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Association of Preoperative Physical Function and Changes in Mental Health After Minimally Invasive Transforaminal Lumbar Interbody Fusion

NATHANIEL W. JENKINS, MD[1]; JAMES M. PARRISH, MD, MPH[1]; CONOR P. LYNCH, MS[1]; ELLIOT D.K. CHA, MS[1]; CAROLINE N. JADCZAK, BS[1]; SHRUTHI MOHAN, BS[1]; CARA E. GEOGHEGAN, BS[1]; AND KERN SINGH, MD[1]

[1]*Department of Orthopaedic Surgery, Rush University Medical Center, 1611 W. Harrison St. Suite #300, Chicago, IL, 60612, USA*

ABSTRACT

Background: Few investigations have focused on the predictive value of Patient-Reported Outcomes Measurement Information System (PROMIS) scores, patient depression measured by the Patient Health Questionnaire-9 (PHQ-9), and their relationship in the setting of minimally invasive transforaminal lumbar interbody fusion (MIS TLIF). This study aims to detail the association between preoperative physical function with postoperative change in physical function and in depressive symptoms.

Methods: A prospectively maintained surgical registry was retrospectively reviewed from March 2016 to February 2019. Inclusion criteria were primary, single-level MIS TLIF procedures. Multilevel procedures and patients without PROMIS or PHQ-9 were excluded. Patients were grouped by preoperative PROMIS score (<35.0 and ≥35.0), with higher scores indicating greater physical function. A *t* test analyzed differences between PROMIS subgroups for operative time (skin incision to closure), estimated blood loss, length of stay, and discharge day. A *t* test also assessed the difference in PROMIS Physical Function (PF) and PHQ-9. Linear regression evaluated the relationship between pre- and postoperative PROMIS and PHQ-9.

Results: Of 119 patients, 53.8% were male and 47.9% were obese. The mean ± SD age was 52.2 ± 10.7 years. The PROMIS <35.0 group had a larger improvement of PROMIS scores compared to the PROMIS ≥35.0 group at 6 weeks, 12 weeks, and 6 months. There was a negative association between preoperative PROMIS and PROMIS score improvement at 6 weeks, 12 weeks, and 6 months. For all time points, improvement in PHQ-9 was not associated with preoperative PROMIS scores.

Conclusion: From 0 weeks to 6 months after MIS TLIF, patients with lower preoperative physical function had larger improvements in PROMIS PF scores. Preoperative function was not predictive of postoperative changes in PHQ-9. While relationships between mental and physical health cannot be discounted, the lack of PHQ-9 association with physical function demonstrates the impact that MIS TLIF can have, regardless of PROMIS PF score.

Clinical Relevance: Patients demonstrating lower levels of preoperative physical function may be in position for greater improvements in physical function following MIS TLIF surgery. In this study, there was no clear relationship between preoperative physical function levels and postoperative improvement in mental health, suggesting that all patients may achieve similar mental health improvement following MIS TLIF.

Level of Evidence: 3.

Minimally Invasive Surgery

Keywords: minimally invasive transforaminal lumbar interbody fusion, MIS TLIF, patient-reported outcomes measurement information system, PROMIS, Patient Health Questionnaire-9, Oswestry Disability Index, visual analog scale, Short Form-12

INTRODUCTION

Patient-reported outcomes (PRO), such as the Patient-Reported Outcomes Measurement Information System (PROMIS), are frequently utilized to evaluate postoperative changes in patients undergoing spinal and elective orthopedic procedures.[1,2] Previous research has investigated the relationship between preoperative physical function and postoperative physical function changes.[3] Several researchers have demonstrated a relationship between depression and decreased physical performance.[4,5] Furthermore, the perception of decreased physical function—independent of actual decreased physical function—may be associated with increased rates of depression in the elderly.[6]

The Patient Health Questionnaire-9 (PHQ), initially utilized as a part of the Primary Care Evaluation of Mental Disorders diagnostic instrument package, is a self-administered version of the depression module and has been utilized as a standardized means of depression evaluation.[7] The reliability and brevity of the PHQ-9 survey make it a common choice for diagnostic evaluation of patients.[8–10] The frequent use of both PROMIS-based assessments and PHQ-9 surveys among the same patient populations has led to an interest in understanding the association between these systems. Reflecting this interest, a new PROsetta Stone "crosswalk" tool has been created to convert between PROMIS and PHQ-9. While physical function scores have been investigated in association with patient depression, their relationship in the setting of patients undergoing minimally invasive transforaminal lumbar interbody fusion (MIS TLIF) has not yet been described.

To investigate physical function, the PROMIS Physical Function (PF) system is particularly advantageous because of its computer adaptive testing (CAT) system. This system allows for increased survey efficiency because the evaluation responds to patient answers and delivers appropriately tailored questions.[11] Although PROMIS, PROMIS PF, and PROMIS PF CAT all refer to different technical terms, throughout the rest of this manuscript, they all will refer to the score derived from the PROMIS PF CAT examination. Using these evaluations, this study will investigate the association between preoperative physical function (measured by PROMIS PF) with change in postoperative physical function and change in postoperative depression (measured by PHQ-9) in patients after MIS TLIF.

