

Outcomes after Surgically-Treated Ankle Fractures with or without Surgical Fixation of Posterior Malleolar Fracture

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Abstract

Background: Ankle fractures are highly variable, as is their management. Surgeons generally perform reduction and internal fixation of the posterior malleolar fragment if the fracture involves more than 25% of the joint surface. This study examines the functional and radiographic outcomes in patients with operatively managed ankle fractures involving the posterior malleolus by comparing internal fixation to no fixation of the posterior malleolus.

Methods: This is a retrospective cohort study of adults with surgically-treated ankle fractures, all of whom had posterior malleolar fractures (PMF) managed with or without internal fixation (IF) from November 2012 through May 2015. We retrieved demographic, injury, and Short Musculoskeletal Functional Assessment (SMFA) information. Pre and postoperative x-rays were measured for articular displacement and posterior malleolar fragment size.

Results: Of 147 adults who met criteria for PMF, 63 received IF, and 84 did not. Mean age was 46.1, 53.7% were female. Adults treated with IF had larger PMF fragments (mean 9.7 vs. 5.6 mm) and greater displacement (mean 9.3 vs. 2.7 mm) than adults without PMF IF. Mean SMFA score at 6 months did not differ between groups (52.0-14.6 IF vs. 51.0-11.4 without fixation, N = 41, 28% of sample).

Conclusions: Adults with larger, displaced PMF fragments were treated with internal fixation. Functional 6-month SMFA outcomes were comparable in this underpowered study; a Type II error is possible. This study provides precursory information toward a multicenter, randomized controlled trial of adult ankle fractures to evaluate the comparative effectiveness of internal fixation versus no fixation of PMF.

Level of evidence: Level III

Keywords: Ankle fractures; Posterior malleolus fractures; Fracture fixation, Internal; Patient outcome assessment

Introduction

Ankle injuries are common, complex, and highly variable injuries encountered in emergency departments and orthopedic practices. Injuries vary from isolated soft tissue injuries to trimalleolar fractures or dislocations [1-3]. Among those with ankle fractures, there is additional variation in posterior malleolus involvement, ranging from small avulsion fractures to large, displaced fracture fragments that contribute to ankle joint instability. Posterior malleolar fractures occur in 14-50% of all ankle fractures; isolated posterior malleolar fractures are uncommon accounting for only 1% of ankle fractures

[4,5]. The posterior inferior tibiofibular ligament (PITFL) attaches to the posterior malleolus which may contribute to instability even in the setting of minimally displaced fractures or avulsion fractures as this is hypothesized to change load distribution of the joint and lead to early arthritis [3,6].

Ankle fractures are a significant source of morbidity for patients and society. Most ankle fractures occur in working-aged adults and these fractures often necessitate time off from work [7]. Roughly 10% of patients with ankle fractures will go on to develop posttraumatic ankle arthrosis, with ongoing pain, additional surgical procedures [8], and potentially further lost work time [9]. Patients who sustain trimalleolar fractures have the highest rates of joint subluxation and posttraumatic arthritis compared to patients who sustained uni- or bimalleolar fractures [2]. It has also been shown that incongruence of the joint surface, with or without internal fixation of the posterior malleolus leads to poorer outcomes [10].

Treatment and fixation vary based on the injury. The syndesmosis is frequently involved in ankle fractures.³ Syndesmotic injuries may require internal fixation, directly, or indirectly through the posterior malleolus, since the posterior malleolus is a significant contributor to syndesmotic stability [11]. Typically, orthopedic surgeons perform reduction and fixation of posterior malleolar fractures that involve more than 25% of the tibiotalar joint surface [2,3]. This has been based on historical teaching and expert opinion. Evidence based treatment algorithms are needed to address treatment of posterior malleolar fragments when present to maximize patient's clinical outcomes and functionality.

