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Research Article

The Effect of Augmentative Plating for the Treatment of Nonunion of Femoral Shaft Fractures after Intramedullary Nailing: A Case Series

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Abstract

Background: Several treatment approaches are now considered to manage femoral nonunion following intramedullary (IM) nailing. Augmentation plating over a maintained IM nail was a successful treatment for femur fracture nonunion in recent years. We aimed to describe our experiences in evaluating the union of bone for these patients after plate augmentation with serial examinations and radiologic studies.
Methods: This was a case study on 21 patients who had a nonunion or delayed union of the femoral shaft fracture (FSF) after IM nailing. After initial intervention, they were monitored for 20.4 months (range: 12-72 months).
Results: A closed IM nail was used in 18 patients, while the other three patients were shown as non-IM nail cases with a dynamic hip screw (DHS) in one patient, an external fixator in one other patient, and plate fixation in another one that was planned for augmentation plating. After plating, appropriate union appeared in all patients. Fracture union took an average of 7 months ranging from 3 to 12 months.
Conclusion: Augmentation plating for treating FSF nonunion with leaving the nail in place results in excellent and favorable clinical outcomes with the radiographic recovery of the nonunion site in all of the cases with no complication.

Keywords: Femoral Fractures; Bone; Bone Fractures; Bone Transplantation; Fracture Malunion

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Background

Bone fractures mainly heal through bone regeneration, but sometimes due to various reasons, fracture healing is disrupted and delayed, which will eventually lead to dissatisfaction of both the patient and the surgeon (1). Femoral shaft fractures (FSFs) mainly stem from high-energy injuries to the femur that may lead even to life-threatening injuries, including cerebral and pulmonary complications. This fracture can occur in the elderly even with low-energy injuries and, therefore, will cause far more clinical problems.

Intramedullary (IM) nailing is the treatment of choice for FSF (2). According to the literature (3), 6.8% of FSF cases suffered from nonunion, considering the critical position of the femur in the lower limb as the strongest tubular bone in the body, and given that it is the prominent weight-bearing bone in this part, femoral shaft nonunion could be disabling (4).

In this regard, treatment options for nonunion of the FSF, especially following IM nailing of these fractures, are controversial. Reamed swap nailing (5-7), dynamization (8), nail removal accompanied by plating (9), fixation with or without bone grafting (10-13), and external fixation (14) are currently available treatments for femoral nonunion after IM nailing.

Plate augmentation over a maintained IM nail has been a successful treatment for femoral fracture nonunion recently as the biomechanical environment strengthens the fracture site without further biological damage (15-18). Augmentation plating was found to have a higher rate of union and less common postoperative complications than exchange IM nailing in a recent systematic study of 21 articles. With plate augmentation, the union and complication rates were 99.8% and 4.0%, respectively, compared to 74% and 20% with replaced nailing (19). A few cases of femur shaft nonunion handled with plate fixation and the nail in place have been recorded (12, 17, 20). In this study, we treated 21 consecutive cases of FSF nonunion after primary IM nailing with augmentation plating.

Methods

This was a case study of 21 patients who had a nonunion or delayed union of the FSF after IM nailing and plate fixation. Pathological fractures and contaminated nonunion were excluded. At the time of fracture, demographic data, mode of injury, and the occurrence of any related injuries were all reported. Besides, the primary operative intervention and the time to reoperation before secondary operative intervention were assessed. Any rotational deformity, shortening, or abnormal knee joint range of motion (ROM) was also noted. The appearance of a radiolucent line or radiolucent defect at the fracture site on anteroposterior (AP) and lateral femur X-ray was deemed diagnostic of a nonunion or delayed union. Sclerosis of the bone ends at the site of fracture, inability to demonstrate any union progression in roentgen visual appearance over a six-month interval, a lucent interval across the callus itself, and bone atrophy at the top and bottom of the fracture site are both used to diagnose nonunion (21). Delayed union was described by

Food and Drug Administration (FDA) as a fracture with no evidence of union for more than six months (22). Nonunion is defined by FDA as no fracture healing after nine months with no radiological progression for three consecutive months (22). Nonunion type (atrophic or hypertrophic) was diagnosed with an X-ray and confirmed intraoperatively.

In our study, all patients received autogenous bone grafting. The surgical operation was performed using a lateral approach, and tension plate fixation with Arbeitsgemeinschaft für Osteosynthesefragen (AO) 4.5 mm dynamic compression plate (DCP) was done. The patient was positioned in a supine posture. Nonunion site rotational instability was demonstrated intraoperatively. After developing the osteoperiosteal flaps, bone ends were freshening until they reached the paprika sign, and autologous cancellous bone from the iliac crest was used for bone grafting. A narrow or heavy (depending on the patient's femoral bone) AO 4.5 mm DCP with four to six cortices on each side was used to stabilize the nonunion site. The size of the nonunion gap determined the length of the plate. A longer DCP was used in more significant nonunion gaps to span the nonunion site and sufficiently fix the screws above and below the nonunion site. The missing nail procedure was used to position the screws, which required them to be placed in an anteromedial or posteromedial direction to stop the nail. A unicortical hold was found on certain screws.

