RESEARCH ARTICLE

Union Following Biological and Rigid Fixations of Distal Tibia Extra-articular Fractures

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Abstract

Background: Distal tibia fractures are among the most common bony injuries, with a significant rate of nonunion and delayed union. There are multiple methods for the management of distal tibia fractures. Among the plating methods, there are bridge plating and compression plating techniques. There is still a lack of evidence about whether one method has a higher rate of union than the other. The present study aimed to assess the union rate of extra-articular distal tibia fractures using biological fixation with bridge plating and rigid fixation with compression plating.

Methods: This retrospective analysis was performed on 41 adult patients with distal tibia fractures. The subjects were divided into two groups based on the fixation method, namely bridge plating and compression plating. Baseline characteristics, fracture characteristics, and union status were analyzed and compared in this study.

Results: Baseline and fracture characteristics were similar between the groups. Only higher translation in any planes was noted in the bridge plating group (2.80±3.04 mm; *P<0.001*). As for union status, the rates of the union during 3 months and delayed/no union were similar between the two groups (*P=0.18*). During a 6-month follow-up, 92% and 93.8% of the patients achieved union in the bridge plating and compression plating groups, respectively.

Conclusion: Rates of delayed union and nonunion are similar regarding extra-articular distal tibia fractures treated with either bridge plating or compression plating.

Level of evidence: III

Keywords: Bridge plate, Compression plate, Distal tibia, Fracture, Union

Introduction

Distal tibial shaft fractures are frequent injuries, with an incidence varying between 16.1/100,000 and 22.0/100,000 per year (1). Tibial nonunion is a major complication of such fractures occurring within a rate of 3% to 48% (2). They can be managed using various surgical methods. Their optimal treatment has not been definitively determined and is still unsatisfactory, resulting in a substantial rate of nonunion (3, 4).

Open reduction and compression plating lead to anatomic reduction and rigid internal fixation. It was previously considered the standard method for the treatment of fractures (5). The main limitation of this method is that it manipulates the biology of the fracture by disrupting the osteogenic fracture hematoma that affects healing through decreasing perfusion to the fracture fragments (6). In addition, the adoption of this method results in infection and sequestrum formation and can disrupt the vascularity of the fracture, which can ultimately lead to delayed union and nonunion (5, 7).

Bridge plating is a relatively new method of indirect reduction of fractures using the concept of relative stability. The principle of bridge plating is the

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preservation of fracture biology by avoiding soft tissue stripping of fracture fragments (8-10). It also preserves the osteogenic fracture hematoma and vascular perfusion (4, 11). The results of studies have shown that the use of bridge plating minimizes periosteal damage, provides a favorable microenvironment for fracture healing, and reduces the time of union (4, 11, 12). However, bridge plating has been associated with several complications, such as infection, pain from implant prominence, as well as nonunion and malunion (11, 13, 14).

Given the lack of evidence about whether any of the aforementioned fixation methods have a higher rate of union, favoring one reduction method over the other might not be straightforward. The present study aimed to assess the rate of delayed union and nonunion of extra-articular distal tibia fractures with the use of bridge plating and compression plating. Approval of the Institutional Review Board was obtained prior to the initiation of the study.

Materials and Methods

In this retrospective observational study, the union rate of distal tibia fractures following open reduction and internal fixation was compared with compression plating and minimally invasive plate osteosynthesis (MIPO) with bridge plating. In the present study, compression plating was defined as the application of a locking compression plate (LCP) with an interfragmentary screw. Flexible fixation was described as the use of the same LCP in a bridging fashion employing MIPO as the surgical approach.

For both fixation methods, 3.5 mm LCP medial distal tibial plates (DePuy Synthes®) were used in this study. The length of the used plates was either 194 (10-hole plate) or 220 mm (12-hole plate). Distally, five or six unicortical screws (obtaining 5-6 cortices) were inserted in a locking fashion; however, three or four bicortical screws (obtaining 6-8 cortices) were also proximally inserted in a locking fashion. Depending on the length of the used plate, six to nine holes were left empty between the proximal and distal set of screws to ensure the adequate working length of the plate. The medial malleolar tab was cut off from all of the used plates.

