



Original Article

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Association of Preoperative PROMIS Scores With Short-term Postoperative Improvements in Physical Function After Minimally Invasive Transforaminal Lumbar Interbody Fusion

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Objective: This study examines the associations between preoperative Patient-Reported Outcomes Measurement Information System (PROMIS) physical function (PF) score, measured by PROMIS-PF and the change between pre- and postoperative PROMIS-PF scores.

Methods: A prospectively maintained surgical registry was retrospectively reviewed for spine surgeries between May 2015–June 2019. Inclusion criteria were primary, single-level minimally invasive transforaminal lumbar interbody fusions. Revisions, multilevel procedures, and patients missing preoperative surveys were excluded. Patients were grouped by preoperative PROMIS-PF scores of ≥ 35 and < 35 , with higher scores indicating greater PF. A chi-squared and Student t-test were used to analyze categorical and continuous variables respectively. Linear regression evaluated the relationship of PROMIS-PF score improvement.

Results: Of the 180 subjects, 84 were in the PROMIS-PF < 35 group which had more obese patients ($p < 0.001$) and more males ($p = 0.001$). Length of stay was greater for the PROMIS-PF < 35 group (36.2 hours vs. 28.7 hours, $p = 0.014$). PROMIS-PF and Oswestry Disability Index scores were significantly different between subgroups at all timepoints. PROMIS-PF < 35 cohort had larger postoperative PROMIS-PF improvements at 6 weeks ($p = 0.008$) and 12 weeks ($p = 0.003$). Linear regression demonstrated a negative association between preoperative PROMIS-PF scores and improvement at 6 weeks, 12 weeks, 6 months, and 2 years ($p < 0.001$). PROMIS-PF < 35 demonstrated significantly lower rate of achieving minimum clinically important difference at 6 months, otherwise no difference observed throughout the 2-year follow-up.

Conclusion: Up to 6 months postoperatively, lower preoperative PROMIS-PF scores were associated with larger PROMIS-PF improvements. Understanding the relationship preoperative PROMIS-PF scores have with postoperative improvement may enable better patient counseling.

Keywords: Minimally invasive transforaminal lumbar interbody fusion, Patient-Reported Outcomes Measurement Information System, Physical function, Visual analogue scale, Oswestry Disability Index



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INTRODUCTION

The Patient-Reported Outcomes Measurement Information System (PROMIS) is a type of patient-reported outcome (PRO)

that has become increasingly utilized to examine postoperative success among patients undergoing open lumbar discectomy or other elective procedures.^{1,2} Spine surgeons utilize PROs to improve clinical practice.^{3,4} PROMIS PF computer adaptive testing

(CAT) is unique in that the survey modifies its questions based upon patient response, which may help with accurate data collection.^{5,6} Although the terms PROMIS, PROMIS PF, and PROMIS PF CAT refer to different technical items, these terms are used interchangeably to refer to the PROMIS PF CAT score.

Questions that make PROMIS useful specifically for spine surgery are those contained in the physical function (PF) subsection. Such questions ask patients about their perceived ability to move, their relative strength, and their coordination when making movements.⁶⁻⁸ There is limited research on the association of preoperative PROMIS PF scores with postoperative improvement in patients undergoing minimally invasive transforaminal lumbar interbody fusion (MIS TLIF).²

To evaluate outcomes in patients undergoing spine surgery, PROs such as the Oswestry Disability Index (ODI), visual analogue scale (VAS), and 12-Item Short Form Survey (SF-12) are often utilized.^{2,9} During recovery from MIS TLIF, preoperative PROMIS scores (specifically the PF domain) have been associated with improved scores at 12 weeks and 6 months. PROMIS scores after MIS TLIF were also associated with the ODI, VAS, and SF-12, suggesting that PROMIS is likely a reliable measure after MIS TLIF.² Part of the utility of PROMIS scoring is that, although it is periodically updated, scores from different versions can still be compared to each other.¹⁰ However, despite the fact that PROMIS can be used to monitor clinical outcomes, its utility in spine surgery has still not been fully elucidated.¹¹

Previous studies have demonstrated that PROMIS scores may be associated with patient outcomes after MIS TLIF.² However, spine surgeons are still determining the relationship between preoperative PROMIS scores, postoperative outcomes, and how the surgeon and patient can address these synergistically to create realistic postoperative expectations.¹¹ The primary objective of the study is to examine preoperative PROMIS PF score, measured by PROMIS PF, and the change between pre- and postoperative PROMIS PF score at 6 weeks, 12 weeks, 6 months, 1 year, and 2 years following MIS TLIF.

