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AAOS 2024--Disaster-plasty: A case-based guide to leveraging trauma and arthroplasty skills for the extreme challenges
Moderator: Elizabeth B. Gausden, M.D., M.P.H.
OUTLINE (90 minutes)

Introduction- GH (5 minutes)

1. Periprosthetic femur fracture nonunion: What do I do now? (David S. Wellman, M.D.) (7 minutes)
2. Fractured... and Infected: Dealing with infections following periprosthetic fractures (Chloe Scott, M.D.) (7 minutes)
3. Periprosthetic Fractures of the Femur with Massive Bone Loss: Managing with Revision Arthroplasty (Brian Gladnick, M.D.) (7 minutes)
4. Periprosthetic acetabular fractures: Approach and timing (Frank Liporace, M.D.) (7 minutes)
5. Periprosthetic fractures of the tibia: use of the extreme tibial nail and when to plate (Richard Yoon, M.D.) (7 minutes)
6. Malunion and arthroplasty: Addressing alignment through revision
7. (Mathias Bostrom, M.D.) (7 minutes)
8. Revision TKA in setting of massive osteolysis: Cones have changed the game (Nicholas Bedard, M.D.) (7 minutes)
9. Bridge plating to prevent inter-prosthetic femur fractures: Call me now or call me later! (Brandon Yuan, M.D.) (7 minutes)
10. Use of distal femoral replacement for periprosthetic distal femur fractures: My tips to make this last (Cara Cipriano, M.D.) (7 minutes)
11. Extreme nailing of periprosthetic distal femur fractures (Elizabeth Jacobs, M.D.)
12. Rapid Fire Case-Based Examples (Elizabeth Gausden, M.D., M.P.H.) (10 minutes)

Periprosthetic femur fracture nonunion: What do I do now?

David S. Wellman, M.D.

- Nonunion workup
    - Why didn't it heal?
        - Patient issue?
        - Infection?
        - Biology?
        - Technical/Mechanical Issue?
    - Can that problem be corrected, and most importantly, can the patient tolerate it?
        - How to correct technical/mechanical issues
        - How to add biology
        - Don't forget to assess if arthroplasty is worth saving

    What are the advantages and disadvantages of each approach?
    - Execute
        - Correcting the technical/mechanical issue - Case example of revision ORIF
        - Bypassing the biologic or patient issue – Case example of revision arthroplasty
        - When do you need to do both? – Case example of ORIF + revision (examples of femoral nonunions above unstable CR TKAs, I have some video of this)

Fractured... and Infected: Dealing with infections following periprosthetic fractures

Chloe Scott, MD, MSc
Edinburgh Orthopaedics, Royal Infirmary of Edinburgh, UK

Definition:

- Rate of fracture-related infection (FRI) very variable: 3 – 20%
- Definitely infected: wound breakdown and purulent drainage
- Possibly infected: Erythema, warmth and swelling. Also present in aseptic non-union.

Diagnosis:

- *Blood tests:* CRP and blood cultures.
- *Imaging:* Fracture union, implant loosening and osteomyelitis (periosteal reaction) may be evident on plain radiographs but may require CT which will also identify sequestrations and associated collections. Collections/effusions should be aspirated +/- ultrasound guidance.
- *Microbiology:* aspirates and deep tissue samples essential for microbiology and histology. Do not send wound edges/sinus tracts due to contamination with multiple organisms.

Avoiding infection

Soft tissue management:

- *Timing of surgery*: the majority of PPFFs are low energy and benefit from prompt fixation. Some high energy injuries with significant soft tissues injury (eg. button holing through knee capsule) may require surgical delay.
- *Approach:* haemeostasis with sequential identification and tying off of perforating vessels minimizes blood loss, haematoma formation and postoperative anaemia
- *Skin closure:* consider deep tension nylon mattress suture closure in fragile skin/high BMI
- *Negative pressure dressings:* where there is concern about the potential for wound leakage.
- *Resting:* splinting knees in extension for 1-2 weeks until the skin has healed or using negative pressure dressings can be useful where skin is fragile or multiply operated

Antibiotics:

- Extended antibiotic prophylaxis (for 3-7 days), intra-incisional Vancomycin; antibiotic cement.

