*Article*

AMERICAN ORTHOPAEDIC FOOT & ANKLE SOCIETY

Foot & Ankle Orthopaedics
2023, Vol. 8(1) 1–11

DOI: 10.1177/24730114221151077
journals.sagepub.com/home/fao

# Clinical Improvement Following Operative Management of Ankle Fractures Among Patients With and Without Moderate to High Depressive Symptoms: An Analysis Using PROMIS

**David N. Bernstein, MD, MBA, MA[1], Gabriel Ramirez, MS[1,2,3], Caroline P. Thirukumaran, MBBS, MHA, PhD[2,3], A. Samuel Flemister, MD[2,3], Irvin C. Oh, MD[4], John P. Ketz, MD[2,3], and Judith F. Baumhauer, MD, MPH[2,3]**

## Abstract

**Background:** Understanding the recovery trajectory following operative management of ankle fractures can help surgeons guide patient expectations. Further, it is beneficial to consider the impact of mental health on the recovery trajectory. Our study aimed to address the paucity of literature focused on understanding the recovery trajectory following surgery for ankle fractures, including in patients with depressive symptoms.

**Methods:** From February 2015 to March 2020, patients with isolated ankle fractures were asked to complete Patient-Reported Outcomes Measurement Information System (PROMIS) Physical Function (PF), Pain Interference (PI), and Depression questionnaires as part of routine care at presentation and follow-up time points. Linear mixed effects regression models were used to evaluate the patient recovery pattern, comparing the preoperative time point to $<$3 months, 3-6 months, and $>$6 months across all patients. Additional models that included the presence of depression symptoms as a covariate were then used.

**Results:** A total of 153 patients met inclusion criteria. By 3-6 months, PROMIS PF ($\beta$: 9.95, 95% CI: 7.97-11.94, $P < .001$), PI ($\beta$: −10.30, 95% CI: −11.87 to −8.72, $P < .001$), and Depression ($\beta$: −5.60, 95% CI: −7.01 to −4.20, $P < .001$) improved relative to the preoperative time point. This level of recovery was sustained thereafter. When incorporating depressive symptoms into our model as a covariate, the moderate to high depressive symptoms were associated with significantly and clinically important worse PROMIS PF ($\beta$: −4.00, 95% CI: −7.00 to −1.00, $P = .01$) and PI ($\beta$: 3.16, 95% CI: −0.55 to 5.76, $P = .02$) scores.

**Conclusion:** Following ankle fracture surgery, all patients tend to clinically improve by 3-6 months postoperatively and then continue to appreciate this clinical improvement. Although patients with moderate to high depressive symptoms also clinically improve following the same trajectory, they tend to do so to a lesser level than those who have low depressive symptoms.

**Level of Evidence:** Level III, case-control study.

**Keywords:** ankle fracture, depression, mental health, PROMIS, PROMs, value-based health care

## Introduction

Ankle fractures are the most common fracture of the foot and ankle,[29] with incidence rates of between 168.7 and 179 per 100 000 in the population per year reported.[7,15] Although nonoperative management with cast immobilization or other means (such as walking boots) can be considered for

stable ankle fractures, a notable portion of all ankle fractures will ultimately require operative treatment (ie, open reduction and internal fixation [ORIF]).[27] Further, prior literature has reported that many patients benefit from operative management of ankle fractures.[18,26,30] However, better understanding the recovery trajectory of patients undergoing operative management for ankle fractures and the impact of mental health conditions, such as depression, on recovery trajectories would help trauma and foot and ankle surgeons better set patient expectations preoperatively and manage patients during recovery to engage in shared clinical decision-making discussions.

Although prior research has recognized the impact of depression on surgical outcomes in orthopaedic surgery,[3,6,19] including in ankle fractures,[21,28,31] there is a paucity of literature examining this association over time in a sample of operatively treated ankle fractures. Perhaps the best way to evaluate recovery is using patient-reported outcome measures (PROMs), which are instruments that measures the outcomes most important to patients and provide patients with a greater voice in their own care.[1] Within foot and ankle care, the Patient-Reported Outcomes Measurement Information System (PROMIS) is a recommended set of standardized outcome measures,[14] and they have been shown to be useful in predicting clinical outcomes in foot and ankle patients.[12] Thus, using PROMIS as a means of evaluating postoperative recovery in patients undergoing ORIF for an ankle fracture is important to advance the understanding of trauma care in the foot and ankle patient population.

In this study, we asked 3 questions: (1) What is the recovery pattern, as measured by PROMIS Physical Function (PF), Pain Interference (PI), and Depression, of patients undergoing operative management for ankle fractures? (2) What is the association between moderate or high levels of depressive symptoms (ie, PROMIS Depression score $\geq 60$) and function and pain (ie, PROMIS PF and PI) during patient recovery following surgery for ankle fractures? (3) Does changing the cut-off for moderate or high depressive symptoms (ie, PROMIS Depression $\geq 55$ or $\geq 65$) alter the association between depressive symptoms and function and pain (ie, PROMIS PF and PI) during patient recovery following surgery for ankle fractures?

## Materials and Methods

This retrospective observational study used data from our institutional PROMIS data repository, which is collected prospectively as part of routine clinical foot and ankle care.[24] Patients diagnosed with an isolated ankle fracture undergoing operative management between February 2015 and March 2020 were identified using *Current Procedural Terminology* (*CPT*) codes (27766, 27792, 27814, 27822, and 27823). In order to be included in our study, patients were required to have at least 1 preoperative and 1 postoperative visit with PROMIS PF, PI, and/or Depression questionnaires completed. Preoperative visits were required to be within 90 days of surgery to be included. Initially, 411 patients were identified. Of those, 27 patients (6.6%) were excluded because they had no complete PROMIS evaluations within the study time frame. An additional 209 patients (51%) were excluded because they lacked completed preoperative PROMIS evaluations but had postoperative PROMIS evaluations. Lastly, 22 patients (5.4%) were excluded because they had no postoperative PROMIS questionnaires completed. This left a total of 153 patients (37%) for our study. Importantly, using chi-square and Kruskal-Wallis tests to compare the distribution of characteristics, patient characteristics among those patients included compared with those patients excluded were largely similar (Appendix A).

