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Epidemiological Relevance of Elevated Preoperative Patient Health Questionnaire-9 Scores on Clinical Improvement Following Lumbar Decompression

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ABSTRACT

Background: Limited research exists regarding the influence of preoperative depression on postoperative mental health, physical function, and pain in lumbar decompression (LD) patients. This study aims to evaluate the association of depressive symptoms as measured by the Patient Health Questionnaire-9 (PHQ-9) with other mental health and physical function clinical outcomes among patients undergoing LD.

Methods: A prospectively maintained surgical registry was reviewed for primary LD from March 2016 to May 2019. Patients were stratified into 3 preoperative PHQ-9 score subgroups. Higher PHQ-9 scores indicated greater depressive symptoms. We assessed demographic and perioperative characteristics among subgroups with appropriate statistical testing. We also evaluated outcome instruments and postoperative improvement for the following outcomes: PHQ-9, Short Form 12 (SF-12), Veterans RAND 12-Item (VR-12), Patient-Reported Outcomes Measurement Information System Physical Function (PROMIS-PF), visual analog scale (VAS) leg, and VAS back.

Results: The 351-subject cohort was 70.4% men with an average age of 47 years; 186 subjects had minimal preoperative depressive symptoms (PHQ-9 <5), 94 had moderate (5≤ PHQ-9 ≤10), and 71 had severe (PHQ-9 >10). Subgroups with more severe symptoms of depression had worse mental health outcome scores (PHQ-9, 12-Mental Health Composite Score [12-MCS], and VR-12-MCS) and a positive linear association with greater pre- to postoperative mental health improvements at all timepoints. Subgroups with more severe symptoms of depression had worse PROMIS-PF scores at all timepoints, though VAS pain scores had no depression symptom association by 1 year.

Conclusion: Patients with more severe preoperative depressive symptoms, as evaluated by PHQ-9, have a greater improvement in PHQ-9, SF-12, and VR-12 scores, but more severe PHQ-9 scores are associated with worse overall physical function scores. This study demonstrates the relevance of preoperative depressive symptoms and their necessity in future risk factor models.

Level of Evidence: 3.

Clinical Relevance: Severity of preoperative PHQ-9 acts as a significant risk factor to postoperative pain and mental and physical health improvement.

Minimally Invasive Surgery

Keywords: Patient Health Questionnaire-9 (PHQ-9), major depressive disorder (MDD), lumbar decompression, risk factors, Short Form-12 (SF-12), Veterans RAND 12 Item Health Survey (VR-12)

INTRODUCTION

Spinal decompression surgery may be necessary to alleviate some of the most common symptoms of central canal and foraminal stenosis.[1–3] Symptoms indicative of possible surgical intervention include claudication, gait irregularities, and radiculopathy of the lower extremities.[4] Hence, instruments aiding in selecting patients who will benefit the most from lumbar decompression (LD) are of continued interest within spine surgery literature. Patient characteristics thought to be the most associated with postoperative outcomes are typically thought to be dependent on patient population and procedure. Risk factors associated with worse outcomes and postoperative complications following lumbar surgery include postoperative blood transfusion,[5] cancer, ethnicity, open wounds, ascites, renal failure, frailty,[6] body mass index (BMI), and cardiovascular diseases, which are among the most commonly studied.[7] Many of the aforementioned medical risk factors have been studied and analyzed on their own and in the context of risk prediction modeling.

While risk prediction modeling can be helpful among certain patient populations, models often suffer from a narrow scope or cumbersome practical utilization.[8–14] Risk prediction instrument examples include the Seattle

Spine Score[15] and the Stanford spine Risk Assessment Tool.[9] Although model validation techniques have been utilized in these examples, they often are applied as a part of a single-institutional project. Another predictive model, the Canadian Study of Health and Aging (CSHA) Frailty Index,[16] differs in that it has been applied to numerous populations. Critics cite that theCSHA lacks applicability to elective degenerative spine surgeries due to its frailty-centered structure.[6,17]

Other difficulties encountered with predictive model use are related to the requirements for proprietary software, limited-access calculators, and significant institutional resources.[7] Risk models typically focus on perioperative factors, variables that are disease-specific, and medical characteristics. Even in light of the increased discussion regarding the influence of psychiatric symptoms on spine surgery outcomes, this discussion is very limited within risk factor modeling.