To date, we are unaware of clinical outcomes studies that directly compare ankle fracture patients who have undergone reduction and fixation of posterior malleolar fractures versus not, and their 6-month outcomes.

The purpose of this study was to determine whether surgical fixation of posterior malleolus fractures in adults result in better functional and radiographic outcomes compared with no posterior malleolar fixation. We hypothesized that reduction and stabilization of posterior malleolar fragments results in improved alignment and stability; this would lead to decreased rates of syndesmotic fixation and improved functional outcomes. We believe this would reduce the incidence of malreduction of the syndesmosis, screw breakage, and subsequent surgeries.

Materials and Methods

We conducted a retrospective cohort study of patients age 18 and over who underwent surgical management of an isolated ankle fracture and had the posterior malleolar fracture treated with or without fixation. IRB approval was obtained following our institution's standard process prior to study initiation.

We utilized an existing, combined ankle fracture database from two metropolitan facilities: a Level 1 trauma center, and an outpatient orthopedic surgery center. This database was initiated in November 2012 and includes all patients who presented with an ankle fracture; patients with injuries classified as pilon fractures were not included. The database included patient demographic information, information about the injury, surgical treatment, treating surgeon, and patient-reported outcomes obtained via the Short Musculoskeletal Function Assessment questionnaire (SMFA) at baseline, 6 weeks and 6 months.

We extracted all adults who were treated operatively from November 2012 through May 2015. Patients were included for initial screening if they underwent surgical management for their ankle injury

(OTA classification 44-A3, 44-B3, or 44-C2) and included a posterior malleolar fracture. 213 patients were identified for further screening using the information available within the database.

We reviewed the electronic medical records for completeness of data on injury and patient demographics, and for sufficient radiographic quality. We excluded adults with polytrauma, open fractures, prior ankle injury, early weight bearing protocol patients, and insufficient radiographs to obtain study measurements. All surgeons treating ankle fractures at these two institutions were included; determination of surgical approach, treatment, and type of fixation of the posterior malleolar fragment as well as syndesmosis was performed at the individual surgeon's discretion. Early weight bearing protocol patients were excluded due to the new introduction of the protocol during this period and concern that this may influence their functional outcomes scores. Using these criteria, 147 patients met study selection criteria; 63 had undergone internal fixation to include the posterior malleolus, and 84 patients had surgical fixation of the ankle without fixation of the posterior malleolus (Figure 1).

All initial injury films were reviewed to confirm the presence

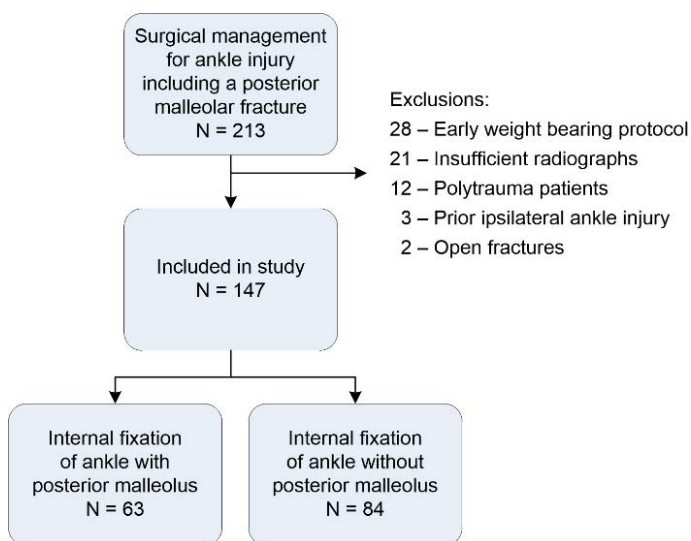


Figure 1: Flow diagram of screened patients and exclusions.