In the relative stability group (i.e., bridge plating), the plate was introduced through a medial 4-cm longitudinal incision in an extra periosteal fashion. Another 3-cm incision was performed for the proximal screws' fixation. The biology of the fracture was respected as the fracture hematoma was not violated. The reduction was indirectly performed and checked using fluoroscopy.

In the absolute stability group (i.e., interfragmentary compression), the distal incision was enlarged to allow for the anatomic reduction and insertion of one or two screws to provide the interfragmentary compression of the fracture. The screws were inserted either through the plate or separately. Fibula fractures were fixed with lateral malleolar plates (DePuy Synthes®) and screws if the fibula fracture line was within the 7 cm of tip of the lateral malleolus.

Patients

The data were collected from all adult patients who underwent the surgical fixation of distal tibia fractures (CPT code 27758 and 27759) at the American University of Beirut Medical Center in Beirut, Lebanon, during January 2001 and June 2017. Those who underwent fixation using compression plating or bridge plating were included in the study. Any subjects younger than 18 years of age, with an open or pathologic fracture or previous surgical procedure on the same limb were excluded from the study. Finally, a total of 41 patients were included for analysis. The medical records and radiographs of the study subjects were reviewed in this study.

The data on demographics, fracture characteristics, functional status at 3 months, and clinical risk factors (i.e., smoking history, alcohol intake, and medical comorbidities) were collected from medical charts. Functional status was defined as the degree to which the patient's functionality is affected by the fracture and subsequent fixation 3 months postoperatively. Patients with no functional limitation were regarded as having a good functional status; however, those reporting any functional limitations due to their fracture were considered having a bad functional status.

Radiographic analysis

Fracture characteristics were obtained by viewing the radiographs on Enterprise Imaging viewer (version 8.1.2, Agfa Healthcare, Belgium). The radiographs were analyzed by an orthopedic surgery resident and a senior orthopedic surgeon separately, and the surgical outcome measures were noted in this regard. The measurements were recorded as the average of both readings obtained by the two surgeons. The measurements included angulation in the coronal (varus/valgus) and sagittal planes (procurvatum), as well as translation of the fracture in both planes at 3 months postoperatively.

For the lateral angulation, the angles between 78-82° were considered normal, and angles > 82° or < 78° were considered abnormal. For the anteroposterior angulation, the angles between 88-92° were considered normal, and angles > 92° or < 88° were considered abnormal. The translations were measured and compared between the two groups on the basis of whether the translation occurred or not regardless of the translation plane.

Outcomes

The primary outcome of the present study was union status at 3 months postoperatively. Healing was defined as union irrespective of time. Radiographic union was described as fracture consolidation with the callus formation of 3 out of 4 cortices as observed on the radiograph. The clinical union was also defined as the absence of pain and ability to bear weight on the affected extremity as documented in the medical records within 3 months or less.

The different union complications, such as delayed union, nonunion, or malunion, were recorded in the study. The delayed union was defined as union after 3 months but before 6 months postoperatively; however, nonunion was defined as the failure of the fracture to unite after 6 months. The rates of union and different union complications were compared between the two fixation methods and assessed as related to the clinical risk factors and fracture characteristics.

Statistical analysis

Frequencies, means, and standard deviations were calculated for continuous variables; nevertheless, the numbers and frequencies were used for categorical variables. The rates of union and union complications were calculated in the study. Pearson's correlation coefficient was utilized to determine if there was a correlation between these rates with different fixation methods, as well as other fracture and clinical parameters that were collected. The statistical significance was calculated using the student's t-test where a *P value* less than 0.05 was considered statistically significant, and data analysis was performed using SPSS software (version 18).

