2009 OTA Annual Meeting

Manchester Grand Hyatt
San Diego, CA

(#F11): Mini Symposium:

Considerations and Techniques in the Management of Peri-Prosthetic Fractures

Elizabeth Ballroom, Level II

1:31pm – 3:01pm
Friday, October 9, 2009

Moderator: Samir Mehta, MD

Faculty: **David P. Barei, MD**
James A. Goulet, MD
Thomas J. Ellis, MD
George J. Haidukewych, MD
Andrew H. Schmidt, MD

The material presented at this course has been made available by the Orthopaedic Trauma Association for educational purposes only. This material is not intended to represent the only, nor necessarily best, methods or procedures appropriate for the medical situations discussed, but rather is intended to present an approach, view statement or opinion of the faculty which may be helpful to others who face similar situations.

Disclosure: Faculty disclosure can be found starting on page 67 of the 2009 OTA Annual Meeting program.

OTA 2009 San Diego

Considerations & Techniques in Periprosthetic Fracture Management

---

Algorithmic Approach to Periprosthetic Fractures

Andrew H. Schmidt, MD
Associate Professor
University of Minnesota
Hennepin County Medical Center
Minneapolis, MN

In general, regardless of the bone / implant, periprosthetic fractures tend to be categorized based on the proximity to the implant and the functioning status of the implant (stable or loose, functioning or failing).

THA: Johanson, Vancouver classifications

Johansson Classification

Type I: Proximal to tip with stem in distal fragment.
Type II: Fracture about stem extending below tip, with stem dislodged.
Type III: Entirely distal to prosthesis.

Classification of Duncan and Masri:

Based on fracture location, fixation of the stem, and the quality of the bone.

Type	Location	Subtype
A	Trochanteric region	A(G): Greater trochanter A(L): Lesser trochanter
B	Around stem tip	B(1): Prosthesis stable B(2): Prosthesis unstable B(3): Bone stock inadequate
C	Well below the stem	

TKA: Rorabeck classification

Type I: undisplaced, stable prosthesis
Type II: displaced, stable prosthesis
Type II: loose prosthesis

These classifications facilitate an algorithmic approach to treatment
Stable Prosthesis: Internal Fixation
Failed Prosthesis: Revision Arthroplasty

Fractures about THA

Type A Fractures

Represent fractures of the greater or lesser trochanter and generally do not threaten the stability of the implant. Lesser trochanteric fractures may be less common but are more ominous as they could represent loss of bone support in the region of the posteromedial calcar femorale. As such, the finding of a lesser trochanter fracture may warrant further imaging and close follow-up. If occurring intraoperatively, a long-stem should be used.

Type B Fractures: Internal Fixation or Revision Arthroplasty

Duwelius et al reported the results of a "modernized" protocol for addressing periprosthetic femur fractures, designed to utilize contemporary methods of fracture fixation and revision arthroplasty. Fractures about loose implants were treated with long-stem revision arthroplasty using long, fully-coated, uncemented stems with allograft cortical struts. Fractures about stable implants were treated with open reduction and internal fixation using indirect reduction methods and state-of-the-art lateral femoral plating techniques; most often combined with an anterior cortical allograft strut. In all cases of ORIF, screw fixation was obtained in both proximal and distal fragments, supplemented by cerclage wires.

Type B1: Fracture about stable implant: ORIF is the standard treatment

Type B2: Loose implant: Revision arthroplasty generally indicated

Type B3: Loose implant with inadequate bone stock – proximal femoral replacement generally needed.

Type C Fractures: Well below the THA

These do not involve the implant and are best treated with ORIF using plates that overlap the femoral stem.

Fractures about TKA:

Nearly always occur in the distal femur.