Static quadriceps exercises were begun on the first post-operative day, followed by active quadriceps exercises. Patients started touchdown weight-bearing assisted with a walker or axillary crutches. Partial weight-bearing with a walker or axillary crutches after three months was formed and eventually continued with full weight-bearing after six months when the bone union was achieved.

Results

Twenty-one patients (15 men and six women) with an average age of 36.5 years ranging from 18 to 78 years were included. After initial intervention, the subjects were followed up for 20.4 months (range: 12 to 72 months). The pain was the principal chief complaint in all patients. In 18 patients, closed reamed antegrade IM nail was used. In comparison, three patients were shown as non-IM nail cases with a dynamic hip screw (DHS). In one patient, the external fixator and plate in another were all planned for augmentation plating (for a patient with external fixator, the external fixator was removed, and augmented plating was performed). After plating, the pointed subjects achieved union. Fracture union took an average of 7 months (range: 3 to 12 months). Two radiological views of augmentative plating outcomes are shown in figure 1.

Discussion

What was reported in this case series was that augmentation plating for treating FSF nonunion without taking out the nail resulted in excellent and favorable clinical outcomes for patients, with the radiographic recovery of the nonunion in 100% of cases with no complication. The effectiveness of this procedure in the treatment of femoral shaft aseptic nonunion has been verified by several surgeons (15, 17, 18, 22). Uliana et al. recorded an 86.4% union rate using augmentation plating in a retrospective study of 22 patients with FSF nonunion or delayed unions after IM nailing (23).

Figure 1. Preoperative, early, and 18-month postoperative views of augmentative plating

In their research, antegrade nailing and retrograde nailing were performed for 11 patients in every group. In 12 patients, reaming was done during the IM nailing procedure and in eight individuals, open reduction was made. Moreover, the results of Jhunjhunwala and Dhawale's study reported a 97.5% success rate in 40 patients undergoing augmentation (17). In Chiang et al.'s study, 30 patients were treated with augmentation plating over a preserved nail, with 29 patients experiencing uneventful union (15).

Although there is no clear guideline for the best technique for the treatment of FSF nonunion after nailing, our findings show that the augmentation plating technique produces acceptable results. Thus, using augmentation is recommended for FSF nonunion.

All patients were treated successfully and achieved union clinically and radiographically in our series. Autogenous bone grafts are necessary for the effectiveness of augmentation plating techniques for FSF nonunion after nailing. Previous scholars have repeatedly pointed out the importance of biologic augmentation for avascular nonunion and vascular nonunion (15, 16, 23). Regardless of bone defect size, most investigators suggest autogenous corticocancellous bone grafts of the iliac crest (15-18, 23).

We acknowledge that the current investigation has many drawbacks. First, the study's retrospective nature and the lack of a control group for direct contrast are potential limitations. Another potential limitation is the lack of considering patients' underlying risk factors such as diabetes mellitus (DM), history of smoking, and addiction, because of the incompleteness of such information in many patients. However, all the patients achieved union; therefore, any other patient factors do not harm this technique. Nevertheless, extensive, well-designed studies are needed to prove this issue.

Additionally, we looked at a limited sample size of

21 patients. Other scholars have published case series ranging from 11 to 40 patients, showing a low nonunion rate after nailing as well as a slow transition from previous techniques to augmentation plating (15, 17, 18, 23). We highlighted our higher rate of union achievement (100%) in our cases. Besides, our operation was on relatively young patients (the average age was 36.5 years). Nowadays, femoral diaphyseal fractures are often found in elderly patients in most countries, which may interfere with bone healing before and after plate augmentation (24). However, we had elderly patients in our study. Several writers have found decent outcomes after additional plating with the maintained nail in place in older patients beyond this concern (15, 17, 24). Finally, we used means for descriptive statistical analysis and frequencies and percentages for categorical data. While descriptive statistics cannot infer predictive findings, this approach appears to be ideal for the recent study, which sought to determine if plate augmentation over a retained IM nail was a prosperous treatment choice for FSF nonunion.

Conclusion

Augmentation plating with the nail in place is an outstanding choice for treating FSF nonunion. For most FSF nonunion that arises after IM nailing, we believe that this option can replace other expressed treatments.

Conflict of Interest

The authors declare no conflict of interest in this study.

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