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ORIGINAL ARTICLE

Fully threaded headless compression screw versus partially threaded cancellous lag screw in medial malleolus fractures: clinical and radiological outcomes

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Abstract

Purpose The aim of this study was to evaluate the clinical and radiological results of medial malleolar fractures, which were treated with fully threaded headless compression screws and to compare the clinical and radiological results of this screws and partially threaded cancellous lag screws.

Methods Sixty-one patients who attended the final follow-up examination were included in the study. Group 1 comprised 29 patients applied with fully threaded headless compression screws and Group 2 comprised 32 patients with partially threaded cancellous lag screws. Radiological evaluation was made with standard radiographs. The clinical evaluations were applied using the AOFAS ankle hindfoot scale. Pain or sensitivity by touching over the medial malleolus was recorded and scored according to Visual Analog Scale.

Results No significant differences were determined between the groups with respect to age, gender, fracture type, follow-up time, bone union time and AOFAS scores. The medial sensitivity associated with implant irritation was significantly lower in Group 1. There was no need for removal of the fixation material in any patient of Group 1.

Conclusions The results of this study showed satisfactory results in the two fixation techniques in medial malleolar fractures. However, the rates of medial sensitivity associated with implant irritation were lower in the group where fully threaded headless compression screws were used. Therefore, to prevent postoperative patient dissatisfaction caused by persistent medial sensitivity associated with implant irritation, despite successful surgical treatment, the primary choice may be fully threaded headless compression screws.

Keywords Medial malleolar fracture · Ankle fracture · Headless compression screw · Cancellous lag screw

Introduction

Medial malleolar fractures can be isolated or a part of bimalleolar or trimalleolar fractures. In the literature, the importance of the malleolar and deltoid ligament complex has been emphasized for the stability of the ankle [1–3]. The restoration of these fractures is necessary for the continuation of the ankle biomechanics.

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The current treatment standard for medial malleolar fractures is open reduction and internal fixation for which various methods have been described in the literature such as unicortical or bicortical screws, tension band wiring, medial malleolar plates or sled fixation [3–9]. The optimal fixation method still remains unclear in the literature. Because there is no clear evidence as to which technique is clinically superior.

Traditionally, medial malleolus fractures are treated operatively with internal fixation using screws. AO Foundation advocates two parallel 4.0 mm partially threaded cancellous lag screws oriented perpendicular to the fracture for medial malleolar fracture [10]. But there is no consensus on the optimal screw characteristics and types in the literature [4, 11–13].

When the relevant literature is examined, it can be seen that authors have generally focused on the efficacy of the

techniques used in medial malleolar fracture surgery [3, 4, 8, 14]. However, another factor requiring attention in the selection of the implant is postoperative pain related to the implant. Despite successful surgery, persistent postoperative pain associated with implant irritation causes patient dissatisfaction. This dissatisfaction sometimes even supersedes the success of the surgery, which can then cast a shadow on the success of the orthopedic surgeon. This is therefore, one of the reasons continuing to drive orthopedic surgeons in the search for an alternative fixation method [8, 9, 12, 13].

In recent years, fully threaded headless compression screws, which are widely used in intra-articular fractures, primarily scaphoid fractures, have started to be used in medial malleolar fracture surgery [13]. It is thought that fully threaded headless compression screws have high compression ability besides they cause less frequent implant irritation due to their headless design. Thus, it may be an alternative fixation method in medial malleolar fracture surgery. There are very few studies in the literature on this subject [13].

The aim of this study was to evaluate the clinical and radiological results of medial malleolar fractures, which were treated with fully threaded headless compression screws and to compare the clinical and radiological results of this screws and partially threaded cancellous lag screws. We hypothesized that in patients with medial malleolar fractures treated with fully threaded headless compression screws, persistent medial pain/sensitivity due to implant irritation and postoperative patient dissatisfaction caused by this condition would be less.

