Asian Spine Journal
Clinical Study
Asian Spine J 2023;17(1):96-108 • https://doi.org/10.31616/asj.2021.0388

Does Baseline Mental Health Influence Outcomes among Workers' Compensation Claimants Undergoing Minimally Invasive Transforaminal Lumbar Interbody Fusion?

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Study Design: This was a retrospective cohort study.

Purpose: This study investigated the influence of preoperative mental health on patient-reported outcome measures (PROMs) and minimal clinically important difference (MCID) among workers' compensation (WC) recipients undergoing minimally invasive transforaminal lumbar interbody fusion (MIS TLIF).

Overview of Literature: No studies have evaluated the impact of preoperative mental functioning on outcomes following MIS TLIF among WC claimants.

Methods: WC recipients undergoing single-level MIS TLIF were identified. PROMs of Visual Analog Scale (VAS) for back and leg pain, Oswestry Disability Index (ODI), 12-item Short Form Physical and Mental Composite Scale (SF-12 PCS/MCS), and Patient-Reported Outcomes Measurement Information System Physical Function evaluated subjects preoperatively/postoperatively. Subjects were grouped according to preoperative SF-12 MCS: <41 vs. ≥41. Demographic/perioperative variables, PROMs, and MCID were compared using inferential statistics. Multiple regression was used to account for differences in spinal pathology.

Results: The SF-12 MCS <41 and SF-12 MCS ≥41 groups included 48 and 45 patients, respectively. Significant differences in ΔPROMs were observed at SF-12 MCS at all timepoints, except at 6 months ($p \leq 0.041$, all). The SF-12 MCS <41 group had worse preoperative to 6-months SF-12 MCS, 12-weeks/6-months VAS back, 12-week VAS leg, and preoperative to 6-months ODI ($p \leq 0.029$, all). The SF-12 MCS <41 group had greater MCID achievement for overall ODI and 6-weeks/1-year/overall SF-12 MCS ($p \leq 0.043$, all); the SF-12 MCS ≥41 group had greater attainment for 6-month VAS back ($p=0.004$).

Conclusions: Poorer mental functioning adversely affected the baseline and intermediate postoperative quality-of-life outcomes pertaining to mental health, back pain, and disability among WC recipients undergoing lumbar fusion. However, outcomes did not differ 1–2 years after surgery. While MCID achievement for pain and physical function was largely unaffected by preoperative mental health score, WC recipients with poorer baseline mental health demonstrated higher rates of overall clinically meaningful improvements for disability and mental health.

Keywords: 12-Item Short Form Mental Composite Scale; Transforaminal lumbar interbody fusion; Workers' compensation; Patient-reported outcome measures; Minimal clinically important difference

Received Sep 21, 2021; Revised Feb 23, 2022; Accepted Mar 17, 2022

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Asian Spine Journal • pISSN 1976-1902 eISSN 1976-7846 • www.asianspinejournal.org

Introduction

Lower back pain (LBP) is a global issue encompassing various underlying complex pathologies, including spinal stenosis, spondylolisthesis, and disk herniation causing nerve root impingement, among others [1]. Minimally invasive transforaminal lumbar interbody fusion (MIS TLIF) is a common procedure for managing spinal pathology-induced back and/or leg pain refractory to conservative measures [1]. With an initial incision of approximately 4 cm less than that in open surgery, MIS TLIF has been shown to reduce estimated blood loss and length of stay (LOS), with patients having significantly lower postoperative back pain, disability, and hospital anxiety and depression scale scores than those undergoing open TLIF (O-TLIF) [2].

The symptomatology of LBP can lead to both mental and physical repercussions, including declining mental health and prolonged disability [3]. Early literature has demonstrated inferior lumbar surgery outcomes among workers' compensation (WC) claimants, including greater disability, pain, dissatisfaction, delayed return to work (RTW), increased loss of employment, and more opiate use among this population [4]. When analyzing spine patients (irrespective of WC status), preoperative mental health has also been associated with poorer recovery in terms of pain, neurogenic symptoms, and return to function following spine surgery [5]. Importantly, Collie et al. [6] studied more than 3,000 WC recipients and discovered that more than 25% of patients had psychological distress, whereas, of those with musculoskeletal impairment and psychological distress, only 27.2% used mental health services. Thus, baseline mental health status is important to consider when evaluating treatments for WC recipients; however, to our knowledge, no study has directly evaluated the influence of preoperative mental health on postoperative outcomes among WC recipients undergoing lumbar surgery—a deficiency in the literature we aim to address.

Patient-reported outcome measures (PROMs) signify a transition from purely quantitative to qualitative markers of surgical success, empowering patients by providing their perspective a voice and contributing to the evolution of value-based care [7]. Minimal clinically important difference (MCID) is a mutually agreed upon and validated threshold employed to rate clinical efficacy among various PROMs used in spine surgery, including Oswestry Disability Index (ODI), Visual Analog Scale for back and leg pain (VAS back and VAS leg, respectively), Patient-Reported Outcomes Measurement Information System Physical Function (PROMIS-PF), and 12-item Short Form Physical Composite Scale (SF-12 PCS) [8-11].

This study was designed to evaluate the influence of differing levels of preoperative mental functioning on PROMs and MCID achievement rates across PROMs among WC claimants undergoing MIS TLIF.