Symptoms associated with preoperative depression and anxiety have been observed to predict greater postoperative pain, physical impairments, and lower health-related quality of life in patients undergoing surgery.[18,19] After undergoing spine surgery, depressed patients report more severe pain, increased narcotic use, and less clinical improvement after surgical intervention.[20] Patients who suffer from increased depressive symptoms are thought to require customized treatment modalities within pain management protocols.[21] Furthermore, patients who experience chronic low back pain also present with major depression at a rate three to four times higher than the general population, and approximately one-third of patients with chronic low back pain who undergo surgery present with symptoms of preoperative depression.[21]

The Patient Health Questionnaire-9 (PHQ-9) assists clinicians in making the diagnosis of depression and quantifies depression symptoms with the intention to monitor severity over time. The PHQ-9 has been shown to be a reliable and valid measure of depression severity for two decades, and its ease of access and brevity make it a useful clinical and research tool.[22] Although several studies have researched the influence of preoperative depressive symptoms on postoperative surgical outcomes, there is a scarcity of literature regarding the correlation of preoperative depression and its impact on mental health and physical function clinical outcomes among patients who undergo surgical LD. The primary objective of this study is to investigate the association of PHQ-9 scores with mental health and physical function clinical outcomes among patients who underwent LD. The secondary aim of this study is to identify if mental health might be a valid consideration within more broader outcome prediction models.

METHODS

Patient Population

After obtaining institutional review board approval (ORA# 14051301), a prospectively maintained surgical registry was retrospectively reviewed for eligible patients who underwent LD surgeries from March 2016 to May 2019. Inclusion criteria were patients undergoing elective, primary, LD for degenerative spine pathologies. Our study excluded patients who failed to fill out a preoperative PHQ-9 survey.

Data Collection

Patients were grouped by their preoperative symptoms of depression as evaluated by PHQ-9 subgroup score according to previously established cutoff points[23] (<5, minimal; 5–10, moderate; >10, severe), with higher scores indicating increased symptoms of depression. The following baseline demographics were recorded: age, gender, smoking status, comorbid diagnosis, preoperative duration of spine-related symptoms, BMI, Charlson Comorbidity Index (CCI), and insurance coverage. Perioperative characteristics were recorded including operative time (from skin incision to closure), estimated blood loss (EBL), length of stay, and discharge day. Patient-reported outcome differences were assessed among PHQ-9 subgroups for pre- and postoperative (eg 6 weeks, 12 weeks, 6 months, and 1 year) mental health scores using PHQ-9, 12-item Short Form (SF-12) Mental Health Composite Score (MCS), Veterans RAND 12-item MCS (VR-12 MCS), Patient-Reported Outcome Measurement Information System Physical Function (PROMIS-PF), visual analog scale leg pain (VAS leg), and VAS back surveys.

Statistical Analysis

Stata 16.0 (StataCorp, College Station, TX) was used to perform all calculations and statistical analyses. A χ^2 test analyzed the association of PHQ-9 subgroups in the following: gender, smoking status, comorbid diagnosis, BMI, and insurance coverage. Linear regression was used for continuous variables, which included age and CCI. Mean differences among PHQ-9 subgroups were assessed via linear regression for operative variables, including operative time, EBL, length of stay, and discharge day. Linear regression was used to assess mean differences among PHQ-9 subgroups for postoperative

Table 1. Patient demographics by PHQ-9 score.

