Women fare best following surgery for degenerative lumbar spondylolisthesis: a comparison of the most and least satisfied patients utilizing data from the Quality Outcomes Database

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OBJECTIVE The American Association of Neurological Surgeons launched the Quality Outcomes Database (QOD), a prospective longitudinal registry that includes demographic, clinical, and patient-reported outcome (PRO) data, to measure the safety and quality of neurosurgical procedures, including spinal surgery. Differing results from recent randomized controlled trials have established a need to clarify the groups that would most benefit from surgery for degenerative lumbar spondylolisthesis. In the present study, the authors compared patients who were the most and the least satisfied following surgery for degenerative lumbar spondylolisthesis.

METHODS This was a retrospective analysis of a prospective, national longitudinal registry including patients who had undergone surgery for grade 1 degenerative lumbar spondylolisthesis. The most and least satisfied patients were identified based on an answer of “1” and “4,” respectively, on the North American Spine Society (NASS) Satisfaction Questionnaire 12 months postoperatively. Baseline demographics, clinical variables, surgical parameters, and outcomes were collected. Patient-reported outcome measures, including the Numeric Rating Scale (NRS) for back pain, NRS for leg pain, Oswestry Disability Index (ODI), and EQ-5D (the EuroQol health survey), were administered at baseline and 3 and 12 months after treatment.

RESULTS Four hundred seventy-seven patients underwent surgery for grade 1 degenerative lumbar spondylolisthesis in the period from July 2014 through December 2015. Two hundred fifty-five patients (53.5%) were the most satisfied and 26 (5.5%) were the least satisfied. Compared with the most satisfied patients, the least satisfied ones more often...
Degenerative lumbar spondylolisthesis is a significant cause of back pain. Surgical treatment has been shown to be effective and is considered when conservative treatment has failed. In 2007, in a randomized controlled trial of patients with degenerative spondylolisthesis and at least 3 months of symptoms, Weinstein and colleagues demonstrated that surgery, as compared with nonsurgical treatment, significantly decreased pain and improved function.

More recently, 2 randomized controlled trials, which arrived at different conclusions, have renewed interest in the outcomes of surgery for degenerative lumbar spondylolisthesis. In the Spinal Laminectomy versus Instrumental Pedicle Screw (SLIP) trial by Ghogawala and colleagues, the addition of fusion, as compared with laminectomy alone, was associated with a significant improvement in quality of life as well as a lower rate of reoperation (14% vs 34%). However, in a subgroup analysis of patients with degenerative spondylolisthesis, Forsth and colleagues found no significant benefit to the addition of fusion in any patient-reported outcome (PRO) metric at the 2-year follow-up. These somewhat conflicting results call for the identification of factors that portend the best outcomes following surgery for degenerative lumbar spondylolisthesis.

One outcome metric for quality of care is patient satisfaction. Several studies have shown that high patient satisfaction may be correlated with efficient and high-quality surgical care and superior surgical outcomes. Authors investigating lumbar spine surgery have specifically linked various patient characteristics to satisfaction, including smoking, depression, disability-derived unemployment, sex, obesity, preoperative diagnosis, payer status, worse baseline pain and disability scores, and psychological comorbidity. However, the patient characteristics affecting postoperative satisfaction in those undergoing surgery for degenerative lumbar spondylolisthesis, in particular, remain unclear. Identifying factors that predict which patients will be most satisfied after surgery for degenerative lumbar spondylolisthesis is valuable to multiple stakeholders, including hospitals, surgeons, patients, and payers.

To this end, we analyzed the data from 11 sites participating in the prospective, multicenter, multidisciplinary Quality Outcomes Database (QOD) to identify factors associated with the most and the least satisfaction following surgery for grade 1 degenerative lumbar spondylolisthesis.

Methods

The QOD is a prospective longitudinal registry that includes demographic, clinical, and PRO data to measure the safety and quality of neurological and orthopedic outcomes, including spinal surgery. The QOD was established with the aim of evaluating risk-adjusted expected morbidity and surgical outcomes to improve care for patients undergoing spinal surgery. In contrast to the narrow inclusion criteria of randomized clinical trials, the registry offers a glimpse into the actual practice patterns of high-volume neurological and orthopedic spine centers in the United States. Outcomes reported in the QOD include the PROs collected directly from patients through the spine surgeon’s office, allow unique insights into the efficacy of surgery for lumbar spondylolisthesis.

Eleven of the highest-enrolling sites participate in a lumbar spondylolisthesis module, as we reported in a prior study. We queried the lumbar spondylolisthesis module for patients who had undergone surgery for grade 1 lumbar spondylolisthesis in the period from July 2014 through December 2015. Preoperative plain radiographs (standing or dynamic) were obtained and were evaluated by surgeons at the participating sites to confirm the diagnosis of grade 1 spondylolisthesis (Fig. 1) as defined by the Meyerding classification. Patients with grade 2 or higher spondylolisthesis were excluded.

