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Does It Matter the Fixation Method of The Posterior Malleolar Fragment in Trimalleolar Fractures?

Záleží na metodě fixace zadního maleolárního fragmentu u trimaleolární zlomeniny?

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ABSTRACT

PURPOSE OF THE STUDY

The purpose of this study was to evaluate if the fixation method of a posterior fragment in trimalleolar ankle fractures affects the surgical outcomes.

MATERIAL AND METHODS

A retrospective evaluation was made of all the cases of trimalleolar fractures over a 9-year period in a trauma center. Patients aged 18 – 70 years were enrolled in the study. Patients were separated into 2 groups according to the fixation method (A – P percutaneous screw, and posterior open reduction – internal fixation). The fractures were classified according to the AO classification system and the Haraguchi posterior malleolar fracture classification system. The FAOS and SF-36 scores, postoperative reduction quality, arthritis scores and minor – major complications were evaluated.

RESULTS

86 patients were found to eligible for the study. The PMF was fixed using anteroposterior percutaneous screw in 50 (58.1 %) patients and with posterior open reduction-internal fixation in 36 (41.9 %) patients. AO 44 B type fracture was determined in 89.5 % of the patients, AO 44 C type was seen in 10.5 %. There were 27 patients (31.4 %) with Haraguchi type 1 fracture and 59 patients (68.6 %) with type 2 fracture. The mean step-off of the articular surface was statistically greater in Group 1 than in Group 2. No statistically significant difference was determined between the two groups in respect of syndesmosis malreduction. The mean arthritis score was higher in Group 1 than in Group 2. Mean scores of the SF-36 and FAOS questionnaire was statistically significantly improved in the patients with open reduction and internal fixation.

DISCUSSION

Although there is no consensus on the treatment of posterior malleolar fractures, the indication for surgery is mainly based on posterior fragment size in the literature. The anatomic articular reduction has been emphasized recently. In this study, it was determined that the anatomic articular reduction was correlated with better surgical outcomes.

CONCLUSIONS

The study results demonstrated that better functional and radiological outcomes was observed with direct open reduction and fixation of the posterior fragment than indirect reduction and percutaneous fixation in the patients with trimalleolar fracture. The arthritis risk and patient satisfaction were seen to be correlated with the anatomic reduction of the articular surface.

Key words: trimalleolar fracture, posterior malleolar fracture, percutaneous screw, open reduction and fixation, ankle fracture.

INTRODUCTION

Ankle fractures are among the most frequent lower extremity injuries requiring surgery and constitute almost one-tenth of all fractures (8). The most common type of injury mechanism that results in ankle fracture is a rotational force impacting on the supinated or pronated foot (35). Supination external rotation (SER) and pronation external rotation (PER) injuries are the majority of rotational ankle fractures according to the Lauge – Hansen classification (5). Type III and type IV SER and PER injuries are considered unstable fractures which may result in total disruption of the syndesmosis. These unstable fractures consist of either a posterior inferior tibiofibular ligament (PITFL) tear or a posterior malleolar fracture in addition to anterior inferior tibiofibular ligament (AITFL) tear and lateral malleolar fracture.

Ankle fractures with a posterior malleolar fragment lead to worse outcomes compared to ankle fractures with intact malleolus and ligamentous structure (29). As PITFL comprises 42 % of the syndesmosis, the inferior outcome is due to the concomitant posterior malleolar fracture. In general, posterior malleolus fractures are evaluated according to the fracture fragment size compared to the tibia plafond on the lateral ankle radiograph. In 2006, Haraguchi et al. suggested a new concept of a common approach that at least 25 – 30 % of the tibial

