Posterior malleolar fractures
Diagnostic accuracy, morphology and clinical outcome
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WHAT FACTORS ARE ASSOCIATED WITH OUTCOMES SCORES AFTER SURGICAL TREATMENT OF ANKLE FRACTURES WITH A POSTERIOR MALLEOLAR FRAGMENT?
ABSTRACT

Background
Psychosocial factors, such as depression and catastrophic thinking, might account for more disability after various orthopaedic trauma pathologies than range of motion and other impairments. However, little is known about the influence of psychosocial aspects of illness on long-term symptoms and limitations of patients with rotational-type ankle fractures, including a posterior malleolar fragment. Knowledge of the psychosocial factors associated with long-term outcome after operative treatment of trimalleolar ankle fractures might improve recovery.

Questions/purposes
(1) Which factors related to patient demographics, physical exam, diagnosis, or psychological well-being (in particular, depression), if any, are associated with better or worse scores on validated lower-extremity outcomes instruments after surgical treatment for rotational ankle fractures (including a posterior malleolar fragment) at long-term follow-up?

Methods
Between 1974 and 2002, 423 patients underwent open reduction internal fixation for rotational ankle fractures with posterior malleolar fragments according to the basic principles of the AO (Arbeitsgemeinschaft für Osteosynthesefragen). Minimum follow-up for inclusion here was 10 years (range, 12.5–39.4 years). When posterior malleolar fragments involved more than 25% of the articular surface as assessed on plain lateral radiographs, the fracture was generally fixed with AP or posterior-anterior (PA) screws. Of those treated surgically during the period in question, 319 were lost to follow-up, had too much missing data to include, or declined to participate in this study (or could not because of reasons of mental illness) (68%), leaving 104 (32%) for analysis in this retrospective study. Independent observers not involved in patient care measured disability using the patient-based Foot and Ankle Ability Measure questionnaire and using the subscale Activities in Daily Living (ADL) and pain score of the Foot and Ankle Outcome Score. General physical and mental health status was evaluated using the SF-36. Depressive symptoms were measured with the Center for Epidemiologic Studies-Depression scale score (range, 0-60 points). A score above 16 indicated a depressive disorder. Misinterpretation or overinterpretation of nociception was measured with the Pain Catastrophizing Scale score. Scores above 13.9 were considered abnormal. Statistical analyses included uni- and multivariate regression analysis. In general, patients in this series reported good to excellent outcomes; the mean ± SD scores were 91 ± 15 for Foot and Ankle Ability Measure, 93 ± 16 for Foot and Ankle Outcome Score (ADL), 91 ± 15 for Foot and Ankle Outcome Score (pain), 49 ± 9 for SF-36 mental component score, and 52 ± 9 for SF-36 physical component score.

Results
Implant removal (β = -8.199, p < 0.01) was associated with worse Foot and Ankle Ability Measure scores. Better flexion/extension arc (β = 0.445, p < 0.01) and lower Center for Epidemiologic Studies-Depression scores (β = -0.527, p < 0.01) were associated with better Foot and Ankle Ability Measure scores. Osteoarthritis (β = -4.823, p < 0.01) was associated with worse Foot and Ankle Outcome Score (pain) scores. Better flexion/extension arc (β = 0.454, p < 0.01) and lower Center for Epidemiologic Studies-Depression scores (β = -0.557, p < 0.01) were associated with better Foot and Ankle Outcome Score (pain) scores. Osteoarthritis (β = -4.823, p < 0.01) was associated with worse Foot and Ankle Outcome Score (pain) scores. Better flexion/extension arc (β = 0.431, p < 0.01) and lower Center for Epidemiologic Studies-Depression scores (β = -0.557, p < 0.01) were associated with better Foot and Ankle Outcome Score (ADL) scores. Finally, we found that a better inversion/eversion arc (β = 0.122, p = 0.024) was associated with better SF-36 physical component score and that a lower Center for Epidemiologic Studies-Depression score (β = -0.567, p < 0.01) was associated with better SF-36 mental component score.

