

Injury and Aging: Do Fractures in the Elderly Heal Differently?

Eric Meinberg, MD

Associate Professor

UCSF Department of Orthopaedic Surgery

UCSF/SFGH Orthopaedic Trauma Institute

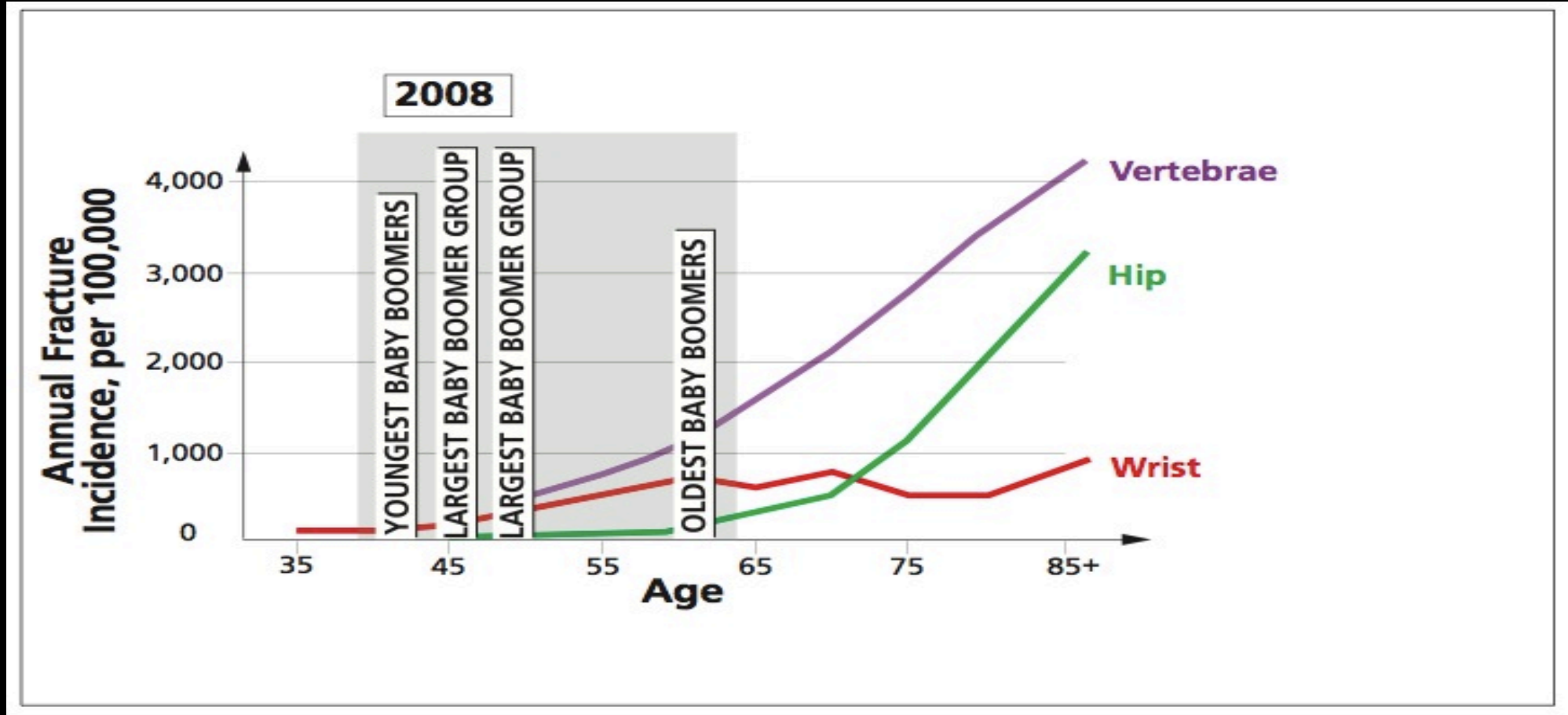
Are there differences seen
clinically?

The Issues

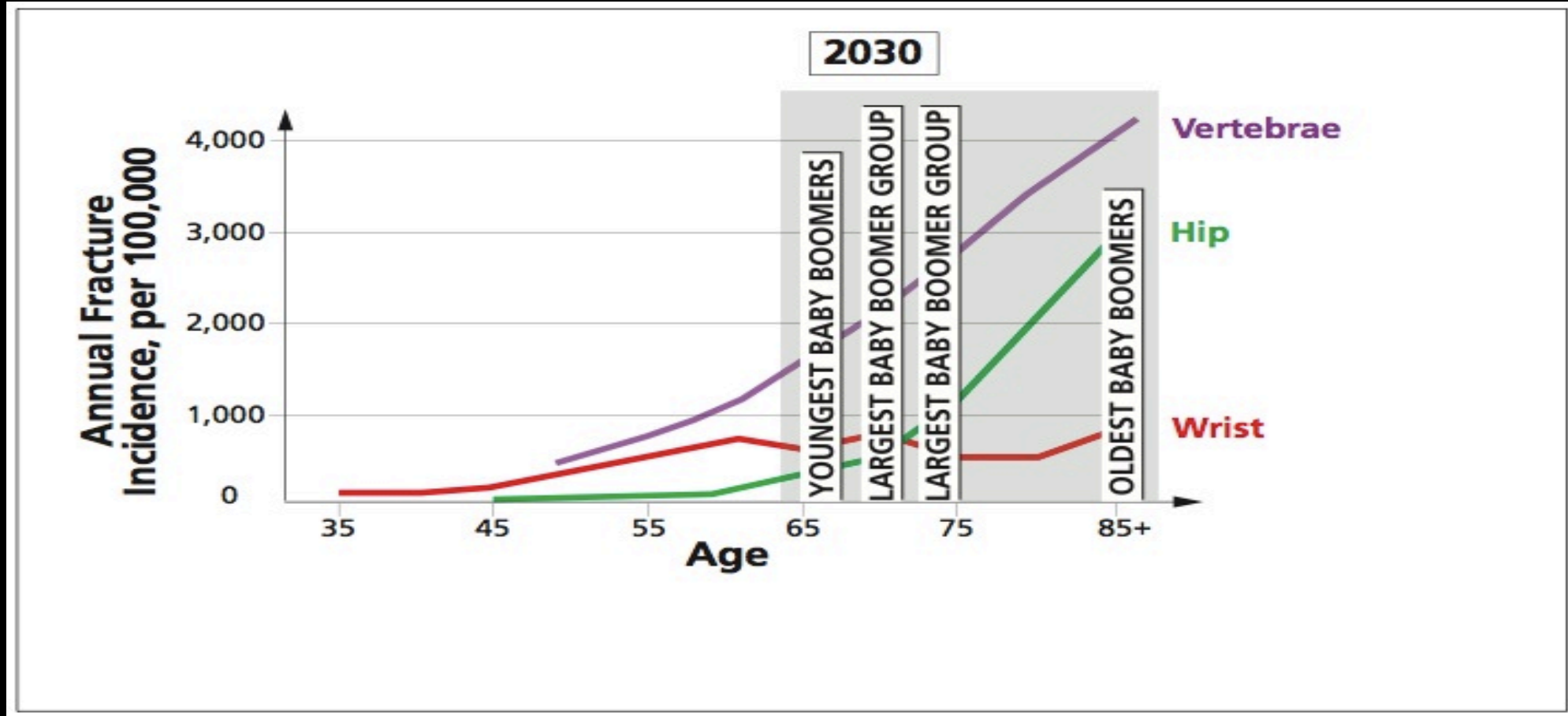
- Patients
 - 1.5 million osteoporosis fractures/year in the US
 - 90% of all women >75y have osteoporosis
 - 320,000 hospitalizations/year for hip fractures
 - 25% one-year mortality
 - 25% require nursing home placement
 - 53% of hip fracture patients >65y lose independence



The Issues



The Issues



The Challenge

“Appropriate evaluation and treatment of low energy (fragility) fractures is generally the exception, not the rule”

-Tosi, et al, JBJS 2008;90:163

Up to 50% reduction in risk of a second fragility fracture if treatment is initiated

Only 20% of patients with a previous fragility fracture receive treatment for osteoporosis

Osteoporosis

- = low bone mass with microarchitectural deterioration and microfractures
- Peak bone mass acquired by age 30
- WHO Definition
 - Normal: <1 SD from peak bone mass (T score < -1.0)
 - Low (osteopenia): -1.0 to -2.5
 - Osteoporosis: <-2.5
- Etiology
 - Multifactorial
 - Estrogen withdrawal
- Clinical presentation
 - Fracture following minor trauma
 - Low BMD

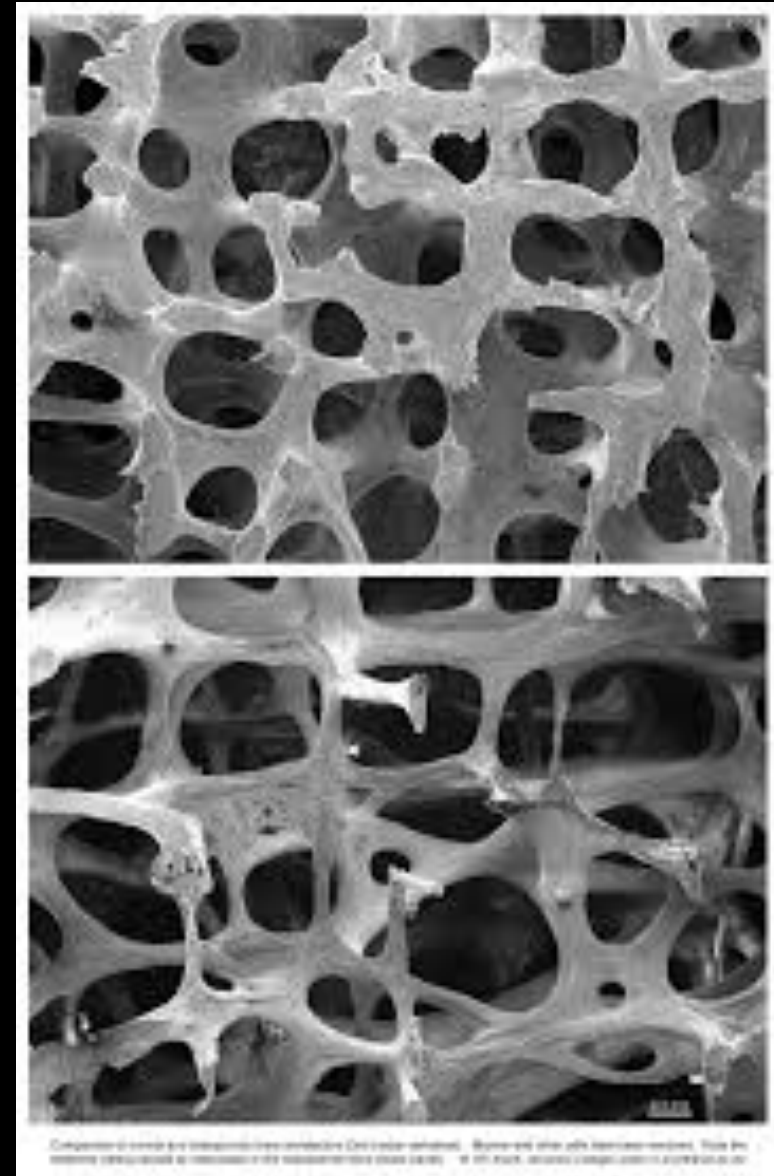
Osteoporosis

- Risk factors
 - Age
 - Female
 - Early menopause
 - Low body weight
 - Smoking, EtOH, steroids, low protein
 - Anticonvulsants