Demographic, Clinical, and Surgical Variables

The QOD registry collects data on demographic variables (age, sex, body mass index [BMI], ethnicity, insurance, education level, employment), patient comorbidities (smoking, diabetes, anxiety, coronary artery disease [CAD], osteoporosis, depression, American Society of Anesthesiologists [ASA] classification), clinical characteristics (dominant presenting symptom, ambulation status, presence of motor deficit), baseline and follow-up PRO scores ( Oswestry Disability Index [ODI], EQ-5D [the EuroQol health survey], Numeric Rating Scale for leg pain [NRS-LP] and back pain [NRS-BP]), North American

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Spine Society [NASS] Satisfaction Questionnaire), and surgical variables (type of approach, use of minimally invasive [MI] techniques, performance of laminectomy, whether fusion was performed, estimated blood loss, operative time, length of hospitalization, discharge disposition).

Ethnicity (Hispanic or Latino vs Not Hispanic or Latino), insurance status (private insurance vs Medicare, Medicaid, or Veterans Affairs [VA]/government), education level (4-year-degree post–high school education or greater vs less than a 4-year-degree post–high school education), employment status (employed or on leave vs unemployed), ambulation status (independently ambulatory vs nonindependently ambulatory [for example, with assistive device]), and discharge disposition (discharge to home or home health care vs discharge not to home or home health care) were 2-level variables. Dominant presenting symptom was a 3-level variable (pain predominant, motor predominant, or sensory predominant).

Surgical approaches included posterior only, anterior only, lateral only, and a staged approach. In accordance with our prior work,19 surgeries were categorized as utilizing MI techniques if any of the following were involved: MI laminectomy, MI pedicle screws, MI interbody grafts, cortical screws, or percutaneous screws.

Primary Outcome
The NASS Satisfaction Questionnaire assesses patient satisfaction following surgery via 4 questions whose answers are scored 1–4: 1) Surgery met my expectations; 2) I did not improve as much as I had hoped, but I would undergo the same operation for the same results; 3) Surgery helped, but I would not undergo the same operation for the same results; and 4) I am the same as or worse than before surgery. This questionnaire has been established as a valid and reliable measure of outcomes, including satisfaction, following surgery.8 A study investigating the effectiveness of the questionnaire has demonstrated high test-retest and internal reliability,8 and the satisfaction portion of the questionnaire has been published in multiple articles on lumbar spine surgery.5,7,26,27 At the 12-month follow-up, we identified patients who scored a 1 as the most satisfied and those who scored a 4 as the least satisfied.

Statistical Analysis
Descriptive statistics were reported as the means ± standard deviations or frequencies and percentages, as appropriate. Continuous variables were compared using rank-sum tests, and categorical variables were compared using Pearson's chi-square test and Yates' correction for continuity, as appropriate, via custom and built-in scripts (MATLAB, MathWorks). Multivariate linear regression models were fitted for predictors of the most satisfaction, compared with predictors of the least satisfaction, after controlling for covariates of interest. Variables that reached a significance level of p < 0.20 on univariate analyses were included in the multivariate analysis, which was conducted using R 2.15.2 (R Foundation for Statistical Computing). Missing values in the data were imputed using the “missForest” R package, a nonparametric imputa-
surgical approach (p = 0.89), the use of an MI technique (p = 0.51), or the performance of laminectomy or arthrodesis (p = 0.78 and 0.64, respectively). Neither were there any differences in perioperative outcomes in terms of blood loss (p = 0.11), operative time (p = 0.77), length of hospitalization (p = 0.88), or discharge disposition (p = 0.83).

### Readmission, Reoperation, and PROs

Nine (3.5%) most satisfied patients and 3 (11.5%) least satisfied patients required a readmission within 3 months of surgery. Thirteen (5.1%) most satisfied patients and 3 (11.5%) least satisfied patients required reoperation within the 12-month follow-up period. There were no significant differences between the 3-month readmission rates and 12-month reoperation rates (p = 0.16 and p = 0.37, respectively).

There were no significant differences in baseline NRS-BP scores between the 2 cohorts; however, the least satisfied patients had worse scores than the most satisfied patients at 3 months (5.2 ± 2.6 vs 2.2 ± 2.3, p < 0.001) and 12 months (6.1 ± 2.6 vs 2.1 ± 2.4, p < 0.001). Both cohorts significantly improved from baseline at the 3- and 12-month follow-ups (p < 0.05 for all comparisons). Figure 2A demonstrates the trend in NRS-BP scores according to patient satisfaction over the study period.

