Periprosthetic Fractures Around THA – When/How to fix, When to Revise
Boot Camp 2013
Phoenix, AZ

Burden of illness

- Increasing prevalence
- Growing population with arthroplasties
- Increasing survival of patients
- More active life-style following arthroplasties
- Increased risk following revision surgery
- Incidence
  - Between 0.1-18% (JAAOS 2009)
  - 3rd most common reason for THA reoperation 9.5%
  - 5th most common reason for revision 5%
  - Fracture risk after Primary THA 0.4%-1.1%
  - Fracture risk after Revision THA 2.1%-4%
- High mortality rate (post THA) at 1 yr:
  - 11% vs hip fracture (16%) vs primary arthroplasty (2.9%)
- High Complication rate: Bhattacharyya et al, JBJS, 2007
  - High complication rate (up to 48%) and re-operation rate (up to 52% in Vancouver C fractures)
- Risk Factors: Zurmond et al, Injury, 2010
  - Osteoporosis
  - Increased age, BMI
  - Surgical technique
  - Revision procedures
  - High energy trauma in young patients
- Other factors:
  - Osteolysis/Aseptic Loosening
  - Multiple Revisions
  - Index diagnosis of hip Fracture at arthroplasty
  - Implant and Surgeon specific issues

Important Considerations

- Location of fracture
- Intra-op vs post-op?
- Primary vs Revision
- Well fixed vs loose implant
- Pre-injury status of implant
- Rule out infection
- Assessment of bone stock

Prevention:
- Avoid intraoperative cracks, defects or windows
- Bypass stress risers
- Avoid cement extravasation
- Cerclage nondisplaced fractures
- Cerclage before reaming or impacting in high risk situations
- Bone graft defects
- Postoperative Surveillance: osteolysis, change in pain or function
- Better outcomes when revise for loosening than fracture

Preop Evaluation:
- Patient
    - Co-morbidities
    - Consultation (anaesthesia, medicine)
    - Need for peri-operative monitoring
- Quality radiographs
    - Status of implant
    - What implant? Get records.
    - Location of fracture
    - May need CT scan to evaluate
        - Fracture - extent
        - Bone quality/ integrity of femur
        - Status of implant

Goals and Principles of treatment:
- Accurate diagnosis

- Optimize long term function of patient and implant
- Obtain fracture union
- Maintain or obtain stability of implant components
- Ensure adequate pre-op planning
- Minimize soft tissue trauma
- Ensure satisfactory fracture reduction
- Ensure stability of implants intra-op and have revision components available if necessary
- Have plates with locked and non locked options available
- Have cables available as necessary
- Manage bone stock deficiency with allograft
- Implants should be long enough to bypass fracture by at least two cortical diameters
- Avoid stress risers

Questions to address
- Stem in varus?
- Stem loose or fixed?
- No stem revision vs revision
- Single lateral plate vs 90/90 fixation
- Plate fixation: screws vs cables
- Plates alone vs plates + allograft struts
- What is ideal plate fixation construct?
- Does type of plate matter?

Classification
- Intraoperative:
  - Vancouver Classification Fracture
  - Location
    - A Metaphysis
    - B Diaphysis
    - C Distal
  - Each subdivided in
    - 1 Perforation
    - 2 Nondisplaced Crack
    - 3 Displaced Fracture

- Postoperative
  - Vancouver Classification:
    - A. Peri trochanteric
      - AL: Fractures at lesser trochanter
      - AG: Fractures at Greater Trochanter
    - B. Periprosthetic tip of the stem
      - B1: Well fixed stem
      - B2: Loose stem, adequate bone stock
      - B3: Loose stem, inadequate bone stock
    - C. Distal to the stem

