Clinical Comparison of Minifragment Plates Versus Conventional Semitubular Plates for Fixation of Distal Fibula Fractures

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Abstract *Background:* Although operative stabilization of unstable distal fibula fractures is frequently performed and discussed, the ideal implant and technique for these injuries is still debated. *Questions/Purposes:* The purpose of this study was to determine if minifragment plating of distal fibula fractures would clinically provide equivalent fixation and cost and minimize hardware prominence when compared with standard one-third tubular plating. *Patients and Methods:* A retrospective review was conducted on 44 patients who had undergone operative stabilization of a displaced fibula fracture. Inclusion required fibula fixation with either a traditional one-third semitubular plate or a 2.7-mm minifragment plate. Retrospective review of the patient demographics, injury and surgical variables, and radiographs was completed by two surgeons not involved with the patients' original care. *Results:* The minifragment group demonstrated equivalency in maintenance of fracture reduction relative to standard tubular plating. Both groups were able to maintain the talocrural angle with less than 1° of change from initial postoperative to final postoperative

radiographs. No significant differences were seen in postoperative hardware irritation between groups. *Conclusions:* Use of a minifragment plating system for displaced fibula fractures appears to be safe but comes with the significant potential added cost of the technology. Interestingly, no significant differences were seen in implant-related irritation or implant removal, but further investigation with a larger study population would help better determine these outcomes.

Keywords distal fibula fracture · minifragment fixation · ankle fracture · small fragment

Introduction

Ankle fractures are one of the most common injuries requiring surgical treatment, and it has been demonstrated that displaced, unstable lateral malleolus fractures have improved outcomes with anatomic reduction and surgical stabilization [1, 6, 9]. Traditionally, these fractures have been treated with either lateral plating of the fibula with an interfragmentary lag screw or posterior lateral plating with an antiglide plate [9, 12–14]. However, debate still exists regarding the optimal fixation method as well as the ideal implant.

Posterior antiglide plating allows for bicortical distal fragment fixation and has been shown in some studies to be biomechanically superior to lateral plating, especially in osteoporotic bone [12, 13]. However, increased peroneal tendon irritation has been associated with posterior plating [3, 9]. Nonetheless, laterally placed fixation is often palpable due to its subcutaneous location and can frequently be a source of irritation and pain [7]. Furthermore, semitubular plates offer limited availability for screw placement in the distal fragment. Newer locking plates have increased in popularity, particularly in osteoporotic patients where it is difficult to achieve adequate distal fixation. These plates

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Fig. 1. **a** A 2.7-mm 12-hole LCP plate. **b** A 2.7-mm 7-hole adaption plate.

allow for increased distal fixation and have been shown to be mechanically superior to conventional plates, but these plates tend to be thicker and more symptomatic [8]. Recently, minifragment fibula fixation has been explored as a means to provide lower profile constructs with enhanced stability. Minifragment plates allow for increased screw fixation distally and for locking fixation if desired, especially in instances of small, comminuted distal fibula fractures. In biomechanical testing of an osteoporotic model, there was no significant difference in peak torque and stiffness between a 2.4-mm T-plate construct and a 3.5-mm tubular plate construct [2].

To our knowledge, there have been no studies that compare the clinical efficacy of minifragment fixation with

traditional one-third tubular plates for fixation of distal fibula fractures. The aim of this investigation was to assess the ability of minifragment fixation constructs to maintain fracture reduction, as compared to the aforementioned traditional fixation constructs. In addition, this study will evaluate and compare the complication rates of the two fixation methods. Finally, this investigation will evaluate the costs of the instrumentation necessary for each method used.

Patients and Methods

A retrospective review was conducted on 93 patients who had undergone open reduction and internal fixation (ORIF) for displaced ankle fractures by a single surgeon during a 4-year period from December 2009 to December 2013. Patients were included in the study if they had an unstable ankle fracture treated with ORIF of the distal fibula with plates and screws consisting of either a traditional one-third semitubular construct (Synthes, Paoli, PA) or a 2.7-mm minifragment construct with a standard 2.7-mm LCP plate or a 2.7-mm LCP adaption plate (Synthes, Paoli, PA) (Fig. 1). The patients were 18 years or older and skeletally mature and had at least 6 months of radiographic follow-up after their surgical stabilization. Patients who had adjunctive external fixation or fibular fixation without these devices were excluded from the study. Forty-four patients that met the inclusion criteria were then subdivided into those with one-third semitubular plate constructs (28 patients) versus those with minifragment constructs (16 patients). The semitubular fixation construct patients immediately preceded the minifragment fixation construct patients, as the operating surgeon adopted minifragment fixation exclusively for these injuries. The operating surgeon utilized the fixation construct, including the number and placement of screws, according to the demands of the injury or fracture pattern.