Materials and methods

This retrospective study was approved by the Institutional Review Board of our university. The review was made of 247 patients who underwent surgery in our clinic for a medial malleolar fracture between 2013 and 2017. Patients were excluded if they were less than 18 years of age (12 patients), had a follow-up period less than 1 year (45 patients), had complex ankle fracture such as pilon fracture or open fracture (8 patients), and were treated with any other fixation methods except partially threaded cancellous lag screw or fully threaded headless compression screw (96 patients).

After the patients who were excluded (161 patients) and lost to follow-up (25 patients), a total of 61 patients who attended the final follow-up examination were included for evaluation (Fig. 1). Group 1 consisted of 29 patients

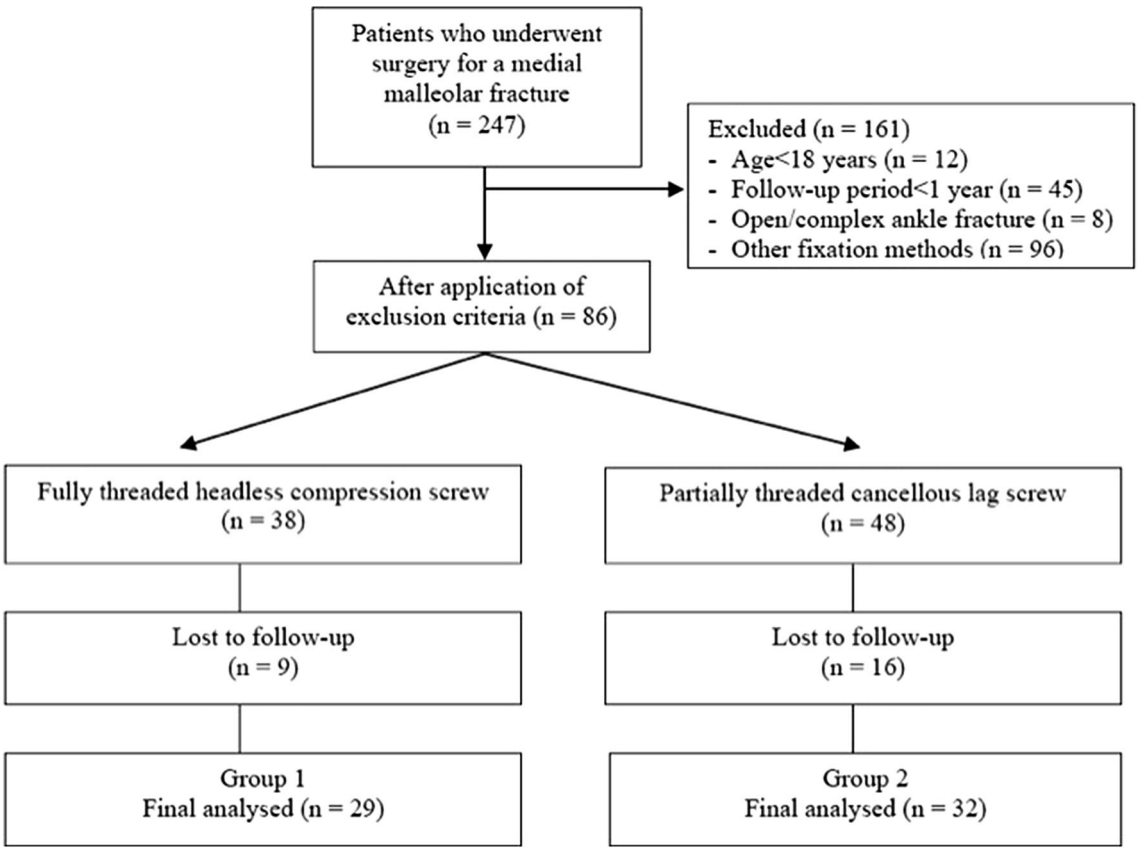

Fig. 1 The diagram illustrates the flow of participants through each stage of the study

