Lengthening of the Femur Over an Existing Intramedullary Nail

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Summary: Leg length discrepancies can occur despite successful union of femur fractures after intramedullary nailing (IMN). Often, the leg length discrepancy can result in significant disability to the patient, altered gait biomechanics, pelvic obliquity, and pain. Therefore, a successful clinical result for such deformities after IMN involves addressing the leg length inequality. Femoral reconstruction with an osteotomy around an existing intramedullary nail was introduced to address axial deformity correction and limb lengthening without changing or removing a previously inserted IMN. This technique uses the principles of lengthening over an IMN. The presence of the nail has minimized the time needed for the external fixator because the nail supports the regenerate bone or osteotomy during the consolidation phase. With this technique, surgery is minimized by avoiding the need for exchange nailing.

Key Words: posttraumatic deformity, Ilizarov, femur, osteotomy, intramedullary nail

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INTRODUCTION

Closed intramedullary nailing (IMN) is an excellent treatment option for femoral shaft fractures, particularly those that are in the middiaphyseal region. For this reason, it is currently known to be the gold standard of treatment.[1,2] Although angular deformity (including varus, valgus, apex anterior, and apex posterior deformities) is mostly prevented by the straight nature of the IMN, axial deformity is more subtle and difficult to control. Shortening and rotational malalignment are not uncommon.[3] These malalignments can lead to significant compromise in the normal mechanics of gait making activities of daily living difficult tasks for the patient. More demanding tasks such as running are often not possible for these patients.[4–6]

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When angular deformities result, the mechanical axis can be significantly affected, leading to asymmetric joint loads across the hip, knee, and ankle as well as alterations in the lever arms of muscle (ie, extension/flexion deformities). This can lead to quadriceps weakness as well as increased energy expenditure for gait.[1] Axial deformities that result in a significant leg length discrepancy and/or rotational deformities can also be problematic for the patient and may lead to hip, knee, and low back pain; awkward gait; and extensor mechanism weakness if left untreated.[1,3–5]

Correcting these malunions can be challenging, and often reoperation can lead to significant morbidity for the patients. The abductors can become more scarred and weakened and sometimes the deformity can persist despite efforts for correction. This has led to a novel technique in which bony deformity can be corrected without nail removal obviating the need to surgically violate the hip abductors in anterograde nailing. In the case of retrograde nails, there is no need to perform an arthrotomy, split the patella tendon, or evert the patella.[7]

We report the results of reconstruction with an osteotomy around an existing nail to address limb length discrepancies without changing or removing a previously inserted intramedullary nail (Fig. 1). This technique uses the principles of lengthening over the nail. The presence of the nail has minimized the time needed for the external fixator because the nail supports the regenerate bone or osteotomy during the consolidation phase. Using the existing nail minimizes surgery and obviates the need for nail exchange before osteotomy.

Surgical Technique

The patient is positioned on a radiolucent table with fluoroscopy access to the entire femur (Fig. 2). A bump is placed under the buttock to tilt the pelvis 15°. This enables an anteroposterior and lateral x-ray view of the hip. First, the distal locking screws are removed from the antegrade nails and the proximal screws are removed from the retrograde nails.

A rail frame is then applied to the thigh parallel to the IMN in both the coronal and sagittal planes. External fixation pins are placed posterior to the IMN using cannulated wire technique. The first external fixator pin is inserted perpendicular and posterior to the IMN at the level of the lesser trochanter. Care is taken to avoid contact between the internal and external fixation. The rail frame is applied to the pin and is used as a guide for inserting the most distal pin. One additional pin is inserted into the proximal and distal pin clamps.

