Plate augmentation in aseptic nonunited femoral fractures fixed by dynamized intramedullary nail

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Objectives
There are several methods to manage an aseptic nonunited fracture femur over a dynamized interlocking nail. The aim of this study is to report and evaluate the outcome of plate augmentation in the management of aseptic nonunited femoral fractures fixed by a dynamized intramedullary nail.
Patients and methods
This prospective study included 17 patients (10 male and seven females) with an aseptic nonunited fracture femur over a dynamized intramedullary locked nail. Patients' ages varied from 27 to 65 years, with a mean age of 45.5 years. All patients were managed by augmenting the fracture site by plate fixation, and an autograft was used in five patients.
Results
All our patients achieved painless unaided full weight bearing within 5 months (mean duration 15 months). The complete union was achieved in all patients, which was radiologically evident at a mean duration of 16 (ranging from 14 to 22 months). Complications occurred in two (11.7%) cases: one experienced postoperative hematoma, and the experienced from 1.5-cm limb shortening.
Conclusion
Plate augmentation is a reliable procedure for the management of aseptic nonunited femoral fractures fixed by a dynamized intramedullary nail.

Keywords:
interlocking nail, nonunited femur, plate augmentation

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Introduction

Fracture of the femur occurs in young men owing to high-energy trauma and can also occur as a result of low-energy fall in elderly women and osteoporotic patients [1]. For these fractures, operative management is usually recommended, and the intramedullary nail is the implant of choice [2].

According to the US Food and Drugs Administration, nonunion is defined as a fractured bone that has not completely united in nine months of injury and that has not shown a progression of healing over 3 months on serial radiography [3].

Intramedullary nail fixation for femoral fractures has a very good union rate, varying from 85 to 100%. For the cases that experience nonunion, risk factors include lack of proper mechanical stability at fracture site owing to the use of small diameter or unreamed nails, postoperative use of NSAIDs, smoking patients, and open fractures. Aseptic hypertrophic nonunion is the most common type [4].

Many strategies are used to treat aseptic femoral nonunion. These include nail exchange with a larger-sized one, dynamization, removal of nail and fixation by plate, applying bone graft, and plate augmentation [1].

Interlocking nail dynamization is a simple and cost-effective procedure, so it can be an effective choice for managing delayed union and nonunion over interlocking nail femur. Vaughn *et al*. [5] performed a study in 2016 which included 19 patients with fracture femur fixed by interlocking nail and suffering from a delayed union and nonunion, and after dynamization, 54% of patients achieved full union.

For patients whose dynamization failed to achieve union, plate augmentation remains as an option to add stability to the fracture and promote union.

Aim

The aim was to evaluate the effectiveness of plate augmentation in treating aseptic femoral nonunited fractures fixed with a dynamized intramedullary nail.

Patients and methods

We conducted a multicenter prospective study from January 2017 to December 2018. The study was approved by the institutional ethics committee in the Orthopedic Department of Orthopaedic Surgery, Helwan University, Cairo, Egyp. The study included 17 patients (10 male and seven females) with an aseptic nonunited fracture femur over a previously dynamized intramedullary locked nail.

Patients' ages varied from 27 to 55 years, with a mean age of 41.3 years. The total nonunion period (time from fracture fixation by nail till plate augmentation operation) varied from 9 to 18 months, with an average of 12.5 months, whereas the period from dynamization till plate augmentation varied from 3 to 6 months, with an average of 4 months.

Among our patients, 12 (70.5%) of them had hypertrophic nonunion and five (29.5%) had oligotrophic nonunion.

Inclusion criteria

Patients with radiological evidence of persistent femoral nonunion after dynamization of interlocking nail femur were included.

Exclusion criteria

The following were the exclusion criteria:

(1) Cases experiencing infected nonunion.
(2) Poor skin condition or soft tissue coverage over the fracture site.
(3) Any systemic condition making them unfit for the operation.

First, the patients underwent a preoperative evaluation to confirm the diagnosis and roll out the possibility of infection. A full history was taken from each patient followed by clinical examination, and serial radiological evaluations were done to confirm nonunion. In addition, laboratory investigations were performed including complete blood count, erythrocyte sedimentation rate, and C-reactive protein to detect infection.

A direct lateral approach was used to explore the site of fracture nonunion. The fracture's edges were identified, interposed fibrous tissue excised, and edges refreshed. With the nail in place, we used AO broad dynamic plate (precontoured as needed according to the fracture site) to fix the fracture. We used at least three screws at each fracture site; screws were inserted at an inclined direction (aiming anterior or posterior) to avoid the nail.

