



## Article

# Impact of Resilience on Patient Reported Outcome of First Metatarsophalangeal Arthrodesis

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**Abstract:** Resilience is a dynamic construct defined as the ability to recover from stress. There is no literature examining the impact of resilience on outcomes following foot and ankle surgery. Retrospective analysis of patients who underwent first MTP arthrodesis from September 2011 to May 2020 were reviewed for patient characteristics and union status. PROMIS Physical Function (PF), Pain Interference (PI), Depression (D), and Foot Function Index (FFI) were collected. Resilience was measured using the Brief Resilience Scale. A multivariable linear regression analysis examining the impact of resilience on patient reported was conducted. At an average of 3.4 years postoperatively, resilience was found to independently affect patient reported outcomes across all instruments, except the FFI pain subscale. In the first study examining the impact of resilience following foot and ankle surgery, we found that resilience has an independent positive effect on overall physical function, disability, pain, and mental health following MTP arthrodesis. Preoperative resilience scores could be used to predict postoperative functional outcomes following MTP arthrodesis and guide postoperative rehabilitation. These findings help establish the role of early positive psychosocial characteristics within orthopaedic foot and ankle population.

**Keywords:** first metatarsophalangeal arthrodesis; MTP Fusion; PROMIS; resilience; FFI; Brief Resilience Scale; Foot Function Index



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## 1. Introduction

Resilience is an interactive dynamic construct that has been assigned numerous descriptions and definitions. Most simply, it is defined as the ability to recover from stress. This construct prognosticates outcomes by characterizing a patient's ability to positively adapt to adversity. Resilience has even been shown to affect outcomes including quality of life and suicide in military personnel [1]. While many would agree there is value in assessing such biopsychosocial factors prior to orthopaedic surgeries, the stigma associated with mental health concerns and surgeons' lack of comfort discussing these issues yields a significant barrier [2]. There is a considerable amount of research investigating resilience in response to stressors, and this topic is becoming increasingly popular in the orthopaedic surgery literature. This is in part due to literature showing high-resilience groups utilize healthcare significantly less than members of low-resilience groups [3]. Additionally, resilience has been shown to be correlated with positive surgical outcomes in orthopaedic procedures of the shoulder, knee, and spine [4–6]. To date, there is no literature examining the impact of resilience on the outcomes of foot and ankle surgery.

Patient reported outcome measures provide holistic evaluations of pre- and post-surgical satisfaction, level of function, pain, and mental health [7]. Legacy patient reported outcome measures, such as The Foot Function Index (FFI), have attempted to measure foot function in regard to pain, disability, and activity restriction across a wide variety of

foot and ankle pathologies [8,9]. While the FFI has proven to be reliable and valid, a new generation of patient reported outcome measures seek to minimize time and patient burden while capturing a wider snapshot of patients' health states. As a part of this new generation, the significant value of the Patient Reported Outcomes Measurement Information System (PROMIS) lies in its ability to detect and accurately categorize broad ranges of pain and functionality while minimizing patient test burden [10–12]. Multiple PROMIS domains have been validated for use in foot and ankle surgery patients, but still relatively few studies have implemented this system [13–21]. The positive patient psychometric trait of resilience can also be measured in a similar standardized fashion using the Brief Resilience Scale (BRS) that has been shown to be reliable in patients of all ages [1,22].

In orthopaedic foot and ankle surgery, fusion of the metatarsophalangeal joint of the hallux (MTP arthrodesis) is a very common and reliable procedure for several pathologies including hallux rigidus, hallux valgus, and hallux varus [23,24]. Multiple case series reported excellent objective results of this procedure, with union rates between 88% and 100% [23]. Most studies of MTP arthrodesis to date have failed to consider patient reported outcome measures with the combined physician reported American Orthopaedic Foot and Ankle Society (AOFAS) scores being the most widely reported [23]. While the AOFAS scores have been widely used, the scoring system has never been validated and possesses low reliability [25]. As a result, several recently published studies have utilized the Short Form Health Status Survey (SF-36), Foot and Ankle Ability Measures (FAAM), or the Foot Function Index (FFI) as validated instruments to evaluate patient reported outcomes after MTP arthrodesis [26–29]. No study to date has utilized the new PROMIS computer adaptive outcomes measure to examine the outcomes of first MTP arthrodesis.

The purpose of this study is to investigate the relationship between patient-reported outcomes and resilience following metatarsophalangeal fusion of the hallux. We hypothesized that patients with higher resilience would report more favorable FFI and PROMIS scores due to their increased ability to cope and recover from such a stressor.