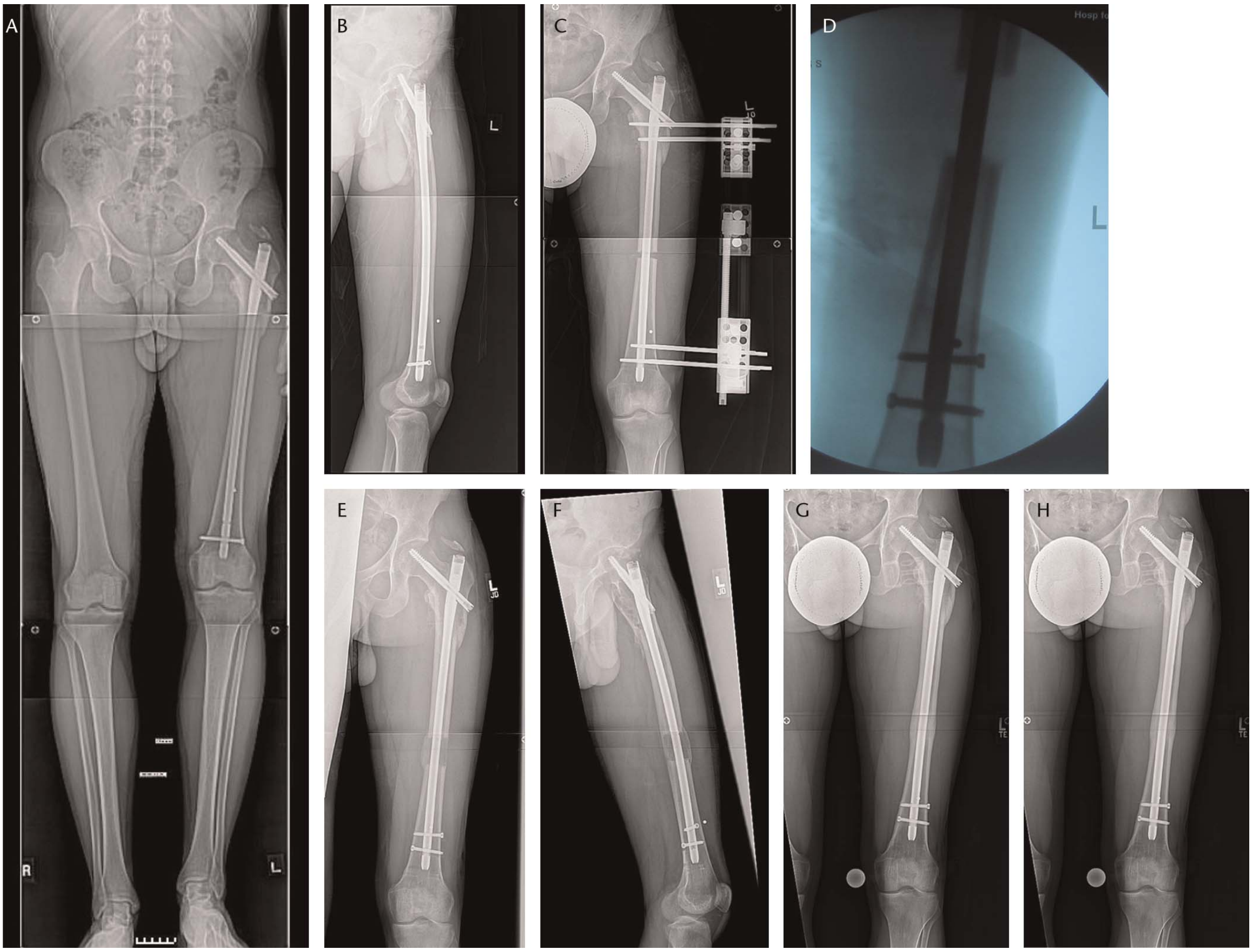

FIGURE 1. (A) A 25-year-old man with 3-cm shortening after intramedullary (IM) nailing of a femur fracture. (C) Anteroposterior (AP) x-ray 2 weeks after surgery showing early distraction around the IM nail. The rail external fixator is parallel to the IM nail. (D) Intraoperative x-ray after completion of the 3-cm lengthening and insertion of locking screws and removal of the external fixator. (E–F) AP and lateral x-rays 1 month after insertion of interlocking screws. Note progression of bony union. (G–H) AP and lateral x-rays 10 months after insertion of interlocking screws. Note complete bony union.

We usually use two 6-mm hydroxyapatite-coated half pins in both the proximal and distal segments.

Then the osteotomy site is planned based on bone quality and IMN position. One must calculate where the distal nail will migrate with the lengthening and make sure there is adequate IMN left in the distal fragment. For a retrograde nail, one calculates where the proximal tip of the nail will migrate with the lengthening and make sure there is adequate IMN in the proximal fragment. Ideally the osteotomy is placed in metaphyseal bone and at a site different from the original fracture malunion.

The osteotomy is performed through two 1-cm incisions at the osteotomy level, one lateral and the second anterior at the medial border of the femur. The anterior incision is placed with the assistance of fluoroscopy. Through the lateral incision, the anterior, posterior, and lateral cortex are cut with an osteotome. Through the anterior incision, the medial cortex is cut. Care is taken to avoid damaging the IMN. The osteotomy is performed percutaneously and uses the fluoroscopy and tactile positional sensation. The goal is to achieve corticotomy by approaching the periphery of the bone and avoiding the intramedullary canal and the IMN.

