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ORIGINAL ARTICLE • ANKLE - FRACTURES

Negative prognostic factors in surgical treatment for trimalleolar fractures

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Abstract

Purpose Trimalleolar fractures are a common injury of the ankle that require surgical treatment to obtain an anatomic reduction of both malleoli and stabilization of the syndesmosis. This study aims to report the outcomes of surgical treatment for trimalleolar fractures, identifying the risk factors determining a worse result.

Materials and methods Between January 2013 and December 2016, 48 patients with trimalleolar fracture treated with open reduction and internal fixation were retrospectively analyzed. The mean age was 44.69 years, and average body mass index (BMI) was 29.04. According to the Danis–Weber classification, 30 (62.5%) fractures were type B and 18 (37.5%) were type C. Clinical and radiographic evaluations at 3, 6, and 12 months were assessed. The functional results of Visual Analogue Staircases and Olerud–Molander (O&M) ankle score were reported.

Results No significant difference was found among the size of the PM in patients with and without ankle dislocation ($p = 0.364$). Therefore, there is no correlation between the size of the posterior fragment and the ankle dislocation and the size of the posterior malleolus and syndesmosis stability ($p = 0.328$). Age over 61 years, BMI > 40, ASA > 1, type C fracture, and fracture dislocation were considered as negative prognostic fractures.

Conclusions Surgical treatment for trimalleolar fractures needs accurate preoperative planning. Age over 61 years, BMI > 40, ASA > 1, type C fracture, and fracture dislocation were considered as negative prognostic fractures.

Keywords Trimalleolar fractures · Posterior malleolus · Outcome · Open reduction · Internal fixation

Introduction

Malleolar fractures are frequent and have a 66% incidence for the isolated malleolar fractures, 25% for the bimalleolar fractures, and around 7% of trimalleolar fractures [1–3]. Several studies in the literature show a notable increase in the malleolar fractures, especially in the old patients [4]. The trimalleolar fractures have a worse clinical outcome and an increase in the risk of osteoarthrosis [5, 6].

In 1931, Bohler described the joints as no longer congruent and, therefore, abraded. With time, the greater the displacement, the more pronounced the arthritic changes: Therefore, the ankle joint remains permanently painful [7]. The ankle joint is essential for walking and maintaining a standing position. As Yablon and colleagues reported, in bimalleolar ankle fractures, "the talus faithfully followed the lateral malleolus," causing derangement of the contact between the tibia and talus [8]. After 1958, when the Association of the Internal Fixation (AO) began their study of fracture treatment, several biomechanical, anatomic, and clinical studies in the 1970s showed the importance of accurate anatomic reduction of the medial and lateral malleoli in ankle fractures; suddenly, excellent results began to be reported [7, 9]. In the literature, there are some contradictory studies on the surgical indications of the posterior malleolus (PM). For a long time, the indications for the fixation for posterior malleolus were found on the greatness and dislocation of the fragment [5]. Fixation was recommended for fragments more than 25% of the articular surface measured on radiography on lateral view and dislocation more than 2 mm [10].

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Various fixation opinions were described. The anterior percutaneous approach and fixation with cancellous cannulated partially threaded screws is the most used technique [5]. It could be used when the posterior fragment is large, not comminuted, not dislocated, and does not allow an anatomical reduction. Therefore, the posterior–lateral approach is the most recommended one to anatomically reduce the PM. The fixation could be affected with cancellous cannulated partially threaded screws or also with plates and screws. The posterior–medial access is recommended when the PM is comminuted, and the medial malleolus is involved. Only for PM unstable to the posterior drawer stress test after synthesis of both malleolus and stabilization of the syndesmosis, surgical fixation is required [11].

The purpose of this study is to analyze the positive and negative prognostic factors and the ability of the patients to return to their daily (and sports) activities.

Patients and methods

Demographic data

Between January 2013 and December 2016, 48 patients with trimalleolar ankle fractures have been retrospectively analyzed at our institute. Exclusion criteria were: uni- or bimalleolar fractures, open fractures, polytrauma, patients with associated lower limb fractures, pathological fractures, neurovascular lesions, and age less than 18 years.