The dynamic compression plate helped in closing the fracture gap when needed. In cases with hypertrophic nonunions, the excised callus was used to fill any residual fracture gap. In cases of oligotrophic nonunion (five cases), an iliac crest autogenous bone graft was used to fill the fracture gap. Decortication was done for all patients.

Patients were instructed to partial weight bearing at the second day postoperatively. Patients were discharged 2–3 days after the procedure and were followed up at the outpatient clinic.

During follow-up, serial radiograph were done at a 6-week interval to assess fracture union. Union was said to be achieved when we detected bridging callus in more than three-fourth of the fracture site on anteroposterior and lateral radiograph views [6].

Results

In this study, the average duration of surgery ranged from 55 to 100 min, with an average of 75 min. The average estimated blood loss was 220 ml (ranging from 200 to 500 ml). Iliac bone graft was harvested in five patients; these cases had an increased average estimated blood loss, ranging from 400 to 500 ml.

At follow-up, radiological evidence of callus formation was observed at a mean duration of 8.1 months (ranging from 6 to 11 months). A complete union was achieved in all patients, which was radiologically evident at a mean time of 18.4 months (ranging from 14 to 24 months).

Thankfully, all our patients were able to achieve painless unaided full weight bearing within 6 months (mean time 15) (Table 1).

In this study, two (11.7%) cases had complications. One patient experienced postoperative hematoma, which required operative drainage; there were no further complications in this case and the wound healed uneventfully. The second case had a limb shortening of 1.5 cm owing to fracture gap compression by the plate; this was managed by shoe elevation, and the patient successfully returned to his normal life activities with no complaint (Fig. 1).

Table 1 Data of the patients

Number of patients	Sex	Age	Iliac graft	Radiological union (weeks)	Type of nonunion	Blood loss	Operative time (min)
1	M	27	–	14	Hypertrophic	200	55
2	M	35	–	16	Hypertrophic	300	70
3	F	45	Done	20	Atrophic	400	100
4	M	55	–	18	Hypertrophic	300	80
5	F	35	–	16	Hypertrophic	200	70
6	F	42	–	24	Hypertrophic	200	70
7	M	50	Done	22	Atrophic	500	100
8	M	34	–	18	Hypertrophic	300	80
9	M	40	–	18	Hypertrophic	200	80
10	F	32	–	16	Hypertrophic	200	80
11	F	45	–	18	Hypertrophic	300	60
12	M	52	Done	24	Atrophic	400	100
13	M	50	Done	20	Atrophic	400	90
14	F	40	–	18	Hypertrophic	300	80
15	F	43	–	18	Hypertrophic	300	70
16	M	47	Done	20	Atrophic	500	100
17	M	30	–	14	Hypertrophic	200	80

F, female; M, male.

Discussion

Aseptic nonunions can be classified as hypertrophic, oligotrophic, and atrophic nonunions [7]. In hypertrophic nonunion, abundant callus and radiolucent line at the fracture site can be observed, which denote lack of mechanical stability (can be due to small-sized nail or lack of rotational stability after dynamization) but sufficient blood supply. On the contrary, atrophic and oligotrophic nonunions are characterized by the absence of callus owing to impaired vascularity [1].

To enhance the mechanical stability of the fixation, there are various options. Exchange nailing with a nail larger in size, removal of the nail and fixation by plating, and plate augmentation over the existing nail are all options [8–10].

Weresh *et al*. [9] performed a study that included 19 patients experiencing femoral nonunion over an interlocking nail. In this study, patients were managed by reamed exchange nailing. Among them, 53% had a union rate, and 47% required additional procedures to achieve fracture healing.

Niedzwiedzki *et al*. [11] conducted a study that included 22 patients with femoral nonunion. They stated that exchanging nailing used in the treatment of delayed union of long-bone shafts does not result in bone healing in all patients, and additional procedures are often required.

In a work performed by Bellabarba *et al*. [10], they studied 23 patients experiencing nonunion of femoral shaft fractures previously treated with intramedullary nailing. Their patients underwent removing of the nail followed by plating and applying bone graft. They achieved a union rate of 91%, but 9% of their cases had early hardware breakage and required repeating the surgery. Nevertheless, this method needed more surgical procedures for nail removing, which consumes more operative time, has greater blood loss, and has more wounds.