METHODS

Patient Population

An institutional review board–approved prospectively maintained surgical registry of patients undergoing spine surgery between March 2016 and February 2019 was retrospectively reviewed for eligible patients. Inclusion criteria were primary, single-level MIS TLIF procedures for degenerative pathology. Exclusion criteria included revisions, multilevel (<1) procedures, and missing preoperative PROMIS or PHQ-9 surveys. All patients were treated by a single surgeon at a single academic institution.

Data Collection

Patient demographics and baseline characteristics were recorded, including age, sex, body mass index (BMI), smoking status, insurance coverage (Medicare/Medicaid or Workers Compensation/Private), and Charlson Comorbidity Index (CCI). Preoperative comorbid conditions were recorded, including myocardial infarction, uncomplicated and complicated diabetes, hypertension, neurologic disease, arthritis, acquired immunodeficiency syndrome, paraplegia, congestive heart failure, peripheral vascular disease, liver failure, gastrointestinal bleeding, chronic obstructive pulmonary disease, renal failure, malignancy, and metastatic disease. PROMIS PF CAT surveys were administered using OBERD software system (Universal Research Solutions, Columbia, MO, USA). Preoperative PROMIS scores were recorded and patients were grouped by preoperative PROMIS score (≥35.0, <35.0), with higher scores indicating greater physical function. The 35.0 cut point was selected using previously defined divisions between "fair" (≥35.0) and "poor" (<35.0) subgroups.[12,13] PROMIS PF and PHQ-9 scores were recorded at the preoperative, 6-week, 12-week, 6-month, and 1-year time points. Perioperative characteristics were collected, including operative time (time from skin incision to closure), estimated blood loss (EBL), length of hospital stay, and discharge day.

Statistical Analysis

Stata 16.0 (StataCorp, College Station, TX, USA) was used to perform a χ^2 analysis to detect associations of PROMIS subgroups in the following demographic perioperative variables: gender, smoking status, diagnosis, BMI, and insurance coverage. A Student *t* test was used for continuous demographic variables: age, preoperative PHQ-9, and CCI. A Student *t* test was used to analyze differences between PROMIS subgroups for the continuous operative variables: operative time, EBL, length of hospital stay, and discharge day. Mean PROMIS and PHQ-9 scores at all time points were evaluated using a *t* test to detect a difference between PROMIS subgroups. Postoperative improvement (postop-preop) was evaluated using a Student *t* test to detect a difference between groups for PROMIS and PHQ-9 at preoperative and postoperative (6 weeks, 12 weeks, 6 months, and 1 year) time points.[2] Patients who did not fill out a survey at a time point were removed from that time point's analysis. Finally, other PRO measures were used to validate our improvement findings among the 2 PROMIS subgroups. PROs included for validation purposes were Oswestry Disability Index (ODI), visual analog scale (VAS)-back, VAS-leg, Short Form-12 (SF-12) Mental, and SF-12 Physical. GraphPad Prism 8.0 for Mac (La Jolla, CA, USA) was used to perform a linear regression to evaluate the relationship between preoperative PROMIS scores and postoperative PROMIS or PHQ-9 score improvements. Additionally, the influence of PROMIS score improvement on PHQ-9 score improvement was also evaluated using linear regression. Finally, statistical significance was set at $P < 0.05$.

Table 1. Patient demographics by PROMIS score.

Demographic	Total (*N* = 119)	PROMIS ≥35 (*n* = 55)	PROMIS <35 (*n* = 64)	*P* Value[a]
Age (mean + SD)	52.2 ± 10.7	51.7 ± 11.6	52.6 ± 10.0	0.619
Gender, n (%)				0.002
Female	55 (46.2%)	17 (31.0%)	38 (59.4%)	
Male	64 (53.8%)	38 (69.0%)	26 (40.6%)	
Body mass index, n (%)				0.002
Nonobese (<30 kg/m^2)	62 (52.1%)	37 (67.3%)	25 (39.1%)	
Obese (≥30 kg/m^2)	57 (47.9%)	18 (32.7%)	39 (60.9%)	
Smoking status, n (%)				0.996
Non-smoker	106 (89.1%)	49 (89.1%)	57 (89.1%)	
Smoker	13 (10.9%)	6 (10.9%)	7 (10.9%)	
Insurance coverage, n (%)				0.387
Private or WC	115 (96.6%)	54 (98.2%)	61 (95.3%)	
Medicare/Medicaid	4 (3.4%)	1 (1.8%)	3 (4.7%)	
Ageless CCI, mean ± SD	0.96 ± 1.0	0.84 ± 1.1	1.06 ± 1.0	0.233
Preoperative PHQ-9, mean ± SD	6.9 ± 6.6	5.4 ± 6.0	8.3 ± 6.8	0.018
Preoperative diagnoses, n (%)[b]				
Myocardial infarction	3 (2.5%)	2 (3.6%)	1 (1.6%)	0.472
Uncomplicated diabetes	10 (8.4%)	3 (5.5%)	7 (11.0%)	0.282
Complicated diabetes	2 (1.7%)	1 (1.8%)	1 (1.6%)	0.914
Hypertension	39 (32.8%)	16 (29.1%)	23 (36.0%)	0.428
Neurologic disease	2 (1.7%)	1 (1.8%)	1 (1.6%)	0.914
Arthritis	22 (18.5%)	7 (12%)	15 (23.4%)	0.133
Malignancy	12 (10.1%)	5 (9.1%)	7 (11.0%)	0.739