Gender, side, mean age, body mass index (BMI), the global anesthesiologic risk according to the classification of the American Society of Anesthesiologists (ASA) [12], and the type of fracture according to Danis–Weber classification [13, 14] were recorded. For each patient, the extension of the posterior malleolus was measured in lateral view X-ray, using Carestream Vue PACS.

Surgical technique

Forty-five patients (93.7%) were treated with ORIF, and three patients (6.3%) with severe dislocated fractures were initially treated with temporary external fixation and successively converted to ORIF.

Medial malleolus fractures were fixed with cancellous cannulated partially threaded 3.5-mm screws. Lateral malleolus was fixed with 3.5-mm lag screws and a one-third tubular/anatomical DCP neutralization plate. PM was fixed with cancellous cannulated partially threaded 3.5-mm screw, when the posterior drawer stress test (movement of PM at stabilization of ankle while posterior shifting of the talus) was positive and a preoperative CT scan demonstrated an involvement of the fragment more than 25% of the articular surface.

The unstable syndesmosis was treated, after intraoperative Cotton test (widening of the syndesmosis with lateral pull on the fibula) and fluoroscopic views, with a tricortical syndesmotic 3.5-mm screw in the apex of the syndesmosis and 20 mm above the tibiotalar joint through the neutralization plate [15].

After surgery, the ankle was immobilized with a cast in the neutral position of the foot. After 2 weeks, cast removal and mobilization of the ankle have been granted. At 6 weeks from surgery, partial weight-bearing was allowed. The syndesmotic screw was removed after 6–8 weeks in local anesthesia. The load was gradually increased by 10 kg per week.

Clinical and radiographic assessment

Follow-up was assessed at 3, 6, and 12 months with clinical and X-ray evaluation. The functional results have been determined with the clinical evaluation of swelling, rigidity, and pain residual, the Visual Analogue Staircases (VAS), the score of Olerud–Molander (O&M) ankle, the ability to return to the sporting activities, the satisfaction to the surgery, and the presence of surgical complications.

Statistical analysis

For the analysis of the data, *t* tests were used for comparisons of averages. The statistical significance level was fixed to $p < 0.05$. All analyses were done using a Microsoft Excel spreadsheet. For the O&M numerical variable, the assumption of normal distribution was verified using a frequency histograms and Chi-square test.

Results

Of 48 patients treated, 22 patients (46%) were male and 26 (54%) female, with a 1.2 female-to-male ratio; the left side was involved in 29 patients (60%); and the mean age was 44.7 ± 16.1 years (range 19–72 years). The average BMI was 29.0 ± 5.7 (range 20.3–43.3). According to ASA classification of global anesthetic risk, 21 patients (44%) belonged to class 1, 21 (44%) to class 2, and six (12%) to class 3.

According to Weber classification, the fracture was type B in 30 patients (62.5%) and type C in 18 patients (37.5%). The size of the PM fragment in latero-side radiographies varied from 5 to 45% (Table 1).

Fixation of the PM was performed in only eight (17%) of the trimalleolar fractures. The fixation of lateral and medial malleoli combined with stabilization of the syndesmosis led to an anatomical reduction of the posterior fragment in 40 patients (83.3%), which was stable at intraoperative posterior drawer stress test. Twenty-three (48%) subjects affected by ankle dislocation were observed, with posterior fragment

Table 1 Demographic data and treatment details

Demographics, *n*	48
Patient demographics	
Mean age (range), years	44.69 (19–72)
Standard deviation	15.79
Male, *n* (%)	22 (46)
Female, *n* (%)	26 (54)
ASA classification	
Class 1, *n* (%)	21 (44)
Class 2, *n* (%)	21 (44)
Class 3, *n* (%)	6 (13)
Class 4, *n* (%)	0 (0)
Class 5, *n* (%)	0 (0)
BMI (mean: 29.04; max: 43.34; min: 20.31; SD: 5.75)	
≤ 18.49, *n* (%)	0 (0)
18.5 ≤ BMI ≤ 24.9, *n* (%)	13 (27)
25 ≤ BMI ≤ 29.9, *n* (%)	14 (29)
30 ≤ BMI ≤ 39.9, *n* (%)	20 (42)
≥ 40, *n* (%)	1 (2)
Fracture classification	
Weber B, *n* (%)	30 (62.5)
Weber C, *n* (%)	18 (37.5)
Mean posterior fragment size, % (range)	18 (5–45)
Mean posterior fragment fixed, % (range)	26 (10–40)
Posterior malleolus size > 25%, *n* (%)	13 (27)
Fracture dislocation, *n* (%)	23 (48)
Syndesmosis fixed, *n* (%)	6 (13)
Posterior malleolus fixed, *n* (%)	8 (17)

