Treatment of femoral and tibial fractures aseptic nonunion after intramedullary nailing by plate augmentation and bone graft

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Objective
Intramedullary nailing is widely used in the treatment of femoral and tibial fractures. But some patients suffer from nonunion after treatment by intramedullary nails. This paper investigates the methods and effects of augmentative compression plate and bone graft in the treatment of femoral and tibial nonunion after intramedullary nailing.

Patients and methods
Twenty patients treated between July 2009 and December 2014 were included in this retrospective study. The nonunions included 12 femora and 8 tibiae. The duration of nonunion ranged from 6 to 28 months. There were 7 women and 13 men with a mean age of 40 years (range, 21–64 years). Broad and narrow dynamic compression plating combined with bone grafting was the procedure chosen to treat every cases of femoral and tibial nonunion, respectively, in this series.

Results
The mean follow-up duration was 31.5 months (range, 10–52 months). All the femoral and tibial fractures achieved radiological union. The mean time to union was 20.8 months (range, 12–36 months). One patient had refracture of femoral shaft fracture after removal of interlocking nail and broad dynamic compression plate with refixation by interlocking nail and broad dynamic compression plate again with full union after 18 weeks. Apart from that case of refracture after hardware removal there were no serious complications such as infection, breaking or loosening of the plate and screws during the follow-up period.

Conclusion
Augmentation plating with bone grafting is a highly effective treatment for aseptic nonunion of the femur and tibia after intramedullary nailing.

Keywords:
bone graft, intramedullary nailing, tibial fractures

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Introduction

Nonunion following intramedullary nailing of long bones is a known complication [1]. Occurrence of this complication has been attributed to lack of complete mechanical stability allowing macromotion to occur at the fracture site due to the small nail size, lack of locking, and wide displacement of fragments or the presence of distraction at the fracture site. Other causes of failure of union are devitalization of tissues by trauma or open reduction [2,3]. After treatment with intramedullary nails fractures located around the metaphyses of long bones are especially prone to nonunion. Aseptic nonunion is relatively common in femoral and tibial fractures [4]. Nonunion is considered when the patient has pain on weightbearing or when there is gross motion and pain at the fracture site on physical examination with obvious radiographic signs of bone healing cessation at 6 months postoperatively [5]. Many treatment options exist for femoral and tibial nonunion after intramedullary nail: exchanging unlocked nail with a locked nail, reamed exchange nailing, dynamizing a locked nail, plating after nail removal (with or without bone graft), or external fixation [6–11].

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 nonunion [5,12].

There are some reports of managing nonunion of femoral and tibial shaft fractures with dynamic compression plate and bone graft with good results [3,4,8,13–15].

Patients and methods

From 2009 to 2014, 20 patients (12 femoral and eight tibial nonunion) after intramedullary nail fixation were treated with the augmentation plating procedure and iliac crest bone grafting. The study was approved by the institutional ethics committee in the Orthopedic Department of Orthopaedic Surgery, Ain Shams University, Cairo, Egypt. All the nails were interlocking nails except that two were reconstruction nails. There were 13 men and seven women. Patients' average age at the time of our surgery was 40 years (range, 21–64 years). Plate augmentation and bone grafting were done at an average of 10.8 months (range, 6–28 months) after the primary procedure.

All the cases were closed fractures. There were 11 atrophic, four oligotrophic, and five hypertrophic nonunion. Infected nonunions were excluded from this study. All patients underwent blood tests (ESR, CRP, and CBC) to exclude the presence of infection preoperatively. The average number of previous surgeries performed for the fracture before plate augmentation was 1.4 (range, 1–3). These patients were followed up for an average of 31.5 months (range, 10–52 months).

