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Revision of Nonunited Fracture Tibia and Femur with Compression Plate

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Abstract*:* Nonunion of femoral and tibial shaft fractures is common but challenging complication for treatment, the current main treatment modalities include nail dynamization, nail exchange and bone transport but compression technique by plating is rarely used. To evaluate the outcome of treating femoral and tibial nonunions by compression plates we reviewed 10 patients with nonunited femoral and tibial nonunion treated by compression plates either convential or locking. All cases were aseptic nonunion. Patients' history and clinical exam data, fracture characteristics, previous interventions all are recorded. Patients were treated by hardware removal and with or without bon grafting. The compression technique and bone grafting were individualized in each case according to patient's and fracture's factors. Each patient finished at least a two-year follow-up, and all cases achieved complete healing. Our study showed that compression plating was an effective method to treat diaphyseal nonunions of the tibia and the femur.

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1. Introduction

Lower limb Long bone nonunions have a devastating impact on patient's health and cause a bad socioeconomic state [1].

The incidence of nonunion is multifactorial and many mechanical and biological factors are included like, inadequate immobilization, commination, bone defects, disrupted vascularity of the fracture fragments, poor soft tissue envelop, and local infection [2].

However, diaphyseal long bone nonunion as of the tibia and the femur still remain a common complication and are difficult to treat [3].

Currently, several techniques have been used to treat diaphyseal long bone nonunions including nail dynamization, exchange nailing, augmentation plating and bone transportation with external fixation. [4]

Exchange nailing has been considered as a standard option with both biological and mechanical advantages. However, there were confusion about its success [5] and its use also has limitations [6, 7]. Compression plating is rarely mentioned in the treatment of tibia and femur diaphyseal nonunions [8, 9] as a successful treatment like in humeral shaft nonunions [10]

Plating was believed to have little role in treating such nonunions especially if there is infection or bone loss [4,11].

In our work we studied a number of nonunion cases treated by compression plating. Our main aim was to investigate the effectiveness of compression techniques in such challenging nonunions by showing this technique highlighting its advantage in treating diaphyseal nonunion of tibia and femur.

2. Material and methods

This was a retrospective study and was approved by the ethic committee of our hospital. The following inclusion criteria were used. (1) tibia or femur nonunion at the area between the two diaphyseal-metaphyseal junction sites and treated by compression plating (2) minimum of 1 years of radiological and clinical follow-up after treatment performed by our surgical team. Patients with congenital limb deformities, pathologic fractures, and nonunions following peri-prosthetic fractures were excluded. From 2018 to 2022 a total of 10 tibia and femur diaphyseal nonunion cases were treated by compression plating all cases finished the full follow up.

The diagnosis of nonunion was established by clinical and radiological assessment. Plain radiograph was the main investigation to identify nonunion. CT scan only done when there was doubt on X-rays. basically, diaphyseal fractures nonunion is defined as failing to heal after 9 months with no progress during the previous 3 months. The diaphyseal region was further divided into three parts: the proximal, middle and distal third to better describe the location of

nonunion. The state of patients, fracture data, and past history of treatments were reviewed. AO/OTA classification was applied to describe the pattern and severity of fractures. X-rays after surgeries were obtained to evaluate patients' initial fixations and fracture reductions. causes which might lead to nonunion were analyzed. poor bony contact is defined as Fracture gap that resulted from bone loss comminution, or poor compression between fragments after plating or nailing. Bone defects which may need surgical reconstruction were addressed. Inappropriate fixation is noted when there were insufficient fracture stability caused by inappropriate choice of implants, undersized nail or plate, and insufficient screw purchase. Local infections were excluded by elevated blood C-reactive protein (CRP) and erythrocyte sedimentation rate ESR and radiologic study.

All patients were assessed for skin condition, bone loss, previous fixation, soft tissue condition, presence of infection and comminution. In our case series, compression plating was generally used to treat tibia and femur diaphyseal nonunion. In all cases we applied compression plates for cases previously treated by patient who failed revision by nailing, nonunion previously fixed by an intramedullary nail which has the largest diameter and nonunion with large bone defect which may require structural bone grafting. The main contraindication of plating was Poor soft tissue coverage. All patients underwent surgical treatment with open reduction and internal fixation. Our technique included removal of the previous fixing devices, excision of nonunions, re-stabilization using compression plates (LCPs) with or without grafting.