Results

Baseline characteristics

Table 1 tabulates the baseline characteristics of 25 and 16 patients in the bridge plate and compression plate groups, respectively. The mean scores of age were 44.96±16.21 and 46.93±13.69 years in the bridge plate and compression plate groups, respectively (*P=0.70*). There was no statistical difference in the baseline characteristics of the subjects treated with each method with respect to age, gender, functional status after 3 months, smoking status, alcohol drinking frequency, or comorbidities [Table 1].

Fracture characteristics

The distribution of fracture types based on the Orthopedic Trauma Association classification was observed to be similar between the two groups (*P= 0.67*) (15). There were significantly higher rates of fracture translation (mm) in any planes (i.e., sagittal and coronal) in the bridge plate (2.80±3.04 mm) and compression plate (0.20±0.41 mm) groups (*P<0.001*). As for the coronal and sagittal angulations, no statistically significant difference was noticed between the two groups (*P=0.62* and *P=0.32*, respectively). These results are presented in Table 2.

Postoperative outcomes

Out of 25 cases in the bridge plate group, 23 subjects were treated after a period of 6 months, and 2 patients did not heal and were managed with reoperation for hypertrophic nonunion with bone graft placement [Figure 1]. Out of 16 cases in the compression group, 15 subjects were treated after 6 months, and 1 case did not heal and was managed with reoperation for hypertrophic nonunion with bone graft placement [Figure 2].

Table 1. Baseline characteristics of the patients

Baseline characteristics	bridge			compress			*P-value*
	frequency	%	n	frequency	%	n	
Age (yrs)*	44.96 ± 16.21		25	46.93 ± 13.69		16	0.70
Gender							
male	16	64.0	25	5	33.3	15	0.06
female	9	36.0		10	66.7		
Functional status							
bad ADL	9	56.3	16	4	36.4	11	0.44
good ADL	7	43.8		7	63.6		
Smoking status							
no	15	60.0	25	7	53.8	13	0.75
yes	10	40.0		6	46.2		
Alcohol intake							
no	16	64.0	25	10	76.9	13	0.49
yes	9	36.0		3	23.1		
Comorbidities							
no	16	64.0	25	6	46.2	13	0.29
yes	9	36.0		7	53.8		

* calculated as mean ± SD
ADL: activities of daily living, where 'bad' is the presence of any functional limitation and 'good' is the absence of any functional limitation.
Comorbidities included osteoporosis, Dyslipidemia, Hypertension, Cardiovascular disease

Table 2. Fracture characteristics of bridge and compression plating

Fracture characteristics	Bridge plate		Compression plate		*P-value*
	n		n		
OTA classification(15)					0.67
42-A	5		1		
42-B	3		1		
42-C	1		1		
43-A	16		13		
Translation (mm)*	2.80 ± 3.04	25	0.20 ± 0.41	15	<0.001
AP angulation (°)*	90.67 ± 4.02	25	89.46 ±2.95	15	0.32
Lateral angulation (°)*	79.26 ± 3.50	24	79.73 ± 1.41	15	0.62
Pain score (0-10)*	0.88 ±2.63	16	0.64 ± 1.43	11	0.79

* calculated as mean ± SD
AP: antero-posterior
OTA: Orthopedic Trauma Association

