

Determinants of functional outcome following ankle fracture

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Abstract

Objectives: To assess the patient and injury characteristics that impact functional outcomes after ankle fracture.

Design: Retrospective study.

Setting: Urban level I trauma center.

Patients/Participants: One thousand patients underwent fixation of ankle fracture (AO/OTA 44) between 2006 and 2015. Four hundred sixteen completed functional outcome surveys by telephone or mail at a mean of 5.9 years after injury.

Intervention: Open reduction internal fixation.

Main outcome measure: Foot Function Index (FFI) and Short Musculoskeletal Function Assessment (SMFA).

Results: Mean age was 46.7 years, with 46.2% male. Higher (worse) FFI scores were seen in tobacco users (38.9 vs 30.1), recreational drug users (45.9 vs 32.7), and the morbidly obese (52.0 vs 30.6), all $P < .005$. Higher (worse) SMFA dysfunction and bothersome scores were also seen in these groups, and in females and alcohol users. Multiple regression analysis identified female gender, obesity, tobacco and alcohol use, complications, secondary procedures, and multiple additional injuries as independent predictors of higher scores (all $P < .04$). Fracture patterns, open fracture, and development of arthritis had no impact on FFI or SMFA scores.

Conclusion: Patient characteristics, not under surgeon-control, such as female sex, obesity, and substance use, appear to contribute to patient-reported functional outcome scores more than injury characteristics.

Level of Evidence: Level 3, prognostic

Keywords: ankle, ankle fracture, complications, FFI, outcomes, SMFA, substance abuse, torsional

1. Introduction

Ankle fractures are one of the most common fractures of the lower extremity, with an incidence of 187 per 100,000 patients each year.^[1–3] Most are considered to be relatively mild injuries, with good to excellent clinical outcomes expected for a majority of patients following reduction and fixation of displaced torsional ankle fractures.^[4–12] However, many patients report

continued pain and functional limitations.^[11,13–21] Several studies have identified patient and injury characteristics associated with worse short-term functional outcomes, including smoking history, female sex, increased age, fracture dislocation, syndesmotic injury, bimalleolar or trimalleolar fracture pattern, and postoperative articular incongruity.^[8,19,22–27] However, few studies examine the long-term functional consequences of displaced ankle fracture.

This study will evaluate demographic variables, injury and treatment characteristics, and social factors potentially associated with poor patient-reported functional outcomes. We propose to provide prognostic information to improve surgeon ability to manage patient expectations following displaced torsional ankle fracture. We hypothesized that socioeconomic factors may be associated with patient reported outcomes.

2. Patients and methods

One thousand consecutive skeletally mature patients who underwent operative treatment of ankle fracture (OTA/AO 44A, 44B, or 44C) within a Level 1 trauma system between 2006 and 2015 were identified.^[28] IRB approval was obtained for this study, and any information from human subjects was obtained as required. Medical records and radiographs were retrospectively reviewed for patient demographic, comorbidity, injury, and treatment data. Comorbidities included history of cerebrovascular disease, pulmonary disease, renal disease, diabetes, neuropathy, and psychiatric illness. Tobacco use was defined as any history of tobacco smoking within 6 months of the injury.

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Alcohol use was defined as any reported alcohol consumption. Recreational drug use was defined as use of any other recreational substance, including marijuana. Complications were recorded, including infection, wound-healing problems such as dehiscence, malunion, or nonunion. Infections were noted to be either superficial, requiring local wound care and oral antibiotics, or deep, requiring surgical irrigation and debridement and intravenous antibiotics. Nonunions were defined as incomplete fracture union 6 months after surgery and were further noted to be either symptomatic or asymptomatic. Malunions were defined as angular deformity 5 or more degrees on plain radiograph.

In patients with radiographic follow-up for greater than 12 months, development of posttraumatic arthrosis (PTA) was defined as the presence of any joint space narrowing, subchondral sclerosis or cysts, and/or formation of osteophytes. In patients with evidence of ankle arthrosis at the time of initial injury, development of PTA was defined as progression of underlying arthrosis. Trained researchers not involved in the patients' care performed data collection.

