Clinical Study

Achieving Construct Stability in Periprosthetic Femur Fracture Treatment

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One of the greatest challenges in treating patients with periprosthetic femoral fractures is achieving bone fixation in the presence of a well-fixed stem. Three techniques are described, which allow for improved fixation. A clinical series of fourteen patients with periprosthetic femur fractures that underwent open reduction internal fixation utilizing these techniques were reviewed. Thirteen patients had clinical and radiographic union. One patient required conversion to a revision total hip arthroplasty when it was noted that he had a loose prosthesis. Average time to radiographic union was 122 days. The described techniques allow surgeons to obtain multiple points of fixation around the prosthesis in an effective manner.

1. Introduction

The incidence of periprosthetic femoral fractures is increasing, likely due to the larger number of total knee and hip arthroplasties being performed and the increased survivorship of the arthroplasty population [1–3]. Fractures can occur during the initial arthroplasty or at any time postoperatively. The incidence of postoperative periprosthetic fracture of the knee and hip ranges from 0.5% to 2.5% [4, 5]. The majority of these fractures can be classified as fragility fractures, due to the fact that they occur from a relatively low energy mechanism [2]. These fractures are challenging to treat due to host factors, such as poor bone quality, as well as the complex mechanical interplay between fracture and arthroplasty implants.

A variety of treatment options are available to orthopaedic surgeons who treat these fractures. There is no single approach that can be used to treat such a heterogeneous group of fractures. Generally speaking, most femur fractures that

occur below a hip prosthesis should be stabilized. Vancouver B2 and B3 types, those with loose arthroplasty components, should be revised with stems that extend beyond the fracture [3]. Nonoperative management is reserved for cases of stable trochanteric fractures around a well-fixed implant (Vancouver A), or those in patients who are unable to undergo surgical treatment. Displaced fractures are seldom treated with nonoperative modalities due to the unacceptable rate of complications [6]. Many fractures occur below a well-fixed stem, the Vancouver B1 and Vancouver C fractures. These fractures are indicated for open reduction and internal fixation. The goal of surgical fixation is restoration of anatomic alignment which leads to early postoperative mobilization and return to function. Stable fixation is achieved to promote bony union.

Fixation options include plates, screws, cortical allograft struts, cerclage wires, and intramedullary nails. A variety of plates can be used for fixation, including traditional nonlocking, locking, and variable angle locking plates. Standard large

FIGURE 1: Fixation options through large fragment plate. Far left, 4.0 mm tibial nail set bolt. Center, 3.5 mm screw through conical washer (DePuy-Synthes). Far right, 4.5 mm screw. Not shown, locking screw.

FIGURE 2: Postoperative images after revision open reduction internal fixation using one curved broad 22-hole 4.5 mm LCP (DePuy-Synthes) that was contoured proximally and distally in order to allow for progression of the screw into the greater trochanter above the prosthesis and distally for purchase into the condylar region (not shown). Note the 3.5 mm screws with conical washers in holes 1, 2, 3, and 5 that were placed around the prosthesis. Two locking attachment plates were also used for additional fixation with 3.5 mm nonlocking and locking screws.

fragment nonlocking plates have been shown to be sufficient for periprosthetic femur fractures that occur around the tip of a hip prosthesis [7]. Poor bone quality and limited area for screw fixation around cemented or noncemented stems can make open reduction internal fixation a challenge. Use of standard 4.5 mm screws through the plate may be insufficient for proximal fragment fixation. Simply put, the presence of the stem often precludes the use of the standard bicortical screw. The focus of this paper is to provide alternative strategies for screw fixation around the prosthesis using large fragment plates.

2. Techniques

- (1) Use of 3.5 mm screw placed through a conical washer.
- (2) Use of 4.0 mm locking bolt from tibial nail set.
- (3) Use of locking attachment plate.

2.1. Use of 3.5 mm Screw Placed through a Conical Washer. Cortical self-tapping 3.5 mm screws are much easier to maneuver around the prosthesis when there is limited room for screw placement. The smaller caliber of the screw is often an advantage in trying to find room for the screw between the cortex and the prosthetic stem. In addition, the smaller screw

can be angled more acutely through the plate, optimizing screw placement. However, the screw heads of the 3.5 mm screws will slide through the screw holes in large fragment plates, mitigating their fixation. Our solution is to use a conical washer when using these screws to prevent the head from penetrating through the plate hole. The conical washers fit flush into the plate and allow for an arc of placement within nonlocking holes of a variety of standard fragment plates (Figures 1 and 2). The arc of motion is 90 degrees in line with the plate (45 degrees in each direction) and 60 degrees perpendicular to the plate (30 degrees in each direction). If the conical washer is not available, multiple 3.5 mm washers can be used as can a 1/4 tubular plate cut with one hole and be used as a washer. We find that the conical washer is a much better fit in the plate and could potentially lead to less irritation from the implant, especially in the greater trochanter region.

2.2. Use of 4.0 mm Locking Bolt from Tibial Nail Set. An alternative solution to achieving fixation around the prosthesis when a 4.5 mm screw is not feasible is to use a 4.0 mm locking bolt from a tibial intramedullary nail set. These screws have a smaller core diameter than the 4.5 screws and are therefore more likely to get around the stem. The arc of motion is 30 and 60 degrees perpendicular and in line with plate, respectively.

