

# Femoral Neck Fractures

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Original Authors:

Brian Boyer, MD; March 2004  
Steven A. Olson, MD; March 2006  
James C. Krieg, MD; May 2011

Revised: March 2016

# Epidemiology

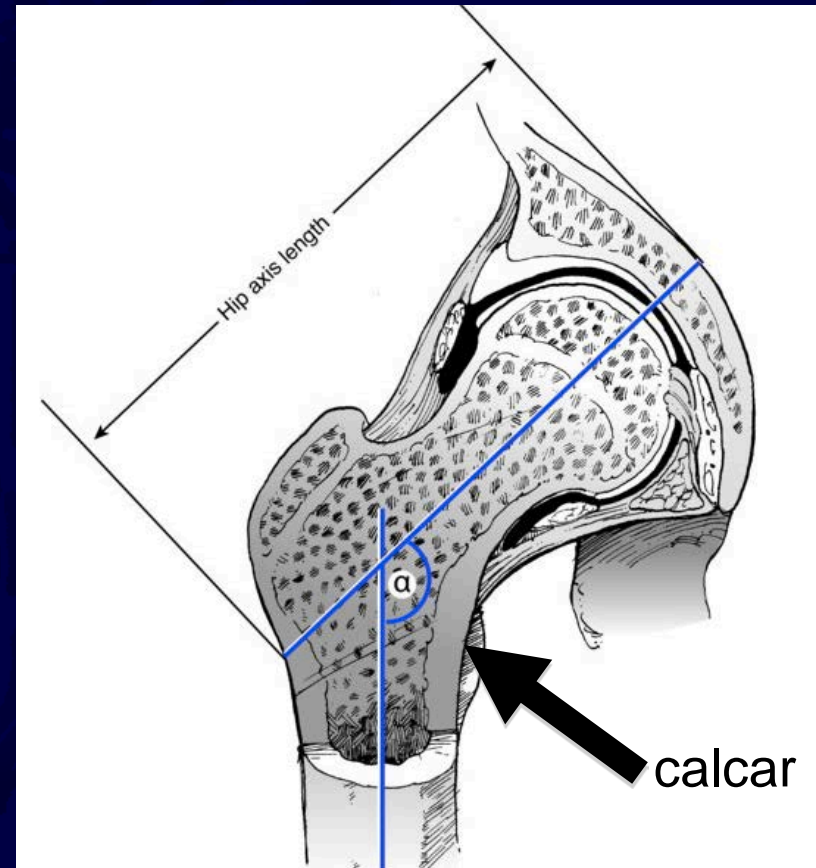
- > 300,000 Hip fractures annually in the US
  - Accounts for 30% of all hospitalizations
  - Expected to surpass 6 million annually worldwide by 2050
- Significant morbidity, mortality, expense
  - \$10-15 billion/year in the US

# Epidemiology: Bimodal Distribution

- Elderly
  - incidence doubles each decade beyond age 50
  - higher in caucasians
  - smokers, lower BMI, excessive caffeine & ETOH
- Young
  - high energy trauma

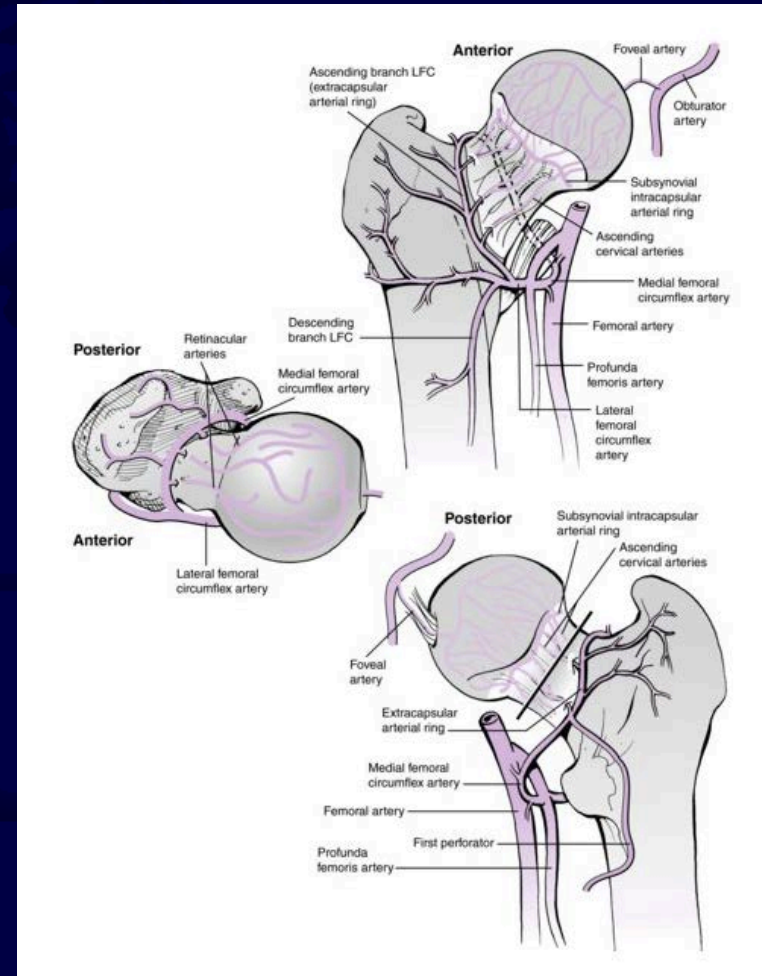
# Anatomy

- Physeal closure age 16
- Neck-shaft angle  
 $130^{\circ} \pm 7^{\circ}$
- Anteversion  
 $10^{\circ} \pm 7^{\circ}$
- Calcar Femorale  
Posteromedial  
dense plate of bone



# Blood Supply

- **Lateral epiphysel artery**
  - terminal branch MFC artery
  - **predominant blood supply to weight bearing dome of head**
- After fracture, blood supply depends on retinacular vessels



# Blood Supply

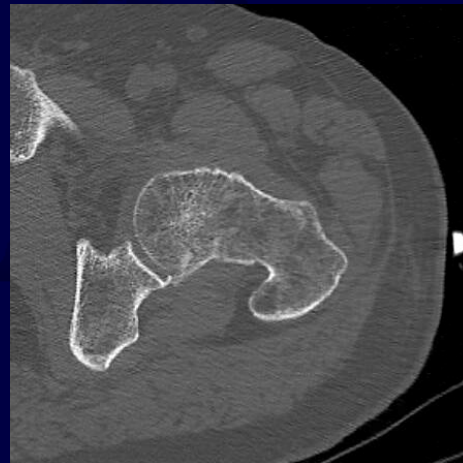
- Greater fracture displacement = greater risk of retinacular vessel disruption
- Tamponade effect of blood in intact capsule
  - Theoretical risk of AVN with increased pressure