Patient-reported functional outcomes were assessed using Foot Function Index (FFI) and Short Musculoskeletal Function Assessment (SMFA) surveys, representing both injury-specific and generalized functional outcomes.^[29–33] These measurements were collected as a questionnaire that was administered over the phone or by mail. The FFI is a lower extremity-specific outcome index which consists of subscores for pain (81 points), disability (81 points), and activity (45 points).^[29] The FFI total score is an average of these 3 subscores, with higher scores indicating worse outcomes. The SMFA is a generalized musculoskeletal outcome questionnaire consisting of 46 questions with subscores for daily activities, emotional status, arm and hand function, mobility, function, and bothersome, each with a maximum of 100 points, with worse outcomes indicated by a higher score.^[34] It is a shortened version of the Musculoskeletal Function Assessment, which consists of 100 yes/no questions divided into 10 categories regarding daily activities, physical function, and emotion. The creators of the SMFA chose items from the original Musculoskeletal Function Assessment that were considered clinically important and well supported. The SMFA contains a 34-question dysfunction index and a 12-item bothersome index, which are each individually scored by the patient using a 5-point Likert scale. Both the FFI and the SMFA have consistently proven to be valid, reliable, and reproducible.^[29,32,33,35,36]

Independent samples Student *t* tests were conducted to compare means of continuous variables between patients lost to follow-up and those who completed outcome surveys. One-way analysis of variance was performed to compare means of continuous variables with more than 2 groups. Pearson Chi-square tests, and Fisher exact tests where appropriate, were performed to compare frequencies of categorical variables. For univariate tests, the significance threshold was set to $P < .05$. Linear regression analysis was performed to identify significant independent predictors of worse functional outcome scores. Given the large number of possible predictors, a 2-step regression method was used to reduce the number of variables used in multiple linear regression analysis, thereby avoiding multicollinearity and over-fitting the model. A screening step using simple linear regression was initially performed with each predictor entered into the model individually to predict the functional outcome score of interest. Predictors found to have a $P < .20$ in the simple linear regression model were then entered simultaneously into the multiple linear regression analysis. At this stage, any predictor with $P < .05$ in the multiple linear regression

model was determined to be a significant independent predictor of the given outcome score.

3. Results

Four hundred sixteen patients (42%) completed the FFI and SMFA surveys a mean of 5.9 years after their injury (range 1.7–13.2 years). Their mean age was 46.7 years, and 224 were female (53.8%). Mean body mass index (BMI) was 32.0. Two most common mechanisms of injury were fall from standing ($n=282$ (67.8%)), followed by motor vehicle or motorcycle collision ($n=87$ (20.9%)). Fracture patterns included 7 (0.7%) 44A, 300 (72.3%) 44B, and 108 (26.0%) 44C fractures. Sixty-six patients (15.9%) had an open fracture, and 176 (42.3%) had an associated dislocation. One hundred forty-three patients (34.4%) had at least 1 medical comorbidity. One hundred seventy-three patients (43.7%) reported tobacco use, 200 (51.0%) reported alcohol use, and 44 (11.4%) reported illicit drug use. Comparison of demographic, injury, and treatment data with patients who did not complete surveys is shown in Table 1. Differences were noted between the 2 groups with respect to mean age (43.6 years), sex (46.6%), and tobacco use (51.8%). Ground level falls were less common among the nonresponders (56.6%).

Mean total FFI score for all patients was 33.7. Reference values for FFI scores for patients without foot or ankle pathology have been previously published.^[30,31] Comparison of the mean FFI total score for our patients with the reference value (33.7 vs 13.0) demonstrates impairment of function following ankle fracture. Mean SMFA scores for the entire group were 27.9 for dysfunction and 28.0 for bothersome. Similar to the FFI, our mean SMFA dysfunction and bothersome subscores were higher (worse) than those reported for patients without prior orthopaedic issue (dysfunction: 27.9 vs 12.7, bothersome: 28.0 vs 13.8).^[30,31]