Patient records were evaluated for patient age, gender, presence of diabetes or tobacco use, and the initial injury mechanism (Table 1).

Operative reports were reviewed to determine the style of plate used, plate positioning, presence of lag screw fixation, number of locking and nonlocking screws utilized in the construct, and operative time. Cost of each construct was calculated from assessing the number and type of each screw and plate used for each procedure, and using the costs provided by the manufacturer at the time of the investigation, in order to limit effects of price changes.

Table 1 Patient demographics and injury characteristics

Variable	Standard fixation	Minifragment fixation	P value
Age (years)	41.5±15.7 (18–65)	51.1±13.5 (30–75)	0.04
Sex (male)	8 (28.6%)	7 (43.8%)	0.31
Diabetes mellitus	3 (10.7%)	2 (12.5%)	0.88
Tobacco use	11 (39.2%)	4 (25%)	0.34
Fibular fracture level (Weber classification)			
Weber A	0 (0%)	1 (6.3%)	0.18
Weber B	21 (75%)	11 (68.8%)	0.65
Weber C	7 (25%)	4 (25%)	1

Level of the fibula fracture (OTA [11] and Danis-Weber classifications [4, 15]) and initial injury pattern (Lauge-Hansen classification [10]) were determined from preoperative plain radiographs. Radiographs were assessed immediately postoperative and at final follow-up to determine medial clear space, tibiofibular clear space, tibiofibular overlap, talocrural angle, and associated fibular shortening (Fig. 2); these were assessed by two orthopedic trauma fellows, with differences in measurement of greater than 2 mm or 4 between the two investigators being separately measured by a fellowship-trained orthopedic trauma surgeon not involved in the care of the patients. Postoperative complications including superficial and deep infections, delayed union or nonunion, and symptomatic hardware were also evaluated (Table 2).

All patients in the study were followed up to radiographic or clinical union with the exception of one patient who developed a nonunion as described below, and the mean length of postoperative follow-up was 12.1 months. A significantly younger population was treated with the small fragment plates, but no other significant findings were noted in the demographic data reviewed. No significant differences were seen in the injury mechanism or Lauge-Hansen

classification between the two groups. A supination-external rotation (SER) mechanism accounted for 75% of the injuries in the standard group and 68.8% of those in the minifragment group. Pronation-abduction (PAB) and pronation-external rotation (PER) mechanisms accounted for 14% and 10.7% in the standard group and 12.5% and 12.5% in the minifragment group. The level of fibula fracture was similar in both groups with a predominance of Weber B-type fractures (OTA 44-B). The standard semitubular fixation group consisted of 21 Weber B fractures (75%), 13 44-B2 and 8 44-B3, and 7 Weber C fractures (25%), all seven of 44-C2. The minifragment group contained 1 Weber A fracture (6.3%), a 44-A3; 11 Weber B fractures (68.8%), three 44-B2 and eight 44-B3; and 4 Weber C fractures (25%), two 44-C1 and two 44-C2.

After data collection, stats were analyzed with means, ranges, and confidence intervals calculated for continuous variables and compared using Student's *t* tests. Frequencies were calculated for continuous variables and compared using Fisher's exact test for increased accuracy in small proportion analysis. A significance level of $P > 0.05$ was set as significant, with a trend being defined as a *P* value being between 0.05 and 0.10. Post hoc power analysis of this investigation revealed a power of 0.95 when assessing the complaints of implant prominence.

Results

Radiographic analysis immediately postoperatively and at final follow-up revealed equivalent maintenance of fracture reduction between the groups. There was no difference between the groups regarding the maintenance of medial clear space, tibiofibular overlap, tibiofibular clear space, and talocrural angle. Both of the surgical constructs maintained the talocrural angle with less than 1° of change from initial postoperative to final postoperative radiographs (Fig. 3).

Cost analysis of the constructs, which included the price of the lag screws, the plate, and all screws placed through the plate, revealed a significant difference between the two groups. The mean manufacturer's price for the conventional semitubular group was \$400.77 (range \$290–707) versus \$1528.25 (range \$966–1957) in the minifragment group (P value < 0.01).

