

PREDICTORS OF SHORT-TERM FUNCTIONAL OUTCOME FOLLOWING ANKLE FRACTURE SURGERY

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Background: Ankle fractures are among the most common injuries treated by orthopaedic surgeons. However, very few investigators have examined the functional recovery following ankle fracture surgery and, to our knowledge, none have analyzed factors that may predict functional recovery. In this study, we evaluated predictors of short-term functional outcome following surgical stabilization of ankle fractures.

Methods: Over three years, 232 patients who sustained a fracture of the ankle and were treated surgically were followed prospectively, for a minimum of one year. Trained interviewers recorded baseline characteristics, including patient demographics, medical comorbidities, and functional status according to the Short Musculoskeletal Function Assessment (SMFA). Laboratory findings, the American Society of Anesthesiologists (ASA) class, and operative findings were recorded from the chart during hospitalization. Follow-up information included the occurrence of complications or additional surgery, weight-bearing status, functional status according to the SMFA, and the American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot score. The data were analyzed to determine predictors of functional recovery at three months, six months, and one year postoperatively.

Results: Complete follow-up data were available for 198 patients (85%). At one year, 174 (88%) of the patients had either no or mild ankle pain and 178 (90%) had either no limitations or limitations only in recreational activities. According to the AOFAS ankle-hindfoot score, 178 (90%) of the patients had $\geq 90\%$ functional recovery. A patient age of less than forty years was a predictor of recovery, as measured with the SMFA subscores, at six months after the ankle fracture. At one year, however, age was no longer a predictor of recovery. Patients who were younger than forty were more likely to recover $\geq 90\%$ of function ($p = 0.004$), and men were more likely than women to recover function ($p = 0.02$). ASA Class 1 or 2 ($p = 0.03$) and an absence of diabetes ($p = 0.02$) were also predictors of better functional recovery at one year. SMFA subscores were below average at baseline, indicating a healthy population. At three and six months postoperatively, all SMFA subscores were significantly higher than the baseline subscores ($p < 0.001$); however, at one year, the SMFA subscores were almost back to the baseline, normal level.

Conclusions: One year after ankle fracture surgery, patients are generally doing well, with most experiencing little or mild pain and few restrictions in functional activities. They have a significant improvement in function compared with six months after the surgery. Younger age, male sex, absence of diabetes, and a lower ASA class are predictive of functional recovery at one year following ankle fracture surgery. It is important to counsel patients and their families regarding the expected functional recovery after an ankle injury.

Level of Evidence: Prognostic Level I. See Instructions to Authors for a complete description of levels of evidence.

Ankle fractures are among the most common orthopaedic injuries^{1,2}, and many within the orthopaedic community perform operative treatment of unstable ankle fractures. Associations between the final postoperative radiographic result and the clinical outcome have been well established^{3,5}. In addition, other factors under the surgeon's control, such as postoperative immobilization protocols, may lead to a faster return of function^{6,7}.

While the results of open reduction and internal fixation of isolated fibular, bimalleolar, and trimalleolar ankle fractures have been frequently reported, studies of patient-oriented, validated functional outcomes are scarce in the literature⁸⁻¹¹. The purpose of this study was to prospectively evaluate patient-reported functional outcomes at three, six, and twelve months following operative treatment of an unstable ankle fracture and to identify demographic and patient

Follow-up Pain After Ankle Fracture (AOFAS Ankle Hindfoot Score; n = 198)