Treatment Algorithms
Intraoperative Fractures

- Calcar
  - A1 Bypass, bone grafting
  - A2 Removal Stem, Cerclage reinsertion same stem
  - A3 Implant Stability Affected, Bypass with Diaphyseal Fitting Stem Cerclage
- Trochanteric
  - A1 BoneGraft
  - A2 Protected Weightbearing, Brace (Have low Threshold for fixing)
  - A3 ORIF Trochanteric Claw
- Diaphyseal
  - B1 Bypass, onlay cortical graft
  - B2 Distal Split –
    - cerclage if seen intraop,
    - if seen postop, TDWB 6 weeks
  - B3 - Displaced Diahpyseal Fracture
    - If unstable, bypass with longer stem into stable isthmus
    - If implant stable then cerclage, consider onlay graft to bypass.
- Distal
  - C1 Bypass, onlay cortical graft
  - C2 Cerclage, onlay cortical graft
  - C3 Cerclage, ORIF, proximal femoral replacement if proximal femur also deficient, imperative to obtain implant stability

Postoperative Fractures

- Things to remember:
    - Fracture location
    - Stability of the implant and fracture
    - Quality of the host bone stock
    - Patient physiology and age
    - Surgeon Experience
    - Alignment matters: Tadross et al, J Arthroplasty, 2000 - 9 periprosthtic fractures
        - 3 successes: no varus
        - 6 failures: all in varus
        - Must have **implant well aligned** and **not in varus**
- **Vancouver A**
    - If minimal displacement and stable implant - treat nonop
    - If displacement is unacceptable and/or osteolysis is present consider surgery
    - **AL**: Rare, avulsions from osteopenia and lysis
        - If large, displaced and include large portion of calcar, these can destabilize stem and neccessitate femoral revision
        - If involves calcar, be concerned for loose stem, especially in early post op period
            - May be indicator of missed intraop fracture
        - May have stable distal fixation – treat nonop
    - **AG**: More common, often due to trauma (direct blow) or osteolysis.
        - Does not usually affect implant stability
        - Morbidity related to displacement and abductor deficiency
        - Minimal displacement
            - Treat closed x 3 months
            - Revise later if needed to remove the particle generator, debride defects and bone graft
        - Displaced with good host bone stock
            - Consider early ORIF and bone grafting
- **Vancouver B is the Problem**
- **B1** solid stem; good bone
    - Rarely non-op
    - Need to carefully identify stem fixation

        - Lindhall, JBJS, 2006 – 1049 fractures / 245 re-operations
            - B2's (loose stem) classified as B1's are doomed to fail
                - Intraoperative test may be needed
                - Exploit the fracture and try to move the stem.
                - If it moves, revise the stem
            - B1's correctly identified treated with plate, allograft struts or both
            - Treatment with single plate a risk factor for failure.
                - 90/90 with plate/strut better.
    - ORIF with femoral component retention
        - High union rates with component retention
    - Fixation – struts / plates
- **B2** loose stem; good bone
    - Fixation alone will not work
    - Revise the femoral component ,+/- strut allograft, +/- plates
    - Best results seen with patients revised with uncemented, extensively porous coated femoral stems (proximal shieling long term?)
    - May also consider use modular, fluted taper stems
        - Need good quality intact diaphyseal bone to engage the taper.
        - The more proximal the intact diaphysis the better
        - Consider placing a cerclage around intact bone to prevent propogation
- **B3** loose stem; poor bone – Revision +Allograft, plate
    - Uncemented Femoral Stem – bypass poor bone and get distal fixation.
        - Extensively porous coated,
        - Fluted, tapered stem
        - Allograft strut
        - Bone Graft
    - Bone stock is by definition inadequate here.
        - Proximal femoral replacement/Tumor prosthesis
        - Allograft Prosthetic Composite (APC)
- **Vancouver C -** fracture distal to the tip of the stem
    - Treat with standard fracture techniques, but consider overlap vs. stress riser
    - Rarely nonoperative
    - Fixation options

        - Cerclage
        - Strut Allograft
        - Plate fixation – screws/cables, locked/nonlocked
        - Retrograde IM nail (rare)
        - Combination of above
    - Avoid stress risers between implants
        - Bypass (overlap) fixation
        - Or consider allowing 2.5 cortical diameters between devices
        - Newer periprosthetic plate designs are long (entire length of femur) for this reason.

