Nonunion of a Pertrochanteric Femur Fracture Due to a Low-Velocity Gunshot

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Abstract

The treatment of nonunions often can be a complex and challenging venture. This case report details the treatment of a young patient's pertrochanteric femoral nonunion due to a low-velocity gunshot. Fracture fixation and union were attempted with various implants, including a sliding hip screw, blade plate, and proximal femoral locking plate; however, all eventually failed. Successful union ultimately was obtained only after use of a cephalomedullary nail. There have been few reports in the literature on the failure of proximal femoral locking plates in the treatment of pertrochanteric femur fractures, though much has been published regarding the sliding hip screw and blade plate. Multiple options for use in nonunion surgery were used and discussed in this case, such as autogenous bone graft, bone morphogenic protein, and implantable bone stimulators.

The current "gold standard" for treatment of simple intertrochanteric or pertrochanteric femur fractures is the sliding hip screw.[1] Other treatment options include using a blade plate, proximal femoral locking plate, and cephalomedullary nail. Failure of the sliding hip screw can occur in as many as 10% of cases,[2,3] with that number increasing to 22% if the lateral femoral wall is compromised.[3] The most common mode of failure is cut-out of the lag screw from the femoral head due to malposition. Failure due to nonunion is uncommon. In cases where internal fixation fails, revision internal fixation should be considered because it produces high rates of union with good clinical outcomes.[4,5] Hip arthroplasty should be reserved for older patients or those with poor bone quality who have failed standard treatment. There are multiple factors that can affect the outcome of different fixation devices, including the health and habits of the patient, the quality of the bone stock,[4,5] the integrity of the lateral femoral wall,[3,6,7] and the use of proper surgical technique to achieve the surgical goals.

In this paper, we present the case of a young patient who developed a pertrochanteric nonunion following a fracture due to a gunshot wound. The patient's informed consent for print and electronic publication of this report was obtained and approval was received from the institutional review board.

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Case Report

Two years prior to the time of presentation at our institution, a 36-year-old man experienced a gunshot wound causing a pertrochanteric fracture of the right femur (Figure 1). He initially was treated with open reduction and internal fixation using a sliding hip screw (Figure 2). Plain radiographs taken 1-month postoperatively revealed the beginning of implant failure and fracture of the lateral femoral wall with complete failure evident by plain radiographs at 4 months (Figure 3). Nine months following the initial open reduction and internal fixation, the patient underwent hardware removal because of continued

Figure 1. Anteroposterior radiograph of pertrochanteric fracture after gunshot wound.

Figure 2. Fixation was achieved with a sliding hip screw. Postoperative anteroposterior radiograph (day 0) shows stable fracture reduction, stable-appearing instrumentation, and screw fixation.

Figure 3. Anteroposterior radiograph at 4-months postoperative shows complete implant failure, screw pullout, and broken hardware.

Figure 4. Anteroposterior radiograph of pertrochanteric fracture at first presentation to authors' clinic shows chronic nonunion with retained hardware, bone loss, shortening, and varus deformity. The joint surface appears well-preserved and the femoral head appears viable.

pain. The treating surgeon believed the fracture was clinically healed at that time.

Eight months after hardware removal, the patient presented to our clinic reporting right hip pain. His medical history revealed heavy use of tobacco at 40-pack years. On examination, his right leg length was 7 cm shorter than the left leg. The patient had a combined technetium and indium-labeled white blood cell scan, which was negative for osteomyelitis. Plain radiographs showed a chronic nonunited pertrochanteric fracture of

Figure 5. Fixation with a blade plate. Anteroposterior radiograph at 7-weeks postoperative shows stable reduction, apparent interval bone consolidation, and proper hardware alignment.

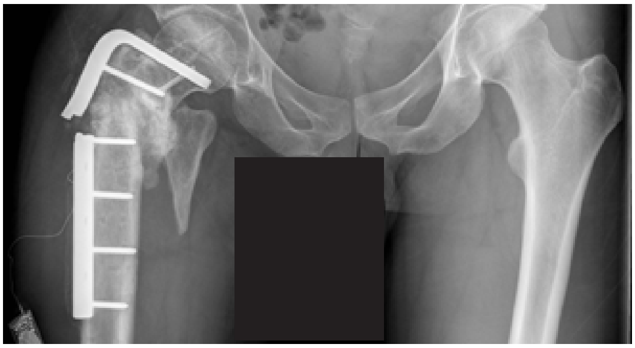

Figure 6. Anteroposterior radiograph at 10-weeks postoperative shows broken blade plate and loss of reduction.

the right femur with bone loss (Figure 4). After reviewing surgical options with the patient, he was scheduled to undergo repair of the nonunion with bone graft and an implantable bone stimulator. He was instructed in nicotine cessation and told he would be monitored with urine nicotine screens prior to surgery.