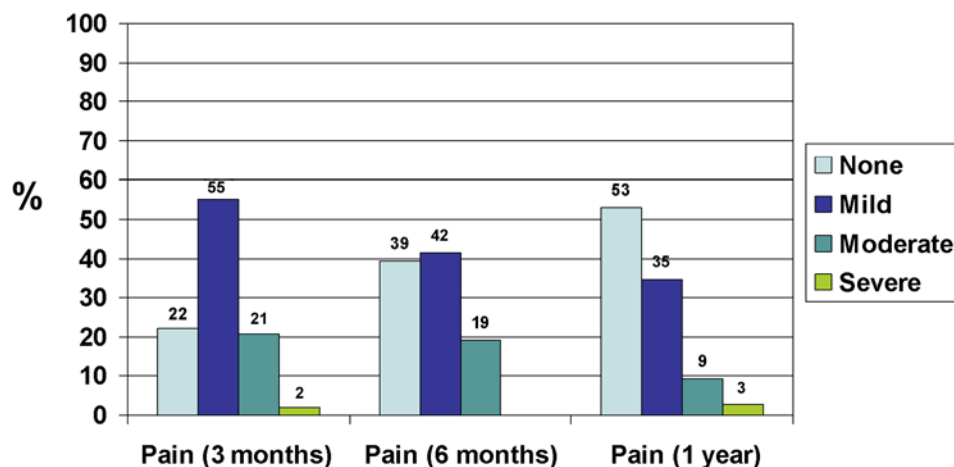


Fig. 1

AOFAS scores for pain over the one-year postoperative period.

factors that are associated with functional recovery.

Materials and Methods

This study was approved by our institutional review board. Between October 15, 2000, and September 30, 2003, all skeletally mature patients who presented with an ankle fracture to one of the institutions within our hospital system were evaluated by either an attending orthopaedist or an orthopaedic resident under the supervision of an attending surgeon. A complete history was recorded, and a physical examination was performed. Instability was defined according to the Lauge-Hansen system¹². All bimalleolar and trimalleolar fractures and fracture-dislocations were considered to be unstable. In addition, isolated fibular fractures that presented with >5 mm of medial clear-space widening or evidence of syndesmotic widening were deemed to be unstable^{2,12-15}. If instability could not be determined on the basis of the mechanism of injury, fracture pattern, or associated injury, a physician-assisted radiographic stress examination without anesthesia was performed to screen for potential subtle instability¹³. A medial clear space of >4 mm was considered to be a positive finding on the stress radiograph^{13,16}. All measurements were made by the treating surgeon. Fractures were classified with use of the Orthopaedic Trauma Association (OTA) system and the Lauge-Hansen system^{12,17}. In the OTA classification, the three general categories of fracture are 44A (infrasyndesmotic), 44B (transsyndesmotic), and 44C (suprasyndesmotic).

Once they had been selected for surgical stabilization of the fracture, patients were asked to consent to have baseline demographic and functional data obtained and placed in a prospective database. The baseline characteristics, which were obtained by trained interviewers, included patient demograph-

ics, associated medical comorbidities, and functional status as measured with the Short Musculoskeletal Function Assessment (SMFA)^{18,19}. The American Society of Anesthesiologists Classification (ASA)²⁰ and the operative findings were recorded during hospitalization.

Surgical stabilization consisted of open reduction and internal fixation of the fibula and the medial malleolus, if fractured, with small-fragment plates and screws. Fixation of the posterior malleolus was performed either directly or indirectly if the fragments remained displaced or if they comprised more than one-third of the joint surface on the lateral radiograph. Syndesmotic fixation was performed in cases of obvious widening as well as for mortises that widened on stress-testing after fixation of the medial and lateral malleoli. No attempt was made to repair the deltoid ligament. All patients were operated on at either a level-I trauma center or a tertiary care referral center within our academic medical center. All operations were performed by resident physicians under the direct supervision of one of three fellowship-trained trauma surgeons⁷.

All patients were managed with a similar postoperative protocol, which included immobilization for one week in a short leg splint until the time of suture removal. All patients wore a removable fracture brace and were instructed how to perform active and passive range-of-motion exercises of the ankle and subtalar joints. All patients remained non-weight-bearing for a minimum of six weeks, after which time they were allowed to bear weight as tolerated and were referred for outpatient physical therapy⁷. Patients with a syndesmotic screw were allowed to bear weight as tolerated at six weeks if they did not desire screw removal. If, however, they requested screw removal, they remained non-weight-bearing for an additional four weeks, after which time they underwent removal of the syndesmotic screw as an outpatient. Patients with a di-

agnosis of insulin-dependent diabetes were protected with regard to weight-bearing for an additional two to four weeks at the treating surgeon's discretion.

Radiographs consisting of a standard trauma series (anteroposterior, lateral, and mortise views) were made at six, twelve, twenty-four, and fifty-two weeks. Radiographs made at the time of the latest follow-up were evaluated for evidence of fracture union, maintenance of the ankle mortise, and the presence of posttraumatic arthritis of the ankle joint.