Boldface indicates statistical significance ($P < 0.05$).
[a]*P* value was calculated using Student *t* test (continuous), χ^2 (categorical), or Fisher exact test (categorical).
[b]There were no patients in our study with a recorded medical history of AIDS, paraplegia, congestive heart failure, peripheral vascular disease, metastatic disease, liver disease, renal failure, chronic obstructive pulmonary disease, or gastrointestinal bleeds.
Abbreviations: CCI, Charlson Comorbidity Index; PROMIS, Patient-Reported Outcomes Measurement Information System; SD, standard deviation; WC, workers compensation.

RESULTS

Demographic Characteristics

Between March 2016 and February 2019, a total of 119 patients were identified who underwent primary, single-level MIS TLIF. The cohort was 53.8% male with a mean age of 52.2 ± 10.7 years of which 47.9% were obese (BMI ≥30 kg/m^2) (Table 1). Fifty-five subjects were in the preoperative PROMIS ≥35.0 group which had a significantly larger proportion of males (69.0% vs 40.6%, $P = 0.002$), was less obese (32.7% vs 60.9%, $P = 0.002$), and had a lower mean preoperative PHQ-9 score (5.4 vs 8.3, $P = 0.018$) compared to the PROMIS <35.0 group. There was no statistical difference between the groups for age, smoking status, insurance coverage, ageless CCI, or preoperative comorbid diagnoses.

Perioperative Characteristics

The PROMIS <35 group had a significantly longer hospital stay (34.4 vs 23.2, $P = 0.002$) and discharge day ($P = 0.003$) when compared to PROMIS ≥35.0, as seen in Table 2 . The remaining operative characteristics (operative time, EBL) were not significantly different between PROMIS score subgroups.

PROMIS PF Outcomes

Mean PROMIS scores at all time points for each subgroup is demonstrated in Table 3. The PROMIS <35.0 group had significantly lower PROMIS scores preoperatively (30.2 vs 40.2, $P < 0.001$), at 6 weeks (34.0

Table 2. Operative characteristics by PROMIS score.

Characteristic	PROMIS ≥35 (*n* = 55)	PROMIS <35 (*n* = 64)	*P* Value[a]
Operative time[b] (min), mean ± SD	121.8 ± 19.4 (*n* = 54)	128.0 ± 22.3	0.133
Estimated blood loss (mL), mean ± SD	43.3 ± 19.9	54.5 ± 54.9	0.165
Length of hospital stay (h), mean ± SD	**23.2 ± 17.7** (*n* = 54)	**34.4 ± 19.9**	**0.002**
Discharge day (%)			**0.003**
POD 0	**22 (40.0%)**	**7 (10.9%)**	
POD 1	**26 (47.3%)**	**38 (59.4%)**	
POD 2	**6 (10.9%)**	**14 (21.9%)**	
POD 3	**0 (0%)**	**3 (4.7%)**	
POD 4	**1 (1.8%)**	**2 (3.1%)**	

Boldface indicates statistical significance ($P < 0.05$).
[a]*P* value was calculated using Student *t* test (continuous), χ^2 analysis (categorical), or Fisher exact test (categorical).
[b]Operative time was measured from skin incision to skin closure.
Abbreviations: POD, postoperative day; PROMIS, Patient-Reported Outcomes Measurement Information System.

Table 3. PROMIS PF and PHQ-9 score distribution by preoperative subgroup.

Time Period	PROMIS ≥35 Mean ± SD (*n*)	PROMIS <35 Mean ± SD (*n*)	*P* Value[a]
PROMIS			
Preoperative	**40.2 ± 4.7 (55)**	**30.2 ± 3.5 (64)**	**<0.001**
6 weeks	**40.8 ± 6.5 (43)**	**34.0 ± 5.6 (48)**	**<0.001**
12 weeks	**43.5 ± 5.2 (33)**	**39.0 ± 8.6 (38)**	**0.011**
6 months	**46.7 ± 5.8 (36)**	**40.6 ± 7.2 (33)**	**<0.001**
1 year	**48.3 ± 8.1 (24)**	**41.0 ± 8.3 (31)**	**0.002**
PHQ-9			
Preoperative	**5.4 ± 6.0 (55)**	**8.3 ± 6.8 (64)**	**0.018**
6 weeks	**3.8 ± 5.4 (46)**	**6.2 ± 5.7 (54)**	**0.029**
12 weeks	**2.4 ± 3.7 (38)**	**4.5 ± 4.4 (53)**	**0.017**
6 months	2.8 ± 4.2 (45)	4.7 ± 5.3 (46)	0.056
1 year	2.8 ± 4.4 (24)	4.7 ± 5.7 (31)	0.180