The patient was unable to stop smoking and returned 7 months later reporting continued right hip pain and leg shortening. The patient again was offered repair of his pertrochanteric nonunion. This was performed using a 95° blade plate with iliac crest bone graft supplemented with bone morphogenic protein-7 (OP-1, Stryker Biotech, Hopkinton, Massachusetts) and tricalcium phosphate and implantation of an electrical bone stimulator (OsteoGen, EBI, Inc., Parsippany, New Jersey).

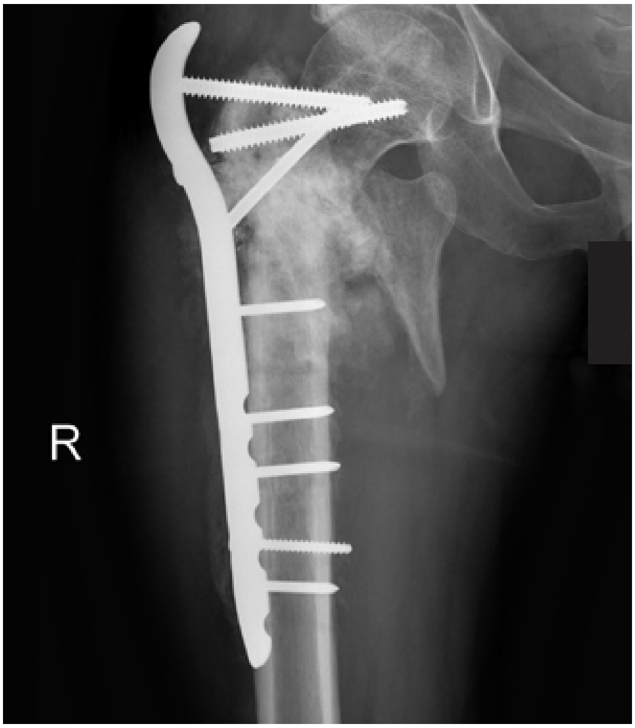

Figure 7. Revision to proximal femoral locking plate. Anteroposterior radiograph at 3-weeks postoperative shows failure at the screwhead/shaft interface.

Figure 8. Revision to cephalomedullary nail. Anteroposterior radiograph at 1-year postoperative shows complete consolidation of the nonunion site.

Given the patient's smoking history and the large bone defect, it was felt autograft alone would not be sufficient for healing of the nonunion, which led to the decision to supplement the autograft. In the operating room, the pseudarthrosis site was opened and fluid was sent for culture and gram stain, which were negative for infection. The patient was discharged from the hospital 2 days postoperatively.

The patient returned to the clinic 11 days postoperatively with his pain well controlled. No signs of infection were noted. Smoking cessation again was discussed with the patient and he was instructed to return to the clinic in 4 to 5 weeks for follow-up and radiographs. At that time, 7 weeks after surgery, the patient had no complaints, no pain, a 1-inch leg-length discrepancy (affected side short), and flexion to 95°, internal rotation to 10°, and external rotation to 30°. Plain radiographs showed apparent interval bone consolidation (Figure 5). The patient was instructed to continue toe-touch weight-bearing.