Conclusion
Psychological aspects of recovery from musculoskeletal injury merit greater attention, perhaps even over objective, unmodifiable predictors. A mean of 24 years after surgical treatment of ankle fractures with a posterior malleolar fragment, patient-reported outcome measures have little to do with pathophysiology; they mostly reflect impairment and depression symptoms. Further research is needed to determine whether early identification and treatment of at-risk patients based on psychosocial factors can improve long-term outcomes.
INTRODUCTION

Ankle fractures are among the most common injuries treated by orthopaedic surgeons, but only 79.3% of all types of anatomically reduced ankle fractures showed good to excellent long-term outcomes. Studies state that posterior malleolar fractures are nonmodifiable predictors that negatively affect outcome. One year after open reduction and internal fixation of rotational-type ankle fractures, Egoł et al. identified unmodifiable outcome predictors that included younger age, male sex, absence of diabetes, and a lower American Society of Anesthesiologists (ASA) class.

The psychologic aspects of recovery from musculoskeletal injury merit greater attention. A recent meta-analysis showed that the prevalence of depression after acute orthopaedic trauma was 32.6%. In general, in patients with upper extremity trauma, measurements of depression and pain catastrophizing are known predictors of disability. Psychologic factors predict perceived disability and pain intensity after skeletal trauma because these are important predictors of outcome that seem modifiable using mind-body skills-based intervention addressing mood and coping strategies. Surgeons may improve their treatment by focusing on nontraditional but modifiable outcome predictors: depression symptoms and pain catastrophizing. To the best of our knowledge, it is unknown if depression symptoms and pain catastrophic thinking account for the variability in unsatisfactory outcomes in patients experiencing disability after rotational-type ankle fractures.

We, therefore, asked: (1) Which factors related to patient demographics, physical exam, diagnosis, or psychological well-being (in particular, depression), if any, are associated with better or worse scores on validated lower extremity outcomes instruments after surgical treatment for rotational ankle fractures (including a posterior malleolar fragment) at long-term follow-up?

PATIENTS AND METHOD

Our institutional review board approved this retrospective study in accordance with the Declaration of Helsinki.

Between 1974 and 2002 patients who underwent operative treatment for ankle fractures at our Level I trauma center were included in our AO (Arbeitsgemeinschaft für Osteosynthesfragen) database and categorized according to the AO/Orthopaedic Trauma Association (OTA). A total of 423 AO/OTA-44 fractures were identified for this retrospective study. After fracture analysis, which was done by two independent observers not involved in patient care (JND, SAS), 98 patients had died, five patients were considered mentally ill (three had dementia diagnosed by a neurologist, and two were under the care of a psychiatrist); seven patients had undergone an arthrodesis and were considered as having a poor result, since physical examination was not possible; one patient had an amputation of the affected leg 20 years after a trimalleolar ankle fracture as a result of multiple operations, bad healing, misalignment, and persistent pain; one patient had a musculoskeletal disorder (multiple sclerosis) and was unable to come to the hospital; and three patients fractured their ankle again as a result of a second trauma. The remaining 308 patients were invited for a long-term follow-up visit at our outpatient clinic under a protocol approved by our institutional review board. Of this group, 68 patients (22%) declined participation, and 36 patients (12%) had incorrect or outdated demographic data, so we were unable to reach them. Of 204 eligible patients, 76 patients (37%) did not respond and/or could not be contacted after three attempts by letter, phone, or after contacting their general practitioner and were considered lost to follow-up. Twenty-four patients were evaluated in an earlier study. Our institutional review board did not approve inviting these patients to the hospital again, therefore, we missed several outcome data that could not be regained. One hundred four patients (34%) of the remaining of 308 were eligible for analyses.

There were 63 women (61%) and 41 men (39%) with a mean age of 63 years (range, 37-91 years) and a mean follow-up of 24 years (range, 13-39 years). With regard to trauma-related circumstances, three patients (3%) fell from a height of 2 meters and 17 (16%) fell from a standing height. Most patients, 53 (51%), fractured their ankles by taking a misstep. Fifteen (14%) injuries were sports-related, eight (8%) as result of a traffic accident, and eight (8%) caused by a heavy weight. Nineteen traumas (18%) were considered high-energy traumas, five fractures (5%) were open traumas, and seven patients (7%) had an ipsilateral leg injury.