Boldface indicates statistical significance ($P < 0.05$).
[a]*P* value was calculated using Student *t* test (continuous).
Abbreviations: PF, Physical Function; PHQ-9, Patient Health Questionnaire-9; PROMIS, Patient-Reported Outcome Measurement Information System.

vs 40.8, $P < 0.001$) , at 12 weeks (39.0 vs 43.5, $P = 0.011$), at 6 months (40.6 vs 46.7, $P < 0.001$), and at 1 year (41.0 vs 48.3, $P = 0.002$) postoperatively when compared to PROMIS ≥35.0 group (Table 3). The PROMIS <35.0 group had significantly greater PHQ-9 scores preoperatively (8.3 vs 5.4, $P = 0.018$), at 6 weeks (6.2 vs 3.8, $P = 0.029$), and at 12 weeks (4.5 vs 2.4, $P = 0.017$) postoperatively when compared to PROMIS ≥35.0 group (Table 3).

There was no statistically significant difference between subgroups at 6 months (4.7 vs 2.8, $P = 0.056$) or at 1 year (4.7 vs 2.8, $P = 0.18$) postoperatively.

Postoperative PROMIS and PHQ-9 improvement at postoperative time points for each subgroup are displayed in Table 4. The PROMIS <35.0 group had a significantly larger improvement of PROMIS scores when compared to the PROMIS ≥35.0 at the 6-week (4.0 vs 0.85, $P = 0.026$), 12-week (9.2 vs 3.3, $P = 0.003$), and

Table 4. Postoperative improvement over predetermined time periods.

Time Period	Postoperative Improvement Mean ± SD (*n*) PROMIS ≥35	Postoperative Improvement Mean ± SD (*n*) PROMIS <35	*R2*	*P* Value[a]
PROMIS				
Preoperative	—	—	—	—
6 weeks	**0.85 ± 7.0 (43)**	**4.0 ± 6.2 (54)**	**0.054**	**0.026**
12 weeks	**3.3 ± 5.8 (33)**	**9.2 ± 9.6 (38)**	**0.120**	**0.003**
6 months	**5.8 ± 7.1 (36)**	**11.1 ± 9.0 (33)**	**0.101**	**0.008**
1 year	8.3 ± 7.4 (24)	10.7 ± 8.9 (31)	0.019	0.305
PHQ-9				
Preoperative	—	—	—	—
6 weeks	−2.2 ± 4.6 (46)	−1.9 ± 5.4 (54)	0.001	0.808
12 weeks	−2.4 ± 4.5 (38)	−2.8 ± 5.1 (53)	0.001	0.712
6 months	−2.4 ± 4.5 (45)	−3.2 ± 6.1 (46)	0.005	0.490
1 year	−2.0 ± 5.0 (24)	−1.5 ± 7.9 (31)	0.001	0.807

Boldface indicates statistical significance ($P < 0.05$).
[a]*P* value was calculated using linear regression
Abbreviations: PHQ-9, Patient Health Questionnaire-9; PROMIS, Patient-Reported Outcomes Measurement Information System.

Table 5. Effect of PROMIS PF improvement on improvement in PHQ-9.

	Effect Size	95% CI	*R2*	*P* Value[a]
Delta PHQ-9				
Preoperative	—	—	—	—
6 weeks	−0.143	[−0.030, 0.012]	0.038	0.071
12 weeks	−0.117	[−0.25,−0.015]	0.047	0.083
6 months	**−0.144**	**[−0.28,−0.005]**	**0.061**	**0.042**
1 year	**−0.225**	**[−0.42,−0.259]**	**0.101**	**0.028**

Boldface indicates statistical significance ($P < 0.05$).
[a]*P* value was calculated using linear regression.
Abbreviations: PHQ-9, Patient Health Questionnaire-9; PROMIS PF, Patient-Reported Outcomes Measurement Information System Physical Function.

6-month (11.1 vs 5.8, $P = 0.008$) time points but not at 1 year (10.7 vs 8.3, $P = 0.305$). No significant difference in postoperative PHQ-9 improvement was observed between subgroups (Table 4). Evaluation of the effect of improvement in postoperative PROMIS PF scores on improvement of PHQ-9 scores demonstrated a significant association at the 6-month ($\beta = -0.144$, $R^2 = 0.061$; $P = 0.042$) and 1-year ($\beta = -0.225$, $R^2 = 0.101$; $P = 0.028$) time points only (Table 5).