Women had worse SMFA dysfunction (30.0 vs 25.4, $P=.045$) and bothersome scores (30.8 vs 24.7, $P=.02$), and trended toward worse FFI scores (35.7 vs 31.4, $P=.12$, Table 2). Younger patients had worse mean scores. Those less than age 60 years reported worse SMFA dysfunction (29.0 vs 23.0, $P=.04$) and bothersome scores (29.9 vs 20.2, $P=.002$), with a trend toward worse FFI scores (34.8 vs 29.0, $P=.09$). Morbid obesity (BMI \geq 40) was associated with some of the worse outcome scores for any individual subset of patients, with the highest FFI 52.0 versus 30.6, $P < .001$, SMFA dysfunction (41.4 vs 25.7, $P < .001$), and SMFA bothersome scores (39.5 vs 26.2, $P < .001$).

Similarly, tobacco users had worse FFI (38.9 vs 30.7, $P < .001$), SMFA dysfunction (32.8 vs 25.2, $P=.001$), and SMFA bothersome scores (33.3 vs 24.8, $P=.002$) than nonsmokers. Alcohol consumption was also associated with worse SMFA scores (dysfunction: 31.7 vs 25.1, $P=.005$; bothersome: 32.7 vs 24.1, $P=.001$), and trended toward worse FFI scores (36.8 vs 31.5, $P=.06$). Recreational drug users had particularly high FFI (45.9 vs 32.7, $P=.003$), SMFA dysfunction (37.4 vs 27.5, $P=.01$), and SMFA bothersome scores (38.1 vs 27.5, $P=.015$). Fracture pattern and presence of open fracture were not associated with worse scores.

One hundred twenty-two patients (29.3%) experienced 148 complications (Table 3), with PTA occurring in 18%. Development of any complication during the course of treatment was associated with worse FFI (43.7 vs 29.6), SMFA dysfunction (35.1 vs 24.9), and bothersome scores (36.1 vs 24.7), all $P < .001$. Fifty-one patients (12.3%) underwent at least 1 secondary procedure, the majority of which were for removal of implants ($n=33$ (65%)). Patients who underwent a secondary procedure

Table 1**Comparison of demographics, comorbidities, and injury features for all patients, patients lost to follow-up, and patients who completed surveys.**

	All patients (N = 1000)	Lost to follow-up (N = 584)	Complete survey (N = 416)	P value
Demographics				
Age, years, mean (range)	44.9 (16–98)	43.58 (16–98)	46.7 (18–89)	.002
Female, n (%)	496 (49.6%)	272 (46.6%)	224 (53.8%)	.023
BMI, mean (range)	31.2 (16.4–73.9)	30.6 (16.4–73.9)	32.0 (18.5–66.0)	.006
Comorbidities				
Any comorbidity	340 (34.0%)	197 (33.7%)	143 (34.4%)	.83
Tobacco use	452 (48.3%)	279 (51.8%)	173 (43.7%)	.015
Alcohol use	458 (49.6%)	258 (48.6%)	200 (51.0%)	.47
Alcohol abuse	60 (6.0%)	37 (6.3%)	23 (5.5%)	.59
Recreational drug use	106 (11.7%)	62 (11.9%)	44 (11.4%)	.81
Mechanism of injury				
Fall (ground level)	612 (61.3%)	330 (56.6%)	282 (67.8%)	<.001
MCC/MVC	242 (24.2%)	155 (26.6%)	87 (20.9%)	.039
Pedestrian struck	49 (4.9%)	26 (4.5%)	23 (5.5%)	.44
Fall (from height)	41 (4.1%)	31 (5.3%)	10 (2.4%)	.022
Altercation	38 (3.8%)	32 (5.5%)	6 (1.4%)	.001
Crush	17 (1.7%)	9 (1.5%)	8 (1.9%)	.65
Injury features				
Open fracture	161 (16.1%)	95 (16.3%)	66 (15.9%)	.87
44A	12 (1.2%)	5 (0.5%)	7 (0.7%)	.25
44B	725 (72.7%)	425 (73.0%)	300 (72.3%)	.80
44C	260 (26.1%)	152 (26.1%)	108 (26.0%)	.97

Bold value denotes statistical significance.

had significantly worse FFI (43.6 vs 32.4, $P = .006$), SMFA dysfunction (35.2 vs 26.9, $P = .017$), and bothersome scores (37.7 vs 26.6, $P = .005$). Of note, no differences in outcome scores were identified when comparing patients with and without PTA.

