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Comparison of different locking plate fixation methods in lateral malleolus fractures

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ABSTRACT

Background: Several fixation methods may be used for displaced lateral malleolar fractures. We aimed to compare clinical and radiologic outcomes associated with use of locking one third tubular plate vs. anatomical distal fibula locking plate in lateral malleolar fractures.
Methods: A total of 62 orthopedic patients operated for lateral malleolus fracture were included in this retrospective study. Patients were divided into two groups regarding the plate used for fixation as locking one third tubular plate (group I; n = 37) and locking anatomical distal fibula plate (group II; n = 25). Data on Danis–Weber ankle fracture classification (Type A, Type B), duration of follow up, clinical outcome [ankle range of motion (ROM), American Orthopaedic Foot & Ankle Society (AOFAS) score], radiological outcomes (adequacy of reduction, loss of alignment), time to fracture healing and complications were recorded in study groups.
Results: No significant difference was noted between groups in terms of AOFAS score [87.0 (73–100) vs. 85.0 (71–100), respectively (p = 0.339)] and no patients had severe restriction in sagittal and hindfoot motion in both groups. The two groups showed similar healing time [9.0 (7–13) weeks vs. 10.0 (8–13) weeks, respectively (p = 0.355)] and complication rate [0.0% vs. 4.0%, respectively (p = 0.403)].
Conclusions: This study revealed no significant difference between use of locking one third tubular plate and locking anatomical distal fibula plate in lateral malleolar fixation, in terms of clinical and radiological outcomes, complication rates and fracture healing time.

1. Introduction

Ankle fractures are among the most common injuries while distal fibular fractures comprise the most common type of ankle fractures that usually occur in a relative young and active population [1–5]. Given the association of regaining the length and alignment of the fibula and maintaining the stability of the lateral malleolus with the best possible outcomes, surgical treatment with open reduction and internal fixation is used as a standard practice in displaced and unstable lateral malleolar fractures [4–7]. Although surgical intervention provides better functional outcome and anatomical alignment, surgical interventions have frequently been associated with complications such as nonunion, malunion, posttraumatic osteoarthritis and wound infection particularly in elderly population [7–12].

There are several fixation methods for lateral malleolar fractures as plate fixation via one-third tubular plate, dynamic compression plate and locking plate with or without an independent lag screw [6,12–15]. As the locking plates reduce periosteal compression they provide protected blood supply and an improved rate of bone healing [16,17]. Although use of locking plates is considered a standard surgical approach for osteoporotic or short end-segment fractures, inconsistent data exist regarding the type of locking plates as; either a locking tubular or a locking pre-shaped anatomic plate for the distal fibular fractures [5,6].

The present study was therefore designed to compare clinical and radiologic outcomes associated with use of locking one third tubular plate vs. locking anatomical distal fibula plate in lateral malleolar fixation.

2. Materials and methods

2.1. Study population

Patients that were operated in our hospital for ankle fractures between 2013 and 2016 were analyzed retrospectively in the study. A total of 139 patients were operated for ankle fractures in this

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time period. Patients with bimalleolar/trimalleolar fracture (n = 38), pathologic fractures (n = 4), pediatric fractures (n = 9), previous ankle fracture history (n = 7), open fractures or associated neurovascular injury (n = 8) and associated syndesmotic injury (n = 11) were excluded from the study. Finally 62 patients that were operated for displaced Danis–Weber type A or B lateral malleolar fractures were included in this study. Patients with more than 3 mm displacement of lateral malleolar fractures were treated surgically in this study as reported before [18,19].

Patients were divided into two groups based on locking plate fixation technique including locking one third tubular plate (group I; n = 37) (Fig. 1) and anatomical distal fibula locking plate (group II; n = 25) (Fig. 2) groups. The study was conducted in full accordance with Good Clinical Practice (GCP) guideline and current legislations, while the permission was obtained from our institutional ethics committee for the use of patient data for publication purposes.

2.2. Assessments

Data on Danis–Weber ankle fracture classification (Type A, Type B), use of an interfragmentary screw, duration of follow up, complications and time to fracture healing were recorded for all patients.