Materials and Methods

1. Patient population

Patient informed consent and Institutional Review Board (IRB) approval (ORA #14051301) at Rush University were obtained before the conduction of this study. The consent of all patients adhered to the IRB standards; all included subjects have continued, active informed consent for this retrospective cohort study that has not expired or been revoked. A retrospective database was searched for patients who underwent fusion of the lumbar spine performed by a single-surgeon. WC claimants with an available preoperative 12-item Short Form Mental Composite Scale (SF-12 MCS) score who underwent single-level MIS TLIF for recurrent herniated nucleus pulposus, degenerative spondylolisthesis, or isthmic spondylolisthesis were included. Those undergoing surgery for degenerative scoliosis or traumatic, malignant, or infectious indications were excluded.

2. Data collection

Demographic data, such as age, gender, body mass index (BMI), ethnicity, smoker status, hypertensive status, American Society of Anesthesiologists (ASA) score, and age-adjusted Charlson comorbidity index (CCI), were collected. The perioperative variables acquired included spinal diagnosis, mean operative time (minutes), mean operative blood loss (mL), postoperative LOS (hours), day of discharge, and 1-year arthrodesis rate as measured using computed tomography. Preoperative spinal pathologies consisted of recurrent herniated nucleus pulposus, isthmic spondylolisthesis, and degenerative spondylolisthesis. Additionally, the foraminal and central distribution of stenosis was determined. PROMs, including SF-12 PCS/MCS, PROMIS-PF, VAS back, VAS leg, and ODI, were

collected before surgery and 6 weeks, 12 weeks, 6 months, 1 year, and 2 years after surgery.

3. Statistical analysis

Stata ver. 16.0 (Stata Corp., College Station, TX, USA) was used to perform all data analyses. Using measures of central tendency (e.g., mean and median) from a normal distribution plot, patients were grouped into groups based on the baseline SF-12 MCS score: <41 versus ≥41. The SF-12 MCS cutoff score of 41 was chosen to divide the groups because it closely represents the median (40.1) and mean (41.5) preoperative scores among the patients included after the implementation of the selection criteria. Demographic and perioperative characteristics were evaluated in each group using Student *t*-test or the chi-square test. The paired samples *t*-test was used to determine significance in improvement from the preoperative period to each postoperative timepoint. Student *t*-test for independent samples was used to compare ΔPROMs between the two SF-12 MCS groups. Student *t*-test was used to compare the mean PROMs among the mental health groups, while multiple regression analysis was used to determine the influence of SF-12 MCS grouping on PROMs after accounting for varying presenting spinal pathologies of recurrent herniated nucleus pulposus, degenerative spondylolisthesis, and isthmic spondylolisthesis between the groups. MCID achievement was determined by comparing ΔPROMs to established threshold values acquired from previously published studies that have calculated these variables: VAS back=2.1 [8]; VAS leg=2.8 [8]; ODI=14.9 [8]; SF-12 PCS=2.5 [9]; SF-12 MCS=9.1 [10]; and PROMIS-PF=4.5 [11]. Patients who achieved MCID were considered to have improved in a clinically meaningful/significant manner for that PROM. MCID achievement was compared among the groups using the chi-square test for independence.

Results

1. Descriptive analysis

Ninety-three patients with a mean age of 47.2 years were included upon implementing the selection criteria, with 48 patients comprising the SF-12 MCS <41 group and 45 patients comprising the SF-12 MCS ≥41 group. Most patients were male (76.1%) and obese (55.9%) with a BMI of ≥30 kg/m^2. Most patients were nondiabetic, nonsmokers, and normotensive at presentation. No significant intergroup differences in demographic variables were observed (Table 1). The proportions of spinal pathologies in the entire cohort were as follows: 29.0% with recurrent herniated nucleus pulposus, 22.1% with isthmic spondylolisthesis, and 36.8% with degenerative spondylolisthesis. Most patients had central stenosis (78.5%), whereas almost half of the patients had foraminal stenosis (44.1%). Meanwhile, the SF-12 MCS ≥41 group had significantly more patients with recurrent herniated nucleus pulposus (p=0.024); the incidence of other spinal pathologies was comparable between the two groups. The SF-12 MCS <41 group had a mean operative time, estimated blood loss, and LOS of 16.4 minutes, 50.1 mL, and 38.4 hours, respectively. The SF-12 MCS ≥41 group had a mean operative time, estimated blood loss, and LOS of 130.3 minutes, 48.1 mL, and 31.5 hours, respectively, without significant differences in these perioperative characteristics between the mental health groups. The mean postoperative narcotic consumption on day 0 in the entire cohort was 65.8 oral morphine equivalent (OME), whereas, on day 1, the mean postoperative narcotic consumption was 47.9 OME; no significant differences were found between the groups. Most patients were discharged on day 1 after surgery for both groups, without significant differences in the day of discharge between the mental health groups. While the proportion of patients achieving 1-year arthrodesis was slightly higher in the SF-12 MCS <41 group (93.8% versus 88.9%), the difference did not reach statistical significance (Table 2).