# Diagnosis

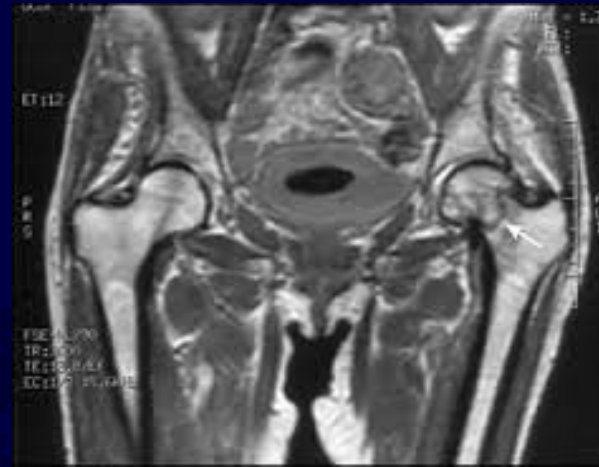
- Plain Film
  - Consider traction-internal rotation view if comminuted



- CT scan
  - Displacement
  - comminution



# Diagnosis



- MRI
  - For evaluation of occult femoral neck fracture
    - Consider MRI in an elderly patient who is persistently unable to weight bear
  - 100% sensitive and specific
    - May reduce cost by shortening time to diagnosis



# Classification

- Garden (1961)
  - Degree of displacement
  - Relates to risk of vascular disruption
  - Most commonly applied to geriatric/insufficiency fractures

# Garden Classification



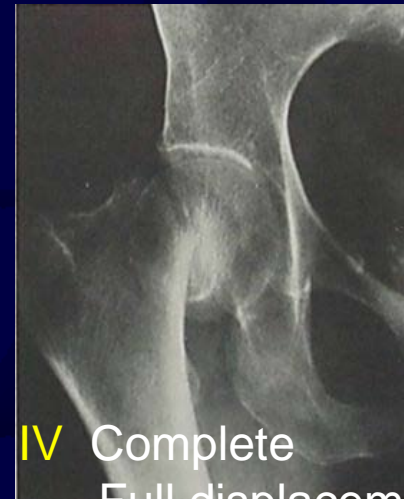
I Valgus impacted or incomplete



II Complete Non-displaced



III Complete Partial displacement



IV Complete Full displacement

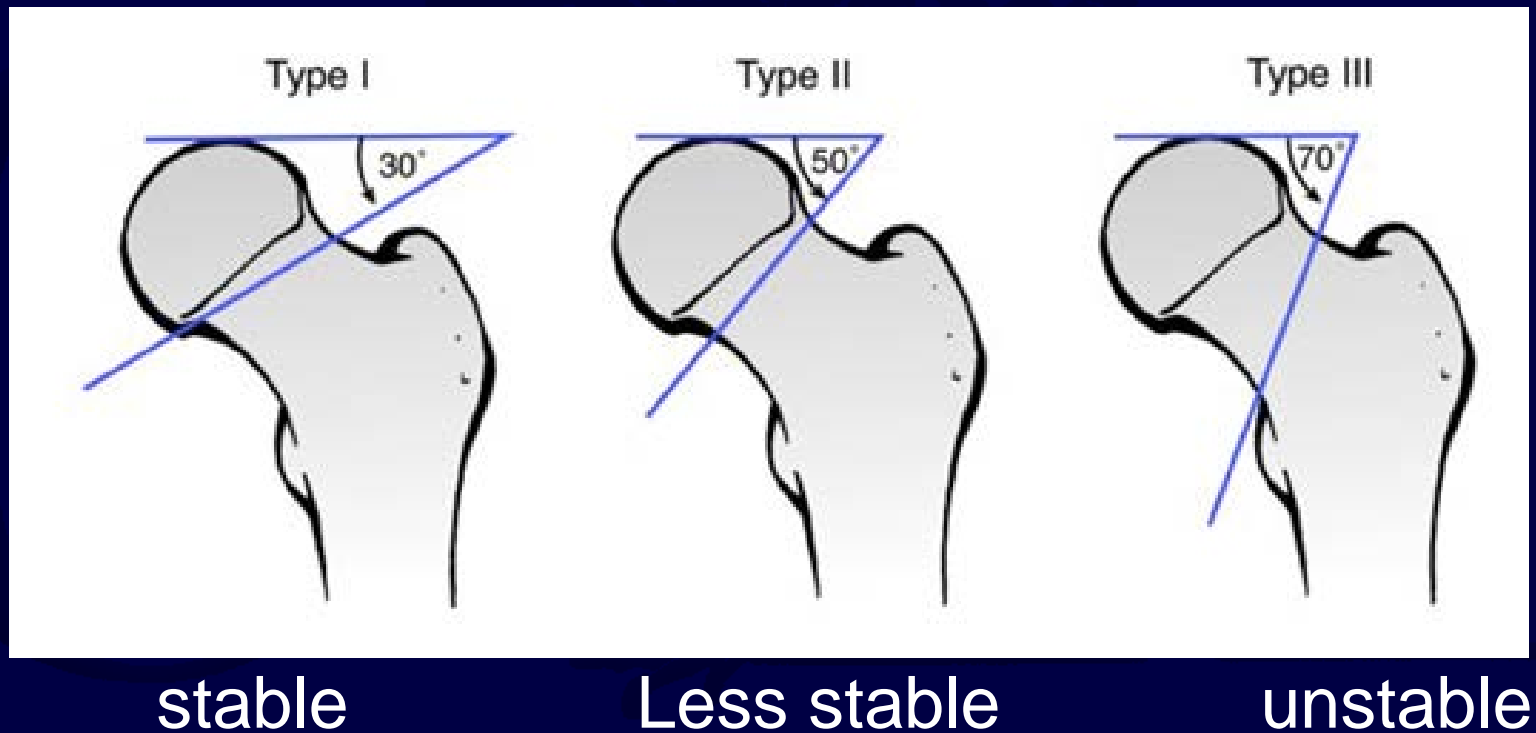
# Garden Classification

- Poor interobserver reliability
- Modified to:
  - Non-displaced
    - Garden I (valgus impacted)
    - Garden II (non-displaced)
  - Displaced
    - Garden III and IV

# Classification

- Pauwels (1935)
  - Fracture orientation
  - Relates to biomechanical stability
  - More vertical fracture has more shear force
  - More commonly applied to younger patients or higher energy fractures