MATERIALS AND METHODS

1. Patient Population

An Institutional Review Board approved prospectively maintained surgical registry of patients undergoing spine surgery between May 2015 and June 2019 was retrospectively reviewed for eligible patients (ORA #14051301). This was a unique MIS TLIF patient cohort that was first assessed for this manuscript. Furthermore, this is the first MIS TLIF patient cohort that this

lab has analyzed with the National Institutes of Health established PROMIS threshold of 35. Inclusion criteria were primary, single-level MIS TLIF procedures for degenerative pathology. Exclusion criteria included revisions, multilevel (> 1) procedures and patients missing preoperative PROMIS surveys. All patients were treated by a single surgeon at a single academic institution.

2. 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 acquired immunodeficiency syndrome, arthritis, chronic obstructive pulmonary disease, congestive heart failure, gastrointestinal bleeding, hypertension, liver failure, malignancy, metastatic disease, neurologic disease, paraplegia, peripheral vascular disease, renal failure, uncomplicated, and complicated diabetes. Spinal pathology diagnosis was recorded including, spondylolisthesis, central stenosis, and foraminal stenosis. The OBERD software system (Universal Research Solutions, Columbia, MO, USA) was used to administer PROMIS PF CAT and Patient Health Questionnaire-9 surveys. Preoperative PROMIS and ODI scores were recorded and patients were grouped by preoperative PROMIS score (≥ 35 , < 35), with higher scores indicating greater PF. The 35 cut point was selected using previously defined divisions between “fair” ≥ 35 and “poor” < 35 subgroups.^{12,13} Postoperative PROMIS and ODI scores were recorded at the 6-week, 12-week, 6-month, 1-year, and 2-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.

3. Statistical Analysis

Stata ver. 16.0 (StataCorp, College Station, TX, USA) was used to perform a chi-square analysis to detect for association of PROMIS subgroups in the following demographic preoperative variables: sex, smoking status, diagnosis, BMI, insurance coverage (e.g., private, workers’ compensation, medicare, or medicaid), and spinal diagnosis. Insurance status was assessed due to the consistent observation that workers’ compensation patients have worse outcomes compared to non-workers’ compensation patients with regard to reoperation, fusion, and return to work.¹⁴⁻¹⁹ A Student t-test was used for continuous demographic variables: age 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. Postoperative improvement (post-op–preop) was evaluated using a Student t-test to detect a difference at preoperative and postoperative (6 weeks, 12 weeks, 6 months, and 1 year) timepoints.² Patients who did not fill out a survey at a timepoint were removed from that time points analysis. Mean PROMIS and ODI scores at all time points were evaluated using a t-test to detect a difference between PROMIS subgroups. Both mean PROMIS score and improvement in PROMIS score were graphed using a scatter plot. A linear regression

was designed with GraphPad Prism 8.0 for Mac (La Jolla, California, USA). The linear regression evaluated our entire patient cohort as a whole without dividing it into subgroups. The purpose of the linear regression was to evaluate a possible monotonic relationship between preoperative PROMIS scores and postoperative PROMIS score improvement among our entire patient cohort. The rate of minimum clinically important difference (MCID) achievement was evaluated between the preoperative PROMIS PF subgroups using chi-square analysis. The most recently established MCID value for PROMIS PF = 8.0.²⁰ Statistical significance was set at $p < 0.05$.