Patients with femoral nonunions were operated in a lateral position with lateral subvastus approach to the femur for elevation of vastus lateralis with soft tissue and vascular preservation as much as possible. Rotational stability was assessed by applying an external rotation force at the distal thigh while the knee was in flexion. Rotation stability at the nonunion site was detected in all patients and was considered to be the main underlying cause of nonunion. Dense fibrous tissue was removed with freshening of the fracture ends and periosteal surfaces were made raw or shingled by raising the osteoperiosteal flaps using an osteotome in all cases. The retained nail maintained the alignment of the fracture and the proximal or distal locking screws were removed. Every attempt was made to get bone to bone contact on reduction of the fracture. A 4.5 mm broad dynamic compression plate was applied to the lateral aspect of the femur with bicortical screws obliquely inserted to engage anterior or posterior to the nail in an eccentric manner to attain axial compression to the nonunion site. The plates and screws used were of the same material as the nail that remained. Three or four screws were fixed on each nonunion fragment obtaining at least six cortical purchases.

Autogenous iliac bone graft was performed in all cases regardless of the nonunion type. Aerobic and anaerobic cultures were collected from the nonunion site in all cases to rule out hidden infections. The surgical wound was then irrigated, negative pressure drainage placed under the vastus lateralis, and the incision closed routinely in layers.

Tibial nonunions were exposed through a 1 cm incision lateral to the tibial crest with the patient in the supine position. The steps of the procedure were the same except the use of 4.5 mm narrow dynamic compression plate on the medial tibial surface. Fibular osteotomy was needed in two cases with united fibula fracture with tibial nonunion gap of about 1 cm that prevented fracture ends approximation.

On the second postoperative day, the patients were allowed to walk without weightbearing using walkers and to have their adjacent joints gently put through active assisted range of motion. Partial weightbearing was allowed as soon as tolerated until union was achieved. Each patient was followed once every 2 weeks in the first month and once a month thereafter. Additional visits were prescribed if needed. Functional and radiological evaluations were done in monthly visits till union and at 6 months interval after union (Fig. 1).

Union was clinically defined as the absence of tenderness or movement on palpation and the patient was pain free on full weightbearing. Radiological healing was reached when there was continuity of three cortices in anteroposterior, lateral, and oblique views.