# Pauwels Classification

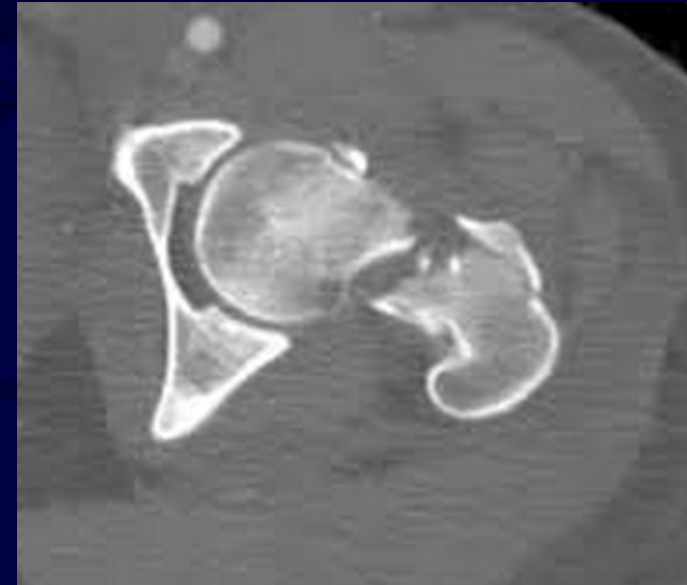


# Treatment Goals: Geriatric Patients

- Mobilize
  - Weight bearing as tolerated
  - Minimize period of bedrest
- Minimize surgical morbidity
  - Safest operation
  - Decrease chance of reoperation

# Treatment Goals: Young Patients

- Spare femoral head
- Avoid deformity
  - Improves union rate
  - Optimal functional outcome
- Minimize vascular injury
  - Avoid AVN



# Treatment Options

- Non-operative
  - Limited role
  - Usually high operative risk patient
  - Valgus impacted fracture
  - Elderly need to be WBAT
  - Mobilize early



# Treatment Options

- Reduction and fixation
  - Open or percutaneous
- Arthroplasty
  - Hemi or total

# Decision Making Variables: Patient Factors

- Young (active)
  - High energy injuries
    - Often multi-trauma
  - Often High Pauwels Angle (shear)
- Elderly
  - Lower energy injury (falls)
  - Comorbidities
  - Pre-existing hip disease

# Decision Making Variables: Fracture Characteristics

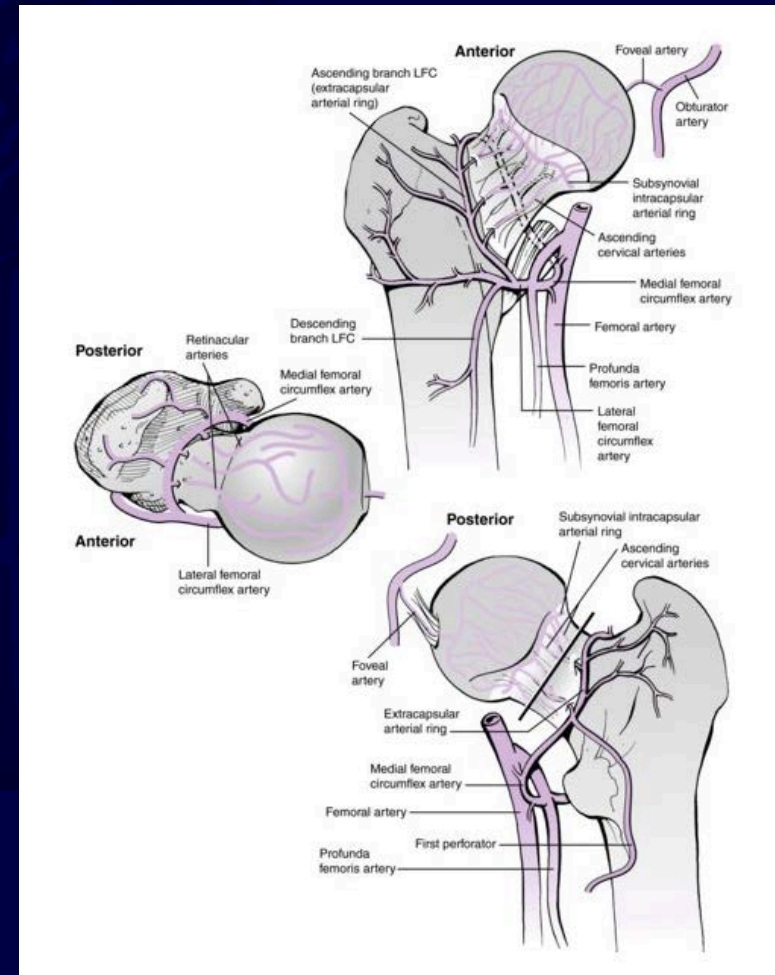
- Displacement
- Stability
  - Pauwels angle
  - Comminution, especially posteromedial

# Pre-operative Considerations

- Traction not beneficial
  - No effect on fracture reduction
  - No difference in analgesic use
  - Pressure sore/ skin problems
  - Increased cost
  - Traction position decreases capsular volume
    - Capsule volume greatest in flexion/external rotation
    - Potential **detrimental** effect on blood flow by increasing intracapsular pressure

# Pre-operative Considerations: Timing of ORIF in Young

- Surgical Urgency
  - may unkink vessels
  - Release tamponade in capsule
- Effect of time to reduction controversial but generally try to get reduced and fixed within 12-24 hours



# Time to Surgery

## DIFFERENCE

- Jain et al, JBJS Am 2002
  - < 60 years old, 12 hr cutoff
  - 6/38 (16%) with AVN in delayed group vs 0/15 in early group
- Duckworth et al, JBJS Br 2011
  - > 24 hr to surgery associated with failure

## NO DIFFERENCE

- Swiontkowski et al, JBJS Am 1984, 12 hr cutoff
  - 20% AVN in < 8 & > 36 hr groups
- Haidukewych, JBJS Am 2004
  - < 50 years old, 24 hr cutoff
  - 20% AVN in both groups
  - Displacement and reduction most important

# Capsular Tamponade

- Bonnaire et al, CORR, 1998
  - Prospective Study
  - Increased pressure at 6 hr; 24 hrs; 2 weeks
  - Displaced and nondisplaced equal
  - Pressure increases with extension and internal rotation
  - **75% had increased pressure and hemarthrosis**
- No clinical proof of efficacy, but basic science data compelling

# Capsulotomy?

- During open reduction or percutaneously
  - Reduces intracapsular pressure from fracture hematoma
    - Bonnaire et al, CORR 1998
    - Harper et al, JBJS Br 1991
    - Holmberg et al, CORR 1987
- Increased capsular pressure not clinically associated with AVN
  - Maruenda et al, CORR 1997
    - 80% of patients with AVN had low intracapsular pressure
      - Vascular damage at time of injury may be more important





# Pre-operative Considerations: Geriatric

- Surgical Timing
  - **Surgical urgency** in relatively **healthy** patients
    - decreased mortality, complications, length of stay
  - **Surgical delay** up to 72 hours for medical stabilization **warranted** in **unhealthy** patients
  - **2.25 increase in MORTALITY** if **> 4 day delay**
    - Most likely related to increased severity of medical problems

# Pre-operative Considerations: Geriatric

- **Regional vs. General Anesthesia**
  - Mortality / long term outcome
    - No Difference
  - Regional
    - Lower DVT, PE, pneumonia, resp depression, and transfusion rates
  - **Further investigation** required for definitive answer

# Treatment Issues:

## Young patient

- Open reduction
  - Improved accuracy
  - Decompresses capsule
- Closed reduction
  - Less surgical morbidity
- May have greater risk of infection

