

# Predictive model for long-term patient satisfaction after surgery for grade I degenerative lumbar spondylolisthesis: insights from the Quality Outcomes Database

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**OBJECTIVE** Since the enactment of the Affordable Care Act in 2010, providers and hospitals have increasingly prioritized patient-centered outcomes such as patient satisfaction in an effort to adapt the "value"-based healthcare model. In the current study, the authors queried a prospectively maintained multiinstitutional spine registry to construct a predictive model for long-term patient satisfaction among patients undergoing surgery for Meyerding grade I lumbar spondylolisthesis.

METHODS The authors gueried the Quality Outcomes Database for patients undergoing surgery for grade I lumbar spondylolisthesis between July 1, 2014, and June 30, 2016. The primary outcome of interest for the current study was patient satisfaction as measured by the North American Spine Surgery patient satisfaction index, which is measured on a scale of 1-4, with 1 indicating most satisfied and 4 indicating least satisfied. In order to identify predictors of higher satisfaction, the authors fitted a multivariable proportional odds logistic regression model for  $\geq 2$  years of patient satisfaction after adjusting for an array of clinical and patient-specific factors. The absolute importance of each covariate in the model was computed using an importance metric defined as Wald chi-square penalized by the predictor degrees of freedom.

RESULTS A total of 502 patients, out of a cohort of 608 patients (82.5%) with grade I lumbar spondylolisthesis, undergoing either 1- or 2-level decompression (22.5%, n = 113) or 1-level decompression and fusion (77.5%, n = 389), met the inclusion criteria; of these, 82.1% (n = 412) were satisfied after 2 years. On univariate analysis, satisfied patients were more likely to be employed and working (41.7%, n = 172, vs 24.4%, n = 22; overall p = 0.001), more likely to present with predominant leg pain (23.1%, n = 95, vs 11.1%, n = 10; overall p = 0.02) but more likely to present with lower Numeric Rating Scale score for leg pain (median and IQR score: 7 [5–9] vs 8 [6–9]; p = 0.05). Multivariable proportional odds logistic regression revealed that older age (OR 1.57, 95% CI 1.09-2.76; p = 0.009), preoperative active employment (OR 2.06, 95% CI 1.27-3.67; p = 0.015), and fusion surgery (OR 2.3, 95% CI 1.30-4.06; p = 0.002) were the most important predictors of achieving satisfaction with surgical outcome.

ABBREVIATIONS ASA = American Society of Anesthesiologists; BMI = body mass index; CAD = coronary artery disease; LOS = length of stay; NASS = North American Spine Surgery; NRS = Numeric Rating Scale; ODI = Oswestry Disability Index; PRO = patient-reported outcome; QOD = Quality Outcomes Database. SUBMITTED December 28, 2018. ACCEPTED February 6, 2019. INCLUDE WHEN CITING DOI: 10.3171/2019.2.FOCUS18734.

**CONCLUSIONS** Current findings from a large multiinstitutional study indicate that most patients undergoing surgery for grade I lumbar spondylolisthesis achieved long-term satisfaction. Moreover, the authors found that older age, preoperative active employment, and fusion surgery are associated with higher odds of achieving satisfaction.

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**KEYWORDS** patient satisfaction; outcomes; spine surgery; Quality Outcomes Database; QOD; spondylolisthesis; laminectomy; decompression; arthrodesis; fusion

**D**EGENERATIVE lumbar spondylolisthesis is one of the most common causes of low-back pain, with a reported prevalence of 11.5% in the United States.<sup>27</sup> Surgical intervention may be considered for carefully selected patients in whom conservative management has failed, and it has been found to be associated with superior outcomes compared to nonsurgical therapy for this subset of patients.<sup>41</sup> However, it remains unclear what factors are associated with optimum patient-reported outcomes (PROs).

Since the enactment of the Patient Protection and the Affordable Care Act of 2010, providers and hospitals have increasingly prioritized patient-centered outcomes in an effort to adapt the "value"-based healthcare model that is geared toward increasing access and quality of healthcare while simultaneously controlling cost.<sup>22</sup> In its annual report to Congress on National Quality Strategy for Quality Improvement, the Department of Health and Human Services listed "patient satisfaction" as one of the metrics of public reporting to improve quality.<sup>2</sup> Low-back pain and spinal surgery have been increasingly targeted for quality improvement initiatives in recent years due to the high prevalence and also the billions of dollars in direct and indirect cost associated with treating low-back pain.<sup>30,36,38</sup>

In the current study, we queried a prospectively maintained multiinstitutional spine registry to construct a predictive model for long-term patient satisfaction by using demographic, clinical, and operative factors obtained in patients undergoing surgery for grade I lumbar spondylolisthesis.