2. Primary outcome measures

Patients presenting with lower mental functioning had significantly improved PROMIS-PF 6 months and 1 year after surgery, SF-12 PCS 1 year after surgery, SF-12 MCS 1 year after surgery, VAS back 2 years after surgery, VAS leg 1 year after surgery, and ODI from 12 weeks to 1 year after surgery (all p≤0.031). Patients presenting with higher baseline SF-12 MCS had significantly improved PROMIS-PF 6 months and 1 year after surgery, SF-12 PCS 6 months after surgery, VAS back from 6 weeks to 6 months after surgery, VAS leg at all timepoints except for 1 year after surgery, and ODI 12 weeks and 6 months after surgery (all p≤0.046). This cohort did not report significant improvements in SF-12 MCS at any postoperative timepoint (all

Table 1. Patient demographics

Characteristic	Total (n=93)	SF-12 MCS <41 (n=48)	SF-12 MCS ≥41 (n=45)	*p*-value[a]
Age (yr)	47.2±9.4	46.3±9.6	48.1±9.0	0.347
Body mass index (kg/m^2)				0.126
<24.9	9.7 (9)	12.5 (6)	6.7 (3)	
25.0–29.9	34.4 (32)	25.0 (12)	44.4 (20)	
≥30.0	55.9 (52)	62.5 (30)	48.9 (22)	
Gender				0.683
Female	17.2 (16)	18.8 (9)	15.6 (7)	
Male	82.8 (77)	81.3 (39)	84.4 (38)	
Ethnicity				0.642
Caucasian	46.2 (42)	42.6 (20)	50.0 (22)	
African-American	20.9 (19)	23.4 (11)	18.2 (8)	
Hispanic	27.5 (25)	25.5 (12)	29.6 (13)	
Asian	1.1 (1)	2.1 (1)	0	
Other	4.4 (4)	6.4 (3)	2.3 (1)	
Diabetic status				0.440
Non-diabetic	86.0 (80)	83.3 (40)	88.9 (40)	
Diabetic	14.0 (13)	16.7 (8)	11.1 (5)	
Smoking status				0.653
Non-smoker	85.0 (79)	83.3 (40)	86.7 (39)	
Smoker	15.1 (14)	16.7 (8)	13.3 (6)	
Hypertension status				0.554
Normotensive	69.6 (64)	72.3 (34)	66.7 (30)	
Hypertensive	30.4 (28)	27.7 (13)	33.3 (15)	
American Society of Anesthesiologists classification				0.232
<2	19.1 (17)	23.9 (11)	14.0 (6)	
≥2	80.9 (72)	76.1 (35)	86.1 (37)	
Charlson comorbidity index score	1.2±1.2	1.2±1.2	1.2±1.1	0.830

Values are presented as mean±standard deviation or % (number).
SF-12 MCS, 12-item Short Form Mental Composite Scale.
[a]Calculated using Student *t*-test for continuous variables and chi-square analysis for categorical variables.

p>0.05). Comparing ΔPROMs, patients in the SF-12 MCS <41 group experienced significantly greater improvements in SF-12 MCS at all timepoints, except for 6 months after surgery (all $p \leq 0.030$), without further differences in the magnitude of improvements observed (Table 3).

Patients with baseline SF-12 MCS of less than 41 demonstrated significantly poorer SF-12 MCS from presentation to 6 months after surgery (all $p<0.001$), higher VAS back 12 weeks and 6 months after surgery (both $p \leq 0.005$,), higher VAS leg 12 weeks after surgery ($p=0.029$), and higher ODI from the preoperative period to 6 months after surgery (all $p \leq 0.018$) (Table 4). After considering spinal pathologies at presentation, the SF-12 MCS <41 group had significantly lower PROMIS-PF 6 weeks after surgery ($p=0.022$) and SF-12 MCS from the preoperative period to 6 months after surgery (all $p<0.001$). Furthermore, the SF-12 MCS <41 group had greater VAS back 6 months after surgery ($p=0.021$) and ODI from the preoperative period to 12 weeks after surgery (all $p \leq 0.043$) (Table 4).

No significant difference in the MCID achievement rates were observed among the groups for physical function and pain; however, the SF-12 MCS ≥41 group had higher attainment rates for VAS back 6 months after surgery ($p=0.004$). Moreover, the SF-12 MCS <41 co-

Table 2. Perioperative characteristics

Characteristic	Total (n=93)	SF-12 MCS <41 (n=48)	SF-12 MCS ≥41 (n=45)	*p*-value[a]
Spinal pathology				
Recurrent herniated nucleus pulposus	29.0 (27)	18.8 (9)	40.0 (18)	**0.024**
Isthmic spondylolisthesis	22.1 (21)	25.0 (13)	18.6 (8)	0.455
Degenerative spondylolisthesis	36.8 (35)	34.6 (18)	39.5 (17)	0.621
Foraminal stenosis	44.1 (41)	41.7 (20)	46.7 (21)	0.627
Central stenosis	78.5 (73)	75.0 (36)	82.2 (37)	0.397
Operative time (min)	128.3±23.9	126.4±24.0	130.3±23.9	0.436
Estimated blood loss (mL)	49.1±23.1	50.1±23.5	48.1±22.9	0.682
Length of stay (hr)	35.0±23.8	38.4±24.8	31.5±22.5	0.178
Postoperative narcotic consumption (OME)				
POD 0	65.8±38.8	65.3±37.7	66.2±40.2	0.910
POD 1	47.9±38.8	51.2±39.6	44.3±37.9	0.399
Day of discharge				0.668
POD 0	23.0 (20)	18.2 (8)	27.9 (12)	
POD 1	43.7 (38)	43.2 (19)	44.2 (19)	
POD 2	18.4 (16)	20.5 (9)	16.3 (7)	
POD 3	13.8 (12)	15.9 (7)	11.6 (5)	
POD 4	1.2 (1)	2.3 (1)	0	
1-Year arthrodesis (computed tomography)	91.5 (54)	93.8 (30)	88.9 (24)	0.504

Values are presented as % (number) or mean±standard deviation. Boldface indicates statistical significance.
SF-12 MCS, 12-item Short Form Mental Composite Scale; OME, oral morphine equivalent; POD, postoperative day.
[a]Calculated using Student *t*-test for independent samples for continuous variables and chi-square analysis for categorical variables.

hort had higher 6-week, 1-year, and overall SF-12 MCS MCID achievement rates (all $p \leq 0.033$), along with overall achievement for ODI ($p=0.043$) (Table 5).