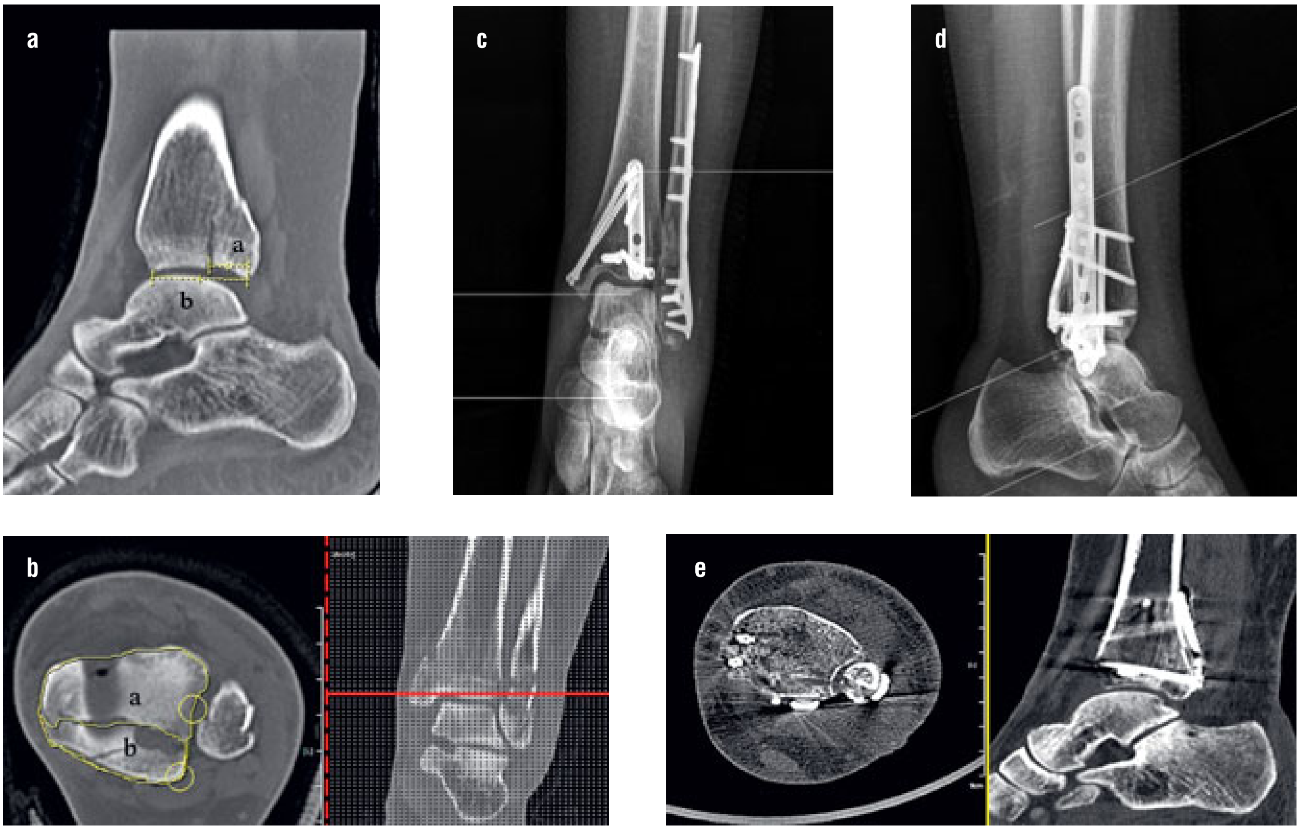

Fig 1. The posterior fragment was fixed by posterior open approach: a – percentage of the posterior fragment: a/b x 100, b – percentage of the posterior fragment: b/a+b x 100, c, d – AP and lateral X-rays, e – CT scan, postoperatively.

plafond should be fixed (12). The advancement of knowledge of the posterior malleolus anatomy and the ligamentous attachments which contribute to syndesmosis stability has changed surgeons' approaches to treatment of posterior malleolus fractures. Although the management of medial and lateral malleolus fractures is well established, the treatment of trimalleolar fractures with posterior malleolus fractures remains controversial.

The indications for surgery and the type of fixation of a posterior malleolar fracture remain controversial (31). Many studies have suggested that better ankle joint stability and structural integrity can be achieved with fixation of a posterior malleolar fragment or PITFL repair. In addition, fixation of a posterior malleolus has a major role in the stability of the ankle joint at least equivalent to that of syndesmotic screw fixation (17).

The purpose of this study was to evaluate if the presence of a posterior malleolar fracture in SER and PER type III and type IV ankle fractures affects the surgical treatment outcomes when posterior malleolar fracture and restoration of the syndesmosis were addressed with different two fixation techniques; open reduction and internal fixation and anteroposterior percutaneous screw fixation.