Medical management:

- *Anticoagulation*: DOACs can cause wound league in elderly. Use LMWH in preference until skin has healed.
- *Optimize medical management* – manage diabetes and anaemia. Orthogeriatric and microbiology/infectious diseases multidisciplinary care.

Management of PPF infection:

- Antibiotic suppression until fracture union AND surgical eradication of the biofilm
- Fracture stability is essential for infection eradication.
- Mean time to periprosthetic femoral fracture union is ~6 months - osteomyelitis can occur while waiting for union.
- Staph aureus and coagulase negative staph are most common organisms in FRI.
- Treatment strategy (Eradication Vs long term suppression) determined by fracture pattern, organism, and host.
- Eradication requires a stable construct, a good soft tissue envelope and an effective surgical debridement.
- Scenario 1: Bone preservation and <u>infection eradication</u>
    - Requires good host and easy to treat infection (sensitive single organism)
    - Debride and sample, suppress, obtain union, revise (in 1 or 2 stages).

- Scenario 2: Non-bone preserving <u>infection eradication</u>
    - Requires good host and easy to treat organism
    - Radical debridement, single stage endoprosthetic replacement
- Scenario 3: <u>Long term suppression</u>
    - When the implant must be retained (fracture not united) OR difficult to treat organism (multiresistent/polymicrobial) OR unfit host.
    - Washout, debridement, and sampling followed by antibiotic suppression +/- sinus formation. As implant is retained biofilm cannot be eradicated.
    - May be needed in frail elderly patients regardless of organism if too frail for extensive revision surgery. This approach may also be required in less frail patients with resistant organisms that are difficult to treat or polymicrobial infection.

Periprosthetic Fractures of the Femur with Massive Bone Loss: Managing with Revision Arthroplasty
(Brian Gladnick, M.D.) (7 minutes)

Background:
Periprosthetic fractures of the femur are a devastating complication after total hip arthroplasty and are associated with significant morbidity. Risk of complications such as fracture, instability, and infection are increased in these high-risk patients, and mortality after revision may be as high as 21% at one year post-operatively [1].

Perhaps one of the most challenging aspects of treating these injuries is dealing with the inherent bone loss that is typically seen in the revision scenario, but can be compounded in the periprosthetic fracture setting [2]. Patients are typically older, with poor bone quality and low bone mineral density. Furthermore, comminution at the fracture site or bone loss that occurs during cement removal may. compound these reconstructive challenges.

One of the most important components of pre-operative planning for revision THA of a periprosthetic femur fracture is assessing where the best residual bone exists, and templating a reconstruction that maximizes the chance of getting durable mechanical fixation with a stable fracture construct [3]. The Vancouver classification is the most well-known and useful classification in this scenario and provides an algorithm for fixation that is matched to the patient's fracture type. Vancouver B2 fractures are fractures that occur around the femoral component, with coincident debonding of the implant from bone, cement, or both. In Vancouver B3 fractures, the stem is similarly loose, but with the added complication of poor proximal bone stock. While Vancouver B2 fractures may commonly be reduced anatomically and revised with either a longer primary or revision stem, Vancouver B3 fractures often are more challenging to reduce, and may require even longer modular stems with or without bone grafting in order to achieve a stable construct, ideally with at least 4cm of stem-cortical contact length [4,5].
Finally, intraprosthetic fractures below the tip of a well-fixed stem can be a unique challenge due to the difficulty of achieving either proximal or distal fixation, and may require longer revision constructs to bridge the fracture zone, particularly when prior plating has been unsuccessful [6].

Case 1:
Vancouver B3 fractures may occur in situations in which a previously loose stem has caused progressive proximal bone loss, ultimately resulting in a fracture due to the weakened bone, mechanical fall, or a combination of both. Osteolysis from polyethylene wear may influence the loss of proximal bone stock, and pre-operative radiographs should be scrutinized for eccentric wear of the femoral head.

In the present case, a loose cemented stem in a 79-year-old female has caused progressive proximal bone loss, with a capacious proximal canal and cortical thinning, especially posteriorly. Pre-operative plan was to bypass this area of poor proximal bone with a modular, splined tapered stem, achieving at least 4cm of cortical contact distally. Intra-operative clinical photographs show that the stem was grossly loose, and was removed through a direct anterior approach with its cement mantle intact. Reduction was achieved with luque wires and a turkey-claw fracture clamp, which allows for stable fracture reduction while reaming. A wire has been placed below the fracture site to prevent distal propagation. Post-op films demonstrate reduction of the fracture, which has been bypassed by a modular splined tapered stem with at least 4cm of cortical contact distally. Note the proximal bone loss and thinned cortices on the post-operative view.

