Monofocal Compression-Distraction Osteosynthesis in a Distal Femoral Nonunion Using a Magnetic Medullary Nail

A Case Report

John A. Scolaro, MD, MA, and Bryan J. Mark, MD

Investigation performed at the University of California, Irvine Medical Center, Orange, California

Abstract

Case: A 65-year-old woman presented with a malaligned, shortened supracondylar distal femoral nonunion. An acute medial closing wedge osteotomy was performed through the nonunion and compressed with a retrograde magnetically controlled intramedullary nail. Osteogenesis with sequential compression and then distraction was performed at the osteotomy site using the nail to successfully restore limb length and alignment.

Conclusion: A magnetically controlled nail can be used to perform monofocal sequential compression-distraction osteosynthesis through a nonunion after an alignment correcting osteotomy.

The complication rate after treatment of supracondylar distal femur fractures treated with a locked lateral plate is not insignificant[1]. Healing difficulty can be multifactorial, but restoration of alignment and stable fixation is essential when treating a fracture nonunion. The physiologic age of the patient and presence of knee osteoarthritis commonly dictate reconstructive options when nonunion and/or malalignment exist[2].

In the supracondylar distal femur, multiple options have been suggested for the treatment of recalcitrant nonunions. Conversion of plate fixation to a retrograde intramedullary nail (IMN), use of combined plate-nail fixation, and compression plating of amenable patterns have all been described[3-5].

Correct implant placement alone can correct malalignment when fragment mobility is present, but commonly, an osteotomy must be performed to correct the deformity. A simple opening or closing wedge osteotomy is effective, but neither have a pronounced effect on restoring overall limb length[6]. Other osteotomies have been described for extra-articular deformity correction, but these are not commonly used in the setting of a concurrent nonunion and have limitations regarding their ability to acutely generate length[7].

This case report presents a novel approach to a maligned distal femoral nonunion in 65-year-old woman previously fixed with an isolated distal femoral locking plate.

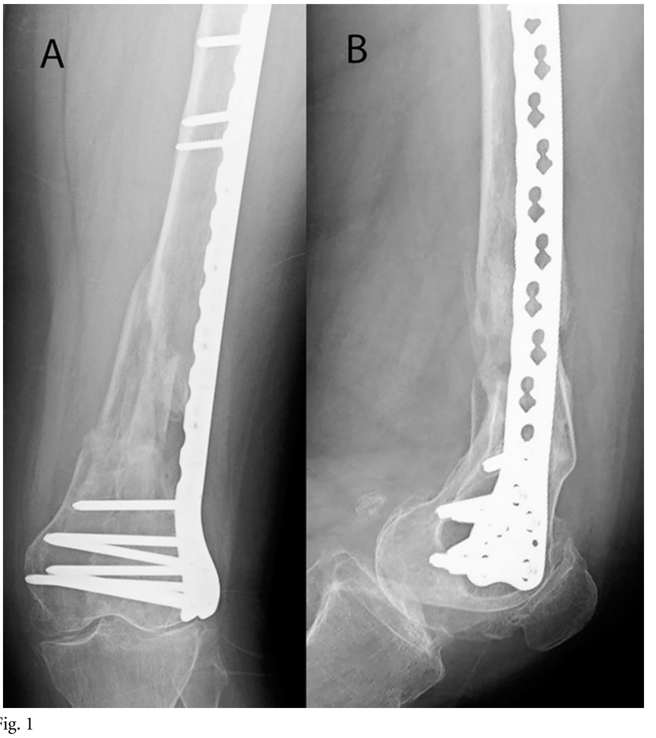

Fig. 1

Anterior-posterior (**Fig. 1-A**) and lateral (**Fig. 1-B**) radiographs of the left distal femur 10 months after treatment of her supracondylar distal femur fracture.

Disclosure: The **Disclosure of Potential Conflicts of Interest** forms are provided with the online version of the article (http://links.lww.com/JBJSCC/B257).