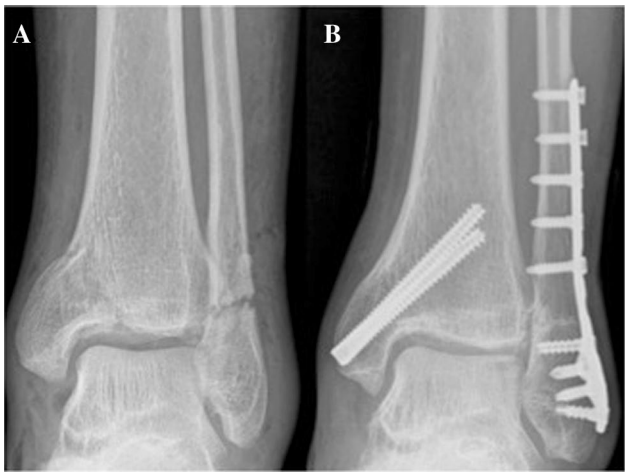

Fig. 2 **a** Preoperative anteroposterior radiograph of a bimalleolar fracture. **b** Postoperative anteroposterior radiographic view demonstrating two fully threaded headless compression screws used for fixation of medial malleolus fracture

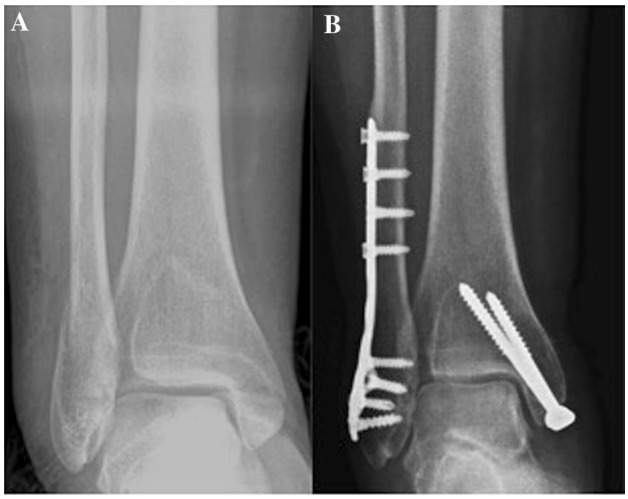

Fig. 3 **a** Preoperative anteroposterior radiograph of a bimalleolar fracture. **b** Postoperative anteroposterior radiographic view demonstrating two partially threaded cancellous lag screws used for fixation of medial malleolus fracture

treated with fully threaded headless compression screws (Fig. 2). Group 2 consisted of 32 patients treated with partially threaded cancellous lag screws (Fig. 3). The fixation method was selected according to the surgeon's personal preference. One or two screws were used according to the size of the fracture fragment and the surgeon's preference. Medial malleolar fractures in both groups were fixed with unicortical screw/screws. All lateral malleolar fractures were fixed with locking lateral malleolar plate. None of the posterior malleolar fractures were fixed because all these fractures did not comprise more than %25 of the articular surface.

In the preoperative medial malleolar fracture evaluation, classification was made according to the Herscovici et al.'s classification system, which is based on the fracture level [15]. In this system, Type-A fractures involve avulsions of the tip of the malleolus distal to the ankle joint line, Type-B involves fracture between the tip of the malleolus and the level of the tibial plafond, Type-C involves fracture at the level of the plafond, and Type-D involves fracture that extends vertically above the level of the tibial plafond.

Radiological evaluation was made with standard anteroposterior, mortise and lateral radiographs of the ankle. Non-visualization of the fracture line on the radiographs and/or bony callus tissue bridging the fracture line was evaluated as a radiological union. A period of 3 months with no progressive fracture healing was considered to represent delayed union and, if present at a period of at least 6 months, was considered a non-union.

The clinical outcomes were measured using the American Orthopedic Foot and Ankle Society (AOFAS) ankle hindfoot scale. On this 100 point AOFAS scoring system, a score of ≥ 90 points was considered excellent, 80–89 points good, 70–79 points fair, and a score ≤ 69 points was considered poor [16, 17]. Pain/sensitivity to palpitation of the medial malleolus was also recorded and was measured using a 10-cm visual analog scale (VAS). The VAS scale consisted of a 10-cm line, the left end labeled 'no pain' (0 cm) and the right end 'very severe pain' (10 cm). Investigators showed patients this 10-cm ruler and asked to mark the point along the ruler that represented their pain severity. Because our study used a scale of 0–10 cm, we rounded off using the usual rules. For example, 7.3 cm was rounded off to 7 and 5.8 cm was rounded off to 6.