Osteoporosis

- Radiographic appearance
 - Osteopenia
 - Thinned cortices
 - Loss of trabecular bone
- Pathology
 - Loss of trabecular bone
 - Loss of continuity of trabecular bone (microfractures)



Diagnosis and Treatment

Osteoporosis Treatment Principles

- Prevention is most important
 - attainment of peak bone mass (age 20-30)
 - Prevention of postmenopausal resorption and age related bone loss
 - Calcium and Vitamin D
 - Bisphosphonates
 - Selective estrogen receptor modulators
 - Calcitonin
 - PTH

Future fracture risk

- Previous fracture increases future fracture risk regardless of bone density
 - 2x if T score > -1
 - 4x if T score < -1 but > 2.0
 - 8x if T score < 2.0
- With prior vertebral fracture
 - 5x greater chance of another vertebral fx
 - 2x greater chance of a hip fx

IT'S ALL ABOUT BONE QUALITY

- More than just bone mass
 - Mass plus distribution = strength
- Architecture
 - Trabecular and cortical bone
 - distribution and balance
- Structural integrity
 - Remodeling rate
 - Collagen structure (rigid or lax)



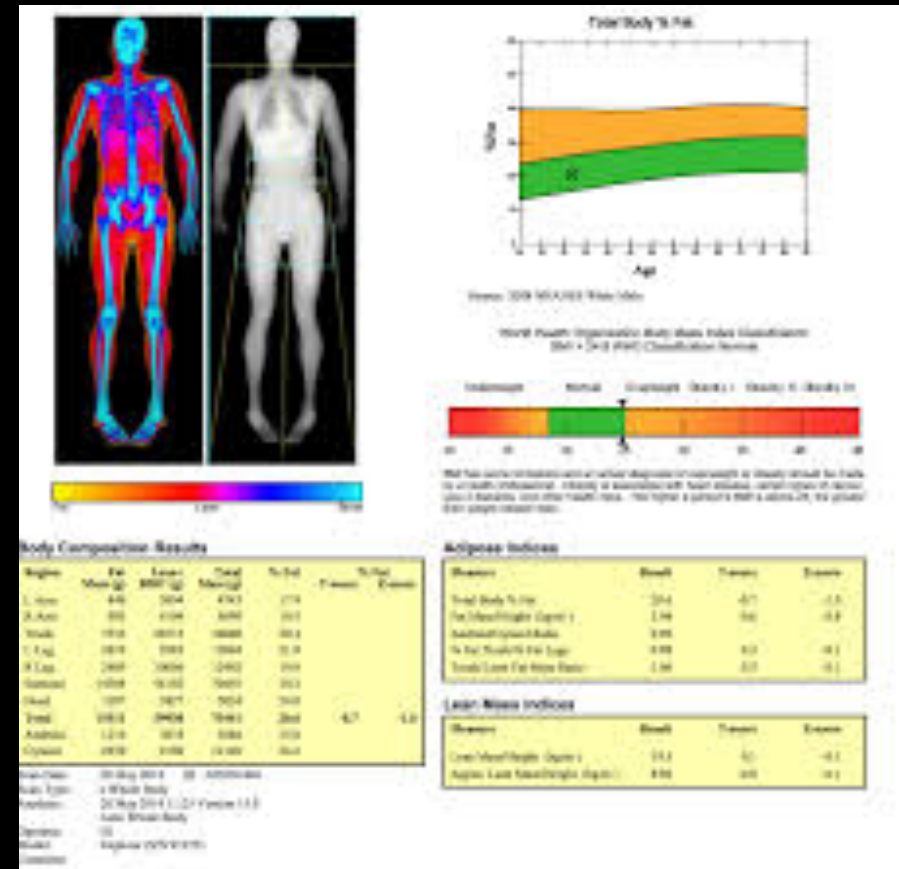
BMD Testing

- Recommended for:
 - Men >70
 - Women > 65 (<65 if risk factors)
 - Fragility fractures
 - Bone-losing medical treatment



DXA Scan

- Currently the standard for BMD assessment
- T score
 - Compares density relative to peak bone mass (Normal healthy 25 year old)
- Z score
 - Compares density to peers your same age
 - Use in people under age 25



FRAX

- Fracture risk calculation tool –
 - Can be used to help decide if treatment
 - HAVE NOT fractured yet
 - HAVE NOT been on prior treatment
 - accounts for other risk factors
 - treatment warranted if 10 year risk of hip fracture >3%, or of other osteoporotic fracture >20%
 - on line tool access: www.shef.ac.uk/FRAX/



Calculation Tool

Please answer the questions below to calculate the ten year probability of fracture with BMD.



Weight Conversion:

pound:

[convert](#)

125 pound = 56.7 kg

Height Conversion:

inch:

[convert](#)

65 inch = 165.1 cm

Country : **US (Caucasian)** Name / ID :

[About the risk factors](#)

Questionnaire:

1. Age (between 40-90 years) or Date of birth

Age: Date of birth: Y: M: D:

2. Sex Male Female

3. Weight (kg)

4. Height (cm)

5. Previous fracture No Yes

6. Parent fractured hip No Yes

7. Current smoking No Yes

8. Glucocorticoids No Yes

9. Rheumatoid arthritis No Yes

10. Secondary osteoporosis No Yes

11. Alcohol 3 or more units per day No Yes

12. Femoral neck BMD (g/cm²)

Select DXA

[Clear](#)

[Calculate](#)

BMI 20.8

The ten year probability of fracture (%)

without BMD

Major osteoporotic **20**

Hip fracture **3.4**

Now what?

How do we initiate treatment?

Universal Recommendations

- Avoid Tobacco
- Limit Alcohol
- Prescribe exercise for muscle strengthening and balance (PT/OT)
- Falls Prevention Program



Exercise

- Weight bearing exercise
 - Especially important in kids and young adults
 - In older adults it helps to slow down bone loss
- Tai Chi
 - Helps with strength and balance
 - Shown to help in fall prevention and coordination in elderly



Exercise

- NO CRUNCHES/ SIT-UPS
- No overhead lifting
- Extension type exercises
- Bend at hip instead of waist
- Less than 10 lbs carried in the hand
- Less than 25 lbs carried close to the chest
- Gliding exercises



Diet

- Bone first source for calcium
- Dietary requirement varies with age
- Most Americans short 500mg calcium daily
- Vitamin D is also **VERY IMPORTANT** for good bone health



DAILY CALCIUM REQUIREMENTS

- Child 700 Mg
- Teen - Young Adult 1300 Mg
- Adult 1000 Mg
- Pregnancy 1500 Mg
- Lactation 2000 Mg
- Post Menopausal 1500 Mg
- Major Fracture 1500 mg

Calcium sources

• Milk (8oz, skim)	302mg
• Nonfat yogurt (8 oz)	452mg
• Frozen yogurt (1/2 cup)	90mg
• Cottage cheese (1 cup)	155mg
• Collard greens (1 cup)	357mg
• Broccoli (1 cup)	178mg
• Cheese pizza (1 slice)	290mg
• Vanilla ice cream (1/2 cup)	85mg
• Calcium fortified orange juice(1 cup)	300mg

Calcium Supplements

- Calcium carbonate (Oscal, Caltrate, Viactiv, TUMS)
 - Highest concentration of calcium
 - Needs acid environment to dissolve
 - Beware elderly (>age 70), H2 blockers
- Calcium citrate (Citrical)
 - Dissolves in absence of acid
 - Increased risk of kidney stones in some patients (<10% get citrate stones)

Provocative Findings about Vit D

- Appears to play a role in disease susceptibility
 - Breast cancer
 - Prostate cancer
 - Sarcoid
 - Inflammatory bowel disease
 - Lymphoproliferative disorders
 - Multiple sclerosis
- Appears to play a role in body's ability to fight disease
 - Importance of Vit D for dendritic cell function
 - Ability to kill tuberculosis mycobacterium

Provocative Findings about VitD

- Sun exposure to maintain adequate levels
 - 20 minutes to hands and face daily
- SPF 8 sunscreen blocks 95% of Vit D production
- Above 35 N latitude (Atlanta)
 - cannot make Vit D in skin between Nov-Feb



Vitamin D

- 25-OH Vit D levels
 - best indicator of nutritional Vit D status
- 25-OH Vit D substrate for conversion to 1,25-OH Vit D
 - Approx 85% of Vit D is metabolized outside of the kidney
 - Nervous system
 - Muscle
 - Immune system
 - Skeletal system (osteoblasts)

Vitamin D

- Levels <15ng/ml (Deficiency)
 - Rickets/osteomalacia
 - secondary hyperparathyroidism
- Levels < 32ng/ml (insufficiency)
 - Increased muscle weakness
 - Balance difficulties
 - Increased osteoporosis rates
 - May have secondary hyperparathyroidism
 - immune system response
 - deleterious effects at levels <40ng/ml

Vitamin D

- “New Normals”
 - Range now 32ng/ml to 100ng/ml
 - Considered physiologically adequate range
- Physiologic normal production
 - Up to 10,000 IU -25,000 IU daily
 - No signs of toxicity at 120ng/ml levels
 - Career lifeguards have levels in the low 200’s with no problems