Validation of all PRO measures between the preoperative and every postoperative time point demonstrated statistically significant improvement, with the exception of the SF-12 mental component at 1 year (Table 6). Figures 1 to 3 demonstrate that following linear regression; there was a significant negative association between preoperative PROMIS score and the magnitude of improvement in PROMIS scores at the 6-week, 12-week, and 6-month postoperative time points while the association was lost at the 1-year mark (Figure 4). The figures also demonstrate that for all postoperative time points, the magnitude of improvement in PHQ-9 was not associated with preoperative PROMIS scores.

DISCUSSION

While numerous studies have evaluated the role of preoperative depression on pre- and postoperative physical function,[14–20] the association of preoperative physical function on postoperative depression remains amorphous. At the time of manuscript completion, this is the first study known by the authors to examine the relationship between preoperative PROMIS scores and postoperative PHQ-9 scoring evaluated after spine surgery. In light of the recent emphasis on multidisciplinary health care, understanding the possible influence that preoperative PROMIS scores could have on postoperative mental health might allow surgeons to better anticipate, stratify, and address the mental health needs of patients undergoing TLIF procedures.

This study is in general agreement with the findings of others, that a general improvement in PROMIS scores

Table 6. Postoperative improvement over predetermined time periods for other patient-reported outcomes.

	Postoperative Improvement Mean ± SD (*n*) PROMIS ≥35	*P* Value[a]	Postoperative Improvement Mean ± SD (*n*) PROMIS ≥35	*P* Value[a]
ODI				
Preoperative	—	—	—	—
6 weeks	**9.7 ± 17.7 (49)**	**<0.001**	**8.4 ± 18.2 (57)**	**0.001**
12 weeks	**13.4 ± 14.6 (42)**	**<0.001**	**14.5 ± 21.1 (55)**	**<0.001**
6 months	**17.1 ± 15.0 (47)**	**<0.001**	**19.7 ± 20.3 (44)**	**<0.001**
1 year	**19.5 ± 10.8 (20)**	**<0.001**	**18.8 ± 27.1 (26)**	**<0.001**
VAS Back				
Preoperative	—	—	—	—
6 weeks	**2.9 ± 2.7 (47)**	**<0.001**	**2.3 ± 3.2 (57)**	**<0.001**
12 weeks	**2.9 ± 2.6 (41)**	**<0.001**	**2.7 ± 3.1 (55)**	**<0.001**
6 months	**2.9 ± 3.1 (46)**	**<0.001**	**2.2 ± 3.6 (43)**	**<0.001**
1 year	**4.1 ± 3.1 (20)**	**<0.001**	**2.8 ± 4.5 (26)**	**0.004**
VAS Leg				
Preoperative	—	—	—	—
6 weeks	**2.6 ± 3.1 (47)**	**<0.001**	**3.2 ± 3.0 (57)**	**<0.001**
12 weeks	**2.9 ± 2.9 (42)**	**<0.001**	**3.7 ± 3.2 (55)**	**<0.001**
6 months	**2.9 ± 3.4 (47)**	**<0.001**	**3.7 ± 3.3 (43)**	**<0.001**
1 year	**3.7 ± 3.0 (20)**	**<0.001**	**2.7 ± 4.0 (26)**	**0.002**
SF-Physical				
Preoperative	—	—	—	—
6 weeks	**−2.5 ± 9.9 (45)**	**<0.001**	**−2.2 ± 7.2 (57)**	**<0.001**
12 weeks	**−3.1 ± 11.0 (36)**	**0.099**	**−6.9 ± 10.8 (51)**	**<0.001**
6 months	**−7.6 ± 10.8 (38)**	**<0.001**	**−8.6 ± 10.7 (37)**	**<0.001**
1 year	**−12.0 ± 9.5 (22)**	**<0.001**	**−9.8 ± 13.0 (33)**	**<0.001**
SF-Mental				
Preoperative	—	—	—	—
6 weeks	**−3.7 ± 9.1 (45)**	**<0.001**	**−1.6 ± 8.4 (57)**	**<0.001**
12 weeks	**−3.5 ± 7.7 (36)**	**0.011**	**−2.6 ± 8.4 (51)**	**0.036**
6 months	**−1.9 ± 5.7 (38)**	**0.046**	**−4.3 ± 8.8 (37)**	**0.005**
1 year	−3.1 ± 10.4 (22)	0.179	−3.0 ± 8.9 (33)	0.067

Boldface indicates statistical significance.

[a]*P* value was calculated using paired Student *t* test (continuous).