# Closed versus Open Reduction

- Upadhyay et al, JBJS Br 2004
  - Prospective RCT comparing open versus closed reduction with cannulated screws
    - 102 patients < 50 years old
  - No difference in AVN or nonunion
  - Posterior comminution, poor reduction, and poor screw placement associated with nonunion
  - **> 48 hours to surgery in both groups**
  - **Varying constructs**

# Closed versus Open Reduction

Evidence based update: Open versus closed reduction

Pouriya Ghayoumi <sup>a,1</sup>, Utku Kandemir <sup>b,2</sup>, Saam Morshed <sup>b,\*</sup>

<sup>a</sup>University of California, San Francisco School of Medicine, United States

<sup>b</sup>University of California, San Francisco, Orthopaedic Trauma Institute at San Francisco General Hospital, United States

- Higher rate of deep infection in open reduction group
  - 0.5% versus 4%
- No difference in AVN
  - 17% in both groups
- No difference in nonunion
  - 12% in closed group versus 15% in open group ( $p = 0.25$ )

# Closed versus Open Reduction

- Closed versus open reduction does not seem to affect nonunion or AVN rates but data is very limited
  - **MUST achieve an appropriate reduction regardless of either method**

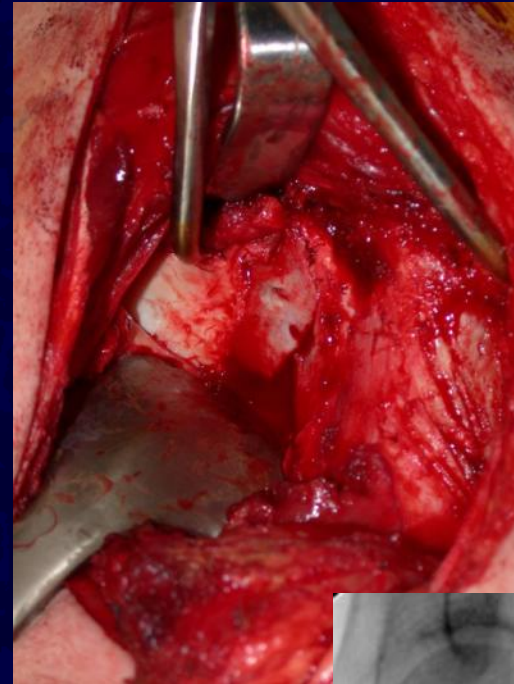
# Closed Reduction

- Flexion, slight adduction, slight traction
- Apply traction, internally rotate to 45 degrees, followed by full extension, slight abduction



# Open approach

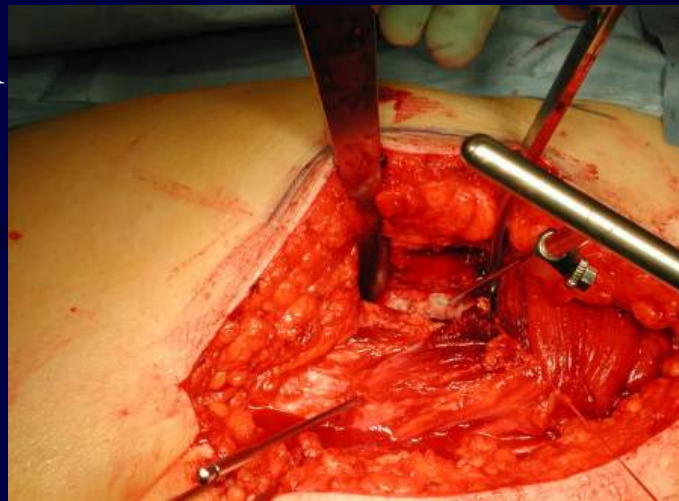
- Smith-Peterson
  - Direct access to fracture
  - Between TFL and sartorius
  - Second approach needed for fixation
- Heuter modification
  - Skin incision over TFL to avoid injury to **LFCN**
  - Interval same as Smith-Peterson



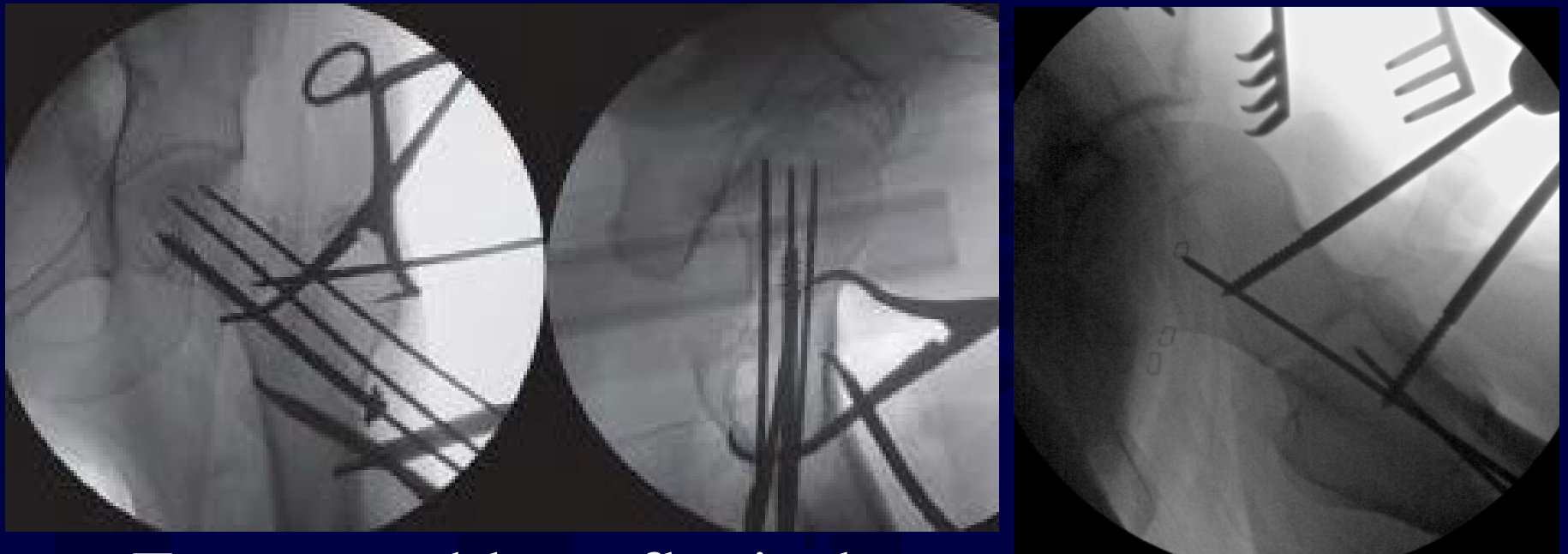


# Open approach

- Watson-Jones
  - anterolateral
  - Between TFL and gluteus medius
  - Same approach for fixation
  - Best for basicervical