MATERIAL AND METHODS

A retrospective review was made of all patients operated on for an isolated ankle fracture with a posterior malleolar fracture between 2010–2019 with a minimum follow-up of 1.5 years. Patients aged 18–70 years were enrolled in the study. Exclusion criteria were open fractures, multi-trauma injuries, those who had ankle pathology prior to ankle fracture, pathological fractures, patients with inflammatory arthritis and cases where the posterior malleolar fragment was not fixed. The patients with both preoperative and postoperative X-rays and CT scans were included in the study. A total of 86 patients were found to be eligible for inclusion. All patients were contacted by phone or e-mail to attend the outpatient clinic for a physical examination. Those who agreed to participate in the study provided an informed consent form and approval for the study was granted by the hospital Internal Ethics Committee. Questionnaires (FAOS and SF-36) were completed, and the general medical history was noted. X-rays (mortise, AP, and lateral ankle radiographs) were taken. Postoperative complications were also recorded.

A preoperative computed tomography (CT) scan and X-rays (mortise, AP, and lateral ankle) of each fracture were evaluated. The sagittal plane CT image was first analyzed to measure the size of posterior fragment (Fig. 1a). The percentage of the posterior fragment in relation to the tibial articular surface was calculated. Then the axial CT scan was analyzed to measure the percentage of the posterior malleolar fracture to the weight – bearing tibial articular surface in the axial plane. The axial CT scan was crosslinked to coronal plane at the

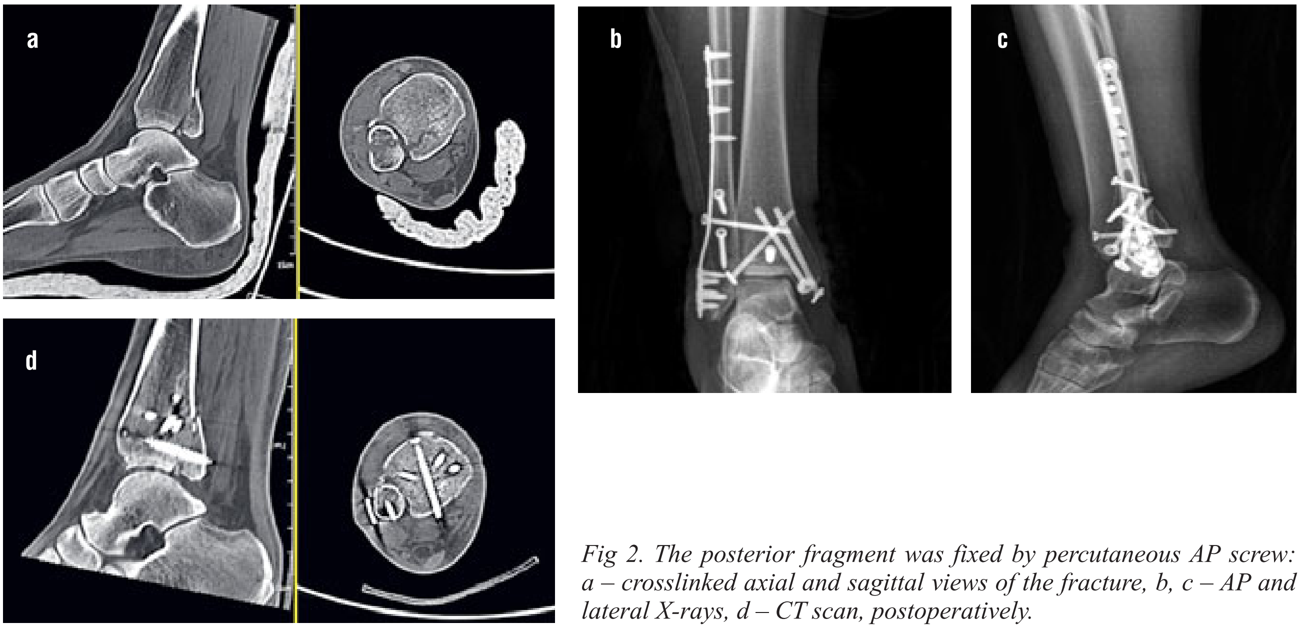

Fig 2. The posterior fragment was fixed by percutaneous AP screw: a – crosslinked axial and sagittal views of the fracture, b, c – AP and lateral X-rays, d – CT scan, postoperatively.

level of articular surface. The medial malleolus was not included in the measurement to calculate the exact weight – bearing surface (Fig. 1b).

Patients were separated into 2 groups according to the fixation method; Group 1: fixation with AP percutaneous screw, and Group 2: posterior open reduction – internal fixation.