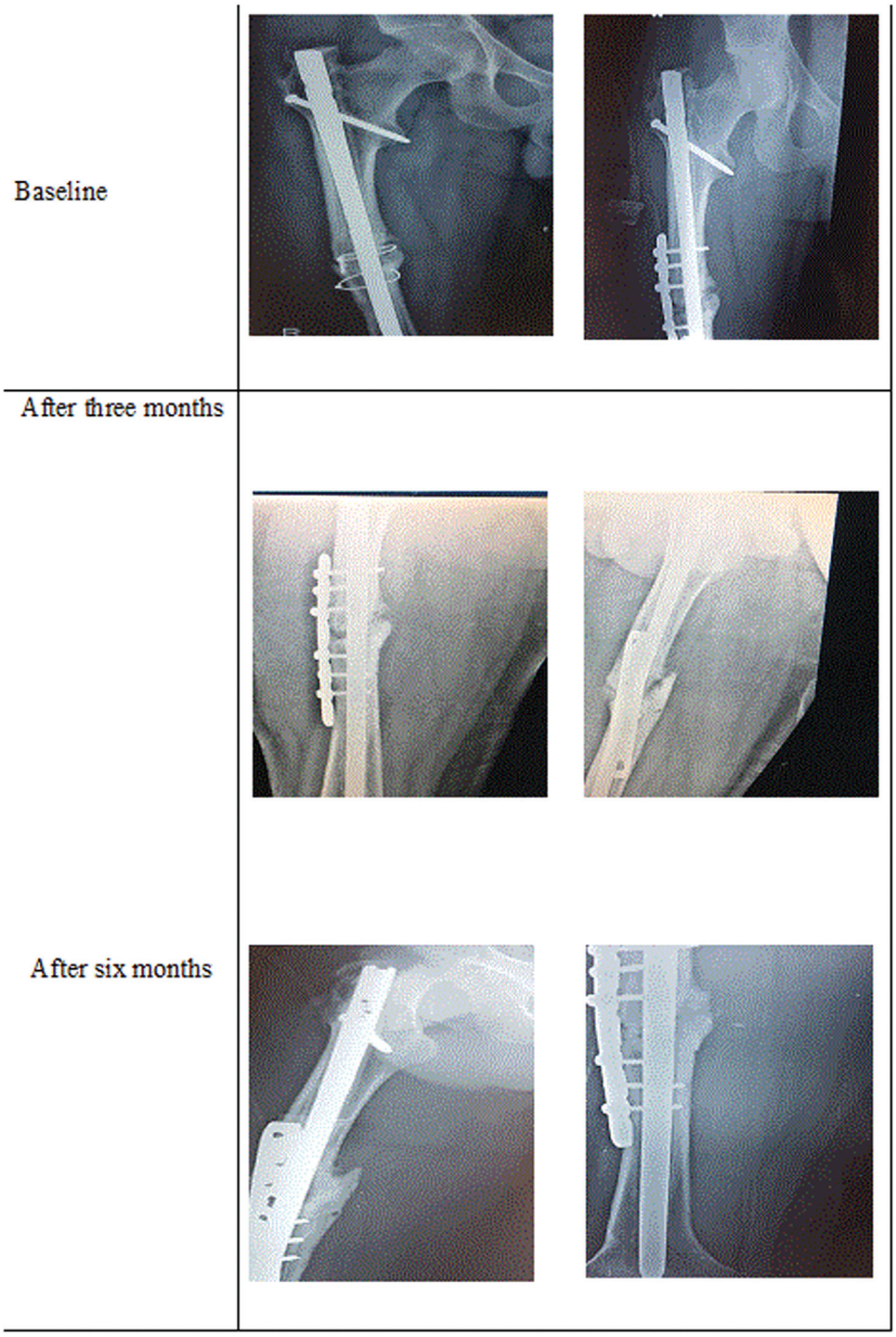
In our study, by retaining the nail in situ and augment the fixation by a plate, we achieved full union in all cases. Leaving the nail in situ helps to maintain the fracture's alignment, enhances the stability, and acts as a loading-sharing device. This gives rise to a reliable rigid fixation and can confidently allow patients for early weight bearing [6].

With plate augmentation, a bone graft can be precisely applied in the fracture site if needed. Therefore, plate augmentation over interlocking nail femur can offer rigid fixation, early compressing mechanical force, and autograft application, which promotes bone healing and increases the union rate [12–14].

Conclusion

The use of plate augmentation in cases experiencing aseptic nonunited fracture femur over a dynamized interlocking nail can be a reliable procedure, which can achieve rigid enough construct that allows for early weight bearing, allows for bone graft application, and full union can be reliably expected.

Figure 1



A 27-year-old male.

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Conflicts of interest
There are no conflicts of interest.

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