Discussion

LBP is a debilitating medical condition for a large portion of the American adult population with an annual prevalence rate of 10%–30% and a lifetime prevalence of 60%–85% [12]. This high prevalence translates into LBP serving as the third more prevalent form of disability among adults aged between 45 and 65 years [13]. Spinal fusion surgery is often performed once noninterventional techniques have been exhausted to alleviate LBP [1]. One widely used operative technique among patients with degenerative disease of the lumbar spine is TLIF, which can be performed via minimally invasive surgery (MIS TLIF) or open approach (O-TLIF) [1]. While MIS TLIF and O-TLIF have been shown to demonstrate similar rates of arthrodesis, literature has reported several advantages of the former: reduced blood loss, shorter postoperative stay, and better quality-of-life outcomes related to back pain, disability, and mental functioning [2].

To predict postoperative success more accurately, however, patient factors at presentation (i.e., insurance status and baseline mental functioning) must be considered. Most studies have indicated that patients receiving WC insurance have poorer outcomes following spinal surgery [4]. Among patients undergoing lumbar procedures, a meta-analysis by Russo et al. [4] revealed that WC recipients had postponed RTW, higher postoperative pain and disability, and lower postoperative satisfaction. Diminished preoperative mental health status has also translated to lower outcomes following spinal surgery [5]. For MIS TLIF specifically, patients demonstrating worse preoperative mental health status had worse postoperative PROMIS-PF. All patients demonstrated similar levels of improvement from baseline for shorter timepoints; however, those with worse mental health status demonstrated worse postoperative improvement 1 year after MIS TLIF

Table 3. Improvement in patient-reported outcomes by preoperative SF-12 MCS grouping

PROMs	SF-12 MCS <41 (n=48)	*p*-value[a]	SF-12 MCS ≥41 (n=45)	*p*-value[b]	*p*-value[c]
PROMIS-PF					
Preoperative	31.1±5.0	-	33.4±6.1	-	-
6 Weeks	31.1±4.8	0.674	34.1±4.0	0.135	0.140
12 Weeks	34.6±6.0	0.094	36.6±6.2	0.201	0.930
6 Months	36.7±7.4	**0.010**	38.4±7.4	**0.008**	0.679
1 Year	39.2±8.4	**0.015**	39.6±7.6	**0.037**	0.360
2 Years	35.2±7.9	0.521	36.9±10.6	0.095	0.267
SF-12 PCS					
Preoperative	28.0±5.8	-	27.3±9.4	-	-
6 Weeks	27.0±5.9	0.856	27.6±8.8	0.981	0.892
12 Weeks	28.4±6.4	0.426	28.0±7.2	0.859	0.660
6 Months	28.3±6.2	0.711	31.7±8.3	**0.026**	0.091
1 Year	31.9±10.3	**0.035**	31.3±10.3	0.268	0.843
2 Years	29.2±8.5	0.586	32.9±13.0	0.068	0.182
SF-12 MCS					
Preoperative	32.4±6.4	-	51.2±6.7	-	-
6 Weeks	38.6±10.3	**0.002**	52.4±9.1	0.884	**0.030**
12 Weeks	38.5±10.4	**0.004**	52.2±10.7	0.839	**0.025**
6 Months	38.5±10.7	**0.002**	54.9±10.3	0.415	0.073
1 Year	44.3±11.2	**<0.001**	51.1±10.1	0.267	**<0.001**
2 Years	39.8±10.7	0.070	44.0±13.1	0.109	**0.023**
VAS back					
Preoperative	7.5±1.8	-	6.7±2.2	-	-
6 Weeks	6.1±2.0	**<0.001**	5.4±2.1	**<0.001**	0.844
12 Weeks	6.6±1.9	**0.009**	5.0±2.4	**<0.001**	0.535
6 Months	6.3±2.1	**0.003**	4.6±2.5	**<0.001**	0.066
1 Year	5.4±2.7	**0.007**	4.7±2.6	0.102	0.919
2 Years	5.3±2.9	**0.031**	5.5±1.3	0.478	0.247
VAS leg					
Preoperative	6.7±2.5	-	5.7±2.8	-	-
6 Weeks	4.8±3.1	**<0.001**	4.1±3.1	**0.037**	0.297
12 Weeks	5.1±2.4	**0.001**	3.7±2.9	**0.003**	0.806
6 Months	4.8±2.7	**<0.001**	3.8±2.8	**<0.001**	0.561
1 Year	5.0±3.0	**0.005**	3.4±2.7	0.134	0.761
2 Years	4.6±4.2	0.084	3.4±2.7	0.013	0.843
ODI					
Preoperative	56.4±15.5	-	46.0±13.8	-	-
6 Weeks	55.2±15.7	0.811	46.4±16.1	0.694	0.669
12 Weeks	50.0±13.6	**0.005**	40.4±15.1	**0.046**	0.303
6 Months	46.3±14.3	**<0.001**	35.9±19.3	**<0.001**	0.679
1 Year	42.0±21.4	**0.003**	30.5±18.0	0.069	0.806
2 Years	48.3±28.9	0.812	40.9±20.7	0.179	0.268

Values are presented as mean±standard deviation, unless otherwise stated. Boldface indicates statistical significance.
SF-12 MCS, 12-item Short Form Mental Composite Scale; PROMs, patient-reported outcome measures; PROMIS-PF, Patient-Reported Outcomes Measurement Information System Physical Function; SF-12 PCS, 12-item Short Form Physical Composite Scale; VAS, Visual Analog Scale; ODI, Oswestry Disability Index.
[a]Calculated using paired samples *t*-test to determine improvement from preoperative to postoperative PROMs among SF-12 MCS <41 cohort. [b]Calculated using paired samples *t*-test to determine improvement from preoperative to postoperative PROMs among SF-12 MCS ≥41 cohort. [c]Calculated using Student *t*-test for independent samples to compare mean delta ΔPROMs between SF-12 MCS <41 and SF-12 MCS ≥41 cohorts.