All operations were performed by three experienced surgeons with at least 5 years of experience in trauma and foot and ankle surgery. The posterolateral approach described by Hoogendoorn et al. (14) was used in the posterior open reduction and internal fixation method (Fig. 1). In the AP screw method, following the fixation of the fibula and the medial malleolus with direct incision, the posterior malleolus reduction was achieved with ligamentotaxis. The reduction was checked with fluoroscopy. After the verification of the reduction, the fixation was made using one or two partially threaded 4.5 mm cannulated screws (Fig. 2). The integrity of the syndesmosis was evaluated intraoperatively under imaging control. If necessary, the syndesmosis was secured with one screw after fixation of the trimalleolar fracture. All patients were applied with the same postoperative rehabilitation protocol. A plaster cast was applied to all the patients postoperatively. In the 3rd postoperative week, active range-of-motion exercises were started. The plaster cast was continued for 6-8 weeks in the patients with accompanying medial malleolar fracture or deltoid ligament injury. Full weight-bearing was allowed at 10–12 weeks postoperatively.

The ankle fractures were classified according to the AO (Arbeitsgemeinschaft fur Osteosynthesefragen) classification scheme (18). The posterior malleolar fractures were classified according to the posterior malleolar fracture classification established by Haraguchi et al. (12):

Group 1: posterolateral – oblique fractures with wedge-shaped fragments involving the posterolateral corner of the plafond,

Group 2: transverse medial – extension with a fracture line extending from the fibular notch of the tibia to the medial malleolus,

Group 3: small – shell fractures at the posterior lip of the plafond.

To distinguish the posterior malleolar fracture from a partial tibial pilon fracture, fractures with a posterior fragment involving the anterior colliculus of the medial malleolus or a posterior fragment involving more than 50 % of the fibular notch were considered a tibia pilon fracture and excluded from the study (2). Persistence of articular gap or step-off was measured on the postoperative radiographs and CTs. The presence of step-off or a gap at the articular joint surface > 2 mm, or a loose body within the joint were evaluated as articular incongruity. Syndesmotic reduction was evaluated 1 cm proximal to the articular surface by measuring the distance between the fibula and the anterior and posterior facets of the incisura fibula on the axial CT view. A difference > 2 mm between the anterior and posterior measurements was classified as malreduction of the syndesmosis (10). Osteoarthritis of the ankle joint was assessed according to the osteoarthritis classification system described by Giannini et al. (11):

Stage 0: Normal joint or subchondral sclerosis

Stage 1: Presence of osteophytes without joint space narrowing

Stage 2: Joint space narrowing with or without osteophytes

Stage 3: Subtotal or total disappearance or deformation of joint space

Patients were asked to complete two self-assessment questionnaires. The Foot and Ankle Outcome Score (FAOS) was used to evaluate patient symptoms (25). This questionnaire comprises 42 items with Likert-type responses in 5 sub-categories of symptoms (7 items), pain (9 items), function (17 items), sport performance (5 items) and quality of life (4 items). The total score ranges from 0 to 100, with 0 indicating the best score and 100, the worst score.

The Short Form 36 Health Survey Questionnaire (SF-36) was used to evaluate quality of life (34). Posner et al. concluded that the SF-36 is a useful tool to assess outcomes following an ankle fracture (23). The SF-36 is scored between 0 and 100, with 0 indicating the worst quality of life and 100 indicating the best quality of life. The questionnaire comprises 36 items in 8 sub-categories of physical functioning, role-physical, bodily pain, general health, vitality, social functioning, role-emotional, and mental health. Two summary scores of physical health score (PHC) and mental health score (MHS) are also evaluated.

Non – weight bearing active dorsiflexion and plantar flexion of the ankle joint were measured and categorized as normal if a minimum of the following values were observed; dorsiflexion ≥ 20∅, plantarflexion ≥ 40∅. Both the healthy and fractured sides of the patients were evaluated. All measurements were performed by a single examiner using a standard two-arm 30 cm goniometer. Each patient was seated on an examination table and the proximal arm of the goniometer was aligned with fibula, the distal arm was aligned parallel to the fifth metatarsal. Ankle motion was measured according to neutral – zero method (26). The starting point (0^0) was the neutral position of the ankle joint and the angular movement either dorsal or plantar direction was assessed according to the neutral position (1).

Non-union, deep infection, major neurovascular injury and implant failure were defined as major complications. Superficial wound separation or infection, local hematoma – seroma were considered as minor complications.