Characteristic	Total (n = 351)	PHQ-9 <5 (n = 186)	PHQ-9 5–10 (n = 94)	PHQ-9 >10 (n = 71)	P value[b]
Age, y, mean ± SD	46.8 ± 14.3	48.6 ± 14.9	46.4 ± 13.6	42.5 ± 12.4	0.008
Gender					0.605
Female	29.6% (104)	27.4% (51)	33.0% (31)	31.0% (22)	
Male	70.4% (247)	72.6% (135)	67.0% (63)	69.0% (49)	
Body mass index					0.041
Nonobese (<30 kg/m^2)	57.0% (200)	62.9% (117)	53.2% (50)	46.5% (33)	
Obese (≥30 kg/m^2)	43.0% (151)	37.1% (69)	46.8% (44)	53.5% (71)	
Smoking status					0.085
Nonsmoker	88.9% (312)	91.4% (170)	89.4% (84)	81.7% (58)	
Smoker	11.1% (39)	8.6% (16)	10.5% (10)	18.3% (13)	
Insurance coverage					0.334
Private or workers compensation	97.4% (338)	96.2% (179)	98.9% (92)	98.5% (67)	
Medicare/Medicaid	2.6% (9)	3.8% (7)	1.1% (1)	1.5% (1)	
Ageless CCI, mean ± SD	0.63 ± 0.9	0.65 ± 0.9	0.69 ± 0.9	0.51 ± 0.8	0.432
Duration of symptoms, mo, mean ± SD	34.0 ± 57.0	30.0 ± 64.4	20.0 ± 59.6	16.4 ± 31.2	0.144
Preoperative diagnosesa					
Chronic obstructive pulmonary disease	0.8% (1)	1.8% (1)	1.8% (1)	0% (0)	0.
Myocardial infarction	2.3% (8)	2.7% (5)	1.1% (1)	2.8% (2)	0.652
Diabetes	5.4% (21)	3.2% (6)	12.8% (12)	4.2% (3)	0.005
Congestive heart failure	0.6% (2)	0.5% (1)	1.1% (1)	0% (0)	0.665
Hypertension	23.4% (82)	23.1% (43)	29.8% (28)	15.5% (11)	0.099
Neurologic disease	0.6% (2)	1.1% (2)	0.0% (0)	0% (0)	0.410
Arthritis	8.6% (30)	9.7% (18)	6.4% (6)	8.5% (6)	0.648
Renal failure	0.3% (1)	0.5% (1)	0.0% (0)	0.0% (0)	0.648
Malignancy	4.6% (16)	7.0% (13)	3.2% (3)	0.0 % (0)	0.042

Abbreviations: CCI, Charlson Comorbidity Index; PHQ-9, Patient Health Questionnaire-9.
Data presented as % (n) unless otherwise indicated.
[a]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, or gastrointestinal bleeds.
[b]P value was calculated using Student's t test (continuous), χ^2 (categorical), or Fisher's exact test (categorical).

mental health scores and delta values between pre- and postoperative timepoints (eg, 6 weeks, 12 weeks, 6 months, and 1 year) for PHQ-9, SF-12-MCS, and VR-12 MCS. Linear regression also evaluated the relationship among preoperative PHQ-9 subgroups for postoperative physical function and pain scores and for delta values between pre- and postoperative timepoints as evaluated by PROMIS-PF, VAS leg, and VAS back. Statistical significance was set at $P < 0.05$.

RESULTS

Demographic Characteristics

A total of 351 subjects were included in the study. The cohort was 70.4% men with an average age of 46.8 years, and 43.0% were obese (BMI ≥30 kg/m^2). Subcategorization resulted in 186 subjects in the preoperative minimal PHQ-9 <5 group, 94 in moderate PHQ-9 5–10, and 71 in severe PHQ-9 >10. There was a statistically significant difference between subgroups for age (P = 0.008), BMI (P = 0.041), diabetes (P = 0.005), and malignancy (P = 0.042, Table 1). PHQ-9 subgroups showed no differences with regard to the remaining baseline demographics.

Perioperative Characteristics

PHQ-9 subgroups demonstrated no statistically significant differences for any of the recorded perioperative variables including operative time, EBL, hospital length of stay, and discharge day (Table 2).

Patient-Reported Outcomes

At all pre- and postoperative timepoints, a significant positive linear association was demonstrated between the mean mental health survey score (PHQ-9, SF-12-MCS, and VR-12-MCS) and PHQ-9 subgroups (all $P < 0.013$, Table 3). The postoperative mental health improvement delta demonstrated a significant positive linear association between preoperative PHQ-9 subgroups and postoperative PHQ-9 scores at 6 weeks, 12 weeks, 6 months, and 1 year (all $P < 0.001$, Table 4). Furthermore, no significant difference was calculated among subgroups at 12 weeks for SF-12 MCS (P = 0.167), at 6 months for SF-12 MCS (P = 0.053), or at 12 weeks for VR-12 MCS (P = 0.108). SF-12 MCS and VR-12 MCS demonstrated statistically significant differences in improvement at 1 year (P = 0.005 and P = 0.014, respectively).

Table 2. Operative characteristics by PHQ-9 score.

