Treatment of Segmental Femoral Nonunion/Malunion With Mini-Fragment Plate Fixation and Revision Cephalomedullary Nail

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**Summary:** The concurrent use of plates and intramedullary nails has been described in the treatment of both acute and nonunited long bone fractures. This technique aids in the maintenance of reduction during nailing, which can be especially useful in nondiaphyseal locations. If left in place, the plates can also serve to provide adjunctive fixation after nail placement. This case demonstrates the use of mini-fragment plates and revision intramedullary nailing to successfully treat a complex segmental femoral malunion/nonunion.

**Key Words:** femur, nonunion, malunion, mini-fragment

**INTRODUCTION**

Compared with acute diaphyseal femur fractures, fractures of the proximal and distal femur are at increased risk of malalignment, especially when treated with an intramedullary nail (IMN). Deforming muscular forces about the hip and knee, as well as the non-uniform function of an IMN within the metaphyseal region of the proximal and distal femur make successful IMN fixation of these injuries more difficult. Provisional plate fixation of both open and closed long bone fractures before intramedullary nailing has been reported to be a successful means of maintaining fracture alignment during nailing.

In the setting of fracture malunion or nonunion repair, a similar strategy using supplemental plate fixation can be used to maintain and support reduction while definitive fixation is placed. This case demonstrates this technique in a patient with a concurrent proximal femoral malunion and distal femoral nonunion.

**History of Present Illness:** The patient is an active 62-year-old man who presented to the outpatient orthopaedic clinic approximately 7 months after he was involved in a motorcycle collision. He sustained an isolated closed segmental right femur fracture (AO-OTA 32C2) and was treated at an outside institution with a cephalomedullary femoral nail. There was no history of wound drainage or infection after his initial surgery. He was made partial weight bearing for approximately 6 weeks and then advanced to full weight bearing. Over the course of 5 months, the patient continued to walk with crutches because of persistent leg pain. He was unable to progress with therapy and recently experienced worsening pain in his proximal thigh and knee. He noted that his right leg felt shorter than his uninjured left leg. He voiced concerns that his leg was getting weaker, felt unstable, and that he would never be able to return to work or his previous level of activity. The patient reported smoking occasional cigars and marijuana but revealed no other medical issues.

**CLINICAL FINDINGS**

On examination, the patient had no gross deformity of the right leg. The leg was well perfused with well-healed surgical incisions; sensory and motor functions were normal. Range of motion of the right knee was 0–120 degrees without crepitus or instability. There was tenderness to palpation above the right knee at the level of the distal femoral metaphysis and there was minor discomfort with log roll of the right leg. There was a 10-degree external rotation deformity of the right leg as compared to the left leg. Complete laboratory studies were obtained and showed no elevation of inflammatory markers and no chemical or metabolic abnormalities.

**RADIOGRAPHIC FINDINGS**

Anterior posterior (AP) and lateral radiographs of the right femur showed a segmental fracture pattern with a cephalomedullary nail in
Proximally, an 11-degree varus and 13-degree apex anterior deformity were measured with an increased lesser trochanter profile. The gap and absence of fracture callus were noted at the lateral cortex, and an indeterminate amount of consolidation and healing was observed medially. The start point of the IMN was noted to be lateral to the tip of the greater trochanter. On the lateral view, there was incomplete bridging of the callus at the anterior and posterior cortex (Figs. 1A and B). Distally, there was 7 mm of medial and 8 mm of anterior translation of the articular segment, which was also noted to be shortened by 1.2 cm. There was incomplete healing of the distal fracture, with persistence of the fracture line on the AP and lateral views. The distal interlocking bolt showed slight distal deflection (Figs. 2A and B). Full-length standing films noted a 1.9-cm leg-length discrepancy between the right and left leg. A computed tomography of the right femur showed incomplete healing at the proximal fracture with complete medial bridging callus but absence of any healing about the majority of the anterior, lateral, or posterior cortices. Distally, there was incomplete bridging callus across the fracture site with sclerotic fracture edges; the scan revealed that the distal interlocking bolt was broken.

**ASSESSMENT**

Segmental femur fracture with proximal deformity and incomplete union with concurrent distal segment deformity and non-union. A preoperative surgical plan was created. First, the previous IMN would be removed. Next, the proximal and distal fracture sites would be mobilized, reduced, and held with laterally based mini-fragment fixation. Finally, revision fixation with a larger diameter cephalomedullary nail would be performed. Grafting of the fracture sites would be performed as needed.

**SURGICAL MANAGEMENT**

The patient was taken to the operating room and placed in the supine position on a radiolucent flat table. General endotracheal
anesthesia with chemical skeletal relaxation was provided. The ipsilateral hip was elevated on a bump and the right leg prepped in its entirety. First, the previous implant was removed through the previously made incisions, including the distal broken interlocking bolt.

