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Original Research

Comparison of Medial Malleolar Fracture Healing at 8 Weeks After Open Reduction Internal Fixation Versus Percutaneous Fixation: A Retrospective Cohort Study

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ABSTRACT

Unstable medial malleolar fractures are treated with either standard open reduction internal fixation (ORIF) or a percutaneous approach. The percutaneous approach avoids the potentially excessive soft tissue dissection associated with an open approach but can also result in inadequate anatomic reduction. No studies have compared the incidence of radiographic healing of medial malleolar fractures between an open approach and percutaneous fixation. A retrospective comparative study was performed at a single institution across multiple sites. Electronic medical records and digital radiographs were reviewed for 845 patients who had undergone either ORIF or percutaneous screw fixation (PSF) of a medial malleolar fracture. The interval to fracture healing was measured. Logistic regression analysis was used. Of the 490 included patients, 458 (93.44%) underwent standard ORIF and 32 (6.53%) underwent PSF. Patients who underwent ORIF were 5 times more likely to have a healed fracture at 8 weeks than were patients who had undergone PSF ($p < .001$). Compared with standard ORIF, PSF of medial malleolar fractures leads to an increased risk of an unhealed fracture at 8 weeks. This was likely due to a combination of soft tissue interposition within the fracture site and inadequate fluoroscopic reliability, leading to poor anatomic reduction and inaccurate fixation.

Ankle fractures are one of the most common types of fractures encountered by the orthopedic foot and ankle surgeon (1). The operative goals are to achieve a stable ankle with maximal function, to restore the ankle mortise and reduce the risk of post-traumatic degenerative changes (2). Supination, pronation, external rotation, and abduction are all mechanisms that can result in a fracture of the medial malleolus (3). These fractures can occur in isolation or in conjunction with a fibular fracture, posterior malleolar fracture, or tibial plafond fracture. In the early days of ankle fracture surgery, the medial malleolus was considered the main stabilizer of the ankle mortise, but this was later disproved in a landmark report in 1979 by Yablon et al (4), which shifted the focus to the lateral malleolus. Despite later studies that emphasized the importance of the medial malleolus and deltoid ligament as the primary sources of ankle stability, limited attention has been given to treatment options and surgical outcomes of medial malleolar fractures (5).

Open reduction and internal fixation (ORIF) can be considered the standard approach to the treatment of unstable and displaced medial malleolar fractures (4,6). Many fixation methods have been described, including Kirschner wire, suture anchors, intraosseous wire loop fixation, and antiglide plating (7–11). Studies have shown that the most stable fixation methods include compression lag screws or figure-of-eight tension band wiring (5,12–14). The choice of fixation is often determined by the fracture pattern, fragment size, and bone quality. A standard approach to ORIF of a medial malleolar fracture involves an anteromedial approach with a longitudinal incision centered over the medial malleolus or a J-shaped incision (15,16). This allows for direct visualization of the fracture line, followed by excavation of the fracture hematoma and removal of soft tissue interposition before achieving anatomic reduction and stable fixation (17).

Percutaneous screw fixation (PSF) has been advocated for a variety of minimally to nondisplaced fractures of the ankle, including posterior, lateral, and medial malleolar fractures (18,19). The advantages of a percutaneous approach are that it avoids

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Table 1
Demographic and clinical characteristics stratified by surgical procedure

	ORIF (n = 458)	PSF (n = 32)	*p* Value*
Age at surgery (yr)	46.7 ± 18.4	45.6 ± 17.6	.74
Gender			.01
Male	235 (51.3)	24 (75.0)	
Female	223 ± (48.7)	8 (25.0)	
Race			.26
White	283 (61.8)	22 (68.8)	
Black	24 (5.2)	3 (9.4)	
Other	151 (33.0)	7 (21.9)	
BMI (kg/m^2)	29.1 ± 6.4	28.7 (6.5)	.71
Fracture healed at 8 wk	423 (92.4)	23 (71.9)	<.001
Postoperative protocol			.31
Standard	410 (89.5)	27 (84.4)	
Early weightbearing	36 (7.9)	3 (9.4)	
Other	12 (2.6)	2 (6.3)	
Side of procedure			.85
Right	248 (54.1)	18 (56.3)	
Left	206 (45.0)	14 (43.8)	
Unknown	4 (0.9)	0 (0)	
Interposed soft tissue†	361 (93.3)	NA	NA
Smoking	188 (41.0)	10 (31.3)	.27
Diabetes	59 (12.9)	5 (15.6)	.59
Osteoporosis	65 (14.2)	2 (6.3)	.29
PVD	36 (7.9)	1 (3.1)	.50
Neuropathy	48 (10.5)	3 (9.4)	1.00

Abbreviations: BMI, body mass index; NA, not applicable; ORIF, open reduction internal fixation; PSF, peripheral screw fixation; PVD, peripheral vascular disease; SD, standard deviation.
Data presented as mean ± standard deviation or n (%).
* *p* Values for continuous variables calculated using *t* tests; *p* values for categorical variables calculated using Fisher's exact tests.
† Because of missing data (n = 95), no *p* value was calculated for interposed soft tissue.

excessive soft tissue dissection and decreases the risk of the wound healing complications associated with ORIF. This would make PSF an ideal option for patients with comorbidities such as osteoporosis, diabetes, peripheral vascular disease, and tobacco smoking (20–22).