Very rare to find a failed prosthesis. ORIF almost always indicated

References

1. Lewallen DG, Berry DJ: Periprosthetic fracture of the femur after total hip arthroplasty: treatment and results to date. JBJS 79A:1881-90, 1997
2. Bethea JS III, DeAndrade JR, Fleming LL, et al: Proximal femoral fractures following total hip arthroplasty. Clin Orthop170:95-106, 1982
3. Duwelius PJ, Schmidt AH, Kyle RF, Talbott V, Ellis TJ, Butler JB. A prospective, modernized treatment protocol for periprosthetic femur fractures. Orthop Clin N Am 35(4):485-92, 2004.
4. Schwartz JT Jr, Mayer JG, Engh CA: Femoral fracture during non- cemented total hip arthroplasty. J Bone Joint Surg 71A:1135-42, 1989
5. Fitzgerald RH Jr, Brindley GW, Kavanagh BF: The uncemented total hip arthroplasty: Intraoperative femoral fractures. Clin Orthop 235:61-66, 1988
6. Serocki JH, Chandler RW, Dorr LD: Treatment of fractures about hip prostheses with compression plating. J Arthroplasty 7:129-135, 1992
7. Noorda RJ, Wuisman PI. Mennen plate fixation for the treatment of periprosthetic femoral fractures: a multicenter study of thirty-six fractures. J Bone Joint Surg Am, 84-A(12):2211-5, 2002
8. Tadross TSF, Nanu AM, Buchanan MJ, et al: Dall-Miles plating for periprosthetic B1 fractures of the femur. J Arthroplasty, 15:47-51, 2000
9. Dennis MG, Simon JA, Kummer FJ, et al: Fixation of periprosthetic femoral shaft fractures occurring at the tip of the stem. A biomechanical study of 5 techniques. J Arthroplasty 15:523-8, 2000
11. Wong P, Gross AE: The use of structural allografts for treating periprosthetic fractures of the hip and knee. Techniques in Orthopaedics 14(2):102-106, 1999
12. Haddad FS, Duncan CP, Berry DJ, et al. Periprosthetic femoral fractures around well-fixed implants: use of cortical onlay allografts with or without a plate. J Bone Joint Surg Am, 84-A(6): 945-50, 2002
13. Springer BD, Berry DJ, Lewallen DG. Treatment of periprosthetic femoral fractures following total hip arthroplasty with femoral component revision. JBJS 85A: 2156-62, 2003.
14. Duncan CP, Masri BA: Fractures of the femur after hip replacement. Instructional Course Lectures 44:293-304, 1995

15. Jukkala-Partio K, Partio EK, Solovieva S, et al. Treatment of periprosthetic fractures in association with total hip arthroplasty - a retrospective comparison between stem revision and plate fixation. Ann Chirurg et Gynaecol 87:229-35, 1998.
16. Mont MA, Maar DC: Fractures of the ipsilateral femur after hip arthroplasty. A statistical analysis of outcome based on 487 patients. J Arthroplasty 9(5):511-9, 1994
17. Beals RK, Tower SS: Periprosthetic fractures of the femur. An analysis of 93 fractures. Clin Orthop:238-46, 1996

Periprosthetic Fractures of the Hip: When Internal Fixation is Not the Right Choice

George J. Haidukewych MD
Professor, University of Central Florida
Co-Director of Orthopedic Trauma
Director, Complex Adult Reconstructive Service
Orlando Regional Medical Center

Fractures around the femoral component of a total hip arthroplasty are becoming more common as our population ages. These patients often present to the emergency room and increasingly are being managed by orthopedic traumatologists with varying amounts of revision experience. Osteopenic bone, the presence of a femoral component, often loose, and an elderly patient population with medical comorbidites pose challenges to a successful outcome. It is important to note that the majority of peri-prosthetic fractures around the stem of a femoral component are associated with a loose femoral implant, and in these cases, revision is preferable to internal fixation attempts. Since most orthopedic traumatologists are not familiar with femoral revision principles, the discussion below will focus on the fundamental decision-making and technical aspects of management of periprosthetic fractures of the femur associated with a loose femoral component.

The Vancouver classification is clinically helpful for guiding treatment. It is based on the location of the fracture, the fixation status of the femoral component, and the quality of the remaining bone stock. Vancouver A type fractures involve the greater or lesser trochanter and are almost always associated with osteolysis related avulsions. The mainstay of treatment of such fractures is to address the osteolysis, typically with polyethylene liner exchange. Lytic lesions are bone grafted with allograft and greater trochanteric fractures are stabilized if unstable. Tension-band techniques have been recommended using wire or heavy braided suture. It is important to understand that the bone quality is typically extremely poor as the trochanter has been “hollowed out” by the lytic process. If displaced and unstable, the author prefers to obtain heavy suture fixation into the abductor tendon, which typically provides more robust fixation. These techniques are analogous to the fixation of tuberosities of the shoulder in osteopenic patients.