Abbreviations: ODI, Oswestry Disability Index; PHQ-9, Patient Health Questionnaire-9; SD, standard deviation; SF, Short Form; VAS, visual analog scale.

are realized between preoperative PROMIS scores and postoperative PROMIS scores taken from evaluations at the 6-week, 12-week, and 6 months postoperative time periods.[3] At the time of this study's completion, however, it is among the first to evaluate subgroups according to their ≥35 and <35 PROMIS score US population subdivisions (Table 4).[12,13] Furthermore, this study also evaluated PHQ-9 mean improvement

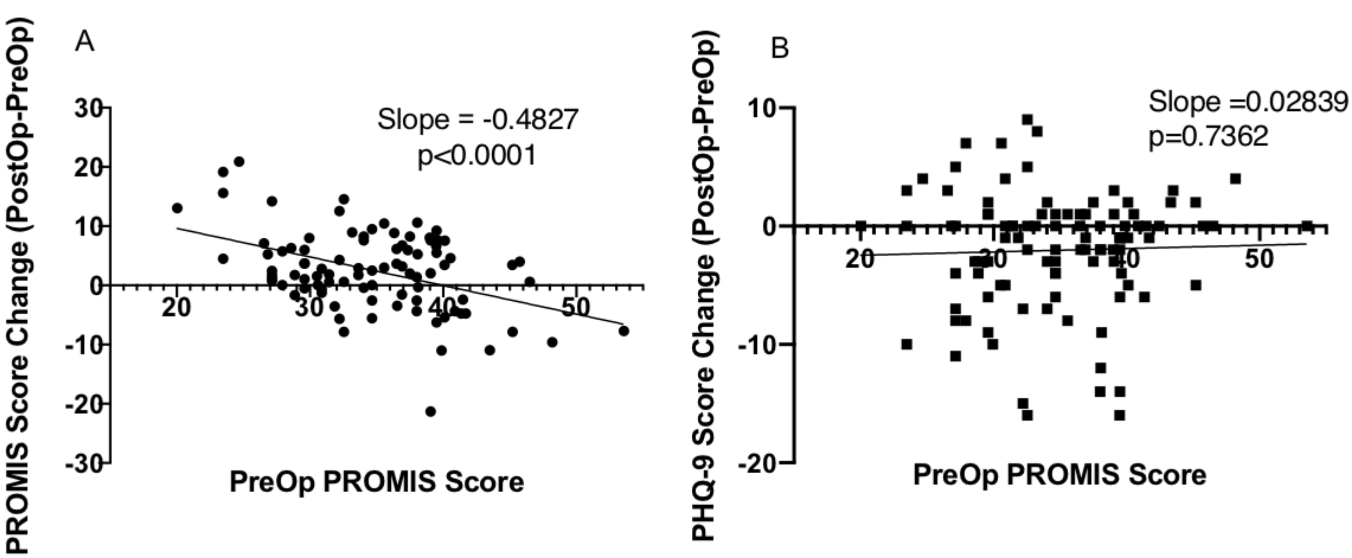

Figure 1. 6-week (A) Patient-Reported Outcomes Measurement Information System Physical Function (PROMIS PF) and (B) Patient Health Questionnaire-9 (PHQ-9) improvement plotted against preoperative PROMIS PF scores. PROMIS score change slope was −0.4827 (*P* < 0.0001), and PHQ-9 score change slope was 0.0284 (*P* = 0.7362).