Table 2 Clinical Outcomes

Outcome variables	
Residual ankle pain, *n* (%)	25 (52)
Residual ankle stiffness, *n* (%)	29 (60)
Residual ankle swelling, *n* (%)	27 (56)
VAS, mean (range)	2.23 (0–7)
Standard deviation	1.95
Olerud–Molander score, mean (range)	75.31 (35–100)
Standard deviation	15.86
≤ 30, *n* (%)	0 (0)
30 < O&M ≤ 60, *n* (%)	11 (23)
60 < O&M ≤ 90, *n* (%)	29 (60)
≥ 91, *n* (%)	8 (17)

sizes varying from 5 to 45%. At lateral view radiograph, no statistically significant differences were reported among the size of the PM fragment between patients with or without ankle dislocation ($p = 0.364$). Therefore, there is no statistical correlation among the size of the posterior fragment and the ankle dislocation condition. Stabilization of unstable syndesmosis was performed in six subjects (12.5%), with PM sizes varying from 5 to 40%. No statistically significant differences were reported for the size of the PM fragment between patients with or without surgical syndesmosis stabilization. Therefore, there is no statistical correlation between the size of the posterior fragment and syndesmosis stability ($p = 0.328$) (Table 1). The mean follow-up was 31.13 months ± 12.8 (range 11–59 months).

Clinical assessments reported an average O&M score of 75.3 ± 15.9 (range 35–100). The average VAS score was 2.2 ± 1.9 (range 0–7). Twenty-five subjects (52%) complained about residual pain, and 29 (60%) and 27 (56%) about lingering stiffness and ankle swelling, respectively (Table 2).

Twelve subjects (25%) practiced sports before the ankle trauma; nine (75%) returned to normal sport activity, of which four (33%) did not report any difficulty after ankle surgery, three (25%) reported small difficulty, and two (17%) complained moderate to severe difficulty. Three patients (25%) were not able to return to their usual sporting activities. No statistically significant differences were found between the sexes among residual symptoms and the recovery of sporting activity, O&M score ($p = 0.277$), and VAS score ($p = 0.383$).

Regarding age, the 19- to 40-year-old group performed better than the 41- to 60-year-old group following O&M ($p = 0.0021$) and VAS ($p = 0.0056$). Subjects aged from 41 to 60 years obtained better results in O&M score ($p = 0.001$), but not in VAS score ($p = 0.90$). Furthermore, the 19- to 40-year-old group was compared to a third group, including subjects older than 60 years, reporting a substantial difference, following O&M ($p = 0.000002$) and VAS ($p = 0.048$).

Concerning BMI, morbidly obese subjects with BMI values over 40 performed worst in every standard evaluation. Comparing normal-weight subjects with obese ones, a significant difference was found between their results (O&M $p = 0.019$, VAS $p = 0.026$) (Table 3).

Following the Weber classification, patients with type C fracture had worst results for every standard evaluation: 13 subjects (72%) presented residual pain, 14 (78%) lingering stiffness, and 14 (78%) ankle swelling; the VAS score was 3.06, while the O&M score was 69.72 (range 35–100). Subjects with type B fractures performed better than the others: 12 (40%) presented residual pain, 15 (50%) lingering stiffness, and 13 (43%) ankle swelling; VAS score 1.73 and O&M score 78.67 (45–100) (O&M $p = 0.03$, VAS $p = 0.011$) (Table 4).