According to the Weber classification, there were two 44A fractures (2%) (one 44A1 and one 44A2), 65 44B fractures (62%) (one 44B1 and 64 44B3), and 37 44C (36%) (seven 44C1, 10 44C2, and 20 44C3).

SURGICAL TECHNIQUE

Between 1974 and 2002, 423 patients underwent open reduction and internal fixation for rotational ankle fractures with posterior malleolar fragments. During the extended study period, multiple orthopaedic and general trauma surgeons cared for the included patients. There was no standardized treatment algorithm or protocol in place. However, patients were treated according to the basic principles of the AO without major deviations to the following approach: in general, patients with stable rotational type ankle fractures without talar shift were offered nonoperative treatment in a cast. Unstable rotational type ankle fractures were treated with a direct lateral approach to address the distal fibular fractures, and a standard medial approach was used to address the medial malleolar fracture, if present. Standard 3.5-mm lag screws, 1/3 tubular plates with 3.5-mm screws, and either 3.5-mm or 4.5-mm positioning screws, depending on surgeons’ preference, were used if syndesmotic fixation was indicated. The indication for fixation of syndesmotic injury was based on these rotational type ankle fractures was based on the overall fracture pattern in the case of Maisonneuve type, or Weber C type ankle fractures, and furthermore, it was based on intraoperative stress tests (exorotation stress and hook tests) under image intensifier in syndesmotic injuries that were not as apparent preoperatively. All patients were treated according these basic AO principles. During the study period, no contemporary distal fibular locking plates were used, nor were there any associated syndesmotic injuries fixed with a TightRope construct (Arthrex, Munich, Germany).

Finally, as there was no standard treatment algorithm in place to decide whether or not to fix the posterior malleolar fractures—a debate that is still ongoing—it was up to the surgeon’s discretion at the time of surgery. In general, in our institution, the classic 25% cutoff was applied; the decision was made to fix the posterior malleolar fracture in one-fifth of patients (18%) with either AP or
PA screw fixation. In this series, no preoperative CTs were made, and we did not yet understand the poor reliability of lateral radiographs to estimate fracture size or the importance of posterior malleolar fracture morphology versus fracture size; therefore, if the fracture involved more than 25% of the articular surface as assessed on plain lateral radiographs, it was generally indirectly fixed with AP or PA screws in 19 instances (18%). During the study period, no patients underwent a direct posterolateral approach to directly reduce and fix the posterior malleolar fracture with a buttress plate.

Standard AP and lateral roentgen images were obtained pre- and postoperatively and at final follow-up. After initial surgical treatment, three patients needed a reoperation within 2 weeks. Five patients experienced a postoperative wound infection that was treated with oral antibiotics; two patients developed thrombosis, and one patient had a nonunion, which was treated with a new osteosynthesis.

## OUTCOME PARAMETERS

Two independent observers (DTM, BDJG) who were not involved in patient care gathered all data. The data was obtained for this specific study and was not part of routine patient care. All data was obtained in person and not by postal survey. Ankle-specific perceived disability was evaluated with use of validated a patient-based Foot and Ankle Ability Measure questionnaire to quantify disability.20,21 A score of 90 to 100 points was considered excellent, 80 to 89 points good, 60 to 79 points fair, and 59 points or less was classified as poor.21 The mean Foot and Ankle Ability Measure score was 91 (95% confidence interval [CI], 88% – 94%). Six patients (6%) showed poor results, 11 patients (11%) fair results, 10 (10%) obtained good results, and 77 (75%) had excellent results.

In addition, a subscale of the Foot and Ankle Outcome Score questionnaire, the Activities in Daily Living (ADL), evaluated perceived disability.20 Pain was recorded using a subscale of the Foot and Ankle Outcome Score questionnaire.24 Foot and Ankle Outcome Score scores range from 0 to 100 points, worst to best. The mean scores for the Foot and Ankle Outcome Score subscores were 93 (95% CI, 90% – 96%) for the Foot and Ankle Outcome Score (ADL) and 92 (95% CI, 89% – 95%) for the Foot and Ankle Outcome Score (pain).