Table 1. Patient demographics by PROMIS score

Variable	Total (n = 180)	PROMIS ≥ 35 (n = 96)	PROMIS < 35 (n = 84)	p-value [†]
Age (yr)	51.6 \pm 11.0	50.88 \pm 11.6	52.33 \pm 10.4	0.400
Sex				0.001*
Female	74 (41.1)	29 (30.2)	45 (53.6)	
Male	106 (58.9)	67 (69.8)	39 (46.4)	
Body mass index				< 0.001*
Nonobese (< 30 kg/m ²)	99 (55.0)	65 (67.7)	34 (40.5)	
Obese (≥ 30 kg/m ²)	81 (45.0)	31 (32.3)	50 (59.5)	
Smoking status				0.926
Nonsmoker	159 (88.3)	85 (88.5)	74 (88.1)	
Smoker	21 (11.7)	11 (11.5)	10 (11.9)	
Insurance coverage				0.868
Private or WC	174 (96.7)	93 (96.9)	81 (96.4)	
Medicare/medicaid	6 (3.3)	3 (3.1)	3 (3.6)	
Ageless CCI	0.8 \pm 1.0	0.8 \pm 1.0	0.8 \pm 1.0	0.226
Preoperative diagnoses [‡]				
Myocardial infarction	3 (1.7)	2 (2.1)	1 (1.2)	0.641
Uncomplicated diabetes	11 (6.1)	3 (3.1)	8 (9.5)	0.074
Complicated diabetes	2 (1.1)	1 (1.0)	1 (1.2)	0.924
Hypertension	52 (28.9)	25 (26.0)	27 (32.1)	0.368
Neurologic disease	2 (1.1)	1 (1.0)	1 (1.2)	0.924
Arthritis	33 (18.3)	14 (14.6)	19 (22.6)	0.165
Malignancy	17 (9.4)	9 (9.4)	8 (9.5)	0.973
Spinal pathology				
Spondylolisthesis	147 (81.7)	76 (79.2)	71 (84.5)	0.354
Central stenosis	164 (91.1)	86 (89.6)	78 (92.9)	0.441
Foraminal stenosis	96 (53.3)	45 (46.9)	51 (60.7)	0.063

Values are presented as mean \pm standard deviation or number (%).

PROMIS, Patient-Reported Outcomes Measurement Information System; WC, workers compensation; CCI, Charlson Comorbidity Index.

* $p < 0.05$. [†]p-value was calculated using Student t-test (continuous), chi-square (categorical). [‡]There were no patients in our study with a recorded medical history of acquired immunodeficiency syndrome, paraplegia, congestive heart failure, peripheral vascular disease, metastatic disease, liver disease, renal failure, chronic obstructive pulmonary disease, or gastrointestinal bleeds.

4. Surgical Technique

The senior author performed a primary, single-level spine surgery on all patients in this study utilizing an MIS TLIF technique. A nonexpandable 21-mm tube was used in order to perform a laminectomy, bilateral facetectomy, and fusion. After completing a subtotal discectomy, an interbody cage was selected based on surgeon preference. Before placing in the interbody space, the cage was prepared with either bone morphogenic protein-2 or local bone graft. Finally, unilateral or bilateral percutaneous pedicle screws were installed with a guidewire.

RESULTS

1. Demographic Characteristics

Between May 2015 and June 2019, a total of 180 patients were identified who underwent primary, single-level MIS TLIF. The cohort was 58.9% male with a mean age of 51.6 ± 11.0 years of which 45% were obese (BMI ≥ 30 kg/m²) (Table 1). Eighty-four subjects were in the preoperative PROMIS < 35 group which had a significantly greater number of obese patients (59.5% vs. 32.3%, p < 0.001) and a greater percentage of females (53.6% vs. 30.2%, p = 0.001) when compared to the PROMIS ≥ 35 group as seen in Table 1. There was no statistical difference between the groups for age, smoking status, insurance coverage, ageless CCI, preoperative comorbid diagnoses, or spinal pathology.

Table 2. Operative characteristics by PROMIS score

Variable	PROMIS ≥ 35 (n = 96)	PROMIS < 35 (n = 84)	p-value [†]
Operative time* (min)	123.5 ± 23.7	126.3 ± 22.6	0.432
Estimated blood loss (mL)	52.8 ± 51.9	53.2 ± 51.0	0.891
Length of hospital stay (hr)	28.7 ± 16.8	36.2 ± 20.9	0.014*
Discharge day			0.116
POD 0	15 (15.6)	8 (9.5)	
POD 1	54 (56.3)	46 (54.8)	
POD 2	12 (12.5)	19 (22.6)	
POD 3	2 (2.1)	5 (6.0)	
POD 4	13 (13.5)	6 (7.1)	

Values are presented as mean ± standard deviation or number (%). PROMIS, Patient-Reported Outcomes Measurement Information System; POD, postoperative day.