# **Methods**

## Cohort

We queried the Quality Outcomes Database (QOD) for patients undergoing surgery for Meyerding grade I degenerative lumbar spondylolisthesis between July 1, 2014, and June 30, 2016. The QOD is a prospective, multiinstitutional registry, established in 2012, with the objective to assess risk-adjusted expected morbidity and 30-day and 12-month PROs and clinical outcomes in order to establish a data-driven mechanism of providing insights into improving quality of care for routinely performed spine surgeries in the United States.<sup>16,32</sup> As of December 2018, over 107,000 patients across 216 participating sites nationwide have been enrolled in the Spine Surgery QOD (https://www.neuropoint.org/registries/qod/). Among these sites, 12 sites came together to initiate a focused project to assess the impact of fusion on PROs in patients undergoing surgery for grade I lumbar spondylolisthesis.<sup>7–10,35</sup> This focused group consisted of 1) sites with a study coordinator and 2) a centralized auditing mechanism to ensure data accuracy. To determine the diagnosis of grade I spondylolisthesis, surgeons at each of the participating sites evaluated preoperative standing or dynamic radiographs.<sup>7–10,35</sup> Intraoperative variables, including laminectomy performed, fusion performed, and number of levels of fusion or laminectomy, and minimally invasive versus open surgery, were also abstracted for all eligible patients.<sup>7–10,35</sup> For the current article, we only included patients who underwent elective 1- or 2-level decompression or 1-level decompression and fusion for grade I spondylolisthesis, according to the Meyerding classification,<sup>33</sup> and who had available data for North American Spine Surgery (NASS) satisfaction after 2 years.

# **Outcome of Interest**

The primary outcome of interest for the current study was patient satisfaction after 2 years, as defined by the NASS patient satisfaction index, which is measured on a scale of 1–4, with the choices representing, respectively: "the treatment met my expectations" (score of 1), "I did not improve as much as I had hoped, but I would undergo the same treatment for the same outcome" (score of 2), "I did not improve as much as I had hoped, and I would not undergo the same treatment for the same outcome" (score of 3), and "I am the same or worse than before treatment" (score of 4). For descriptive univariate analysis, patients were classified as following: patients with NASS satisfaction scores of 1 and 2 were considered "satisfied" while patients with scores of 3 and 4 were considered "not satisfied." This binary categorization captured patients who would undergo surgery again (i.e., scores 1 and 2) compared with those who would not be willing to undergo surgery again (i.e., scores 3 and 4). In addition, for our multivariable proportional odds logistic regression model, we used the NASS satisfaction score in its natural ranked order with 1 indicating highest satisfaction and 4 indicating lowest satisfaction.

# Covariates

The following covariates were included in the analysis:<sup>7–10,35</sup> demographic characteristics, including age, sex, body mass index (BMI), ethnicity, type of insurance, education level, employment status, workers' compensation; comorbidities, including smoking status, diabetes, anxiety, osteoporosis, depression, American Society of Anesthesiologists (ASA) classification; clinical characteristics such as symptom duration, dominant symptom, am-

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bulatory status, presence of a motor deficit; and baseline PROs, including Oswestry Disability Index (ODI),<sup>19</sup> EQ-5D score,<sup>18</sup> and Numeric Rating Scale (NRS) back and leg pain scores.<sup>28</sup> Other surgical variables, such as intraoperative blood loss, operative time, placement of an interbody graft, and employment of minimally invasive techniques, were also documented. A case was classified as a minimally invasive procedure if there was documentation of utilization of percutaneous or tubular screw fixation or tubular laminectomy, with or without intervertebral body graft placement.