[14]. This trend was similarly found among patients with isthmic spondylolisthesis, as the mean pain and disability PROMs were lower and long-term improvements across PROMs were less frequent among patients presenting with poorer preoperative SF-12 MCS [15].

WC recipients have high rates of mental health issues stemming from various cofactors, including worse general health, psychological distress, and absence from work; however, their use of mental health services remains low [6]. Hee et al. [16] have used the 36-item Short Form Health Survey (SF-36) to evaluate outcomes among WC claimants with spinal disorders; however, their study evaluated individual and summary scores of the SF-36 as outcomes or dependent variables. Although WC patients have worse mental health status, which may be correlated with worse postoperative outcomes, to the best of our knowledge, no direct link has been established. Thus, we sought to use the SF-12 MCS as an independent variable to determine whether varying severities of the preoperative mental health dimension of the SF-36 questionnaire had implications on postoperative outcomes. This will provide insight to providers in their preoperative communication on expectations with WC patients and allow surgeons to better understand whether baseline mental health affects PROMs and MCID attainment following MIS TLIF.

1. Physical function

Previously, Yoo et al. [17] have demonstrated that for anterior cervical diskectomy and fusion (ACDF), WC

Table 4. Comparison of mean patient reported outcomes by preoperative SF-12 MCS grouping

PROMs	SF-12 MCS <41 (n=48)	SF-12 MCS ≥41 (n=45)	*p*-value[a]	*p*-value[b]
PROMIS-PF				
Preoperative	31.1±5.0	33.4±6.1	0.310	0.510
6 Weeks	31.1±4.8	34.1±4.0	0.068	0.022
12 Weeks	34.6±6.0	36.6±6.2	0.364	0.930
6 Months	36.7±7.4	38.4±7.4	0.536	0.208
1 Year	39.2±8.4	39.6±7.6	0.687	0.503
2 Years	35.2±7.9	36.9±10.6	0.726	0.868
SF-12 PCS				
Preoperative	28.0±5.8	27.3±9.4	0.671	0.247
6 Weeks	27.0±5.9	27.6±8.8	0.768	0.665
12 Weeks	28.4±6.4	28.0±7.2	0.810	0.759
6 Months	28.3±6.2	31.7±8.3	0.156	0.235
1 Year	31.9±10.3	31.3±10.3	0.862	0.750
2 Years	29.2±8.5	32.9±13.0	0.467	0.835
SF-12 MCS				
Preoperative	32.4±6.4	51.2±6.7	**<0.001**	**<0.001**
6 Weeks	38.6±10.3	52.4±9.1	**<0.001**	**<0.001**
12 Weeks	38.5±10.4	52.2±10.7	**<0.001**	**<0.001**
6 Months	38.5±10.7	54.9±10.3	**<0.001**	**0.001**
1 Year	44.3±11.2	51.1±10.1	0.074	0.313
2 Years	39.8±10.7	44.0±13.1	0.436	0.816
VAS back				
Preoperative	7.5±1.8	6.7±2.2	0.081	0.342
6 Weeks	6.1±2.0	5.4±2.1	0.165	0.319
12 Weeks	6.6±1.9	5.0±2.4	**0.005**	0.056
6 Months	6.3±2.1	4.6±2.5	**0.002**	**0.021**
1 Year	5.4±2.7	4.7±2.6	0.461	0.185
2 Years	5.3±2.9	5.5±1.3	0.904	0.730
VAS leg				
Preoperative	6.7±2.5	5.7±2.8	0.091	0.091
6 Weeks	4.8±3.1	4.1±3.1	0.332	0.753
12 Weeks	5.1±2.4	3.7±2.9	**0.029**	0.287
6 Months	4.8±2.7	3.8±2.8	0.118	0.444
1 Year	5.0±3.0	3.4±2.7	0.148	0.053
2 Years	4.6±4.2	3.4±2.7	0.527	0.885
ODI				
Preoperative	56.4±15.5	46.0±13.8	**0.001**	**0.007**
6 Weeks	55.2±15.7	46.4±16.1	**0.018**	**0.043**
12 Weeks	50.0±13.6	40.4±15.1	**0.008**	**0.039**
6 Months	46.3±14.3	35.9±19.3	**0.011**	0.084
1 Year	42.0±21.4	30.5±18.0	0.119	0.117
2 Years	48.3±28.9	40.9±20.7	0.584	0.951

Values are presented as mean±standard deviation, unless otherwise stated. Boldface indicates statistical significance.
SF-12 MCS, 12-item Short Form Mental Composite Scale; PROMs, patient-reported outcome measures; PROMIS-PF, Patient-Reported Outcomes Measurement Information System Physical Function; SF-12 PCS, 12-item Short Form Physical Composite Scale; VAS, Visual Analog Scale; ODI, Oswestry Disability Index.
[a]Calculated using Student *t*-test for independent samples to compare mean PROMs. [b]Calculated using multiple linear regression to determine the impact of SF-12 MCS grouping on PROMs, while accounting for preoperative spinal pathology (recurrent herniated nucleus pulposus, degenerative spondylolisthesis, and isthmic spondylolisthesis).