Multiple linear regression analysis for worse outcomes scores identified several patient factors as predictors of worse

outcome scores (Table 4). Body mass index, tobacco use, complications, and multiple additional injuries were found to be significant independent predictors of higher FFI scores. Female sex, BMI, tobacco use, and development of a complication were each significant independent predictors of worse SMFA scores.

Table 2**Comparison of patient-reported outcomes scores based on various patient demographic, medical, and social history characteristics, as measured by the mean scores for Foot Function Index and Short Musculoskeletal Function Assessment.**

	FFI total (N = 414)	P value	SMFA dysfunction (N = 401)	P value	SMFA bothersome (N = 396)	P value
All patients	33.7		27.9		28.0	
Sex						
Male	31.4	.118	25.4	.045	24.7	.020
Female	35.7		30.0		30.8	
Age						
Age <60	34.8	.088	29.0	.037	29.9	.002
Age ≥60	29.0		23.0		20.2	
BMI						
BMI <40	30.6	<.001	25.7	<.001	26.2	<.001
BMI ≥40	52.0		41.4		39.5	
Tobacco Use						
No	30.7	.004	25.0	.001	24.8	.002
Yes	38.9		32.8		33.3	
Alcohol Use						
No	31.5	.060	25.1	.005	24.1	.001
Yes	36.8		31.7		32.7	
Drug use						
No	32.7	.003	27.5	.010	27.5	.015
Yes	45.9		37.4		38.1	
Diabetes						
No	32.7	.041	27.5	.33	27.9	.81
Yes	40.9		30.9		28.8	

Bold value denotes statistical significance.

Table 3

Comparison of patient-reported outcomes scores based on various injury features, postoperative complications, and secondary procedures, as measured by the Foot Function Index (FFI) and Short Musculoskeletal Function Assessment (SMFA).

	FFI total (N=414)	P value	SMFA dysfunction (N=401)	P value	SMFA bothersome (N=396)	P value
Complication						
No	29.6	<.001	24.9	<.001	24.7	<.001
Yes	43.7		35.0		36.1	
Posttraumatic arthritis						
No	43.3	.47	37.9	.60	37.1	.78
Yes	46.4		36.0		38.4	
Secondary procedure						
No	32.4	.006	26.9	.017	26.6	.005
Yes	43.6		35.2		37.7	
Isolated ankle injury						
No	38.0	.08	30.9	.13	29.5	.50
Yes	32.4		26.9		27.5	
Multiple injuries						
No	33.0	.018	27.4	.06	27.6	.11
Yes	48.8		38.1		38.1	

Bold value denotes statistical significance.

4. Discussion

Ankle fractures are extremely common orthopaedic injuries, and operative treatment of these fractures is well supported.^[5,6,8,9,12,37] However, it has been demonstrated that 50% of patients report substantial pain 5 years following ankle fracture, and 39% feel that they have not recovered completely.^[21,38] The goal of our study was to characterize the patient demographics, social factors, and injury characteristics that contribute to worse functional outcomes following ankle fracture. We found that female sex, increased BMI, tobacco use, and alcohol use were significant independent predictors for worse functional outcomes scores using the FFI and SMFA at a mean of 5.9 years postinjury; these factors not under surgeon-control had greatest impact on functional outcome scores.