Figure 2: Lateral radiograph demonstrating measurement technique. A to B distance measured in millimeters to determine displacement at the articular surface. B to C distance measured in millimeters to determine the size of the posterior malleolar fragment.

of a posterior malleolar fracture. Radiographic measurements were made by a single investigator for consistency. The lateral film was utilized to measure 1) the amount of displacement at the articular surface, and 2) the size of the posterior malleolar fragment (Figure 2). The initial postoperative lateral x-ray was utilized to measure the amount of displacement at the articular surface following surgery. This measurement was then used along with the articular surface displacement measured on the injury film to determine the amount of change effected through surgery. Radiographs varied due to individual surgeon practice in this retrospective study. The radiographs were considered insufficient for inclusion if there was not a preoperative and postoperative lateral radiograph adequate for measuring the displacement and fragment size as demonstrated in Figure 2. Radiographs were considered inadequate if the necessary elements of the posterior malleolar fragment and involved articular surface could not be visualized for measurement (points A, B, and C as noted in Figure 2).

The SMFA is a short patient questionnaire designed for the evaluation of functional status of patients with musculoskeletal disease. The SMFA was designed from the longer Musculoskeletal Function Assessment to be readily available in the clinic setting. This questionnaire has two components that are scored separately: a bother index, and a dysfunction index. The bother index represents the effects on the patient's emotional well-being with the dysfunction index representative of the impact their injury/disease has on their ability to function in their daily lives. This questionnaire has been validated in prior studies for clinical assessment of the impact of treatment on musculoskeletal injury [12].

Existing SMFA data were retrieved from the described ankle fracture database. Complete SMFA data was available only for a subset of patients. All patients were given a baseline SMFA survey at their initial visit, and had repeat SMFA surveys at the 6-week and 6-month follow-up visits. Although our interest was in 6-month outcomes, we retained patients who met selection criteria regardless of their follow-up duration.

Description of statistics

Descriptive statistics identified sample features for 1) all patients from the fixation and non-fixation groups, and 2) for the subsets from each group who completed the SMFA function (and bother) questionnaires at baseline and 6-months. For continuous variables, mean, standard deviation, and range were reported for each group. For categorical variables, the frequency and percentage of each level were reported. Differences in outcomes were compared between the fixation group and non-fixation group. For a continuous variable, the normality of the data was checked; if the data were normally distributed, a two-sample t-test was used to compute the p-value for the difference between the groups; otherwise a Wilcoxon test was used. For a categorical variable, a Fisher's exact test was used to compute the p-value for the difference between the groups.

Results

One hundred forty seven adults met sample selection criteria: 63 had IF of PMF, 84 had no internal fixation of PMF. Mean age differed by group, with nonoperative PMF patients on average, younger than IF patients (43.9 vs. 49.0 years, p = 0.04). More than half were female (55.6% IF vs. 52.4% no fixation PMF).

Overall, analyzing the full cohort our data shows that adults treated with PMF internal fixation were younger, had larger posterior malleolar fracture fragments with greater initial displacement and a larger decrease in the amount of articular displacement following surgery compared to those that did not have fixation (Table 1a and 1b) of the posterior malleolar fragment. The average fragment size in the group undergoing internal fixation was 10.4 mm with a range of 3.6-21.0 mm compared to 5.7 mm with a range of 1.4-18.0 mm in the group

Table 1a: Demographics of all patients.

		Fix N = 63	No fix N = 84	p-value
Gender				
Female	N (%)	35 (55.6)	44 (52.4)	0.7
Male	N (%)	28 (44.4)	40 (47.6)	
Tobacco use				
Yes / current	N (%)	16 (25.4)	22 (26.2)	0.91
No / former	N (%)	47 (74.6)	62 (73.8)	
BMI	Mean (SD) (Range)	29.6 (5.1) (18.8-43.5)	30.6 (5.6) (20.6-52.0)	0.28
Age	Mean (SD) (Range)	49.0 (15.9) (19-88)	43.9 (14.4) (19-79)	0.04

Table 1b: Demographics of patients with complete function scores at baseline, 6-week follow-up, and 6-month follow-up.