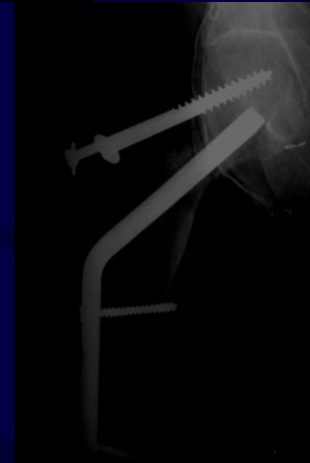
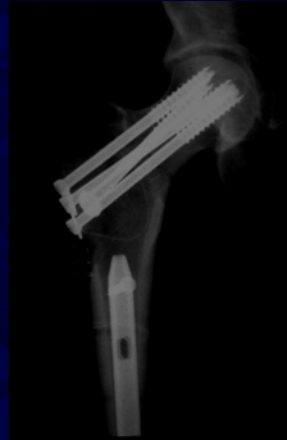
# Open Reduction Technique



- Fracture table or flat jackson
  - Radiolucent under pelvis
- Use schanz pins, weber clamps, or jungbluth clamp for reduction

# Fixation Constructs

- 3 Screws
  - Holmes, 1993
  - Swiontkowski, 1986
  - Swiontkowski, 1987
  - Springer, 1991
- 4 Screws
  - Kauffman, 1999
- Dynamic hip screw
  - Holmes, 1993
- Blade plate
  - Broos, 1998



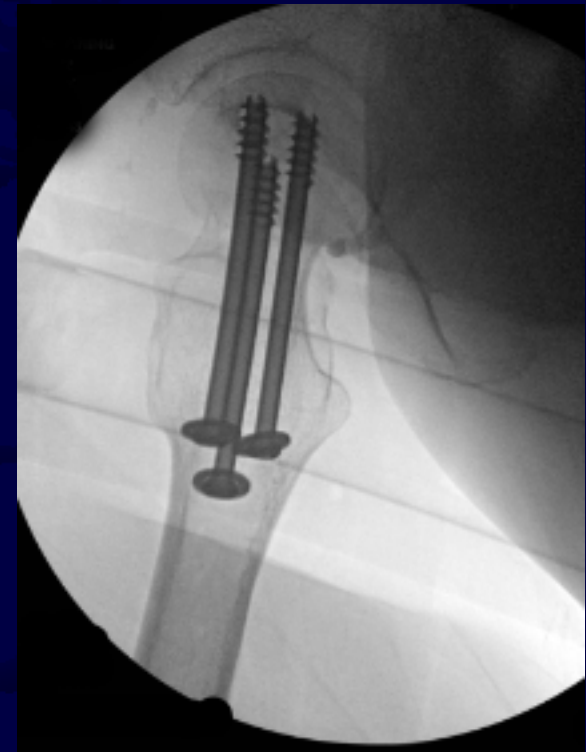
# Fixation Concepts

- Reduction makes it stable
  - Avoid ANY varus
  - Avoid inferior offset
- Malreduction likely to fail



# Fixation Concepts

- Screw position matters
  - Booth et al, Orthopedics 1998
    - Inferior within 3 mm of cortex
    - Posterior within 3 mm of cortex
    - Need a screw resting on calcar
  - Threads should end at least 5mm from subchondral bone
  - Multiple “ around the world views to check appropriate depth
  - Avoid posterior/superior
    - to avoid iatrogenic vascular damage
  - Should not start below level of lesser trochanter
    - Avoid stress riser



# Fixation Concepts

Lateral  
Epiphyseal  
Artery

Good

Bad

Posterior

Anterior

- Good spread
- Hugging Calcar and posterior cortex
- Posterior and inferior screws are most important

- Clustered together
- Nothing on calcar



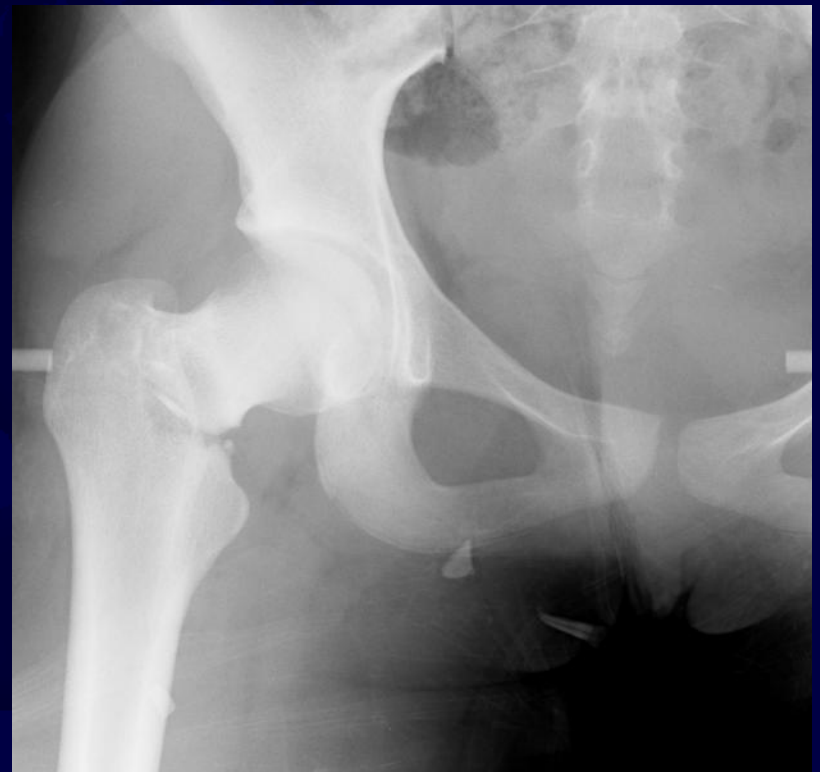
# Fixation Concepts

- Screw position matters
  - Inferior within 3 mm of cortex
  - Posterior within 3 mm of cortex
  - Avoid posterior/superior
    - to avoid iatrogenic vascular damage



# Fixation Concepts

- Sliding hip screw
  - May help with comminution
  - Basicervical
  - Accessory screw for rotation





# Fixation Concepts

- Sliding hip screw
  - May help with comminution
  - Basicervical
  - Accessory screw for rotation
    - Can use small frag plate for reduction as well



# Cannulated Screws versus Fixed Angle Device

- Most RCT included elderly patients
- Retrospective cohort studies
  - Liporace et al, JBJS Am 2008
    - Fixed angle (mix of devices) versus cannulated screws (multiple configurations)
      - 19% nonunion in screws versus 9% nonunion in fixed angle. Not statistically significant
  - Hoshino et al, OTA 2013 paper 54
    - Higher reoperation rate with cannulated screw (pauwel's configuration)



# Cannulated Screws versus Sliding Hip Screw

- Gardner et al, J Orthopaedics 2015
  - Retrospective review of 3 level 1 trauma centers
  - 40 sliding hip screw, 29 cannulated screws
  - **Poor reduction** highly significant for **failure**
  - **Cannulated Screws** had **higher short term failure**