Characteristic	PHQ-9 <5 (n = 186)	PHQ-9 5–10 (n = 94)	PHQ-9 >10 (n = 71)	P value[b]
Operative time,[a] min, mean ± SD	49.8 ± 24.7	46.4 ± 20.2	50.8 ± 24.5	0.4160
Estimated blood loss, mL, mean ± SD	27.5 ± 11.5	28.9 ± 13.9	34.1 ± 57.5	0.239
Length of hospital stay, h, mean ± SD	9.4 ± 21.6	5.4 ± 23.9	8.5 ± 14.7	0.320
Discharge day, % (n)				0.183
POD 0	83.9% (156)	86.2% (81)	87.3% (62)	
POD 1	14.5% (27)	8.5% (8)	8.5% (6)	
POD 2	0.0% (0)	3.2% (3)	1.4% (1)	
POD 3	1.6% (3)	2.1% (2)	2.8% (2)	

Abbreviations: PHQ-9, Patient Health Questionnaire-9; POD, postoperative day.
[a]Operative time was measured from skin incision to skin closure.
[b]P value was calculated using Student's t test (continuous), χ^2 analysis (categorical), or Fisher's exact test (categorical).

We observed that increasingly severe preoperative depression symptoms were associated with worse physical function scores through the 6-month timepoint as evaluated by PROMIS-PF (all $P < 0.036$, Table 5). While associations between increasingly severe symptoms of depression, back pain, and leg pain were demonstrated through the 6-month follow-up, this association was lost by 1 year. More specifically, relative to the least severe depressive group (PHQ-9 <5), a more severe depression score (PHQ ≥5) demonstrated a significant effect on PROMIS-PF values (both $P \leq 0.001$). A similar result was also observed at 6 weeks (both $P \leq 0.024$) and 12 weeks ($P \leq 0.021$), but at the 6-month timepoint, only a PHQ-9 >10 demonstrated a significantly effect on PROMIS-PF ($P = 0.020$). For VAS back, a PHQ-9 ≥5 demonstrated a significant effect on preoperative back pain scores relative to a PHQ-9 <5 (both $P < 0.001$). Postoperatively, the most severe depressive group (PHQ-9 >10) demonstrated a significant effect on VAS back scores at 6 weeks ($P = 0.006$), 12 weeks ($P = 0.002$), and 6 months ($P = 0.004$). A PHQ-9 of 5–10 only demonstrated a significant effect on VAS back scores at the 6-month timepoint ($P = 0.041$). Only a PHQ-9 >10 demonstrated a significant effect on VAS leg scores from the preoperative through the 6-month timepoints (all $P < 0.04$). In our comparison of mean pre- to postoperative improvement delta values among PHQ-9 subgroups, only VAS leg delta scores at the 6-month timepoint ($P = 0.036$) were observed to have a significant association with preoperative depressive symptom scores (Table 6).

DISCUSSION

Orthopedic research continues to focus a considerable effort on the influence of preoperative mental health on postoperative outcomes.[24–30] Numerous studies within spine literature have identified associations between

Table 3. Postoperative mental health over predetermined time periods.

PROM	PHQ-9 <5 (n = 186)	PHQ-9 5–10 (n = 94)	PHQ-9 >10 (n = 71)	P value[a]
PHQ-9				
Preoperative	1.9 ± 1.6 (186)	6.8 ± 1.4 (94)	15.4 ± 4.2 (71)	<0.001
6 wk	1.7 ± 2.6 (132)	3.3 ± 4.3 (73)	8.2 ± 6.0 (53)	<0.001
12 wk	1.8 ± 3.4 (72)	5.2 ± 6.8 (44)	8.5 ± 7.2 (31)	<0.001
6 mo	1.3 ± 1.8 (55)	5.2 ± 5.6 (36)	8.8 ± 6.4 (25)	<0.001
1 y	1.3 ± 2.2 (32)	4.0 ± 4.8 (21)	7.8 ± 7.4 (19)	<0.001
Short Form 12-item MCS				
Preoperative	54.9 ± 8.8 (178)	46.0 ± 10.8 (89)	37.7 ± 9.4 (69)	<0.001
6 wk	57.5 ± 7.4 (123)	52.7 ± 10.3 (64)	45.6 ± 10.8 (55)	<0.001
12 wk	58.3 ± 6.4 (71)	50.4 ± 13.1 (39)	46.1 ± 11.5 (23)	<0.001
6 mo	58.0 ± 6.2 (52)	51.3 ± 8.6 (30)	48.5 ± 11.3 (22)	<0.001
1 y	56.8 ± 7.7 (30)	51.7 ± 10.4 (21)	48.1 ± 12.3 (18)	0.013
Veterans RAND 12-item MCS				
Preoperative	56.9 ± 7.7 (178)	48.3 ± 9.6 (89)	39.4 ± 9.5 (69)	<0.001
6 wk	60.2 ± 7.4 (124)	55.4 ± 10.2 (64)	47.6 ± 11.5 (55)	<0.001
12 wk	61.0 ± 6.8 (72)	53.4 ± 13.3 (39)	49.5 ± 12.5 (23)	<0.001
6 mo	60.4 ± 6.1 (52)	54.8 ± 8.5 (30)	50.6 ± 13.4 (22)	<0.001
1 y	59.9 ± 8.4 (30)	54.7 ± 11.4 (21)	50.1 ± 13.9 (18)	0.013