PROMIS domains were developed through support from the US National Institutes of Health (NIH).[2] Each questionnaire produces a *t* score that is normed to the general US population, with a mean *t* score of 50 and SD of 10.[11] For all domains, higher PROMIS scores represent more of the construct being measured, whereas lower PROMIS scores represent less of the construct being measured. For example, higher PROMIS Depression scores represent greater levels of depressive symptoms, whereas lower PROMIS PF scores suggest decreased functional ability.

In prior literature, PROMIS Depression scores of $\geq 60$ have constituted moderate depression,[5] and this has been robustly validated using the Patient Health Questionnaire (PHQ)-9 to PROMIS Depression.[4] Thus, for our baseline assessment analyzing the association of moderate or severe depression on functional and pain outcomes, we used this PROMIS Depression threshold score. When doing so,

[1]Harvard Combined Orthopaedic Residency Program (HCORP), Massachusetts General Hospital, Boston, MA, USA
[2]Department of Orthopaedics & Physical Performance, University of Rochester Medical Center, Rochester, NY, USA
[3]University of Rochester School of Medicine and Dentistry, Rochester, NY, USA
[4]Department of Orthopaedics and Rehabilitation, Yale New Haven Hospital, Yale School of Medicine, New Haven, CT, USA

**Corresponding Author:**
Judith F. Baumhauer, MD, MPH, Department of Orthopaedics & Physical Performance, University of Rochester Medical Center, 601 Elmwood Ave, Box 665, Rochester, NY 14642, USA.
Email: judy_baumhauer@urmc.rochester.edu

**Table 1.** Patient Characteristics (Low Depressive Symptoms: PROMIS Depression Score <60 vs Moderate to High Depressive Symptoms: PROMIS Depression Score ≥60).

| Characteristic | Low Depressive Symptoms (n = 116) | Moderate to High Depressive Symptoms (n = 37) | Total (n = 153) | *P* Value |
|---|---|---|---|---|
| Sex, n (%) | | | | |
| Female | 56 (48) | 24 (65) | 80 (52) | .12 |
| Male | 60 (52) | 13 (35) | 73 (48) | |
| Race, n (%) | | | | |
| Not White | 15 (13) | 9 (24) | 24 (16) | .16 |
| White | 101 (87) | 28 (76) | 129 (84) | |
| Ethnicity, n (%) | | | | |
| Hispanic | 6 (5.1) | 2 (5.4) | 8 (5.2) | .71 |
| Not Hispanic | 110 (95) | 35 (95) | 145 (95) | |
| Marital status, n (%) | | | | |
| Married | 55 (47) | 9 (24) | 64 (42) | .02 |
| Single | 61 (53) | 28 (76) | 89 (58) | |
| Age, mean (SD) | 44 (18) | 43 (18) | 45 (30, 59) | .58 |
| Day of evaluation prior to surgery, median (IQR) | −5 (−8, −2) | −4 (−8, 0) | −4 (−7, −1) | .87 |
| Insurance, n (%) | | | | |
| Commercial | 79 (68) | 16 (43) | 95 (62) | .01 |
| Other | 37 (32) | 21 (57) | 58 (38) | |
| BMI, mean (SD) | 30 (6.6) | 31 (7.0) | 29 (25, 34) | .33 |
| Underlying conditions, n (%) | | | | |
| 0 | 90 (78) | 29 (78) | 119 (78) | .48 |
| 1 | 19 (16) | 4 (11) | 23 (15) | |
| ≥2 | 7 (6.0) | 4 (11) | 11 (7.2) | |

Abbreviations: BMI, body mass index; IQR, interquartile range; PROMIS, Patient-Reported Outcomes Measurement Information System.

patient characteristics among those patients who had moderate to high depressive symptoms were largely similar to those patients who had low levels of depressive symptoms after comparing the distribution of characteristics using chi-square and Mann-Whitney *U* tests (Table 1). The 2 exceptions were that patients with low depressive symptoms were more likely to be married (55 of 116 [47%] vs 9 of 37 [24%], $P = .02$) and more likely to have commercial health insurance (79 of 116 [68%] vs 16 of 37 [43%], $P = .01$).

## *Statistical Analysis*

To address the first study question, linear mixed effects regression models[17] were used to assess for differences in PROMIS PF, PI, and Depression at each time point (preoperative, <3 months, 3-6 months, and >6 months) when accounting for other patient and procedure characteristics. Patient and procedure characteristics controlled for included age (years), gender (male or female), self-reported race (White or not White), ethnicity (Hispanic or not Hispanic), marital status (married or not married), insurance type (commercial or other), body mass index (BMI), *CPT* code (27766, 27792, 27814, 27822, 27823), and underlying conditions (0, 1, ≥2). Underlying conditions included AIDS/HIV, cancer, metastatic cancer, stroke, pulmonary disease, congestive heart failure, dementia, diabetes with complication, diabetes without complication, hemiplegia or paraplegia, mild liver disease, moderate or severe liver disease, myocardial infarction, peptic ulcer disease, peripheral vascular disease, renal disease, and rheumatic disease.

To address the second study question, similar statistical methods were used to assess for differences in PROMIS PF and PI at each time point (preoperative, <3 months, 3-6 months, and >6 months) while also controlling for preoperative PROMIS Depression and accounting for other confounding patient and procedure characteristics. In this case, the additional PROMIS Depression score categorical covariate was created as follows: low or moderate to high depressive symptoms (low depressive symptoms: PROMIS Depression < 60; moderate to high depressive symptoms: PROMIS Depression ≥ 60). The preoperative PROMIS Depression score was used to make this determination. A total of 116 patients (76%) were included in the low depressive symptoms subgroup, whereas 37 patients (24%) were included in the moderate to high depressive symptom subgroup.