The SF-36 is a well-known questionnaire often used to evaluate general health. We calculated the physical component summary (PCS) and the mental component summary (MCS) scores for this analysis. Both component scores range from 0 to 100 points. A score of 50 is equal to the mean score for the general population.22

The SF-36 to evaluate general health was equal to the mean score for the general population: 52 (95% CI, 51% – 54%) for the SF-36 MCS and 48 (95% CI, 47% – 50%) for the SF-36 PCS.22 Depressive symptoms during the previous week of the interview were quantified with the use of the validated Dutch form of the Center for Epidemiologic Studies-Depression scale.26 Scores range between 0 and 60 points, with a higher score indicating a higher level of depression. A mean Center for Epidemiologic Studies-Depression scale of 13 was measured in a healthy Dutch population. 

## STATISTICAL ANALYSIS

Continuous data are presented as the mean ± standard deviation with accompanying percentages. By use of bivariate analyses, demographic and clinical variables were examined with respect to each of the patient-reported outcome instruments (Foot and Ankle Ability Measure, Foot and Ankle Outcome Score pain and ADL, SF-36, Pain Catastrophizing Scale and MCS). These variables included gender, high-energy trauma, Weber classification, implant removal, age at follow-up, follow-up time, van Dijk osteoarthritis score, total arc of flexion and extension, total arc of inversion and eversion, Center for Epidemiologic Studies-Depression scale, and Pain Catastrophizing Scale. Pearson correlation coefficients were calculated to assess the association between continuous independent variables and the outcome instruments. The association with
WHAT FACTORS ARE ASSOCIATED WITH OUTCOMES SCORES AFTER SURGICAL TREATMENT OF ANKLE FRACTURES WITH A PMF

RESULTS
Factors associated with outcomes scores after ankle fracture
Implant removal ($\beta = -0.199$, $p < 0.01$) was associated with worse Foot and Ankle Ability Measure scores. Better flexion/extension arc ($\beta = 0.445$, $p < 0.01$), and lower Center for Epidemiologic Studies-Depression scores ($\beta = -0.527$, $p < 0.01$) were associated with better Foot and Ankle Ability Measure scores.

We found that osteoarthritis ($\beta = -4.823$, $p < 0.01$) was associated with worse Foot and Ankle Outcome Score (pain) scores. Better flexion/extension arc ($\beta = 0.454$, $p < 0.01$) and lower Center for Epidemiologic Studies-Depression scores ($\beta = -0.596$, $p < 0.01$) were associated with better Foot and Ankle Outcome Score (pain) scores.

Better flexion/extension arc ($\beta = -0.431$, $p < 0.01$) and lower Center for Epidemiologic Studies-Depression scores ($\beta = -0.557$, $p < 0.01$) were associated with better Foot and Ankle Outcome Score (ADL) scores.

Finally, we found that a better inversion/eversion arc ($\beta = 0.122$, $p = 0.024$) was associated with better SF-36 physical component score and that lower Center for Epidemiologic Studies-Depression score ($\beta = -0.567$, $p < 0.01$) was associated with better SF-36 mental component score (Table 1).

DISCUSSION
Studies on factors that predict functional recovery after ankle fracture surgery are scarce, and few investigators report on long-term functional outcomes. Factors for functional recovery help us to educate patients and their families regarding expected functional impairment and may help us to manage expectations regarding perceived disability after an ankle injury in the short and long term. Moreover, outcome may improve if we identify factors that surgeons may influence to prevent perceived disability and/or limit functional impairment. This study shows that decades after an ankle fracture, patient reported outcome measure scores have little to do with pathophysiology; they mostly reflect impairment and depression symptoms.