		Fix N = 17	No fix N = 24	p-value
Gender				
Female	N (%)	11 (64.7)	13 (54.2)	0.53
Male	N (%)	6 (35.3)	11 (45.8)	
Tobacco use				
Yes / current	N (%)	3 (17.6)	4 (16.7)	1
No / former	N (%)	14 (82.4)	20 (83.3)	
BMI	Mean (SD) (Range)	29.2 (4.5) (22.7-36.8)	30.9 (4.3) (20.6-39.6)	0.23
Age at injury	Mean (SD) (Range)	52.2 (13.6) (26-69)	45.2 (14.4) (27-72)	0.12

Table 2a: Radiographic measurements and SMFA scores of all patients.

	Fix		No Fix		p-value
	N	Mean (SD) (range)	N	Mean (SD) (range)	
Posterior malleolar fracture fragment size (mm)	63	10.4 (3.3) (3.6-21.0)	84	5.7 (3.2) (1.4-18.0)	< 0.0001
Initial displacement (mm)	63	8.3 (6.1) (0-24.6)	84	3.9 (3.3) (0-16.0)	< 0.0001
Change in displacement (mm)	63	6.9 (6.1) (-0.7-24.6)	84	2.0 (3.1) (-7.3-14.0)	< 0.0001
SMFA function score at baseline	47	47.4 (13.9) (20.2-75.7)	69	51.1 (13.7) (0-74.3)	0.15
SMFA bother score at baseline	39	40.4 (23.0) (2.1-75.0)	61	49.7 (18.1) (0-93.8)	0.02
SMFA function score at 6 weeks	40	38.5 (11.7) (19.1-65.2)	63	37.1 (14.0) (3.5-70.6)	0.59
SMFA bother score at 6 weeks	37	34.4 (17.3) (0-62.5)	56	33.6 (19.6) (0-85.4)	0.83
SMFA function score at 6 months	25	17.5 (14.1) (0-47.3)	27	10.5 (10.6) (0-36.6)	0.04
SMFA bother score at 6 months	23	19.0 (16.6) (0-64.6)	25	9.7 (9.3) (0-27.1)	0.02

not undergoing fixation. The average initial displacement was 8.3 mm vs. 3.9 mm and the average change or improvement in displacement following surgery was 6.9 mm and 2.0 mm (Table 2a).

Complete SMFA scores were available for a subset of our sample: 116 (78.9%) at baseline, 103 (70.1%) at 6 weeks, and 52 (35.4%) at 6 months (Table 2a) with 17 (27.0%) patients from the fixation group having complete data from all three time points and 24 (28.6%) patients from the non-fixation group having complete data (Table 2b).

Initial SMFA function data for both groups were similar with mean

scores of 47.4 for the group undergoing fixation compared to 51.1 for the group treated without posterior malleolar fixation. However the initial mean bother index was 40.4 (fixation) compared to 49.7 (no fixation) reaching a significant difference. Both groups showed improvement at their 6-week follow-up visit with similar function and bother scores at this time point, 38.5 and 34.4, respectively for the fixation group and 37.1 and 33.6 for the group treated without fixation. When comparing the initial SMFA data and final SMFA data, our final SMFA data obtained at the 6 month postoperative visit showed a greater improvement in outcomes for the group that did not undergo fixation

Table 2b: Radiographic measurements and SMFA scores of patients with complete function scores at baseline, 6-week follow-up, and 6-month follow-up.