Statistical analysis

Data obtained in the study were analyzed statistically using SPSS vn. 22.0 software. Descriptive statistics were stated as mean ±standard deviation (SD) values, or frequency (n) and percentage (%). The Independent Samples t-test was used for the comparison of quantitative data (SF-36 and FAOS). The Chi-Square test was applied in the comparisons of qualitative data. A value of $p < 0.05$ was accepted as statistically significant.

Table 1. Demographic data of the patients

		n	%
Group 1 (anterior subcutaneus screw)		50	58.1
Group 2 (posterior open fixation)		36	41.9
Gender	male	53	61.6
	female	33	38.4
Side	left	36	41.9
	right	50	58.1
Smoking	–	61	70.9
	+	25	29.1

Table 2. Demographic data of the patients

	n	X	s.d.
Age	86	41.70	14.24
Postoperative day	86	62.77	24.24
BMI	86	22.79	4.06

Table. 3 Demographic data of the groups

		Group 1		Group 2		
		n	%	n	%	
Gender	male	29	58.0%	24	66.7%	0.28
	female	21	42.0%	12	33.3%	
Side	left	20	40.0%	16	44.4%	0.42
	right	30	60.0%	20	55.6%	
Smoking	-	35	70.0%	26	72.2%	0.51
	+	15	30.0%	10	27.8%	
AO type	44B	46	92.0%	31	86.1%	0.30
	44C	4	8.0%	5	13.9%	
Haraguchi type	1	15	30.0%	12	33.3%	0.46
	2	35	70.0%	24	66.7%	
Syndesmosis Malreduction	-	46	92.0%	35	97.2%	0.29
	+	4	8.0%	1	2.8%	
Syndesmosis Screw	-	36	72.0%	27	75.0%	0.48
	+	14	28.0%	9	25.0%	

RESULTS

Demographic results

Evaluation was made of 86 patients, comprising 53 (61.6 %) males and 33 (38.4 %) females, with mean BMI of 22.8 ± 4.0, and mean postoperative follow-up period of 62.8 ± 24.2 months (range, 24–110 months). The PMF was fixed using anteroposterior percutaneous screw in 50 (58.1 %) patients and with posterior open reduction-internal fixation in 36 (41.9 %) patients. The demographic data of the patients are presented in Tables 1 and 2. When the subjects were separated as 2 groups according to the fixation technique of the posterior malleolar fracture, no statistically significant differences were determined between the two groups in respect of gender distribution, age, smoking history, postoperative follow-up and BMI of the patients (Table 3). No major complication developed in any patient. Minor complications were observed in 3 patients in Group 1 (2 wound separation, 1 superficial infection at the site of lateral ankle incision) and in 4 patients in Group 2 (2 wound separation, 2 superficial infection at the site of posterolateral incision).

Radiological results

There were 77 patients (89.5 %) with AO 44 B type and 9 patients (10.5 %) with AO 44 C type. There were 27 patients (31.4 %) with Haraguchi type 1 fracture and

Table 4. Radiological findings of the patients

	Group 2	Group 2	
	X±s.d. / % (mean)	X±s.d. / % (mean)	
Sagittal rate	19 %	21 %	0.52
Axial rate	24 %	26 %	0.55
Arthritis stage	0.98±0.91	0.39±0.60	p<0.05
Articular Step-off	1.68±0.89	0.80±0.54	p<0.05
Loss of dorsiflexion	4.9±0.7	4.06±0.8	0.43
Loss of plantar flexion	2.9±0.5	2.2±0.3	0.37

Table 5. SF-36 Scores of the patients

	Group 1	Group 2	
	X±s.s.	X±s.s.	
Physical functioning (PF)	67.50±8.99	72.64±8.58	p<0.05
Role – physical problems (RP)	58.00±17.38	63.47±19.23	p<0.05
Pain (P)	55.15±29.10	64.18±20.74	p<0.05
General health (GH)	66.40±18.57	68.06±17.29	0.52
Vitality (V)	63.20±19.48	65.67±17.97	0.32
Mental health (MH)	68.00±16.60	67.83±17.71	0.47
Social functioning (SF)	60.30±18.06	62.03±15.34	0.26
Role – emotional problems (RE)	68.29±26.11	69.25±19.78	0.43