2.3. Surgery and postoperative care

Patients were operated with a pneumatic tourniquet in supine position. All patients were examined for possible sydesmotic injuries during the surgery with external rotation stress test under fluoroscopy; widening more than 5 mm in medial clear space is accepted as syndesmotic injury and underwent repair. Patients with syndesmotic injuries were not included in this study. After fracture reduction was performed, inter-fragmentary screws were used in an appropriate manner when possible and then the fracture was fixed with an either a locking tubular (1/3 Tubular Locking Compression Plates ©Xrbest Jiangsu. China) or locking anatomical plate (Distal Fibula Locking Compression Plates ©Xrbest Jiangsu. China). The cost of each plate that were used in recent study was approximately 360 $ for locking anatomical distal fibular plates and 250 $ for the tubular plates.

A short leg cast was applied for soft tissue control on the first 3 days. After 3 days passive range of motion exercises was advised for all and all patients were allowed to 'weight bear as tolerated' after cast removal. Patients were requested for follow-up visits on 15th day and monthly after surgery. Full weight bearing was allowed after fracture healing about 6 weeks after surgery.

2.4. Outcomes

Clinical outcome was assessed by both the ankle range of motion (ROM) from the full extension to full flexion and by American Orthopedic Foot & Ankle Society (AOFAS) clinical scoring system [20,21]. The ROM of each ankle was measured twice in the supine position with a goniometer at the time of discharge and every follow-up. Radiographs of the antero-posterior, lateral and mortise view of the involved ankle were obtained preoperatively, postoperatively and at every follow-up. Radiographic confirmation of lateral malleolar fracture union was defined as the complete disappearance of fracture lines in the antero-posterior, lateral, and internal oblique views as determined by a single radiologist who was blinded to the aim and protocol of this study [17]. Fracture healing was defined as being pain-free at fracture location and identification of three of the four cortices to be bridged by visible callus on both the antero-posterior and lateral views [5].

Complications (superficial infection, deep infection, loss of reduction, nerve injury etc.) were recorded during the inpatient period and every follow-up time point.

2.5. Statistical analysis

Statistical analysis was evaluated with Statistical Package for Social Sciences (IBM SPSS Statistics for Windows, version 21 New York, USA). Categorical variables are summarized as frequencies and percentages; continuous variables are summarized with median and minimum/maximum values. Comparison of categorical variables in study groups were performed by chi-square and Fisher's exact tests. Due to non-normal distribution patterns of continuous variables, group comparisons were done by Mann Whitney U test. Type 1 error level was set 5%. $p < 0.05$ was considered statistically significant.

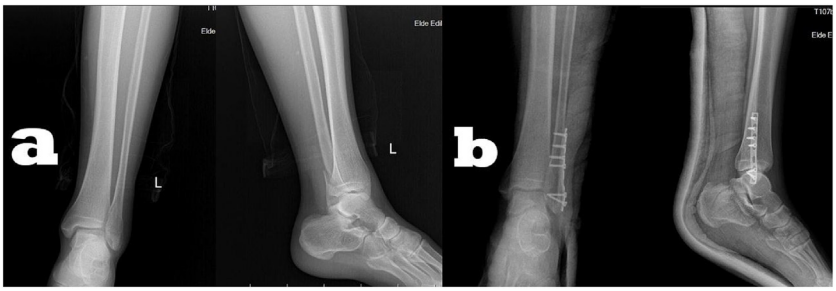

Fig. 1. Fixation of a lateral malleol fracture with one-third locking plate; pre-operative (a) and post-operative (b) X-rays.

Fig. 2. Fixation of a lateral malleol fracture with locking anatomical plate; pre-operative (a), post-operative (b) and follow-up (c) X-rays.

3. Results

No significant difference was observed between groups in terms of age [group I: 44.0 (21–59) and group II: 40.0 (23–58) years] and Danis–Weber ankle fracture classification category (Type A in 51.4% in group I and 48.0% in group II) (Table 1).

No significant difference was noted between the two groups in terms of median (min-max) values for AOFAS score [87.0 (73–100) vs. 85.0 (71–100), respectively ($p = 0.339$)] and no patients had severe restriction in sagittal or hindfoot motion in both groups (Table 2).

