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Research Article

Evaluating the Effect of Double Plating Fixation with Bone Graft in Nonunion of Femoral and Tibial Fractures after Primary Surgery

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Abstract

Background: Several treatment approaches are now considered to manage tibial and femoral shaft nonunion after primary surgeries. Double-locking plates with channel bone grafting technology are treatments that surgeons could choose. We aimed to describe our experiences in evaluating the union of bone for these patients after using double-locking plates with channel bone grafting with serial examinations and radiologic studies.
Methods: This case study was conducted on 33 patients consisting of 20 femoral nonunion and 13 tibial nonunion cases. They underwent double plate fixation with bone grafting at Sina Hospital, Tehran, Iran, from 2015 to 2020. They were monitored for an average of 60 months after surgery.
Results: Union was achieved in all the patients in a mean of 10.03 months (range: 8-18 months). During patients' follow-up, no plate and screw breakage, device loosening, deformity, and infection were seen. No additional surgery was needed for any of our patients.
Conclusion: There are various treatment options for nonunion of long bones. This study described the double plating approach for treating femoral and tibial shaft nonunion. The technique of double plate fixation and bone grafting had reasonable union rates in long bone nonunion. The present case series analysis also shows that it is more beneficial to manipulate this promising method for long bone nonunion whenever possible.

Keywords: Femoral Fractures; Tibial Fractures; Ununited Fractures

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Background

Tibial shaft fractures occur 16.9 times per 100000 people per year (1), while femoral shaft fractures (FSFs) occur ten times per 100000 people per year (2).

Long bone fractures are best treated with intramedullary (IM) nailing (3). Nonunion of the FSF could be disabling (3). It may necessitate numerous procedures, posing a therapeutic challenge for surgeons and putting a strain on patients' physical function and the economy (5, 6).

Given the prominent position of femur and tibia in the lower extremity as the strongest tubular bone in the human body and the prominent weight-bearing bone in this part, nonunion of the FSF could be disabling (7). Treatment options for nonunion of the long bone fractures, particularly with IM nailing of the fractures, are debatable in this regard. Treatments for long bone nonunion following IM nailing include:

- Reamed swap nailing (8)
- Dynamization (9)
- Nail removal with plating (10)
- Fixation with or without bone grafts (11, 12)
- External fixation (2)

However, each of these approaches has its own set of drawbacks, and there is no current consensus on the best strategy (13, 14).

Long bone fractures treated with IM nailing and single-plate fixation generally achieve high union rates (15). Furthermore, it is difficult to obtain a rigid, stable, and three-dimensional (3D) fixation in certain nonunion with significant bone defects by only using a single plate fixation or even IM nailing. To put it another way, the new strategies for correcting deformities, rigid attachment, and achieving bony union are not optimal or reliable (16).

Double-locking plate with channel bone grafting technology has the following distinct advantages over other schemes: (1) no additional expansion of the medullary cavity is required when cleaning the nonunion site, and this technique will preserve IM blood supply, (2) does not interfere with the broken end's blood circulation, and aids in healing, (3) single-plate fixation's poor stability is avoided, and the fractured end becomes entirely stable, and (4) maximizes the biological effects of bone and soft tissue while lowering the likelihood of post-surgery mobility limitation (7). Currently, double plating is the approach of choice for treating femoral and tibial shaft nonunion in our ward. In this study, we will describe our technique and results with this approach.

Methods

A total of 33 patients consisting of 20 femoral nonunion and 13 tibial nonunion cases were treated with double plate fixation with bone grafting at Sina Hospital, Tehran, Iran, from 2015 to 2020. The Institutional Review Board approved this study. Each patient filled and signed the informed consent. In general, nonunion is defined as

no fracture healing after nine months with no radiological progression for three consecutive months. In this study, all known nonunion cases were included. The diagnosis of nonunion was made based on history, physical examination, and radiographs. Pathologic fractures and active infection accompanied by nonunion were excluded from the study. The average age of the patients in the study was 40.2 years (range: 11-70 years); 26 cases were men, and 7 patients were women. FSFs were the most common fracture site in the study.

Surgical Technique: Under general or spinal anesthesia, the senior author (BS) performed all the operations. The patient was positioned supine on a radiolucent table with a sandbag beneath the pelvis of the involved side. Proximal and middle femoral shaft nonunions were fixed with two orthogonal (one anterior and one lateral) plates via lateral incision, centered on the nonunion site. Distal femoral nonunions were fixed with two plates via two parallel (lateral and medial) incisions. Tibial nonunions were approached via an anterolateral incision. Proximal tibial nonunions were fixed with two medial and lateral plates. Midshaft nonunions were fixed with two (lateral and anteromedial) plates, and distal nonunion was addressed with two plates (medial and anterior). The scar tissue and sclerotic bone were debrided adequately (a piece of these tissues was sent as biopsy and culture specimen). Finally, autologous iliac bone grafting was performed.

Postoperative Care: The multimodal pain management protocol was given postoperatively. Patients started assisted weight-bearing with two crutches and started active and passive ankle motion, the day after the operation. According to union progression on X-ray, progressive weight-bearing was allowed, and full weight-bearing was allowed after the union was confirmed on radiographic examination. Bone healing and functional outcome were evaluated in all patients.