All patients were followed until clinical healing had occurred. Follow-up information included the occurrence of complications or the need for additional surgery, the weight-bearing status, and the results of two functional assessments—the American Orthopaedic Foot and Ankle Society (AOFAS) ankle-hindfoot scale⁸ and the SMFA score. Both functional assessments were performed at each of the standard follow-up periods—i.e., at three, six, and twelve months.

Statistical Analysis

Preliminary analyses were performed with use of contingency table methods (chi-square) or the Student t test. In order to determine the role of covariates and potential confounders, multiple logistic regression was performed. A p value of <0.05 was considered significant. The covariates that were examined were diabetes, patient age, gender, cigarette use, ASA classification, and presence of a fracture-dislocation.

Results

Of the 232 patients who were eligible for the one-year follow-up examination, 130 (56%) were male and 102 (44%) were female, and their average age was forty-two years (range, sixteen to eighty-nine years). The mechanisms of injury included 165 falls (71%), sixteen pedestrian-motor vehicle acci-

dents (7%), twenty-eight sports injuries (12%), and twenty-three motor-vehicle collisions (10%). According to the OTA fracture classification, there were eighteen type-44A (8%), 158 type-44B (68%), and fifty-six type-44C (24%) injuries. One hundred and forty-eight of the injuries were fractures (64%), and eighty-four were fracture-dislocations (36%). Forty-nine patients (21%) were currently cigarette smokers, and thirty-one patients (13%) had diabetes.

Complete (one-year) follow-up data were available for 198 patients (85%). At one year, 174 patients (88%) had either no or mild ankle pain and 178 patients (90%) had either no limitations or limitations only in recreational activities. We observed significant increases in the proportion of individuals with no pain between the three-month (22%; forty-four patients) and six-month (39%; seventy-seven patients) postoperative evaluations ($p < 0.001$) and between the six-month and twelve-month (53%; 105 patients) evaluations ($p < 0.001$) (Fig. 1). There was a similar increase in the proportion of individuals with no physical limitations between three months (23%; forty-six patients) and six months (46%; ninety-one patients) ($p < 0.001$) and between six months and twelve months (63%; 125 patients) ($p < 0.001$) (Fig. 2). The SMFA subscores were below average at baseline, indicating a healthy population. At three and six months postoperatively, all of the SMFA subscores were significantly higher than the baseline values, indicating impairment ($p < 0.001$). However, at one year, the SMFA subscores had returned to baseline, normal levels (Fig. 3). An age of less than forty years was a predictor of recovery, as measured with the SMFA subscores, at six months after the ankle fracture, but this association was not significant at twelve months. The type of fracture, an associated dislocation, and a history of smoking had no influence on functional recovery.

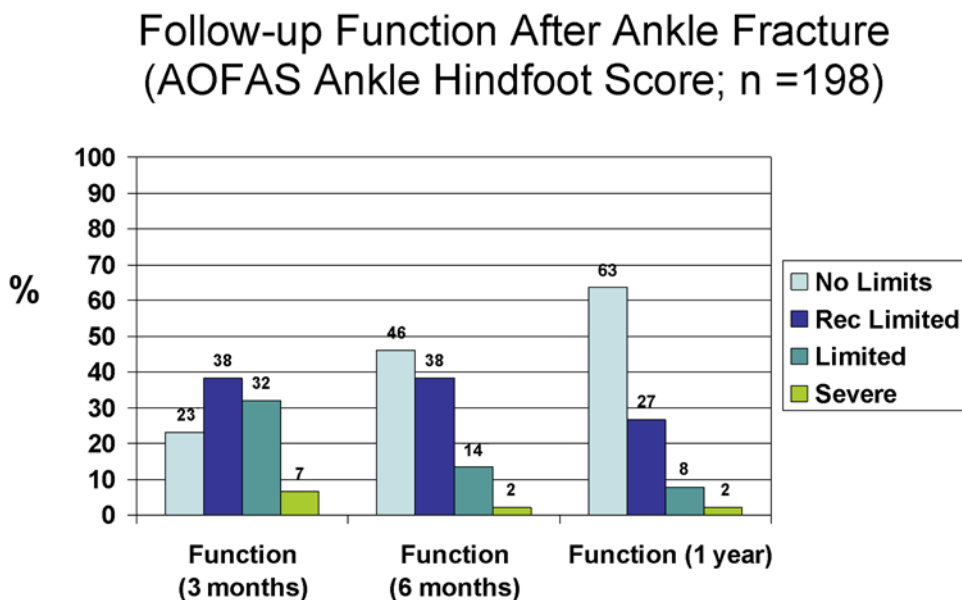


Fig. 2

AOFAS scores for function over the one-year postoperative period.