The radiological measurements (radiological bone union and fracture classification) were made by a radiology specialist and all the clinical evaluations by an orthopedic specialist.

All the patients were followed according to the standard postoperative follow-up protocol established in our clinic. In accordance with this protocol, all patients were immobilized for the first 1–2 weeks postoperatively with a short-leg brace. During this time, venous thrombosis prophylaxis was applied to patients. After the brace was removed, active and passive ankle joint range of motion exercises was started. Weight-bearing was permitted when there was evidence of radiographic healing combined with a clinical exam.

Statistical analyses

Data analyses were performed using IBM SPSS Statistics Version 24.0 software. In the comparisons between groups, Fisher's exact test and Pearson's Chi-square test were applied to categorical variables and independent sample *t* test and Mann–Whitney *U* test were performed for continuous data.

A probability of the null of $p \leq 0.05$ was considered statistically significant.

Results

The results are depicted in Tables 1 and 2. No statistically significant differences were determined between the groups with regard to age (mean age, 42.8 ± 14.3 years; range 19–83; $p = 0.650$), gender ($p = 0.913$), fracture type (isolated, bimalleolar or trimalleolar fracture; $p = 0.531$), preoperative fracture classification (Herscovici Types B, C and D; $p = 0.972$), the number of screws (one or two; $p = 0.804$), and the duration of follow-up (mean 22.1 ± 7.0 months; range 12–38; $p = 0.414$).

When the postoperative radiographs were examined, the anatomic reduction was seen in all patients. Malunion, reduction loss, or implant failure was not seen in any patient. Radiological bone union was obtained in all patients. The mean time to radiological bone union was 9.5 ± 2.2 (range 7–15) weeks in Group 1, and 9.6 ± 2.3 (range 7–16) weeks in Group 2 ($p = 0.827$).

Regarding AOFAS hindfoot-ankle scores, the mean AOFAS score was 95.1 ± 5.9 (range 85–100) in Group 1 and

Table 1 Patient characteristics and results

	Group 1 ($n = 29$)		Group 2 ($n = 32$)		Total ($n = 61$)		p
	n	%	n	%	n	%	
Gender							
Female	14	48.3	15	46.9	29	47.5	0.913[a]
Male	15	51.7	17	53.1	32	52.5	
Medial sensitivity							
Yes	4	13.8	21	65.6	25	41.0	**< 0.001**[a]
No	25	86.2	11	34.4	36	59.0	
Hardware removal (medial malleol)							
Yes	–	–	4	12.5	4	6.6	0.114[b]
No	29	100.0	28	87.5	57	93.4	
Fracture type							
Isolated	11	37.9	10	31.3	21	34.4	0.531[a]
Bimalleolar	7	24.2	12	37.4	19	31.2	
Trimalleolar	11	37.9	10	31.3	21	34.4	
Herscovici classification							
B	6	20.7	8	25.0	14	23.0	0.972[a]
C	15	51.7	14	43.8	29	47.5	
D	8	27.6	10	31.2	18	29.5	
Clinical results (AOFAS)							
Good	7	24.1	11	34.4	18	29.5	0.381[a]
Excellent	22	75.9	21	65.6	43	70.5	
Number of screws							
1	20	69.0	23	71.9	43	70.5	0.804[a]
2	9	31.0	9	28.1	18	29.5	
	Mean ± (range)		Mean ± (range)		Mean ± (range)		p
Age (years)	43.7 ± 13.1 (19–68)		42.0 ± 15.6 (21–83)		42.8 ± 14.3 (19–83)		0.650[c]
Union time (week)	9.5 ± 2.2 (7–15)		9.6 ± 2.3 (7–16)		9.5 ± 2.3 (7–16)		0.827[d]
Follow-up time (month)	21.3 ± 7.9 (12–38)		22.8 ± 6.2 (12–33)		22.1 ± 7.0 (12–38)		0.414[c]
AOFAS score	95.1 ± 5.9 (85–100)		92.6 ± 5.9 (85–100)		93.8 ± 6.0 (85–100)		0.136[d]
VAS score	0.2 ± 0.6 (0–3)		2.1 ± 1.9 (0–7)		1.2 ± 1.7 (0–7)		**< 0.001**[d]