Results

The mean follow-up time was 60 months (12-120 months). Union was achieved in all the patients in a mean of 10.03 months (range: 8-18 months). During follow-up, no plate and screw breakage, device loosening, deformity, and infection were seen among the patients. No additional surgery was needed for any of our patients. Figure 1 shows preoperative, postoperative, and follow-up images of a 40-year-old man with a nonunion diagnosis undergoing double plating with bone graft.

Discussion

According to the literature, many challenges regarding long bone fracture nonunion management and dealing with complications such as infection, shortening, or deformity are complex (18, 19). Semi-invasive surgical methods like internal fixation using an interlocking nail (20, 21), infiltration of aspirated bone marrow (22), plate-screw fixation (23, 24), mono-lateral external fixation and Ilizarov ring (25-29), autogenous or allogenic bone grafting (30, 31), extracorporeal shock wave therapy (ESWT), low-intensity pulsed ultrasound, and electric stimulation (28, 29) represent treatment options for long bones nonunion. This study described the double plating approach for treating femoral and tibial shaft nonunion.

Many authors advocate IM nailing for femoral nonunion, because it is a minimally invasive technique with a high union rate, and does not disturb the periosteal blood supply (32, 33).

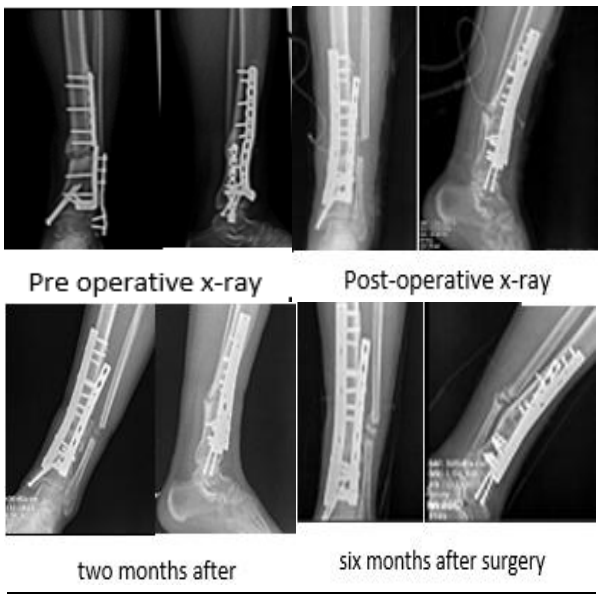

Figure 1. Preoperative, post-operative, and follow-up images of a 40-year-old man with nonunion diagnosis undergoing double plating with bone graft

Although many authors support that exchange reamed IM nailing has good outcomes such as lower morbidity, there is a controversy about the impact of exchange nailing in managing femoral nonunion (34, 35). Furthermore, activating different growth factors, providing mechanical rigidity, and elevation of periosteal blood flow in this method can promote the healing rate to 53-100 percent (20, 21, 36-40). Hierholzer et al. (41) and Swanson et al. (42) reported 98% and 100% union rates in patients with exchange nailing, respectively.

Despite all these successes, two studies cast doubt on the effectiveness of this method indicating failure rates of 27% and 42% (43, 44). In addition, stabilizing and preventing displacement of the grafted bones is difficult.

Infected nonunion of tibia was treated using the Ilizarov ring. This apparatus corrects the deformity and leg length discrepancy with minimal invasion. Disadvantages include neurovascular injury, pain, pin tract infection (PTI), and high cost, which are weak points of this technique (45, 46). Harshwal et al. reported the healing rate of 91.9% in nonunion (7 femurs and 30 tibias) treated with a mono-lateral external fixator and also indicated that with distraction osteogenesis (DO), quality, criteria, and differences in the complications variate the management of nonunion (25).

A subsidiary alternative is the treatment of femoral nonunion by bone grafting combined with nailing or plating (45, 46). Distal femur nonunion was treated with open reduction and internal fixation effectively (47), but fixation applying for a single plate or leaving the IM nail makes it hard to know if the grafted bone is stable.

Wu and Shih (48) represented 22 cases of nonunion of long bone fractures treated with double plating. All patients achieved union by 5.8 months on average. This method offers stable fixation with outstanding rigidity. A 90° angle was made by placing the implants in the femoral anterior and lateral side, generating a 3D fixing environment and resisting the shear effect. Fixing another plate can be done through the same incision.

Moreover, double plating ensures no displacement of the grafted bones. In our study, for all patients, double plate fixation with bone grafting was done with a union rate of 100%. It is worth noting that the mean time of follow-up was 60 months (from 12 to 120 months) with union achievement by 10.3 months, on average.

Patient demographics, comorbidities, treatment choices, injury characteristics, and technical aspects were predictive factors of long bone fracture nonunion (47). Tibial fracture derives a benefit from dynamization, but due to the importance of timing of nail dynamization, there is still a controversy about the role of dynamization in femoral fracture.

FSFs are a common orthopedic problem. Higher union rates can be achieved by internal fixation. Although there are still complications, including plate and screw breakage, internal fixator loosening, deformity, and infection (48), none of them were observed in our patients. No additional surgery was needed for any of our patients. Assessment of the final results was consistent with Paley et al. (49) criteria that were excellent in our study.

The limitations of this study were the small sample size and lack of other methods to compare the results.

Conclusion

The technique of double plate fixation and bone grafting had reasonable union rates in long bone nonunion. The present case series analysis also shows that it is more beneficial to manipulate this promising method for long bone nonunion whenever possible.

Conflict of Interest

The authors declare no conflict of interest in this study.

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