Vancouver B type fractures occur around the tip of the stem, and are the most common fractures encountered. B1 fractures occur around a well fixed implant, B2 fractures around a loose implant with good remaining bone stock, and B3 fractures around a loose implant with poor remaining proximal bone stock. For fractures around a well fixed implant (B1), internal fixation with a plate with or without an allograft strut is recommended. Obtaining stable proximal fixation is paramount, and the author prefers a lateral locked plate with a combination of unicortical locked screws and cables. Cable fixation alone proximally is inadequate. The need for a supplementary allograft strut is controversial. The author currently individualizes the need for strut augmentation based on bone quality. If a strut is used, it should be contoured with a high speed burr to provide good contact with

host bone. Orthogonal placement to the locked plate (strut anterior on the femur) is generally preferred since this avoids medial dissection.

For fractures around a loose implant (Vancouver types B2 and B3) revision of the femoral component is recommended. This strategy addresses both the loose component and the fracture and provides intramedualllary stability by virtue of the typically long stems used for revision. Attempting to plate these fractures around a loose implant typically leads to nonunion, since the unstable femoral component probably hinders stable proximal fixation. Additionally, multiple distal screws and bony defects from failed hardware can compromise revision options. Knowledge of specific revision techniques is necessary to effectively handle these challenging cases. Thorough medical optimization is recommended preoperatively. Good quality orthogonal radiographs are mandatory to evaluate the fixation status of the acetabular component and remaining acetabular and femoral bone stock. If possible, the operative note from the original arthroplasty should be obtained. The presence of pre-fracture hip symptoms, such as thigh or groin pain, can alert the surgeon to potential loosening of the components, if the radiographs are equivocal. Radiographic signs of femoral component loosening included subsidence, cement mantle fractures, and complete radiolucencies at the bone cement interface. Serologies such as sedimentation rates and C reactive proteins are of unknown benefit in the presence of an acute fracture. If there is any concern of infection, a preoperative aspiration should be considered. Generally, a culture result can be obtained within 48 hours while medical optimization is taking place. Skeletal traction may be required for more unstable fracture patterns in this scenario. In general, the author prefers to proceed based on intraoperative frozen section obtained from the membrane around the loose femoral component, not the fracture site itself. If there is any concern of infection, all components and residual cement is removed, and an antibiotic cement spacer is made to provide some stability. The author prefers the use of a metal guide pin with a cement "nail" made utilizing antibiotic impregnated cement with 3 grams of Vancomycin and 2.4 grams of Tobramycin per 40 gram batch of cement. The fracture fragments can be cerclaged around such a "spacer nail" to allow reasonable alignment of the fracture fragments. A period of organism-specific intravenous antibiotics are given, and the revision is performed in a staged fashion.

The specific femoral revision strategy chosen depends on the quality of the remaining bone stock, the diameter of the femoral canal distal to the fracture, and patient factors, such as age. Many different surgical exposures can be useful for revision in this setting. The author generally prefers a posterior approach because it is widely extensile. The fracture lines can be used to remove cement, and cement restrictors. If necessary, the proximal fracture fragment can be split coronally to allow access for stem removal and direct visualization of the distal canal to allow accurate reaming. The acetabular component is typically exposed after the femoral component is removed. The liner is removed, if modular, and the acetabular component is manually tested for stability. If it is loose, acetabular revision is performed. A full discussion of acetabular revision methods is beyond the scope of this manuscript, however, in general, the use of a larger hemispherical acetabular component with screw augmentation is recommended. If the acetabular component is well fixed, the liner is typically exchanged, and the head size increased, if possible, to allow improved hip stability. Anecdotally, the author has noted that in the overwhelming majority of cases the acetabular component is well fixed in the setting of a femoral periprosthetic fracture.