(Continued on next page)

patients have lower preoperative and postoperative PROMIS-PF than non-WC patients. However, both cohorts experienced similar postoperative changes from baseline. Goh et al. [18] found that patients with worse mental health had lower preoperative PROMs but attained similar outcomes from 3 months to 2 years after MIS TLIF. Meanwhile, in the first study to assess the combined effect of depression and anxiety on PROMs after lumbar fusion, Goyal et al. [19] found no significant difference in terms of the change in PROMs between both groups. Similarly, this study found no statistical difference between the two cohorts (SF-12 MCS <41 and SF-12 MCS ≥41) preoperatively or postoperatively in terms of the magnitude of improvement or the mean PROMIS-PF or SF-12 PCS scores. However, after accounting for preoperative presenting pathologies, the SF-12 MCS <41 cohort had a significantly lower mean PROMIS-PF 6 weeks after surgery.

A well-established manifestation of depression is the reduction in physical activity, which may hinder physical rehabilitation and patient perception of physical health progress [20]. No differences were found throughout the later postoperative period for either physical function PROM, suggesting that there is initial difficulty in perception of recovery, but, with time, patients with mental health troubles may realize more significant physical recovery. Goyal et al. [19] also found no differences in MCID attainment for physical function between both cohorts, along with Patel et al. [15] who focused on analyzing the influence of SF-12 MCS among patients with isthmic spondylolisthesis. Meanwhile, Goh et al. [18] found greater attainment of MCID for PCS in the cohort with

Table 5. MCID achievement

PROMs[a]	SF-12 MCS <41 (n=48)	SF-12 MCS ≥41 (n=45)	*p*-value[b]
ODI			
6 Weeks	20.5	11.4	0.290
12 Weeks	34.4	15.2	0.072
6 Months	51.4	28.6	0.051
1 Year	35.0	30.8	0.801
2 Years	0	28.6	0.104
Overall	53.3 (24)	31.7 (13)	**0.043**
PROMIS-PF			
6 Weeks	17.7	66.7	0.331
12 Weeks	28.6	23.1	0.745
6 Months	61.5	36.4	0.219
1 Year	50.0	62.5	0.571
2 Years	37.5	42.9	0.833
Overall	66.7 (14)	50.0 (9)	0.291
SF-12 PCS			
6 Weeks	37.0	22.7	0.280
12 Weeks	43.5	36.0	0.597
6 Months	35.0	45.0	0.519
1 Year	66.7	50.0	0.324
2 Years	33.3	58.3	0.256
Overall	66.7 (24)	63.6 (21)	0.792
SF-12 MCS			
6 Weeks	44.4	16.7	**0.033**
12 Weeks	34.8	18.5	0.191
6 Months	45.0	20.0	0.091
1 Year	72.2	6.3	**<0.001**
2 Years	33.3	25.0	0.676
Overall	66.7 (24)	28.6 (10)	**0.001**
VAS back			
6 Weeks	30.8	33.3	0.812
12 Weeks	29.0	36.4	0.532
6 Months	20.6	54.3	**0.004**
1 Year	30.0	53.9	0.171
2 Years	37.5	42.9	0.833
Overall	48.9 (22)	69.1 (29)	0.056
VAS leg			
6 Weeks	37.8	33.3	0.695
12 Weeks	35.5	30.3	0.659
6 Months	44.1	42.9	0.916
1 Year	25.0	46.2	0.208
2 Years	57.1	50.0	0.797
Overall	55.8 (24)	52.5 (21)	0.762

Values are presented as % or % (number). Boldface indicates statistical significance.
MCID, minimal clinically important difference; PROMs, patient-reported outcome measures; SF-12 MCS, 12-item Short Form Mental Composite Scale; ODI, Oswestry Disability Index; PROMIS-PF, Patient-Reported Outcomes Measurement Information System Physical Function; SF-12 PCS, 12-item Short Form Physical Composite Scale; VAS, Visual Analog Scale.
[a]The following MCID thresholds were utilized among PROMs listed: VAS back=2.1; VAS leg=2.8; ODI=14.9; SF-12 PCS=2.5; and PROMIS-PF=4.5. [b]Calculated chi-square test for independence.

worse initial mental health. While our analysis is unique in that it focuses entirely on a WC cohort, our data are consistent with those of Goyal et al. [19] and Patel et al. [15], as both cohorts had similar levels of physical MCID achievement. While preoperative mental health management may be beneficial to patients with WC insurance, our analysis reveals that it may not pose significant limitations on long-term PROMs or meaningful clinical improvement.

2. Mental health

Patients presenting with poorer preoperative mental health experienced significant improvements in SF-12 MCS scores from the preoperative period to most postoperative timepoints, whereas those presenting with better preoperative mental health ratings did not significantly improve in SF-12 MCS score at any postoperative timepoint following MIS TLIF. When comparing the mean ΔPROM scores for postoperative mental health, patients in the SF-12 MCS <41 group experienced significantly greater magnitude of improvement (at most timepoints) than those in the SF-12 MCS ≥41 group. Additionally, the MCID achievement rates among patients in the SF-12 MCS <41 group were significantly higher than those in patients in the SF-12 MCS ≥41 groups 6 weeks and 1 year after surgery and overall. Our findings therefore suggest that patients presenting with greater psychological distress are more likely to experience improvement in postoperative mental health functioning to a clinically meaningful extent. As higher levels of postoperative depression have been associated with an increase in dissatisfaction following lumbar surgery, our findings of drastic mental health improvements may provide comfort to MIS TLIF surgical

