Augmentation Plate Fixation for the Treatment of Femoral and Tibial Nonunion After Intramedullary Nailing

ALI BIRJANDINEJAD, MD; MOHAMMAD H. Ebrahimzadeh, MD; HOSEIN AHMADZADEH-CHABOCK, MD

Abstract

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Nonunion after intramedullary nailing of femoral and tibial fractures, although infrequent, remains a challenge for orthopedic surgeons. Augmentation plate fixation can be a reasonable choice in this situation. From 2003 to 2005, 38 patients (25 femoral nonunions and 13 tibial nonunions) were treated after intramedullary nailing with augmentation plate fixation, leaving the nail in situ, with or without autogenous cancellous bone graft. Patients were followed for at least 1 year postoperatively.

All 25 femoral nonunions healed with solid union (100% union rate), but 2 of 13 tibial nonunions remained symptomatic and did not achieve union (84.6% union rate) at a mean 4.78 months postoperatively (range, 1-6 months). No serious complications were encountered at 1-year follow-up. We suggest augmentation plate fixation for femoral and tibial nonunion after intramedullary nailing.
Many treatments exist for femoral and tibial nonunions when treated preliminary by intramedullary nailing. Although exchange nailing with or without adjunct bone graft is the standard treatment, recent unsatisfactory results after exchange nailing have raised questions about the efficacy of this technique. Some studies have reported nonunion healing rates as low as 53% after exchange nailing in femoral nonunions and recommended reevaluation for exchange nailing.\(^1\)\(^2\) Plate augmentation in femoral nonunions treated initially with intramedullary nailing was introduced by Ueng et al\(^3\)\(^4\) with promising results. This article presents our experience in augmentation plating for femoral and tibial nonunions initially treated with intramedullary nailing.

**MATERIALS AND METHODS**

From 2003 to 2005, 38 patients (25 femoral and 13 tibial nonunions) were admitted to our referral trauma center after intramedullary nailing. There were 31 men and 7 women with a mean age of 31.4 years (range, 18-53 years). All patients sustained fractures in traffic accidents. Thirteen of 25 femoral nonunions and 8 of 13 tibial nonunions were open. Infected nonunions were excluded from the study.

All 25 femoral nonunions were initially treated with open reamed intramedullary nailing, often with a mini incision (<5 cm) technique for directing the guide wire and checking rotation of the segments. All 13 tibial nonunions were treated with unreamed tibial nailing. Two closed nonunions required open reduction via mini incision without using bone holders due to problems encountered during closed reduction. Nonunion was considered when the patient had pain on weight bearing or there was gross motion and pain at the fracture site on physical examination with obvious radiographic signs of bone healing cessation at 6 months postoperatively. Patients were treated with augmentation plates with the nail left in situ. Autogenous cancellous bone graft was applied in 31 patients (13 tibial and 18 femoral nonunions).

Patients with femoral nonunions were operated in a lateral or semilateral position with a standard lateral approach to the femur. In contrast to primary plate fixation for femoral fracture, there is no need for extended exposure of the nonunion site and the plate can be applied with soft tissue and vascular supply preservation. Rotational stability was assessed by applying an external rotation force at the distal thigh while the knee was in flexion. Rotation instability at the nonunion site was detected in all patients and was considered to be the main underlying cause of nonunion. When >1 cm of bone loss existed between 2 segments or <50% of bone contact was evident, cancellous bone graft from the ipsilateral iliac crest was considered, regardless of nonunion type (hypertrophic, oligotropic, or atrophic). A narrow 4.5-mm dynamic compression plate was applied to the medial side of the tibia with at least 2 bicortical screws in each segment, leaving the nail in situ without extensive exposure of the nonunion site. Subcutaneous tissue and skin were repaired sequentially over a suction drainage.

Tibial nonunions were exposed through a 1-cm incision lateral to the tibial crest with the patient in the supine position. Rotational instability was detected in all 13 patients and was considered to be the main underlying cause of nonunion. When >1 cm of bone loss existed between 2 segments or <50% of bone contact was evident, cancellous bone graft from the ipsilateral iliac crest was considered, regardless of nonunion type (hypertrophic, oligotropic, or atrophic). A narrow 4.5-mm dynamic compression plate was applied to the medial side of the tibia with at least 2 bicortical screws in each segment, leaving the nail in situ without extensive exposure of the nonunion site. Subcutaneous tissue and skin were closed over a suction drainage.