Lastly, to address our third study question, a sensitivity analysis was conducted using similar statistical methods by

using additional preoperative PROMIS Depression stratification scheme: one with a PROMIS Depression score cut-off of ≥55 and one with a PROMIS Depression score cut-off of ≥65. Each of the selected values for the sensitivity analysis are considered a minimal clinically important difference (MCID) using a distribution-based approach of one-half of 1 SD,[22] which for PROMIS domains is equivalent to a *t* score of 5 points. However, when evaluating our findings, we also used additional distribution-based and anchor-based MCID estimates, which begin at a *t* score difference of 3 for both PROMIS PF and PI.[13]

## Results

A total of 153 patients met inclusion criteria (Table 1). The average age was 45 years (range, 30-59 years) and just over half of the sample was female (n = 80 [52% of 153]) (Table 1). Across all included patients, the median number of days patients were evaluated prior to surgery was 4 days (interquartile range [IQR] −7 days to −1 day) (Table 1). At the preoperative, <3- month, 3-6-month, and >6-month time points, we had complete data on 153 (116 patients with low depressive symptoms [76% of 153 patients]), 153 (116 patients with low depressive symptoms [76% of 153 patients]), 82 (61 patients with low depressive symptoms [74% of 82 patients]), and 58 patients (43 patients with low depressive symptoms [74% of 58 patients]), respectively. The cut-off used in this initial designation of low vs moderate to high depressive symptoms was a PROMIS Depression *t* score of 60. The average PROMIS PF *t* score at presentation for the low depressive symptoms patient group was significantly better than the moderate to high depressive symptoms patient group (34.74 [SD: 13.28] vs 28.55 [SD: 9.05], $P = .01$). There was no difference in the average PROMIS PI *t* score at presentation for the low depressive symptoms patient group and was significantly better than the moderate to high depressive symptoms patient group (63.03 [SD: 9.84] vs 66.69 [SD: 6.53], $P = .09$).

There was no statistical difference in PROMIS PF scores between preoperative and 0-3 months following surgery (β: −0.91, 95% CI: −2.50 to 0.68, $P = .26$) (Table 2). However, although both PROMIS PI (β: −3.64, 95% CI: −4.89 to −2.38, $P < .001$) and Depression (β: −1.41, 95% CI: −2.52 to −0.30, $P = .01$) scores statistically improved, only PROMIS PI did so to an appreciable level when considering the range of previously published MCID estimates. By 3-6 months, PROMIS PF (β: 9.95, 95% CI: 7.97-11.94, $P < .001$), PI (β: −10.30, 95% CI: −11.87 to −8.72, $P < .001$), and Depression (β: −5.60, 95% CI: −7.01 to −4.20, $P < .001$), all statistically and clinically improved from the preoperative time point. This level of clinical improvement compared to the preoperative time point remained consistent at >6 months postoperatively for all PROMIS domains.

When incorporating depressive symptoms into our model as a covariate, we discovered that moderate to high depressive symptoms were associated with significantly and clinically appreciable worse PROMIS PF scores (β: −4.00, 95% CI: −7.00 to −1.00, $P = .01$) (Table 3). Similarly, we discovered that moderate to high depressive symptoms were associated with significantly and clinically appreciable worse PROMIS PI scores (β: 3.16, 95% CI: −0.55 to 5.76, $P = .02$). Thus, although all patients clinically improve following surgery for ankle fractures, those with moderate to high depressive symptoms do so to a lesser extent.

When incorporating depressive symptoms into our model as a covariate with a cut-off PROMIS Depression score of ≥55, we found that moderate to high depressive symptoms were associated with significantly and clinically appreciable worse PROMIS PF scores (β: −3.04, 95% CI: −5.63 to −0.45, $P = .02$) (Table 4). Similarly, we discovered that when moderate to high depressive symptoms were determined with a cut-off PROMIS Depression score of ≥65, they were associated with significantly and clinically appreciable worse PROMIS PF scores (β: −5.26, 95% CI: −9.73 to −0.80, $P = .02$). These findings were fairly consistent with the main analysis PROMIS Depression cut-off of 60.

When incorporating depressive symptoms into our model as a covariate with a cut-off PROMIS Depression score of ≥55, we found that moderate to high depressive symptoms were associated with significantly and clinically appreciable worse PROMIS PI scores (β: 3.60, 95% CI: 1.39-5.81, $P < .01$) (Table 5). In contrast, we noted that when moderate to high depressive symptoms were determined with a cut-off PROMIS Depression score of ≥65, we found that moderate to high depressive symptoms were not associated with PROMIS PI scores (β: 3.12, 95% CI: −0.77 to 7.01, $P = .12$). These findings were fairly consistent with the main analysis PROMIS Depression cut-off of 60.

## Discussion

Ankle fractures are common injuries to the lower extremity that often require operative management. In a large majority of cases, surgery for this injury leads to positive clinical outcomes.[18,25,26,30] However, an understanding of the recovery pattern using the patient's own voice via validated PROMs is not well documented in the literature but could help trauma and foot and ankle surgeons set preoperative patient expectations, engage in shared clinical decision-making discussions, and more easily monitor expected clinical improvement. In the present study, we found patients tend not to clinically improve within the first 3 months following surgery for ankle fractures; by 3-6 months postoperatively, patients tend to clinically improve and remain at the same improved functional, pain, and mental health levels through 1 year postoperatively. In

**Table 2.** Evaluation of the Recovery Trajectory of All Patients With Ankle Fractures Undergoing Operative Management Using PROMIS Domains.