Three weeks later, the patient presented to the clinic, now 2-months postoperative, reporting that he fell the previous week and had right hip pain, which was not present prior to the fall. The patient stated he was feeling quite well and began ambulating and weight-bearing as tolerated, despite instructions to remain non–weight-bearing. Plain radiographs showed a broken plate and loss of reduction (Figure 6). The patient again was offered repair of his nonunion. The nonunion site was explored and found to have a fusion mass medially, but only a fibrous union laterally. Deep bone biopsies were taken and the patient was revised to a proximal femoral locking plate (PFLP) (Synthes, Paoli, Pennsylvania). Because of severe pain from the previous iliac crest bone graft, the patient declined a contralateral harvest of iliac crest bone graft. Local autograft from the proximal femur was taken and mixed with aspirated osteoprogenitor cells from iliac crest and with bone morphogenic protein-2 (BMP-2) (Infuse; Medtronic, Inc., Memphis, Tennessee). The use of BMP-2 in femoral nonunion is an off-label application. The PFLP failed within 3 weeks. Plain radiographs revealed failure at the screw head/shaft interface of the proximal locking screws (Figure 7). The patient was offered arthroplasty versus a repeat attempt at repair of the nonunion with a cephalomedullary nail. Smoking cessation counseling was given again as the patient's use of nicotine was considered a major contributor to repeated failures. The patient was revised to a cephalomedullary nail with iliac crest autograft, another implantable bone stimulator, and more BMP-2. Given the patient's recalcitrant nonunion, it was felt the bone stimulator and bone morphogenic protein might improve the patient's chance of success with revision surgery. The patient was discharged 2 days later with instructions to be touch-down or minimal weight-bearing on the right lower extremity.

At 1-month postoperative, the patient remained adherent to with his weight-bearing restrictions and had successfully stopped smoking. His remaining postoperative course was unremarkable except for a possible superficial wound infection that resolved with oral antibiotics at 7-weeks postoperative. When last seen, the patient was 1-year status postrepair of this proximal femur nonunion with no pain, was walking with a minimal limp without an assistive device, and had no limitation in the distance he could walk. His hip had good range of motion with flexion to 85° and he was able to straight-leg raise and abduct against resistance. He had a 2-inch leg-length discrepancy that was fully corrected with a built-up shoe. Plain radiographs showed signs of complete consolidation at the nonunion site (Figure 8).

Discussion

Cephalomedullary nails have significantly improved the treatment of unstable pertrochanteric hip fractures when compared with fixed-angled plates, which do not allow the sharing of the load between the implant and fracture fragments.[2] Sliding hip screws remain the standard of care for typical obliquity intertrochanteric or pertrochanteric femur fractures, but there is a trend toward the use of cephalomedullary nails for unstable intertrochanteric or pertrochanteric fractures with subtrochanteric extension, especially among young practitioners.[8] Failure of sliding hip screws is reported to range from 4% to 10%[2,3] with unstable fracture failure rates reaching 16%.[2] Crucial to proper fixation when using sliding hip screws is placement of the lag screw in the central and deep position, with a tip to apex distance of less than 25 mm.[9] Failure may be due to loss of dynamic action, additional fixation,[3] varus malunion, lag screw cutout, or excessive lag screw sliding.[5] Additionally, continued cycling of the implant caused by delayed union or nonunion eventually will lead to failure, even if the implant is positioned appropriately.

Most pertrochanteric femur fractures treated with internal fixation heal without incident, but if nonunion or loss of fracture fixation occurs, treatment can include revision internal fixation or hip arthroplasty.[4,5] In a study by Haidukewych and colleagues,[4] 20 failed internal fixations of pertrochanteric fractures were treated with revision internal fixation with bone grafting.[4] Of the 20 nonunions, 19 went onto heal with 16 patients having no pain and 3 patients with persistent mild pain.[4] A similar study, by Said and colleagues,[5] had 18 patients undergo revision internal fixation following failure of sliding hip screw with hip screw reinsertion, valgus osteotomy and revision dynamic hip screw, and valgus osteotomy with insertion of a blade plate; all revision internal fixations went on to union with an average time of 17 weeks.[5] These results show revision internal fixation with bone grafting can lead to high rates of union with good clinical results. For physiologically younger patients with good bone quality, preservation of the femoral head with revision internal fixation is desirable. Hip arthroplasty should be considered in older patients or in those patients with poor bone quality or damaged articular surfaces.[4,5]

A compromised lateral femoral wall has significant prognostic value. The lateral wall is the proximal extension of the femoral shaft and may be a predictor of instability in 3- or 4-part pertrochanteric hip fractures.[6] In a study by Palm and colleagues,[3] integrity of the lateral femoral wall was the most important predictor of reoperation—22% of patients having a fractured lateral wall required revision compared with 3% of those patients with an intact lateral femoral wall.[3] Fracture of the lateral cortex leads to loss of the buttressing action of the distal fragment causing medial displacement of the femoral shaft and collapse.[6,7] It has been hypothesized that pertrochanteric fractures involving the lateral femoral wall are not treated adequately with a sliding compression hip screw as the risk of reoperation due to technical failure is 8 times higher.[3] It also should be noted that the lateral femoral wall initially may be intact, but then fractured intraoperatively with implant placement.