candidates with baseline mood disorder [21]. Other authors have also suggested that spine surgery can improve mental health, such as Cushnie et al. [22] reporting improvements in SF-12 MCS from as early as 3 months to 1 year following surgery. A plausible explanation for the drastic improvements in SF-12 MCS among patients with worse mental health is that poorer preoperative mental health may be associated with poorer overall health-related quality-of-life [22]. A study has also suggested a close relationship between depression, somatization, and LBP [3]. Therefore, as MIS TLIF has been shown to significantly improve quality-of-life outcomes following surgery [2], relief of pain and disability may improve depressive symptoms, a potential contributor for the significant improvements observed in our low SF-12 MCS cohort. Nonetheless, while possible confounding demographic variables (e.g., age, BMI, gender, ethnicity, diabetic status, smoking status, hypertensive status, ASA classification, and CCI score) did not significantly differ between the two groups, other confounders may have biased postoperative mental health scores, an important limitation to this result.

Upon comparing the mean PROMs between the two groups, the SF-12 MCS <41 group on average had lower mental functioning scores (both before and after accounting for presenting spinal pathologies) from the preoperative period to 6 months after surgery. However, the significance of differences did not persist 1 or 2 years following MIS TLIF. Therefore, WC patients with mental health conditions may be reassured that while post-MIS TLIF mental health outcomes will likely remain lower at baseline and in the early/intermediate postoperative period, longer-term scores are likely to equalize. Nevertheless, spine surgeons should continue to screen for mental health conditions at postoperative follow-up to ensure early management and maximize patient satisfaction.21

3. Pain

Tabaraee et al. [23] have previously considered VAS scores following ACDF between WC and non-WC individuals. Preoperatively, VAS scores did not vary between the two cohorts. Both groups demonstrated improvement; however, the mean VAS score was significantly higher in the WC cohort by approximately 1 point at all timepoints (i.e., 6 weeks, 12 weeks, and 6 months after surgery) [23]. Pelton et al. [24] also reported that WC status is an indicator of high rates of pain following MIS TIlF. Meanwhile, Goyal et al. [19] reported that depression and anxiety had no effect on preoperative and postoperative VAS scores. Goh et al. [18] found that preoperative VAS back scores were significantly higher in individuals with poorer mental health. This difference remained significant 1 month after surgery only. Similarly, VAS leg scores were only significantly higher in the cohort with poorer mental health preoperatively and 1 month after surgery. No long-term differences were observed between the two groups [18]. We found that the mean VAS back score for the cohort with poorer mental health 12 weeks and 6 months after surgery was significantly higher by more than 1 point. However, this did not extrapolate to longer timepoints of 1 year or 2 years after surgery, and the 12-week difference did not remain after accounting for presenting spinal pathologies. Similarly, the mean VAS leg score was significantly higher in the lower mental health cohort 12 weeks after surgery; however, this difference did not remain after accounting for varying presenting spinal pathologies at presentation. Therefore, patients with mental health problems may be less likely to perceive pain progress in an optimistic light at intermediate timepoints, until a certain magnitude of improvement is reached at the longer-term 2-year timepoint. Moreover, the fact that most differences observed dissipated after accounting for differing preoperative spinal diagnoses is particularly encouraging. For MCID achievement, the achievement rates in the better mental health cohort were significantly higher in terms of VAS back 6 months after surgery. However, this significant difference did not extrapolate into the longer-term 1-year or 2-year follow-up timepoints. Furthermore, no difference was observed in the MCID attainment rates across VAS leg scores between the two cohorts. Regarding postoperative goals of pain recovery, surgeons should not be deincentivized to provide treatment to patients with lower baseline mental health, as there appears to be no long-term difference in patient-perceived pain or clinically meaningful improvement in patients with poorer preoperative mental health.

4. Disability

Carreon et al. [25] found that after controlling for lumbar fusion, WC patients had significantly lesser improvements in disability (ΔODI) than non-WC patients. Meanwhile, Mayo et al. [26] grouped patients according to preoperative MCS and reported no significant difference in

postoperative improvement for ODI between groups. Similarly, in this study, both SF-12 MCS cohorts exhibited significant improvement in disability (measured using the ODI) from the preoperative period to multiple postoperative timepoints, and ΔPROM values for postoperative ODI did not differ between the two cohorts. Of note, the 2-year ODI scores did not differ significantly from the preoperative period to the postoperative period for either group. Loss of follow-up by the final timepoint likely contributed to the selection bias to this result and decreased the statistical power of this finding because of less patient data 2 years after surgery. Furthermore, the mean ODI scores were still more than 5.0 points lower from the preoperative period to the final timepoint for both groups.

However, upon comparing the mean ODI score between the two groups, we discovered that disability was significantly higher for patients with SF-12 MCS <41 preoperatively and 6 weeks, 12 weeks, and 6 months after surgery, with this relationship generally maintained following multiple regression analysis for covariates of differing spinal pathologies. As PROMs are grounded on perception, this may be in part due to predilection for negative thoughts about oneself, a well-established trend among patients with depression, applied to their postsurgical outlook on progress [27]. However, there was no significant difference at the long-term timepoints of 1 and 2 years, suggesting that with greater time passed from surgery, perception normalizes.