Rates of postoperative complications were not significantly different between the groups. Two patients (7%) developed superficial infections in the standard group that were successfully treated with oral antibiotics, while one patient (6.3%) in the minifragment group developed a deep infection that required formal irrigation and debridement in the operating room along with oral antibiotics. One radiographic nonunion developed in the minifragment fixation group; however, the patient was clinically asymptomatic and did not wish to pursue any further intervention. The two groups were not significantly different in regards to symptomatic implants, as the standard group had eight patients (28.6%) who complained of implant-related pain at final follow-up versus two (12.5%) in the minifragment group.

Fig. 2. Radiographic measurement technique. The line depicted by letter *A* is the medial clear space. *B* The tibia-fibular (syndesmotic) clear space. *C* The two lines required for measurement of the talocrural angle. *D* The tibia-fibular overlap measurement.

Table 2 Surgical and follow-up data

Variable	Standard fixation	Minifragment fixation	P value
Medial malleolus fixation	14 (50%)	9 (56.3%)	0.69
Syndesmosis fixation	16 (57.1%)	7 (43.8%)	0.39
Fibular lag screw	17 (77.3%)	11 (68.8%)	0.59
Number of screws			
Fibular plate	3.75±0.8 (3–6)	6.2±1.2 (3–8)	<0.01
Nonlocking screws	3.5±0.8 (2–6)	2.7±2.2 (1–7)	0.17
Locking screws	0.2±0.5 (0–2)	3.5±2.2 (0–6)	<0.01
Fibular plate position			
Lateral	17 (60.7%)	14 (87.5%)	0.06
Posterior	11 (39.2%)	2 (12.5%)	0.06
Operative time (min)	76.0±24.8 (27–120)	92.5±33.0 (56–167)	0.15
Total fibular implant cost (\$)	400.77±94.49 (290–707)	1528.25±363.12 (966–1957)	<0.01
Complications			
Superficial infection	1 (3.5%)	1 (6.3%)	0.68
Deep infection	0	1 (6.3%)	0.18
Delayed union	0	1 (6.3%)	0.18
Nonunion	0	1 (6.3%)	0.18
Symptomatic implants	8 (28.6%)	2 (12.5%)	0.22
Implant removal	5 (17.9%)	2 (12.5%)	

Discussion

Our investigation aimed to determine if the use of a minifragment plating system would provide benefit to the patient in regards to implant prominence while maintaining the reduction obtained in the operating room.

Our study has several limitations. Our investigation carries the burden of the biases inherent to retrospective studies, but the two groups were evenly matched for demographic and surgical data. We did have a significant percentage of patients that were lost to follow-up, but the proportion was not significantly different between the groups; we do admit that the loss of these patients to follow-up may lead to inaccurate conclusions based on incomplete data. Post hoc power analysis revealed that 95 patients would be necessary for evaluation with the current values of symptomatic implants in order to obtain a 95% confidence level with 80% power. Further follow-up on these patient groups would also be of benefit, as we could better determine if the implants would become symptomatic at a later date. In addition, we did not have a standardized fixation construct for either cohort, as the fracture was fixed according to its particular needs as determined by the operative surgeon. For example, the minifragment construct was one of two methods, either a seven-hole 2.4-mm LCP adaption plate or a ten-hole 2.7-mm LCP plate, depending on fibular size and fracture characteristics. The minifragment fixation group also had a trend to increased lateral plate placement ($P=0.06$), and this may have also played a role in the outcomes measured during this investigation. Another weakness is that the inter- and intraobserver reliability of the radiographic parameters was not measured during this investigation; we attempted to rectify this at the time of measurement by providing a cutoff of 2 mm or 4 between the two investigators as a difference for each measurement point, with the final result in those instances obtained by the senior orthopedic surgeon involved in this study.

Fixation of lateral malleolus fractures is most commonly performed with laterally based plate osteosynthesis using a one-

third semitubular plate, although various other constructs have been reported. The two common problems inherent to this technique include symptomatic hardware and limited distal fixation. Jacobsen et al. reported that 66% of patients with laterally based plates had complaints related to the implant that led to removal, with 75% of these patients experiencing pain relief after removal [7]. More recently, Brown et al. demonstrated that 31% of patients had lateral pain overlying their fracture hardware after ORIF of ankle fractures, with 23% requesting that their hardware be removed [3].