Abbreviations: MCS, Mental Health Composite Score; PHQ-9, Patient Health Questionnaire-9.
Data presented as mean ± SD (n).
[a]P value was calculated using linear regression.

Table 4. Postoperative improvement (Delta) over predetermined time periods.

PROM	PHQ-9 <5 Δ ± SD (*n*)	PHQ-9 5–10 Δ ± SD (*n*)	PHQ-9 >10 Δ ± SD (*n*)	*P* value[a]
PHQ-9				
Preoperative	-	-	-	-
6 wk	–0.1 ± 2.7 (132)	–3.3 ± 4.5 (73)	–7.4 ± 5.8 (53)	<0.001
12 wk	–0.3 ± 3.5 (72)	–1.5 ± 6.7 (44)	–6.3 ± 6.2 (31)	<0.001
6 mo	–1.1 ± 2.1 (55)	–1.6 ± 5.5 (36)	–6.3 ± 7.2 (25)	<0.001
1 yr	–0.2 ± 2.4 (32)	–3.1 ± 4.4 (21)	–7.9 ± 8.1 (19)	<0.001
Short Form 12-item MCS				
Preoperative	-	-	-	-
6 wk	2.4 ± 9.1 (123)	5.9 ± 11.2 (62)	7.5 ± 10.3 (55)	0.004
12 wk	3.9 ± 9.0 (70)	4.4 ± 11.4 (37)	8.6 ± 12.3 (23)	0.167
6 mo	4.3 ± 10.8 (52)	4.6 ± 9.9 (29)	10.9 ± 11.9 (22)	0.053
1 y	0.3 ± 10.2 (29)	7.8 ± 13.5 (21)	11.4 ± 10.6 (18)	0.005
Veterans RAND 12-item MCS				
Preoperative	-	-	-	-
6 wk	3.4 ± 8.1 (121)	6.5 ± 10.2 (62)	7.9 ± 9.9 (55)	0.005
12 wk	4.5 ± 8.2 (71)	5.5 ± 12.1 (37)	9.7 ± 12.7 (23)	0.108
6 mo	4.3 ± 9.2 (52)	5.9 ± 9.6 (29)	11.5 ± 12.8 (22)	0.023
1 y	1.8 ± 10.6 (29)	8.4 ± 13.7 (21)	12.2 ± 11.7 (18)	0.014

Abbreviations: MCS, Mental Health Composite Score; PHQ-9, Patient Health Questionnaire-9.
Data presented as mean ± SD (*n*).
[a]*P* value was calculated using linear regression.

more severe anxiety or depression with worse outcomes.[20,24,29,30] To our knowledge, however, there have been no published studies that have used the PHQ-9 to assess preoperative depression and to relate it to 1-year LD physical and mental health outcomes. This expands on observations that endorse more severe symptoms of mental health disorders as risk factors for lower postoperative scores.[20,24,29,30] Furthermore, our results suggest that current predictive model literature might consider mental health variables in order to more accurately predict postsurgical outcomes. While further research is necessary to accurately assign a role for mental health assessments within predictive models, the results of this study call for the use of mental health assessments during pre- and postoperative evaluations for patients undergoing LD surgery.