| | PROMIS Physical Function Trend | | | | PROMIS Pain Interference Trend | | | | PROMIS Depression Trend | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | β | Lower CI (α = 0.05) | Upper CI (α = 0.05) | *P* Value | β | Lower CI (α = 0.05) | Upper CI (α = 0.05) | *P* Value | β | Lower CI (α = 0.05) | Upper CI (α = 0.05) | *P* Value |
| Month | | | | | | | | | | | | |
| 0 | | Reference | | | | Reference | | | | Reference | | |
| >0, ≤3 | −0.91 | −2.50 | 0.68 | .26 | −3.64 | −4.89 | −2.38 | <.01* | −1.41 | −2.52 | −0.30 | .01* |
| >3, ≤6 | 9.95 | 7.97 | 11.94 | <.01* | −10.30 | −11.87 | −8.72 | <.01* | −5.60 | −7.01 | −4.20 | <.01* |
| >6 | 12.37 | 10.09 | 14.64 | <.01* | −10.28 | −12.08 | −8.48 | <.01* | −5.01 | −6.63 | −3.40 | <.01* |
| Gender | | | | | | | | | | | | |
| Female | | Reference | | | | Reference | | | | Reference | | |
| Male | 2.55 | −0.03 | 5.13 | .05 | −0.96 | −3.19 | 1.27 | .40 | −4.19 | −7.07 | −1.31 | <.01* |
| Race | | | | | | | | | | | | |
| Not White | | Reference | | | | Reference | | | | Reference | | |
| White | −0.39 | −4.21 | 3.42 | .84 | −0.47 | −3.76 | 2.82 | .78 | −3.24 | −7.48 | 1.00 | .14 |
| Ethnicity | | | | | | | | | | | | |
| Hispanic | | Reference | | | | Reference | | | | Reference | | |
| Not Hispanic | 4.05 | −1.67 | 9.76 | .17 | −4.13 | −9.05 | 0.80 | .10 | −5.65 | −11.98 | 0.68 | .08 |
| Marital status | | | | | | | | | | | | |
| Married | | Reference | | | | Reference | | | | Reference | | |
| Single | −0.91 | −3.96 | 2.14 | .56 | −0.96 | −3.59 | 1.68 | .48 | −0.26 | −3.66 | 3.15 | .88 |
| Age | −0.11 | −0.21 | −0.02 | .02* | 0.08 | −0.01 | 0.16 | .08 | 0.00 | −0.10 | 0.11 | .95 |
| *CPT* code | | | | | | | | | | | | |
| 27766 | | Reference | | | | Reference | | | | Reference | | |
| 27792 | 0.40 | −5.07 | 5.86 | .89 | 2.62 | −2.09 | 7.33 | .28 | 1.79 | −4.27 | 7.84 | .56 |
| 27814 | 1.38 | −3.81 | 6.57 | .60 | 0.02 | −4.45 | 4.49 | .99 | −0.95 | −6.69 | 4.79 | .75 |
| 27822 | 3.51 | −1.97 | 8.99 | .21 | −3.67 | −8.39 | 1.05 | .13 | −3.36 | −9.43 | 2.71 | .28 |
| 27823 | −1.65 | −8.03 | 4.73 | .61 | 3.88 | −1.62 | 9.38 | .17 | 2.07 | −5.00 | 9.14 | .57 |
| Insurance | | | | | | | | | | | | |
| Commercial | | Reference | | | | Reference | | | | Reference | | |
| Other | −1.76 | −4.64 | 1.13 | .23 | 2.62 | 0.13 | 5.10 | .04* | 3.98 | 0.78 | 7.18 | .02* |
| BMI | 0.19 | −0.01 | 0.38 | .06 | −0.15 | −0.31 | 0.02 | .08 | −0.01 | −0.23 | 0.20 | .92 |
| Number of underlying conditions | | | | | | | | | | | | |
| 0 | | Reference | | | | Reference | | | | Reference | | |
| 1 | −0.22 | −3.76 | 3.33 | .91 | 1.29 | −1.78 | 4.36 | .41 | −4.54 | −8.51 | −0.57 | .03* |
| ≥2 | −2.75 | −8.18 | 2.69 | .32 | 3.57 | −1.12 | 8.27 | .14 | 4.56 | −1.53 | 10.64 | .14 |

Abbreviations: BMI, body mass index; *CPT*, *Current Procedural Terminology*; PROMIS, Patient-Reported Outcomes Measurement Information System.
*Statistically significant ($P < .05$).

addition, moderate to high depressive symptoms are associated with clinically worse functional and pain outcomes over time; importantly, however, patients with moderate to high depressive symptoms still appreciably improve from surgery but simply not to the same extent as those without moderate to high depressive symptoms. The association between moderate to high depressive symptoms and functional outcomes following ankle surgery remains regardless of whether the PROMIS Depression threshold score for moderate to high depressive symptoms used was 55, 60, or 65. Our work further highlights the importance of the biopsychosocial model of care in ankle fracture care that has previously been emphasized.[33]

We found that patients with ankle fractures requiring operative management improve across all PROMIS domains (ie, PF, PI, and Depression) to a clinically appreciable level between 3 and 6 months postoperatively. Further, clinical improvement plateaus between 3 and 6 months, yet, importantly, appreciable functional and pain improvement continues past 6 months and up through 1 year postoperatively. By understanding this typical recovery trajectory, trauma and foot and ankle surgeons can better set patient expectations preoperatively. This is crucial to patient-centered care in the setting of ankle fractures, which can be devastating to patients and their lives,[20] as research has shown that optimizing patient expectations can improve

**Table 3.** Evaluation of the Recovery Trajectory of Patients With Ankle Fractures Undergoing Operative Management When Considering Depressive Symptoms.