*p < 0.05. †p-value was calculated using Student t-test (continuous), chi-square analysis (categorical), or Fisher exact test (categorical).

*Operative time was measured from skin incision to skin closure.

2. Perioperative Characteristics

The hospital length of stay was statistically greater for the PROMIS < 35 group when compared to PROMIS ≥ 35 as seen in Table 2 (36.2 hours vs. 28.7 hours, p = 0.014). The remaining operative characteristics (operative time, EBL, and discharge day) were not statistically different between PROMIS score subgroups.

3. PROMIS PF Outcomes

Mean PROMIS and ODI scores at all time points for each subgroup are demonstrated in Table 3. The PROMIS < 35 group had significantly lower PROMIS scores preoperatively (30.3 vs. 39.7, p < 0.001), at 6 weeks (33.5 vs. 39.8, p < 0.001), at 12 weeks (37.9 vs. 43.5, p < 0.001), at 6 months (39.3 vs. 47.4, p < 0.001), at 1 year (39.6 vs. 49.6, p < 0.001), and at 2 years (39.8 vs. 49.2, p < 0.001) postoperatively when compared to PROMIS ≥ 35 group (Table 3, Fig. 1). Mean ODI scores demonstrated a significant difference among PROMIS subgroups at all timepoints (all p < 0.008). The PROMIS < 35 cohort had a significantly larger magnitude of improvement in postoperative PROMIS scores when compared to the PROMIS ≥ 35 group at the 6-week (3.3 vs. 0.38, p = 0.008) and 12-week (8.0 vs. 3.8, p = 0.003) postoperative time points (Table 4, Fig. 2). At the postoperative

Table 3. PROMIS PF and ODI score distribution by preoperative subgroup

Patient-Reported Outcome	PROMIS ≥ 35	PROMIS < 35	p-value [†]
PROMIS time period			
Preoperative	39.7 ± 4.1 (96)	30.3 ± 3.4 (84)	< 0.001*
6 Weeks	39.8 ± 6.3 (76)	33.5 ± 5.8 (64)	< 0.001*
12 Weeks	43.5 ± 5.7 (67)	37.9 ± 8.2 (50)	< 0.001*
6 Months	47.4 ± 5.7 (64)	39.3 ± 7.1 (47)	< 0.001*
1 Year	49.6 ± 8.1 (52)	39.6 ± 8.1 (43)	< 0.001*
2 Years	49.2 ± 7.7 (44)	39.8 ± 8.3 (34)	< 0.001*
ODI time period			
Preoperative	33.3 ± 13.7 (94)	49.9 ± 15.0 (82)	< 0.001*
6 Weeks	27.5 ± 18.3 (85)	40.9 ± 18.7 (76)	< 0.001*
12 Weeks	20.8 ± 14.6 (78)	35.9 ± 18.9 (73)	< 0.001*
6 Months	16.2 ± 15.4 (83)	30.8 ± 19.3 (60)	< 0.001*
1 Year	9.9 ± 9.3 (51)	31.3 ± 22.1 (40)	< 0.001*
2 Years	13.2 ± 16.6 (35)	26.1 ± 19.2 (24)	0.008*

Values are presented as mean ± standard deviation (number). PROMIS PF, Patient-Reported Outcomes Measurement Information System physical function; ODI, Oswestry Disability Index.

*p < 0.05. †p-value was calculated using Student t-test (continuous).

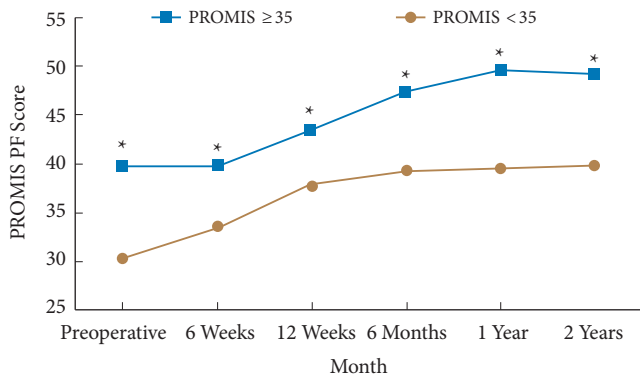


Fig. 1. Average PROMIS PF score between ≥ 35 and < 35 Preoperative PROMIS PF subgroups. *Significant difference calculated using Student t-test. PROMIS PF, Patient-Reported Outcomes Measurement Information System physical function.