Attention is then turned to the femur. Several strategies can be effective, but all rely on obtaining secure distal fixation. Very, very rarely, cemented long stem revision is considered. This can be useful in very osteopenic bone with capacious canals where obtaining a press-fit may be impossible. For example, a ninety year old patient with a fracture around a loose Austin Moore type hemiarthroplasty may be a candidate for long stem cemented fixation. Generally, if the fracture is anatomically reduced and fixed with cerclage cables and if the cement is not vigorously pressurized,

cement extravasation through the fracture lines will not occur. After cementation, intraoperative radiographs are recommended to determine if any problematic cement extravasation has occurred. It should be emphasized that cemented reconstructions are rarely useful in the setting of periprosthetic fractures. The most effective strategies in the available literature have been documented with uncemented, distal fixation techniques, and these should be considered the reconstructions of choice.

Several preoperative radiographic findings can help guide the selection of the appropriate uncemented reconstruction. These include the endosteal diameter and morphology of the distal fragment. If the distal fragment demonstrates parallel endosteal cortices with 5 centimeters or more of tubular diaphysis (usually with a diameter of less than 18 millimeters), then extensively coated uncemented long stem prostheses are appropriate, and have a good track record. These types of stems have demonstrated excellent long term survivorship in the revision setting and for periprosthetic fracture situations as well. The distal canal is reamed and a trial stem is potted into the distal fragment. In general a slight under-ream (0.5 to 1mm) is appropriate for such stems, but for longer, curved stems, a line to line ream is appropriate, since there is inevitably a slight mismatch in femoral bow, which does provide some press-fit. The proximal fragments can then be reduced using the trail as a template. The author prefers to select a trial one size smaller than the definitive implant, and use that trial as a guide to proximal fragment reduction. Essentially, you build the proximal femur around a trial a few millimeters smaller than the real implant, then impact the slightly larger real implant to get a press-fit. Cerclage cables are applied, and a trial reduction is performed. If leg length and stability are acceptable, the trial is removed and the real femoral component is impacted. The cerclage calbles are then re-tensioned, crimped and cut. The appropriate femoral head length is selected, and the reconstruction completed.

If the distal diaphysis demonstrates divergent endosteal morphology, less than 5 centimeters of parallel endosteal cortex, or large endosteal diameters (typically over 18 millimeters), fluted grit blasted titanium tapered modular stems can be used effectively and efficiently. These stems are commercially available in diameters up to 30 millimeters and can be useful in capacious canals. It is wise to ream under fluoroscopic control and “by hand”, especially in osteopenic bone, in order to avoid anterior femoral cortical perforation. Remember, one is reaming a straight cone into a bowed canal. The typical malalignments are in varus and with anterior cortical impingement or perforation. When axial stability is obtained by diaphyseal reaming, the implant is impacted into place. It is wise to place prophylactic cable at the mouth of the distal fragment prior to stem impaction. The proximal bodies of the modular implants are then chosen to restore appropriate leg length, offset and hip stability. After trialing the components are assembled and the hip reduced. The proximal fragments are then reduced and cerclaged around the body of the implant. The author finds this strategy effective for B2 and even some B3 fractures, however, concerns remain about the durability of the modular junction of such stems without proximal bony support. The advantage of these modular constructs are the independent control of distal diameter, leg length, offset, and anteversion that make such reconstructions very time efficient.

Rarely, the proximal bone is so deficient that a modular proximal femoral replacement (so called “tumor prosthesis”) is appropriate. These are typically used in very osteopenic bone, therefore, cemented distal fixation is recommended. Preserving a sleeve of remaining proximal bone, albeit deficient, can provide some soft tissue attachment and assist in maintaining a stable hip. A coronal split (Wagner type) of the proximal bone can facilitate stem removal. The implant is cemented into the distal fragment, and then the proximal sleeve of remaining bone and soft tissue can be cerclaged around the body of the prosthesis with cable or heavy braided suture. It is important to note that if the abductors are deficient then the construct should probably include a constrained acetabular liner to minimize the risk of postoperative dislocation. If the acetabular component is of sufficient

diameter and a compatible constrained liner is not available, some surgeons have recommended cementing a constrained liner into a well fixed acetabular component. Good containment of the locked liner by the acetabular component is required, and cup position should be acceptable. Contouring the backside of the liner to be cemented is recommended (if it is smooth) to allow cement interdigitation. The author prefers to routinely add antibiotics to any cemented reconstructions in this setting in a ration of 1gram of Vancomycin powder to a 40 gram batch of cement.