## 2. Materials and Methods

After obtaining appropriate IRB approval, a review of patients undergoing MTP arthrodesis from September 2011 to May 2020 at a single institution was conducted. A total of 221 patients were identified by use of relevant CPT codes. All operations were completed by a single fellowship trained foot and ankle surgeon. Patients receiving revision MTP arthrodesis, possessing concurrent ipsilateral infection, lacking at least 6 months of clinical follow-up, or lacking response to a patient reported outcome surveys were excluded from this study. Of the 227 patients who underwent MTP arthrodesis, 36 patients had inadequate clinical follow up, leaving 185 for potential inclusion in this study. A total of 101 patients (54.5%) responded to the patient reported outcome questionnaire required for inclusion. Three patients received revisional MTP arthrodesis and were excluded, leaving a final cohort of 98 patients and 98 feet.

The surgical technique was consistent throughout the cohort. The senior author used a standard dorsal approach to the first MTP joint, and then the corresponding joint surfaces were prepared with cup and cone shaped power reamers. After desired deformity correction was achieved, a Kirschner wire was placed to temporarily fixate the MTP joint while a dorsal plate fixation construct was applied. In most patients, an interfragmentary screw was placed across the MTP joint to provide additional compression of the cancellous surfaces (Figure 1). All patients were kept partial weightbearing as tolerated immediately after surgery in a forefoot offloading post-op shoe with heel and transitioned to full weight bearing at 6 weeks postoperatively. Sutures were removed at the 2-week postoperative appointment and radiographs were obtained at 2, 6, and 12 weeks, 6 months, and 12 months postoperatively.



**Figure 1.** Representative image of patient achieving union after MTP arthrodesis with dorsal locking plate and interfragmentary screw. Frames (A–C) show preoperative weight-bearing views of the foot. Frames (D–F) show postoperative weightbearing views of the foot with evident bony union.

Information of interest regarding relevant demographics, comorbidities, substance use, concomitant procedures, and surgical techniques used were collected from each patient's electronic medical records. The 1st Intermetatarsal angle (IMA), Hallux Valgus angle (HVA), and dorsiflexion angle of the 1st hallux were recorded at preoperative and final radiographic follow up. Union status was determined by the presence of bridging callus on at least 3 cortices in 2 orthogonal views, lack of tenderness over fusion site, and painless weight bearing. All suspected non-unions were confirmed with use of computed tomography (CT) scans. Complications including infection, wound dehiscence, and reoperation were recorded.

PROMIS Pain Interference, PROMIS Physical Function, PROMIS Depression, Brief Resilience Scale (BRS), and Foot Function Index (FFI) were collected via telephone postoperatively. Three contact attempts were made before a patient was considered a nonrespondent. The administration of these surveys via telephone has been verified as an acceptable means of obtaining pertinent information from patients, particularly in those who are considered hard-to-reach or otherwise unavailable for in-person visits [30]. Furthermore, the use of telephone surveys can decrease the travel and time burden on patients.

The Brief Resilience Scale was created to measure the positive psychometric trait of resilience defined as "One's ability to bounce back from stress." The six-question questionnaire is graded on a five-point Likert scale with 3 out of the 6 questions scored in reverse (scores are then averaged against the number of questions answered). The BRS has shown excellent psychometric properties in both healthy individuals and those with chronic disease [1,22]. Population studies have suggested the average score is 3.7 with a score of less than 3 defining low resilience and greater than 4.3 defining high resilience [1].

The PROMIS Physical Function (v1.2), Pain Interference (v1.1), PROMIS Depression (v1.0) domains were created using modern item response theory to enable quantification and stratification of patients across a wide spectrum of these underlying variables [31]. Computer adaptive testing allows these measures to draw from a large set of questions (121 for Physical Function, 40 for Pain Interference, and 28 for Depression) and customize each survey to the individual participant based on their prior responses [32]. PROMIS scores

of 50 represent a population average with a standard deviation of 10. The interpretation of PROMIS scores depends on the connotation of the given characteristic measured. For example, a high physical function score would be viewed positively (increased function), while conversely a high pain interference score (more pain) would be viewed as a negative outcome [31,32].

The FFI is a 23-question instrument originally developed in 1991 for evaluation of foot function in patients with rheumatoid arthritis using classical test theory [33]. Questions are scored on a scale of 0–10 and summed for each subscale. The summed total is divided by the total possible score for each section. Scores of 0 indicate the least amount of pain and disability with severity increasing sequentially.

Data was compiled in Microsoft Excel and entered in SAS for statistical analysis. After checking for normality using a Shapiro–Wilk test, bivariate correlations of continuous variables (including resilience scores) with PROMIS and FFI scores were completed using Spearman rank tests. The effect of categorical variables on PROMIS and FFI scores was investigated using Mann–Whitney U tests. A separate multiple linear regression model was constructed for each PROMIS and FFI outcome measures. Time from surgery to patient reported outcome score collection was chosen for inclusion in all regression models a priori. Other variables were chosen for inclusion in the regression models based on an a priori criterion of  $p \leq 0.05$  in bivariate analysis for each outcome score. Regression results are presented as unstandardized beta values reflecting the change in outcomes variable per unit increase in the given predictor variable. Outcome variables were also compared using regression model adjusted means between resilience groups.