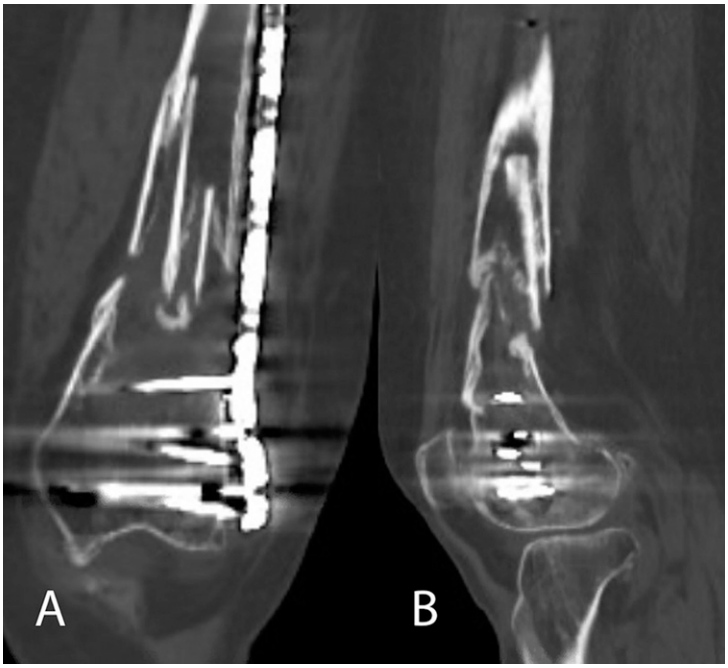

Fig. 2

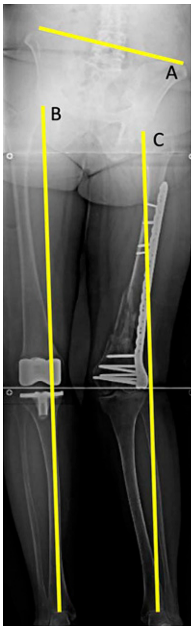

Fig. 3

Fig. 2 Coronal (**Fig. 2-A**) and sagittal (**Fig. 2-B**) computed tomography reconstructions showing distal femoral nonunion. **Fig. 3** Full length preoperative standing radiographs showing pelvic tilt (**A**) and mechanical axis of right (**B**) and left (**C**) legs.

The patient was informed that data concerning the case would be submitted for publication, and she provided consent.

Case Report

A 65-year-old woman presented for the treatment of a supracondylar distal femoral nonunion 10 months after