Case 2:
In the setting of conversion arthroplasty, the first step in pre-operative planning should always be to

rule out infection. This is particularly concerning in the setting of femoral nonunion, where the rate of indolent infection may be as high as 21-44%, and the offending organism is most often Staphylococcus species [7]. Patients should be questioned specifically about infection history surrounding the previous fracture surgery, including wound healing issues, prolonged drainage, extended use of antibiotics, or return trips to the OR for irrigation and debridement. Laboratory workup includes ESR and CRP; if these labs are elevated or if there is any clinical suspicion for infection, aspiration and culture should be performed. If radiology aspiration is not feasible, a staged procedure including removal of hardware may be performed in order to obtain samples of the fracture site and hardware for culture to rule out infection prior to definitive arthroplasty. Once infection has been definitely ruled out, arthroplasty may proceed; however care must be taken to address any bone defects, screws holes, or other stress risers which may exist after removal of the femoral hardware. If the femoral architecture is relatively preserved, reconstruction may be accomplished with a primary-type stem, but in cases of nonunion, malunion, or severe proximal bone defect, it may be necessary to bypass the deficient area with a distally engaging revision stem.

In the present case, a 68-year-old female presents with an extensive surgical history involving her left femur, including multiple revision ORIF procedures for nonunion and ultimately requiring a vascularized fibular autograft to achieve femoral union. Her pre-operative ESR and CRP were elevated. Because of the likely low utility of IR aspiration of the fracture site, she instead underwent a staged procedure including removal of multiple proximal screws in order to culture both the hardware and screw tracts prior to definitive arthroplasty. While cultures were all negative for infection, unfortunately she suffered a fall from her wheelchair four weeks out from hardware removal, resulting in a transverse fracture through one of the residual screw tracts, greatly increasing the complexity of the reconstruction.

A two-incision approach is planned, as seen in the preoperative clinical photograph. The fracture is provisionally reduced with a plate applied via a lateral approach to the lateral aspect of the femur via cables. Definitive stability is achieved by placing a modular splined-tapered stem through a direct anterior approach. The tapered, splined stem design provides axial and torsional stability, essentially acting like an intramedullary nail. Proximally, a modular cone body is mated to the distal stem component, completing the femoral component of the arthroplasty.

Case 3:
Vancouver C periprosthetic fractures are located distal to the tip of a well fixed femoral stem, and are usually amenable to open reduction and plating [4]. However, the presence of the femoral stem in the canal of the femur increases the complexity of the biomechanical environment of the fracture. A stress riser at the tip of the stem, particularly in a stiff, distally fitting stem, may significantly impair fracture healing. Furthermore, proximal fixation is compromised due to the presence of the femoral stem. In the setting of a concomitant knee replacement, distal fixation may also be compromised; these interprosthetic femur fractures are particularly challenging and have a revision rate as high as 24% [6].

The present case is a 78-year-old femur with a previous left THA and left TKA, who presented with a short oblique Vancouver C interprosthetic fracture below the tip of an SROM stem. This was initially treated with open reduction and lateral plating. Due to limited screw options proximally with the canal completely filled by the distally-reamed SROM stem, proximal fixation was limited to using a combination of cables and unicortical locking screws. The patient did well clinically and was fully weight bearing by three months post-operatively. However, at one year post-operative, she re-presented
acutely with a hypertrophic varus malunion at the fracture site and fracture of the lateral plate.

In order to stabilize her fracture site and promote bony healing, the SROM stem was revised to a longer diaphyseal-engaging stem that bypasses the fracture site, acting as an intramedullary nail. A lateral plate was then re-applied, spanning the entire femur, and a fibular strut graft was cabled anteriorly across the fracture site. The patient went on to achieve full radiographic union with this construct.