### 3. Results

#### 3.1. Clinical Outcomes

The average age of the 73 females and 25 males in this study was 58.4 with a standard deviation of 11.3 (Range 23 to 80 years old). The average BMI was 30.7 with a standard deviation of 6.3. The indication for surgery was Hallux Valgus in 50 patients (51%), Hallux Rigidus in 41 patients (42%), and Hallux Varus in 7 (7%) patients. The prevalence of comorbidities, various other patient characteristics, and concomitant procedures are reported in Table 1. Interfragmentary compression screws were used in 74 (76%) patients with all patients receiving locked dorsal fixation plates. The average postoperative hallux valgus angle  $16.1^\circ \pm 10.5^\circ$  (SD) degrees compared with  $25.7^\circ \pm 19.0^\circ$  (SD) degrees preoperatively. The average postoperative intermetatarsal angle was  $10.1^\circ \pm 4.2^\circ$  (SD) compared to  $11.5^\circ \pm 5.1^\circ$  (SD) preoperatively. The average postoperative dorsiflexion angle was  $24.5^\circ \pm 17.1^\circ$  (SD). Bony union was present in 91 (93%) patients with 7 (7%) patients experiencing nonunion. A total of four (4%) of patients experienced a wound dehiscence and three patients had deep infections requiring prolonged antibiotic therapy. Revision surgery was required in a total of nine patients. Three patients had revision surgery due to deep infection and concomitant nonunion. Five patients had revision surgery for painful hardware and only one of these patients experienced nonunion before revision. One patient required revision surgery due to hardware failure after successful union was achieved. The average time from surgery to patient reported outcome administration was 3.4 years (2.65 SD, Range 0.4–8.4 years). Importantly, patient reported outcome scores were not correlated with time from surgery, but this potential confounder was still included in the multivariable regression modeling (Tables 2 and 3). Median PROMIS and FFI values for the cohort are also reported in Table 1. The median BRS score for all patients was 4.00 (IQR 0.54, Range (2.0–4.83)).

**Table 1.** Patient characteristics, frequency of concomitant procedures, clinical outcomes, and patient-reported outcomes.

Patient Factor	N (%) Unless Otherwise Noted	Patient Factor	N (%) Unless Otherwise Noted	Patient Factor	N (%) Unless Otherwise Noted
Age (Mean $\pm$ SD)	58.4 $\pm$ 11.4	ASA Class		Complications:	
BMI (Mean $\pm$ SD)	30.7 $\pm$ 6.3	1	2 (2%)	Wound Complication	6 (6%)
Sex		2	40 (41%)	Revision Surgery	
Female	73 (74%)	3	54 (55%)	Infection	3 (3%)
Male	25 (26%)	4	2 (2%)	Painful Hardware	5 (5%)
Isolated MTP Arthrodesis	56 (57%)	Tobacco Users	15 (15%)	Hardware Failure	1 (1%)
Concomitant Procedures		Hypertension	59 (60%)	Radiographic Union:	
Weil Osteotomy	23 (24%)	Diabetes Mellitus	15 (15%)	Union	91 (93%)
Hammer Toe Correction	14 (14%)	Hypothyroidism	11 (11%)	Nonunion	7 (7%)
PIP Arthroplasty	4 (4%)	Rheumatoid Arthritis	12 (12%)	Time from surgery to survey in years (Mean $\pm$ SD)	3.42 $\pm$ 0.65
Midfoot Arthrodesis	4 (4%)	COPD	5 (5%)	PROMIS Domain Scores (Median $\pm$ IQR)	
Gastrocnemius Recession	3 (3%)	CAD	6 (6%)	Physical Function	43.2 $\pm$ 14.7
EHL Augmentation	4 (4%)	Osteoporosis/Osteopenia	8 (8%)	Pain Interference	54.1 $\pm$ 14.4
Neuroma Excision	2 (2%)	Psychiatric Condition	21 (21%)	Depression	43.5 $\pm$ 17.6
Metatarsal Head Resection	7 (7%)	Immunosuppression	15 (15%)	FFI Scores (Median $\pm$ IQR)	
		Interfragmentary Screw	74 (75%)	Pain	27.5 $\pm$ 41.7
				Disability	34.4 $\pm$ 45.0
				Activity Limitation	10.0 $\pm$ 25.0
				Total	32.1 $\pm$ 43.1

**Table 2.** Bivariate tests for correlation and association for continuous variables with patient reported outcomes. Variables found to have a significant association with an outcomes score (indicated by bolding and an asterisk) were included in the respective multivariable regression model for the given outcome score. Bold text illustrates significant values.

