Polymethylmethacrylate Augmentation in Revision of a Proximal Femur Fracture

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Summary: This case report describes a 73-year-old woman who presented after intramedullary nailing of her subtrochanteric left femoral fracture. After the initial surgery, the proximal screw lost fixation in the femoral head, and the fracture displaced into an unstable varus position. The patient subsequently underwent revision fixation with a cephalomedullary nail with a fenestrated blade. Polymethylmethacrylate was injected into the fenestrated blade to fill the femoral head bone void created by the failure of the previous device. The new construct remained stable through union, and the patient regained preinjury function. Augmentation of fixation using polymethylmethacrylate is a reliable method to increase stability in complex proximal femoral fractures.

Key Words: PMMA, augmentation, femoral head, void

INTRODUCTION

Cephalomedullary nailing of OTA/AO 31A3 fractures is commonly performed. In 1995, Baumgaertner et al described the “tip-apex” distance for sliding hip screw implants used in intertrochanteric fractures. A “tip-apex” distance greater than 25 mm correlated with an increased risk of lag screw cutout in the femoral head and failure. Many have generalized this information to other constructs used to stabilize proximal femoral fractures. Unfortunately, cases of fixation devices “cutting out” of the femoral head are still reported.

CASE PRESENTATION

A 73-year-old woman sustained a left, closed (OTA/AO 31A3) pertrochanteric femur fracture after a ground-level fall. She was initially treated with a cephalomedullary nail approximately 8 weeks before presentation to our facility. The patient reported that she had been allowed to bear weight as tolerated since surgery. Her fracture displaced postoperatively into varus as her fixation became unstable (Figs. 1 and 2).

Her preoperative laboratory test results (consisting of basic chemistry, complete blood count, and International Normalized Ratio) were normal, and she reported that she had never smoked. She had no previous history of fracture, a previous dual-energy X-ray absorptiometry scan was normal, and she routinely took the recommended dosage of vitamin D and calcium.

Preoperative physical examination demonstrated that she had very painful active and passive range of motion of the left hip and knee. She was unable to bear weight on the left lower extremity with a walker. Her incisions were healed. Rotation of her hip and her femur seemed normal. On gross examination of length, she had a limb-length discrepancy of approximately 3 cm.

SURGICAL TECHNIQUE

The risks and benefits of cephalomedullary nail removal and open reduction and revision fixation of her fracture were discussed with the patient. After appropriate consent and shared decision making was performed, the patient was brought to the surgical suite. Appropriate measures for patient safety and reducing the incidence of surgical site infections were used. After the induction of general anesthesia, the patient was placed in the lateral decubitus position on a radiolucent table. The affected side was prepared and draped in a sterile manner. The wound was opened through a previous incision extending from the greater trochanter to the proximal thigh. The cephalomedullary nail was exposed through a Medartis cephalomedullary reamer (Medartis, Widnau, Switzerland) and was found to have cutout of the femoral head. The femoral head was exposed through a posterior osteotomy of the femoral neck and acetabular roof. Polymethylmethacrylate was injected into the fenestrated blade to fill the femoral head bone void created by the original device. A new cephalomedullary nail was inserted, and the osteotomy was reduced and fixed with dynamic hip screws. The patient was then transferred to the intensive care unit. She was discharged home on postoperative day 5.

Salvage after cutout can be very challenging because the bone stock of the proximal femur in elderly is often compromised by the cavitation defect created in the femoral head. The bone loss after cutout can often be sufficient to make subsequent fixation technically difficult or impossible. This report describes the use of polymethylmethacrylate (PMMA) to augment femoral head fixation in a patient with cutout after failed fixation of a subtrochanteric femoral fracture.
of anesthesia, the patient was positioned in the right lateral decubitus position using the "bean bag" on a radiolucent operating table. The patient was carefully positioned to ensure optimal access for the surgical approach and decreasing the risk of pressure injuries while under anesthesia. Perioperative antibiotics consisting of 2 g of cefazolin were administered. "Time-out" procedures in compliance with the Joint Commission were conducted, to ensure the correct procedure was performed on the correct patient.

The lateral approach was used in this case. The previous surgical incisions were incorporated in the exposure to access the proximal aspect of the nail, the lag screw, and the distal interlocking screws. After the set screw was loosened, the lag screw was removed. The proximal aspect of the nail was engaged with the extraction device, and then the distal interlocking screw was removed. The nail was then removed from the femoral canal.

The fracture was already malunited, so an open reduction was necessary. After extending the skin incisions, the iliotibial band was incised to gain access to the proximal femur. The fracture was mobilized and reduced. The rongeurs and curettes were used to take down the existing scar tissue and early callus so that the fracture was mobile. The reduction was performed through applying in-line traction and fragment manipulation with threaded Schanz pins. Through the use of the Schanz pin, the proximal fragment was maneuvered out of varus and extension.
The reduction was provisionally stabilized using pointed reduction forceps respecting the soft tissue attachments to the bone fragments. After fracture reduction, the ball-tipped guidewire was placed down the intramedullary canal, and the femur was reamed to 15.5 mm [Reamer Irrigator Aspirator (RIA); DePuy Synthes, West Chester, PA]. Because the fracture had been opened and was available to accept bone graft, the RIA was used to harvest a bone graft from the intramedullary canal while concurrently widening the canal as needed to accept the larger nail. A $14 \times 420$ mm trochanteric femoral nail (TFN-Advanced, DePuy Synthes) was inserted. Using anteroposterior (AP) and lateral fluoroscopy, the 3.2 mm guidewire for the helical blade was drilled through the aiming arm into the femoral head. The cannulated lateral cortical step drill was used to prepare the femur for the proximal fixation. The helical blade was then tapped into place and locked with the set screw.