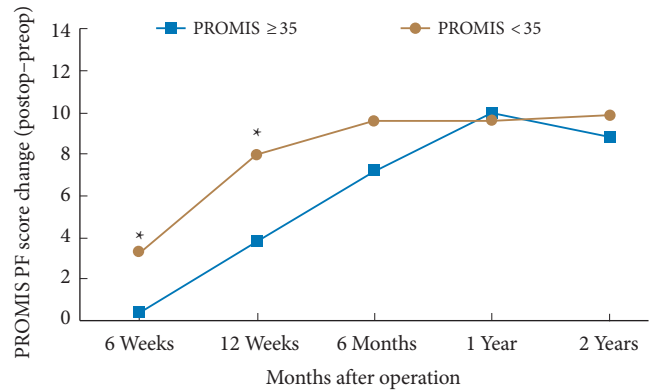


Fig. 2. Postoperative improvement of PROMIS PF score between ≥ 35 and < 35 preoperative PROMIS PF subgroups. *Significant difference calculated using Student t-test. PROMIS PF, Patient-Reported Outcomes Measurement Information System physical function; preop, preoperative; postop, postoperative.

Table 4. Postoperative improvement over predetermined time periods

Patient-Reported Outcome	Postoperative Improvement		p-value [†]
	PROMIS ≥ 35	PROMIS < 35	
PROMIS time period			
Preoperative	-	-	-
6 Weeks	0.38 \pm 6.6 (76)	3.3 \pm 6.1 (64)	0.008*
12 Weeks	3.8 \pm 5.9 (67)	8.0 \pm 8.8 (50)	0.003*
6 Months	7.2 \pm 6.9 (64)	9.6 \pm 8.6 (47)	0.099
1 Year	10.0 \pm 7.5 (52)	9.6 \pm 8.2 (43)	0.815
2 Years	8.8 \pm 9.6 (44)	9.9 \pm 9.5 (34)	0.583
ODI time period			
Preoperative	-	-	-
6 Weeks	-6.1 \pm 18.9 (84)	-9.0 \pm 19.5 (74)	0.340
12 Weeks	-11.6 \pm 15.7 (77)	-14.0 \pm 20.3 (71)	0.414
6 Months	-17.0 \pm 16.3 (82)	-18.8 \pm 19.3 (58)	0.558
1 Year	-20.4 \pm 13.6 (50)	-19.4 \pm 24.3 (38)	0.808
2 Years	-18.2 \pm 17.0 (34)	-23.7 \pm 21.8 (22)	0.291

Values are presented as mean \pm standard deviation (number). PROMIS PF, Patient-Reported Outcomes Measurement Information System physical function; ODI, Oswestry Disability Index. *p < 0.05. [†]p-value was calculated using Student t-test (continuous).

6 months, 2-year time points the PROMIS < 35 group still had increased improvement compared to the PROMIS ≥ 35 group but it did not demonstrate statistical significance (p = 0.099 and p = 0.583, respectively). Following linear regression analysis of the entire cohort (e.g., PROMIS PF subgroups were combined), a significant negative association was demonstrated between preoperative PROMIS scores and magnitude of improvement

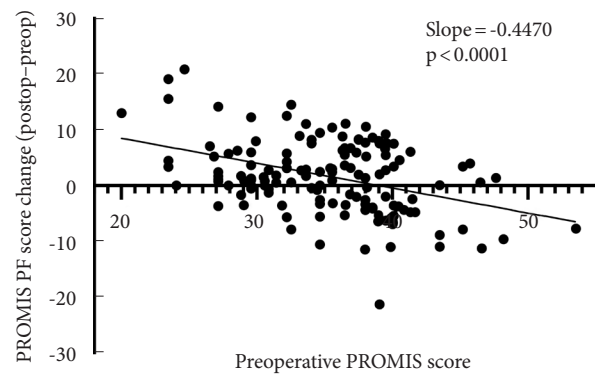


Fig. 3. Linear regression of 6-week difference in postoperative (postop) to preoperative (preop) PROMIS scores in relation to preop PROMIS scores. PROMIS, Patient-Reported Outcomes Measurement Information System.