In this retrospective analysis of 351 patients, we assessed subgroups according to PHQ-9 subgroups using previously established valid cutoff points for no depression (<5), limited depression (5–10), and moderate to severe depression (>10).[23] Although other spine surgery researchers have used PHQ-9

Table 5. Postoperative physical function and pain over predetermined time periods.

PROM	PHQ-9 <5 (*n* = 186)	PHQ-9 5–10 (*n* = 94)	PHQ-9 >10 (*n* = 71)	*P* value[a]
PROMIS-PF				
Preoperative	38.8 ± 7.1 (149)	35.6 ± 6.9 (67)	33.3 ± 5.9 (51)	<0.001
6 wk	44.4 ± 8.3 (112)	41.2 ± 8.1 (52)	38.9 ± 8.7 (36)	0.001
12 wk	47.8 ± 9.7 (69)	43.5 ± 8.3 (39)	42.5 ± 9.7 (21)	0.018
6 mo	46.3 ± 8.6 (56)	42.3 ±10.0 (32)	40.2 ± 12.7 (20)	0.036
1 y	45.3 ± 10.0 (38)	44.9 ± 12.9 (22)	43.4 ± 11.3 (18)	0.836
VAS back				
Preoperative	5.7 ± 2.6 (170)	6.6 ± 2.7 (86)	7.0 ± 2.0 (65)	<0.001
6 wk	2.5 ± 2.4 (131)	2.8 ± 2.7 (63)	3.6 ± 2.9 (55)	0.024
12 wk	2.2 ± 2.4 (56)	3.1 ± 2.7 (42)	4.1 ± 2.7 (29)	0.009
6 mo	2.7 ± 2.5 (40)	4.2 ± 3.4 (32)	5.0 ± 3.1 (22)	0.011
1 y	3.8 ± 3.2 (17)	3.4 ± 3.3 (16)	5.0 ± 2.6 (12)	0.412
VAS leg				
Preoperative	5.7 ± 2.6 (170)	6.3 ± 2.9 (86)	6.8 ± 2.4 (65)	0.009
6 wk	2.3 ± 2.5 (131)	2.7 ± 2.8 (63)	3.7 ± 2.9 (55)	0.009
12 wk	2.5 ± 2.6 (57)	2.7 ± 2.8 (42)	3.8 ± 3.2 (29)	0.110
6 mo	2.4 ± 2.5 (40)	3.3 ± 3.0 (32)	4.7 ± 3.3 (22)	0.017
1 y	2.4 ± 3.0 (17)	2.8 ± 2.8 (16)	4.5 ± 3.6 (12)	0.180

Abbreviations: PHQ-9, Patient Health Questionnaire-9; PROMIS-PF, Patient-Reported Outcomes Measurement Information System Physical Function; VAS, visual analog scale.
Data presented as mean ± SD (*n*).
[a]*P* value was calculated using linear regression.

Table 6. Postoperative physical function and pain over predetermined time periods.

PROM	PHQ-9 <5 Δ ± SD (*n*)	PHQ-9 5–10 Δ ± SD (*n*)	PHQ-9 >10 Δ ± SD (*n*)	*P* value[a]
PROMIS-SF				
Preoperative	-	-	-	-
6 wk	4.9 ± 8.6 (103)	6.9 ± 8.4 (45)	5.5 ± 9.2 (33)	0.425
12 wk	7.8 ± 9.2 (63)	8.9 ± 7.8 (33)	10.1 ± 10.1 (16)	0.617
6 mo	7.8 ± 8.3 (49)	6.5 ± 11.3 (27)	9.0 ± 12.7 (19)	0.703
1 y	6.6 ± 10.4 (34)	9.6 ± 15.8 (17)	12.5 ± 11.9 (14)	0.306
VAS back				
Preoperative	-	-	-	-
6 wk	–3.1 ± 3.0 (129)	–4.1 ± 2.5 (61)	–3.6 ± 3.1 (53)	0.071
12 wk	–3.4 ± 3.0 (55)	–3.5 ± 3.4 (41)	–3.1 ± 2.7 (28)	0.898
6 mo	–3.5 ± 3.2 (40)	–3.1 ± 3.5 (31)	–2.1 ± 2.4 (21)	0.254
1 y	–2.5 ± 3.9 (17)	–3.8 ± 3.0 (16)	–2.4 ± 3.1 (12)	0.469
VAS leg				
Preoperative	-	-	-	-
6 wk	–3.3 ± 3.1 (129)	–3.7 ± 3.5 (61)	–3.3 ± 3.5 (53)	0.685
12 wk	–3.3 ± 3.1 (56)	–3.1 ± 3.3 (41)	–2.8 ± 4.0 (28)	0.838
6 mo	–3.6 ± 3.3 (40)	–2.4 ± 2.7 (31)	–1.4 ± 3.6 (21)	0.036
1 y	–3.2 ± 3.7 (17)	–2.2 ± 3.4 (16)	–1.8 ± 2.7 (12)	0.507

