Union following biologic versus rigid fixation of distal tibia extra-articular fractures

Abstract

Background: Distal tibia fractures are one of the most common bony injuries and have a significant rate of nonunion and delayed union. Multiple methods for the management of distal tibia fractures exist. Among the plating methods, there is bridge plating and compression plating. The evidence is still lacking as to whether one method has a higher rate of union than the other. The aim of this study was to assess the rate of union of extra-articular distal tibia fractures with the use of biological fixation with bridge plating versus rigid fixation with compression plating.

Methods: A retrospective analysis of 41 adult patients with distal tibia fractures was performed. Patients were divided into two groups based on the fixation method: bridge plating versus compression plating. Baseline characteristics, fracture characteristics, and union status were analyzed and compared.

Results: Baseline and fracture characteristics were similar between the groups. Only higher translation in any plane was noted in the bridge plating group (2.80 ± 3.04 mm, p= <0.001). As for union status, the rates of union at three months versus delayed/no union were similar between the two groups (p= 0.18). At six-month follow-up, 92% and 93.8% of patients had achieved union in the bridge plating and compression plating groups, respectively.

Conclusion: The rates of delayed union and non-union are similar for extra-articular distal tibia fractures treated with either bridge plating or compression plating.

Level of evidence: II

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

Introduction

Distal tibia shaft fractures are frequent injuries, with an incidence varying between 16.1/100,000 per year and 22.0/100,000 per year (1). Tibial non-union is a major complication of such fractures occurring at a rate of 3% to 48% (2). They can be managed by 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 leads to anatomic reduction and rigid internal fixation. It was previously considered the standard method for treating fractures (5). The main limitation of this method is that it manipulates the fracture's biology by disrupting the osteogenic fracture hematoma which affects healing by decreasing perfusion to the fracture fragments (6). In addition, this method is beset with 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 preservation of fracture biology by avoiding soft tissue stripping of fracture fragments (8-10). It also preserves the osteogenic fracture hematoma and vascular perfusión (4, 11). Studies have shown that the use of bridge plating minimizes periosteal damage, provides a favorable microenvironment for fracture healing, and reduces the time to union (4, 11, 12). However, it has been associated with several complications such as infection, pain from implant prominence, as well as non-union and malunion (11, 13, 14).

Given the scarcity of evidence on whether any of the aforementioned fixation methods has a higher rate of union, favoring one reduction method over the other might not be straightforward. The aim of this study was to assess the rate of delayed union and non-union of extra-articular distal tibia fractures with the use of bridge plating versus compression plating. Institution Review Board (IRB) approval was obtained prior to initiation of the study.

Patients and Methods

This is a retrospective observational study comparing the union rate of distal tibia fractures following open reduction and internal fixation (ORIF) with compression plating versus minimally invasive plate osteosynthesis (MIPO) with bridge plating. In our study, compression plating was defined as the use of the LCP applied as a compression plate with an interfragmentary screw. Flexible fixation was defined 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. The length of the plates used were either 194 mm (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, while three or four bicortical screws (obtaining 6-8 cortices) were inserted proximally also in a locking fashion. Depending on the length of the plate used, six to nine holes were left empty between the proximal and the distal set of screws to ensure adequate working length of the plate. The medial malleolar tab was cut off from all of the used plates. In the relative stability group (bridge plating), the plate was introduced through a medial 4 cm longitudinal incision in an extra periosteal fashion. Another 3 cm incision was done for the proximal screws' fixation. The biology of the fracture was respected as the fracture hematoma was not violated. Reduction was performed indirectly and checked with fluoroscopy. In the absolute stability group (interfragmentary compression), the distal incision was enlarged to allow for anatomic reduction and insertion of one or two screws to provide 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 7 cm of tip of the lateral malleolus.

Patients

Data on all adult patients who underwent surgical fixation of distal tibia fractures (CPT code 27758 and 27759) at our institution between 1-Jan-2001 and 1-Jun-2017 were collected. Those who have undergone fixation using compression plating or bridge plating were included. Any patient younger than 18 years of age, with an open or pathologic fracture, or who had previously undergone a surgical procedure on the same limb were excluded. A total of 41 patients were included for analysis. The medical records and radiographs of the study subjects were reviewed. Data on demographics, fracture characteristics, functional status at 3 months, and clinical risk factors (smoking history, alcohol intake, medical comorbidities) were gathered from the medical charts. Functional status was defined as the degree to which the patient's functionality is affected by his fracture and subsequent fixation three months postoperatively. Patients with no functional limitation were regarded as having a good functional status, while those reporting any functional limitation due to their fracture were considered as having a bad functional status.

Radiographic analysis

Fracture characteristics were obtained by viewing the radiographs on Enterprise Imaging 8.1.2 (Agfa Healthcare, Belgium). Radiographs were analyzed by an orthopedic surgery resident and a senior orthopedic surgeon separately and the surgical outcome measures were noted. The measurements were recorded as the average of both readings obtained by the two surgeons. The measurements included angulation in the coronal (varum/valgus) and sagittal plane (procurvatum, as well as translation of the fracture in both planes at three months postoperatively. For the lateral angulation, angles between 78-82° were considered normal, and angles >82° or <78° were considered abnormal. For the AP angulation, angles between 88-92° were considered normal, and angles >92° or <88° were considered abnormal. Translation were measured and compared between the two groups on the basis of whether translation occurred or not regardless of the translation plane.