Vancouver C type fractures occur well distal to the femoral component, and the component is almost always well fixed. The principles of fixation of these injuries are similar to those of a distal femur fracture. The challenges include the stress riser concern of the femoral component above. Some cadaveric data has demonstrated that if four diameters of diaphysis is available between supracondylar fixation and the tip of the femoral stem, then a short plate can be used without a significant stress riser effect. However, this situation in clinically exceedingly rare. The author prefers to bypass the femoral stem with the proximal part of the plate by about two cortical diameters. I avoid drilling into the cement mantle around the stem laterally if possible. The use of short retrograde nails should be discouraged in this setting.

After revision or internal fixation, patients are mobilized postoperatively, and full weight bearing is typically delayed for 6 weeks until some radiographic healing is evident. I generally allow 50% weight bearing with a walker, and at 6 weeks allow progression to full weight bearing. For revised patients, and abduction brace with a 70 degree flexion stop is used if necessary to avoid hyperflexion and adduction that can cause problems with greater trochanteric and other proximal fragments.

Orthopedic complications include dislocation, infection, leg length discrepancy, abductor limp, and mechanical failure or nonunion of proximal fragments. With modern modular stems limb length and stability can be optimized through adjusting body height, offset, and version. Abductor mechanism problems, however, have no good solution.

With the increasing numbers of older patients sustaining peri-prosthetic fractures around a total hip arthroplasty, the orthopedic traumatologist will have to be well versed in internal fixation and revision techniques. Careful attention to detail and understanding the principles of revision are necessary to minimize complications and provide durable, stable reconstructions for these difficult problems.

Fractures About the Distal Femur

David P. Barei M.D. F.R.C.S.(C)
Associate Professor
Harborview Medical Center
University of Washington
Seattle, Washington

Introduction

- The number of primary hip and knee arthroplasties continues to rise.
- The aging population, improved techniques and materials, and predictable results are some of the factors responsible. The incidence of periprosthetic fractures will also rise.
- Incidence of fracture after TKR: 0.3-2.5%. Prevalence after 6 years is 1.8%.
- Most common fracture about a TKR is the supracondylar femur fracture.

- Local factors, such as osteolysis, implant loosening, and notching of the anterior femoral cortex have been associated with this fracture.
- Periprosthetic fractures of the lower extremity are typically the result of low-energy mechanisms, such as simple falls. High-energy mechanisms with multi-system involvement are unusual. Patients are typically older and may have significant co-morbidities. Poor bone quality and associated joint ailments are common findings.
- Increasingly common are younger or older arthroplasty patients that are more physically active and exposed to higher energy injuries.

  The general approach to the management of any periprosthetic fracture should proceed as follows:

  1. Assessment of the stability of the prosthesis.
  1. Assessment of the fracture characteristics, particularly, displacement and angulation, location relative to the prosthesis, comminution, and bone quality.
  2. Assessment of patient characteristics, particularly functionality, general medical condition, and associated injuries.

FRACTURES AROUND TOTAL KNEE ARTHROPLASTY

Supracondylar Femur Fractures

Classification

- Three types, using fracture displacement and prosthetic stability as variables:
  - Type I fractures are undisplaced with a stable prosthesis.
  - Type II fractures demonstrate displacement with a stable prosthesis.
  - Type III fractures are displaced fractures with a loose or unstable prosthesis.

Treatment

Nonoperative Treatment

- Include the use of casts, cast-braces, and traction.
- Nonop techniques are associated with higher rates of malunion, nonunion, complications of prolonged recumbency and the loss of pre-injury motion.
- Present day indications are typically reserved for Type I undisplaced fractures, or for those patients who are unable or unwilling to tolerate a surgical procedure.