| | Physical Function | | | | Pain Interference | | | |
|---|---|---|---|---|---|---|---|---|
| | β | Lower CI (α = 0.05) | Upper CI (α = 0.05) | *P* Value | β | Lower CI (α = 0.05) | Upper CI (α = 0.05) | *P* Value |
| Depression | | | | | | | | |
| Low (≤60) | | Reference | | | | Reference | | |
| High (>60) | −4.00 | −7.00 | −1.00 | .01* | 3.16 | 0.55 | 5.76 | * |
| Month | | | | | | | | |
| 0 | | Reference | | | | Reference | | |
| >0, ≤3 | −0.91 | −2.50 | 0.68 | .26 | −3.64 | −4.89 | −2.38 | <.01* |
| >3, ≤6 | 9.99 | 8.00 | 11.97 | <.01* | −10.32 | −11.89 | −8.74 | <.01* |
| >6 | 12.36 | 10.09 | 14.63 | <.01* | −10.29 | −12.09 | −8.48 | <.01* |
| Gender | | | | | | | | |
| Female | | Reference | | | | Reference | | |
| Male | 1.91 | −0.66 | 4.48 | .15 | −0.46 | −2.69 | 1.77 | .69 |
| Race | | | | | | | | |
| Not White | | Reference | | | | Reference | | |
| White | −0.69 | −4.42 | 3.04 | .72 | −0.23 | −3.46 | 3.00 | .89 |
| Ethnicity | | | | | | | | |
| Hispanic | | Reference | | | | Reference | | |
| Not Hispanic | 4.05 | −1.53 | 9.63 | .16 | −4.15 | −8.98 | 0.69 | .09 |
| Marital status | | | | | | | | |
| Married | | Reference | | | | Reference | | |
| Single | −0.30 | −3.31 | 2.71 | .85 | −1.44 | −4.05 | 1.18 | .28 |
| Age | −0.11 | −0.21 | −0.02 | .02* | 0.08 | −0.01 | 0.16 | .07 |
| *CPT* code | | | | | | | | |
| 27766 | | Reference | | | | Reference | | |
| 27792 | 0.48 | −4.85 | 5.82 | .86 | 2.55 | −2.08 | 7.17 | .28 |
| 27814 | 0.74 | −4.35 | 5.83 | .78 | 0.53 | −3.88 | 4.94 | .82 |
| 27822 | 2.93 | −2.44 | 8.30 | .29 | −3.22 | −7.87 | 1.44 | .18 |
| 27823 | −1.24 | −7.48 | 5.00 | .70 | 3.57 | −1.83 | 8.98 | .20 |
| Insurance | | | | | | | | |
| Commercial | | Reference | | | | Reference | | |
| Other | −1.02 | −3.90 | 1.85 | .49 | 2.04 | −0.45 | 4.53 | .11 |
| BMI | 0.20 | 0.01 | 0.39 | .04* | −0.16 | −0.32 | 0.00 | .05 |
| Number of Underlying Conditions | | | | | | | | |
| 0 | | Reference | | | | Reference | | |
| 1 | −0.71 | −4.19 | 2.77 | .69 | 1.68 | −1.35 | 4.70 | .28 |
| ≥2 | −2.62 | −7.93 | 2.69 | .33 | 3.46 | −1.15 | 8.07 | .14 |

Abbreviations: BMI, body mass index; *CPT*, *Current Procedural Terminology*.
*Statistically significant ($P < .05$).

patient outcomes themselves,[32] as well improve postoperative satisfaction.[16]

The impact of mental health, especially depression, on clinical outcomes in orthopaedic surgery is well documented.[3,6,19,21,28] However, we sought to move beyond this common knowledge by better understanding the association of moderate or high levels of depression, defined in our primary analysis as a PROMIS Depression score ≥ 60, occurring at different time frames during the recovery phase following operative management of ankle fractures. Moderate or high levels of depressive symptoms were associated with worse PROMIS PF and PI scores at the preoperative visit, as well as at each time frame following, compared with low levels of depressive symptoms. However, and important to note, patients with moderate or high levels of depressive symptoms still demonstrated clinically appreciable functional and pain improvement (ie, they achieve MCID), albeit not to the same extent as those with low levels of depressive symptoms. This is consistent with prior literature in hip, knee, and shoulder total joint

**Table 4.** Evaluation of the Functional (ie, PROMIS PF) Recovery Trajectory of Patients With Ankle Fractures Undergoing Operative Management When Considering Different PROMIS Depression Cut-Offs.

| | Depression Cutoff: 55 | | | | Depression Cutoff: 65 | | | |
|---|---|---|---|---|---|---|---|---|
| | β | Lower CI (α = 0.05) | Upper CI (α = 0.05) | *P* Value | β | Lower CI (α = 0.05) | Upper CI (α = 0.05) | *P* Value |
| Depression | | | | | | | | |
| Low (≤cutoff) | | Reference | | | | Reference | | |
| High (>cutoff) | −3.04 | −5.63 | −0.45 | .02* | −5.26 | −9.73 | −0.80 | .02* |
| Month | | | | | | | | |
| 0 | | Reference | | | | Reference | | |
| >0, ≤3 | −0.91 | −2.50 | 0.67 | .26 | −0.91 | −2.50 | 0.68 | .26 |
| >3, ≤6 | 9.97 | 7.98 | 11.95 | <.01* | 9.96 | 7.98 | 11.94 | <.01* |
| >6 | 12.37 | 10.10 | 14.64 | <.01* | 12.36 | 10.09 | 14.63 | <.01* |
| Gender | | | | | | | | |
| Female | | Reference | | | | Reference | | |
| Male | 2.02 | −0.56 | 4.60 | .13 | 2.25 | −0.31 | 4.80 | .09 |
| Race | | | | | | | | |
| Not White | | Reference | | | | Reference | | |
| White | −0.39 | −4.13 | 3.36 | .84 | −0.99 | −4.78 | 2.79 | .61 |
| Ethnicity | | | | | | | | |
| Hispanic | | Reference | | | | Reference | | |
| Not Hispanic | 4.09 | −1.53 | 9.71 | .15 | 3.26 | −2.40 | 8.91 | .26 |
| Marital status | | | | | | | | |
| Married | | Reference | | | | Reference | | |
| Single | −0.77 | −3.77 | 2.23 | .62 | −1.17 | −4.18 | 1.84 | .45 |
| Age | −0.12 | −0.21 | −0.02 | .02* | −0.12 | −0.22 | −0.03 | .01* |
| *CPT* code | | | | | | | | |
| 27766 | | Reference | | | | Reference | | |
| 27792 | 0.55 | −4.82 | 5.92 | .84 | 0.25 | −5.12 | 5.62 | .93 |
| 27814 | 1.07 | −4.04 | 6.18 | .68 | 0.48 | −4.68 | 5.63 | .86 |
| 27822 | 2.55 | −2.90 | 8.00 | .36 | 2.73 | −2.70 | 8.16 | .32 |
| 27823 | −1.16 | −7.45 | 5.13 | .72 | −2.13 | −8.41 | 4.16 | .51 |
| Insurance | | | | | | | | |
| Commercial | | Reference | | | | Reference | | |
| Other | −1.10 | −4.00 | 1.79 | .46 | −0.96 | −3.87 | 1.96 | .52 |
| BMI | 0.18 | −0.01 | 0.37 | .06 | 0.20 | 0.01 | 0.39 | .04* |
| Number of underlying conditions | | | | | | | | |
| 0 | | Reference | | | | Reference | | |
| 1 | −0.52 | −4.02 | 2.98 | .77 | −0.76 | −4.28 | 2.75 | .67 |
| ≥2 | −2.22 | −7.58 | 3.14 | .42 | −2.45 | −7.80 | 2.90 | .37 |

Abbreviations: BMI, body mass index; *CPT*, *Current Procedural Terminology*; PF, Physical Function; PROMIS, Patient-Reported Outcomes Measurement Information System.
*Statistically significant ($P < .05$).

arthroplasty.[10,34] Unique to our study is that ankle fractures are not prescheduled, elective surgical procedures; therefore, even in the setting of traumatic injury, this important finding is present.