Case 4:
Interprosthetic fractures in which the patient has undergone previous revision arthroplasty are a unique reconstructive challenge. The presence of a revision implant (including stems, cones, sleeves, or other internal fixation) often makes revision surgery with typical revision implants difficult and sometimes impossible, because the patient may lack enough residual bone for fixation either proximally or distally. In these patients, bypassing the entire construct with a total femur replacement may be the only durable reconstructive option. Patients should be adequately counseled pre-operatively, as these operations have a high complication rate, and post-operative functional status may be limited by the extensive dissection and bone resection often required in such procedures [8].

In the present case, a 61 year-old-male presents with a right femur interprosthetic fracture between a total hip replacement and a distal femoral replacement, which had already failed two attempts at ORIF. The presence of a distal femoral replacement prevents the possibility of spanning the fracture with a long-stemmed THA construct, hence the decision was made to move forward by spanning the entire femur with a total femur replacement. Due to the patient's young age and prior functional status, the implant of choice was a bone-conserving intramedullary total femur. This device acts as an intramedullary nail spanning the fracture zone, but is a distal femur endoprosthesis at the knee, and proximally mates with a THA cone body, similar to reconstruction with any modular stem. A trochanteric claw plate which locks into the cone body was used to stabilize a fracture of the greater trochanter. Six year follow up films demonstrate durability of. the endoprosthetic construct and healing of the diaphyseal nonunion.

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Periprosthetic acetabular fractures: Approach and timing
(Richard Yoon, M.D.) (7 minutes)

I.) Epidemiology

II.) Risk Factors

III.) Classification

IV.) Treatment Options & When to Enlist Them

a. Non-operative management

b. Revision style jumbo cup as a plate

c. Plate plus multi-hole cup

d. Cup-cage

e. Triflange

Malunion and Arthroplasty: Addressing alignment through revision

Mathias Bostrom, M.D.

I. Causes of extra-articular deformity around TKA
  a. Congenital abnormalities
  b. Posttraumatic malunion
  c. Previous osteotomies

II. Evaluation
  a. Long leg hip to ankle radiographs
  b. Dedicated knee films likely to miss extra-articular deformity
  c. CT scan useful to assess for union in posttraumatic cases
  d. Previous operative reports for assistance with hardware removal

III. Planning
  a. Assess leg length discrepancy
  b. Intraarticular correction
    i. If extra-articular deformity is <20 degrees in the coronal plane on femoral side or <30 degrees on the tibial side or when the CORA is located outside the metaphyseal region
  c. More severe deformities, consider extra-articular osteotomy
    i. If the intraarticular correction will compromise ligamentous attachments
    ii. Staged technique

IV. Cases

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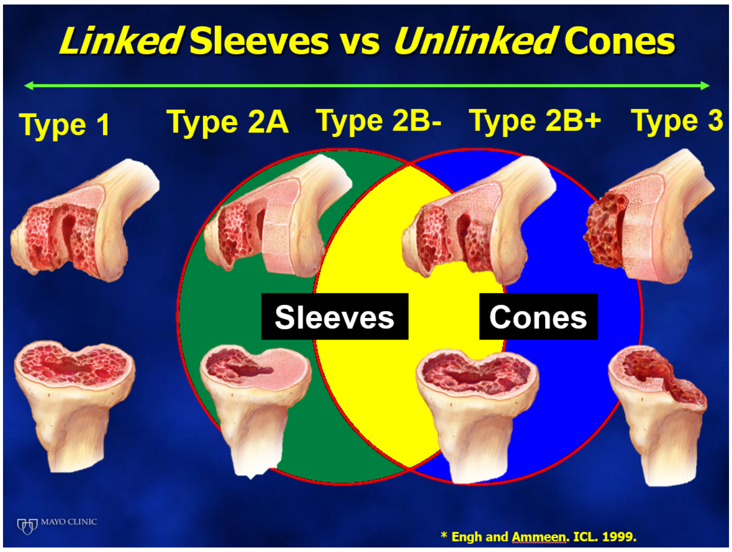
Revision TKA in the Setting of Massive Osteolysis: Cones Have Changed the Game

Nicholas Bedard, M.D.
Mayo Clinic

Massive bone loss on the femur and tibia during revision total knee arthroplasty (TKA) remains a challenging problem.

Osteolysis can be a result of infection, loose implants, corrosion, or polyethylene wear. It is important to rule out infection with serum ESR/CRP and aspiration prior to revision TKA. The results of the synovial cell count may be falsely elevated in the setting of osteolysis (especially if it is due to metallosis) so a manual cell count is recommended to evaluate for infection.