Operative Treatment

- Operative treatment techniques can be grouped into three main categories:
  - Medullary implants, including retrograde supracondylar nails, standard retrograde nails and flexible medullary nails.
  - Screw-plate implants, including condylar buttress plates, 95-degree angled blade plates, 95-degree dynamic condylar screws and fixed-angled screw-plate implants.
  - Revision total knee arthroplasty.
- Successful management requires achieving satisfactory stabilization of the distal condylar fragment. There are numerous factors that may complicate achieving this goal:
  - The capaciousness of the distal femoral canal.
  - Co-existing osteopenia secondary to age, pre-existing arthritic condition, stress shielding from the distal femoral implant, bone remodeling in response to the surgical implantation, cementation, etc.
  - Extreme distal fracture locations.

- These conspire to allow toggling of the condylar fragment despite a locked medullary implant or complicate secure screw purchase with conventional implants, allowing loss of fixation and reduction.
- Other challenges include patient comorbidities, location of previous surgical incisions, accurate assessment of patient functionality.

Author's Preferred Method

- Locked distal femoral plating is the author's preferred implant for these injuries.
- The pre-operative plan should consider:
  - The potential need for polyaxial locking plate designs that may allow for avoidance (or purposeful interaction) with posts, pegs, cement, areas of reasonable quality bone
  - Identification of plate length. This becomes increasingly important when associated with an ipsilateral total hip arthroplasty stem, metadiaphyseal comminution, and the potential for creating a stress riser at the location of the end of the stabilizing distal femoral implant.
  - A plan for augmentation of the condylar fixation should it become evident that large bone voids are present, eg, PMMA, drillable calcium phosphate bone substitutes, etc.
  - Open versus percutaneous reduction and fixation. Open fixations are occasionally preferred in situations with altered femoral anatomy (bowing, previous fixations, etc.) Minimization of direct fracture comminution manipulation should be minimized.

References

1. Althausen PL, Lee MA, Finkemeier CG, Meehan JP, Rodrigo JJ. Operative stabilization of supracondylar femur fractures above total knee arthroplasty: a comparison of four treatment methods. *J Arthroplasty 2003;18-7:834-9.*
2. Anakwe RE, Aitken SA, Khan LA. Osteoporotic periprosthetic fractures of the femur in elderly patients: outcome after fixation with the LISS plate. *Injury 2008;39-10:1191-7.*
3. Appleton P, Moran M, Houshian S, Robinson CM. Distal femoral fractures treated by hinged total knee replacement in elderly patients. *J Bone Joint Surg Br 2006;88-8:1065-70.*
4. Berry DJ. Epidemiology: hip and knee. *Orthop Clin North Am 1999;30-2:183-90.*
5. Chettiar K, Jackson MP, Brewin J, Dass D, Butler-Manuel PA. Supracondylar periprosthetic femoral fractures following total knee arthroplasty: treatment with a retrograde intramedullary nail. *Int Orthop 2009;33-4:981-5.*
6. Erhardt JB, Grob K, Roderer G, Hoffmann A, Forster TN, Kuster MS. Treatment of periprosthetic femur fractures with the non-contact bridging plate: a new angular stable implant. *Arch Orthop Trauma Surg 2008;128-4:409-16.*
7. Fulkerson E, Tejwani N, Stuchin S, Egol K. Management of periprosthetic femur fractures with a first generation locking plate. *Injury 2007;38-8:965-72.*
8. Gliatis J. Periprosthetic distal femur fracture: plate versus nail fixation. Opinion: intramedullary nail. *J Orthop Trauma 2007;21-3:220-1.*
9. Gliatis J, Megas P, Panagiotopoulos E, Lambiris E. Midterm results of treatment with a retrograde nail for supracondylar periprosthetic fractures of the femur following total knee arthroplasty. *J Orthop Trauma 2005;19-3:164-70.*
10. Haidukewych G, Sems SA, Huebner D, Horwitz D, Levy B. Results of polyaxial locked-plate fixation of periarticular fractures of the knee. *J Bone Joint Surg Am 2007;89-3:614-20.*
11. Haidukewych G, Sems SA, Huebner D, Horwitz D, Levy B. Results of polyaxial locked-plate fixation of periarticular fractures of the knee. Surgical technique. *J Bone Joint Surg Am 2008;90 Suppl 2 Pt 1:117-34.*
12. Haidukewych GJ. Periprosthetic distal femur fracture: plate versus nail fixation. Opinion: open reduction internal fixation. *J Orthop Trauma 2007;21-3:219-20.*
13. Haidukewych GJ, Jacofsky DJ, Hanssen AD. Treatment of periprosthetic fractures around a total knee arthroplasty. *J Knee Surg 2003;16-2:111-7.*