Continuous Variables	PROMIS Physical Function R Value (p Value)	PROMIS Pain Interference R Value (p Value)	PROMIS Depression R Value (p Value)	FFI Pain R Value (p Value)	FFI Disability R Value (p Value)	FFI Activity Limitation R Value (p Value)	FFI Total R Value (p Value)
Age	−0.048 ( <i>p</i> = 0.636)	−0.016 ( <i>p</i> = 0.879)	−0.134 ( <i>p</i> = 0.190)	−0.135 ( <i>p</i> = 0.185)	−0.073 ( <i>p</i> = 0.476)	0.037 ( <i>p</i> = 0.720)	−0.070 ( <i>p</i> = 0.491)
BMI	−0.038 ( <i>p</i> = 0.710)	0.101 ( <i>p</i> = 0.325)	0.025 ( <i>p</i> = 0.808)	0.088 ( <i>p</i> = 0.387)	0.101 ( <i>p</i> = 0.387)	0.158 ( <i>p</i> = 0.120)	0.120 ( <i>p</i> = 0.238)
Preop HVA	−0.120 ( <i>p</i> = 0.240)	0.040 ( <i>p</i> = 0.695)	−0.045 ( <i>p</i> = 0.662)	0.055 ( <i>p</i> = 0.593)	0.109 ( <i>p</i> = 0.287)	0.059 ( <i>p</i> = 0.561)	0.076 ( <i>p</i> = 0.455)
Postop HVA	<b>−0.279 (<i>p</i> = 0.005) *</b>	0.142 ( <i>p</i> = 0.163)	0.105 ( <i>p</i> = 0.303)	0.101 ( <i>p</i> = 0.323)	0.141 ( <i>p</i> = 0.166)	0.158 ( <i>p</i> = 0.120)	0.129 ( <i>p</i> = 0.204)
Preop IMA	−0.096 ( <i>p</i> = 0.327)	−0.037 ( <i>p</i> = 0.720)	0.079 ( <i>p</i> = 0.440)	−0.078 ( <i>p</i> = 0.445)	0.017 ( <i>p</i> = 0.865)	0.002 ( <i>p</i> = 0.985)	−0.014 ( <i>p</i> = 0.894)
Postop IMA	−0.138 ( <i>p</i> = 0.175)	0.027 ( <i>p</i> = 0.788)	0.110 ( <i>p</i> = 0.281)	−0.026 ( <i>p</i> = 0.799)	−0.022 ( <i>p</i> = 0.831)	0.044 ( <i>p</i> = 0.668)	−0.010 ( <i>p</i> = 0.925)
Postop dorsiflexion angle	0.103 ( <i>p</i> = 0.313)	0.024 ( <i>p</i> = 0.818)	−0.182 ( <i>p</i> = 0.073)	−0.109 ( <i>p</i> = 0.284)	−0.115 ( <i>p</i> = 0.260)	−0.074 ( <i>p</i> = 0.467)	−0.124 ( <i>p</i> = 0.224)
Time from surgery to patient reported outcome collection	0.078 ( <i>p</i> = 0.447)	−0.061 ( <i>p</i> = 0.549)	−0.045 ( <i>p</i> = 0.663)	−0.115 ( <i>p</i> = 0.261)	−0.115 ( <i>p</i> = 0.259)	−0.069 ( <i>p</i> = 0.501)	−0.101 ( <i>p</i> = 0.325)
Resilience	<b>0.345 (<i>p</i> = 0.001) *</b>	<b>−0.244 (<i>p</i> = 0.015) *</b>	<b>−0.523 (<i>p</i> &lt; 0.001) *</b>	<b>−0.204 (<i>p</i> = 0.044) *</b>	<b>−0.413 (<i>p</i> &lt; 0.001) *</b>	<b>−0.391 (<i>p</i> &lt; 0.001) *</b>	<b>−0.380 (<i>p</i> &lt; 0.001) *</b>

**Table 3.** Results of linear regression modeling for independent predictors of patient reported outcomes instruments. The results for all covariables including unstandardized beta value, 95% confidence intervals, and associated *p*-values are presented for each variable included within the given outcome scores regression model. Variables found to be independently associated with each outcomes score are indicated by bolding and asterisk. Unstandardized beta values indicate the change in the outcome variable per unit change in the given predictor variable. Bold text illustrates significant values.