Table 6. FAOS scores of the patients

	Group 1	Group 2	
	X±s.s.	X±s.s.	
Symptoms	60.02±6.63	56.56±3.87	p<0.05
Pain	74.76±12.23	69.67±11.16	p<0.05
Activities of daily living	76.60±11.64	70.33±10.23	p<0.05
Sports	50.92±14.89	49.00±13.38	0.12
Quality of life	58.44±9.31	57.22±6.92	0.21

Table 7. Range of motion of the ankle joints

	Group 1	Group 2	
	X±s.s.	X±s.s.	
Frc. drflx.	15.84±2.46	16.5±2.40	0.42
Hlth drflx.	20.76±1.49	20.56±1.61	0.55
Frc. pflx	44.9±3.57	45.14±4.05	0.77
Hlth. pflx	47.8±4.42	47.36±4.39	0.65

59 patients (68.6 %) with type 2 fracture. There were no statistically differences between the groups in respect of fracture types (Table 4). In Group 1, the PMF was fixed using 2 screws in 34 patients and 1 screw in 16 patients. In Group 2, the PMF was fixed using a plate in 24 patients, 2 screws in 10 patients and 1 screw in 2 patients. The syndesmosis was treated with one additional screw in 28 % of Group 1 and in 25 % of Group 2, with no statistically significant difference determined between the groups.

The mean joint surface involvement of PMF in the sagittal plane was 19 % in Group 1 and 21 % in Group 2 with no statistically significant difference determined between the groups. The involvement of the fracture on the axial plane was calculated as 24 % in Group 1 and 26 % in Group 2, and there was no statistically significant difference between the groups. The mean step-off of the articular surface was statistically greater in Group 1 than in Group 2; 2.3 ± 0.9 and 0.8 ± 0.3, respectively. More patients were determined with syndesmosis malreduction in Group 1 than in Group 2; 4 (8 %) and 1 (2.8 %), respectively. However, no statistically significant difference was determined between the two groups in respect of syndesmosis malreduction. The mean arthritis score was higher in Group 1 than in Group 2; 1.0 ± 0.9 and 0.4 ± 0.6, respectively (Table 4).

Clinical results

The evaluation of the outcomes after osteosynthesis of the PMF revealed that the mean scores of the physical functioning section of the SF-36 questionnaire was statistically significantly improved in the patients with open reduction and internal fixation except for the general health score. The mean PF, RP, P and total scores were statistically significantly higher in Group 2 than in Group 1. The mean scores of the mental health section (V, MH, SF, RE) of the SF-36 questionnaire were similar in both groups, with no statistically significant difference (Table 5).

The results of the FAOS were similar to the results of the SF-36. The patients with a posterior open internal fixation were less symptomatic and had less pain than the patients with percutaneous anteroposterior fixation (Table 6). Participation in sporting activities was restricted in both groups, with no significant difference determined between the two groups in respect of the sport scores. No statistically significant difference was determined between the two groups in respect of the scores related to quality of life. The patients in both groups were observed to share the same perception of quality of life.

Clinical examination of the patients determined no statistically significant difference between the two groups in respect of plantar flexion and dorsiflexion of the fractured side (Table 7). The mean loss of dorsiflexion was 5° in Group 1 and 4° in Group 2. The mean loss of plantar flexion was 3° in Group 1 and 2° in Group 2. There was no statistically significant difference between the groups in terms of loss of ankle joint range of motion (Table 4).

DISCUSSION

The management of posterior malleolar fracture has evolved over the last decades. Although there is no consensus on the treatment of posterior malleolar fractures, clinically it is generally accepted that of patients with a rotational ankle fracture, worse outcomes are observed in patients with a trimalleolar fracture. Compared with bimalleolar fractures, a higher risk (up to 34 %) of post-traumatic arthritis has been reported in literature (20). Furthermore, trimalleolar fractures after a severe rotational injury may result in ankle instability and functional impairment in cases with persistent bone instability and syndesmosis malreduction (7).

The contribution of the posterior malleolus to ankle stability has been investigated with experimental fracture models and conflicting results have been obtained. Scheidt et al. found that PMF involving 25 % of the articular surface might lead to excessive internal rotation and posterior instability (27). However, Raasch et al. demonstrated that even after up to 40 % of posterolateral tibia osteotomy, posteriorly directed force did not create posterior translation of the talus (24). Some studies have shown that a fragment of PM more than a third of the distal tibia decreased the joint surface area contact and changed the load distribution pattern (13, 21). In contrast, Vrahas et al. found that even after removing 40 % of the posterior malleolus, there was no any change in the peak contact pressure (33).