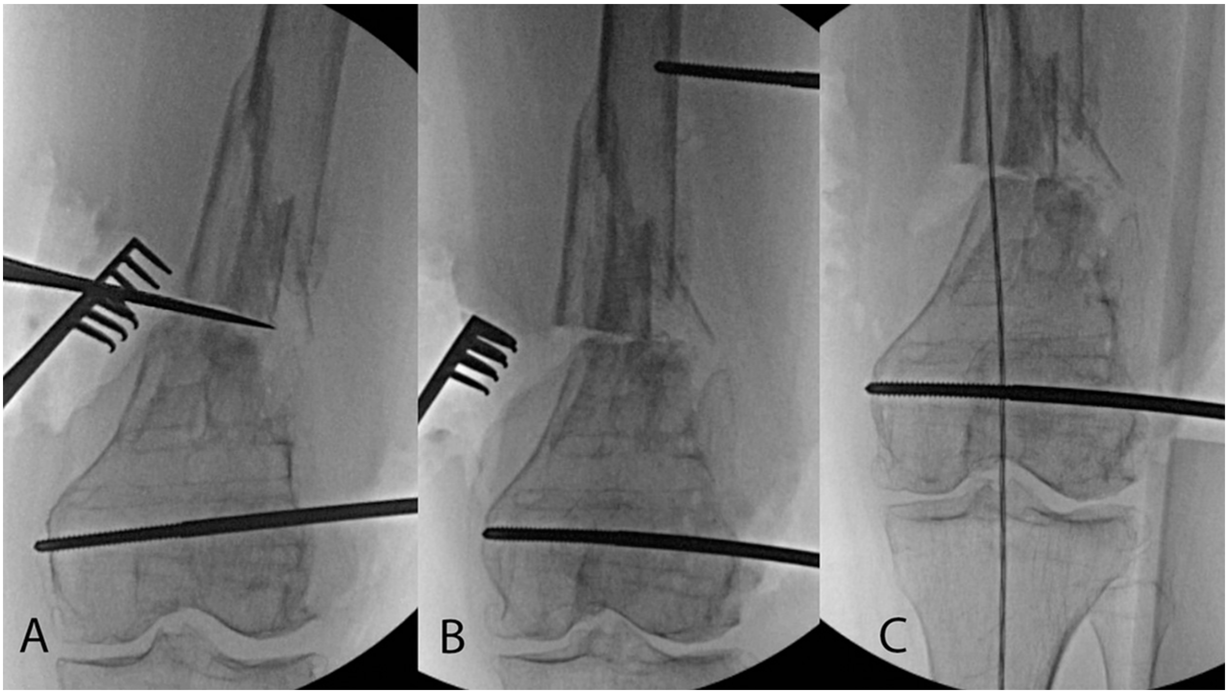

Fig. 4

Sequential intraoperative fluoroscopic images showing medial femoral osteotomy at nonunion (**Fig. 4-A**); external fixator–assisted realignment (**Fig. 4-B**); intraoperative confirmation of mechanical axis correction (**Fig. 4-C**).

Fig. 5

Anterior-posterior (**Fig. 5-A**) and lateral (**Fig. 5-B**) immediate postoperative radiographs showing correction of malalignment and magnetic intramedullary nail fixation.

initial treatment with a lateral distal femoral locking plate. Initial radiographs (Figs. 1-A and 1-B) and computed tomography scan (Figs. 2-A and 2-B) showed a nonunion of the distal femur. Full length standing radiographs (Fig. 3) showed an anatomic lateral distal femoral angle of 75° and anatomic femoral leg length discrepancy of 2.5 cm. The patient remained employed as a corporate educator and walked with an assist device; she reported chronic knee pain due to osteoarthritis and had been scheduled for a total knee arthroplasty.

On physical examination, the left lower extremity was in valgus. She had well healed surgical scars on the lateral aspect of the left thigh. Knee range of motion was from 0° to 120°. Distally, she had a well perfused foot with intact normal and equal sensation and motor function in all nerve distributions bilaterally. After her initial consultation, a complete infectious and metabolic workup was performed, which did not show any abnormalities.

Surgical Procedure

The patient was positioned supine on a radiolucent operating room table with a bump under the left hip. After administration of general anesthesia, the ipsilateral lower extremity was prepped in standard fashion.

First a radio-opaque cord was positioned from the center of the femoral head to the center of the distal tibial plafond; a fluoroscopic image showing the intersection of the cord over the knee was taken and saved. Next, the previous hardware was removed through multiple short lateral incisions. A 2-pin external fixator was then placed to stabilize the limb; one pin was placed proximally and posteriorly from lateral to medial into the lesser trochanter and a second pin was placed distally parallel to the joint line from lateral to medial. A submuscular medial approach to the distal femur was then performed. An osteotome was then used to perform a 5° closing wedge osteotomy through the nonunion site (Fig. 4-A).

To correct limb alignment, the external fixator was manipulated to reorient the distal segment; translation of the shaft was corrected with a percutaneous unicortical Schanz pin placed with in the distal aspect of the femoral shaft (Fig. 4-B). Alignment was adjusted until intraoperative measurement of the mechanical axis intersected the intercondylar tibial eminence (Fig. 4-C). Next, the knee was positioned and approached for a retrograde IMN. A starting guide wire was then positioned just medial to the intercondylar notch on the anteroposterior view and just above Blumensaat line on the lateral view. The wire was then advanced into the femoral canal, and the entry reamer inserted over this. A standard guidewire was then placed into the intramedullary canal of the femur, and sequential reaming was performed until intramedullary chatter was encountered at 14.5 mm. A 12.5 mm × 335 mm precise (NuVasive Specialized Orthopaedics) retrograde IMN was then placed into the femur.