Rotational manipulation of the pins and the bone around the IMN is used to confirm that the osteotomy is complete. The rail frame is reapplied. Distraction is started on postoperative Day 5 at a rate of 1 mm per day. We evaluate an x-ray after approximately 1 week of distraction to confirm separation of the osteotomy site. The rate of distraction can be increased if necessary.

At the end of distraction, the patient is taken to the operating room to insert locking screws into the distal or proximal aspect of the IMN for antegrade and retrograde nails, respectively. The frame is prepped into the surgical field and the pin sites are covered with Betadine-soaked sponges.

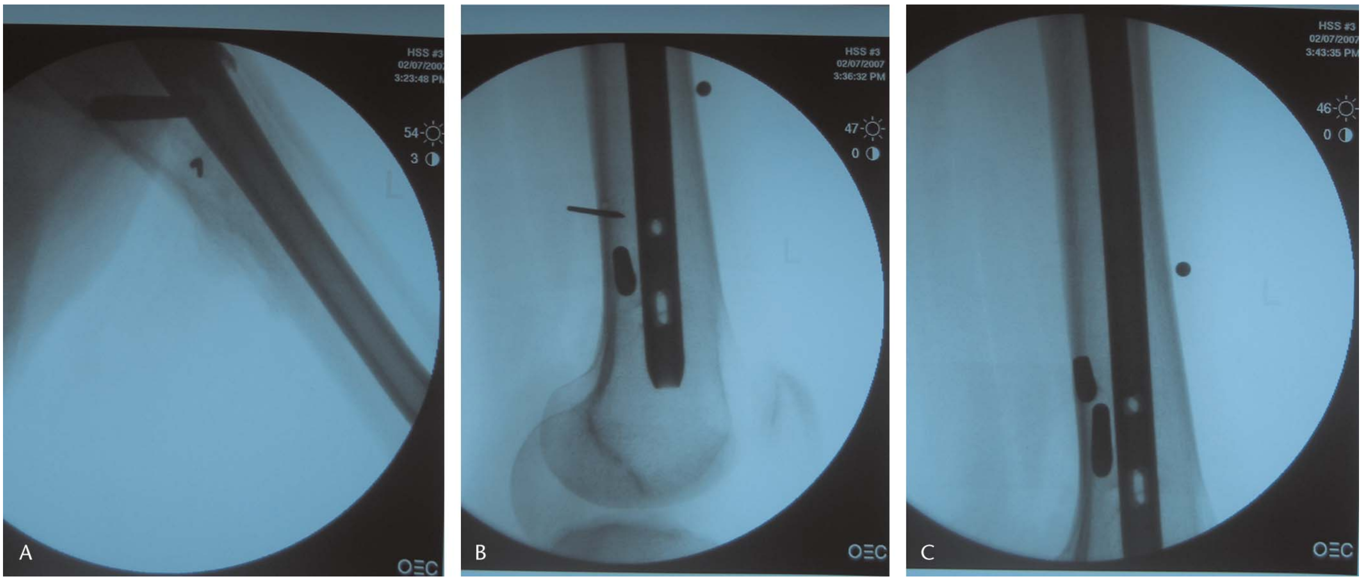

FIGURE 2. (A–B) Intraoperative x-rays showing the use of a cannulated wire technique to insert the pins posterior to the intramedullary (IM) nail. (C) Proximal and distal femur pins inserted posterior to the IM nail.

The frame is covered with towels and care is taken to avoid contact between internal and external fixation. Two interlocking screws are inserted into the distal or proximal aspect of the IMN using a freehand technique and with the assistance of fluoroscopy. Once this is completed, the external fixator is removed because the bony regenerate is well supported by the locked IMN.

Patients were allowed 20 lbs weightbearing only until radiographic healing was seen. This was typically 6 weeks after frame removal. Once healing was noted, patients were progressed to weightbearing as tolerated ambulation. Clinical and radiographic data were recorded. Monthly x-rays were checked until complete healing was seen.