Next, a lateral incision was made along the long axis of the limb. The iliotibial band was split and the vastus lateralis elevated. The location of the proximal fracture was identified. Next, a sharp flat osteotome was used to mobilize the proximal segment in line with the previous fracture plane identified by preoperative plain radiographs, CT, and intraoperative fluoroscopy (Fig. 3). Cultures were taken. Using the linea aspera of the posterior femur and the morphology of the exposed femur, an angular and rotational correction was made to the fracture. Compression was achieved through a modified spin-down Weber clamp with 2 straight tines, each placed within a 2.5-mm drill hole in the lateral cortex of the femur. A 10-hole 2.7-mm mini-fragment plate with 4 unicortical nonlocking 2.7-mm screws was then used to hold and maintain this compressed reduction (Fig. 4). Sharp drill bits and constant saline irrigation were used while the unicortical screw paths were drilled. Attention was then directed distally where a standard lateral approach was made to the distal femur with similar elevation of the vastus lateralis. Again, an osteotome was used to completely mobilize the distal nonunion site (Fig. 5). All fibrous tissue and sclerotic bone were excisionally debrided and cultures taken. The fracture was then reduced with correction of length, distal segment medialization, and sagittal plane translation. An 8-hole 2.7-mm plate with unicortical screws was then applied to the anterior lateral cortex of the distal femur to maintain this reduction (Fig. 6).

Attention was then redirected proximally where a long 3.5-mm small fragment locking plate was modified and placed within the previous, incorrectly positioned, trochanteric start point (Fig. 7). This allowed a more medial start point for the cephalomedullary nail to avoid varus malalignment. The intramedullary guidewire for the reamer–irrigator–aspirator (DePuy Synthes, West Chester, PA) was then placed and seated deep within the distal femoral segment. The intramedullary canal was then reamed with a single pass, with the femur reduced and held by the 2 mini-fragment plates and unicortical nonlocking screws. The intramedullary reamings were saved and the guidewires exchanged. The nail length was measured and a cephalomedullary nail was placed to the appropriate depth. The proximal and distal mini-fragment plates remained in place. The proximal plate was noted to incur some slight deformity with nail placement but held the compressed reduction well (Fig. 8). Two points of fixation were then placed into the femoral neck and head to support proximal fixation. Distally, after nail placement and placement of multiplanar interlocking bolts, the most proximal and distal mini-fragment screws were exchanged for bicortical screws that were placed above the nail.

**FIGURE 4.** Fluoroscopic AP image of reduction and provisional 2.7-mm mini-fragment plate fixation of the proximal femur, showing improved coronal plane alignment.

**FIGURE 5.** Fluoroscopic AP image of the distal femur after osteotomy, showing mobilization of distal supracondylar nonunion.
Acquired reamings were then placed about the proximal and distal fracture sites. Standard irrigation and closure were then performed. The patient was provided 24 hours of antibiotics and allowed to weight-bear immediately on the right lower extremity. He was mobilized on postoperative day 1 and discharged after an uncomplicated postoperative course. All cultures remained negative.

**OUTCOME**

The patient was followed up at 2 weeks for wound check and suture removal. Physical therapy for hip and knee range of motion, quadriceps strengthening, and gait/balance training was initiated, and the patient progressed well. Follow-up again occurred at 6 weeks and then at 3.5 months postoperatively. At his 3.5-month visit, the patient reported discontinuation of narcotic pain medication and was ambulating without an assist device. He had no feelings of instability and was happy with his current level of function, which continues to improve. He noted that his leg length and limb rotation felt equal to the contralateral side. Radiographs at 6 months showed maintained alignment on the AP and lateral views, with no evidence of hardware failure or loss of alignment. Near-complete fracture consolidation had occurred at both the proximal (Figs. 10A and B) and distal fracture locations (Figs. 11A and B).
**DISCUSSION**

Concurrent use of plates and nails to treat both acute fractures and fractures that have progressed to nonunion is well established. In acute fractures, plate and screw constructs can help maintain limb reduction before fixation with an IMN. This can be performed through open fracture wounds and through limited open exposures to closed fractures. The size and location of the plate and screw construct varies by fracture and the anticipated path of the IMN. These studies have, in part, demonstrated that mini-fragment implants can be successfully used to maintain long bone reductions without a large biologic footprint. The 2.7-mm mini-fragment plates with unicortical screws used in this case were successful in maintaining both a proximal metadiaphyseal and distal supracondylar reduction in an adult femur before and during nail placement.

In this case, the mini-fragment plates used to maintain reduction were left in place after nail insertion. Combined use of a plate and nail to treat femoral nonunions has a high reported success rate. Commonly, 3.5-mm (or larger) plates are used when this technique is used. The plates can be used for compression or to provide additional stability. In the presented case, additional stability and resistance to deformity was felt to be adequately obtained by the two 2.7-mm plates. Autogenous bone grafting was also performed, a described technique to address femoral nonunions. As good cortical apposition was achieved during reduction, and a large amount of graft was not needed, autograft from the ipsilateral femoral canal alone was harvested and placed about the nonunion sites.

The treatment of femoral nonunions and malunions requires reduction of deformity, compression (when possible), and stable fixation. The use of mini-fragment plates can be used to help accomplish these goals in both acute fracture and nonunion/malunion surgery.

**CONCLUSION**

Provisional and/or adjunctive plate fixation of both acute long bone fractures and fracture nonunions managed with IMNs is well established. This technique can be especially helpful while managing short proximal or distal segments that are subject to increased deforming forces. In this case, intraoperative maintenance of alignment after deformity correction was performed with biologically conscious application of mini-fragment plates before IMN placement. The plates were left in place to supplement fixation after nail placement. Uncomplicated healing occurred by 3.5 months. Mini-fragment plates can be successfully used intraoperatively to maintain reduction before definitive fixation is performed for the repair of certain malunions and nonunions.
REFERENCES

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