Two orthogonal proximal interlocking bolts were placed, and 2 distal interlocking bolts were placed. In addition, 2 anterior to posterior cortical replacing bolts were then placed just proximal to the most proximal interlocking bolt in the distal segment to control position of the nail. Intraoperative nail compression was then performed until cortical contact and compression was seen at the osteotomy site through the medial surgical exposure.

Postsurgical Protocol

After the initial surgical procedure (Fig. 5), the patient was made 50% weight-bearing on the left leg and seen weekly in outpatient orthopaedic clinic for 1 month. The external remote controller was used to provide 0.5 mm of compression of the osteotomy site at each visit. After 4 weeks of compression, a distraction protocol was initiated. Protocol rate was the total of 0.5 mm/day; rhythm was twice daily. After 2 weeks of lengthening, the most distal interlocking bolt loosened, likely because of its position within a previous screw path from the plate. It was replaced with an interlocking bolt with washers from another manufacturer. An intense physical therapy protocol emphasizing knee range of motion exercises and quadriceps strengthening continued throughout her lengthening period. Routine follow-up at 2-week intervals was performed with femoral radiographs taken at each visit (Fig. 6). After 2.5 cm of lengthening, the patient requested that lengthening be stopped because her pre-existing knee pain was becoming intolerable (Fig. 7).

Fig. 6

Fig. 7

Fig. 6 Anterior-posterior radiographs showing distraction through zone of correction at 3 weeks (**Fig. 6-A**) and 8 weeks (**Fig. 6-B**). **Fig. 7** Full length standing radiographs at completion of lengthening.

After completion of lengthening, which was just over 3 months from the index surgical procedure, the patient was transitioned from flat foot to full weight-bearing on the left lower extremity based on radiographic consolidation of the distal femoral regenerate and the patient's reported comfort. Unfortunately, pain from the patient's degenerative knee osteoarthritis remained. The patient was seen by a joint arthroplasty surgeon for elective total knee arthroplasty (Fig. 8).

Six months after cessation of femoral lengthening, the patient was taken for removal of the retrograde magnetic IMN and total knee arthroplasty. Given the patient's age and our desire to protect the entire femur, an antegrade reconstruction style IMN was placed at that time to protect the femoral neck and span the distal regenerate bone. The patient was allowed to bear weight fully on the left leg and completed uneventful rehabilitation from her arthroplasty procedure (Fig. 9).

Discussion

Acute deformity correction and limb lengthening with magnetic nail technology has been described previously in both pediatric and adult patients[8-10]. Many pediatric cases are performed for congenital deformities, although a greater number of post-traumatic cases are performed in the adult population. In the series by Iobst et al., the average age of the patients was 28 years (range 13-57 years); the series by Horn et al. reported the average patient age to be 23 years (range 11-61 years)[9,10]. In general, few patients older than the age of 65 years embark on limb lengthening procedures because they have either acclimated to, or compensated for, a limb length discrepancy or prefer to avoid elective surgical procedures. It is generally accepted that younger patients are better equipped, from a biologic standpoint, to undergo successful deformity correction and distraction osteogenesis. This case report is also unique in that the patient was a postmenopausal 65-year-old woman.