Vitamin D Supplementation

- Several methods, similar goals
 - Vit D2 or Vit D3
- Certainly goal to get levels above 32ng/ml
 - We often aim for levels above the edge of insufficiency
 - 45-55ng/ml at the end of supplementation at minimum
 - Ability to maintain above 40ng/ml

Vitamin D Supplementation

- Vit D₃ (cholecalciferol)
 - What we produce in our skin
 - Available as supplements
 - Slower initial response (up to 4-6 months to correct)
 - Better long term stability
- Vit D₂ (ergocalciferol)
 - Plant derived
 - Excellent initial response but tails off to 20% efficiency of absorption at about 6 months

Vitamin D Supplementation

- Using Vitamin D3
 - Extra 1000 IU to 2000 IU daily
 - Continue current calcium and vitamins
 - Treatment of 6 months to catch up
 - Better for long term maintenance

Vitamin D Supplementation

Example replacement protocol for post fracture patients who are Vitamin D deficient:

25 OH Vit D level	Treatment with D ₂
20-30 ng/ml	50,000 IU once weekly
10-20 ng/ml	50,000 IU twice weekly
<10ng/ml	50,000 IU three times weekly

Total treatment time of 8 weeks, start 1000IU Vit D₃ daily, and then recheck levels in 3-6 months

Treatment

- Treatment
 - Antiresorptive therapy
 - Bisphosphonates
 - Apoptosis of osteoclasts
 - Prevent farnesyl pyrophosphate
 - Disrupt ruffled border of osteoclasts
 - Side effects
 - Osteonecrosis of jaw
 - Atypical subtrochanteric femoral stress fractures

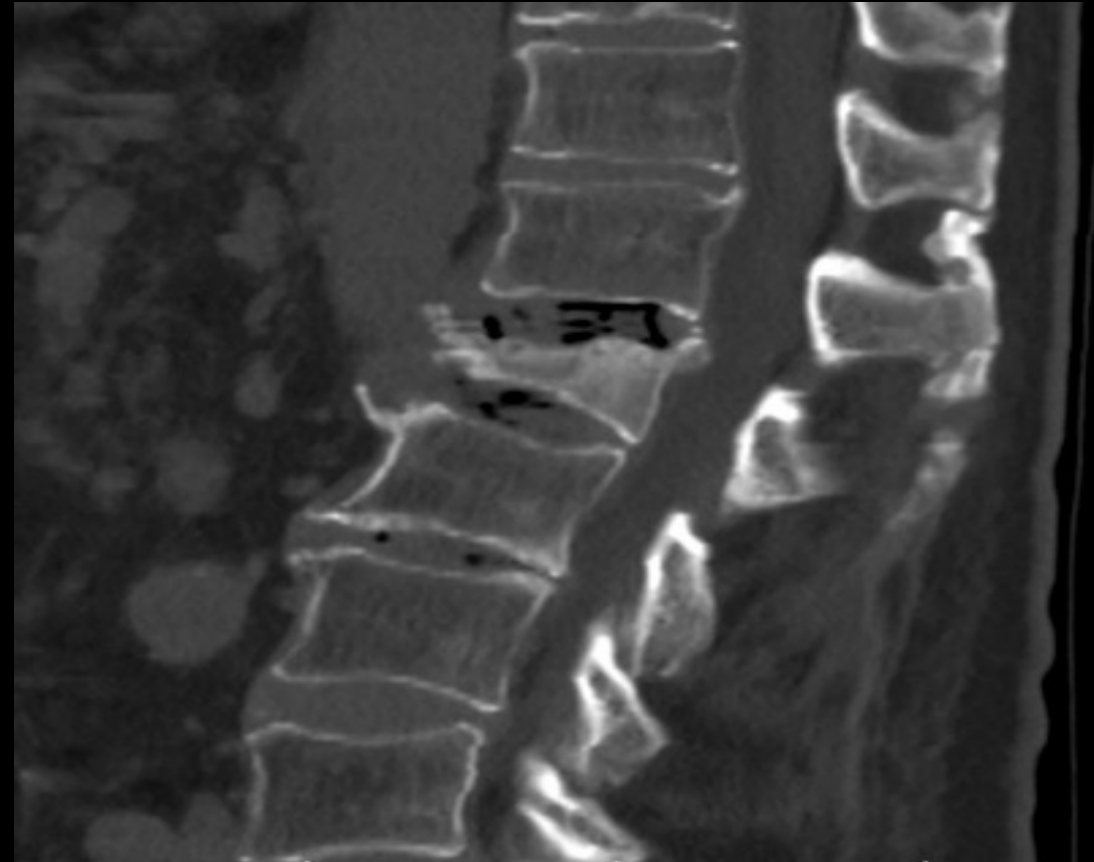
Treatment

- Denosumab (Prolia, Xgeva)
 - RANKL antibody
 - Prevents osteoclast formation temporarily (2m)
 - Decreases fracture risk, decreases fracture complications by 70%, and decreases healing time by 50%
 -
- Teriparatide (PTH) (Forteo)
 - Intermittent low-dose PTH is anabolic to bone
 - Indicated for T-score <3.0
 - Maximum duration of use is 2y
 - Likely acts on osteoblast differentiation, function and survival
 - Mild hypercalcemia
 - Contraindicated in Paget's, children, prior irradiation

Specific Fractures

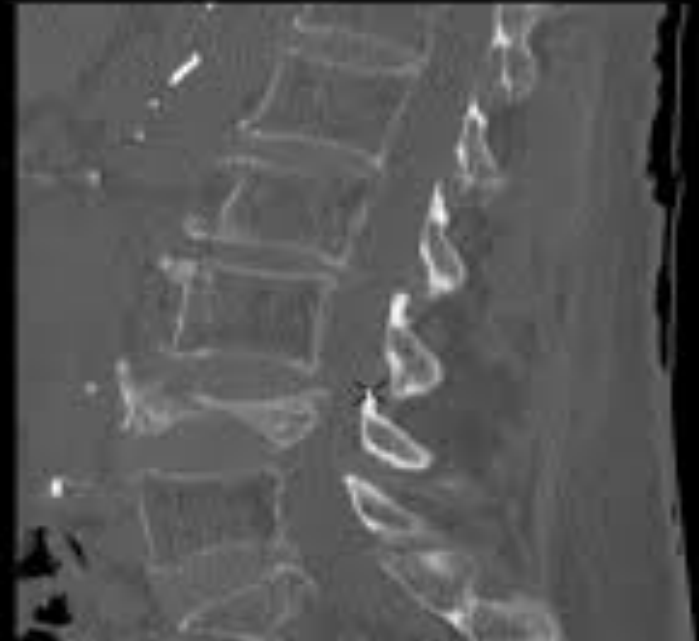
Vertebral Compression Fractures

- Epidemiology
 - Incidence increasing
 - Occur in 20% of people over age 70 (700k fx/yr)
- Treatment
 - Most respond to bracing



Vertebral Compression Fractures

- Open treatment
 - Associated kyphosis or retropulsion causing neuro deficit
 - Requires additional points of fixation, longer constructs, sublaminar wiring, larger pedicle screws, cement augmentation



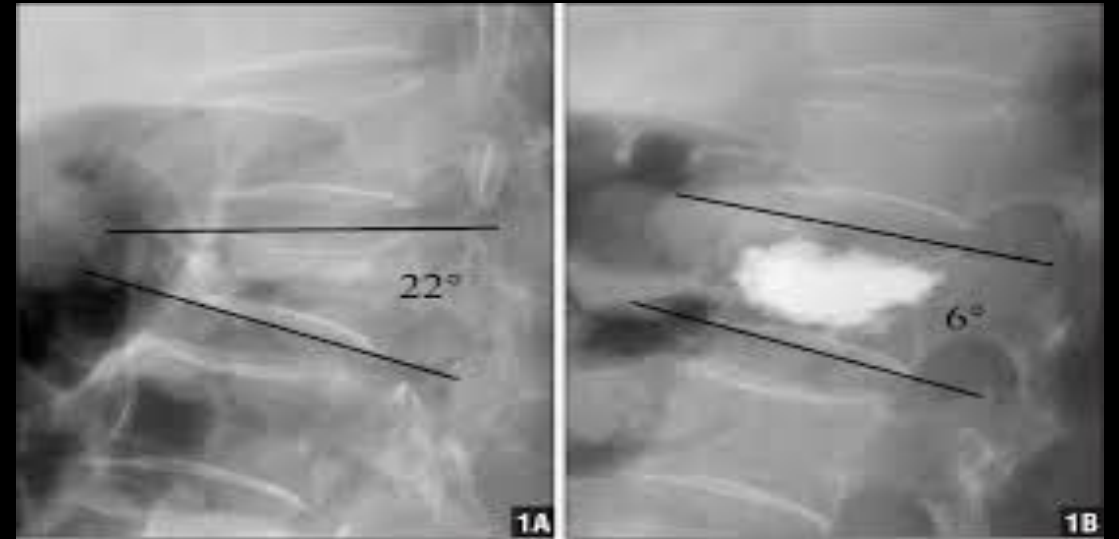
Vertebral Compression Fractures

- Vertebroplasty
 - Percutaneous transpedicular injection of PMMA to decrease pain and stabilize vertebra



Vertebral Compression Fractures

- Kyphoplasty
 - Balloon tamp to create a void to prevent extravasation and partially restore vertebral height (30-50% restoration, 14 degree reduction in kyphosis)
 - No proven clinical benefit
 - Contra-indicated in burst fractures (extravasation)



Proximal Femur Fractures

“The Unsolved Fracture”

“For more than a century its treatment and the results have been a matter of controversy and inquiry among surgeons; and although the results obtained today show improvement, they are not at all comparable to those of other fractures”

-Speed K, *Surg Gyn Obstet* 60:341, 1935

Issues

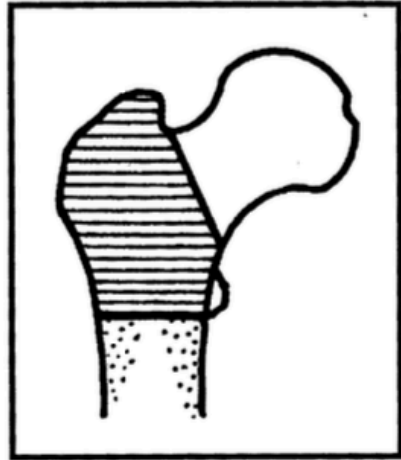
- 700,000 hospital admissions for hip fractures *per year* expected in the U.S. by 2050
- One year mortality between 14 – 36%
- Small percentage occurs in young