Although the moderate to high depressive symptoms cut-off we used is noted in the literature,[4,5] we believe it is important to conduct a sensitivity analysis to ensure our findings are consistent across a variety of cut-off values surgeons may use. Specifically, we wanted to utilize 5-point increments, which is half of the designed PROMIS domains SD, to align with a commonly used MCID estimate approach of one-half of 1 SD.[22] When doing so, we found our findings were generally consistent with those found with our initial moderate to high depressive symptoms cut-off of a PROMIS Depression score ≥ 60. The one exception was PROMIS PI with a PROMIS Depression cut-off of ≥65; in this setting, moderate to high depressive symptoms were not found to be associated with worse

**Table 5.** Evaluation of the Pain (ie, PROMIS PI) Recovery Trajectory of Patients With Ankle Fractures Undergoing Operative Management When Considering Different PROMIS Depression Cut-Offs.

| | Depression Cutoff: 55 | | | | Depression Cutoff: 65 | | | |
|---|---|---|---|---|---|---|---|---|
| | β | Lower CI (α = 0.05) | Upper CI (α = 0.05) | *P* Value | β | Lower CI (α = 0.05) | Upper CI (α = 0.05) | *P* Value |
| Depression | | | | | | | | |
| Low (≤cutoff) | | Reference | | | | Reference | | |
| High (>cutoff) | 3.60 | 1.39 | 5.81 | <.01* | 3.12 | −0.77 | 7.01 | .12 |
| Month | | | | | | | | |
| 0 | | Reference | | | | Reference | | |
| >0, ≤3 | −3.64 | −4.89 | −2.38 | <.01* | −3.64 | −4.89 | −2.38 | <.01* |
| >3, ≤6 | −10.30 | −11.87 | −8.73 | <.01* | −10.30 | −11.87 | −8.72 | <.01* |
| >6 | −10.29 | −12.09 | −8.49 | <.01* | −10.28 | −12.08 | −8.48 | <.01* |
| Gender | | | | | | | | |
| Female | | Reference | | | | Reference | | |
| Male | −0.34 | −2.54 | 1.86 | .76 | −0.78 | −3.00 | 1.44 | .49 |
| Race | | | | | | | | |
| Not White | | Reference | | | | Reference | | |
| White | −0.47 | −3.67 | 2.72 | .77 | −0.11 | −3.40 | 3.19 | .95 |
| Ethnicity | | | | | | | | |
| Hispanic | | Reference | | | | Reference | | |
| Not Hispanic | −4.20 | −8.98 | 0.58 | .08 | −3.67 | −8.58 | 1.25 | .14 |
| Marital status | | | | | | | | |
| Married | | Reference | | | | Reference | | |
| Single | −1.12 | −3.68 | 1.44 | .39 | −0.80 | −3.42 | 1.82 | .55 |
| Age | 0.08 | 0.00 | 0.16 | .06 | 0.08 | 0.00 | 0.16 | .06 |
| *CPT* code | | | | | | | | |
| 27766 | | Reference | | | | Reference | | |
| 27792 | 2.43 | −2.14 | 7.00 | .30 | 2.70 | −1.97 | 7.37 | .26 |
| 27814 | 0.38 | −3.96 | 4.73 | .86 | 0.55 | −3.93 | 5.03 | .81 |
| 27822 | −2.55 | −7.18 | 2.09 | .28 | −3.21 | −7.93 | 1.50 | .18 |
| 27823 | 3.31 | −2.04 | 8.66 | .23 | 4.17 | −1.30 | 9.63 | .13 |
| Insurance | | | | | | | | |
| Commercial | | Reference | | | | Reference | | |
| Other | 1.85 | −0.61 | 4.31 | .14 | 2.14 | −0.40 | 4.68 | .10 |
| BMI | −0.14 | −0.30 | 0.02 | .08 | −0.16 | −0.32 | 0.01 | .06 |
| Number of underlying conditions | | | | | | | | |
| 0 | | Reference | | | | Reference | | |
| 1 | 1.65 | −1.34 | 4.63 | .28 | 1.61 | −1.45 | 4.68 | .30 |
| ≥2 | 2.92 | −1.65 | 7.50 | .21 | 3.39 | −1.27 | 8.05 | .15 |

Abbreviations: BMI, body mass index; *CPT*, *Current Procedural Terminology*; PI, Pain Interference; PROMIS, Patient-Reported Outcomes Measurement Information System.
*Statistically significant ($P < .05$).

PROMIS PI scores. However, we believe this is due to the limited number of patients with such scores in the 3-6 months postoperative bin (n = 7) and >6 months postoperative bin (n = 7). Further work with larger numbers would be needed to verify that our findings are, in fact, due to this one subanalysis being underpowered. Lastly, although some may argue that keeping PROMIS Depression as a continuous variable is preferred, we would counter by noting that unless a change in score meets an MCID estimate, that value is likely not clinically useful. Indeed, by conducting a sensitivity analysis with PROMIS scores varying by 5 points, we believe we have captured the key takeaway messages in the most usable format. Further, from a statistical standpoint, the relationship between PROMIS Depression scores and PROMIS PF and PI scores could be nonlinear. This is an important concept to consider because nonlinearity can only be captured by a categorical specification.