Outcomes

The primary outcome of the study was union status at three months postoperatively. Healing was defined as union irrespective of time. Radiographic union was defined as fracture consolidation with callus formation of 3 out of 4 cortices as observed on the radiograph. Clinical union was also defined as the absence of pain and the ability to bear weight on the affected extremity as documented in the medical record within three months or less. The different union complications such as delayed union, nonunion, or malunion, were recorded. Delayed union was defined as union beyond three months but before six months postoperatively, while nonunion was defined as the failure of the fracture to unite after six months. The rates of union and different union complications were compared between the two fixation methods and were assessed as related to clinical risk factors and fracture characteristics.

Statistical analysis

Frequencies, means, and standard deviations were calculated for continuous variables while number and frequency were used for categorical variables. The rate of the union and union complications were calculated. Pearson’s correlation coefficient was used to determine if there is a correlation between these rates and the different fixation methods, as well as other fracture and clinical parameters that were collected. The statistical significance was calculated using the student test where a p-value less than 0.05 was considered statistically significant. Data analysis was performed using Statistical Package for the Social Sciences (SPSS) 18 (SPSS Inc., Chicago, IL).

Results

Baseline characteristics

Table 1 summarizes the baseline characteristics of the 25 patients in the bridge plate group and 16 patients in compression plate group. The average age was 44.96 ± 16.21 years in the bridge plate group versus 46.93 ± 13.69 years in the compression plate group, respectively ($p=0.70$). There was no statistical difference in the baseline characteristics of the patients treated with either method with respect to age, sex, functional status after three months, smoking status, alcohol drinking frequency, or co-morbidities (Table 1).

Fracture characteristics

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

Post-operative outcomes

In the bridge plate group, 23 of the 25 cases had healed after the period of six months, two did not heal and was managed with reoperation for hypertrophic nonunion with bone graft placement (Figure 1). In the compression group, 15 of the 16 cases had healed 6 months, 1 did not heal and was also managed with reoperation for hypertrophic nonunion with bone graft placement (Figure 2). There was no statistically significant difference in the healing outcome between the two groups (p=0.84, Table 3). Delayed union was observed in nine cases in the bridge plate group and two cases in the compression plate group. Yet, when we compared the union status at three months, where normal union versus delayed union and nonunion rates were contrasted, we found 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 either method. This came in agreement with the observation in similar studies (1, 16), further confirming the resemblance of the union outcome of bridge plating and compression plating in this type of fractures. The study patients in both groups were around 45 years of age, divided almost equally into both groups between the presence or absence of functional limitation, smokers and non-smokers, and those with co-morbidities and those without (Table 1). The average age of our patients was comparable to that of similar studies (3, 17) and the study results can be easily extrapolated to a population with distal tibia fractures.

Radiographic findings were similar in terms of coronal and sagittal angulation between the two groups. However, significant fracture translation (p<0.001) was found in the bridge plate group in contrast to the rigid fixation group. We expected to witness important differences in the fracture characteristics between the two groups based on existing data that rigid fixation allows for less mobility of the fracture and more anatomical fixation, allowing for less angulation and translation of fracture the fragments (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 patients united within three months in the rigid fixation group compared to 56% in the bridge plating group. Additionally, 36% of patients had delayed union in the bridge plating group versus only 12.5% in the rigid fixation group. This difference was also not statistically significant (p=0.22). Since our cohort was not randomized, this tendency toward increased union within three months in the rigid fixation group might be due to the different fracture characteristics dictating the fixation method used.

Similarly, Piatkowski *et al.* found 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 vs 19 weeks or around 5 months in rigid fixation (p=0.49). However, they found a slightly better functional outcome and less pain in the bridge plate group (3). Horn *et al.* found 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 done by observing the callus index in the coronal plane. Of note, in the Horn study, patients with rigid fixation were allowed to bear weight earlier (11 weeks) than patients 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 analysis of the present study is based on a retrospective cohort study with several limitations, allowing only for a descriptive analysis. The diverse fracture patterns and extent of injuries in each group should also be taken into consideration, though only closed fractures were included in the analysis. Additionally, the small sample size and individual differences in terms of patient characteristics, fracture patterns, and weight bearing might have a larger impact compared to a similar study with a larger sample size. The strength of our 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 which paves the way for a larger prospective randomized control study that can effectively determine differences in postoperative outcomes between these two fixation methods.

Conclusion

The rate of union following bridge plating and rigid fixation appears to be similar. Only the time to union was found to be different between the two groups. Based on our findings, either of these methods can be employed for the effective fixation of distal tibia fractures and the outcome of either methods appear to be similar after six months.

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Figure Legend

Figure 1. AO/OTA type 43-A1 fracture treated with a bridging plate. Pre and post-operative (a,b) and follow up at 3 months (c)

Figure 2. AO/OTA type 43-A1 fracture treated with compression plate with a lag screw. Pre and post-operative (a,b) and follow up at 3 months (c)