Covariates for PROMIS Physical Function		PROMIS Physical Function $\beta$	95% Confidence Interval	<i>p</i> Value
Weil Osteotomy		−3.7	−7.4 to 0.02	0.051
ASA Classification		−2.5	−5.3 to 0.312	0.081
Postop Hallux Valgus Angle		<b>−0.27 *</b>	<b>−0.43 to −0.12</b>	<b>0.001 *</b>
Hypertension		<b>−3.7 *</b>	<b>−7.0 to 0.02</b>	<b>0.021 *</b>
Time from surgery to patient reported outcome collection		−0.11	−0.73 to 0.52	0.737
Resilience		<b>5.1 *</b>	<b>2.6 to 7.6</b>	<b>&lt;0.001 *</b>
Covariates for PROMIS Pain Interference		PROMIS Pain Interference $\beta$	95% Confidence Interval	<i>p</i> Value
ASA Classification		2.9	−0.53 to 6.3	0.097
Tobacco		5.3	−0.12 to 10.7	0.055
CAD		8.0	−0.25 to 16.2	0.057
Wound Complication		4.3	−3.9 to 12.5	0.300
Time from surgery to patient reported outcome collection		−0.16	−0.92 to 0.59	0.665
Resilience		<b>−4.7 *</b>	<b>−7.8 to −1.6 *</b>	<b>0.004 *</b>
Covariates for PROMIS Depression		PROMIS Depression $\beta$	95% Confidence Interval	<i>p</i> Value
Weil Osteotomy		<b>6.0 *</b>	<b>1.1 to 10.8 *</b>	<b>0.016 *</b>
COPD		1.7	−8.3 to 11.7	0.743
Psychiatric Condition		2.4	−2.8 to 7.6	0.355
Time from surgery to patient reported outcome collection		0.34	−0.46 to 1.1	0.401
Resilience		<b>−9.7</b>	<b>−13.1 to −6.3 *</b>	<b>&lt;0.001 *</b>
Covariates for FFI Pain		FFI Pain $\beta$	95% Confidence Interval	<i>p</i> Value
EHL Augmentation		−16.9	−39.8 to 6.0	0.147
ASA Classification		4.5	−3.0 to 12.1	0.234
Tobacco Use		<b>15.4 *</b>	<b>3.7 to 27.2 *</b>	<b>0.011 *</b>
CAD		<b>22.3 *</b>	<b>4.6 to 39.9 *</b>	<b>0.014 *</b>
Psychiatric Condition		7	−3.4 to 17.4	0.187
Time from surgery to patient reported outcome collection		−0.36	−2.1 to 1.4	0.683
Resilience		−6.3	−13.0 to 0.45	0.067
Covariates for FFI Disability		FFI Disability $\beta$	95% Confidence Interval	<i>p</i> Value
Weil Osteotomy		6.7	−3.4 to 16.8	0.191
ASA Classification		4.8	−3.0 to 12.6	0.225
Tobacco Use		11.2	−1.1 to 23.5	0.074
Diabetes Mellitus		6.0	−6.2 to 18.3	0.330
COPD		3.6	−17.5 to 24.8	0.734
CAD		<b>21.7 *</b>	<b>3.4 to 39.9 *</b>	<b>0.021 *</b>
Wound Complication		20.6	−1.8 to 43.0	0.071
Nonunion		13.3	−7.0 to 33.6	0.195
Time from surgery to patient reported outcome collection		−1.1	−2.8 to 0.58	0.195
Resilience		<b>−12.2 *</b>	<b>−12.1 to −6.3 *</b>	<b>0.001 *</b>
Covariates for FFI Activity Limitation		FFI Activity Limitation $\beta$	95% Confidence Interval	<i>p</i> Value
ASA Classification		5.4	−2.8 to 13.5	0.193
Tobacco Use		5.2	−7.7 to 18.0	0.426
CAD		<b>39.6 *</b>	<b>20.1 to 59.2 *</b>	<b>&lt;0.001 *</b>
Wound Complication		1.2	−0.20.9 to 23.4	0.914
Revision Surgery		<b>25.1 *</b>	<b>6.3 to 44.0 *</b>	<b>0.010 *</b>
Covariates for PROMIS Physical Function		PROMIS Physical Function $\beta$	95% Confidence Interval	<i>p</i> Value
Time from surgery to patient reported outcome collection		−1.3	−3.2 to 0.57	0.171
Resilience		<b>−14.7 *</b>	<b>−7.4 to −22.1</b>	<b>&lt;0.001 *</b>
Covariates for FFI Total		FFI Total $\beta$	95% Confidence Interval	<i>p</i> Value
Weil Osteotomy		2.8	−6.3 to 12.0	0.543
ASA Classification		6.2	−0.74 to 13.1	0.079
Tobacco Use		<b>13.0 *</b>	<b>1.9 to 24.1 *</b>	<b>0.022 *</b>
COPD		3.2	−15.9 to 22.3	0.739
CAD		<b>26.9 *</b>	<b>10.3 to 43.4</b>	<b>0.002 *</b>
Wound Complication		14.2	−5.6 to 34.1	0.157
Nonunion		14.1	−4.3 to 32.5	0.131
Time from surgery to patient reported outcome collection		−1.1	−2.7 to 0.39	0.142
Resilience		<b>−10.6 *</b>	<b>−4.1 to −17.1 *</b>	<b>0.002 *</b>