# Outcomes

- Slobogean et al, Injury 2015
  - 20% rate of reoperation
- Pollak et al, OTA 2012
  - at 1 year, patients with no complications reach population norm SF-36
  - with complication substantially disabled
    - Especially malunion
- Fewer than 1/3 of published studies include functional outcomes and < 5% included validated HRQoL scoring

# What about Shortening?

## **Femoral Neck Shortening After Fracture Fixation With Multiple Cancellous Screws: Incidence and Effect on Function**

*Michael Zlowodzki, MD, Olufemi Ayieni, MD, Brad A. Petrisor, MD, and Mohit Bhandari, MD, MSc, FRCSC*

- Healed FNF with shortening associated with poorer functional outcomes
  - 56 patients
    - 30% with 1cm neck shortening, 8mm femoral shortening
    - Similar in both nondisplaced and displaced patients

# Outcomes

- Haidukewych et al, JBJS Am 2004
  - 10% conversion to THA at 2 years
  - 20% at 12 years
  - 65% at 14 years

# YOUNG FNF Summary

- Femoral neck fractures in  $< 60$ .
  - take physiology and activity into account
- Ideally, fix within 24 hours
- Reduction is likely more important than:
  - Capsulotomy
  - Type of approach
  - Method of fixation
- Follow closely for shortening, AVN and nonunion

# Treatment Issues: Geriatric Patients

- **Fixation**

- Lower surgical risk
- Higher risk for reoperation

- **Replacement**

- Higher surgical risk (EBL, etc.)
- Fewer reoperations
- Better function

[Lu-yao JBJS 1994]

[Iorio CORR 2001]



# Treatment Issues: Geriatric Patients

- **Fixation**

- Stable (valgus impacted) fractures
- Minimally displaced fractures

- **Replacement**

- Displaced fractures
- Unstable fractures
- Poor bone quality

[Lu-yao JBJS 1994]

[Iorio CORR 2001]

# Arthroplasty Issues: Hemiarthroplasty versus THA

- Hemi

- More revisions
  - 6-18%
- Smaller operation
  - Less blood loss
- More stable
  - 2-3% dislocation

- Total Hip

- Fewer revisions
  - 4%
- Better functional outcome
- More dislocations
  - 11% early
  - 2.5% recurrent

[Cabanela, Orthop 1999]

[Lu –Yao JBJS 1994]

[Iorio CORR 2001]

# Hemiarthroplasty Issues: Unipolar vs. Bipolar

- Unipolar

- Lower cost
- Simpler



- Bipolar

- Theoretical less wear
- More modular
- More expensive
- Can dissociate
- **NO PROVEN ADVANTAGE**



# Arthroplasty Issues: Cement?

- Cement (PMMA)
  - Improved mobility, function, walking aids
  - Most studies show **no difference** in morbidity / mortality
    - Sudden Intra-op cardiac death risk slightly increased:
      - 1% cemented hemi for fx vs. 0.015% for elective arthroplasty
- Non-cemented (Press-fit)
  - Pain / Loosening higher
  - Intra-op or periop fracture risk higher
    - Particularly in men > 80 years

# Arthroplasty Issues: Surgical Approach

- Posterior

- 60% higher short-term mortality
- Higher dislocation rate

- Anterior/Anterolateral

- Fewer dislocations

# ORIF or Replacement?

- Prospective, randomized study ORIF vs. cemented bipolar hemi vs. THA
- ambulatory patients > 60 years of age
  - 37% fixation failure (AVN/nonunion)
  - similar dislocation rate hemi vs. THA (3%)
  - ORIF 8X more likely to require revision surgery than hemi and 5X more likely than THA
  - THA group best functional outcome

# GERIATRIC FNF Summary

- MRI to rule out occult fracture in older patients unable to weight bear
- CRPP for valgus impacted or nondisplaced fractures
- Arthroplasty if displaced
- Consider THA for active older patients

# Special Problems: Stress Fractures

- Patient population:
  - Females 4–10 times more common
    - Amenorrhea / eating disorders common
    - Femoral BMD average 10% less than control subjects
  - Hormone deficiency
  - Recent increase in athletic activity
    - Frequency, intensity, or duration
    - Distance runners most common



# Stress Fractures

- Clinical Presentation
  - Activity / weight bearing related
  - Anterior groin pain
  - Limited ROM at extremes
  - $\pm$  Antalgic gait
  - Must evaluate back, knee, contralateral hip

# Stress Fractures

- **Imaging**

- Plain Radiographs

- Negative in up to 66%

- Bone Scan

- Sensitivity 93-100%
    - Specificity 76-95%

- **MRI**

- 100% sensitivity / specificity
    - Also Differentiates: synovitis, tendon/muscle injuries, neoplasm, AVN, transient osteoporosis of hip



# Stress Fractures

- Classification
  - Compression sided
    - Callus / fracture at inferior aspect femoral neck
  - Tension sided
    - Callus / fracture at superior aspect femoral neck
  - Displaced



26 y.o. woman runner

# Stress Fractures: Treatment

- Compression sided
  - Fracture line extends  $< 50\%$  across neck
    - “stable”
    - Tx: Activity / weight bearing modification
  - Fracture line extends  $> 50\%$  across neck
    - Potentially unstable with risk for displacement
    - Tx: Emergent ORIF
- Tension sided - Nondisplaced
  - Unstable
    - Tx: Expedited ORIF
      - » Protect weight bearing
      - » Schedule for fixation asap
- Displaced
  - Tx: Urgent ORIF
  - Fix within 24 hours

# Stress Fractures: Complications

- Tension sided and Compression sided fx' s (>50%) treated non-operatively
  - Varus malunion
- Displacement
  - 30-60% complication rate
    - AVN 42%
    - Delayed union 9%
    - Nonunion 9%

# Special Problems: Nonunion

- 0-5% in Non-displaced fractures
- 9-35% in Displaced fractures
- Increased incidence with
  - Posterior comminution
  - Initial displacement
  - Imperfect reduction
  - Non-compressive fixation

# Nonunion

- Clinical presentation
  - Groin or buttock pain
  - Activity / weight bearing related
  - Symptoms
    - more severe / occur earlier than AVN
- Imaging
  - Radiographs: lucent zones
  - CT: lack of healing
  - Bone Scan: high uptake
  - MRI: assess femoral head viability



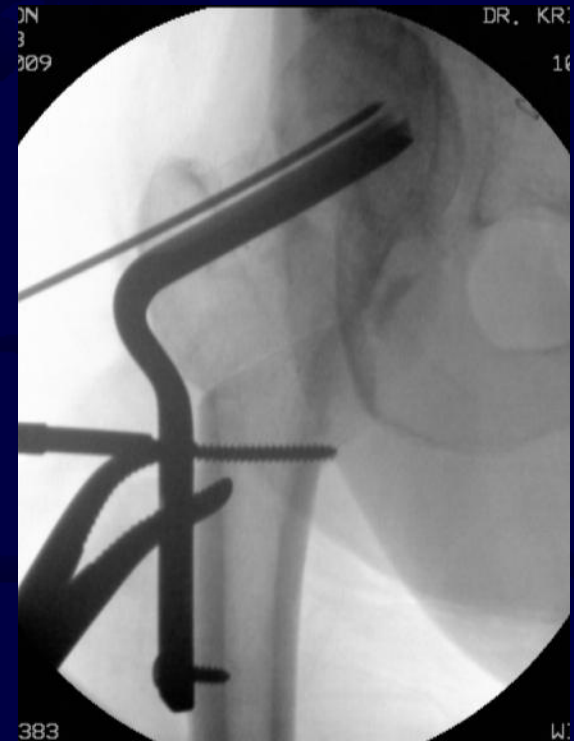
# Nonunion: Treatment

- Elderly patients
  - Arthroplasty
    - Results typically not as good as primary elective arthroplasty
  - Girdlestone Resection Arthroplasty
    - Limited indications
    - deep infection?