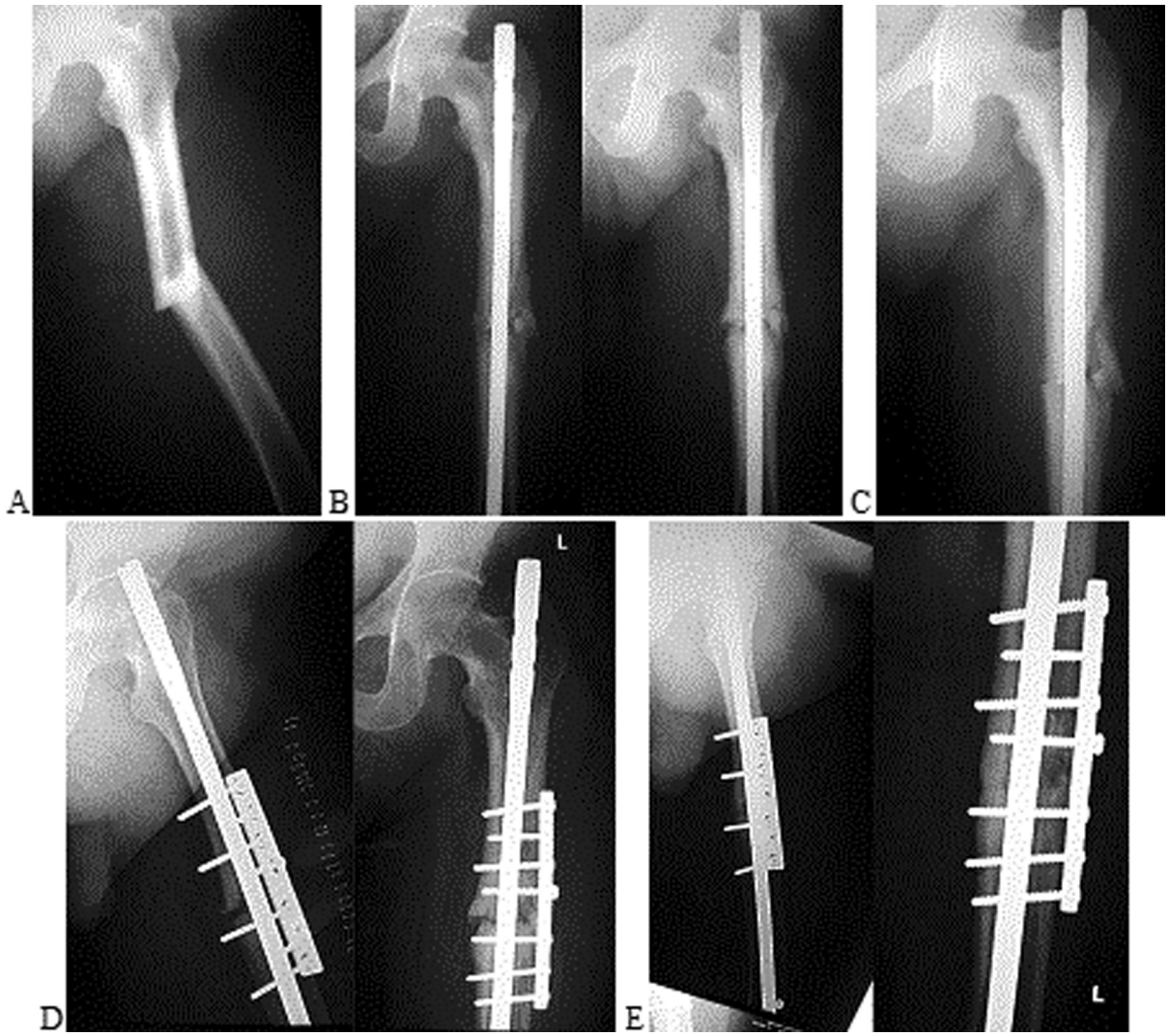
Results

The characteristics of nonunions treated with augmentation plating and autogenous bone grafting are summarized in Table 1. The average follow-up duration was 31.5 months (range, 10–52 months). Union was achieved in all cases without further surgery; the average union time was 20.8 weeks (range, 12–36 weeks). We had no complications such as infection, plate breakage, loose implants, or nerve palsy in this series. One patient had femoral refracture 3 weeks after interlocking nail and augmentation plate removal that was treated by renailing and plating without bone grafting with full union after 18 weeks.

Discussion

Intramedullary nailing has been popularly used in long-bone fractures for many years. Although most fractures

Figure 1



Radiography of case number 1: (a) Radiography of femoral shaft fracture, (b) fracture fixed by ILN after dynamization, (c) ununited fracture after 8 months of dynamization, (d) after plating and bone grafting with ILN retained, and (e) complete fracture healing.

were cured by intramedullary fixation, nonunions do sometimes occur [6]. 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 [12,16].

Exchange nailing is the procedure of choice for treatment of nonunions of long bones specifically in the lower limbs [7,17]. However, exchange nailing has poor results in the treatment of nonunion with extensive comminution at the fracture site, large segmental defects, and in nonisthmal femoral shaft nonunions because it is based on the concepts that mechanical stability is increased through a larger nail, and bone healing is reactivated with more reaming. These concepts do not apply to nonisthmal areas due to the lack of a tight fit between the new larger nail and femoral cortices [2,13,18].

Augmentation plating with the previous nail left in place was first introduced by Ueng *et al*. [19]. Although this procedure showed good clinical results for femoral nonunions, it is more invasive than exchange nailing. In nonisthmal regions, bicortical screw purchase through plate holes can be more regularly achieved than in isthmal regions. These screws may work as blocking screws around the preexisting nail in the metaphyseal area and provide additional stability.

Ueng and colleagues in his study of 17 femoral nonunions showed union of all fractures at 7 months (range, 6–10 months) by using augmentation plates. Bone grafting was performed in seven patients based on the oligotrophic nature of nonunion. The same authors later showed good results of this procedure in the management of tibial nonunions after intramedullary nailing. They treated 12 tibial nonunions with intramedullary nail *in situ* with augmentation plates.