Follow-up Function and Pain After Ankle Fracture (SMFA Score; n = 198)

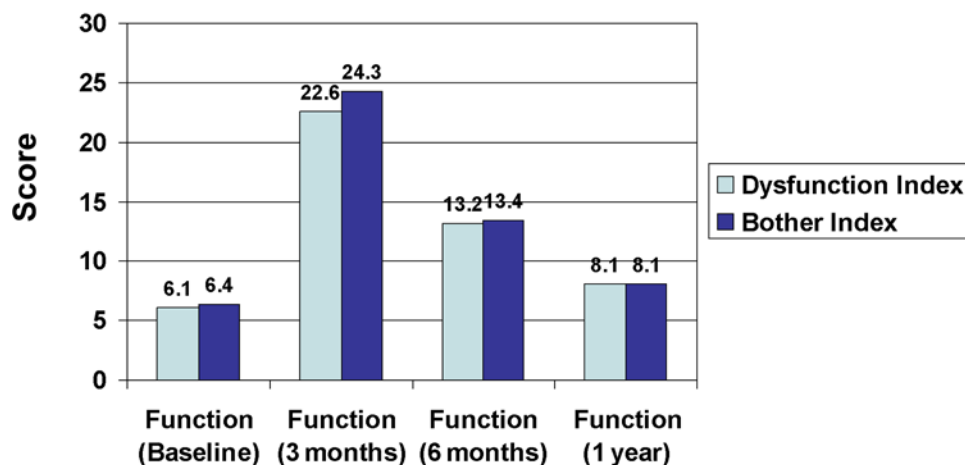


Fig. 3
SMFA scores over the one-year postoperative period.

Although the AOFAS ankle-hindfoot scale was constructed to measure functional status rather than functional recovery *per se*⁸, we assessed whether the measure could be sensitive to change over time by examining the correlation with the SMFA instrument. We interpreted the AOFAS score as the percentage of functional change, given that this score was highly correlated with the SMFA scores at each follow-up time-point ($r = 0.71$, $p < 0.0001$ at three months; $r = 0.703$, $p < 0.0001$ at six months; and $r = 0.72$, $p < 0.0001$ at twelve months) and thus was sensitive to change over time.

As measured with the AOFAS score, 90% (178) of the 198 patients had $\geq 90\%$ functional recovery. Ninety-five percent (105) of the 111 men recovered 90% of functional ability compared with only 85% (seventy-four) of the eighty-seven women; this difference was significant ($p = 0.02$). Age also was a predictor of the ability to recover $\geq 90\%$ of function at one year, with 72% (sixty-one) of the eighty-five patients who were younger than forty years of age and 52% (fifty-nine) of the 113 patients who were older than forty recovering such function ($p = 0.004$). The ASA classification was predictive of functional recovery as well: 93% (164) of the 176 patients with an ASA classification of 1 or 2 had $\geq 90\%$ functional recovery compared with 64% (fourteen) of the twenty-two patients with an ASA classification of 3 or 4 ($p = 0.03$). Finally, the presence of diabetes was significantly associated with functional recovery at one year. Overall, 92% (154) of the 167 patients without diabetes recovered $\geq 90\%$ of function, whereas only 71% (twenty-two) of the thirty-one patients with diabetes did so ($p = 0.02$).

Radiographic examination showed 229 fractures to be united by three months. There was one asymptomatic nonunion of the lateral malleolus; one symptomatic nonunion of the fibula, which was treated with an additional operation;

and one asymptomatic nonunion of the medial malleolus. At one year, no patient with adequate follow-up had evidence of posttraumatic arthrosis. One patient underwent an early ankle arthrodesis following a deep infection at three months.