Subjects belonging to ASA class 1 have better results for almost every valuation standard than classes 2 and 3. The O&M scores between class 1 and class 2 and between class 1 and 3 were significantly different ($p = 0.017$ and $p = 0.026$, respectively). Subjects without ankle dislocation reported better results, with an O&M score of 79.6 (range 45–100)

Table 3 Distribution of participants based on BMI

Distribution of participants based on BMI	18.5 ≤ BMI ≤ 24.9 (normal)	25 ≤ BMI ≤ 29.9 (overweight)	30 ≤ BMI ≤ 39.9 (obese)	≤ 40 (morbidly obese)
Participants, *n*	13	14	20	1
Residual ankle pain, *n* (%)	7 (54)	4 (29)	13 (65)	1 (100)
Residual ankle stiffness, *n* (%)	4 (31)	9 (64)	15 (75)	1 (100)
Residual ankle swelling, *n* (%)	4 (31)	9 (64)	13 (65)	1 (100)
VAS, mean (range)	1.77 (0–4)	1.14 (0–5)	3.15 (1–7)	5 (5–5)
Olerud–Molander score, mean (range)	82.69 (45–100)	77.14 (50–95)	71.25 (50–95)	35 (35–35)
Participants who practice sports activities before trauma, *n*	6	3	2	1
Ability to return to pre-injury sports activities, *n* (%)	5 (83)	2 (67)	2 (100)	0 (0)
No difficulty, *n* (%)	4 (67)	0 (0)	0 (0)	0 (0)
Minimal difficulty, *n* (%)	1 (17)	2 (67)	0 (0)	0 (0)
Moderate difficulty, *n* (%)	0 (0)	0 (0)	2 (100)	0 (0)
Unable to do so, *n* (%)	1 (17)	1 (33)	0 (0)	1 (100)
	Normal versus morbidly obese			
	O&M			VAS
p value	0.019			0.026

Table 4 Distribution of participants based on Weber classification

Distribution of participants based on Weber classification	Type B	Type C
Participants, *n*	30	18
Residual ankle pain, *n* (%)	12 (40)	13 (72)
Residual ankle stiffness, *n* (%)	15 (50)	14 (78)
Residual ankle swelling, *n* (%)	13 (43)	14 (78)
VAS, mean (range)	1.73 (0–7)	3.06 (0–6)
Olerud–Molander score, mean (range)	78.67 (45–100)	69.72 (35–100)
Participants who practice sports activities before trauma, *n*	7	5
Ability to return to pre-injury sports activities, *n* (%)	6 (89)	3 (60)
No difficulty, *n* (%)	2 (29)	2 (40)
Minimal difficulty, *n* (%)	3 (43)	0 (0)
Moderate difficulty, *n* (%)	1 (14)	1 (20)
Unable to do so, *n* (%)	1 (14)	2 (40)
	Type B versus Type C	
	O&M	VAS
p value	0.03	0.011

and a VAS score of 1.6 (range 0–4). Subjects with ankle dislocation reported a worse outcome, with an O&M score of 71.46 (range 35–100) and VAS score of 2.92 (range 0–7); these patients were also slower in recovery time (O&M, $p = 0.026$; VAS, $p = 0.0097$) (Table 5).

Minor complications were reported: two (4.2%) cases of superficial surgical wound infections, treated with better hygiene of the affected site and oral antibiotics, and one case (2.1%) of screw mobilization which required its removal. Internal fixation device removal was performed after 18 months from the surgery for two patients (4.2%) after clinical and radiographic healing.

Table 5 Distribution of participants based on dislocation

Distribution of participants based on dislocation	Type B	Type C
Participants, *n*	23	25
Residual ankle pain, *n* (%)	11 (48)	14 (56)
Residual ankle stiffness, *n* (%)	15 (65)	14 (56)
Residual ankle swelling, *n* (%)	13 (57)	14 (56)
VAS, mean (range)	2.91 (0–7)	1.6 (0–4)
Olerud–Molander score, mean (range)	70.65 (35–100)	79.6 (45–100)
Participants who practice sports activities before trauma, *n*	5	7
Ability to return to pre-injury sports activities, *n* (%)	3 (60)	6 (86)
No difficulty, *n* (%)	2 (40)	2 (29)
Minimal difficulty, *n* (%)	0 (0)	3 (43)
Moderate difficulty, *n* (%)	1 (20)	1 (14)
Unable to do so, *n* (%)	2 (40)	1 (14)
	Type B versus type C	
	O&M	VAS
p value	0.026	0.0097

Discussion

Ankle fractures are extremely common with an incidence of about 107–184 per 100,000 per year. Concomitant fracture of the PM occurs in the 7–14% of all ankle fractures [16].