No studies have directly compared the results of PSF and ORIF in the treatment of medial malleolar fractures. The purpose of the present investigation was to compare the incidence of radiographic healing of medial malleolar fractures at 8 weeks between ORIF and PSF. We also measured the incidence of comorbidities, including smoking, diabetes, osteoporosis, peripheral vascular disease, and neuropathy, and observed the effect of these factors on the incidence of fracture healing. Our hypothesis was that patients who undergo PSF would encounter a greater incidence of delayed union or nonunion compared with patients who undergo ORIF.

Patients and Methods

The present study was a retrospective, comparative medical review of a cohort of patients within a single healthcare system. Our institutional review board approved the present study before the study started. The inclusion criteria were an oblique, vertical shear, or transverse medial malleolar fracture treated with either ORIF or PSF from January 2008 to December 2012. With help from the Kaiser Permanente Division of Research, these patients were identified and accrued using the appropriate Current Procedural Terminology (American Medical Association, Chicago, IL) codes 79.87 and 79.36.

Intervention

All patients were evaluated and underwent surgery by a foot and ankle surgeon within the Kaiser Permanente Northern California Healthcare System. For each patient, fixation by either ORIF or PSF was determined by the fracture pattern identified on radiographs at the discretion of the treating surgeon. In the ORIF group, the presence of interposed soft tissue within the fracture site was noted and removed before anatomic reduction and fixation with a combination of screws, plates, or tension banding. In the PSF group, all fractures were closed reduced, and after making a percutaneous incision, 1 to 2 guidewires were driven across the fracture site under fluoroscopic guidance. The fracture was then fixated with one to two 4.0-mm cannulated screws driven over the guidewire, and a final fluoroscopic image was taken to ensure proper screw positioning and fracture reduction.

Postoperatively, all patients in the PSF group remained non-weightbearing for 6 weeks. In the ORIF group, the patients began partial weightbearing, defined as 50% toe-touch weightbearing, either at 2 weeks or remained non-weightbearing for the entire 6 weeks. This decision was determined by the treating surgeon who performed the case.

Outcome Measures

Electronic medical records and digital radiographs were reviewed by 2 of us (G.W., P.L.) to collect all variable outcomes. The primary outcome measured was the interval to radiographic fracture union within 8 weeks after the date of surgery. This was determined by a review of the digital radiographs by 1 of us (P.L.), with the reviewer unaware of which of the 2 surgical techniques had been used. Fracture union was determined when no fracture line was observed and the cortical borders were intact. The presence of interposed soft tissue in the ORIF group was noted from the operative notes. The secondary variables measured included patient age, gender, race, body mass index, and comorbidities, including a history of smoking, diabetes, osteoporosis, peripheral vascular disease, and neuropathy.

Table 2
Risk analysis of fracture healed at 8 weeks postoperatively (N = 490 patients)

Variable	Univariate		Multivariate	
	OR (95% CI)	*p* Value	OR (95% CI)	*p* Value
Surgical procedures				
ORIF (reference, PSF)*	4.7 (2.0 to 11.0)	<.001	5.0 (1.9 to 12.4)	<.001
SWB (reference, all others)*	2.3 (1.1 to 5.2)	.04	2.5 (1.0 to 5.7)	.03
Interposed soft tissue (reference, none)	0.4 (0.1 to 3.0)	.72	NA	NA
Patient characteristics				
Age ≥60 yr (reference, <60 yr)*	0.4 (0.2 to 0.8)	.006	0.5 (0.2 to 1.1)	.08
Male (reference, female)	0.9 (0.5 to 1.7)	.87	NA	NA
Black (reference, white)*	0.3 (0.1 to 0.7)	.006	0.3 (0.1 to 0.8)	0.02
Other (reference, white)*	1.2 (0.6 to 2.6)	.56	1.1 (0.5 to 2.6)	0.72
BMI ≥30 kg/m^2 (reference, <30 kg/m^2)	0.5 (0.3 to 1.0)	.07	NA	NA
Smoking (reference, none)	0.9 (0.5 to 1.6)	.75	NA	NA
Diabetes mellitus (reference, none)	0.4 (0.2 to 0.7)	.008	NA	NA
Osteoporosis (reference, none)	0.5 (0.2 to 1.1)	.10	NA	NA
PVD (reference, none)	0.3 (0.1 to 0.6)	.003	NA	NA
Neuropathy (reference, none)†	0.3 (0.1 to 0.5)	<.001	0.3 (0.1 to 0.9)	.02

Abbreviations: BMI, body mass index; CI, confidence interval; NA, not applicable; OR, odds ratio; ORIF, open reduction internal fixation; PSF, percutaneous screw fixation; PVD, peripheral vascular disease; SWB, standard weightbearing.
* Variables chosen for multivariate analysis according to univariate *p* value ≤ .05 and model fit statistics.
† Because of correlation among comorbidity variables, only neuropathy chosen for multivariate analysis.