Our study has limitations. First, our patient sample was taken from a single urban, academic, level I trauma center. Thus, our findings may not be generalizable to all settings. However, because one of the inclusion criteria was the presence of preoperative PROMIS scores, polytrauma and emergency cases that did not have a clinic visit prior to surgery would not have been included. Therefore, the patient cases that were included are likely more representative of the general ankle fracture population. Second, because of the limitations of our institutional database, we grouped all ankle fractures into a single patient sample. It is possible that the recovery trajectory is impacted by the type of ankle fracture, as measured by the AO/OTA Classification, for example. However, we believe that the general recovery pattern is likely similar, which is supported in the literature as well.[9] Further, all ankle fractures in our study were operatively managed. Additionally, previous studies have also evaluated clinical outcomes across multiple different ankle fracture types as a single patient sample.[8,23] Indeed, we believe this study provides a crucial framework on expected recovery patterns and lays the groundwork for future, more specific studies in this area. Third, we do not have the ability to assess each included patient's education level or employment type. We are also unable to assess whether included patients have an official diagnosis of depression (and/or other mental illnesses) and are being treated for such diagnoses. However, our sample was derived from a diverse population, and we believe these characteristics would not impact the overall trends appreciated. Fourth, we do not have complete PROMIS data for every patient at every follow-up time point, and our sample size (N) decreased to 58 patients by the final follow-up time point. The linear mixed effects regression models approach allows for missing data and is recognized as a preferred statistical approach capable of using all or nearly all available data in a clinical repeated measures design, such as a recovery pattern.[17] Therefore, we believe our approach and findings offer notable value in understanding recovery following operative management of ankle fractures and the association of moderate and high depressive symptoms on that expected recovery more robustly.

Overall, our study helps provide trauma and foot and ankle surgeons an estimate of the recovery trajectory for patients undergoing operative management for ankle fractures. Further, we assess the association of mental health on this recovery trajectory, finding that patients with moderate to high depressive symptoms still improve from surgery for ankle fractures but not to the same extent as those with low depressive symptoms. We believe this is an important patient group to analyze because of the unexpected nature of ankle fractures. Future research on this topic that assesses patients with ankle fractures undergoing nonoperative management is warranted. Further, future work should seek to understand whether efforts to optimize mental health well-being in patients with moderate or high depressive symptoms preoperatively would lead to functional and pain improvements postoperatively that are more similar to those of patients without such depressive symptoms. If this is the case, the impact of behavioral health initiatives along with physical therapy for musculoskeletal recovery may be worth delaying surgery to improve clinical outcomes for such patients. Nonetheless, our current findings can help improve patient expectation settings preoperatively, guide shared clinical decision-making discussions, and assist in the monitoring of expected patient recovery following operative management for an ankle fracture.

## Ethical Approval

This project was approved by the University of Rochester Medical Center (STUDY00000958).

## Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. ICMJE forms for all authors are available online.

## Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

## ORCID iDs

David N. Bernstein, MD, MBA, MA, https://orcid.org/0000-0002-1784-3288
Irvin C. Oh, MD, https://orcid.org/0000-0002-2648-5849
John P. Ketz, MD, https://orcid.org/0000-0002-8327-9638
Judith F. Baumhauer, MD, MPH, https://orcid.org/0000-0003-2142-7778

## References

1. Baumhauer JF. Patient-reported outcomes - are they living up to their potential? *N Engl J Med*. 2017;377(1):6-9.
2. Cella D, Yount S, Rothrock N, et al. The Patient-Reported Outcomes Measurement Information System (PROMIS): progress of an NIH Roadmap cooperative group during its first two years. *Med Care*. 2007;45(5 suppl 1):S3-S11.
3. Chen YP, Huang YY, Wu Y, Kuo YJ, Lin CY. Depression negatively affects patient-reported knee functional outcome after intraarticular hyaluronic acid injection among geriatric patients with knee osteoarthritis. *J Orthop Surg Res*. 2019;14(1):387.
4. Choi SW, Podrabsky T, McKinney N, Schalet BD, Cook KF, Cella D. *PROMIS Depression and PHQ-9. PROSetta® Stone Analysis Report: A Rosetta Stone for Patient Reported Outcomes*. Vol 1. Department of Medical Social Sciences, Feinberg School of Medicine, Northwestern University; 2012.
5. Clover K, Lambert SD, Oldmeadow C, et al. PROMIS depression measures perform similarly to legacy measures relative