Clinical Series

We report five patients with posttraumatic malunions with axial plane deformity leading to a clinically significant average limb length discrepancy of 3.18 cm (range, 2–5 cm). All patients were treated by two senior surgeons at two academic medical centers. The average patient age was 34.6 years (range, 26–50 years). The average follow-up was 56.1 months (range, 40.5–86.0 months). There were four males and one female. Of the five patients, three had undergone retrograde nailing and two underwent anterograde nailing for the initial treatment of their femoral shaft fractures. The average knee range of motion preoperatively was 0.6° to 130.6°; the average ankle range of motion preoperatively was 41.4° of plantarflexion and 11.4° of dorsiflexion.

The average lengthening accomplished was 2.58 cm (range, 2–3 cm). Time in frame averaged 32.2 days (range, 26–42 days).The time of healing was 20.9 weeks (range, 11–48 weeks). Ankle and knee range of motion did not change with treatment. Complications included superficial pin infections in one patient, which was treated effectively with oral antibiotics, and temporary knee stiffness, which was treated with a miniquadricepsplasty in one patient. There were no deep infections or refractures. External Fixation Index was 0.46 mo/cm (range, 0.31–0.61 mo/cm) and Bone healing Index was 1.71 mo/cm (range, 1–4.07 mo/cm). There were no cases of hardware failure. All five patients are ambulatory without a limp and without assistive devices.

DISCUSSION

Intramedullary nailing for femoral shaft fractures is an excellent treatment option that minimizes blood loss and maximizes stability to allow for bony healing. Nevertheless, deformities after intramedullary nailing are prevalent and some studies note up to a 38% incidence of deformities in the coronal, sagittal, or axial planes after intramedullary nailing.[1,3,6] In addition, fractures with significant midshaft comminution are inherently unstable and can heal in a shortened position resulting in limb length discrepancies.[1] Although small deformities can be tolerated and are usually asymptomatic, larger deformities usually affect gait mechanics resulting in increase energy expenditure and inefficient gait patterns as well as pain in subjacent joints.[4,5]

Reconstruction with osteotomy around an existing nail seems to be an effective procedure for limb lengthening and deformity correction. Eliminating the need for removal of the nail before addressing the deformity has a number of advantages. First, it eliminates the need for reoperation and violation of the abductors in removing anterograde nails and the need for an arthrotomy in retrograde nails. Second, it avoids prolonged operative times in addressing nail removal, which at times can be a challenging procedure. In this technique, the nail provided the stability of the construct during the consolidation phase. This allowed for removal of the external fixator immediately after the distraction phase of lengthening. In addition, it provided an internal scaffold for our rotational corrections, maintaining cortical contact and allowing us to correct the malrotation without concern for translation.

There is a theoretical concern regarding the strength of the IMN and its ability to support the osteotomized bone a second time. These nails have served their purpose to heal the primary fractures. We do not know how much stress was placed across these nails during fracture healing or how close they have come to their fatigue failure point. In creating an osteotomy around the existing nails, we are "reusing" them. In all cases in our series, the nails were able to withstand bone healing stresses a second time. Lengthening patients were kept nonweightbearing after locking the femoral nails until healing of the regenerate bone was seen. Rotational osteotomy patients had load-bearing transverse osteotomies and were allowed weightbearing as tolerated ambulation. If the patient had a history of significantly delayed union, then we would advise against the reuse of the existing nail. It is imperative to avoid damage to the IMN with the osteotome during the osteotomy. Although we did not experience this in our cases, inadvertent damage to the IMN with an osteotome could result in accelerated fatigue failure of the nail.

Another concern would be using this technique for patients in whom a large, tight, and/or ribbed intramedullary nail exists. It may be difficult to move the bone around this type of intramedullary device or to manipulate the alignment in any appreciable way to correct the deformity. This technique is designed to address axial deformities only. Specifically, femoral shortening can be corrected using this technique. Angular deformities such as varus, valgus, apex anterior, apex posterior, and translational deformities in the frontal and sagittal planes cannot be reliably corrected with this technique. These deformities typically require removal of the existing nail to allow for bony reduction.

This article provides clinical and radiographic data on the surgical technique of deformity correction of the femur over an existing intramedullary nail and we feel should be a technique in the armamentarium of methods for correcting significant posttraumatic malunions. The clinical improvement noted in our patients as well as the deformity correction achieved is promising (Fig. 1). Although the number of patients in the study is small, the absence of significant complications and the excellent results obtained suggest that it is a safe procedure that should be a consideration for any patient with persistent axial deformities after intramedullary nailing. Optimizing symmetry after trauma should lead to improved patient satisfaction and function.

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