- Stable fixation, early mobilization, and prevention of complications are essential in patient's outcome

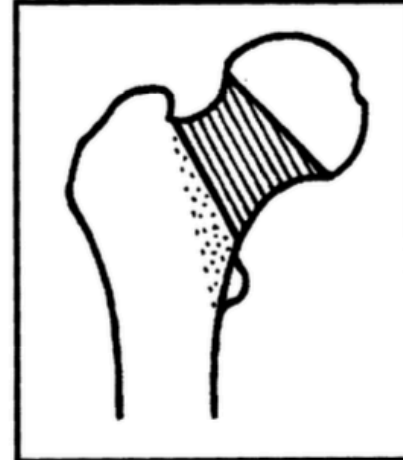
Femoral Neck vs. Intertrochanteric Fractures

Types:

A. Trochanteric area (31-A)



B. Neck fractures (31-B)



Femoral Neck vs. Intertrochanteric Fractures

- Femoral Neck Fx

- Intracapsular fracture
- No blood clot or callus
- Poor blood supply
- Poor bone quality
- Poor stability for fixation

- Intertrochanteric Fx

- Extracapsular
- Soft tissue envelope protects blood clot and callus
- Improved bone quality
- Intrinsic stability
- Reliable bony healing

Femoral Neck Fractures

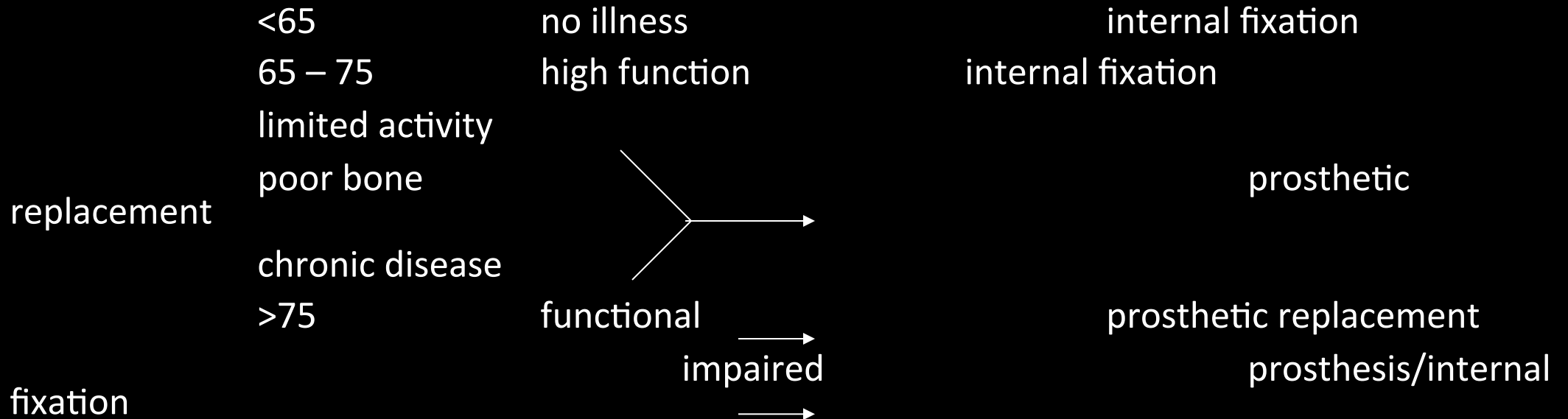
Treatment Algorithm

Swiontkowski MF, JBJS 76-A:129, 1994

Undisplaced Fractures

percutaneous pinning

Displaced Fractures



Treatment Principle

- Goals of treatment
 - Stable reconstruction of fracture
 - Minimal complications
 - ***Serviceable hip for life of patient***

Young Patients

Superior fx fixation

Better tolerance of slow rehab

Limited life-span of THA

ORIF (hip conservation)

Elderly Patients

Poor bone quality

Immediate mobilization

May not tolerate reoperation

Arthroplasty

Treatment Considerations

- How much surgery can the patient tolerate?
- Can the patient tolerate reoperation?
- Can the patient's health be improved at a later time?
- We must individualize the treatment plan for each patient

Nonoperative Management

- High risk of perioperative complications
- Nonambulatory
- Comfortable
- Severe dementia
- Up to 90% 1 year mortality



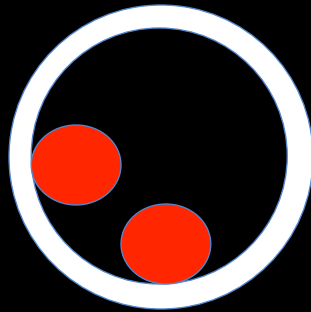
Internal Fixation

- Treatment similar to young patients
 - Multiple cannulated screws
 - Sliding hip screw
- Surgical technique is paramount due to poor bone quality

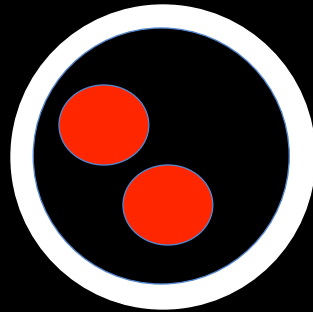


Percutaneous Screw Fixation

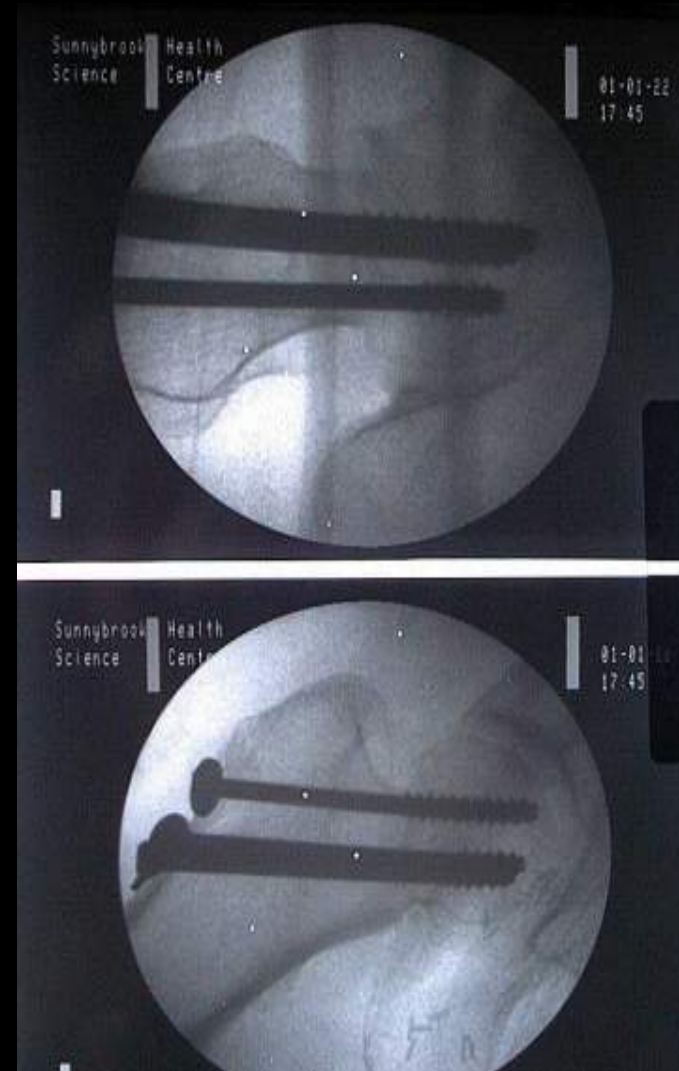
- Proper reduction and screw placement very important!