# **Statistical Analysis**

Continuous variables were summarized using medians with interquartile ranges (IQRs), while categorical variables were summarized using frequencies with proportions. In order to identify predictors of higher satisfaction, we fitted a multivariable proportional odds logistic regression model for  $\geq 2$  years of patient satisfaction after adjusting for age, BMI, sex, insurance status, education status, employment status at the time of surgery, dominant symptom, length of stay (LOS), coronary artery disease (CAD), diabetes, anxiety, depression, osteoporosis, baseline ODI score, EO-5D score, NRS back and leg score, ambulation status, symptom duration, ASA class, and discharge disposition. Odds ratios were obtained by exponentiating the estimates obtained from the regression model. Furthermore, we also analyzed the absolute importance of each covariate in the model on predicting patient satisfaction by using an importance metric defined as Wald chi-square penalized by the predictor degrees of freedom.<sup>25</sup> As per this method, the higher the metric, the more important the variable. The analysis was performed using R 3.1.2 (R: A language and environment for statistical computing. R Foundation for Statistical Computing. https://www.R-project.org) and Package rms. p values were two-tailed and were considered significant at < 0.05.

# Results

A total of 502 patients, out of a cohort of 608 patients (82.5%), with grade I lumbar spondylolisthesis, undergoing either a 1- or 2-level decompression (22.5%, n = 113) or 1-level decompression and fusion (77.5%, n = 389) met the inclusion criteria. Among these, 61.5% (n = 309) had an NASS satisfaction score of 1 (highest satisfaction), 20.5% (n = 103) had a score of 2, 7.56% (n = 38) had a score of 3, and 10.3% (n = 52) had a satisfaction score of 1 or 2 were classified as satisfied (n = 412), while patients with a score of 3 or 4 were classified as not satisfied (n = 90).

# **Demographic Characteristics**

Patients who were satisfied did not differ significantly from those who were not satisfied in terms of age (median 63.1 [IQR 55.7–70.9] vs 61 [IQR 51.2–71]; p = 0.16), sex (females: 60%, n = 54, vs 57.5%, n = 237; p = 0.666), ethnicity (Hispanic: 4.6%, n = 19, vs 4.4%, n = 4; overall p = 0.976), BMI (median 29.2 [IQR 25.6–33.6] vs 29.7 [IQR 26.3–34.9]; p = 0.33), or education status (college and above: 57.6%, n = 232, vs 51.1%, n = 44; overall p = 0.86).

TABLE 1. Distribution of patient satisfaction scores

Score	NASS Satisfaction Measure <sup>15</sup>	No. of Patients (%)
1	The treatment met my expectations	309 (61.5%)
2	I did not improve as much as I had hoped, but I would undergo the same treatment for the same outcome	103 (20.5%)
3	I did not improve as much as I had hoped, and I would not undergo the same treat- ment for the same outcome	38 (7.6%)
4	I am the same or worse than before treatment	52 (10.3%)
Total		502

We also found no difference in insurance status between patients satisfied and not satisfied at follow-up (private insurance: 51.7%, n = 213, vs 52.2%, n = 47; Medicare: 40.3%, n = 166, vs 37.8%, n = 34; Medicaid: 5.1%, n = 21, vs 7.8%, n = 7; Veterans Affairs/government: 2.7%, n = 11, vs 2.2%, n = 11; overall p = 0.853). Satisfied patients were more likely to have workers' compensation compared to those who were not satisfied (4.9%, n = 20, vs 2.2%, n = 2; p = 0.006). Finally, satisfied patients were more likely to be employed and working, compared to those who were not satisfied (41.7%, n = 172, vs 24.4%, n = 22; overall p = 0.001). These results are summarized in Table 2.

#### **Baseline Clinical Characteristics, Comorbidities, and PROs**

Compared to patients who were not satisfied with their surgery after 2 years, satisfied patients were found to have a comparable incidence of past surgery (10.9%, n = 45, vs 11.1%, n = 10; p = 0.96), diabetes (16.3%, n = 67, vs 18.9%, n = 17; p = 0.54), CAD (10.7%, n = 44, vs 10%, n = 9; p = 0.84), anxiety (17.2%, n = 71, vs 13.3%, n = 12; p = 0.367), depression (18.4%, n = 76, vs 24.4%, n = 22; p = 0.193), and osteoporosis (5.3%, n = 22, vs 6.7%, n = 6; p =0.619). We also compared clinical characteristics between satisfied and not satisfied patients and found that satisfied patients were more likely to present with leg pain greater than back pain (23.1%, n = 95, vs 11.1%, n = 10) and less likely to present with equal degrees of leg and back pain (39.8%, n = 164, vs 52.2%, n = 47; overall p = 0.021). However, the two groups did not differ in incidence of motor deficit (24.1%, n = 99, vs 21.1%, n = 19; p = 0.54), ambulation at presentation (not independent: 10.7%, n = 44, vs 11.1%, n = 10; overall p = 0.989), and symptom duration (> 3 months: 93.7%, n = 386, vs 93.3%, n = 84; p = 0.93).Comparing the baseline PROs between the two groups revealed similar scores in NRS-measured back pain (median 7 [IQR 6–9] vs 8 [IQR 6–9]; p = 0.73), ODI (median 48 [IQR 38–60] vs 47 [IQR 32–56]; p = 0.104), and EQ-5D (median 0.597 [0.33-0.71] vs 0.551 [0.31-0.71]; p = 721); however, the not-satisfied patients were likely to present with higher NRS leg pain scores, with p value approaching significance (median 7 [IQR 5-9] vs 8 [IQR 6-9]; p = 0.05). These results are presented in Table 3.