Biologic metaphyseal fixation is key to a successful revision TKA with substantial bone loss. In cases of massive osteolysis and metaphyseal bone loss, metaphyseal cones are preferred over sleeves.



Metaphyseal cones help to rebuild the metaphysis to support the implant and aid in long term fixation via bone ingrowth into the cone.
When revising for massive osteolysis it is important to remove all osteolytic material, soft tissue and/or debris from the bone. This helps to maximize osteointegration of the cones and cement fixation.
Metaphyseal cones come in many shapes and sizes which allow for intraoperative trialing to maximize bone-cone contact. Given that cones are linked to the implant via cement, this allows for the cone to be positioned in a way that appropriatly fills the bony defect and maximizes host bone contact without dictating implant placement.
An intraoperative radiograph with trial implants in place is recommend during revision TKA surgery. This allows for assessment of alignment, stem size and component position while such variables can still be modified during surgery.
It is preferred to utilize cemented stems for implant fixation when using a metaphyseal cone. Cement allows for immediate fixation, shorter constructs, and the ability to cheat anatomy (if needed) in complex revision TKA.
Initial construct rigidity is a key tenant of successfully utilizing metaphyseal cones. If the cone is not held rigidly stable by the cemented stem and implant, then osteointegration will

not occur and the longevity of the construct will be compromised. As such, if the diaphyseal canal has been previously violated (i.e., stemmed implant) there may not be cancellous bone remaining for cemented stem fixation. If the diaphyseal canal is polished and sclerotic from prior instrumentation, then diaphyseal impaction grafting is recommend to optimize diaphyseal fixation and better support the construct for cone osteointegration.

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Bridge plating to prevent inter-prosthetic femur fractures: Call me now or call me later!
(Brandon Yuan, M.D.) (7 minutes)

- Introduction:
  - Answer these questions:
    - Distal femur fracture – Using a plate – ***How long should it be?***
      - Case example – Distal femur fx with THA above and one without.
      - Determine mode of plate application first – Plate length will follow from there.
      - Never leave a stress riser – If you think about it, just do it!
      - Do the screws into the femoral neck really "protect" it?
    - Distal femur fracture with THA – ***Can I still use a nail?***
      - Case example of fracture that should be nailed
      - How/when to plate the stress riser.
      - Never leave a stress riser – If you think about it, just do it!
    - Proximal femur fracture ORIF – ***How distal should the plate go?***
      - Differences in proximal and distal femoral anatomy
      - How to go distal – Plate prominence versus preventing the next fracture
    - What about modular implants – ***How/when to use them***
  - Remember: These people break their bones for a living!

<u>Use of distal femoral replacement for periprosthetic distal femur fractures: My tips to make this last</u>

Cara Cipriano, M.D., M.Sc.
Associate Professor
University of Pennsylvania

I. Indications (DFR vs ORIF)

A. Advantages: Allows immediate weightbearing, avoids risk of nonunion
B. Disadvantages: Loss of bone stock, increased hardware and dead space
C. Considerations
  - Feasibility of salvage (residual bone stock and ligamentous stability)
  - Functionality of current prosthesis prior to fracture
  - Patient preference and tolerance for various risks

II. Technique

A. Approach
  - Medial parapatellar for distal fractures
  - Lateral subvastus for more proximal fractures (extensile, quadriceps-sparing)

B. Rotation
  - External rotation to optimize patellar tracking
  - Assess using linea aspera

C. Length
  - Estimate based on soft tissue tension (ITB)
  - Measure against contralateral limb
  - Caution: extend the knee slowly after placing trials to avoid fracture

III. Implant selection

A. Press fit versus cemented stems
B. Adjustable rotation of distal femoral component relative to stem
C. Minimum resection to accommodate implant
D. Fully vs partially constrained rotation (risk of patellar dislocation in patients with weak quadriceps function)
E. Metaphyseal cones/sleeves (more stable fixation after distal fractures in larger femurs)
F. Tibial fixation

IV. Postoperative care

A. Early mobilization (WBAT, OOB)
B. Dead space control
  - Compressive wrap
  - Drains
    - Leave in place until output is consistently low/plateaus
    - Consider oral antibiotics while drains in place