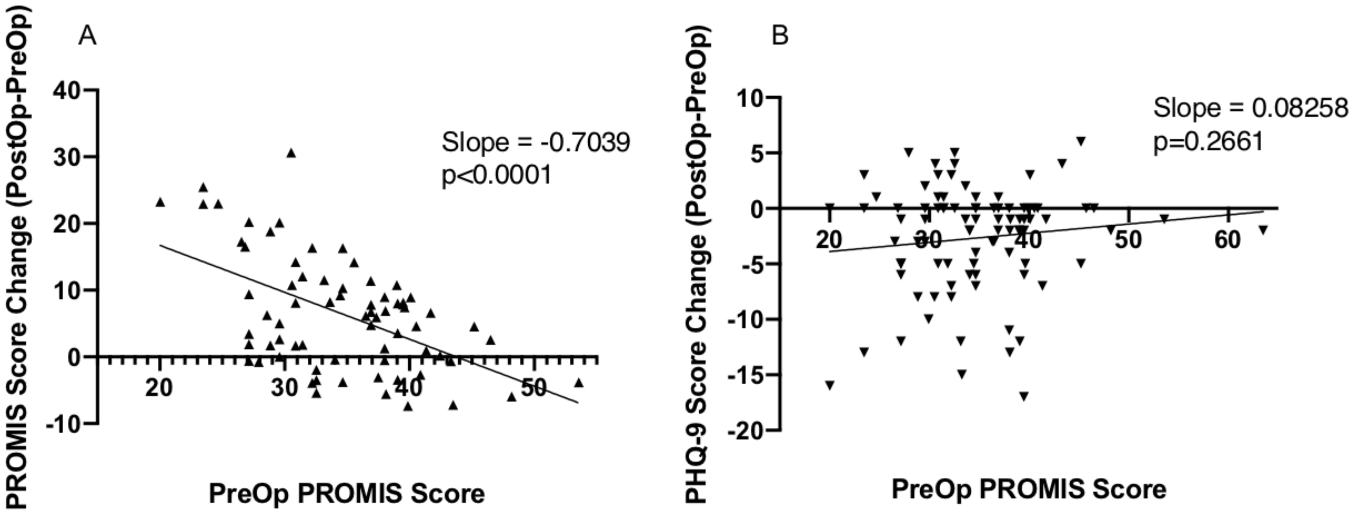

Figure 2. 12-week (A) Patient-Reported Outcomes Measurement Information System Physical Function (PROMIS PF) and (B) Patient Health Questionnaire-9 (PHQ-9) improvement plotted against preoperative PROMIS PF scores. PROMIS score change slope was −0.7039 ($P < 0.0001$), and PHQ-9 score slope was 0.8258 ($P = 0.2661$).

differences at each time point and found an increased mean PHQ-9 score level from the preoperative evaluation through to the 12-week evaluation. The loss of statistical significance between both subgroups at the 6-month and 1-year evaluation time point suggests that patients from both ≥35 and <35 PROMIS preoperative groups ultimately improve to a similar postoperative PHQ-9 score.

Furthermore, it should be acknowledged that mean absolute PHQ-9 score was significantly lower among the low PROMIS score group (Table 4) at the preoperative evaluation. In consideration of the loss of statistical significance between mean PHQ-9 scores at the 6-month and 12-month time points, one might consider the lower PROMIS score may have substantially improved their PHQ-9 score to the point that the difference was no longer observed at the 6-month and 1-year time points. Interestingly, as this study revealed, further evaluation of the mean PROMIS score improvement between subgroups demonstrated no statistically significant difference in the mean improvement (ie, difference between preoperative score at each postoperative time point).

While other studies have evaluated the influence of association of preoperative PHQ-9 scores, pain, opioid consumption, and other PROs,[21] this is the first study to evaluate a possible relationship between preoperative physical function as measured by PROMIS scores. As demonstrated in previous investigations, the authors of

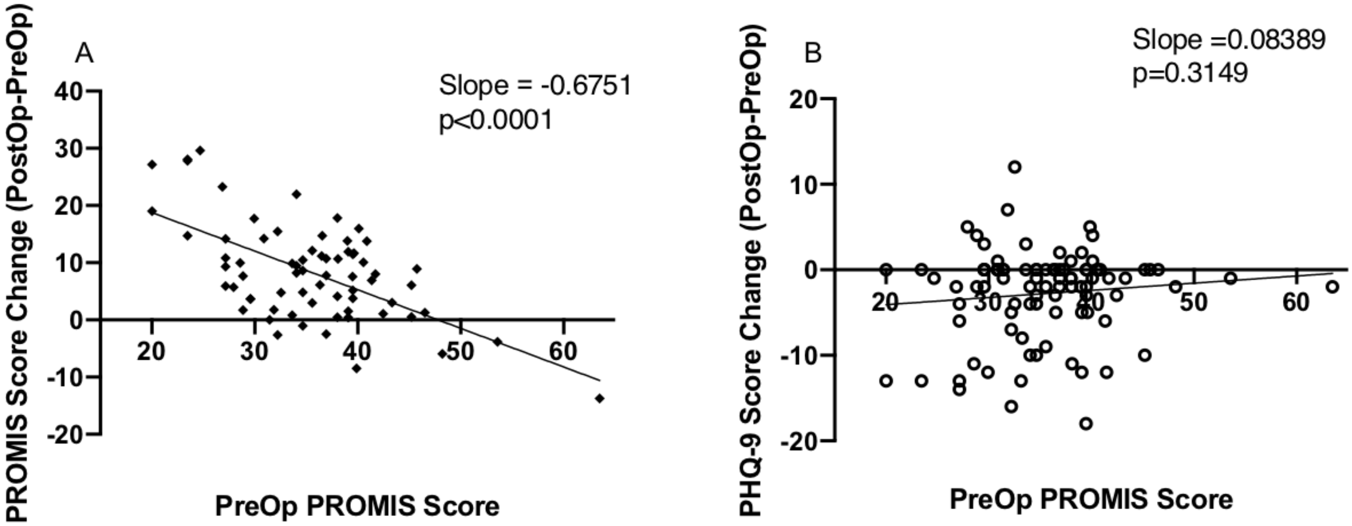

Figure 3. 6-month (A) Patient-Reported Outcomes Measurement Information System Physical Function (PROMIS PF) and (B) Patient Health Questionnaire-9 (PHQ-9) improvement plotted against preoperative PROMIS PF scores. PROMIS score change slope was −0.6751 ($P < 0.0001$), and PHQ-9 score change slope was 0.08389 ($P = 0.3149$).

