impairment was more strongly associated with poor

outcomes than cognitive impairment. There is evidence to show that individuals with cognitive impairment are able to regain their mobility

- Ireland, J Rehab Med 2016
- In-hospital rehabilitation substantially increases total hospital costs. It is associated with improved early and late survival, but not with the likelihood of living independently for up to 2 years after hip fracture
- Burgers, PT, Osteoporosis Int
- The main cost determinants for hemi- or total hip arthroplasty after treatment of displaced femoral neck fractures (€26,399 per patient until 2 years) were rehabilitation and nursing homes.
- Cochrane review 2015
- **There is currently insufficient evidence to draw conclusions about how effective the models of enhanced rehabilitation and care after hip fracture used in these trials are for people with dementia above active usual care. The current evidence base derives from a small number of studies with quality limitations. This should be addressed as a research priority to determine the optimal strategies to improve outcomes for this growing population of patients**
- **ERAS after hip fracture**
 - Enhanced recovery after surgery
 - Consists of several techniques
 - Which matter and which are best?
 - Literature: Wainwright Ann RCSE 2016 Opportunity for ERAS for hip fx
 - Gap: What interventions should be done
 - **Few case reports**
 - **AHRQ study commencing now**
 - **Home health care vs. Rehab center**
 - **Where to discharge patients?**
 - **Big cost differences**
 - **Which gives best outcomes?**
 - **Literature:**
 - **Gap: no clear method is best, duration, setting are all open questions**
- **Readmission after Hip Fracture**
 - 14.5% Nationally
 - Varies by location (state) 7-20%- Dartmouth Atlas data
 - Some reports published
 - Is it preventable and how?
 - Literature: will be reviewed
 - Gap: Are there any strategies to avoid readmits?
 - Elkassabany et al, JAGS 2016: Better nurse staffing and higher case volumes are associated with lower rates of readmission and mortality after hip fracture surgery
 - Kates et al: Mortality 19.5% during readmission- Arch Orthop Trauma Surg 2014
 - Kates et al. Costs ~ 14500 / readmission 2014- GOSR

- Ali, et al, Injury 2017
- Patient-related risk factors such as age, co-morbidities and functional status are stronger predictors of 30-day readmission risk after hip fracture than hospital-related factors. Rates of 30-day readmission may not be a valid reflection of hospital performance
- No papers explain how to prevent them!