	Fix Mean (SD) (range)	No Fix Mean (SD) (range)	p-value
Posterior malleolar fracture fragment size (mm)	9.7 (1.9) (6.8-14.3)	5.6 (2.7) (1.5-11)	< 0.0001
Initial displacement (mm)	9.3 (5.3) (0-18.1)	2.7 (1.7) (0.7-6.1)	0.0001
Change in displacement (mm)	8 (5.1) (0-17.3)	0.8 (2.3) (-7.3-4.7)	< 0.0001
SMFA function score at baseline	52 (11.4) (28.7-75.7)	51 (11.6) (22.8-67.7)	0.79
SMFA function score at 6 weeks	40.7 (9.2) (29.4-57.4)	36.3 (13.2) (3.5-54.8)	0.26
SMFA function score at 6 months	14.6 (11.9) (3.7-44.9)	11.4 (10.9) (0-36.6)	0.38

with an average improvement in the function index of 40.6 points and 40.0 points in the bother index. This is compared to 29.9 and 21.4 point improvement in the fixation group.

However, given the low percentage of patients that completed follow-up and the significant number of questionnaires that could not be scored due to incomplete answers, we reassessed our 6-month outcome data including only the patients that had fully completed the SMFA function index questions and had completed 6 months of follow-up (Table 2b). We found only 17 of the 63 patients undergoing fixation of the posterior malleolus and 24 of the 84 patients without fixation had returned for 6-month follow-up and had fully completed the function index of the questionnaire. Analysis of these groups showed similar data to the overall group with the patients undergoing posterior malleolar fixation having a statistically significant increase in fragment size and displacement however, there were no significant differences in the SMFA function index at baseline, 6-week and 6-month follow-up and both groups showed improvement in functional outcome at 6-week and 6-month follow-up. The 17 patients undergoing fixation had an average posterior malleolar fragment of 9.7 mm (range 6.8-14.3), initial displacement of 9.3 mm (range 0-18.1), baseline function index of 52 (range 28.7-75.7) and 6-month function index of 14.6 (range 3.7-44.9). The 24 patients without fixation had an average fragment size of 5.6 mm (range 1.5-11), initial displacement of 2.7 mm (range 0.7-6.1), baseline function index of 51 (22.8-67.7) and 6-month function index of 11.4 (0-36.6).

A secondary outcome that was measured included the rate of syndesmotomic fixation; due to the retrospective nature of the study the type of fixation varied by surgeon preference. Analyzing our limited cohort of patients completing full 6-month follow-up and function index we found only 3 of 17 patients (17.6%) undergoing posterior malleolar fixation were treated with syndesmotomic fixation compared to 11 of 24 patients (45.8%) without posterior malleolar fixation (Table 3a). This was also consistent with the rates of syndesmotomic fixation performed in our full cohort with 10 of the 63 (15.9%) patients with posterior malleolar fixation undergoing syndesmotomic fixation compared to 45 of the 84 (53.6%) patients without posterior fixation (Table 3b).

Complication rates were similar for both groups with 8 complications in the fixation group (13.1%) compared to 12 in the group without fixation (14.5%). This was similar when looking at our limited cohort with 18.8% in the fixation group and 26.1% in the group without fixation (Table 3a and Table 3b). Tracked complications included superficial and wound complications, implant removal, and nonunion. No significant conclusions could be generated regarding differences in complications due to the low incidence within this cohort.

	Fix N (%)	No fix N (%)	p-value
Syndesmotomic fixation			
Screw fixation	3 (17.6)	8 (33.3)	0.12
Tightrope	0 (0)	3 (12.5)	
None	14 (82.4)	13 (54.2)	
Complication			
No	13 (81.2)	17 (73.9)	0.59
Yes	3 (18.8)	6 (26.1)	

Table 3a: Syndesmotomic fixation and complications of patients with complete function score at baseline, 6-week follow-up, and 6-month follow-up.

Table 3b: Syndesmotomic fixation and complications of all patients.