# Nonunion: Treatment

- Young patients
  - Valgus intertrochanteric osteotomy (Pauwels)



# Nonunion: Treatment

- Young patients
  - Valgus intertrochanteric osteotomy (Pauwels)
  - Creates compressive forces



# Special Problems: Osteonecrosis (AVN)

- 5-8% Non-displaced fractures
- 20-45% Displaced fractures
- Increased incidence with
  - INADEQUATE REDUCTION
  - Delayed reduction
  - Initial displacement
  - associated hip dislocation
  - ?Sliding hip screw / plate devices

# Osteonecrosis (AVN)

- Clinical presentation
  - Groin / buttock / proximal thigh pain
  - May not limit function
  - Onset usually later than nonunion
- Imaging
  - Plain radiographs: segmental collapse / arthritis
  - Bone Scan: “cold” spots
  - MRI: diagnostic

# Osteonecrosis (AVN)

- Treatment
  - Elderly patients
    - » Only 30-37% patients require reoperation
  - Arthroplasty
    - Results not as good as primary elective arthroplasty
  - Girdlestone Resection Arthroplasty
    - Limited indications

# Osteonecrosis (AVN)

- Treatment
  - Young Patients
    - » NO good option exists
  - Proximal Femoral Osteotomy
    - Less than 50% head collapse
  - Arthroplasty
    - Significant early failure
  - Arthrodesis
    - Significant functional limitations

**\*\* Prevention is the Key \*\***

# Complications

- Failure of Fixation
  - Inadequate / unstable reduction
  - Poor bone quality
  - Poor choice of implant
- Treatment
  - Elderly: Arthroplasty
  - Young: Repeat ORIF
    - Valgus-producing osteotomy
    - Arthroplasty

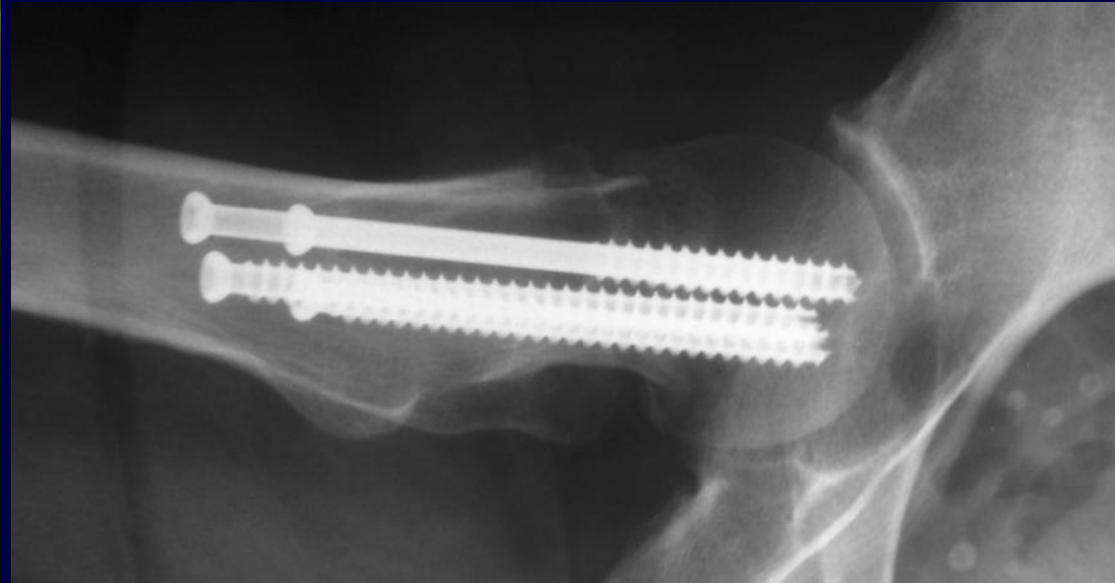
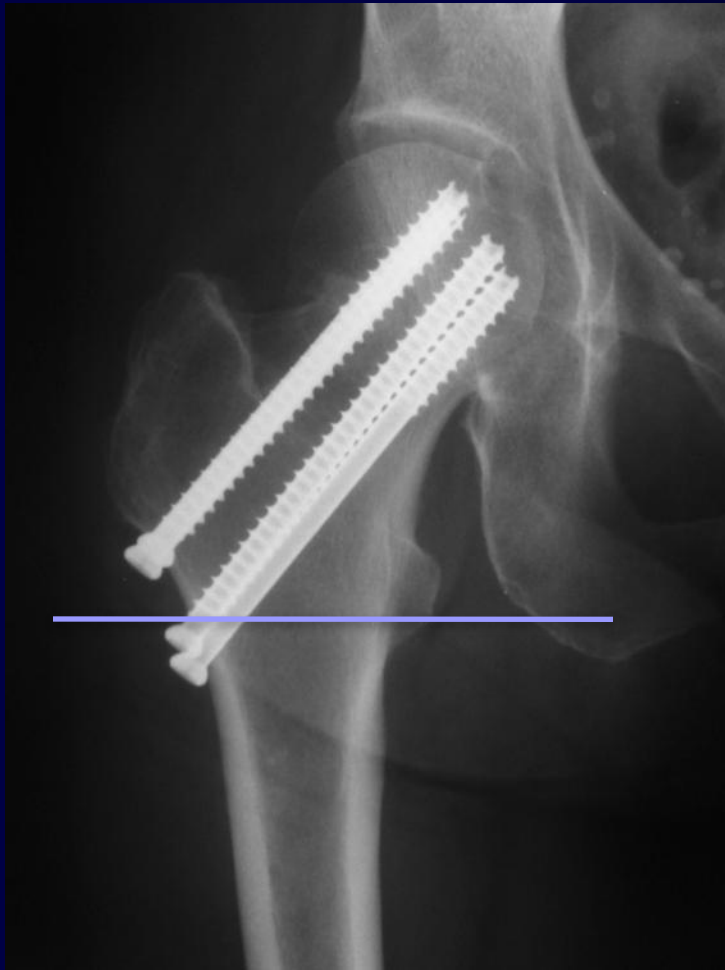
# Complications