at the 6-week, 12-week, 6-month, and 2-year time points with slopes of -0.447, -0.5462, -0.537, and -0.558 respectively (all p < 0.001) as seen in Figs. 3-6. Also among the entire cohort, there was no significant association observed at the 1-year time point (Fig. 7) (p = 0.493). There was no significant difference in ODI score improvement among PROMIS subgroups at any postoperative timepoint (Table 4). Finally, when assessing the patients with higher preoperative PROMIS (≥ 35), those with lower preoperative PROMIS (< 35) scores were observed to have no statistically significant difference in the rate of attaining MCID except for the 6-month postoperative time point (p = 0.038) (Table 5).

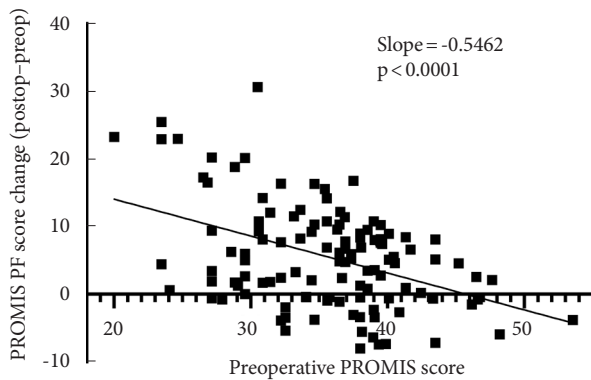


Fig. 4. Linear regression of 12-week difference in postoperative (postop) to preoperative (preop) PROMIS scores in relation to preop PROMIS scores. PROMIS, Patient-Reported Outcomes Measurement Information System.

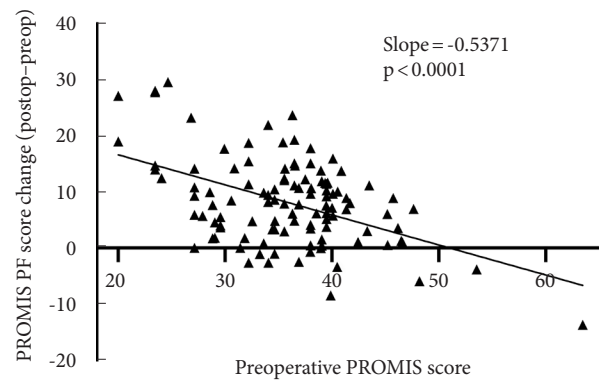


Fig. 5. Linear regression of 6-month difference in postoperative (postop) to preoperative (preop) PROMIS scores in relation to preop PROMIS scores. PROMIS, Patient-Reported Outcomes Measurement Information System.

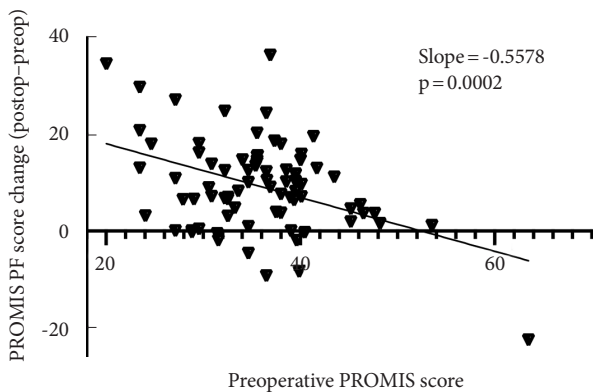


Fig. 6. Linear regression of 2-year difference in postoperative (postop) to preoperative (preop) PROMIS scores in relation to preop PROMIS scores. PROMIS, Patient-Reported Outcomes Measurement Information System.

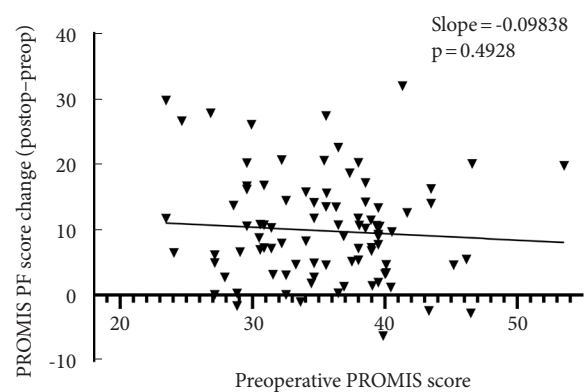


Fig. 7. Linear regression of 1-year difference in postoperative (postop) to preoperative (preop) PROMIS scores in relation to preop PROMIS scores. PROMIS, Patient-Reported Outcomes Measurement Information System.