Technique

- Surgical strategy
    - Implant selection
        - greater trochanter – few long term studies, but overall poor success rates, regardless of design
            - claw system to capture greater trochanter
            - may need extended claw plate
                - longer cable ready plate if fracture extends to metaphysis
        - diaphyseal fracture
            - plate system
                - usually locked plate, though studies to support nonlocked
                - options for conventional and locked fixation
                - options for cable attachment to plate
                - newer designs allow for placement of balanced fixation with polyaxial locked or nonlocked screws and are cable ready.
                - biomechanical and clinical studies support combination of cables and screws superior to screws alone (conventional or locked unicortical)
                - “eyelets” that attach cable to plate superior
                - 90/90 fixation superior in most studies with conventional plating using strut graft as well.

            - Biomechanical studies support dual allograft struts as viable option. Peters et al., Orthopedics, 2003
            - Newer plate designs allow for placement of balanced fixation with polyaxial locked or nonlocked screws and are cable ready.
        - Implant for revision
            - Revision stem must extend 4 – 6 cms past the fracture (2 cortical diameters)
            - 4cm of scratch fit for distal fixation
            - Stems >190 mm must be curved
            - Cementless stem preferred because of problems with fracture healing with cement
    - position of patient: lateral
        - allows for revision if implant unstable
    - Flat radiolucent table
    - Fluorointensifier
    - Femoral distractor in delayed cases or fracture shortening
    - articulated tensioning device ("A TD") if compression required (transverse fracture)
- Fixation strategy
    - Routine fracture fixation techniques.
        - Respect the biology
            - Expose whole length of involved femur but minimize soft tissue stripping
            - If cerclage - use wire passer
    - Use fracture to access canal + prosthesis
    - Remove all granulation tissue, membrane or cement
    - Reduce fracture & get provisional fixation (cerlcage, plate + clamps)
    - With fracture reduced, prepare femur
    - Long plates with "balanced fixation"
    - Conventional screws distal to implant (diaphysis)
        - Can augment with locked screws
        - Bicortical or unicortical locked screws in area of implant / greater trochanter
    - Prosthesis alone does not control rotation / shortening

- Locking plate not superior to regular plate
- Screws in proximal & distal fragments improve rotational stability
- Cables only if added stability required
    - use system "eyelets" that allows direct attachment to plate
- Allograft will incorporate and will add bone stock
    - Allograft struts in cases of bone loss/ comminution or consider in revision cases
        - respect biology
        - avoid violating medial soft tissues

Biomechanical Evidence

- A combination of a non locked plate with an allograft strut remains an optimal configuration in the treatment of periprosthetic fractures around THA's (Use 90/90 configuration)
- Locked plates should be used with caution as a stand alone treatment of periprosthetic fractures around THA's
- Screw-plates provide either greater or equal stiffness compared to cable- plates in almost all cases.
- Spaced fixation of screws and cables NB
- Plate type plays a small role ie no difference between onlay cables, inlay cables and wire mounts.
- Newer periprosthetic plate designs – balance proximal to distal and within rows of available holes (in one row of holes, place one anterior then one posterior, don't leave unbalanced).

Clinical evidence

- Haddad et al, JBJS, 2002.
    - Periprosthetic fractures around well-fixed implants: use of cortical onlay allografts with or without a plate
    - 21 plates with struts and 19 struts only
    - 98% union
    - 1 infection
    - Routine use of struts is suggested
- Buttaro et al, JBJS 2007.

- 14 Locking plates at 20 mo. f/u
    - 6/14 failures: 3 plate fractures / 3 plate pulloff's
    - No advantages to locking plate
    - Should use allograft struts
- Agarwal et al, J Arthroplasty 2005.
    - Single lateral plate should be avoided
    - 4/16 complications
- Corten et al, JBJS, 2009.
    - 45 B1 fractures
    - Joint dislocated and stability of femoral component evaluated
    - Identified B2 in 9 (20%) hips (unstable implant when thought stable)
    - Single plate and cable fixation by direct reduction if integrity of the medial cortex could be restored.
    - Union in 29/30 (97%) at avg 6.4 mos
- Ricci et al, JBJS, 2006. in 50 pts (41 w/ f/u)Vancouver B1 fractures
    - Plating of periprosthetic femur fractures with indirect reduction
    - No allograft
    - No bone grafts
    - Average time to union = 3 months (range 7-23 weeks)
    - One deep infection
    - 30/41 returned to baseline ambulatory status
- Wood et al, J Arthroplasty, 2011. Locked plates in 16 pts.
    - ORIF around well fixed hip/knee implants
    - 14/16 union by 6 months
    - 13/16 ambulatory at 6 months
    - Recommendations:
        - Minimum number of cortices 10 above and 10 below fracture
        - Cortical struts when failed hardware or revision fixation cases
- Deghan, Schemitsch et al, 2011. Systematic review 285 B1 fractures
    - Cable plates / struts vs LP's
        - Union: 97 vs 86%, $p<0.07$
        - Hardware failure: 2%vs 14%, $p<0.07$
        - Complications: 28% vs 45%, $p<0.09$

