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ESSENTIAL SURGICAL TECHNIQUES

SUBSPECIALTY PROCEDURES

Management of Vancouver Type-B2 and B3 Periprosthetic Femoral Fractures

Restoring Femoral Length via Preoperative Planning and Surgical Execution Using a Cementless, Tapered, Fluted Stem

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Introduction

Periprosthetic femoral fractures, which are likely to increase as the population ages and total hip arthroplasty becomes more prevalent[1], can be effectively managed by restoring femoral length via preoperative planning and surgical execution using a cementless, tapered, fluted stem. In practice, these fractures represent notable surgical complexity. Variability in both fracture patterns and treatment options make the Vancouver classification a useful classification system and guide[2,3]. Still, patient-related factors, such as age, activity level, and comorbidity, must be evaluated as periprosthetic fractures are associated with relatively increased mortality[4,5]. In a retrospective survival analysis of the cases of 121 patients, Füchtmeier et al. identified advanced age, American Society of Anesthesiologists score, and the presence of dementia as patient-related risk factors for mortality[6]. Füchtmeier et al. did not find that fracture type or procedural choices increased the risk for either mortality or revision surgery[6]. However, there is evidence that adhering to the Vancouver guidelines when choosing a procedure decreases the risk of prosthesis failure, especially in Vancouver type-B2 and B3 periprosthetic fractures[7,8].

Bone-grafting, cerclage cables, or open reduction and internal fixation are each independent options when the stem remains securely fixed, i.e., in Vancouver type-A or B1 fractures[3]. However, in Vancouver types B2 and B3, in which the femoral prosthesis is unstable or loose, revision total hip arthroplasty is the standard of care[3].

Stem design is also important to consider. The flexibility that modular stems offer may be advantageous in these complex revision cases. However, nonmodular monobloc stems are gaining popularity, and can allow for reliable

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fixation and fracture-healing when used effectively[9-11]. More specifically, cementless, tapered, fluted designs have shown positive outcomes[9-15]. This design is versatile, as it allows the surgeon to ream to a particular depth and diameter, and expect the trial to sit in the prepared position. Assessment of leg length and soft-tissue tension can then be performed. If the trial component sits proud, it can be removed; the canal, reamed deeper; and the trial, reinserted and reassessed. If the trial sits too deep, a larger-diameter trial can be inserted into the same reamed canal, allowing it to sit more proudly. The actual implant can then be inserted. Modular tapered stems that do not have trial components can be similarly deepened through removal and reaming of the canal, while a stem that sits deep can be built up proximally by changing the modular segment. As recommended by Berry [12], the implant is placed into the distal, uninvolved femoral diaphysis to achieve solid fixation and allow for anatomic rebuilding of the fracture around the newly formed strut. Our videos illustrate the use of both modular and monobloc stems with cementless, tapered, fluted designs (Videos 1 through 4). Different implant systems have different personalities regarding the relationship between the trial used and the final implant chosen. The nonmodular implant trial used in 1 of our patients, Case 2, is recommended to match the final implant (Video 3).

Because of the complex nature of these fractures, we find that efficient surgical management benefits from thorough preoperative planning for optimal and reproducible reconstruction and outcomes. We report on a technique that incorporates detailed preoperative planning as described by Rodriguez et al.[15]. In Videos 2 and 3, this integrated preoperative planning and operative technique is demonstrated in 2 patients (Cases 1 and 2). Initial planning centers on the identification of radiographic landmarks in order to restore the prefracture limb length and soft-tissue tension during reconstruction.

In order to estimate the amount of limb lengthening required, the surgeon may (1) compare the prefracture position of the stem tip (if visible) and the postfracture position, or (2) compare the length of the fractured limb and the length of the contralateral, uninjured limb using any available landmarks (e.g., the center of rotation [COR] to the lesser trochanter). The surgeon may then determine the desired COR needed for further templating. Although we provide cases with both examples, radiographic determination of limb shortening is often difficult and relies on local anatomic landmarks that may not be visible or may be distorted by the fracture. Traction views under anesthesia may be of utility in this circumstance.

In order to plan the reaming depth preoperatively, we demonstrate first choosing a template of a femoral stem that may achieve stability in the distal femoral canal, and then identifying an anatomic landmark that can be referenced intraoperatively (such as the most proximal fracture spike of the distal bone segment). Many revision templates make use of a reference line that allows the surgeon to match the desired depth of the implant on templating to the same depth during intraoperative reaming. We measure the distance from the fracture spike to this reference line on the template, and then intraoperatively from the fracture spike to the corresponding reference line on the reamer to match the distance specified in the preoperative plan. We seek a length of 2 cortical diameters distal to the distal point of the fracture, when this is achievable. The tapered portion of the implant should be in intimate contact with the distal intact cortical tube. Reaming and stem trial insertion can be checked using the image intensifier to ensure this relationship. We will usually insert a prophylactic cable distal to the fracture prior to reaming, in order to prevent inadvertent fracture propagation during femoral preparation.

Lastly, relying solely on radiographic assessments is insufficient. The goals of the reported preoperative planning technique are to understand the needs of the implant and to begin thinking about what will be encountered during the surgery. The quality of the reconstruction will be judged on several intraoperative measures. These include assessments of stability, clinical leg-length changes (palpated either at the flexed knee or at the heels with extended knees), quality of fracture reduction, and measurements of offset and COR in comparison with the preoperative plan (Video 3).

Video 1 Introduction
Video 2 Case 1. (The images of the femoral implant are reproduced with permission of Link Bio.)
Video 3 Case 2
Video 4 Conclusion

Indications & Contraindications

Indications

- Vancouver type-B2 periprosthetic femoral fractures.
- Vancouver type-B3 periprosthetic femoral fractures.