Surgical Technique

Figure (1): Male pny 30 yrs old with closed bb leg fracture no med co-mrob fixed by IMN within 3 days post trauma

Figure (2): After revision by removing the nail and applying locked plate and bone graft

Figure (3): After 6 months of follow up complete union is achieved

When there was no need of filling bone graft, we only refreshed the fragment edges and performed interfragmentary compression to procure healing, when iliac crest bone graft used excision of nonunion, refreshing of fracture ends, recanalization and preparation of vascular bed were done.

Application of plates followed the general principles of fracture management. The plate was put on the lateral aspect of the femur or the medial surface of the tibia. Contouring was performed to fit plates to the bone surfaces if necessary. Any malalignment was corrected before completing the final fixation. Compression was a critical step during plate application.

Figure (4): Male Pnt 20 Yrs Old with Lt Femoral Closed Fracure Fixed With IMN

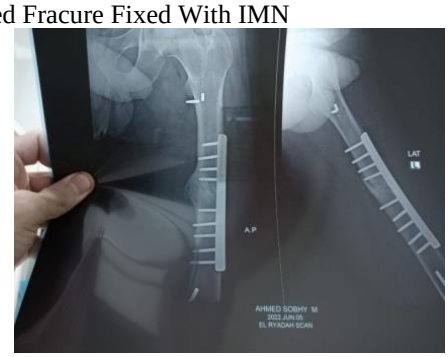

Figure (5): Post-operative x-ray of the patient showing the revision of plate fixation after nail extraction.

Figure (6): Post-operative x-ray of the same patient showing the progress of union after plate fixation.

We performed compression at the nonunion site in every case to decrease the bone gap and promote healing. Trimming at the fracture ends was performed after removal of any fibrous tissue between fracture ends. Compression is completed by performing screw poisoning technique by applying one regular cortical screw eccentrically through a dynamic hole on each side of the fracture.

In cases with compromised bone quality due to osteoporosis, prolonged nonunion, or multiple surgical interventions, locking screws might be used to secure the plate to the fragment. Locking screws were beneficial in such cases [12]

In our study, bone grafting methods are documented as iliac crest bone grafting (ICBG), non-vascularized fibular graft. The grafting Method choice was highly individualized according to the bone deficiency. Generally, most cases were reduced without usage of grafting. Iliac crest bone grafts were commonly used for patients with wedge defects less than 4 cm, cases with prolonged nonunion time, multiple revision surgeries and poor vascularity at the fracture ends to promote healing. Free non-vascularized fibular grafting was used in cases with large or segmental bone defects (usually >4 cm) and patients who had failed from other grafting methods.

All Patients were followed up every month for the first 6 months postoperatively, and then every 2 month till complete healing achieved. Range of motion exercises of the hip, knee, and ankle were started on the 7th postoperative day. Time to weight bearing was dependent on the healing process and was generally delayed to 2-3 months postoperative. Healing was defined on radiographic and clinical base. Radiographically, by the presence of bridging callus across the fracture in both AP and lateral views on X-rays. Clinically, by absence of tenderness on palpation and painless weight bearing.

3. Results

A total of 10 patients were involved in this study. There were 3 females and 7 males with an average age of 30.6 years with an average age of 33.6. There were all aseptic nonunion. A total of 4 femoral and 6 tibial nonunions were included. The mechanism of injury consisted of 5 road traffic accidents, 3 fall from a height, and 2 crush injuries.

Table (1): **Mode of injury**

Type of injury	**No. of patients**	**Percentage**
Road traffic accidents	5	50%
Fall from height	3	30%
Crush injury	2	20%

There were 4 smokers (29.6%) and 1 patients (10%) with metabolic comorbidities. For all cases, approximately 70 % (7 of 10 cases were type B or C fractures according to AO/OTA classification. 2 cases were open fractures at initial fixation. Fracture characteristics including AO/OTA classification, classification of open fractures, fracture locations, and primary fracture treatments are summarized in table 2. There were 7 hypertrophic, 2 oligotrophic, and 1 atrophic non-unions according to the Weber and Cech classification. 2 cases had revision surgeries at other institutes before being enrolled in our hospital. 8 cases were initially fixed by nailing. This result indicates that the non-isthmus regions are easier to develop nonunion after nailing due to instability caused by either a wider canal or inappropriate nailing technique. There were 2 cases initially treated by plating, and traditional dynamic compression plate (DCP) with a principle of rigid fixation was applied in these cases. These observations indicate that damage of blood supply during excessive dissection is likely the main reason for nonunion after plating through radiological study.