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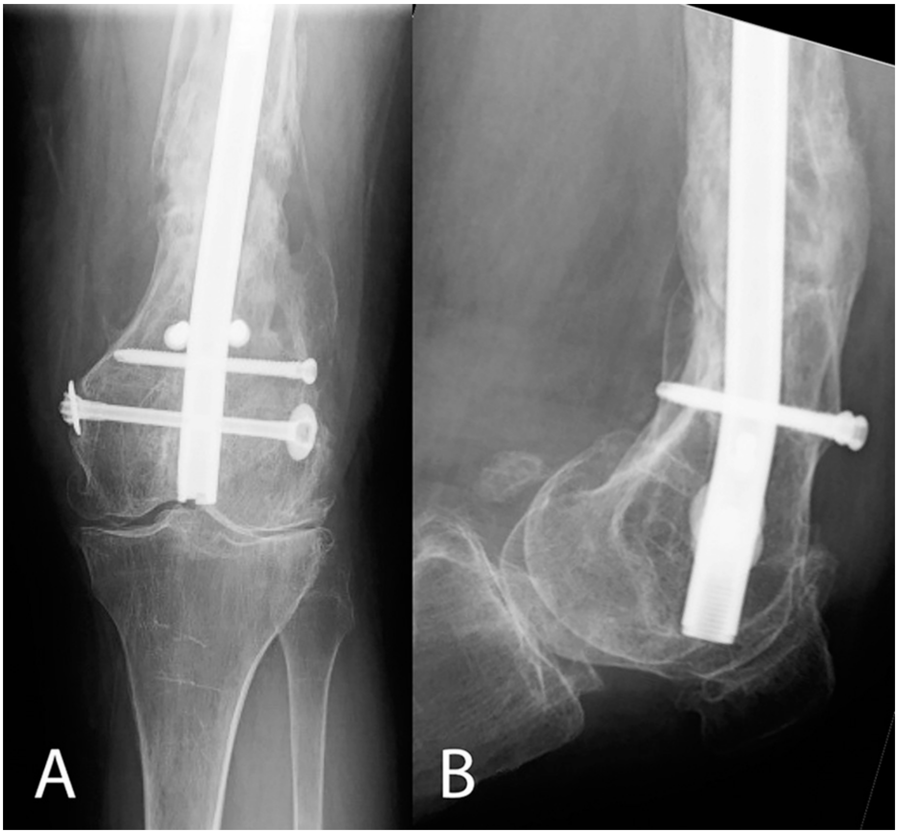

Fig. 8

Fig. 9

Fig. 8 Anterior-posterior (**Fig. 8-A**) and lateral (**Fig. 8-B**) radiographs 6 months after completion of lengthening, before her total knee arthroplasty procedure.
Fig. 9 Full length standing radiograph after total knee arthroplasty and prophylactic nailing of left femur.

To our knowledge, all reported cases involving concurrent deformity correction and subsequent lengthening have been performed in intact long bones. In this case, deformity existed in the setting of a nonunion. Thus, in addition to the patient's maligned and shortened femur, consideration was given to the nonunion. Preoperative planning yielded multiple options, some of which included treatment of the nonunion first with a plate or nail and then staged or concurrent femoral osteotomy and/or lengthening at a remote location. In discussion with the patient, her goal was to achieve alignment correction and have a total knee arthroplasty performed in as short amount of time as possible and avoid prolonged weight-bearing restrictions.

The use of an IMN in this case was preferred, given the advantageous position of the implant and consideration to the fact that the patient was likely going to require a knee arthroplasty. An intramedullary cutting guide or revision-type arthroplasty component would benefit from a patent, well-aligned femoral canal. The magnetic nail was selected for its ability to compress the nonunion/osteotomy and allow for earlier weight-bearing. A compression protocol was then created using previously published data on magnetic nail compression for at-risk fractures and nonunions[11,12]. We elected to compress the osteotomy site to induce initial healing and then proceed with distraction osteogenesis at a responsible rate (0.5 mm/day), with a plan to amend this if necessary.

This case demonstrates the ability of a magnetically controlled IMN to first compress an angulated nonunion after wedge resection, and then, after an appropriate interval, distract the bone at the same location to regain limb length. To our knowledge, this is the first case to demonstrate lengthening at the nonunion level. Previous cases have used a remote level for lengthening or separate surgical procedures to first address the nonunion and then length. This technique can therefore be used with favorable osteotomies to correct alignment and then use the ability of the IMN to restore limb length. Consideration should be given to patient age, demand, and the individual clinical scenario before implementation of this technique. ■

John A. Scolaro, MD, MA[1]
Bryan J. Mark, MD[1]

[1]Department of Orthopaedic Surgery, University of California, Irvine, Irvine, California

E-mail address for J.A. Scolaro: jscolaro@hs.uci.edu

ORCID iD for J.A. Scolaro: 0000-0001-7926-5017
ORCID iD for B.J. Mark: 0000-0002-9685-8751

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