Regarding MCID attainment for ODI, Hijji et al. [28] found no significant difference between WC and non-WC individuals following MIS TLIF. Mayo et al. [26] also found no significant difference in the ODI MCID achievement rates when stratifying lumbar fusion recipients into MCS groups. Interestingly, we found no significant difference in ODI MCID achievement between the SF-12 MCS cohorts at each timepoint. However, when extrapolated to the overall postoperative period, the cohort presenting with poorer mental health had significantly greater amounts of disability-related MCID achievement. This is likely a result of lower preoperative ODI scores for the SF-12 MCS <41 group.

5. Comparisons to existing literature on mental health and spinal surgery outcomes

While our analysis generally did not reveal significant differences in improvement, mean scores, or MCID achievement rates across physical function, mental health, pain, and disability, particularly in the long-term follow-up window (1 year/2 years), some existing literature has suggested poorer postoperative clinical outcomes among patients presenting with poorer mental health. For instance, Stull et al. [29] examined 391 patients stratified into groups according to preoperative SF-12 MCS scores and found that improvements in SF-12 PCS, ODI, VAS back, and VAS leg were lower among patients with lower mental functioning at baseline. Goyal et al. [19] similarly observed worse postoperative SF-12 MCS and ODI in patients with combined depression and anxiety. However, the authors importantly did not find differences in the recovery ratio, delta PROMs, or MCID attainment, aligning with our findings [19]. Other studies have also correlated with our findings, such as the results of Lee et al. [30], indicating no significant association between mental health status and improvement across VAS or ODI. Contrasting findings from our study and the aforementioned literature may be in part because of the inclusion of WC patients only, which, to the best our knowledge, has not been previously evaluated. Based on the fact that WC patients have consistently experienced poorer clinical outcomes following lumbar surgery and are more likely to have higher levels of symptoms at baseline because of work-related injuries, the effects of mental health on postoperative outcomes may be mitigated [4]. Nevertheless, future studies in a multi-centered environment with a larger cohort are required to confirm the conclusions revealed in this study.

6. Limitations

This study has numerous limitations. A single-surgeon registry of procedures performed at a single academic institution was used, limiting the generalizability of the findings. Further multicenter studies may provide greater statistical power and external validity to our results. As heterogeneous pathologies were included, certain diagnoses may have a predilection for differing confidence in surgery, along with varying levels of severity, which may provide confounder bias to our results. To account for the influence of confounder bias related to the present-

ing levels of spinal pathologies, we performed a multiple regression analysis, which demonstrated similar results. Nevertheless, future studies with more subjects may add value by separating outcomes according to presenting pathologies. The outcomes of PROMs and MCID attainment were grounded on patient perception, adding a source of subjective bias on the results. While comparing the mean PROMs by SF-12 MCS grouping, we used Student *t*-test for independent samples; however, mix-model analysis of variance could have provided two-way effect analysis on time and grouping by SF-12 MCS preoperative score. Because of the potential downfall of confounding ordering effects of this technique, we decided to use Student *t*-test for independent samples, however, to ensure a direct comparison of the mean PROMs by each respective timepoint to draw conclusions stratified by timepoint. However, to account for changes in PROMs by time, we evaluated improvements in PROM scores from the preoperative period to each postoperative timepoint within each SF-12 MCS group. We also compared ΔPROMs at each postoperative timepoint to evaluate whether the magnitude of change significantly differed between the SF-12 MCS groups. Additionally, while using the medians and means may offer limitations, such as closeness in baseline mental status among patients with scores centered around these central tendency metrics, the authors' goal was to stratify patients based on relative higher versus lower preoperative mental scores among the cohorts under study. Furthermore, while the mean is subject to outliers, the value of 41 is remarkably close to the median score, which is more resistant to outliers, providing further support in the use of this value. Moreover, not all data on perioperative variables were available for each patient, limiting the statistical power of these results. Finally, most fusion procedures included after the implementation of the inclusion and exclusion criteria were single-level TLIF, while single-level anterior lumbar interbody fusion and lateral lumbar interbody fusion only represented a minority of cases, adding potential selection bias to our results. As these procedures are varied in technique and indications for this study, this may provide skew to our results; however, with no difference among preoperative spinal diagnoses and to maintain statistical power in the number of subjects, including all lumbar fusions it was beneficial to, although this limitation is significant and must be recognized.

Conclusions

WC claimants with lower baseline mental functioning demonstrated poorer mental health and disability PROM scores before surgery and at the intermediate follow-up timepoints (6 weeks to 6 months after surgery) following MIS TLIF. WC patients with lower baseline mental functioning also had higher severity of VAS back in the intermediate follow-up period (12 weeks and 6 months after surgery). However, long-term PROM scores for all questionnaires 1 and 2 years following surgery were comparable between both mental health cohorts. Meanwhile, the overall MCID achievement for ODI was significantly higher for the SF-12 MCS <41 group, suggesting higher rates of disability-related clinically meaningful improvements among patients presenting with poorer mental health. This may be explained by worse baseline ODI scores among this patient cohort, representing a higher capacity for improvement. Nonetheless, clinically meaningful improvements across physical function and pain PROMs were similar to the SF-12 MCS ≥41 group. Before surgery, discussing evidence-based findings with WC patients with mental distress is vital to align expectations with probable outcomes. Further multicenter studies are necessary to strengthen and confirm the trends observed in this single-surgeon, single-center study.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Author Contributions

Analysis of data and drafting manuscript: Madhav R. Patel, Kevin C. Jacob, Kanhai S. Amin, Max A. Ribot; administrative support: Hanna Pawlowski, Michael C. Prabhu, Nisheka N. Vanjani; conception and design, data acquisition, and supervision: Kern Singh; and critical revision: all authors.

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