	Fix N (%)	No fix N (%)	p-value
Syndesmotomic fixation			
Screw fixation	9 (14.3)	37 (44)	< 0.0001
Tightrope	1 (1.6)	8 (9.5)	
None	53 (84.1)	39 (46.4)	
Complication			
No	53 (86.9)	71 (85.5)	0.81
Yes	8 (13.1)	12 (14.5)	

Discussion

SMFA functional scores improved in both groups. Six-month SMFA functional scores were comparable in the subset of adults with complete baseline to 6-month SMFA data. Treatment groups differed in injury severity, with internal fixation patients having larger posterior malleolar fragments and greater displacement than adults without fixation of the posterior malleolar fracture. Adults with internal fixation of posterior malleolar fractures also had greater improvements in alignment at the articular surface postoperatively.

The significant difference in the rate of syndesmotomic fixation between the groups was consistent with our hypothesis that performing fixation of the posterior malleolus would decrease the need for syndesmotomic fixation. Limitations of our study prevent further evaluation of the rate of syndesmosis malreduction in our patient population and associated complications however prior studies have reported rates of 16-52% of postoperative malreduction of the syndesmosis as evaluated by x-ray and CT [13]. A cadaveric study demonstrated malreduction of the syndesmosis resulting in the fibula externally rotating and over compression of the joint when a clamp was used to aid in reduction [14].

The size difference of the posterior malleolar fragment between the two groups remains a confounding variable as we expected given the retrospective nature of this study and the preexisting bias to treat larger fracture fragments with internal fixation. There continues to be an abundance of orthopedic literature related to posterior malleolar fractures however there remains a lack of evidence guiding management based on fracture size as evidenced by Odak et al. in their systematic review of 33 studies including more than 1000 patients [2].

Greater power and long term clinical as well as radiographic follow up is necessary to further evaluate complications including syndesmotic or articular malreductions, development of post-traumatic degenerative changes, infection rates, stiffness, and symptomatic implants requiring a second surgery.

We acknowledge several limitations of our study. Despite our utilization of the shorter SMFA-36, rather than the 101 item questionnaire (the Full Musculoskeletal Function Assessment), [15] less than one in 3 adults had complete SMFA questionnaires through 6 months, which raises the possibility of a Type II error in our conclusions. In planning future studies this could be further simplified for patients by utilizing an electronic capture and utilizing only the function index as this would decrease the patient burden while still allowing functional outcome assessment. Furthermore our study utilized the lateral radiograph to measure both fragment size and displacement; multiple patients were excluded due to incomplete radiographs or views that obscured the target area needed for measurements. This was further limited by the large portion of patients lost to follow-up and the short follow-up period available for both functional and radiographic analysis. The length of follow up and the number of patients lost to follow-up could both be improved in a future prospective trial with standardized follow-up periods and a call back system to encourage patients to return.

Our study represents our initial steps toward planning a randomized controlled trial. The next step to guide orthopedic clinicians in decision making for treatment of posterior malleolar fractures is to design and conduct a randomized controlled trial to limit selection bias in treatment assignment, and determine which patients will benefit from surgical fixation with a minimum of 1-year follow-up. CT along with standardized lateral radiographs could be utilized for accurate assessment of the fracture size and displacement measures. A long-term study would allow evaluation of both functional outcomes as well as the radiographic outcomes such as posttraumatic degenerative changes of the ankle and the impacts of posterior malleolar fixation versus syndesmotic fixation which has also been hypothesized to lead to degenerative arthritis.

Conclusion

Adults with larger posterior malleolar fracture fragments with increased displacement were more likely to be treated with internal fixation in this retrospective study. Functional 6-month SMFA outcomes were comparable between patients undergoing fixation of the posterior malleolar fragment and those without fixation in this underpowered study; therefore a Type II error is possible. Long term radiographic outcomes such as post-traumatic degeneration of the tibiotalar joint could not be adequately assessed in this retrospective study. Information learned from this study will be utilized to plan a multicenter, randomized controlled trial evaluating the comparative effectiveness and long term outcomes of internal fixation versus no fixation of posterior malleolar fractures in adult ankle fractures.

Declaration of Conflicting Interests

The Authors declare that they have no conflicts of interest.

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