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

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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

www.ahrq.gov/data/hcup; Kannus et al, Bone 1996; Dy et al, JBJS 2011
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

Verbeeten et al, Eur Radiol 2005
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

stable  Less stable  unstable

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

Moran et al, JBJS Am 2005
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

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- 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

- 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
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?

- 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
  – ± 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