Surgical decisions are mainly based on fragment size and joint congruity (9). Traditionally, the indication for surgery is the involvement of a fragment more than one – quarter to one – third of the articular surface and more than 2 mm displacement of the fragment (31). According to the AO classification, a posterior malleolar fracture > 25 % of the intraarticular surface needs to be fixated (18). Harper et al. suggested that there was no difference whether PMF > 25 % of the articular surface was fixed or not, while conversely, Jaskulka et al. found that the risk of osteoarthritis may increase even after the tibial rim fractures and emphasized that all PMFs should be fixed regardless of fragment size (16).

The fixation of the posterior malleolar fragment can be achieved with indirect percutaneous AP screw fixation or direct posterolateral - posteromedial approaches to posterior fragment and fixation with a screw or plate. In 1996, Huber et al. reported that the rate of anatomical reduction of the posterior malleolar fragment was 27 % via percutaneous anteroposterior screw fixation, however the anatomical reduction was achieved in 83 % of patients undergoing an open reduction and internal fixation (15). Talbot et al. demonstrated that the posterolateral approach was a favorable technique facilitating anatomical reduction of the articular surface and direct identification of the posterior fragment (30). Choi et al. recommended the single posterolateral approach providing accurate restoration of the articular congruity and fixation of the lateral malleolar fracture in the treatment of large displaced posterior malleolar fracture with an associated lateral malleolar fracture (6). The main result of this study was that better clinical and radiological outcomes were obtained when the PMF was fixed with posterolateral open reduction and internal fixation compared to closed reduction and percutaneous AP screw fixation. Better articular congruity was achieved with open reduction and internal fixation. Furthermore, the risk of post-traumatic arthritis was minimized with better reduction of the fracture. The mean articular step-off was statistically significantly greater in the patients with anteroposterior percutaneous screw compared to the posterior open fixation group (1.68 mm vs. 0.8 mm). Shi et al. achieved better quality of articular congruity and higher functional scores in the patients with posterior malleolar fracture following open reduction and internal fixation of the posterior fragment compared to indirect reduction and percutaneous anteroposterior screw fixation (28). Verhage et al. showed that postoperative step-off of the posterior malleolar fragment larger than 1mm was an independent risk factor for the development of osteoarthritis after trimalleolar fracture (32).

Recent studies have emphasized the anatomic articular reduction without step-off rather than the size of the fracture fragment (3, 7). In the current study, it was determined that the main intention should be better articular congruity rather than fragment fixation. Often small osteochondral fragments or ligamentous structures may be interposed in the fracture site, preventing articular reduction. A direct posterior approach facilitates decreasing the risk of articular step-off by removal of the interposed loose bodies and anatomic reduction of the fracture.

Restoration of the syndesmosis anatomy is another important factor to be able to achieve good functional results after a trimalleolar fracture. The PITFL is the strongest part of the syndesmosis. Fixation with percutaneous screw assumes reduction of the posterior fragment with ligamentotaxis of the PITFL. The general tendency is toward non – operative treatment for small posterior fragments, although recent studies have advocated fragment-specific treatment for the posterior malleolar fractures to achieve the anatomic reduction of the syndesmosis (4, 19). In the current study, although there was no statistically significant difference between the two groups, syndesmosis malreduction was determined in 8 % of Group 1 and in 2.8 % of Group 2.

Functional outcomes were found to be similar to the radiological outcomes. The physical performance of the patients was higher in Group 2 than in Group 1. However, the better physical condition was not correlated with better mental well-being. The patients in both groups demonstrated similar outcomes in terms of mental well-being scores. Loss of dorsiflexion did not exceed 5° and loss of plantar flexion did not exceed 3° in both groups. Previous studies have reported similar results to those of the current study in that better clinical scores were observed in the patients with restoration of the posterior fragment with a direct posterior approach (22, 36).

Retrospective, non-controlled nature of the study contributes to a certain amount of bias. Patients were not randomized, and this could influence the surgeon and choice of fixation method. In addition, the sample size in the subgroups was small. However, we believe that this comparative study presents useful information for the management of trimalleolar ankle fractures.

CONCLUSIONS

In conclusion, direct open reduction and fixation of the posterior fragment demonstrated better functional and radiological outcomes than indirect reduction and percutaneous fixation in the patients with trimalleolar fracture. A posterior open approach facilitates the anatomic reduction of the posterior fragment and direct reduction syndesmosis.

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