Table 5. Achievement of minimal clinically important difference among PROMIS subgroups from baseline

PROMIS PF	6 Weeks	3 Months	6 Months	12 Months	24 Months
PROMIS ≥ 35	69/88 (78.4)	84/88 (95.5)	87/88 (98.9)	87/88 (98.9)	87/88 (98.9)
PROMIS < 35	63/79 (79.8)	71/79 (89.9)	73/79 (92.4)	78/79 (98.7)	78/79 (98.7)
p-value [†]	0.832	0.163	0.038*	0.939	0.939

Values are presented as number (%) unless otherwise indicated.
 PROMIS, Patient-Reported Outcomes Measurement Information System.
 *p < 0.05. †p-value was calculated using chi-square analysis.

DISCUSSION

PROs function to evaluate treatment success and are becoming increasingly referenced in orthopaedic spine surgery literature that is focused on the measurement of postsurgical PF im-

provement. While PROMIS scores have been studied and validated as one of many clinical diagnostics involved in evaluating postsurgical gains in PF after spine surgery, more recent studies have demonstrated preoperative PRO associations with postoperative outcomes.^{11,21} In this study preoperative PROMIS scores

were observed to be associated with postoperative PROMIS score improvement among patients that underwent primary, MIS TLIF procedures when improvement was assessed at 6 weeks, 12 weeks, and 6 months.

When compared to patients with higher preoperative PROMIS scores (≥ 35), those with lower preoperative PROMIS (< 35) scores demonstrated a larger mean difference of postoperative PROMIS scores. While a statistically significant difference in the PROMIS score improvement of PF was not seen at the 1-year postoperative evaluation, these findings nonetheless provide insight for clinicians to more accurately assist and counsel patients during pre- and postoperative evaluations. It is also important to understand that regardless of the differences within this study's subgroups, linear regression demonstrated a tendency toward increased postoperative PROMIS scores with decreased absolute preoperative scores. Effective preoperative counseling might focus attention on the potential association with lower preoperative PROMIS scores for significant postoperative improvement up until the 6-month time period. It is also important to caution such patients that, despite the relative increased early postoperative improvement, the increase in function will likely still be comparable to that of other patients with a preoperative PROMIS score advantage (≥ 35) by the 1-year time point.

While others have investigated the significance of various subgroups of PROMIS PF score groups, our study uniquely investigates the NIH threshold score between "fair" and "poor" levels of PF. Patel et al.⁶ used 3 PROMIS PF subgroups (40–50, 30–39.9, and 20–29.9) which differs from our binary subgroup analysis of fair (≥ 35) and poor (< 35) PF cohorts. In addition, our study included patients with PROMIS PF scores that were greater than 50 while Patel et al. removed these patients.

Other investigators have also observed that, among MIS TLIF patients, PROMIS PF scores demonstrate statistically significant strong correlations with SF-12, ODI, and VAS-leg scores over the first 6 postoperative months.²² Furthermore, it has been demonstrated that PROMIS PF scores increase the most within the first 12 postoperative weeks and within the first 6 postoperative months. Further studies are required to investigate how PROMIS PF scores correlate with SF-12, ODI, VAS-back, and VAS-leg scores beyond 6 months.

While we did find a statistically significant difference among subgroups (those that had preoperative scores of ≥ 35 and < 35) in MCID achievement at 6 months, we found no statistically significant difference between either subgroup at any time point until 2 years. These findings indicate that the 35-point PROMIS

PF score threshold may not necessarily be helpful in assessing whether or not patients are likely to achieve MCID based on their preoperative PROMIS PF score.