Written in bold indicates that it is statistically significant

[a]Pearson Chi-square

[b]Fisher's exact test

[c]Independent sample t test

[d]Mann–Whitney U test

Table 2 Postoperative VAS scores of the patients

	VAS scores											Total (*n*)
	0 cm	1 cm	2 cm	3 cm	4 cm	5 cm	6 cm	7 cm	8 cm	9 cm	10 cm	
Group 1												
n	25	2	1	1								29
%	86	7	3.5	3.5								100
Group 2												
n	11		5	12		2[a]	1[a]	1[a]				32
%	34.4		15.6	37.5		6.3	3.1	3.1				100

[a]The patients whose medial malleol fixation material had to be removed

92.6 ± 5.9 (range 85–100) in Group 2 ($p = 0.136$). As for categorizing the AOFAS scores, excellent results were obtained in 22 (75.9%) patients and good results in 7 (24.1%) patients in Group 1, and excellent results in 21 (65.6%) patients and good results in 11 (34.4%) patients in Group 2 ($p = 0.381$).

Regarding pain upon palpation of the medial malleolus, 4 (13.8%) patients in Group 1, and 21 (65.6%) patients in Group 2 experienced pain. The mean VAS pain score was 0.2 ± 0.6 (range 0–3) cm in Group 1 and 2.1 ± 1.9 (range 0–7) cm in Group 2. The medial sensitivity associated with implant irritation was statistically significantly lower in Group 1 where fully threaded headless compression screws were used ($p < 0.001$). The mean VAS pain score was also statistically significantly lower in this group ($p < 0.001$).

In Group 2, 21 (65.6%) patients had pain or sensitivity on the medial malleolus by palpation. Four of them (12.5%) had more severe persistent medial malleolar pain associated with implant irritation. The mean VAS pain score of four patients was 5.7 ± 0.9 (range 5–7) cm. This situation caused postoperative patient dissatisfaction and, therefore, the fixation material had to be removed from these four patients. There was no need for removal of the fixation material in any patient in Group 1. No statistically significant difference was determined between the groups with respect to the implant removal rates ($p = 0.114$).

Discussion

The medial malleolus prevents medial translation of the talus together with the anterior/posterior talofibular ligament [18]. Therefore, the continuation of the congruence of the medial malleolus within the ankle mortise is necessary for a normal tibiotalar contact surface and normal tibiotalar pressure distribution [18]. Medial malleolar fractures are generally treated operatively to be able to minimize the risk of articular incongruity, instability, nonunion, and posttraumatic arthritis.

Several techniques have been described in the literature for internal fixation of the medial malleolus [8, 11, 19-22]. These techniques have shown superiority to each other with respect to biomechanics [3, 4, 6, 8, 14, 23]. There has been no definitive evidence as to which technique is clinically superior. Although the optimal fixation method is debatable, it is possible to apply operative treatment successfully with all operative stabilization methods. Despite this, persistent pain can develop causing postoperative dissatisfaction in some patients.

The conventional fixation methods most preferred by orthopedic surgeons in daily practice are partially threaded cancellous lag screws or the tension band wiring technique. The implant-related complication rates of these conventional fixation methods, primarily the tension band wiring method, have been reported to be extremely high in literature [5, 6].

One of the most significant problems experienced in fixation of the ankle or surrounding areas is the weakness of the soft tissue surrounding the ankle, primarily the medial cortex of the tibia. Subcutaneous protrusion of the implant can cause chronic pain, significantly affecting the functional results of the patient [24, 25]. Therefore, the fixation material to be used should protrude as little as possible from the bone surface. With innovatively developed fixation methods, such as the malleolar sled device and headless compressive screws, implant-related complication rates have started to decrease [9, 12, 13].