Contraindications

- Insufficient bone stock for distal stem fixation.
- Fractures with comminution that extends into the distal femoral metaphysis can be a particular challenge for planning and achieving stem fixation. In these rare cases, adjunctive fixation with plates and strut allografts may be required.
- Fractures in the setting of infection.

Step 1: Preoperative Plan

Template the contralateral, uninjured side.

- Template the radiograph of the contralateral, uninvolved side, when available, to understand the ideal size and placement of the chosen stem in the intact femur. Specifically aim for reproduction of the anatomic COR with intimate apposition of the distal taper of the implant to the endosteal bone. Then note the relationship of the COR to local anatomic landmarks: greater trochanter, lesser trochanter, etc.

Step 2: Template the Fractured Side

Identify the ideal COR on the injured side and template the femoral stem.

- Identify the ideal COR:
    - If stem migration within the distal end of the bone can be identified relative to a local landmark, such as a cement mantle, as in Case 1:
        - Measure the prefracture location of the stem tip to the current, postfracture location (the amount of limb shortening).
        - Identify the current location of the center of the femoral head.
        - Add the previously measured amount of shortening proximally to the current center of the femoral head to reestablish the COR.
    - If stem migration within the proximal part of the bone, or both the proximal and distal parts of the bone, is present as in Case 2:
        - Measure the distance from the COR to the lesser trochanter on the contralateral side.
        - Measure the distance from the COR to the lesser trochanter on the involved side.
            - Take the difference between these 2 measurements to estimate the amount of limb shortening that has occurred relative to the proximal fragment.
            - Add this amount of shortening proximally to the current center of the femoral head to reestablish the COR.
    - Template the femoral stem:
        - With the desired COR established, attempt to fill the canal of the distal femoral fragment with the greatest possible diameter and length to ensure stability—typically 2 femoral diameters beyond the most distal fracture site.

- When available, a prefracture radiograph can be used for templating in order to gain additional intelligence as demonstrated in Case 1 (Video 2).

Step 3: Establish Depth of Reaming

Use stem templates to establish a reference point on the reamer for use intraoperatively, and identify the distance from that point to an identifiable distal landmark.

- Use stem templates to establish a reference point on the reamer that will then be used intraoperatively. This reference point varies by manufacturer.
- Identify the distance from the reference point to an identifiable distal landmark. In our patients, we demonstrate using the most proximal portion of the distal fragment.
  - This measurement will be referenced intraoperatively to achieve the appropriate depth during reaming.
  - Reaming to this depth should allow for an implant placement that reproduces the prefracture anatomy. However, final decisions must be based on intraoperative assessment of leg length, offset, and implant stability, with modification to optimize these indices.
  - Intraoperative fluoroscopy and attention to tactile feedback also aid in evaluating appropriate size and depth of reaming.
  - Prophylactic cerclage of the intact distal femoral fragment is essential to prevent inadvertent fracture propagation during implant preparation and insertion.

Results

We report on 14 (12 Vancouver type-B2 and 2 Vancouver type-B3) periprosthetic femoral fractures treated with the described method[15]. The mean operating time was 194 minutes (range, 160 to 248 minutes), and the mean blood loss was 1,007 mL (range, 500 to 2,000 mL). Postoperative rehabilitation consisted of partial weight-bearing of 20 lb (9 kg) with crutches for 6 to 12 weeks, depending on radiographic evidence of fracture-healing. The mean follow-up time was 3.3 years (range, 5 months to 7 years), with a mean Harris hip score at the last follow-up of 83.9 (range, 63.7 to 99.8). Fracture union was found in all cases within a range of 3 months to 1 year, although 2 hips had nonunion of the trochanteric fragment. All hips had areas of spot welds with no circumferential lucencies. Both hips with nonunion of the trochanteric fragment proceeded to dislocate. One hip was treated with closed reduction, and the other with revision of the proximal modular implant segment and implantation of a constrained liner. There were 2 hips with measurable subsidence (4 and 8 mm), and 2 hips had superficial infection. Both infections were treated with local debridement and antibiotics. No patient had symptomatic deep vein thrombosis or pulmonary embolism[15].

Pitfalls & Challenges

- Meticulous preoperative planning assists in obtaining optimal surgical outcomes.
  - It may be challenging to identify a preoperative radiographic landmark for intraoperative referencing. Moreover, variability in radiographic technique in the emergency department can create challenges to proper planning. In these cases, conventional intraoperative assessments based on intraoperative fluoroscopy and assessments of leg length and soft-tissue tension must be made.
- Reaming to the appropriate level can be difficult. It is best achieved with a combination of templating, measurements relative to anatomic landmarks, fluoroscopy, and attention to tactile feedback. Note that, in one patient (Case 1), it was necessary to provide countertraction in order to ream centrally within the distal canal.

- The decision to use a monobloc stem versus a modular stem is largely a matter of surgeon preference. Additionally, different stems behave differently in terms of the fit of the final implant. A sound knowledge of the stem used, whether monobloc or modular, is of the utmost importance. Unfortunately, this knowledge is gained with experience and trial and error. For this reason, modular stems may feel more comfortable in the hands of the surgeon, as they allow for greater flexibility. We illustrate the use of both options to underscore that, with appropriate planning and attention to detail, either stem can be used successfully.
- Fracture propagation may occur in the intact femur, and may be prevented with use of a cerclage cable.
- Judgment of soft-tissue tension in the absence of trochanteric attachments is different from that in the proximal portion of an intact femur because, with fewer soft-tissue constraints, there is greater laxity and care should be exercised to avoid overlengthening. Additional stability assessment can be performed after fracture reduction and fixation if a question of stability persists.

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