to a structured diagnostic interview for depression in cancer patients. *Qual Life Res*. 2018;27(5):1357-1367.
6. Crijns TJ, Bernstein DN, Ring D, Gonzalez RM, Wilbur DM, Hammert WC. Depression and pain interference correlate with physical function in patients recovering from hand surgery. *Hand (N Y)*. 2019;14(6):830-835.
7. Elsoe R, Ostgaard SE, Larsen P. Population-based epidemiology of 9767 ankle fractures. *Foot Ankle Surg*. 2018;24(1):34-39.
8. Garratt AM, Naumann MG, Sigurdsen U, Utvåg SE, Stavem K. Evaluation of three patient reported outcome measures following operative fixation of closed ankle fractures. *BMC Musculoskelet Disord*. 2018;19(1):134.
9. Gilley J, Bell R, Lima M, et al. Prospective patient reported outcomes (PRO) study assessing outcomes of surgically managed ankle fractures. *Foot Ankle Int*. 2020;41(2):206-210.
10. Halawi MJ, Cote MP, Singh H, et al. The effect of depression on patient-reported outcomes after total joint arthroplasty is modulated by baseline mental health: a registry study. *J Bone Joint Surg Am*. 2018;100(20):1735-1741.
11. HealthMeasures. PROMIS®. 2020. Accessed May 21, 2020. http://www.healthmeasures.net/score-and-interpret/interpret-scores/promis
12. Ho B, Houck JR, Flemister AS, et al. Preoperative PROMIS scores predict postoperative success in foot and ankle patients. *Foot Ankle Int*. 2016;37(9):911-918.
13. Hung M, Baumhauer JF, Licari FW, Voss MW, Bounsanga J, Saltzman CL. PROMIS and FAAM minimal clinically important differences in foot and ankle orthopedics. *Foot Ankle Int*. 2019;40(1):65-73.
14. Hunt KJ, Alexander I, Baumhauer J, et al. The Orthopaedic Foot and Ankle Outcomes Research (OFAR) network: feasibility of a multicenter network for patient outcomes assessment in foot and ankle. *Foot Ankle Int*. 2014;35(9):847-854.
15. Juto H, Nilsson H, Morberg P. Epidemiology of adult ankle fractures: 1756 cases identified in Norrbotten County during 2009-2013 and classified according to AO/OTA. *BMC Musculoskelet Disord*. 2018;19(1):441.
16. Kahlenberg CA, Nwachukwu BU, McLawhorn AS, Cross MB, Cornell CN, Padgett DE. Patient satisfaction after total knee replacement: a systematic review. *HSS J*. 2018;14(2):192-201.
17. Kwon SS, Lee KM, Chung CY, Lee SY, Park MS. An introduction to the linear mixed model for orthopaedic research. *JBJS Rev*. 2014;2(12):e5.
18. Lindsjö U. Operative treatment of ankle fractures. *Acta Orthop Scand Suppl*. 1981;189:1-131.
19. Martin RL, Christoforetti JJ, McGovern R, et al. The impact of depression on patient outcomes in hip arthroscopic surgery. *Orthop J Sports Med*. 2018;6(11):2325967118806490.
20. McPhail SM, Dunstan J, Canning J, Haines TP. Life impact of ankle fractures: qualitative analysis of patient and clinician experiences. *BMC Musculoskelet Disord*. 2012;13:224.
21. Meijer DT, Gevers Deynoot BDJ, Stufkens SA, et al. What factors are associated with outcomes scores after surgical treatment of ankle fractures with a posterior malleolar fragment? *Clin Orthop Relat Res*. 2019;477(4):863-869.
22. Norman GR, Sloan JA, Wyrwich KW. The truly remarkable universality of half a standard deviation: confirmation through another look. *Expert Rev Pharmacoecon Outcomes Res*. 2004;4(5):581-585.
23. Obremskey WT, Dirschl DR, Crowther JD, Craig WL 3rd, Driver RE, LeCroy CM. Change over time of SF-36 functional outcomes for operatively treated unstable ankle fractures. *J Orthop Trauma*. 2002;16(1):30-33.
24. Papuga MO, Dasilva C, McIntyre A, Mitten D, Kates S, Baumhauer JF. Large-scale clinical implementation of PROMIS computer adaptive testing with direct incorporation into the electronic medical record. *Health Syst (Basingstoke)*. 2018;7(1):1-12.
25. Pincus D, Veljkovic A, Zochowski T, Mahomed N, Ogilivie-Harris D, Wasserstein D. Rate of and risk factors for intermediate-term reoperation after ankle fracture fixation: a population-based cohort study. *J Orthop Trauma*. 2017;31(10):e315-e320.
26. Porter DA, May BD, Berney T. Functional outcome after operative treatment for ankle fractures in young athletes: a retrospective case series. *Foot Ankle Int*. 2008;29(9):887-894.
27. Qin C, Dekker RG 2nd, Helfrich MM, Kadakia AR. Outpatient management of ankle fractures. *Orthop Clin North Am*. 2018;49(1):103-108.
28. Shakked R, McDonald E, Sutton R, Lynch MK, Nicholson K, Raikin SM. Influence of depressive symptoms on hallux valgus surgical outcomes. *Foot Ankle Int*. 2018;39(7):795-800.
29. Shibuya N, Davis ML, Jupiter DC. Epidemiology of foot and ankle fractures in the United States: an analysis of the National Trauma Data Bank (2007 to 2011). *J Foot Ankle Surg*. 2014;53(5):606-608.
30. Simanski CJ, Maegele MG, Lefering R, et al. Functional treatment and early weightbearing after an ankle fracture: a prospective study. *J Orthop Trauma*. 2006;20(2):108-114.
31. Simske NM, Audet MA, Kim C-Y, Benedick A, Vallier HA. Mental illness is associated with more pain and worse functional outcomes after ankle fracture. *OTA Int*. 2019;2(2):e037.
32. Swarup I, Henn CM, Gulotta LV, Henn RF 3rd. Patient expectations and satisfaction in orthopaedic surgery: a review of the literature. *J Clin Orthop Trauma*. 2019;10(4):755-760.
33. Van Son MAC, De Vries J, Zijlstra W, et al. Trajectories in quality of life of patients with a fracture of the distal radius or ankle using latent class analysis. *Qual Life Res*. 2017;26(12):3251-3265.
34. Werner BC, Wong AC, Chang B, et al. Depression and patient-reported outcomes following total shoulder arthroplasty. *J Bone Joint Surg Am*. 2017;99(8):688-695.

**Appendix A.** Patient Characteristics.

| | Excluded cohort | | Included cohort | | Total | | |
|---|---|---|---|---|---|---|---|
| | n = 258 | | n = 153 | | n = 411 | | |
| Characteristic | Mean or n | SD or % | Mean or n | SD or % | Mean or n | SD or % | *P* Value |
| Age, mean (SD) | 51 | 19 | 44 | 18 | 48 | 19 | <.001 |
| BMI, mean (SD) | 31 | 7 | 30 | 7 | 30 | 7 | .42 |
| Sex, n (%) | | | | | | | |
| Female | 140 | 54 | 80 | 52 | 220 | 54 | .77 |
| Male | 118 | 46 | 73 | 48 | 191 | 46 | |
| Race, n (%) | | | | | | | |
| Not White | 49 | 19 | 24 | 16 | 73 | 18 | .48 |
| White | 209 | 81 | 129 | 84 | 338 | 82 | |
| Ethnicity, n (%) | | | | | | | |
| Hispanic | 13 | 5 | 8 | 5 | 21 | 5 | .88 |
| Not Hispanic | 245 | 95 | 145 | 95 | 390 | 95 | |
| Marital status, n (%) | | | | | | | |
| Married | 104 | 40 | 64 | 42 | 168 | 41 | .84 |
| Single | 154 | 60 | 89 | 58 | 243 | 59 | |
| Insurance | | | | | | | |
| Commercial | 138 | 53 | 95 | 62 | 233 | 57 | .02 |
| Other | 120 | 47 | 58 | 38 | 178 | 43 | |
| Underlying conditions, n (%) | | | | | | | |
| 0 | 187 | 72 | 119 | 78 | 306 | 74 | .42 |
| 1 | 52 | 20 | 23 | 15 | 75 | 18 | |
| 2+ | 19 | 7 | 11 | 7 | 30 | 7 | |

Abbreviation: BMI, body mass index.