A multitude of newer plate designs including the periarticular and locking plates have been developed that allow for improved fixation of the distal fragment. Biomechanical testing suggests some superiority with the newer plate designs, most notably in osteoporotic models, although the clinical benefits have yet to be elucidated. In an osteoporotic cadaveric model, a locking plate with two distal fibula locking screws was mechanically equivalent to a nonlocking plate with three distal cancellous screws [8]. Another recent investigation compared precontoured distal fibula plates to conventional one-third tubular plates and observed superior rotational stiffness with the precontoured plates [5]. However, the majority of these plates tend to be more bulky than the conventional semitubular plates and therefore do not eliminate the problem of hardware irritation.

Recently, minifragment fixation has been evaluated as a means to provide improved distal fragment fixation yet minimize hardware construct size and therefore implant irritation. Bariteau et al. demonstrated that a two-2.4-mm-lag-screw construct was equivalent to a one-3.5-mm-lag-screw construct under biomechanical testing [2]. Furthermore, they observed no significant difference in mean stiffness or mean load to a failure between a 2.4-mm plate-screw construct versus a 3.5-mm plate-screw construct. No studies have been published to date that evaluate the actual clinical efficacy of these constructs.

Our population had a typical proportion of the typical injury mechanisms, with the predominant type being the

Fig. 3. Mortise (a) and lateral (b) radiographs of the left ankle demonstrating a displaced Weber type B distal fibula fracture. Intraoperative mortise (c) and lateral (d) radiographs demonstrating interval reduction and stabilization with a 2.7-mm lag screw and a 2.7-mm LCP adaption plate. Mortise (e) and lateral (f) radiographs obtained at 6 months postoperatively demonstrating a healed fracture without change in fracture reduction.

SER pattern followed by PAB and PER. There was also some variation in the level of the fibula fracture being treated with the majority being Weber B-type fractures (OTA 44-B), which we felt was a good representation of what is commonly seen in practice. Our study demonstrated

that the maintenance of fracture fixation was equivalent between conventional one-third semitubular plating and minifragment fixation, consisting of either a seven-hole 2.7-mm LCP adaption plate or a ten-hole 2.7-mm LCP plate. There was no difference in maintenance of medial clear

space, tibiofibular overlap, tibiofibular clear space, and talocrural angle observed between the two groups. Both styles of construct maintained the talocrural angle with less than 1 of change from the initial postoperative radiograph to the final follow-up radiograph.

There were no significant differences in postoperative complications between the two groups. Consideration should be given though, to the incidence of symptomatic hardware, which was more prevalent in the standard group (28.6%) than in the minifragment group (12.5%), although it was not statistically significant. We do hypothesize that this would be a significant finding with a larger patient population, as the minifragment fixation allows for deeper seating of the smaller screw heads than that with the typical semitubular construct. Our hypothesis was that this could help eliminate symptomatic hardware over the lateral fibula, but we were unable to show this as true in the current investigation with the numbers studied.

Of important interest though is the cost difference between the two constructs, as the mean cost for conventional plating group was \$400.77 versus \$1528.25 in the minifragment group. Although there has been rapid advancements in implant options, one must be able to justify their use clinically. If one can demonstrate a significant decrease in elective hardware removal in the minifragment fixation group, this could easily justify their heightened price. However, with the data obtained during our investigation, we are unable to show any benefit with the use of the minifragment instrumentation.

We conclude that minifragment fixation for distal fibula fractures is an adequate construct that is capable of maintaining fracture reduction equivalent to standard one-third semitubular plating in skeletally mature individuals. We did not find any significant differences between fixation groups in regard to implant harp. Larger clinical comparison studies are necessary to demonstrate whether minifragment fixation can statistically significantly reduce the incidence of hardware irritation and lateral wound healing complications and if a smaller construct can minimize elective hardware removal to help justify the increased cost of the implant.

Disclosures

Conflict of Interest: John Gentile, DO and Raymond Chan, DO have declared that they have no conflict of interest. Benjamin C. Taylor, MD reports personal fees from Biomet, DepuySynthes, and Orthobullets.com, outside the work. Bruce French, MD reports personal fees from Biomet, DepuySynthes, and Zimmer, outside the work.

Human/Animal Rights: All procedures followed were in accordance with the ethical standards of the responsible committee on human

experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008 (5).

Informed Consent: Informed consent was waived from all patients for being included in the study.

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