Two groups showed similar healing time [9.0 (7–13) weeks vs. 10.0 (8–13) weeks] and complication rate (0.0% vs. 4.0%, respectively). Total screws used for plate fixation was significantly higher in group II [6 (4–9) vs. 7 (5–9) in group I and II respectively, $p = 0.001$] (Table 2).

Follow-up duration was 35.0 (28–43) months in group I while 29.0 (27.0–30.0) months in group II. Follow-up duration of group I was found significantly higher ($p < 0.001$). One patient in group II developed superficial infection that was treated with regular dressing change and intravenous antibiotic. None of the patients needed for re-operation except two patients in group I needed implant removal after 17 and 20 months of primary surgery after the fracture union achieved. No significant difference was observed between groups regarding need for implant removal ($p = 0.511$).

4. Discussion

Our findings revealed no significant difference between use of locking one third tubular plate and anatomical distal fibula locking plate in treatment of displaced lateral malleolar fractures regarding clinical and radiological outcomes, complication rates and fracture healing time.

Alongside similar AOFAS scores between two techniques indicate an overall favorable outcome in terms of pain, function, gait and alignment [5] and the two locking plate groups in our study were also similar in terms of ankle ROM. This seems notable given that the function is scored in AOFAS based on several items rather than ankle ROM per se and thus may not specifically reflect the difference in ROM between locking plate techniques [5].

Based on no superiority of one locking plate technique to the other in terms of AOFAS scores, ankle ROM, alignment, healing time, and complication, our findings indicate similar efficacy of locking one third tubular plate and anatomical distal fibula locking plate in lateral malleolar fixation. Treatment of lateral malleolar fractures with an anatomical plate will increase the cost of treatment as a result of higher price of the plate and more screws used as demonstrated in this study. In consideration of these findings; anatomical plates must be reserved for further distal fractures with comminution that has limited place available for distal screw insertion to gain a secure fixation. Further studies are

Table 1
Demographic and clinical data through groups.

Study parameters	Group I Locking one third tubular plate (n = 37)	Group II Anatomical distal fibula locking plate (n = 25)	p Value
Age (year)			
Median (min–max)	44.0 (21–59)	40.0 (23–58)	0.914[a]
Danis–Weber ankle fracture classification, n (%)			
Type A	19 (51.4)	12 (48.0)	0.796[b]
Type B	18 (48.6)	13 (52.0)	
Use of interfragmentary screw, n (%)	16 (44.4)	13 (52.0)	0.561[b]
Total screws used for plate fixation			
Median (min–max)	6.0 (4–9)	7.0 (5–9)	=0.001[a]
Follow-up duration (month)			
Median (min–max)	35.0 (28–43)	29.0 (27–38)	<0.001[a]

max: maximum; min: minimum.
[a] Mann–Whitney U test.
[b] $\chi 2$ test.

Table 2
Functional outcomes and Follow-up findings.

		Group I Locking one third tubular plate (n = 37)	Group II Anatomical distal fibula locking plate (n = 25)	p Value
Sagittal motion, n (%)				
Normal or mild restriction (≥30°)		30 (81.1)	17 (68.0)	0.238[b]
Moderate restriction (15–29°)		7 (18.9)	8 (32.0)	
Severe restriction (<15°)		0 (0.0)	0 (0.0)	
Hindfoot motion, n (%)				
Normal or mild restriction (75–100% normal)		35 (94.6)	100 (100.0)	0.511[c]
Moderate restriction (25–74% normal)		2 (5.4)	0 (0.0)	
Marked restriction (<25% normal)		0 (0.0)	0 (0.0)	
AOFAS score	Median (min–max)	87.0 (73–100)	85.0 (71–100)	0.339[a]
Time to fracture healing (week)	Median (min–max)	9.0 (7–13)	10.0 (8–13)	0.355[a]
Need for impant removal n (%)		2 (5.4)	0 (0.0)	0.511[c]
Complication rate, n (%)		0 (0.0)	1 (4.0)	0.403[c]

AOFAS: American Orthopaedic Foot and Ankle Society; max: maximum; min: minimum; ROM: range of motion; SD: standard deviation; p: percentile.
[a] Mann-Whitney U test.
[b] $\chi 2$ test.
[c] Fisher's exact test.

needed to find out the exact indications for using the anatomical locking malleolar plates.