Immediate partial weight bearing and knee range of motion were prescribed, and patients were visited at regular intervals until bony union could be demon-

\[\text{Figure 1: Tibial nonunion after unreamed tibial nailing (A). Plating with autogenous cancellous bone graft (B). Union progression at 5 (C) and 9 months postoperatively (D). Solid union at 41 months postoperatively (E).}\]
strated radiographically and on physical examination, with the disappearance of lucencies between segments and painless full weight bearing on ambulation.

RESULTS

Complete union (radiographically and clinically) was achieved in 36 patients (94.7% union rate). All 25 femoral nonunions were healed, while 2 tibial nonunions did not achieve union, remained symptomatic, and required additional surgeries (84.6% union rate). The mean time required to achieve bony union was 4.78 months (range, 1-6 months). Patients were followed for at least 1-year postoperatively. Wound infection occurred in 1 patient with femoral nonunion treated with a dynamic condylar screw; it was eventually treated with debridement and appropriate antibiotic therapy. There was no implant failure.

DISCUSSION

In 1939, Kuntscher was the first to introduce intramedullary nailing for the treatment of long bone fractures. Since then, biomechanical studies and clinical trials have been conducted to develop biomechanical characteristics of the instrument and to improve the surgical technique. Intramedullary nailing is now the treatment of choice for femoral and tibial fractures, with a low rate of nonunion. With a recent extension of the indications for intramedullary nailing and due to the survival of more severely injured patients, complication rates have increased but remain at acceptable levels.

Femoral and tibial nonunions can be treated with various modalities, ranging from nonoperative treatments like electromagnetic fields and low-intensity ultrasound to surgical methods such as dynamization, ring external fixation, exchange nailing, and bone grafting. However, exchange reamed nailing procedures with or without autogenous bone graft are considered the standard treatment. Although early studies showed satisfactory union rates (96%-100%) after exchange nailing, various later studies demonstrated undesirable results. While some authors reported union rates between 74% and 78%, Weresh et al in 2000 suggested reevaluation of routine exchange nailing for femoral nonunions due to 47% failure rates to achieve union in single surgery. Success of exchange nailing for tibial nonunion varies from 84% to 100%.

Bellabarba et al in 2001 demonstrated that plating of femoral shaft nonunion after intramedullary nailing results in 91% bony union without significant complication. Augmentation plate fixation with an in situ intramedullary nail is not a new idea. Ueng et al in 1997 and 1998 reported 100% success in achieving bony union with augmentation plate fixation in femoral nonunion after intramedullary nailing with or without additional autogenous cancellous bone graft. Chen et al achieved solid union in 7 of 8 femoral nonunions after intramedullary nailing with augmentation dynamic condylar screw fixation and adjunct autogenous bone graft. In 2004, Lee et al reported that nonunions of long bone fractures after intramedullary nailing in the humerus, tibia, and femur achieved 100% solid union when treated with augmentation plating. More recently, Choi and Kim also reported 100% solid union in femoral nonunions after intramedullary nailing with the same technique. Nadkarni et al in 2008 demonstrated a 100% union rate in long bone fracture nonunions (femur, tibia, and humerus) after intramedullary nailing with augmentation locking compression plate and adjunct autogenous cancellous bone graft, leaving the nail in situ. We obtained 100% solid union in femoral nonunions and 84.6% in tibial nonunions after intramedullary nailing when leaving the nail in situ and augmenting the cancellous bone graft.

Since it has been demonstrated that blood supply to the bone is recovered by 6 to 12 weeks postoperatively, we believe that augmentation plate fixation after previous intramedullary nailing by the time nonunion is considered (at least 6 months postoperatively) would not extraordinarily compromise blood supply to the bone.

CONCLUSION

All 25 femoral nonunions and 11 of 13 tibial nonunions in our study achieved solid union. No nonunions were infected. Although this is not a new method for treatment of femoral and tibial nonunions after intramedullary nailing, our series is larger than previous studies. Few reports exist in the literature of this technique used with tibial nonunion. We suggest augmentation plate fixation as a reasonable choice for femoral nonunion after...
intramedullary nailing, although in tibial nonunions after intramedullary nailing, exchange nailing may remain a rival of the augmentation plate.

REFERENCES