### 3.2. Bivariate Analysis

Notably, postoperative resilience was correlated with all patient reported outcomes, including PROMIS Physical Function ( $r = .345$ ,  $p < 0.001$ ), PROMIS Pain Interference ( $r = -0.244$ ,  $p = 0.016$ ), PROMIS Depression ( $r = -0.523$ ,  $p < 0.001$ ), FFI Pain subscale ( $-0.204$ ,  $p = 0.044$ ), FFI Disability subscale ( $r = -0.413$ ,  $p < 0.001$ ), Activity Limitation subscale ( $r = -0.391$ ,  $p = 0.001$ ), and the Total FFI score ( $r = -0.380$ ,  $p < 0.001$ ) (Table 2).

### 3.3. Multivariate Linear Regression

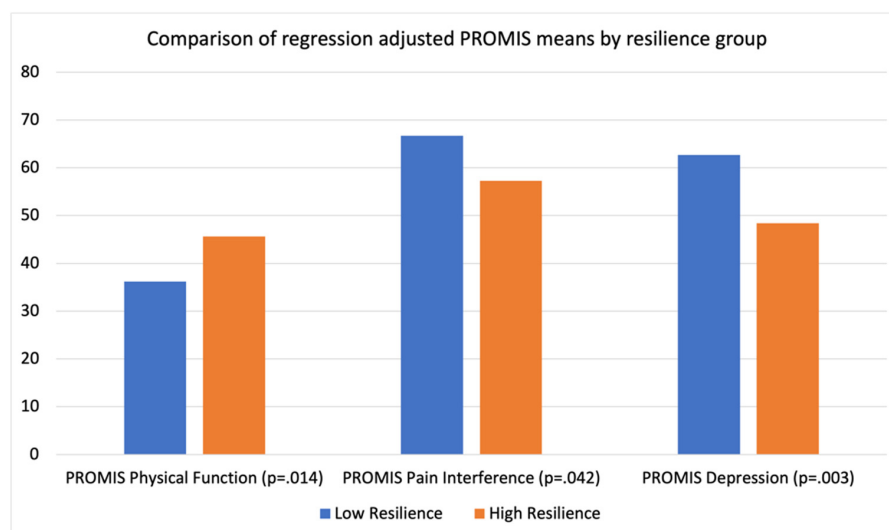
After controlling for multiple covariates, resilience was found to have an independent effect on patient outcomes across all instruments, except the FFI pain subscale (Table 3). The effect of resilience on the instruments was as follows: PROMIS physical function (Unstandardized  $\beta$  5.1, 95% CI 2.6 to 7.6), PROMIS pain interference (Unstandardized  $\beta$   $-4.7$ , 95% CI  $-7.8$  to  $-1.6$ ), PROMIS Depression (Unstandardized  $\beta$   $-9.7$ , (95% CI  $-13.1$  to  $-6.3$ ), FFI disability subscale (Unstandardized beta  $-12.2$ , 95% CI  $-19.4$  to  $-5.1$ ), FFI activity limitation subscale (Unstandardized beta  $-14.7$ , 95% CI  $-22.1$  to  $-7.4$ ), FFI total (Unstandardized beta  $-10.6$ , 95% CI  $-17.1$  to  $-4.1$ ), and FFI pain subscale (Unstandardized beta  $-6.3$ , 95% CI  $-13.0$  to  $0.45$ ).