While the PROMIS system has numerous advantages, the system can be costly for any clinic. According to the PROMIS HealthMeasures publicly available fee documentation, having access to PROMIS can range from an annual \$5,000 (United States dollar, USD) if starting a new study or \$2,500 (USD) to continue a study.²³ However, other costs such as server fees, tablets to administer the surveys and research assistants to analyze the data add additional costs. One recent study estimated the total cost of administration to be approximately \$1,000 per month.²⁴ Fees and other implicit costs are important to acknowledge as these could be significant hurdles for researchers to overcome. While baseline and operative variables were assessed for statistical significance, only 3 variables were observed to have statistically significant differences among the 2 subgroups (e.g., sex, obesity, length of hospital stay). Specifically for length of stay, the clinical significance of an 8-hour difference in the postoperative visit length is dependent on the surgical setting. For example, 8 hours may be the difference between a patient being admitted for greater than or less than 24 hours. In an ambulatory surgical setting, for example, remaining under the 24-hour surgical threshold has a meaningful clinical impact.

This study has several limitations, including additional variables that might be collected in future studies, its retrospective nature, its limited patient follow-up time period, and possible biases such as those related to selection. One variable that might have been useful to record in this study would have been bone mineral density (BMD). Having a record of patient BMD might have been useful to control for possible confounders. The authors of this study were not blinded while conducting the retrospective review, and given the recent increase of literature that investigates the associative nature of preoperative PROMIS scores in other fields,^{11,21} observer biases are plausible, i.e., researchers seeing a pattern they expected to see. Aligned with this, the relatively short follow-up time only permitted the observation of one statistically insignificant time point (e.g., at 1 year). Further follow-up time periods might be necessary in order to better elucidate whether this lack of statistical significance at 1 year is transient or sustained.

Particularly when investigating PROs, though a clinical setting portends numerous advantages in patient evaluation, sick patients are often regarded as more likely to return to clinic. This phenomenon can introduce selection biases, though it is unclear which patient group in this study might be most affect-

ed. Patients who had relatively low preoperative PROMIS scores (<35), might be thought to follow-up with increased frequency based on their perceived low level of function. Contrarily, those who believe they are making less postoperative improvement in PF might also appear as more likely to return to clinic. Regardless of which patient group is more affected, selection bias remains a possible force at play in nearly any PROMIS score investigation because one patient group may have been more likely to return to clinic than another. An additional limitation is that we did not perform a multivariate analysis to evaluate a single dependent variable among our subgroups. While a multivariate regression is likely to be helpful in future studies, we were able to conduct this investigation with, bivariate regressions, t-tests, and chi-square tests. This allowed us to assess our 2 preoperative PROMIS PF subgroups to identify possible differences in postoperative PRO scores and score improvement.

Although our study did not specifically investigate the time required for patients to complete the PROMIS-PF survey, it is important for clinicians to be aware of this possible burden to patients. A previous investigation in a cohort of sports medicine patients by Kadri et al.²⁵ determined that the time to complete the PROMIS-PF CAT questionnaire was 0.74 minutes. An additional limitation involves the subgroups based on the PROMIS-PF 35 cutoff.¹³ Further investigations should evaluate other possible clinically relevant PROMIS-PF subgroups that may be an indicator for postoperative outcomes.

Finally, PROMIS score evaluations require patients to follow-up, and further, they require follow-up at multiple time points. While the best attempts have been made to increase patient follow-up, this study observed a steady decline in the number of patients that continued to follow at each additional time interval. As mentioned earlier, selection bias can result from those who are more sick returning to follow-up more often. Conversely, loss to follow-up might also arise as a result of injured patients becoming less likely to return to clinic. Although numerous methods exist for assessing and altering a dataset that might be affected by selection biases,^{26,27} in this study we have noted the total number of patients at each timepoint, and we only used observations that pertained to a change in score when the same individual had followed up at both the initial (e.g., preoperative) and final (e.g., postoperative) time points.

CONCLUSION

This study identified that, compared to patients with higher relative preoperative PROMIS PF scores, patients undergoing

primary MIS TLIF procedures with reduced PROMIS PF scores, had a larger magnitude of early improvement. We expect the findings of this study to assist clinicians in preoperative counseling and in fostering realistic patient expectations. Compared to patients with higher baseline PROMIS PF scores, patients can be counseled appropriately regarding the potential for early postoperative improvement and similar improvement at 2 years.

CONFLICT OF INTEREST

The authors have nothing to disclose.

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