14. **Herrera DA, Kregor PJ, Cole PA, Levy BA, Jonsson A, Zlowodzki M.** Treatment of acute distal femur fractures above a total knee arthroplasty: systematic review of 415 cases (1981-2006). *Acta Orthop 2008;79-1:22-7.*
15. **Kolb K, Koller H, Lorenz I, Holz U, Marx F, Grutzner P, Kolb W.** Operative treatment of distal femoral fractures above total knee arthroplasty with the indirect reduction technique: a long-term follow-up study. *Injury 2009;40-4:433-9.*
16. **Kregor PJ, Hughes JL, Cole PA.** Fixation of distal femoral fractures above total knee arthroplasty utilizing the Less Invasive Stabilization System (L.I.S.S.). *Injury 2001;32 Suppl 3:SC64-75.*
17. **Large TM, Kellam JF, Bosse MJ, Sims SH, Althausen P, Masonis JL.** Locked plating of supracondylar periprosthetic femur fractures. *J Arthroplasty 2008;23-6 Suppl 1:115-20.*
18. **O'Toole RV, Gobezie R, Hwang R, Chandler AR, Smith RM, Estok DM, 2nd, Vrahas MS.** Low complication rate of LISS for femur fractures adjacent to stable hip or knee arthroplasty. *Clin Orthop Relat Res 2006;450:203-10.*
19. **Parvizi J, Jain N, Schmidt AH.** Periprosthetic knee fractures. *J Orthop Trauma 2008;22-9:663-71.*
20. **Ricci WM, Borrelli J, Jr.** Operative management of periprosthetic femur fractures in the elderly using biological fracture reduction and fixation techniques. *Injury 2007;38 Suppl 3:S53-8.*
21. **Ricci WM, Loftus T, Cox C, Borrelli J.** Locked plates combined with minimally invasive insertion technique for the treatment of periprosthetic supracondylar femur fractures above a total knee arthroplasty. *J Orthop Trauma 2006;20-3:190-6.*
22. **Ritter MA, Thong AE, Keating EM, Faris PM, Meding JB, Berend ME, Pierson JL, Davis KE.** The effect of femoral notching during total knee arthroplasty on the prevalence of postoperative femoral fractures and on clinical outcome. *J Bone Joint Surg Am 2005;87-11:2411-4.*
23. **Wilkens KJ, Curtiss S, Lee MA.** Polyaxial locking plate fixation in distal femur fractures: a biomechanical comparison. *J Orthop Trauma 2008;22-9:624-8.*
24. **Zalzal P, Backstein D, Gross AE, Papini M.** Notching of the anterior femoral cortex during total knee arthroplasty characteristics that increase local stresses. *J Arthroplasty 2006;21-5:737-43.*

Outcome of Periprosthetic Fractures Lower Extremities

Thomas Ellis, M.D.
Associate Professor
Vice Chair, Department of Orthopaedics
Ohio State Medical Center
Columbus, OH

I. Periprosthetic Acetabular Fractures
   a. Very little outcome data
   b. If standard or revision cup can be used and fracture heals, then results can be comparable to an acetabular revision surgery
   c. If acetabular reconstruction ring is necessary, then outcome will be less favorable, but subsequent revision may be less complicated if fracture heals.

II. Periprosthetic Femur Fractures
   a. Vancouver B1 Fractures
      i. Excellent outcomes with lateral non-locking plates
      ii. Addition of anterior allograft strut confers more stability to the fracture, but may not be necessary in patients with good bone stock
      iii. Locked plating not advantageous except in osteoporotic bone
   b. Vancouver B2 Fractures
      i. Revision to a long stem cementless prosthesis results in predictable fracture healing

ii. Augmentation of fixation a lateral plate, allograft strut, or both may improve construct stability

c. Vancouver B3 Fractures
  i. Long stem cementless components or impaction grafting have good results.
  ii. In cases of severe proximal femoral loss, a proximal femoral replacement is an option. Dislocation, wound complications, and refracture occur at higher rate.

d. Vancouver C Fractures
  i. Excellent results with non-locking (good bone quality) or locking (poor bone quality) plates (no anterior strut).