In the literature, several studies confirm a univocal correlation among the PM size and poor clinical outcomes, as well as the increased predisposition of osteoarthrosis degeneration if the fragment accounts for more than the 25% of the articular surface [6, 17]. Hartford et al. showed that resection of 20, 30, and 50% of the PM results in reductions of the articular surface of 4, 13, and 21%, respectively, with a consequent increase in pressure and articular stress [18, 19]. Papachistou et al. [20] sustained that if both malleoli are stabilized, the back quarter of ankle is not involved in loading and does not influence the stability of the ankle. Radiographically, no correlation was found between the PM size, measured in lateral view, the tibiotalar dislocation, and the stability of the syndesmosis.

In our series, after surgical fixation of both malleoli and the stabilization of the syndesmosis, PM was reduced in 82.9% of the cases, resulting in stability at intraoperative posterior drawer stress tests. The syndesmosis plays a fundamental role in the stabilization of the ankle due to the anterior tibiofibular ligament, the interosseous ligament and membrane, the posterior tibiofibular ligament, the deltoid ligament, the anterior and posterior fibula–talar ligaments, and the fibula–calcaneal ligament. In the trimalleolar fractures, the syndesmosis lesion must be stabilized with a screw. In case of posterior tibiofibular ligament lesion, the PM could be displaced despite the stabilization with a screw and its fixation is recommended to allow the complete stability of the syndesmosis and a correct loading during walking [21–24]. In our study, the PM was fixed in 17% of patients, after intraoperative posterior drawer stress test.

Following clinical evaluation with O&M score, 17% of patients reported excellent outcomes (score 91–100) with an early functional recover without any limitation of quality of life and no difficulty in returning to sport activity; 62% reported good outcomes (scores 61–90), having partially recovered the tibiotalar joint function with some limitations in working activities; 23% of cases reported being unsatisfied with the outcomes (score less than 60), with severe limitation on their quality of life. All poor outcomes reported a tibiotalar dislocation due to a high-energy trauma. No patient reported an O&M score less than 30. These findings were comparable to studies of De Vries et al. [16] and Heim et al. [25], who reported fair outcomes for fracture dislocation compared to the fractures without ankle dislocation. Shah et al. [26] reported a series of 69 patients with fractures of types Weber B and C with residual pain in 50% of cases, joint rigidity in 63%, and postoperative joint effusion in 45%. Our study reported comparable outcomes, showing that patients with Weber C fractures have a significantly lower O&M score than Weber B-type patients.

Our demographic data show a greater incidence of 54% in females, as confirmed in a study of Juan et al. [27]. This could be due to the osteopenia or osteoporosis in this group of patients. The data suggested patients with age between 18 and 40 years, normal weight, and with ASA 1, reported better outcomes than patients with age over 61 years, BMI > 40, and ASA 3.

Limits of the study were its retrospective nature, the lack of a control group, the impossibility of finding a CT scan for all patients, and possible bias in radiographic measurement.

Conclusions

In conclusion, the surgical treatment of patients with trimalleolar fractures reported good mid-term outcomes, with a satisfying recovery of daily activities. During the surgery, after reduction and fixation of both malleoli, it is important to perform a stress test for the syndesmosis, such as the Cotton test and Hook test, to detect and fix any potential instabilities of the syndesmosis. Stabilization of the syndesmosis is necessary for all trimalleolar fractures with ankle dislocations. Clinical and radiographic follow-up is necessary to evaluate functional outcomes and to anticipate the onset of possible complications.

Moreover, to evaluate the prognosis, patients with one or more negative factors (aged over 61 years, BMI > 40, class ASA > 1, type C fracture according to Danis–Weber or a fracture dislocation) could have worse outcomes. The knowledge of this risk factor is important to provide information for patients with expectations about the possibility of recovering their quality of life and returning to sports activities.

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Compliance with ethical standards

Conflict of interest All 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.

Informed consent Informed consent was obtained from all individual participants included in the study.

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