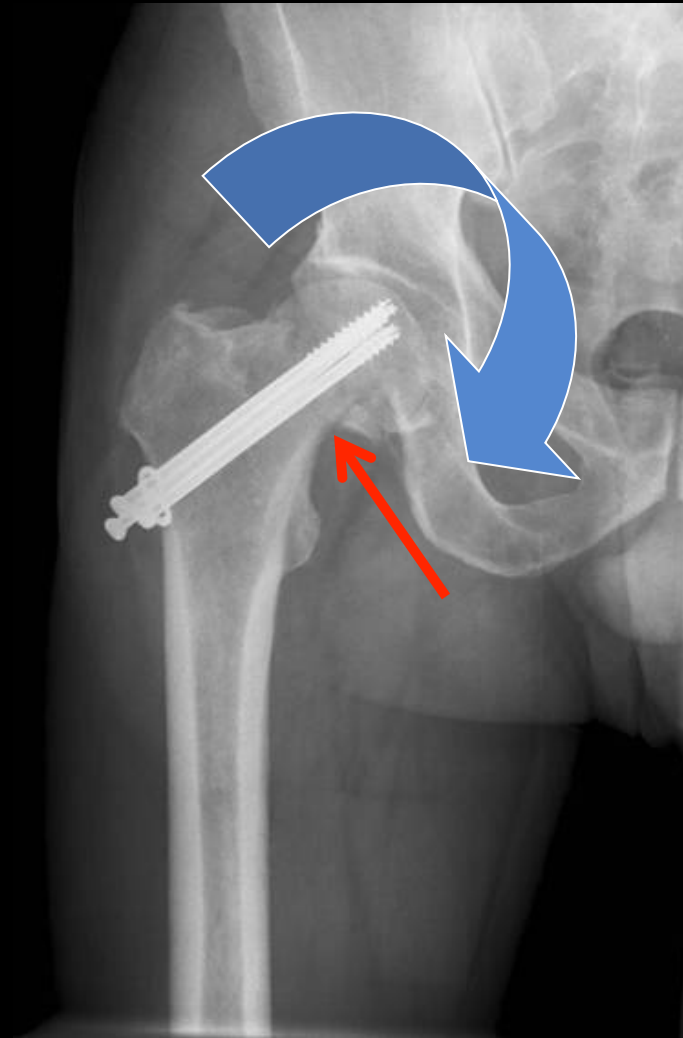
89% union rate



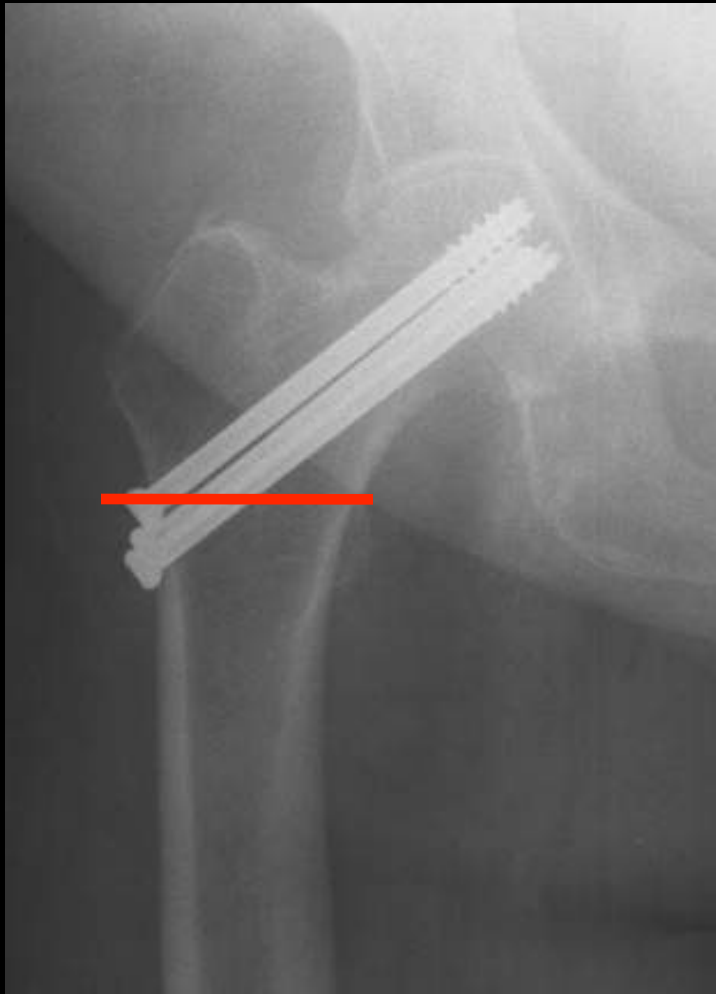
100% failure



Proper Screw Placement

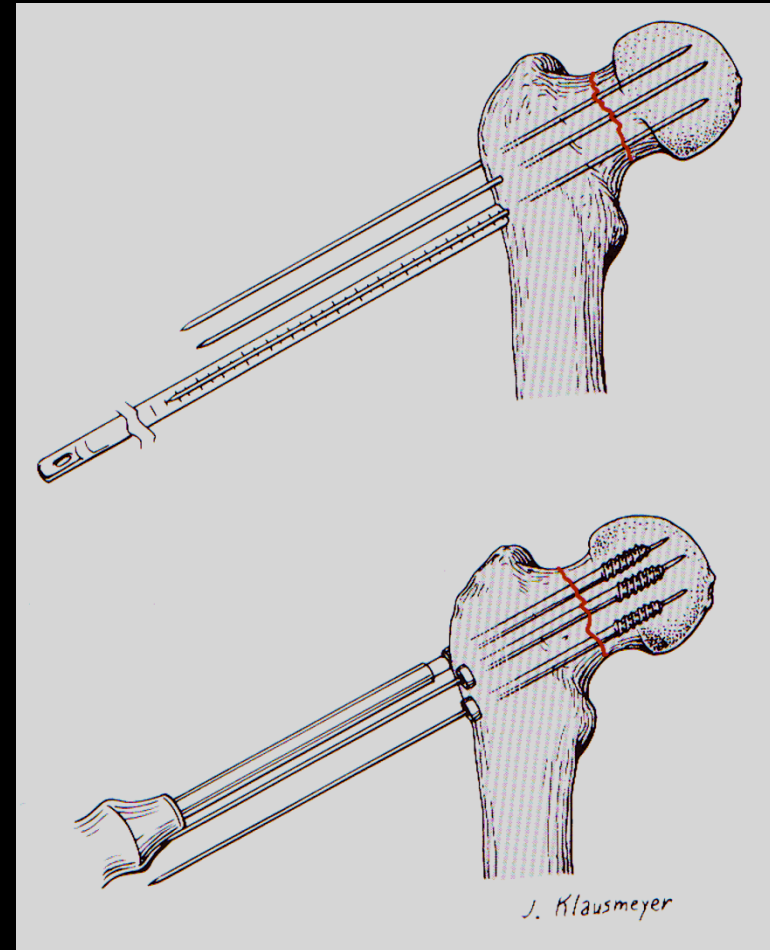


Proper Starting Site



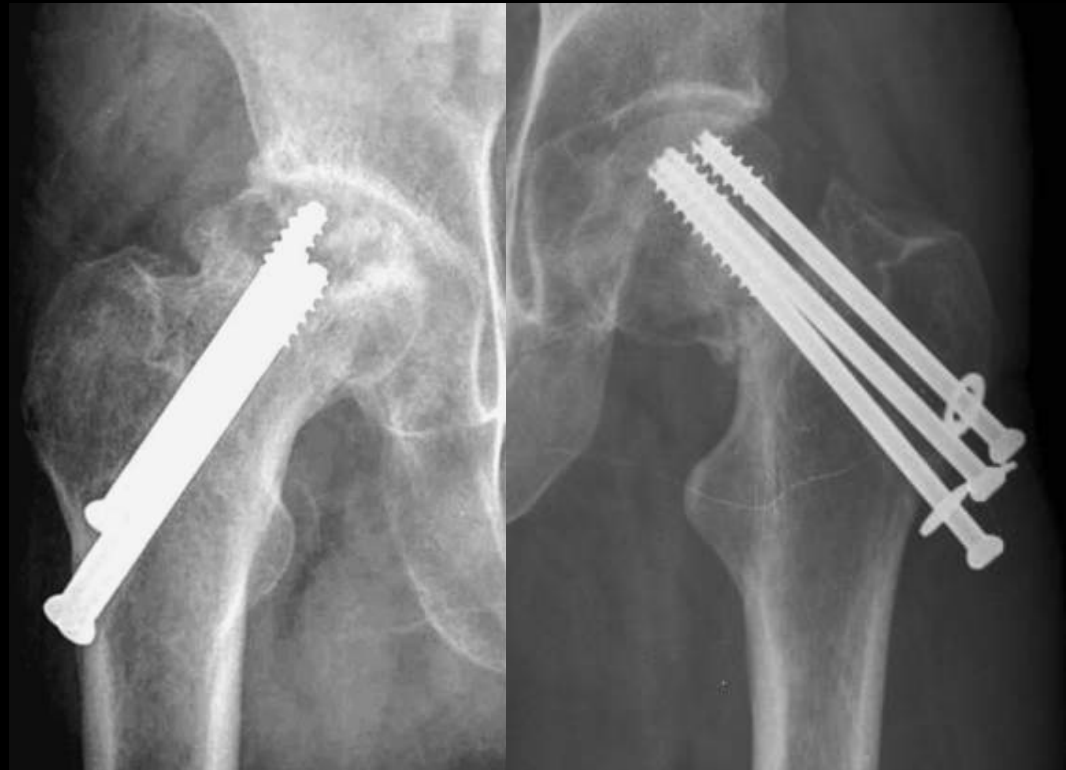
Advantages of Fixation

- Decreased blood loss
- Decreased operative time
- Decreased infection rate



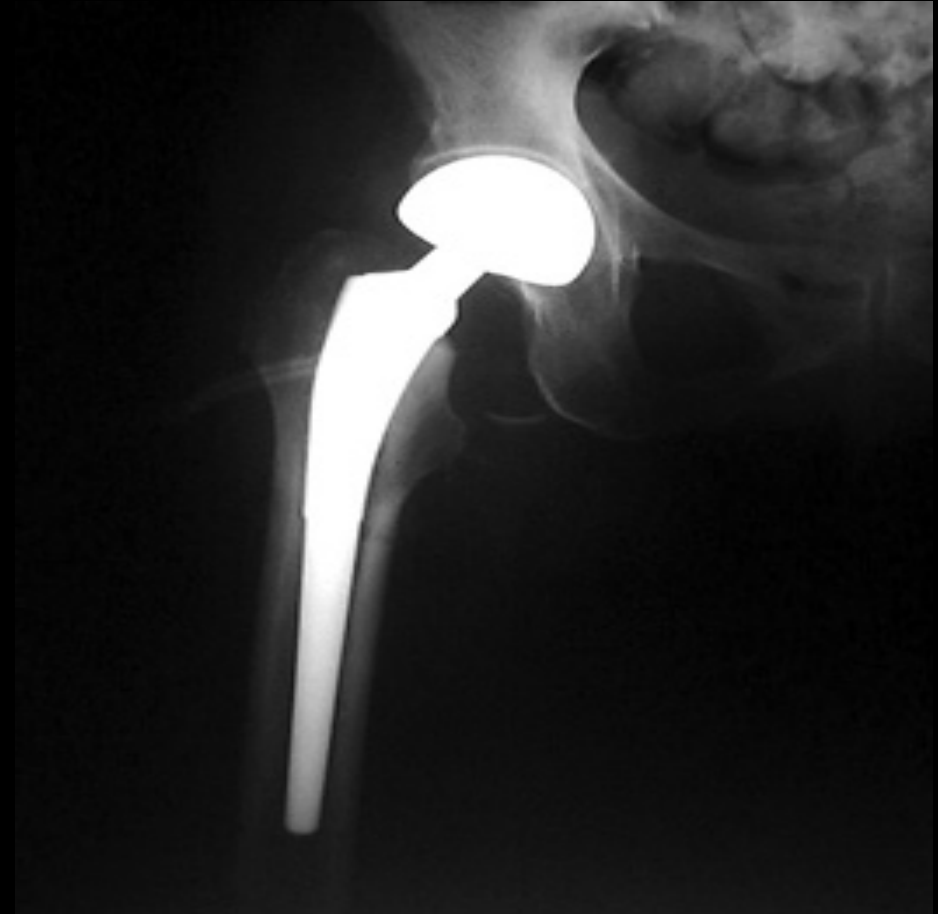
Disadvantages of Fixation

- Higher reoperation rate (40%)
- Loss of fixation 9 – 30%
 - Varus malreduction
 - Poor screw position
- Screw cut-out
 - Up to 20%
 - Slightly lower with SHS
- AVN in up to 16%
- Nonunion in up to 33%