The sled fixation method is a partly new technique for medial malleolar fracture surgery. This technique has shown biomechanical superiority to conventional screws [8]. As it has a low profile compared to conventional techniques, it is thought that it could cause less soft tissue irritation. The hardware protruding from the cortex of the medial tibia has been measured as approximately 2.2 mm in the sled device and approximately 2.8–3 mm in the traditional tension band construct [8]. However, in a recent clinical study by Maniar et al. [9] there was not found to be any major difference between the sled device and conventional screws in respect of implant-related medial pain and implant removal rates. This indicates that the fixation material to be used for medial malleolar fracture surgery should be a material that will make very little protrusion from the bone surface.

Barnes et al. evaluated the clinical results of unicortical partially threaded headless lag screws in medial malleolar

fractures. It was reported that there were no cases of nonunion but a mild level of medial sensitivity developed in 23% of patients and it was necessary to remove the hardware in 1 (2%) patient [12]. Tekin et al. applied fully threaded headless compression screws antegrade in the operative treatment of Herscovici Type B medial malleolar fractures. In this series of 12 patients with an antegrade application, no complications were encountered. There were also no cases of implant-related pain or discomfort or the need for implant removal [13].

In the current study, no difference was determined between the groups with respect to the radiological results and the clinical results according to the AOFAS scores. However, the mean AOFAS score of the fully threaded headless compression screw group was higher (95.1 ± 5.9 points). Excellent clinical results according to AOFAS scoring system were also higher in this group (75.9%). At the same time, the rate of medial sensitivity associated with implant irritation was significantly lower in this group compared with the other group (Group 1: 13.8%, Group 2: 65.6%) and there was no need for implant removal in any patient of this group (Group 1: 0%, Group 2: 12.5%). Mean VAS pain score was significantly lower in Group 1 (Group 1: 0.2 ± 0.6 cm, Group 2: 2.1 ± 1.9 cm). Mean VAS pain scores of the patients in Group 2 whose fixation materials had to be removed were quite higher than the mean score (5.7 ± 0.9). These results can be interpreted as demonstrating the clinical superiority of fully threaded headless compression screws over partially threaded cancellous lag screws.

Fully threaded headless compression screws can be left at the same level as the bone surface during fixation or even at a level below the bone surface, in the same way as they are used in scaphoid fractures and other intra-articular fractures. Therefore, compared to other fixation materials there is less irritation to the deltoid ligament and subcutaneous tissue, resulting in lower rates of implant-related complications.

As a result, these screws are an alternative fixation method to conventional fixation methods. However, there are very few clinical studies in the literature related to the use of fully threaded headless compression screws in medial malleolar fracture surgery [13]. Therefore, a full consensus has not yet been reached on how these screws should be used. We think that antegrade application method of Tekin et al. [13] is not an appropriate fixation method if fully threaded headless compression screws are to be selected for these fractures. In a biomechanical study, the maximum compressive force of this type of screw has been shown to be in the mid-point, and the minimum compressive force in the distal (compressive force; mid-point > proximal > distal) [26]. Thus, maximum compression strength may not always be able to be obtained with the antegrade application. Therefore, in the current study, all the screws were applied with the traditional method (retrograde). Since the increased compression can improve the stability and union rates, ideal screw length for fully threaded headless compression screws should be at least twice the distance from the tip of the medial malleolus to the fracture line. In this way, it can be provided that the fracture line is in the mid-point or proximal half of the screw. But, this situation should be biomechanically tested in future studies.

Limitations of this study can be considered to be that it was retrospective in nature, the number of patients was relatively low, there was no biomechanical comparison between other fixation methods and clinical evaluations were not made by an independent orthopedic surgeon, which may cause potential bias.

In conclusion, the results of this study showed satisfactory results in the two fixation techniques used in the treatment of medial malleolar fractures. However, the incidence of pain/sensitivity upon palpation of the medial malleolus associated with implant irritation was lower in the group in which fully threaded headless compression screws were used. Based on these observations, we recommend that fully threaded headless compression screws be used to fixate medial malleolar fractures.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Since the study was retrospective, informed consent by patients and providers was not required.

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