Locked plating is considered to provide a low profile but stiffer screw-plate construct and increased rigidity of the implant and a higher failure torque to avoid screw loosening and subsequent pullout with poor bone quality [6,14]. Hence, locking plates are considered to provide a potential advantage for cases of poor bone quality and recommended therefore over non-locking plating in osteoporotic patients due to biomechanical advantages [15]. As this study suggested no remarkable supremacy of anatomic locking plates over conventional tubular ones; it can be concluded that two types of these locking plates have similar potential biomechanical benefits. Although the rigidity of locking plates has been associated with a delayed union or nonunion [10,22] we did not observe any non-union in this study.

Although non-locking vs. locking plate systems have been investigated in several studies, along with comparisons between other types of distal fibula locking plate techniques, to our knowledge no data are available in literature regarding the comparison of locking one-third tubular and anatomical distal fibula locking plates specifically in lateral malleolus fixation. In an analysis of three plate systems for lateral malleolar fixation by Huang et al., when compared with one-third tubular plate, locking compression (LCP) distal fibula plate was reported to be associated with higher functional scores in patients with Weber A fracture, while LCP metaphyseal plate had higher functional scores and less healing time regardless of the type of fracture [5]. No significant differences were demonstrated between plate systems in terms of the ankle ROM, reduction accuracy and complication rate [5].

Biomechanical comparison of four different lateral plates constructs for distal fibula fractures by Eckel et al. revealed no significant difference with use of a standard one-third tubular plate with interfragmentary lag screw, a LCP locking plate with lag screw, a low-profile locking plate with lag screw, or a non-locking plate [23]. A biomechanical study by Hallbauer et al., comparing lateral and posterior locking plates in a cadaveric, Danis–Weber type B fracture model, found no statistically significant differences in terms of stiffness and range of motion [24]. However, Minihane et al. reported that posterolateral antiglide plating enables a stiffer construct as compared with lateral locked plating in osteoporotic cadaveric ankles [15].

Increased number of used screws in the anatomical distal fibula locking plate than locking one-third tubular plate group in our study seems consistent with wider design of fibular locking plate than one-third tubular plate [25], while also emphasize the role of newer pre-contoured anatomic plates that allow for multiple smaller screws at each axial level distally in achieving adequate distal fixation despite local anatomy limiting multiple multidirectional metaphyseal locked screws [6]. This is an obvious advantage of anatomical plates over tubular plates that must be considered when handling distal fractures of the lateral malleolus.

The treatment cost varies between two plates as locked anatomical plates have higher cost when compared to tubular ones. As two distal locking screws were reported to provide adequate biomechanical stability even for osteoporotic distal fibular fractures [26], the use of tubular plates sounds favorable when it is possible to insert at least two distal screws. This study obviously indicated that for the most of lateral malleolar fractures, the use of a one-third locking tubular plate is the most cost-effective option and anatomical locking plates offers no benefits except increasing the treatment cost. Although we did not find a significant difference regarding the need for implant removal, further follow-up may change the results as only locked anatomic distal plates needed implant removal in this study. And the need of a second surgery will also alter the treatment cost that the surgeon must consider. We may conclude that more modern and expensive devices may not always provide advantages over conventional and cheaper ones and this must be considered when treating these fractures.

Lack of syndesmotic injuries may be a limitation of this study. Anatomical plates; that allow more screws, may have a major superiority over tubular plates that may change clinical outcomes. There are several methods to identify syndesmotic injuries during surgery reported before [27,28] and we used a commonly accepted external rotation test. There is a need for prospectively designed further studies to find out whether the plate type affects clinical outcomes in patients with associated syndesmotic injuries. Other limitations of the study may be listed as; the small sample size, the retrospective design, shorter follow-up and the mean age of the study population as outcomes may be affected in older patients with poor bone quality.

5. Conclusions

In conclusion, this study demonstrated that locking one-third tubular plates provide similar clinical and radiological outcomes with anatomical distal fibula locking plate and reduce treatment cost thus must be considered when treating displaced lateral malleolar fractures.

Conflict of interest

Authors declare that they have no conflict of interest.

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