Hemiarthroplasty

- Reliable method of treatment
- Immediate mobilization of patient
- Slightly higher blood loss and operative time
- Reoperation rate 5%



Total Hip Arthroplasty

- Patients with OA/RA
- Historically not favored
 - Poorer outcomes
 - Higher dislocation rate
- Modern studies show results equal to 1° THA
- Slightly higher complication rate than hemiarthroplasty
 - Dislocation 1 – 7%
 - Approach and technique dependent
- Cost effective
- **Must be comfortable performing THA!**

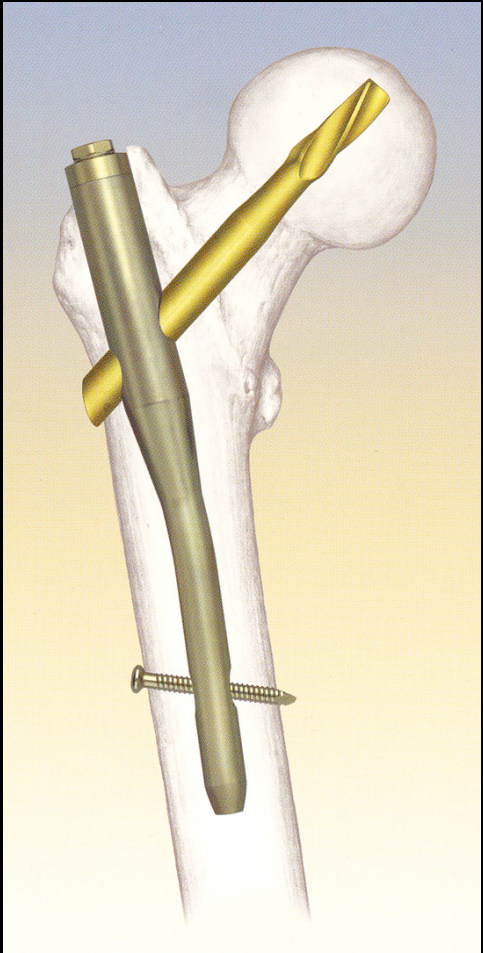
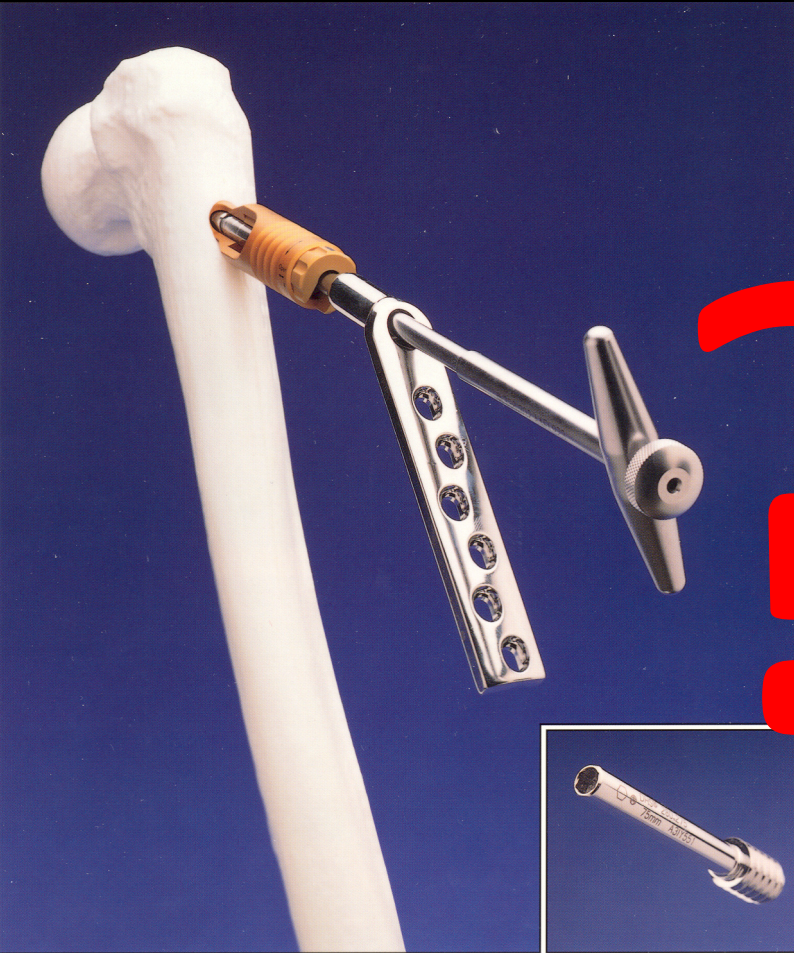


Intertrochanteric Fractures

Treatment Options

- Non-operative management
 - Reserved only for extreme surgical and anesthesia risks
 - 35% mortality
- Sliding compression screw
- Intramedullary hip screw
- Proximal femoral locking plates
- Arthroplasty

SHS or Nail?

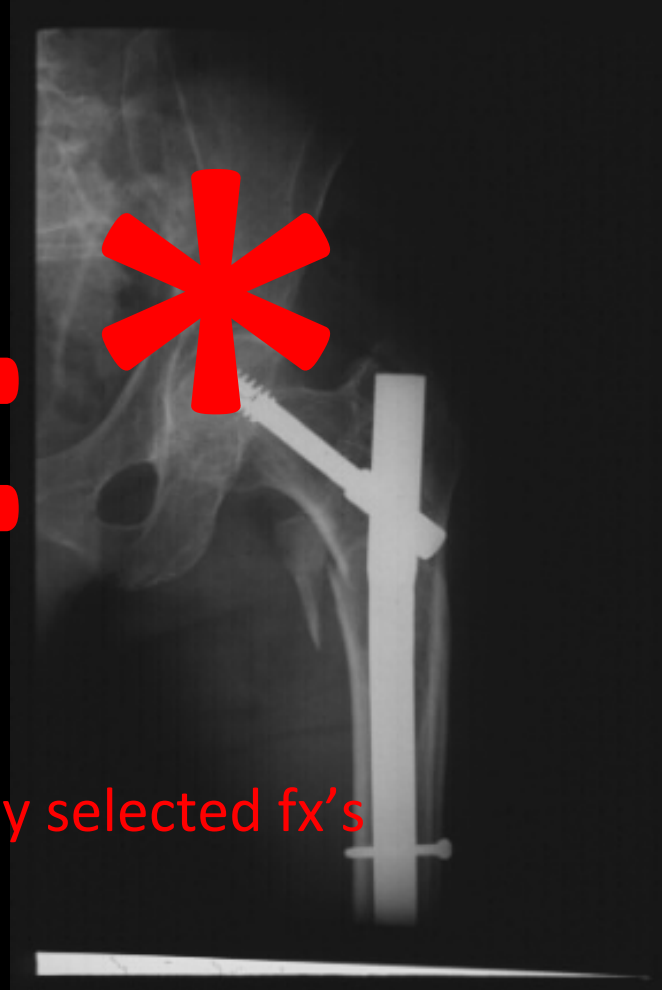
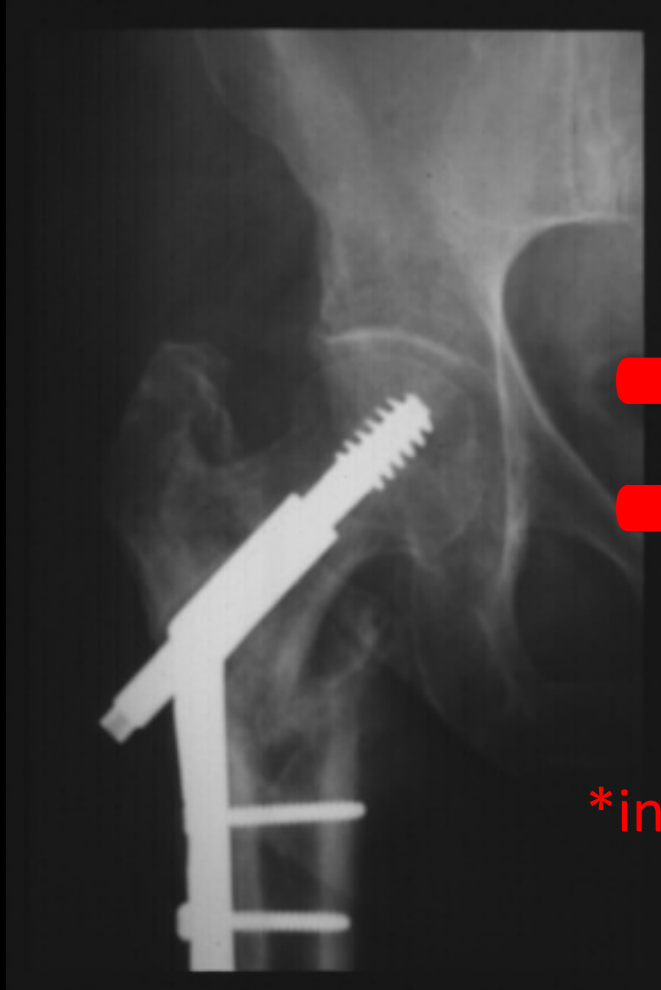


SHS or Nail?

Anglen, et al, JBJS 90A, 2008

- Review of patient outcomes submitted for ABOS part II between 1999 and 2006
- Surgeon-reported pain, deformity, outcome, function, satisfaction, and complications
- Between 1999 and 2006:
 - IM nail use increased from 3% to 67%
 - Plate fixation had slightly less pain and deformity
 - No differences in function or satisfaction
 - Nails had more complications, especially bone fractures

SHS or Nail?