### 3.4. Comparison of Low and High Resilience Groups Using Regression Model Adjusted Means

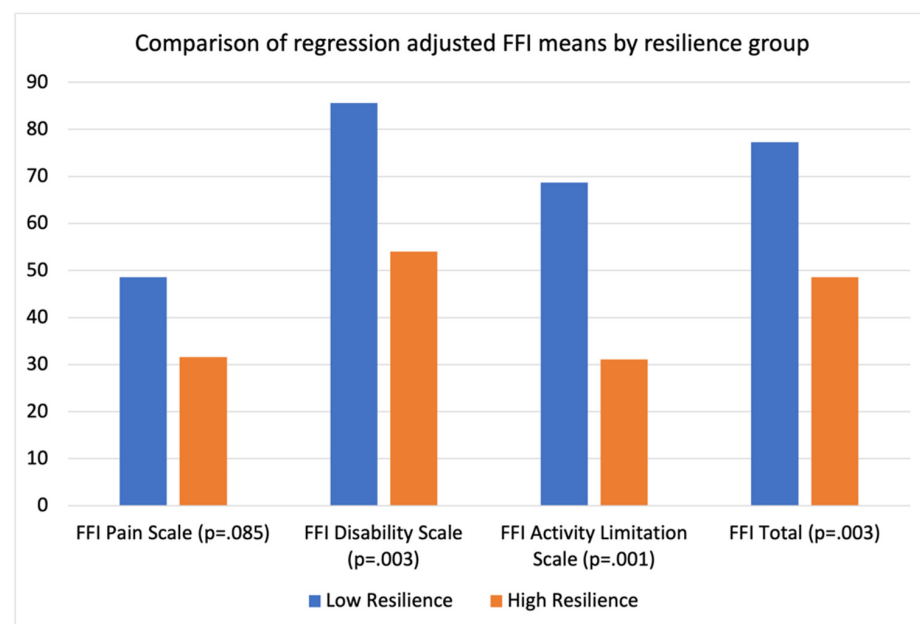
Patients were grouped by low resilience ( $n = 18$ , BRS  $< 3$ ), normal resilience ( $n = 74$ , BRS  $3-4.3$ ), and high resilience ( $n = 6$ , BRS  $> 4.3$ ). Outcome variables were compared by low and high resilience groups utilizing regression model adjusted means to adjust for potential confounders. The high resilience group had scores demonstrating significantly better function, pain, and depression levels compared to the low resilience group (Table 4, Figures 2 and 3).

**Table 4.** Comparisons of regression adjusted patient reported outcomes between low and high resilience groups. Bold text illustrates significant values.

Outcome Metric	Low Resilience (BRS $< 3$ ) Adjusted Means	High Resilience (BRS $> 4.3$ ) Adjusted Means	p-Value
PROMIS Physical Function	36.2	45.6	<b>0.014 *</b>
PROMIS Pain Interference	66.7	57.3	<b>0.042 *</b>
PROMIS Depression	62.7	48.4	<b>0.003 *</b>
FFI Pain Scale	48.6	31.6	<b>0.085</b>
FFI Disability Scale	85.6	54.0	<b>0.003 *</b>
FFI Activity Limitation Scale	68.7	31.1	<b>0.001 *</b>
FFI Total	77.3	48.6	<b>0.003 *</b>



**Figure 2.** PROMIS domains compared between low and high resilience groups.



**Figure 3.** FFI scales compared between low and high resilience groups.

#### 4. Discussion

Foot and ankle surgeons often face the challenge of preoperatively setting patient expectations for symptomatic and functional improvement following a surgical procedure. This challenge is magnified given the many variables, including patient demographics and comorbidities, playing a critical role in clinical improvement postoperatively. In addition to the impact of physical factors on surgical success, recent studies have given more attention to the impact of nonphysical patient-specific factors on treatment success [34,35]. Resilience is one of these patient-specific factors and has been studied in many stress-related medical conditions including cancer, post-traumatic stress disorders, and traumatic brain injury [36–38]. In addition to its benefit in those with severe chronic diseases, high levels of resilience have been associated with an increased ability to cope with chronic pain [1,22,39]. These properties illuminate the possibility that resilience could play a critical role in how patients respond to surgical intervention. Therefore, quantification of patient resilience with instruments, such as the Brief Resilience Scale, may be useful for determining patients at risk of poor recovery and directing postoperative management. This is the first study to investigate the impact of resilience on outcomes of first metatarsophalangeal arthrodesis, and more generally, the field of foot and ankle surgery. We found resilience to have a significant, independent effect on pain, disability, activity limitation, and physical function following MTP arthrodesis (Table 3). Not only was this effect statistically significant, but every unit increase in resilience led to an increase in PROMIS physical function (5.1 points) and decrease in PROMIS pain interference (4.7 points) indicating changes greater than these respective measure's known minimum clinically important difference (MCID) [15].

While this is the first study to examine resilience in foot and ankle surgery, Tokish et al. was the first study to evaluate the relationship between the BRS and outcomes after orthopaedic surgery. They found patients reporting higher resilience had better outcome scores, after total shoulder arthroplasty, compared to those with low resilience [4]. However, the analysis completed by Tokish et al. did not account for confounders by utilizing a comparison of regression adjusted means between high and low resilience groups. Our results show the association of positive outcomes with high resilience groups across almost all outcome measures after adjustment for covariates (Table 4 and Figures 2 and 3). Importantly, the differences between high and low resilience groups exceeded the minimum clinically important difference (MCID) for both PROMIS physical function (9.4 difference vs MCID of 4.6) and pain interference (9.4 difference vs MCID of 4.3) in foot and ankle surgery

patients. This demonstrates that not only are resilience groups statistically different, but there is a clinically significant difference in patient comfort and physical function between these two groups.