FIGURE 3: Postoperative images after open reduction internal fixation using one curved broad 17-hole 4.5 mm LCP (DePuy-Synthes) that was contoured. Note the 4.0 mm interlocking screws (DePuy-Synthes) from tibial nail set that were inserted in holes 1, 2, 5, and 7 to allow for screw purchase around the prosthesis. Two locking attachment plates were also used for additional fixation with 3.5 mm nonlocking screws.

The locking bolts also have the advantage of having a head which does not slide through the plate hole and is also not prominent (Figures 1 and 3). Another potential advantage of these screws, relative to a 3.5 mm screw, is the larger core diameter, reducing the risk of screw failure by breakage. We routinely use 2.5 mm Kirschner wires in lieu of a drill bit to make a path for these screws. The Kirschner wire is less likely to break if it encounters the implant or cement implant interface. Irrigation can help reduce the thermal necrosis of cortical bone that is associated with drilling through the dense cement mantle.

2.3. Use of Locking Attachment Plate. If the holes in the plate do not allow the appropriate screw trajectory, then a locking attachment plate (LAP) can be used (DePuy-Synthes). The LAP screws directly onto locking plates and has two arms on each side of the plate, with either 2 or 4 holes per arm. 3.5 mm locking and nonlocking screws can be placed through the arm holes. Screws placed through these arms offer an alternative fixation trajectory that provides the possibility to avoid the prosthesis stem. These arms are designed to sit on both sides of standard fragment plates and can be bent or cut to fit. Locking guides can be used to direct the arms as well as to provide a conduit for 1.6 mm Kirschner wires. This will allow a provisional path for fixation with a 3.5 mm screw. Locking screws can provide a fixed angle construct. We routinely use a combination of locking and nonlocking screws to obtain compression across implant bone interface with nonlocking screws first and then locking screws to add additional fixation around the stem (Figures 2 and 3). LAPs can be used with a variety of locking 4.5/5.0 plates.

3. Clinical Series

After obtaining IRB approval, a series of sixteen patients with periprosthetic femur fractures, treated between January 1, 2009, and January 1, 2012, with one or more of the above

described surgical fixation techniques, were identified. Two patients were excluded, one for death at four weeks and another patient with no radiographs past the three-month follow-up.

The average age at the time of surgery was 72 years (range 48–94 years). The fractures involved the right side in ten cases and the left side in four cases. Eleven patients were female and three patients were male. Thirteen patients presented with proximal femur fractures and one patient presented with a distal femur fracture. All fractures were intimately associated with the prosthesis. Nine patients had fractures around a cemented total hip or hemiarthroplasty. Four patients had fractures around a noncemented hip arthroplasty. One patient had a fracture across a revision long stem total knee arthroplasty.

Periprosthetic fractures were classified according to the Vancouver classification: eleven were type B1 and two were type B2. All patients were treated with a 4.5 mm standard fragment plate that was contoured. 3.5 mm screws through conical washers were used in eleven fractures as described above. 4.0 mm tibial locking bolts were used in two fractures, and a locking attachment plate was used in four fractures. Cables were used in the distal femur case and a cortical strut allograft was not used in any case. All fourteen cases used a combination of at least two of the above stated techniques. Compression across the fracture site was obtained using an articulating tensioning device in eight cases. Postoperative regimen consisted of non-weight-bearing in four patients, toe-touch weight-bearing in eight patients, and weight-bearing as tolerated in two patients. Average follow-up time was 193 days from the index surgery.

Clinical and radiological union was evident in 13 of 14 cases (93%). One patient required conversion to a revision total hip arthroplasty after six months when it was noted that the patient had a loose prosthesis associated with pain. The average time to radiographic union was 122 days (range 89–155). Implant failure was noted in one case in which 3.5 mm screws through conical washers were used. The failure

FIGURE 4: Postoperative images after revision open reduction internal fixation using one curved broad 17-hole 4.5 mm LCP (DePuy-Synthes) that was contoured. Note the 4.0 mm interlocking screws (DePuy-Synthes) from tibial nail set that were inserted just distal to the fracture. One locking attachment plate was used for additional fixation with a combination of 3.5 mm nonlocking and locking screws. The most distal fixation consisted of a cable in the most distal locking hole of the implant around the megaprosthesis.

occurred at the bone implant interface. Interestingly, the failure occurred after union and the patient was asymptomatic.

4. Discussion

Periprosthetic femur fractures are associated with a high rate of complication and a poor union rate if treated in nonoperative fashion [1, 5, 7, 8]. A number of surgical options are available to the surgeon. Open reduction internal fixation has been shown to be a preferred treatment in the setting of well-fixed prosthesis [1, 4, 7, 8]. Fixation challenges result from the poor bone quality and the ability to achieve sufficient periprosthetic fixation. Traditionally, cerclage cables have been used in many such cases. A theoretical risk is that the cable fixation technique can devitalize the periosteum during the circumferential application. Fixation may be diminished, relative to screw fixation. Plating systems have been developed that allow for placement of locking screws. Even though some plates allow for placement of locking screws at variable angles, they may still prove insufficient in trying to achieve fixation around a well-fixed prosthetic stem. The three above described techniques allow the surgeon to obtain multiple points of fixation around the prosthesis in an effective manner. Furthermore, they are not limited to the proximal femur (Figure 4). They can be used in any clinical situation that requires fixation around an implant through a standard fragment plate.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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