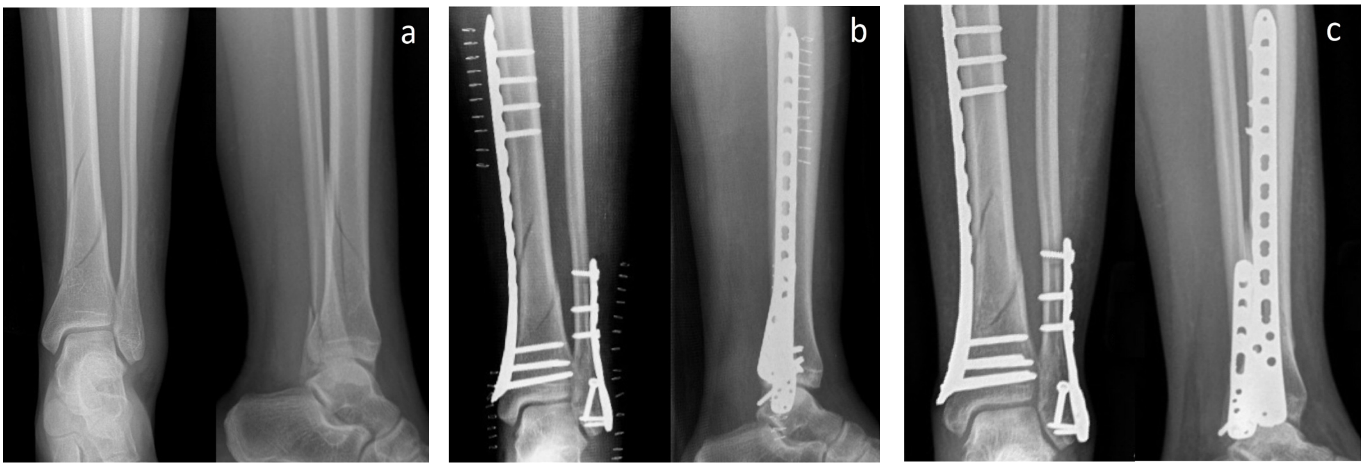

Figure 1. The AO Foundation/Orthopaedic Trauma Association (AO/OTA) type 43-A1 fracture treated with a bridging plate pre and postoperatively (a, b) and at 3-month follow-up (c).

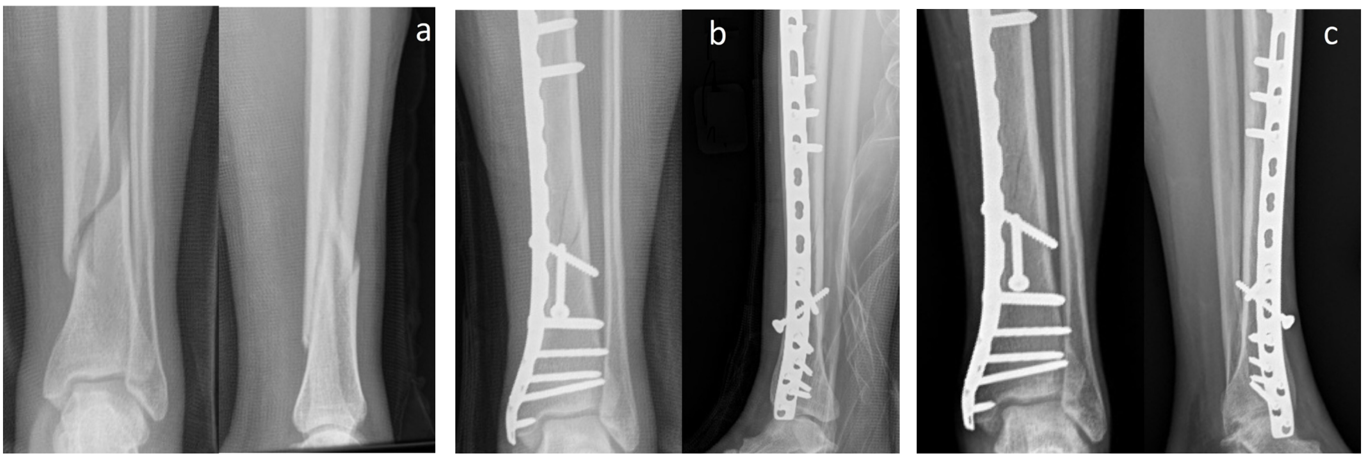

Figure 2. The AO Foundation/Orthopaedic Trauma Association (AO/OTA) type 43-A1 fracture treated with compression plate using a lag screw pre and postoperatively (a, b) and at 3-month follow-up (c).