Although the helical blade occupied nearly the same position as the previous lag screw, the different design of the blade was able to engage the bone. Because of concern for limited stability of the helical blade, 6 mL of polymethylmethacrylate was injected, according to the manufacturer’s guidelines (TRAUMACEM V+; DePuy Synthes, Monument, CO), to improve stability in the femoral head. The cement extruded through the fenestrations in the blade and filled much of the void caused by the lag screw cutout (Figs. 3 and 4). The distal interlocking screw was placed using the standard freehand technique according to the surgical technique guide. The injection of PMMA was carefully monitored under fluoroscopy to ensure that there was no extravasation into the hip. The bone graft obtained with the RIA was placed around the fracture site. The wounds were subsequently closed, and the patient was injected with liposomal bupivacaine for postoperative pain relief.

The patient was admitted to the hospital and placed on postoperative antibiotics and prophylaxis for deep vein thrombosis according to our geriatric proximal femoral fracture protocol. She was mobilized with physical therapy allowing weight-bearing as tolerated on the affected extremity and discharged to home on postoperative day 3 (Figs. 5 and 6). At final follow-up 6 months later, her radiographs demonstrated bridging callus, and she had returned to preinjury function without complaints of pain (Figs. 7 and 8). The patient was evaluated for osteoporosis. Her dual-energy X-ray absorptiometry scans were unchanged, and she was continued to be treated with vitamin D and calcium.

**DISCUSSION**

We present a case of a 73-year-old woman who presented with failure of fixation after a subtrochanteric femoral fracture that was
salvaged with revision cephalomedullary fixation, bone grafting, and PMMA augmentation. Techniques have been developed to augment the fixation of proximal femoral fractures with injectable PMMA, and several studies have documented good outcomes with this procedure. The first report of this technique examined the effect of PMMA augmentation after high pressure irrigation of the osteoporotic femoral head specimen. The authors found that after repetitive cyclical physiological loading, all of the control specimens failed and only half of the augmented specimens became unstable demonstrating the benefit of PMMA. This study paved the way for further work in this area.

Several studies demonstrate excellent outcomes with PMMA augmentation, and no clinical failures are reported in any of these reports. Kammerlander et al found no cutout, blade migration, implant loosening, or breakage in their study of PMMA augmented fractures. In a separate prospective, randomized study, the authors evaluated patient’s walking speed, quality of life, mobility, implant migration, and complications between augmented proximal femur nail antirotation (PFNA) and standard PFNA (DePuy Synthes). Their analysis did not demonstrate any difference between the groups except in the rate of reoperation (5.1% in the control group and 0% in the augmented group).

Mechanical studies using cadaveric femoral heads showed that augmentation with cement yielded better rotational stability and pull-out resistance. Interestingly, the authors noted that the effect of the cement on rotational stability decreased as the bone mineral density of the femoral heads increased. This suggests that cement augmentation is most optimal in patients with significantly osteoporotic bone and was verified in other studies.

Regarding revision surgery, Scola et al reported on 10 patients who sustained proximal femoral fractures that required revision fixation with the PFNA augmented with PMMA. Eight patients in their study demonstrated fracture union without complications, and the remaining 2 died because of unrelated issues.

Limitations of the volume and the effect of cement on the proximal femur have been examined. Raas et al found that even up to 15 mL of PMMA did not increase the surface temperature of the proximal femur above threshold values. They noted an average increase of 9.5°C of temperature during injection of 15 mL of PMMA. Blankstein et al studied the effect injection speed had on intraosseous pressure in the femoral head. They measured the bone pressure when injecting 6 mL of PMMA with both fast (each 1 mL over 5 seconds) and slow (each 1 mL over 10 seconds) technique. Neither group demonstrated excessively high intraosseous pressure, and the authors concluded that either method may increase the risk of pressure-induced avascular necrosis of the femoral head.

Because of the exothermic reaction created with PMMA, there is a concern that the heat generated may damage the proximal femoral bone and articular cartilage. Goetzen et al examined the effect of
injected PMMA in the knee (stifle) in a sheep model. They found no difference between the study and control groups in terms of the cartilage damage and glycosaminoglycan content. As a result, the authors stated that injection of PMMA does not seem to damage the subchondral bone or articular cartilage. Multiple clinical studies have demonstrated the safe usage of PMMA without complications.

One of the potential concerns with injection of these augments is that the cement could penetrate into the hip joint. There are no specific studies in the literature that examine the outcome of this event. The manufacturer of the implants in this case recommends evaluation of the extravasated cement to determine if it “conforms to the architecture of the hip joint” or if it “is abrasive or damages the articular surface.” The surgeon must be ready to evacuate the extruded cement from the hip through arthrotomy or arthroscopy if it goes beyond the articular surface.

Optimal location of PMMA augmentation within the femoral head is also important. Sermon et al examined variable placement in a biomechanical investigation in human cadaver hip joints. The authors found that the best location for superior mechanical stability occurred with cement placement in the cranial position at the tip of the implant.

CONCLUSIONS

PMMA augmentation is a useful augment in both initial and revision fixation in elderly patients with osteoporosis or femoral head bone void. Studies have shown that this significantly increases stability of the construct and lowers failure rate.

REFERENCES


FIGURE 8. Final lateral hip radiograph 8 months after surgery demonstrating final union.

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