The patient's smoking habit also may have contributed to his delayed healing and need for multiple revision operations. Smoking has been shown to have many deleterious consequences for fracture healing, including delayed union and nonunion.[10,11] Laboratory studies have shown that nicotine reduces vascularization at bone healing sites, which is critical for fracture healing and osteogenesis.[10-13] An experimental study involving transplanted autologous cancellous bone grafts in rabbits showed nicotine delayed revascularization within the graft, generated a smaller area of revascularization, and was associated with a larger number of graft necrosis.[12] In a study involving open tibial fractures, patients who smoked had their fractures heal more slowly and had higher rates of nonunion with a corresponding greater need for further revision.[10] A similar study, by Castillo and colleagues,[11] showed that current smokers were 37% less likely to achieve union than nonsmokers. Infection also was higher in the smoking group[10,11] with osteomyelitis 3.7 times as likely in smokers than in nonsmokers.[11] Though these studies involved looking only at tibia fractures, the data can be extrapolated to assume that smoking has similar effects on femur fractures. Despite previous bone grafts, bone stimulators, and numerous implants, it is interesting to note the nonunion did ultimately heal only after this patient stopped smoking.

In cadaveric studies, proximal femoral locking plates provided the greatest amount of stabilization for femoral neck fractures.[14,15] The PFLP showed the greatest stiffness, tolerated higher loads for extended cycles, and only failed when 2- to 3- times normal physiological loads were applied as compared to dynamic hip screws.[14] It is hypothesized, based on these cadaveric studies, that using locking screws would increase the strength of dynamic hip screws, reduce the risk of dynamic hip screw failure, and be useful in patients with poor bone quality or more unstable fractures.[15] The PFLP fulfills the role of a fixed-angle device without the need for excessive bone removal, which is necessary for a dynamic condylar screw device,[16] and it allows for easier placement than a blade plate for many surgeons. The design of the plate allows less contact between the plate and bone, which preserves periosteal blood supply and improves bone perfusion.[8] The use of locking plates in fracture care is increasing,[8] but more data are needed to determine if these new locking plates will be clinically effective. Proximal femoral locking plate failures have not been reported in the literature, but failures of other locking plates certainly have.[17]

In the end, this patient received a good result but only after multiple revision procedures. The patient underwent 4 operations requiring 3 plates, a nail, 2 bone stimulators, and multiple uses of autograft and bone morphogenic protein, with the price of these implants increasing with each surgery, totaling tens of thousands of dollars. It is interesting to note that the patient failed 3 external plates but only received success with the cephalomedullary nail. This could be because of the nail biomechanics; specifically, its intramedullary position and its compression loads bypassing the calcar and concentrating load in the distal femur.[18] The patient's smoking history likely was the most important determinant of this patient's prolonged treatment course; although the surgeons' implant choices also may have played a role. This highlights the need for focus not only on the surgical techniques and implants, but also on the patient's history (such as smoking and nonsteroidal anti-inflammatory drug use) and medical comorbidities (such as alcoholism, malnutrition, diabetes, etc.) to achieve a successful outcome.

This case highlights the complexity of treating nonunions. Even in the hands of experienced orthopedic trauma surgeons, these nonunions can be frustrating for both the surgeon and patient. It is difficult for the general orthopedist (and many times for the orthopedic traumatologist) to know when more expensive products, such as bone morphogenic proteins, bone stimulators, and implants, should be used. Unless the surgeon is experienced in the treatment of nonunions, we recommend referral to an orthopedic trauma surgeon early in the patient's course. Even under the care of experienced surgeons, the prolonged course as outlined here is not uncommon.

Authors' Disclosure Statement

Dr. Evanson reports no actual or potential conflict of interest in relation to this article. Dr. Mullis wishes to note that he is involved in industry teaching for AO and receives research support from Amgen and Synthes. Dr. Anglen wishes to note that he has received royalties from Biomet; he previously was a consultant for Stryker; and he receives a stipend from the *Journal of the American Academy of Orthopaedic Surgeons* as Deputy Editor. He currently serves the American Board of Orthopaedic Surgery as Vice President (a volunteer position), and he is on the Board of the American Academy of Orthopaedic Surgeons.

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