Table 3. Outcomes of the bridge and compression plate methods

Outcomes	Bridge plate			Compression plate			*P value*
	frequency	%	n	frequency	%	n	
Union at six months	23	92%	25	15	93.8%	16	0.84
Union Status at 3 months:							
Union	14	56.0%	25	13	81.3%	16	
Delayed union	9	36.0%	25	2	12.5%	16	0.18
Non-union	2	8.0%	25	1	6.3%	16	
Re-operation for malunion	2	8.0%	25	1	6.3%	16	0.83

There was no statistically significant difference in the healing outcomes between the two groups [*P=0.84*; Table 3]. Delayed union was observed in nine and two cases in the bridge plate and compression plate groups, respectively. However, while comparing the union status at 3 months, where the normal union was contrasted with delayed union and nonunion rates, there was no statistically significant difference between the two groups [*P=0.18*; Table 3].

Discussion

In this study, a similar union rate was observed in extra-articular distal tibia fractures managed with each method. This result was in line with the observations in similar studies, further confirming the resemblance of the union outcomes of bridge plating and compression plating in this type of fractures (1, 16). The study patients in both groups were reported with approximately 45 years of age, divided almost equally into both groups between the presence or absence of functional limitation, smokers and nonsmokers, and those with comorbidities and without [Table 1]. The average age of the patients in this study was comparable to those of similar studies, and the study results can be easily extrapolated to a population with distal tibia fractures (3, 17).

Radiographic findings were similar in terms of coronal and sagittal angulations between the two groups. However, a significant fracture translation (*P<0.001*) was observed in the bridge plate group in contrast to that in the rigid fixation group. It was expected to witness important differences in the fracture characteristics between the two groups based on the existing data. In this regard, rigid fixation allows for less mobility of the fracture and more anatomical fixation; as a result, less angulation and translation of the fracture occur (5).

The rates of healing and union were comparable between the two groups [Table 3]. Nevertheless, it is important to note that 81.3% of the patients were united within 3 months in the rigid fixation group compared to 56% in the bridge plating group. In addition, 36% of the subjects had delayed union in the bridge plating group in comparison to only 12.5% in the rigid fixation group. This difference was not also statistically significant (*P=0.22*). Since the present cohort was not randomized, this tendency toward increased union within 3 months in the rigid fixation group might be due to the different fracture characteristics indicating the application of the fixation method.

Similarly, Piatkowski et al. observed the rates of bone healing to be similar between bridge plating and rigid fixation (3). Moreover, the time to union was 21 weeks or around 6 months in bridge plating and 19 weeks or around 5 months in rigid fixation (*P=0.49*). However, they noticed a slightly better functional outcome and less pain in the bridge plate group (3). Horn et al. demonstrated a difference in the union rates with healing at 11.3 weeks in fractures with lag screws, compared to 14.9 weeks in fractures without lag screws. This was performed by the observation of the callus index in the coronal plane.

It should be noted that in a study conducted by Horn, the patients with rigid fixation were allowed to bear weight earlier (11 weeks) than the subjects with bridging plates (15 weeks), potentially allowing for enhanced healing (17). In addition, Wegner et al. also observed that the combined use of a lag screw with locking plates leads to significant earlier bone healing and ability to allow full weight-bearing. The mean time to radiological union was significantly shorter (*P=0.04*) with 19 weeks for fractures treated with lag screws and neutralization plate, compared to 27 weeks in the bridge plate group (18).

The present retrospective cohort study had several limitations, allowing only for descriptive analysis. The diverse fracture patterns and extent of injuries in each group should also be taken into consideration; however, only closed fractures were included in the analysis. Moreover, the small sample size and individual differences in terms of patient characteristics, fracture patterns, and weight-bearing had greater statistical impacts and clinical applicability if a similar study with a larger sample size was performed.

The strength of the present study lies in the fact that it is one of the very few studies comparing union rates following the aforementioned fixation methods. This can serve as a pilot study paving the way for a larger prospective randomized control study that can effectively determine the differences in postoperative outcomes between these two fixation methods.

The rate of the union following bridge plating and rigid fixation appeared to be similar. Only the time to union was observed to be different between the two groups. Based on the obtained findings, either of these methods can be employed for the effective fixation of distal tibia fractures, and the outcomes of each method appeared to be similar after 6 months.

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