Prior literature has established that certain nonmodifiable patient characteristics may be associated with worse patient-reported functional outcomes following ankle fracture.^[12,39] Female sex, increased age, diabetes, smoking history, and higher ASA score have been associated with worse functional outcomes in the short-term following ankle fracture.^[6,23] Dean et al^[15] assessed the long-term functional outcomes of 142 patients using the Patient Reported Outcomes Measurement System Physical

Function and Pain Interference scores. They found that increased age, higher BMI, and higher ASA score were associated with worse Physical Function scores at a mean of 6.2 years follow-up, and that higher ASA and *lower* BMI were predictive of worse pain scores. Our findings differ in that obesity was associated with worse scores on both generalized and extremity-specific scores, which encompass pain as one of the areas of survey. Our results also differ in that younger patients reported worse scores, which may be consistent with more severe injuries and higher baseline function in our younger population, resulting in a greater level of relative late functional impairment.

There has been conflicting literature regarding the impact of injury and treatment characteristics on functional outcomes following ankle fracture.^[6,15,23,24,39,40] A few studies have found fracture dislocation, syndesmotic injury, and bi- and tri-malleolar fracture patterns to be associated with worse outcomes in the short term.^[6,23] However, we were unable to establish associations between these injury features and outcomes. This suggests that patient factors such as sex and substance use as well as postoperative course may play a larger role than injury and treatment characteristics on functional outcomes following ankle fracture. Future study should further investigate such factors and

Table 4

Results of multiple linear regression using predictors with P<.20 in simple linear regression to predict FFI total score, SMFA dysfunction score, and SMFA bothersome score.

	FFI total (N=414)		SMFA Dysfunction (N=401)		SMFA Bothersome (N=396)	
	B	P value	B	P value	B	P value
Sex (female)	5.13	.059	5.72	.014	6.93	.009
BMI	0.95	<.001	0.76	<.001	0.75	<.001
Diabetes mellitus	4.60	.26	–	–	–	–
Tobacco use	10.43	<.001	8.61	<.001	9.09	.001
Alcohol use	1.43	.61	4.19	.078	6.04	.027
Drug use	7.52	.081	4.74	.20	4.32	.31
Any complication	10.30	.001	7.41	.005	7.92	.009
Secondary procedure	7.09	.10	5.41	.14	8.68	.039
Isolated ankle injury	–3.75	.27	–3.39	.23	–	–
Multiple injuries	16.21	.022	9.55	.12	16.01	.013

B = unstandardized regression coefficient.
 Bold value denotes statistical significance.

should also account for differences in patient expectations, which impact perceived outcomes, including differences in culture, geography, and patient and surgeon communication.^[10,11]

Fracture patterns and energy of injury may also be associated with risk for early and late complications, including PTA. Of note, we did not identify association of PTA with outcome scores. Although PTA occurred often in our patient population, the rate may be biased by those patients who elected to follow-up due to ongoing concerns. Several other studies have reported similarly high rates of posttraumatic arthritis following ankle fracture.^[14,41–43] Functional outcomes were reported in one of these studies, and no association of PTA with poor scores was seen.^[43]

Limitations to our study include the response rate, with only 41% completing the surveys, although this response rate is similar to other studies.^[15] Additionally there were some differences between responders and nonresponders, which may have introduced nonresponse bias. Patients who completed the survey were more likely to be female, older, obese, and nonsmokers, with lower energy mechanisms of injury than those lost to follow-up. Another limitation to the study is the retrospective design in which the accuracy of data depends upon detail previously placed into the medical record, and complete abstraction of such data. We also did not measure the quality of reduction, nor did we include information about postoperative care such as immobilization versus early motion or about timing of weight bearing. Despite the limitations, to our knowledge, this is the largest study to date to examine patient-reported outcomes following operative treatment of ankle fracture.

In conclusion, functional outcomes following ankle fracture demonstrate impairment on both standardized and extremity-specific scores. This information may afford prognostic value for providers and patients. Female sex, morbid obesity, tobacco use, and alcohol use were independent predictors for worse functional outcomes scores using the FFI and SMFA. Presence of early and late complications negatively impacted outcomes. Despite this, most of the noted factors are not modifiable by either the patient or the surgeon, such as female sex and young age. Some factors such as BMI, smoking, and recreational drug use are modifiable by the patient, but attempts to alter behavior may be unlikely to affect change in the acute setting.

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