*in properly selected fx's

Bisphosphonate-related femur fractures

Bisphosphonate-related Fractures

- 2005: First reports of atypical fractures reported



Bisphosphonate-related Fractures

- 2005: First reports of atypical fractures reported
- Minimal trauma



Bisphosphonate-related Fractures

- 2005: First reports of atypical fractures reported
- Minimal trauma
- Transverse subtrochanteric fracture, cortical thickening, beaking



Bisphosphonate-related Fractures

- 2005: First reports of atypical fractures reported
- Minimal trauma
- Transverse subtrochanteric fracture, cortical thickening, beaking
- 9 women treated of avg. 5 years



Koh SK, Yang KY, et al., JBJS-B 89(3) 2007

Risk of Fracture Increases with Treatment

Two years of use:
2/100,000

Risk of Fracture Increases with Treatment

Two years of use:
2/100,000

Eight years of use:
78/100,000

Risk of Fracture Increases with Treatment

Two years of use:
2/100,000

Eight years of use:
78/100,000

Risk of typical hip fracture
1021/100,000 untreated
697/100,000 treated

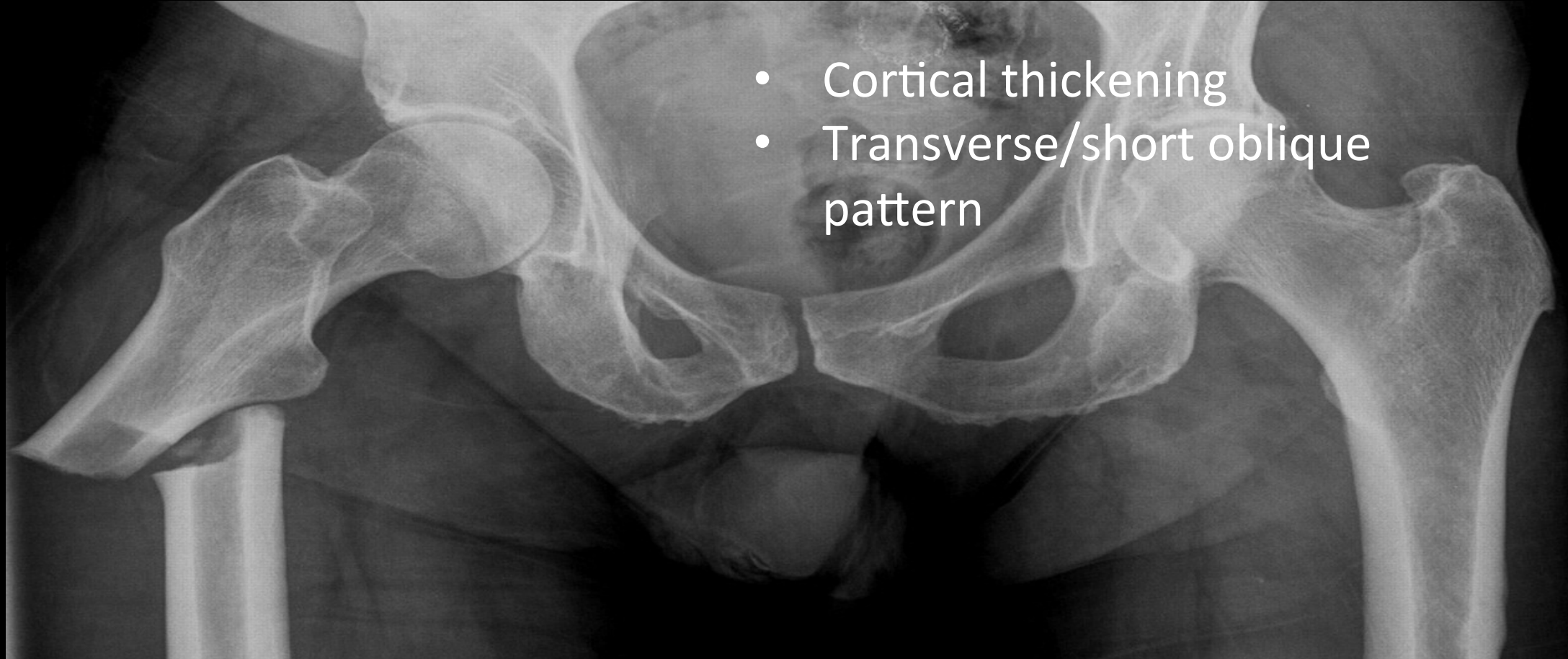
Telltale appearance



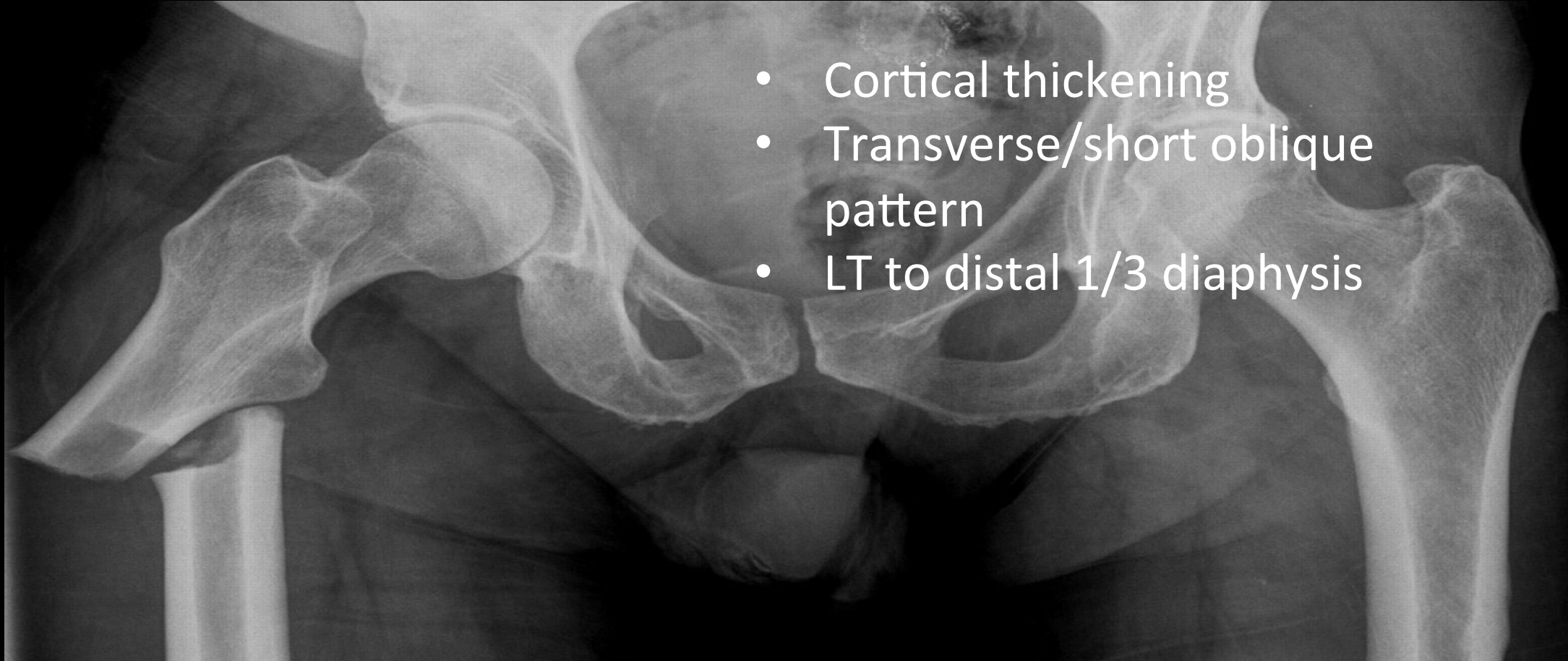
Telltale appearance



Telltale appearance

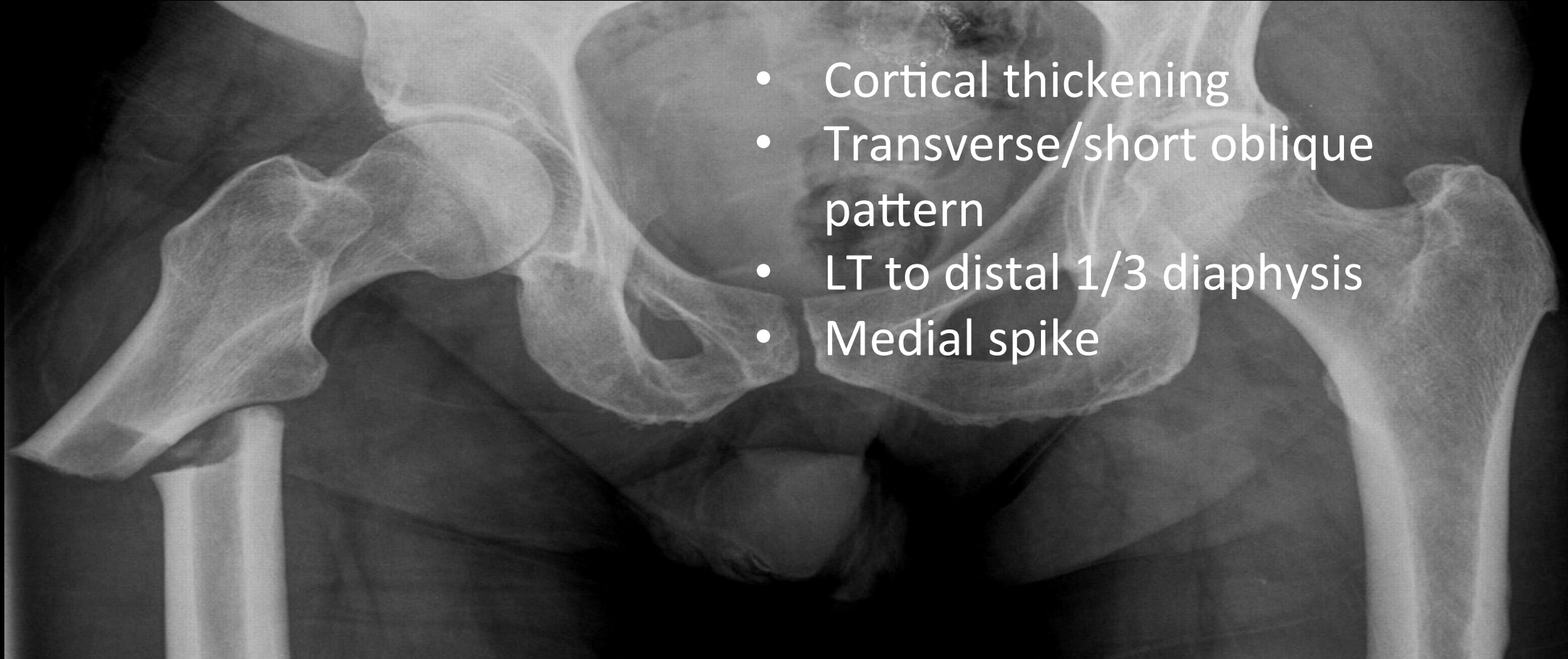


Telltale appearance



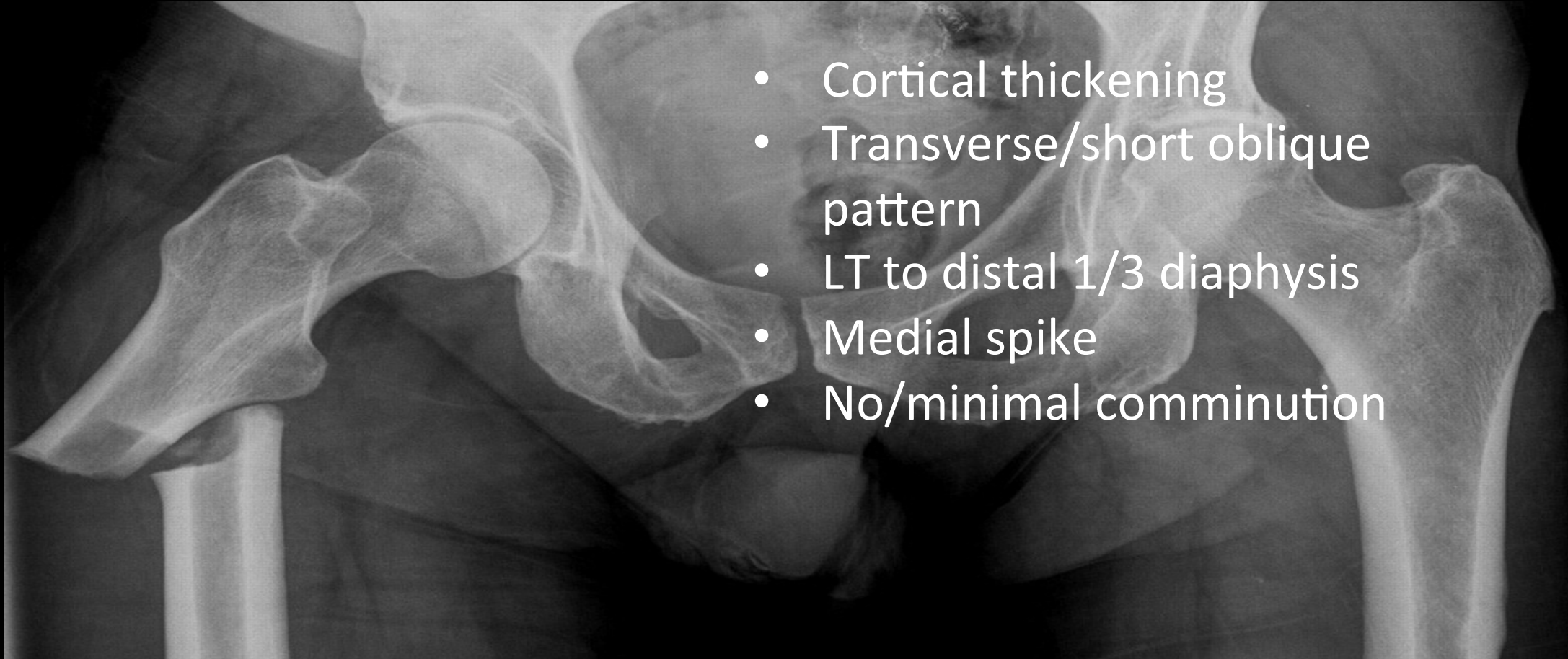
- Cortical thickening
- Transverse/short oblique pattern
- LT to distal 1/3 diaphysis

Telltale appearance



- Cortical thickening
- Transverse/short oblique pattern
- LT to distal 1/3 diaphysis
- Medial spike

Telltale appearance



- Cortical thickening
- Transverse/short oblique pattern
- LT to distal 1/3 diaphysis
- Medial spike
- No/minimal comminution

Associated Risk Factors

TABLE II Prevalence of Factors Shown To Be Associated with Atypical Femoral Fractures^{15,22,29}

Associated Factor	Prevalence* (%)
Asian descent	32.6 to 50.0
Bilateral fractures	28 to 44.2
Prodromal pain	63.6 to 70
Concomitant glucocorticoids	34
Concomitant proton pump inhibitors	39
Delayed fracture-healing	26 to 38.8

*According to previously published studies.

Unnanuntana A, et al., JBJS 95-A (2) e8(1-12), 2013.

From: Atypical subtrochanteric and diaphyseal femoral fractures: report of a task force of the American Society for Bone and Mineral Research. J Bone Miner Res. 2010 Nov;25(11):2267-94.



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20

Impact of Femoral Morphology



- Cortical and medullary bowing increases with age
- Significant increase in bowing in females

Harma A, et al., Surg Radiol Anat 27(6), 2005

- Loss of cross sectional area, increase in anterior bow in women

Karakas HM, Harma A, Diagn Interv Radiol 14(1), 2008

Impact of Femoral Morphology



Triple Whammy!

Impact of Femoral Morphology



Triple Whammy!

- Poorer bone quality
- Exacerbation of deforming forces
- Slower healing due to bisphosphonates

Implications of Bisphosphonates on Fracture Healing

- Slower healing and longer clinical recovery
 - 179 patients treated at 17 centers
 - Average union 5.2 months
 - 12% revision rate