- Fracture Distal to Fixation
  - 20% screws at or below Lesser Trochanter
  - Poor bone quality esp. with anterior start site
  - Poor angle of screw fixation
  - Multiple passes of drill or guide pin
- Treatment
  - Elderly & Young: Repeat ORIF of neck?
    - Refixation of neck and subtrochanteric fx
    - Remove posterior screws & bypass with IMN

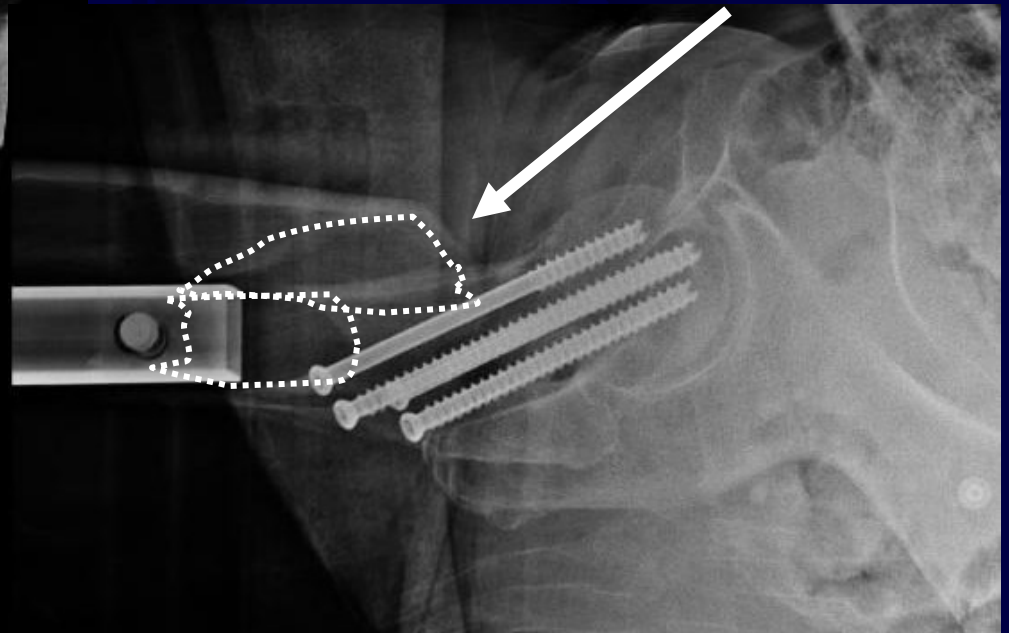




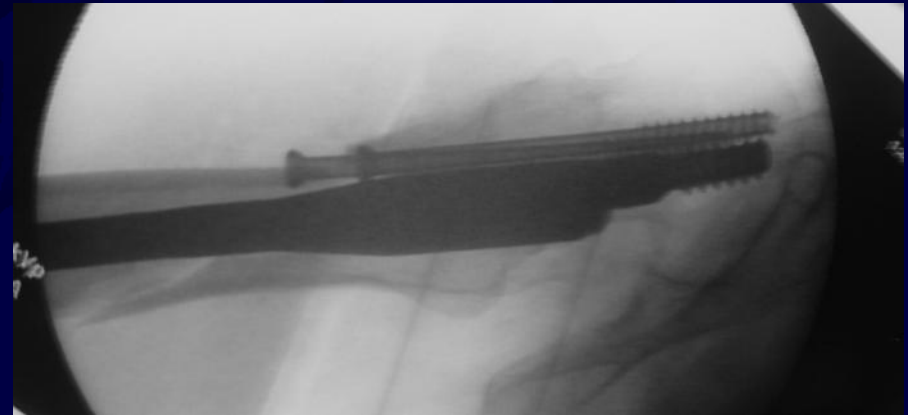
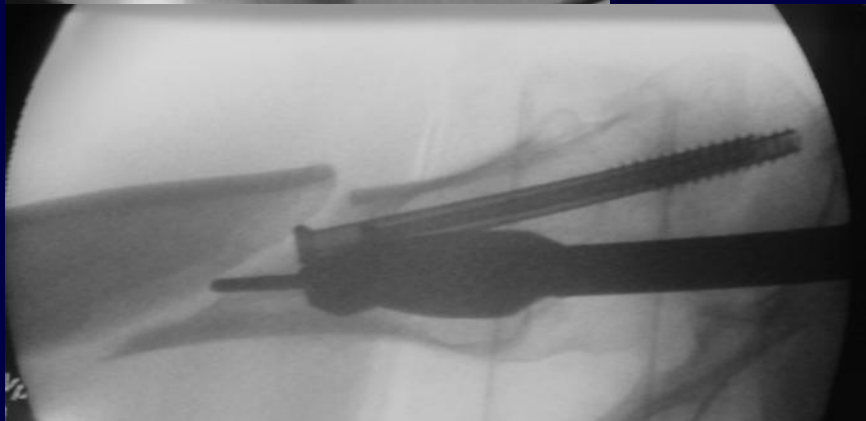
Femoral Neck Fx, Garden I  
CR, Perc Screw Fixation  
Watch Screws Below LT Level  
(20% Fx Rate)



At 3 wks:  
In NH → Fall  
Spiral ST Femur  
Below FN Fx



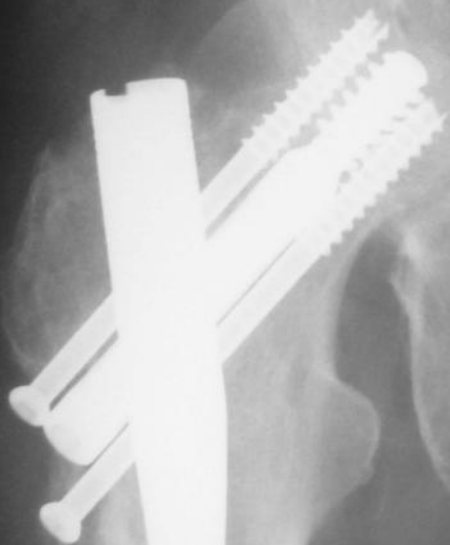
Maintain FN Screws  
Good Alignment & Start  
Ream & Insert Behind FN Screws



**@ 3 Months**

**Healed FN & ST Fx**

**Ambulating without Aide**



# Complications

- Post-traumatic arthrosis
  - Joint penetration with hardware
  - AVN related
- Blood Transfusions
  - THR > Hemi > ORIF
  - Increased rate of post-op infection
- DVT / PE
  - Multiple prophylactic regimens exist
    - Low dose subcutaneous heparin not effective

# Complications

- One-year mortality 14-50%
- Increased risk:
  - Medical comorbidities
  - Surgical delay  $> 3$  days
  - Institutionalized / demented patient
  - Arthroplasty (short term / 3 months)
  - Posterior approach to hip

# Summary

- Different injury in young and old
- Important injury in both young and old
- Understand goals of treatment
- Maximize outcome with least iatrogenic risk

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