After Tokish et al.'s seminal work on resilience in shoulder arthroplasty, studies began to examine resilience across the spectrum of orthopaedics. In patients undergoing total knee arthroplasty, preoperative resilience was found to be positively associated with 3 and 12-month improvements in physical and mental health and quality of life, after controlling for patients' age, sex, and body mass index [5]. In addition, Coronado et al. found that early postoperative resilience and pain self-efficacy (the ability to cope with chronic pain and still perform physical activities) were associated with 12-month patient-reported outcomes after lumbar spine surgery [6]. Compared to our results, Coronado et al. found a higher correlation between resilience and PROMIS pain interference ( $r = -0.41$  vs.  $r = -0.24$ ) [6]. Unlike pain, our results for the relationship between resilience and PROMIS physical function were comparable ( $r = 0.37$  vs.  $r = 0.35$ ). The utility of PROMIS is demonstrated here as it offers a universal patient reported outcome that can be used across all specialties. In our study, we found a correlation between resilience and PROMIS and FFI domains in line with numbers published in shoulder and knee surgery using equivalent outcome measures [4,5]. Taken together, a growing body of evidence suggests that preoperative quantification of resilience has potential utility in identifying patients who may best recover from orthopaedic surgery across all orthopaedic subspecialties.

In addition to resilience effects on pain and physical function, our study adds to the body of evidence linking resilience with depression within the postsurgical setting [40]. Our results demonstrate a significant mental health gap between patients with high and low resilience (Table 4 and Figure 2). Depression has been shown to have a negative impact on the outcomes of numerous other common orthopaedic procedures, including shoulder and knee arthroplasty and hip fracture repair [41,42]. Additionally, depression has been shown to impact the outcomes following operative correction of hallux valgus, total ankle arthroplasty, and fracture repair within foot and ankle surgery [34,43,44]. The lack of resilience in depressed patients could potentially provide an explanation for why these patients often fare worse after these orthopaedic procedures, as they have limited capability to cope with stress. This mechanism has also been proposed within the setting of total joint arthroplasty and our study adds further support for novel interventions directly targeting patient resilience [40].

There is growing effort within the medical and mental health communities to develop interventions to increase resilience. A metaanalysis by Kim et al. found resilience training programs had a small to moderate effect in improving underlying resilience amongst patients with chronic disease [45]. Most interventions attempting to increase resilience utilized various forms of cognitive behavioral therapy, mindfulness training, or support therapy [46]. The primary focus of these interventions is to illuminate the assets patients possess to deal with stress. Outside of the healthcare setting, resilience programs in military families dealing with trauma have shown promise by improving multiple family adjustment and mental health measures [46]. While further work must be completed to fully understand how to improve patient resilience, our work illustrates the important effect such an intervention could have on surgical outcomes. We have demonstrated that small changes in resilience can have large effects on intermediate outcomes of MTP arthrodesis, and therefore, interventions inducing even minor changes in underlying longitudinal resilience may hold promise.

Finally, a comparison of our clinical results to existing literature is warranted. This cohort's outcomes after first MTP joint arthrodesis utilizing a dorsal locking plate and screw construct are similar to the published literature in terms of patient outcomes, union rates, and wound complications [28]. Most importantly, the fusion rate of 93% in our study is consistent with the 93.5% rate found in a systemic review of English literature from 2017 [23]. In terms of patient reported outcomes, most of our patients had little to no functional limitation postoperatively and were satisfied with their outcome (Table 1).

The PROMIS score domains, specifically, showed most patients were within one standard deviation of the population mean, 50+/-10, at intermediate term (>2 years) follow-up. While outcomes of MTP arthrodesis have been studied using different quality of life subscales such as SF-12 and the FAOS, only one published study has looked at the FFI and none have examined PROMIS scores [27,28]. To our knowledge, this is the first study examining the outcomes of first MTP arthrodesis utilizing the new PROMIS computer adaptive outcomes which have been shown to have superior reliability and responsiveness to multiple older functional scores commonly used in foot and ankle surgery [13,32]. Our results demonstrate PROMIS pain, function, and depression correlate with a traditional measure of lower extremity disability, FFI, in this population. The PROMIS scoring system is gaining popularity as it allows for applicability across many medical conditions and comparison with the population mean, and can be completed in less time decreasing patient burden.

## 5. Conclusions

Resilience has an independent positive effect on overall physical function, disability, pain, and mental health following MTP arthrodesis. Preoperative resilience scores could be used to predict outcomes following MTP arthrodesis and guide postoperative rehabilitation. These findings help establish the role of positive psychosocial characteristics within the orthopaedic foot and ankle population. Further study is warranted to determine whether low resilience can be modified and if such an intervention would result in improved postoperative outcomes.

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