 - +/-10% IMN
 - +/-20% plate

Treatment Options

- Nonoperative results are poor
 - Operative vs. nonoperative

Operative

100% union rate

71% pain resolution

Nonoperative

18% union rate

64% pain resolution

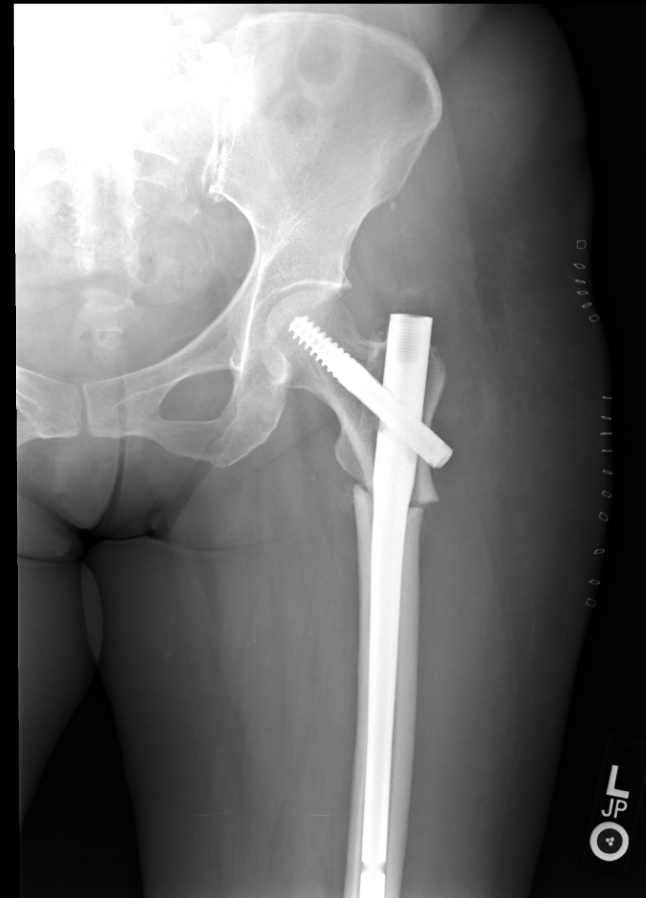
Egel KA, et al., J Orthop Trauma 27(6), 2013

- 5/11 patients with incomplete fx failed within 10 m.

Ha YC, et al., Clin Orthop Relat Res 468(12), 2010

Treatment Options

- Intramedullary nail
 - Antegrade/retrograde
 - Reconstruction
 - Cephalomedullary
- Superior results
- Load-sharing
- Biomechanically robust
- Early weight-bearing



Bisphosphonate holiday

- If fracture, stop bisphosphonates!

Bisphosphonate holiday

- If fracture, stop bisphosphonates!
- Therapeutic pause after 3-5 years
 - Low risk patients (no fracture)
 - Moderate risk (recent fragility fx)

Bisphosphonate holiday

- If fracture, stop bisphosphonates!
- Therapeutic pause after 3-5 years
 - Low risk patients (no fracture)
 - Moderate risk (recent fragility fx)
- High risk patients continue use
 - Glucocorticosteroids, high turnover

Co-managed Care: The BEST for
effective treatment

Low volume community hospital

- Probably best to have standard order sets
- Standard care pathway
- Agreed upon consultative model for care
- Early surgery
- Appropriately manage discharges



Co-management program at UCSF

- Completely co-managed care is the best model if resources are available to support it
- Availability of medical and surgical leadership
- Operating room availability
- Surgeons willing to participate appropriately
- Develop hip fracture program scorecard
- Team should focus on continuous quality improvement
- Program certification



Trauma Center: High volume of hip fractures

- Completely co-managed model is appropriate
- Standard order sets
- Standard protocols in care pathways
- Agreed upon early surgery in trauma room
- Anesthesia Buy in
- Develop appropriate discharge plans with social work and hospital care management team
- Collect and study outcomes
- Get program certified and remain certified



Average Charlson Score @ Highland Hospital, Rochester, NY

- Over 800 patients in 4 years
 - Average age ~85 years

Average Charlson Score ~3

Predicted 52% one year mortality

Average Charlson Score @ Highland Hospital, Rochester, NY

- Over 800 patients in 4 years
 - Average age ~85 years

Average Charlson Score ~3

Predicted 52% one year mortality

Actual mortality - ~20%

University of Rochester Model Results

Length of stay ~ 4.1 days

Re-admission rate ~10.3%

7% medical, 3% surgical

Hospital mortality rate <2.8%

Charges: 45% of US average

Costs: 66% of US average*

The UCSF Protocol

- Daily hip fracture rounds with orthopaedics, geriatrics, case management, PT/OT, nursing
- Standard labs and antibiotics
- Lovenox x 4 weeks
- Bone health labs
- Delirium orders
- PT/OT begins POD#1
- **D/C home POD#2**
- **Scheduled f/u with ortho, primary care and skeletal health**

Thank you!



ZUCKERBERG
SAN FRANCISCO GENERAL
Hospital and Trauma Center