# **Operative Characteristics and Perioperative Outcomes**

On univariate analysis, patients in the two groups did

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Variable	Total (n = 502)	Not Satisfied (n = 90)	Satisfied (n = 412)	p Value
Age (yrs)				0.155
Median	63	61	63.1	
Q1, Q3	55, 70.9	51.2, 71	55.7, 70.9	
Female, no. (%)	291 (58.0%)	54 (60%)	237 (57.5%)	0.666
Ethnicity, no. (%)				0.976
Hispanic	23 (4.6%)	4 (4.4%)	19 (4.6%)	
Non-Hispanic	464 (92.4%)	83 (92.2%)	381 (92.5%)	
Prefer not to answer	15 (3.0%)	3 (3.3%)	12 (2.9%)	
BMI				0.333
Median	29.3	29.7	29.2	
Q1, Q3	25.7, 33.7	26.3, 34.9	25.6, 33.6	
Insurance, no. (%)				0.853
Medicaid	28 (5.6%)	7 (7.8%)	21 (5.1%)	
Medicare	200 (39.8%)	34 (37.8%)	166 (40.3%)	
Private	260 (51.8%)	47 (52.2%)	213 (51.7%)	
VA/government	13 (2.6%)	2 (2.2%)	11 (2.7%)	
Education, no. (%)				0.861
Less than high school	14 (2.8%)	3 (3.3%)	11 (2.7%)	
High school diploma or GED	199 (39.6%)	39 (43.3%)	160 (38.8%)	
2-yr college degree	87 (17.3%)	13 (14.4%)	74 (18.0%)	
4-yr college degree	97 (19.3%)	16 (17.8%)	81 (19.7%)	
Post-college	92 (18.3%)	15 (16.7%)	77 (18.7%)	
Workers' compensation, no. (%)	22 (4.4%)	2 (2.2%)	20 (4.9%)	0.006
Employment, no. (%)	· ·	i	· · ·	0.001
Employed & working	194 (38.6%)	22 (24.4%)	172 (41.7%)	
Employed, not working	28 (5.6%)	10 (11.1%)	18 (4.4%)	
Unemployed	271 (54.0%)	57 (63.3%)	214 (51.9%)	

TABLE 2. Demographic characteristics of patients stratified by satisfaction status

Q1 = 25th quartile; Q3 = 75th quartile; VA = Veterans Affairs.

Boldface type indicates statistical significance.

not differ in incidence of higher ASA class (class 3 or 4: 36.9%, n = 152, vs 40.0%, n = 36; p = 0.757), the type of surgical approach (posterior: 90.8%, n = 374, vs 94.4%, n = 85; p = 0.558), fusion procedure (77.9%, n = 321, vs 75.6%, n = 68; p = 628), minimally invasive decompression (36.2%, n = 149; vs 38.9%, n = 35; p = 0.627), and minimally invasive interbody (26.9%, n = 11, vs 17.8%, n = 16; p = 0.07). The two groups also did not differ in length of surgery (median 171 minutes [IQR 118-222] vs 157 minutes [IQR 116.2-230.5]; p = 0.866), LOS (median 3 days [IQR 2-4] vs 3 days [IQR 1-4]; p = 0.718), discharge disposition (home routine: 86.7%, n = 357, vs 82.2%, n = 74; p = 0.06), or related reoperations (5.8%, n = 24, vs 10%, n = 9; p = 0.148). These results are summarized in Table 4.