Abbreviations: PHQ-9, Patient Health Questionnaire-9; PROMIS-PF, Patient-Reported Outcomes Measurement Information System Physical Function; VAS, visual analog scale.
Data presented as mean ± SD (*n*).
[a]*P* value was calculated using linear regression.

mental health values for preoperative assessments, this study is the first to use both preoperative and postoperative PHQ-9 values alongside other mental health postoperative outcomes such as SF-12 and VR-12 MCS. As our baseline demographic analysis indicated, significant correlations were observed among PHQ-9 subgroups for age, BMI, diabetes diagnoses, and history of malignancy. Among the general population, elderly patients are thought to be more vulnerable to depression on average.[31] However, in the context of patients undergoing LD procedures, it is possible that spinal degeneration may be more "accepted" among older patients, while those experiencing degenerative changes at an earlier age may feel proportionately more impaired compared to their peers. Additionally, the prevalence of patients with a past medical history of malignancy is expected to increase with age, which was a result also observed among the current study's cohort. Relationships between obesity and depression have been previously established in the literature.[32] With respect to the prevalence of diabetes among the three cohorts, previous meta-analyses have demonstrated that among individuals diagnosed with the condition, 11% carried a comorbidity of major depressive disorder.[33] This is similar to our cohort, whereby 14% of diabetic patients had a PHQ-9 >10. While it might be inferred that a longer duration of physical symptoms could be associated with a greater prevalence or severity of depressive symptoms, our analysis revealed no significant relationship between depression severity and the duration of physical symptoms prior to surgery.

In following our patients for 1 year, this study is the first to observe PHQ-9 subgroups in the context of LD and that increasingly severe PHQ-9 scores are significantly correlated with greater PHQ-9 scores. In addition to mean score value differences, we also observed that preoperative scores were significantly correlated with postoperative PHQ-9 improvement. Overall, more severe preoperative PHQ-9 scores were significantly associated with worse overall PHQ-9 scores and worse mental health score improvement (eg PHQ-9, SF-12 MCS, and VR-12 MCS) at time periods of up to 1 year.

Preoperative Mental Health Associations With Postoperative Depression

To our knowledge, only one other study[20] has observed statistically significant correlations with preoperative PHQ-9 scores on postoperative mental health. This study differed from our study in several important ways. First, it did not assess postoperative PHQ-9 scores. Second, it only assessed lumbar fusion procedures out to 6 months postoperatively. Third, its patient cohort was relatively small (n = 94).[20] Netto et al observed a statistically significant postoperative improvement in mental health (P = 0.004) among patients without preoperative depression as compared to those with depression.[24] This latter study was, however, limited by a small patient sample ($n = 32$) and a relatively short (eg 4 months) follow-up time period. In addition to our unique observations regarding the PHQ-9 association with postoperative depression severity, our assessment of PHQ-9 score subgroups revealed associations with physical function scores.

Relating Mental Health With Physical Function and Pain

PHQ-9 score subgroups were observed to have a significant influence on physical function (PROMIS-PF) scores up to 1 year after LD. Our study differs from other studies that have identified no statistically significant relationship between preoperative mental health and postoperative outcome measures. For example, in their investigation of the influence of mental health on postoperative VAS and physical function, Asher et al reported no significant association between preoperative mental health and outcomes such as VAS, ODI, and SF-36 physical component survey.[25] While Asher followed patient outcomes until 1 year, it evaluated a cohort composed of mixed surgical categories (eg surgical decompression, discectomy, and fusion procedures). Furthermore, they did not evaluate patients with the well-validated PHQ-9 survey.