Conclusions

- Periprosthetic fractures after THA are increasing and present technical challenges
- Must confirm prosthesis stability
- Revision if loose or varus stem
- Plate fixation + allograft struts best with standard plates
- Variable results seen with locked plates
    - May be technique dependent
    - Newer designs may offer more fixation options
        - ? clinical outcomes
- Screw fixation better than cables alone

References

- Jimenez ML, Sferra TA, Twigg SL. Morbidity and Mortality Associated with Periprosthetic Fractures of the Femur. *Orthopaedic Trauma Association 20th Annual Meeting.* Florida, Oct 8-10, 2004; paper #63. Lindahl H, Malchau H,
- Oden A, Garrelick G. Risk factors for failure after treatment of a periprosthetic fracture of the femur. *J Bone Joint Surg Br.* 2006;88(1):26-30.
- Pike J, Davidson D, Garbuz D, Duncan CP, O'Brien PJ, Masri BA. Priciples of treatment for periprosthetic femoral shaft fractures around well-fixed total hip arthroplasty. J Am Acad Orthop Surg. 2009 17(11): 677-88
- Jakubowitz et al. The influence of age, bone quality and body mass index on periprosthetic femoral fractures: a biomechanical laboratory study. Med Sci Monit. 2009; 15(11): 307-312.
- Scott RD, Turner RH, Leitzes SM, et al. Femoral fractures in conjunction with total hip replacement. *J Bone Joint Surg Am.* 1975;57:494.
- Stevens SS, Irish AJ, Vachtsevanos JG, Csongradi J, Beaupre GS. A biomechanical study of three wiring techniques for cerclage-plating. *J Orthop Trauma.* 1995;9(5):381- 7.
- Dennis MG, Simon JA, Kummer FJ, Koval KJ, Di Cesare PE. Fixation of periprosthetic femoral fracture shaft fractures occurring at the tip of the stem: a biomechanical study of 5 techniques. *J Arthroplasty.* 2000;15(4):523-8.
- Bethea JS 3rd, DeAndrade JR, Fleming LL, Lindenbaum SD, Welch RB. Proximal femoral fractures following total hip arthroplasty. *Clin Orthop.* Oct 1982;170:95-106.
- Tower SS, Beals RK. Fractures of the femur after hip replacement: the Oregon experience. *Orthop Clin North Am.* Apr 1999;30(2):235-47.
- Brady OH, Kerry R, Masri BA, Garbuz DS, Duncan CP. The Vancouver classification of periprosthetic fractures of the hip: a rational approach to treatment. *Techn Orthop.* 1999;14:107–14
- Beals RK, Tower SS. Periprosthetic fractures of the femur. Analysis of 93 fractures. *Clin Orthop.* 1996;327:238-246.
- Cooke PH, Newman JH. Fractures of the femur in relation to cemented hip prostheses. *J Bone Joint Surg Br.* 1988;70:386.
- Johansson JE, McBroom R, Barrington TW, Hunter GA. Fracture of the ipsilateral femur in patients wih total hip replacement. *J Bone Joint Surg Am.* 1981;63:1435-42.