## **Multivariable Analysis and Predictor Importance**

Multivariable proportional odds logistic regression revealed that older patients were more likely to have a higher satisfaction score (OR 1.57, 95% CI 1.09–2.76; p = 0.009). Moreover, patients who were employed and working at the time of surgery, compared to those who were unemployed,

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were more likely to have a higher satisfaction score (OR 2.06, 95% CI 1.27–3.67; p = 0.015). Finally, the addition of fusion was found to be associated with a higher satisfaction score (OR 2.3, 95% CI 1.30–4.06; p = 0.002). These results are shown in Fig. 1. Predictor importance revealed that the most important predictors of patient satisfaction were employment (Wald  $\chi^2 = 13.5$ , accounting for 25.7% of total Wald  $\chi^2$ ; p = 0.003), fusion (Wald  $\chi^2 = 8.4$ , accounting for 16% of total Wald  $\chi^2$ ; p = 0.003), and age (Wald  $\chi^2 = 5.9$ , accounting for 11.2% of total Wald  $\chi^2$ ; p = 0.01). These results are summarized in Fig. 2.

# Discussion

To the best of our knowledge, this is the largest study to assess predictors of long-term patient satisfaction for patients undergoing 1- or 2-level decompression or 1-level decompression and fusion for grade I spondylolisthesis. It is important to note that 82% patients were satisfied with their surgery after 2 years, having answered the NASS satisfaction questionnaire with either "the treatment met my expectations" or with "I did not improve as much as I

Variable	Total (n = 502)	Not Satisfied (n = 90)	Satisfied (n = 412)	p Value
Major past surgery, no. (%)	55 (11.0%)	10 (11.1%)	45 (10.9%)	0.959
Diabetes, no. (%)	84 (16.7%)	17 (18.9%)	67 (16.3%)	0.545
CAD, no. (%)	53 (10.6%)	9 (10%)	44 (10.7%)	0.849
Anxiety, no. (%)	83 (16.5%)	12 (13.3%)	71 (17.2%)	0.367
Depression, no. (%)	98 (19.5%)	22 (24.4%)	76 (18.4%)	0.193
Osteoporosis, no. (%)	28 (5.6%)	6 (6.7%)	22 (5.3%)	0.619
Dominant symptom, no. (%)				0.021
Back pain dominant	186 (37.1%)	33 (36.7%)	153 (37.1%)	
Back equals leg pain	211 (42.0%)	47 (52.2%)	164 (39.8%)	
Leg pain dominant	105 (20.9%)	10 (11.1%)	95 (23.1%)	
Motor deficit, no. (%)	118 (23.6%)	19 (21.1%)	99 (24.1%)	0.547
Ambulation, no. (%)				0.989
Independently ambulatory	448 (89.2%)	80 (88.9%)	368 (89.3%)	
Ambulatory w/ assistive device	49 (9.8%)	9 (10.0%)	40 (9.7%)	
Wheelchair bound	5 (1.0%)	1 (1.1%)	4 (1.0%)	
Symptom duration, no. (%)				0.934
<3 months	14 (2.8%)	3 (3.3%)	11 (2.7%)	
>3 months	470 (93.6%)	84 (93.3%)	386 (93.7%)	
Unknown	18 (3.6%)	3 (3.3%)	15 (3.6%)	
Baseline NRSBP score				0.737
Median	7	8	7	
Q1, Q3	6, 9	6, 9	6, 9	
Baseline NRSLP score				0.058
Median	7	8	7	
Q1, Q3	5, 9	6, 9	5, 9	
Baseline ODI score				0.104
Median	48	47	48	
Q1, Q3	38, 60	32, 56	38, 60	
Baseline EQ-5D score				0.721
Median	0.597	0.551	0.597	
Q1, Q3	0.312, 0.708	0.308, 0.708	0.330, 0.708	

TABLE 3. Comorbidities, clinical characteristics, and baseline PROs stratified by satisfaction status

NRSBP = NRS back pain; NRSLP = NRS leg pain.

Boldface type indicates statistical significance.

had hoped, but I would undergo the same treatment for the same outcome."