Table 1 Demographics of patients with femoral and tibial shaft nonunions treated using augmentative plating with decortications and autogenous bone grafting

Cases	Sex	Age (years)	Site	Bone	Nonunion type	Time of nonunion (months)	Previous number of operation	Bone graft	Time to union (weeks)	Follow up (months)
1		34	Rt	T	A	8	1	G	21	10
2	M	52	Lt	F	A	11	1	G	25	36
3	F	26	Rt	F	H	9	1	G	18	32
4	M	28	Rt	F	A	16	2	G	26	40
5	M	62	Rt	F	A	7		G	22	26
6	M	36	Lt	T	A	6	1	G	16	20
7	F	42	Lt	F	H	14	3	G	36	50
8	F	30	Rt	T	O	8	1	G	16	36
9	M	34	Rt	F	A	11	1	G	20	36
10	F	22	Rt	T	O	9	1	G	18	24
11	F	54	Lt	F	A	12	2	G	22	36
12	M	48	Rt	F	A	10	1	G	24	52
13	M	64	Lt	T	H	12	1	G	20	28
14	M	49	Rt	F	O	28	3	G	24	28
15	F	21	Rt	T	A	10	1	G	16	24
16	M	33	Lt	T	H	8	2	G	14	28
17	F	46	Rt	F	H	7	1	G	12	36
18	M	60	Lt	F	O	10	1	G	18	24
19	M	38	Lt	T	A	9	1	G	28	40
20	M	23	Rt	F	A	11	2	G	20	24

A, atrophic; F, female; F, femur; G, grafted (months); H, hypertrop; Lt, left; M, male; O, oligotrop; Rt, right; T, tibia.

All of them united within an average of 5.5 months (range, 4–8 months). Bone grafting was performed in one patient who had oligotrophic nonunion. They used a dynamic compression plate in their series [19,20]. Choi and Kim showed radiological union in 15 patients with femoral nonunions when treated with AO plates. Radiological bony union was achieved in all patients in 7.2 months (range, 5–11 months). Bone grafting was performed in all patients [15].

Nadkarni and colleagues showed their good results of treating 11 long-bone nonunions (seven femora, two humeri, two tibiae) without removing intramedullary nails and application of locking compression plates. Corticocancellous autologous bone grafting was performed in every patient to enhance the biology. All the fractures showed radiologic union at 6.2 months (range, 5–8 months) [2].

Theoretically, decortications and bone grafting are unnecessary for hypertrophic long-bone shaft nonunions. However, decortications and bone grafting were performed in all cases because in clinical practice hypertrophic calluses are usually damaged during surgery. Most patients wanted a more definitive treatment option and early return to work, even with donor site morbidity of autogenous iliac bone graft due to long-standing suffering from persistent nonunions. Furthermore, it was difficult to clearly differentiate between hypertrophic and oligotrophic nonunions in most cases. It may be that augmentation plating can be performed without decortications and bone grafting using minimally invasive plate osteosynthesis technique, while protecting hypertrophic calluses if the nonunion is definitively hypertrophic [13].Since it has been demonstrated that blood supply to the bone is recovered by 6–12 weeks postoperatively, it is believed 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 [5].

The limitations of this study include its retrospective nature, relatively small number of cases, and lack of control group with other treatment modalities such as exchange nailing.

Conclusion

Augmentation plating with decortication and autogenous bone graft is a feasible treatment option for tibial and nonisthmal femoral ununited shaft fractures with intramedullary nail *in situ*. Furthermore, this option is useful for selected cases of isthmal femoral shaft nonunions for which exchange nailing failure is expected due to lack of a tight fit between the new larger nail and femoral cortices, or large defects. In cases of malalignment, correction of

deformity especially rotation is possible followed by plate fixation with the nail *in situ*. Augmentation plating, decortications, and autogenous bone grafting have a high success rate, low complication rate, and offers good quality of life.

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Conflicts of interest
There are no conflicts of interest.

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