- Zenni EJ Jr, Pomeroy DL, Caudle RJ. Ogden plate and other fixations for fractures complicating femoral endoprostheses. *Clin Orthop Relat Res.* Jun 1988;231:83-90.
- Berman AT, Zamarin R. The use of Dall-Miles cables in total hip arthroplasty. *Orthopaedics.* 1993; 16:833-5.
- Duncan CP. The reliability and validity of the Vancouver classification of femoral fractures after total hip replacement. *J Arthroplasty.* 2000;15:59-62.
- Duncan CP, Masri BA. Fractures of the femur after total hip replacement. *Inst Course Lect.* 1995;45:293.
- Serocki JH, Chandler RW, Dorr LD. Treatment of fractures about hip prostheses with compression plating. *J Arthroplasty.* 1992;7:129.
- Tsiridis E, Haddad FS, Gie GA. The management of periprosthetic femoral fractures around hip replacements. *Injury.* 2003;34:95-105.
- Wilson D, Masri BA, Duncan CP. Periprosthetic fractures: an operative algorithm. *Orthopaedics.* 2001;24:869-870.
- Ogden WS, Rendall J. Fractures beneath hip prostheses: a special indication for parham bands and plating. *Orthop Trans.* 1978;2:70.
- Dennis MG, Simon JA, Kummer FJ, Koval KJ, Di Cesare PE. Fixation of periprosthetic femoral shaft fractures: a biomechanical comparison of two techniques. *J Orthop Trauma.* Mar-Apr 2001;15(3):177-80.
- Fulkerson E, Egol K, Preston C, Iesaka K, Kummer F, Koval K. Fixation of Periprothetic Femoral Shaft Fractures: A Biomechanical Comparison of Locked Plating and Conventional Cable Plates (Ogden Construct). *Orthopaedic Trauma Association 20th Annual Meeting.* Florida, Oct 8-10, 2004.
- Kelley SS. Periprosthetic Femoral Fractures. *J Am Acad of Orthop Surg.* 1994;2:164-172. Schmotzer H, Tchejeyan GH, Dall DM. Surgical management of intra and post operative fractures of the femur about the tip of the stem in total hip arthroplasty. *J*
- *Arthroplasty.* 1996;11(6):709-17.Chandler HP, King D, Limbird R, Hedley A, McCarthy J, Penenberg B, Danylchuk K.
- The use of cortical allograft struts for fixation of fractures associated with well-
- fixed total joint prostheses. *Semin Arthroplasty.* 1993;4:99-107.Emerson RH Jr, Malinin TI, Cuellar AD, Head WC, Peters PC. Cortical strut allografts in the reconstruction of the femur in revision total hip arthroplasty. A basic science
- and clinical study. *Clin Orthop.* 1992;285:35-44.Haddad FS, Duncan CP, Berry DJ, Lewallen DG, Gross AE, Chandler HP. Periprosthetic

- femoral fractures around well-fixed implants: use of cortical onlay allografts with or without a plate. *J Bone Joint Surg Am.* 2002;84:945-950.
- Tadross TS, Nanu AM, Buchanan MJ, Checketts RG. Dall-Miles plating for periprosthetic B1 fractures of the femur. *J Arthroplasty.* 2000;15:47 –51.
- Tsiridis E, Haddad FS, Gie GA. Dall-Miles plates for periprothetic femoral fractures. A critical review of 16 cases. *Injury.* 2003;34:107-10.
- Peters CL, Bachus KN, Davitt JS. Fixation of periprosthetic femur fractures: a biomechanical analysis comparing cortical strut allograft plates and conventional metal plates. *Orthopedics.* Jul 2003;26(7):695-9.
- Wilson D, Frei H, Masri BA, Oxland TR, Duncan CP. A biomechanical study comparing cortical onlay allograft struts and plates in the treatment of periprosthetic femoral fractures. *Clin Biomech (Bristol, Avon).* Jan 2005;20(1):70-6.
- Zdero R, Walker R, Waddell JP, Schemitsch EH. Biomechanical evaluation of periprosthetic femoral fracture fixation. J Bone Joint Surg (A) 2008; 90(5): 1068- 77.
- Pike J, Davidson D, Garbuz D, Duncan CP, O'Brien PJ, Masri BA. Principles of treatment for periprosthetic femoral shaft fractures around well-fixed total hip arthroplasty. J Am Academy Orthop Surg. 2009 17(11): 677-88
- Dubov et al. The biomechanics of plate repair of periprosthetic femur fractures near the tip of a total hip implant. Proc Inst Mech Eng 2011.
-