III. Periprosthetic Fractures Above TKR
  a. Femur stable
    i. ORIF with locked plate has few complications (nonunion and malunion) compared to intramedullary nailing or non-locking plate
    ii. Intramedullary nailing with fewer complications than non-locking lateral plates, but malunion is frequent due to metaphyseal nature of fracture.
  b. Femur Loose
    i. Good bone stock
      1. Revision to a stemmed posterior stabilized or constrained TKR good option to avoid hinged prosthesis
      2. Results comparable to revision TKR
    ii. Poor bone stock
      1. Distal femoral replacement is a reasonable option, but long term concerns are implant loosening

IV. Periprosthetic Tibia Fractures
  a. Limited data available.
  b. Fracture around unstable tibial component
    i. Revision is required and outcome should be similar to revision TKR
  c. Distal to stable total knee
    i. Treat with locking or standard plate.
    ii. Results should be comparable to treatment of similar fracture in non-total knee situation.

References

1. Bryant GK, Morshed S, Agel J, Henley MB, Barei DP, Taitsman LA, Nork SE. Isolated locked compression plating for Vancouver Type B1 periprosthetic femoral fractures. *Injury* 2009 Jun 18. [Epub ahead of print]
2. Kobbe P, Klemm R, Reilmann H, Hockertz TJ. Less invasive stabilisation system (LISS) for the treatment of periprosthetic femoral fractures: a 3-year follow-up. *Injury* 2008;39(4):472-9.
3. Ebraheim NA, Gomez C, Ramineni SK, Liu J. Fixation of periprosthetic femoral shaft fractures adjacent to a well-fixed femoral stem with reversed distal femoral locking plate. *J Trauma* 2009;66(4):1152-7.
4. Ricci WM, Bolhofner BR, Loftus T, Cox C, Mitchell S, Borrelli J Jr. Indirect reduction and plate fixation, without grafting, for periprosthetic femoral shaft fractures about a stable intramedullary implant. Surgical Technique. *J Bone Joint Surg Am* 2006;88 Suppl 1 Pt 2:275-82.
5. Zdero R, Walker R, Waddell JP, Schemitsch EH. Biomechanical evaluation of periprosthetic femoral fracture fixation. *J Bone Joint Surg Am* 2008;90(5):1068-77.
6. O'Shea K, Quinlan JF, Kutty S, Mulcahy D, Brady OH. The use of uncemented extensively porous-coated femoral components in the management of Vancouver B2 and B3 periprosthetic femoral fractures. *J Bone Joint Surg Br* 2005;87(12):1617-21.
7. Ricci WM, Borrelli J Jr. Operative management of periprosthetic femur fractures in the elderly using biological fracture reduction and fixation techniques. *Injury* 2007;38 Suppl 3:S53-8.

8. Chakravarthy J, Bansal R, Cooper J. Locking plate osteosynthesis for Vancouver Type B1 and Type C periprosthetic fractures of femur: a report on 12 patients. *Injury* 2007;38(6):725-33.
9. Large TM, Kellem JF, Bosse MJ, Sims SH, Althausen P, Masonis JL. Locked plating of supracondylar periprosthetic femur fractures, J Arthroplasty 2008 23(6), 115-120.
10. Herrera DA, Kregor PJ, Cole PA, Levy BA, Jonssan A, Zlowodzki M. Treatment of acute distal femur fractures above a total knee arthroplasty: systematic review of 415 cases (1981-2006). Acta Orthop 2008 79(1), 22-27.
11. Ricci WM, Borrelli J Jr. Operative management of periprosthetic femur fractures in the elderly using biological fracture reduction and fixation techniques. Injury 2007 38 (suppl 3), 53-58.
12. Harrison RJ Jr, Thacker MM, Pitcher JD, Temple HT, Scully SP. Distal femur replacement in useful in complex total knee arthroplasty revisions. Clin Orthop Relat Res. 2006 May;446:113-20.