Discussion

The emphasis on functional recovery following orthopaedic interventions has been increasing recently^{7,9,10,21}. In one study of 141 patients followed for two years after operative stabilization of an ankle fracture, Lash et al.¹⁰ reported that 77% obtained a good or excellent result, as measured with the Olerud-Molander score²², and 21% had some functional impairment.

Obremsky et al. used the Short Form-36 (SF-36) to evaluate the functional results following surgical stabilization of ankle fractures in a small cohort of patients⁹. They found that, at twenty months following the surgery, patients still have some impairment in their overall general health as compared with population norms for age-matched controls. The problem with the SF-36 is that it is not a specific tool for assessing impairment related to musculoskeletal injury.

In a previous study, we used a driving simulator to determine when patients who had undergone surgical treatment of an unstable ankle fracture regained safe braking function after the surgery²¹. All patients still performed below baseline levels at six weeks, and it was not until nine weeks after the surgery that brake-reaction time approached that of controls. In that study, we were unable to find any correlation with objective measures of the AOFAS ankle-hindfoot score that could help guide clinicians regarding when patients could return to safe driving.

In our present study of a large cohort of patients with an operatively treated ankle fracture, we found several factors to

be predictive of functional recovery as measured with the AOFAS ankle-hindfoot scale and the SMFA. These included patient age, gender, the presence of diabetes mellitus, and the ASA classification. With the population continuing to age, we are seeing more unstable ankle fractures in elderly patients²³. Age has been reported to be a predictor of recovery following other types of fractures as well. Several studies have shown that older patients with a hip fracture are less likely to return to baseline functional activities than are younger patients²⁴⁻²⁷. The ASA classification is a general indicator of the patient's health at the time of surgical intervention²⁷. Class-3 and 4 patients are generally sicker, and thus their lack of functional recovery may be due to associated medical conditions.

Diabetes is known to be associated with poor outcomes after ankle fracture, and our findings further illustrate this point. Increased rates of wound complication have been reported in patients with diabetes. Bibbo et al. reported a 46% complication rate in patients with diabetes compared with a 17.4% rate in nondiabetic patients in one series of patients with an ankle fracture²⁸. This led the authors to recommend nonoperative treatment for nondisplaced or minimally displaced fractures and open reduction and internal fixation only for displaced fractures. Furthermore, they recommended prolonged immobilization of the ankle along with stringent glucose control, as monitored with laboratory tests of serum, for all patients. Our results provide no reason to alter that strategy.

Interestingly, we found that men were more likely than women to recover baseline function at one year. While we do not have a good explanation for this finding, the authors of a previous report²⁹ postulated that gender differences in self-reported disability may be due to a greater prevalence of disabling medical conditions, such as arthritis and migraine headaches, in women relative to men. There may also be differences in the reporting of subjective conditions²⁹.

Comparison of the SMFA scores with normative data showed our population to be a healthy one. At six months, the cohort was functionally impaired, with higher values for all subscores. From this time-point, men seemed to recover faster than women. By one year, the mean SMFA scores approached baseline levels, indicating further recovery. However, age was no longer significantly associated with this improvement.

Limitations of this study included the lack of a nonoperative control group. Furthermore, baseline function was re-

corded only after the injury. However, we compared the results of our baseline assessment with the values in a control population in a study by Lomita³⁰, who administered the SMFA to a healthy population of relatives or friends accompanying orthopaedic patients to a clinic at McGill University Medical Center. The dysfunction index score, bother index score, and overall SMFA score in that study were all similar to the retrospectively reconstructed "baseline" scores in our injured population³⁰. Finally, our study included only short-term follow-up. It is possible that outcomes could decline with time. Future studies are needed to address these concerns.

In conclusion, we found that patients were doing well one year after ankle fracture surgery, with most experiencing little or mild pain and few restrictions in functional activities. At one year, the patients had significant improvement in function compared with that at six months after the surgery. We identified several factors that are significantly associated with a delay in functional recovery at one year: older age, an ASA classification of 3 or 4, the presence of diabetes mellitus, and female sex. It is important to counsel patients and their families with regard to the functional recovery that they can expect after the injury. The ability to identify patients who are at risk may allow the treating physician to alter care strategies to maximize recovery. ■

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