Among baseline demographic factors, older age was predictive of a higher satisfaction score after 2 years. This finding has previously been reported in the literature for patients undergoing lumbar surgery, notably by Crawford et al., who reported that older age was predictive of best outcomes in a cohort of 396 patients.<sup>14</sup> On the other hand, Sigmundsson et al. investigated 5100 patients undergoing surgery for spinal stenosis and found that older age was associated with slightly lower odds of satisfaction.<sup>37</sup>

Work-related factors are also known to impact patient outcomes after spinal surgery. Asher et al., in their analysis of 4695 patients, showed that work-related factors accounted for 33.3% of predictability of outcomes following elective lumbar surgery for degenerative surgery.<sup>6</sup> To that end, we found that patients who were employed and working preoperatively were more likely to have higher satisfaction scores after 2 years. Active employment has previously been shown to be associated with positive outcomes following surgical intervention.<sup>5,6,12,24</sup> This may be attributed to the fact that these represent a more driven subset of patients who have better social support, work satisfaction, healthier psychological state, availability of modified duty, optimum physical demand at work, and employer-employee relations including the availability of litigation issues.<sup>4,5,12,26,31,34,40</sup> Together, these factors may contribute to these patients having superior outcomes after spine surgery.

Finally, the addition of fusion was found to be associated with higher satisfaction scores in our cohort. The current literature is conflicted on the role of instrumented fusion for lumbar degenerative lumbar spondylolisthesis.<sup>20,21,23</sup> A recent meta-analysis of 3 randomized con-

Variable	Total (n = 502)	Not Satisfied (n = 90)	Satisfied (n = 412)	p Value
ASA class				0.857
Median	2	2	2	
Q1, Q3	2, 3	2, 3	2, 3	
Surgical approach, no. (%)				0.558
Anterior	13 (2.6%)	2 (2.2%)	11 (2.7%)	
Lateral	7 (1.4%)	0 (0.0%)	7 (1.7%)	
Posterior	459 (91.4%)	85 (94.4%)	374 (90.8%)	
Two-stage	23 (4.6%)	3 (3.3%)	20 (4.9%)	
Group, no. (%)				0.628
Decompression alone	113 (22.5%)	22 (24.4%)	91 (22.1%)	
Fusion	389 (77.5%)	68 (75.6%)	321 (77.9%)	
MIS decompression	184 (36.7%)	35 (38.9%)	149 (36.2%)	0.627
MIS interbody fusion	127 (25.3%)	16 (17.8%)	11 (26.9%)	0.070
Length of surgery				0.866
Median	171	157	171	
Q1, Q3	117.5, 222.5	116.2, 230.5	118, 222	
LOS				0.718
Median	3	3	3	
Q1, Q3	2, 4	1.2, 4	2, 4	
Discharge disposition, no. (%)				0.061
Home routine	431 (85.9%)	74 (82.2%)	357 (86.7%)	
Home w/ home healthcare services	25 (5.0%)	3 (3.3%)	22 (5.4%)	
Post- or non-acute care setting	40 (8.0%)	13 (14.4%)	27 (6.6%)	
Transferred to another acute care facility	4 (0.8%)	0 (0.0%)	4 (1.0%)	
Related reoperations	33 (6.6%)	9 (10.0%)	24 (5.8%)	0.148

TABLE 4. Operative characteristics and perioperative outcomes stratified by satisfaction status

MIS = minimally invasive surgery.

trolled trials and 3 observational studies showed no benefit of adding fusion in the treatment of spondylolisthesis in terms of patient satisfaction.<sup>11</sup> However, it is important to note that several independent observational studies have demonstrated the beneficial role of adding instrumented fusion for patients undergoing surgical intervention for degenerative spondylolisthesis.<sup>1,3,8,9,17</sup>

Some notable associations with patient satisfaction previously identified but not found to be significant in our cohort are worth discussing here. A preoperative diagnosis of depression has been found to be associated with lower odds of satisfaction in previous studies, which was not found to be significantly associated in our cohort. In their study, which analyzed preoperative factors associated with patient satisfaction scores, as documented using the Hospital Consumer Assessment of Healthcare Providers and Systems survey, Levin et al. observed that depression negatively impacted the scores.<sup>29</sup> Moreover, an integrative review by Strøm et al. highlighted the prevalence and challenges faced by providers and surgeons in treating spine surgery patients with anxiety and depression.<sup>39</sup> Smoking status has also been shown to adversely affect outcomes. Crawford et al., in their analysis of 7207 patients undergoing lumbar spine surgery, found that smokers were less likely to be satisfied than nonsmokers.<sup>13</sup> Sigmundsson et al. also reported a 41% decrease in the odds of achieving satisfaction after surgery for smokers among patients undergoing surgery for lumbar spinal stenosis.<sup>37</sup>