We found that in patients after nailing (8 cases), 3 cases (30 %) had problems of inappropriate fixation, 2 with poor bone contact, and 3 with both. These results further suggest that surgery-related instability of fixation exists in the majority of our nonunion cases. Other fixation

Problems identified on the radiographs included malalignment, screw pullout, and implant breakage all were recorded.

Table (2): Fracture characteristics

AO/OTA	No of cases	Percentage
A	3	30%
B/C	7	70%
Gustilo-Anderson		
CLOSE	8	80%
OPEN	2	20%
1RY FRACTURE TREATMENT		
IMN	8	80%
PLATING	2	20%
EX FIX	0	0%
TYPE OF NON UNION		
HYPERTROPHIC	7	70%
OLIGOTROPHIC	2	20%
ATROPHIC	1	10%

The bone grafting methods, in all 10 cases, 5 cases were grafted by iliac crest bone graft, 3 were treated without bone grafting. 2 cases had only bone grafting substitutes.

All 10 patients returned to their normal pre-injury activity level. No complication reported at the bone graft harvest site. No wound complication was found in our case series. We did not. Notice any

malalignment, limb length discrepancy of value. No joint stiffness during follow up.

4. Discussion

Diaphyseal nonunion of the lower limbs is one of the most common problemes after fractures [1]. The treatment is difficult and there is no ideal. There is little literature supporting compression plating like exchange nailing in the treatment of shaft nonunions of lower limb long bones [13].

But due to a high complication rate of plating, nailing was preferred in treating diaphyseal long bone nonunions of the lower limbs [11, 14].

Bellabarba et al reported successful treatment of 23 aseptic femoral nonunions after intramedullary nail fixation by compression plating with conventional DCPs [15]. Ramoutar and colleagues [16] found a high union rate with compression plating in treatment of both upper and lower limb long bone nonunions, but their main focus was the advantages of decortication rather than the technique of compression plating. By highlighting the compression technique, in our study we provided the efficacy of modern compression technique in treating diaphyseal nonunion in femoral and tibial fractures. Compression is very vital in usage of plate in treating fractures. Instability is one of the most important factors leading to nonunion. We showed in our study the role of compression in decreasing strain at fracture site and improve the stability. Compression help bone itself to absorb the axial load and so decrease the strain at fracture as well as the load on the plate improving the whole construct stability.in addition , compression allow bone contact which provide good environment to bone graft to heal. Till now, exchange nailing is considered the standard option supported by highest level of evidences in the treating the diaphyseal nonunions of the tibia and the femur [17]. The advantage of using nailing is by increasing periosteal blood flow and increased construct stiffness by implanting larger diameter nail [18]. But , it was found exchange nailing has limitation especially in cases with sever comminution , segmental bon loss and fractures in metaphyseal–diaphyseal junction, It was also noted that exchang nailing has high failure rate in cases with bone gap of more than 5mm and an atrophic or oligotrophic pattern[19].

Moreover, exchange nailing may be difficult especially where nails with proper sizes were not available in some regions.

Augmentative plating is also another option. Plates can be used with retained nail to prevent motion at the fracture sites. However it is technically demanding to insert bicortical screws in presence of retained nail [20]. Another difficulty is to correct deformity when nailing in situ [21].

Augmentative plating has low evidence level of reports so more studies needed to investigate its efficacy [22] in our study we provided compression plates as alternative option for exchange nailing to treat femoral and tibial diaphyseal nonunion. Plating was improved by previous implant removal, debridement, correction of any deformity, inter fragmentary compression and bone graft usage. Moreover the modern patterns of compression plate like locked plates may contribute to the increased success of revision cases. The limited contact plates have lower infection rates [23] and less damage to the periosteal blood supply than convential DCPs. Locking plates also have more rotional and angular stability than nails especially in nonisthmic fractures. On contrary, the main disadvetages of locking plates were delayed weight bearing, more surgical dissection and more soft tissue cover.

Biological stimulation is also described for nonunion management. Compression plating helps many ways of bone grafting use such as cancellous bone grafting. Decortication only without bone grafting is also described to be beneficial when used in treating long bone nonunions [10].

We found that bone grafting is much easier with plating than nailing. Addition of fibular graft with compression was important especially when there was segmental bone defect [24]. The limitation of our study was the retrospective nature, no control cases, small sized, and different location of nonunions. More studies are needed to further investigate the efficacy of our technique

Conclusion

In brief, we performed effective treatment option in managing diaphyseal nonunion of femur and tibia by compression using either tradional plating of locked ones. Compression is mandatory whatever the methods of it. Use of bone graft is compatable with compression plates we showed good alternative solution in treating challenging problem.

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