This study should be interpreted in light of several limitations. First, a large proportion of patients who underwent ankle fracture surgery were not accounted for here; this series represented slightly more than one third of those alive at the 10-year minimum follow-up period, and thus, there is a potential risk of bias in this sample. Second, participants had to complete five patient-reported outcome questionnaires. Multiple questionnaires may cause respondents to become tired and distracted. The accuracy of the depression diagnosis could have increased when analyzed by mental health professionals instead of multiple questionnaires. Third, this study was performed at a single academic hospital in Amsterdam, which may limit generalizability to hospitals in other regions or countries. Fourth, we do not know if patients already had high Center for Epidemiologic Studies-Depression scores before the injury or if their high scores were due to the ankle fracture alone. Other factors may have influenced the outcome scores on the Center for Epidemiologic Studies-Depression scale.

Disability as a long-term outcome for trimalleolar fractures yields a poor to fair result in 10% to 46% of patients; we know the presence of a posterior malleolus fracture is one possible factor that is negatively associated with poorer patient-reported outcome scores, function and pain. Other nonmodifiable factors include younger age, male sex, absence of diabetes, and a lower ASA class. Moreover, it is unknown if modifiable symptoms of depression and pain catastrophic thinking account for any variability in unsatisfactory outcomes in patients experiencing disability or have objective restrictions causing impairment after rotational-type ankle fractures in the long term. Other studies have shown that patients with less effective coping skills, anxiety, and depression report increased disability from orthopaedic conditions like trigger finger, carpal tunnel syndrome, or Dupuytren’s contracture compared with patients with more effective coping skills, no anxiety, and lower scores of depression in terms of the Disabilities of the Arm, Shoulder and Hand (DASH) scores.

TABLE 1. Result of multivariate regression analysis

<table>
<thead>
<tr>
<th>Predictor</th>
<th>$\beta$ Coefficient</th>
<th>95% CI</th>
<th>$p$ value</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAAI</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Implant removal</td>
<td>-0.20</td>
<td>-1.03 - -0.37</td>
<td>0.001</td>
<td>0.36</td>
</tr>
<tr>
<td>Flexion/extension arc (degrees)</td>
<td>0.45</td>
<td>0.29 - 0.60</td>
<td>&lt; 0.001</td>
<td></td>
</tr>
<tr>
<td>CES-D</td>
<td>-0.53</td>
<td>-0.83 - -0.22</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>FAOS (pain)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>van Dijk osteoarthritis</td>
<td>-4.82</td>
<td>-7.94 - -1.70</td>
<td>0.003</td>
<td>0.37</td>
</tr>
<tr>
<td>Flexion/extension arc (degrees)</td>
<td>0.45</td>
<td>0.24 - 0.67</td>
<td>&lt; 0.001</td>
<td></td>
</tr>
<tr>
<td>CES-D</td>
<td>-0.60</td>
<td>-0.94 - -0.25</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>FAOS (ADL)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexion/extension arc (degrees)</td>
<td>0.43</td>
<td>0.19 - 0.67</td>
<td>0.001</td>
<td>0.22</td>
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<tr>
<td>CES-D</td>
<td>-0.56</td>
<td>-0.96 - -0.16</td>
<td>0.007</td>
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<tr>
<td>SF-36 physical</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inversion/eversion (degrees)</td>
<td>0.12</td>
<td>0.02 - 0.23</td>
<td>0.024</td>
<td>0.04</td>
</tr>
<tr>
<td>CES-D</td>
<td>-0.57</td>
<td>-0.76 - -0.38</td>
<td>&lt; 0.001</td>
<td>0.22</td>
</tr>
</tbody>
</table>

CI = confidence interval; FAAM = Foot and Ankle Ability Measure; FAOS = Foot and Ankle Outcome Score; ADL = Activities of Daily Living; CES-D = Center for Epidemiologic Studies-Depression scale.
Future studies on this topic might address the potential benefits of screening, intervention, and psychological support in musculoskeletal injuries. At-risk patients may benefit from cognitive-behavioral therapy to improve coping strategies to help control depression. In conclusion, decades after an ankle fracture, including a posterior malleolar fragment, patient-reported outcome measure scores have little to do with pathophysiology; they mostly reflect impairment and depression symptoms.

ACKNOWLEDGMENTS
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REFERENCES