#### Limitations

Our study may have some limitations. The current study is a retrospective analysis derived from a prospectively maintained registry that has its associated limitations, most notable of which may be selection bias due to lack of standardized operative technique and patient selection. Moreover, we did not collect other important variables that have been shown to affect outcomes, such as nature of occupation, race, and socioeconomic status. Moreover, the NASS satisfaction instrument may not be an accurate measure of overall satisfaction as it is primarily dependent on whether preoperative expectations were met; a different satisfaction measure may have yielded results different from our findings. Nevertheless, the NASS satisfaction scale is still considered one of the most widely used measures for assessing patient satisfaction with clinical outcomes and not with other nonclinical factors, such as experience with allied health staff, hospital environment, and appointment process. Finally, we were also unable to investigate directly the impact of fusion status on patient satisfaction. We used related reoperations as a sur-



FIG. 1. Multivariable proportional odds logistic regression model for at least 2 years of patient satisfaction after surgery for grade I lumbar spondylolisthesis. NRSBP = NRS back pain; NRSLP = NRS leg pain; RecalcBL = recalculated baseline; Sx = symptom; VA = Veterans Affairs.

rogate for this factor and found that reoperation did not impact long-term satisfaction. We believe that future studies should investigate the association between fusion status at follow-up and patient satisfaction.

Despite these limitations, the current study is one of the largest to date and represents a diverse population derived from 12 institutions across the United States, utilizing prospectively maintained data to analyze patient satisfaction among a homogeneous cohort of patients with Meyerding grade I spondylolisthesis who have undergone either 1- or 2-level decompression or a 1-level fusion procedure.

# Conclusions

The results from a large multiinstitutional study indicate that most patients with Meyerding grade I lumbar spondylolisthesis undergoing surgery achieved long-term satisfaction. Moreover, we found that patient age, preoperative active employment, and the addition of fusion may be associated with higher odds of achieving high level of satisfaction. These results are important in that they may help the surgeons to have a better preoperative discussion with their patients to optimize their outcomes.

							$\chi^2 P$
Education	. • • • • • • • • • • •					2.0	0.7273
Ambulation						0.3	0.8451
Insurance	•••••					2.9	0.5792
NRSLP Baseline	••••					0.0	0.8332
Osteoporosis	••••					0.0	0.8310
Gender	••••					0.1	0.8201
Diabetes						0.1	0.7859
NRS BP Baseline						0.1	0.7819
Depression						0.3	0.5807
CAD						0.3	0.5759
Anxiety						0.4	0.5104
BMI		•				0.9	0.3401
Discharge		• • • • • • • • • • • • • • • • • • • •				4.1	0.3863
Symptom Duration		• • • • • • • • • • • • • • • • • • • •				2.2	0.3278
ASA		• • • • • • • • • • • • • • • • • • • •				4.5	0.3456
LOS		• • • • •				2.1	0.1458
EQ5D Baseline			•			2.5	0.1109
ODI Baseline			•			2.7	0.1018
Related Reoperation			•			2.7	0.1005
Dominant Symptom			•			4.8	0.0914
Age					••••	6.8	0.0090
Employment					• • • • • • • • • • • • • • • • • • • •	9.5	0.0236
Fusion performed					•	8.5	0.0035
	1	1	1	1	1		
	-2	0	2	4	6		
			$\chi^2 -$	df			

FIG. 2. Predictor importance analysis for factors associated with patient satisfaction following surgery for lumbar spondylolisthesis. df = degree of freedom.

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## Disclosures

Dr. Mummaneni reports the following: consultant for DePuy

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#### **Author Contributions**

Conception and design: Bydon, Mummaneni. Acquisition of data: Alvi, Chan. Analysis and interpretation of data: Alvi, Chan. Drafting the article: Bydon, Mummaneni, Alvi, Chan. Critically revising the article: Bydon, Mummaneni, Alvi, Chan, Glassman, Foley, Potts, CI Shaffrey, ME Shaffrey, Knightly, Park, Wang, Fu, Slotkin, Asher, Virk, Kerezoudis, Guan, Haid, Bisson. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Bydon. Statistical analysis: Mummaneni, Alvi, Coric. Administrative/technical/ material support: Bydon, Mummaneni. Study supervision: Bydon, Mummaneni.

#### **Supplemental Information**

#### Videos

Video Abstract. https://vimeo.com/328716401.

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