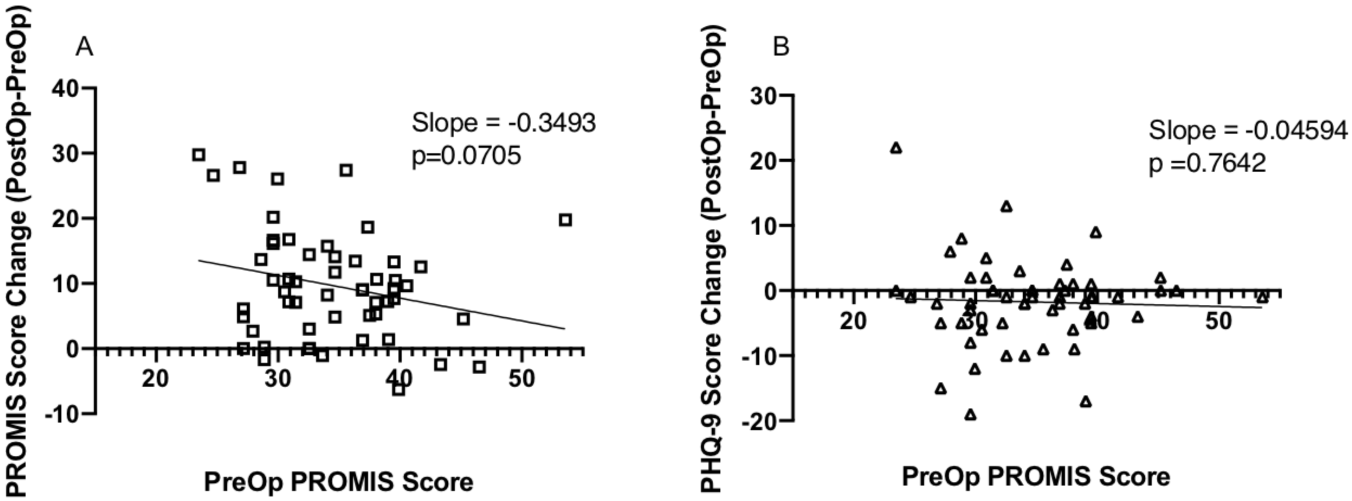

Figure 4. 1-year (A) Patient-Reported Outcomes Measurement Information System Physical Function (PROMIS PF) and (B) Patient Health Questionnaire-9 (PHQ-9) improvement plotted against preoperative PROMIS PF scores. PROMIS score change slope was −0.3493 (P = 0.0705), and PHQ-9 score change slope was −0.0459 (P = 0.7642).

this study observed a statistically significant association with preoperative PROMIS scores and postoperative improvements, though this effect diminished by the 1-year mark. Preoperative PROMIS score was not, however, found to correlate with PHQ-9 improvements at any of the evaluated time points.

Our validation of PROMIS subgroups against all PRO measures demonstrated that each subgroup had statistically significant improvement from their preoperative scores at every time point, with the exception of the SF-12 mental component at 1 year (Table 5). Interestingly, neither PROMIS nor PHQ-9 scores were observed to have a statistically significant improvement at 1 year. Since all physical function (eg, ODI, VAS-B, VAS-L, and SF-12) tests utilized in this study have a more robust historical validation in comparison to PROMIS, this might be an indication that PROMIS is less reliable at a 1-year time point evaluation.

Finally, this study further adds to spine surgery literature by demonstrating that, although preoperative PROMIS score groups might be associated with differing levels of postoperative PROMIS score improvement, the preoperative PROMIS score groups do not appear to be correlated with any statistically significant differences in postoperative PHQ-9 scores at any assessment time point. Further research is needed to elucidate the relationship of preoperative physical function and mental health improvements. Numerous studies have evaluated the relationship between depression and its possible influence on postoperative recovery or gain in physical function.[19,22]

Limitations

The retrospective nature of this study lends itself to possible observer biases. Researchers were not blinded to the results while conducting the retrospective review, which may have resulted in them observing a result they expected to see. To address this, future studies evaluating the association of PROMIS and PHQ-9 should be blinded and prospective in nature. A second limitation is a possible selection bias, which affects most cohort studies in which patients are lost to follow-up.[23] Healthy patients will be less inclined than more disabled patients to return to clinic . As such, the populations that this may affect the most could include patients with <35 preoperative PROMIS scores or those with the greatest postoperative improvement in PROs.

CONCLUSION

During the short-term postoperative period (0 weeks to 6 months), patients with lower preoperative physical function, as evaluated by PROMIS PF, had significantly larger improvements in PROMIS PF scores following MIS TLIF compared to patients with higher preoperative physical function. Preoperative function was not predictive of postoperative changes in depression, as evaluated by PHQ-9. While previously described relationships between psychiatric well-being and global health cannot be discounted, the lack of PHQ-9 association with preoperative physical function demonstrates the resilient impact that MIS TLIF can have on patients, regardless of their preoperative PROMIS PF score.

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Corresponding Author: Kern Singh, Department of Orthopaedic Surgery, Rush University Medical Center, 1611 W Harrison St, Suite #300, Chicago, IL 60612, USA; kern.singh@rushortho.com

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