While several researchers report no statistically significant mental health influence on physical function and postoperative pain levels, numerous other studies have observed significant correlations. Overall, our study is aligned with Merrill et al who demonstrated a statistically significant influence of mental health on physical function as measured by PROMIS-PF ($P = 0.005$) after LD.[26] Another study demonstrated that worse preoperative mental health outcomes were associated with more severe VAS back pain scores up to 6 months[20] for lumbar fusion procedures. Our study differs from these previous studies in that we assessed patients at the 1-year timepoint, had over three times their observational power, and used the well-validated PHQ-9 survey.

While our study included consecutive patients who underwent LD, our findings are also aligned with multiple other studies that have made similar comparisons among nonsurgical patients. In one correlative study, Engel-Yeger et al assessed patients with lumbar disk herniation and established that mental health status had a significant role in pain level as measured by VAS ($P < 0.05$).[34] Likewise, Stienen et al reported that SF-12 MCS score quartile subgroups were associated with VAS back ($P \leq 0.015$) and VAS leg pain ($P \leq 0.035$).[27] Our study differs from Stienen et al in that we focused on multiple VAS evaluations among a surgical patient cohort. One other study assessed a Korean patient population for a relationship of PHQ-9 scores with levels of lower back pain and demonstrated that patients with depression were nearly four times more likely to experience lower back pain (aOR = 3.93, $P < 0.001$).[30] Again, as with Stienen et al, this latter study focused on patients that suffered from lumbar back pain in the absence of surgical intervention.

Finally, while our study observed a statistically significant difference in pain severity as measured by VAS back and leg pain among PHQ-9 subgroups until 6 months postoperatively, this difference was lost by the 1-year follow-up. These findings differ from at least one other analysis that observed differences in VAS scores evident up until a 10-year follow-up point.[28] While a notable strength of the Tuomainen et al's study is its 10-year follow-up, it had a relatively small patient sample size ($n = 72$) and its patient cohort differed from ours in that they were part of a universal healthcare system in Finland. While other studies have recorded similar characteristics to our study, important differences in study design make it difficult to draw meaningful comparisons. For example, while our study compared patients based on their preoperative depressive symptom score, Urban-Baeza et al compared subgroups that changed based on a patient's depression at each postoperative evaluation.[29]

Limitations

This study has several limitations that should be acknowledged. First, our patient sample was drawn from one attending surgeon at a single academic institution. Both of these characteristics may limit this study's generalizability. Second, this study may have been susceptible to selection bias due to the nature of postoperative patient follow-ups. For example, sicker patients may have been more inclined to follow up based on symptom severity. They may have also been discouraged to follow up if their illness prevented them from doing so. Further analyses would be required to assess this effect.

Other limitations were encountered based on our assessment of depressive symptoms. While patient-reported outcome surveys are less susceptible to clinician-influenced biases that can occur during in-person clinical evaluation, this can also be a limitation. Our assessments did not make use of a more in-depth evaluation by a psychiatric physician and were also limited to a 12-month follow-up length. These limitations precluded quantitative assessment of any antidepressant medications being used, as well as the relative prevalence of depression due to organic neurochemical imbalances vs reactive depression directly related to the symptoms of spinal pathology. Further assessment could have investigated past depression diagnoses, as well as pharmaceutical or cognitive-behavioral treatments. Similarly, while we observed differences in VAS pain levels to disappear by 1 year, it is unknown whether this difference might resurface after a decade as Tuomainen et al observed.

Finally, while our analyses did examine PHQ-9 scores in the context of other baseline demographic variables, our analysis was limited to assessing depressive symptom severity in the absence of an all-encompassing model or scoring system. Although our findings demonstrate a statistically significant effect on postoperative physical function up to 1 year, this study serves as a preliminary step in the ultimate implementation of depressive symptoms into an overall patient outcome prediction model.

CONCLUSION

Patients with more severe preoperative depressive symptoms demonstrated a statistically significant association with postoperative mental health improvement and 1-year physical function scores following LD. Overall, these findings illustrate that more severe preoperative depression scores are associated with larger improvements PHQ-9, SF-12 MCS, and VR-12 MCS scores. Less severe preoperative depression scores were associated with better postoperative mental health scores and better pre- to postoperative physical function improvement as measured by PROMIS-PF. Preoperative depression is an important risk factor that should be considered in risk factor modeling for patients undergoing LD.

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