There were no significant differences in baseline NRS-LP scores between the 2 cohorts. The least satisfied patients had greater leg pain than the most satisfied patients at both 3 months (4.5 ± 3.5 vs 1.6 ± 2.5, p < 0.001) and 12 months (6.0 ± 2.7 vs 1.8 ± 2.7, p < 0.001). The most satisfied cohort improved from baseline at both the 3- and 12-month follow-ups (p < 0.001). Though the least satisfied cohort demonstrated significant improvement in leg pain at 3 months (p = 0.02), as compared with baseline,

### TABLE 1. Preoperative characteristics of patients who underwent surgery for grade 1 lumbar spondylolisthesis, stratified by the most versus least satisfaction

| Characteristic | Most Satisfied | Least Satisfied | p Value |
|---------------|----------------|----------------|---------|
| No. of patients | 255 | 26 | 0.80 |
| Mean age in yrs | 63.4 ± 10.6 | 63.0 ± 10.3 | 0.78 |
| Female | 149 (58.4%) | 10 (38.5%) | 0.05 |
| Mean BMI in kg/m² | 30.2 ± 6.0 | 32.9 ± 6.5 | 0.02* |
| Smoker | 23 (9.0%) | 4 (15.4%) | 0.29 |
| Comorbidities | | | |
| Diabetes mellitus | 52 (20.4%) | 7 (26.9%) | 0.44 |
| CAD | 31 (12.2%) | 7 (26.9%) | 0.04* |
| Anxiety | 51 (20.0%) | 3 (11.5%) | 0.30 |
| Depression | 59 (23.1%) | 3 (11.5%) | 0.17 |
| Osteoporosis | 15 (5.9%) | 1 (3.8%) | 0.67 |
| Dominant presenting symptom | 0.75 |
| Pain predominant | 100 (39.2%) | 12 (46.2%) | |
| Motor predominant | 51 (20.0%) | 4 (15.4%) | |
| Sensory predominant | 104 (40.8%) | 10 (38.5%) | |
| Motor deficit | 56 (22.0%) | 8 (30.8%) | 0.31 |
| Independently ambulatory at presentation | 231 (90.6%) | 22 (84.6%) | 0.33 |
| ASA class | 0.29 |
| I or II | 145 (56.9%) | 12 (46.2%) | |
| III or IV | 110 (43.1%) | 14 (53.8%) | |
| Type of insurance | 0.17 |
| Private | 134 (52.5%) | 10 (38.5%) | |
| Medicare, Medicaid, or VA/government | 121 (47.5%) | 16 (61.5%) | |
| Ethnicity | 0.52 |
| Hispanic or Latino | 37 (14.5%) | 5 (19.2%) | |
| Not Hispanic or Latino | 218 (85.5%) | 21 (80.8%) | |
| Level of education | 0.36 |
| 4-yr degree or more | 112 (43.9%) | 9 (34.6%) | |
| <4-yr degree | 136 (53.3%) | 17 (65.4%) | |
| Employment status | 0.39 |
| Employed or on leave | 113 (44.3%) | 9 (34.6%) | |
| Not employed | 138 (54.1%) | 16 (61.5%) | |
| Mean baseline PROs | | | |
| NRS-BP | 6.6 ± 2.7 | 7.4 ± 2.4 | 0.11 |
| NRS-LP | 6.5 ± 2.8 | 6.7 ± 3.0 | 0.88 |
| ODI | 43.4 ± 15.5 | 48.9 ± 20.0 | 0.14 |
| EQ-5D | 0.56 ± 0.20 | 0.52 ± 0.22 | 0.21 |

Values are expressed as the mean ± standard deviation or as frequency (%). Percentages do not add up to 100% where responses were not given by participants. A statistically significant relationship, alpha level 0.05.

### TABLE 2. Surgical variables for the most and least satisfied patients who underwent surgery for grade 1 lumbar spondylolisthesis

| Variable | Most Satisfied | Least Satisfied | p Value |
|----------|----------------|----------------|---------|
| No. of patients | 255 | 26 | 0.89* |
| Approach | | | |
| Posterior only | 239 (93.7%) | 24 (92.3%) | |
| Anterior only | 6 (2.4%) | 0 (0.0%) | |
| Lateral only | 3 (1.2%) | 0 (0.0%) | |
| 2-stage approach | 7 (2.7%) | 2 (7.7%) | |
| MIS | 85 (33.3%) | 7 (26.9%) | 0.51 |
| Laminectomy | 239 (93.7%) | 24 (92.3%) | 0.78 |
| Fusion | 217 (85.1%) | 23 (88.5%) | 0.64 |
| Mean EBL in ml | 246.5 ± 248.9 | 390.8 ± 629.6 | 0.11 |
| Mean op time in mins | 200.9 ± 86.1 | 203.3 ± 101.3 | 0.77 |
| Mean hospital LOS in days | 3.1 ± 1.8 | 2.8 ± 1.8 | 0.88 |
| Discharge disposition | 0.83 |
| Home or home health care | 229 (89.8%) | 23 (88.5%) | |
| Not to home or home health care | 26 (10.2%) | 3 (11.5%) | |

EBL = estimated blood loss; LOS = length of stay; MIS = minimally invasive surgery. Values are expressed as the mean ± standard deviation or as frequency (%). * Chi-square comparison made using approach as a 2-level variable (posterior-only approach vs non–posterior-only approach).
there was no significant improvement at 12 months ($p = 0.38$). Figure 2B demonstrates the trend in NRS-LP scores according to patient satisfaction over the study period.

There was no significant difference in baseline ODI scores between the 2 cohorts. However, the least satisfied patients had worse ODI scores than the most satisfied patients at 3 months ($41.5 \pm 23.9$ vs $19.6 \pm 15.5$, $p < 0.001$) and 12 months ($43.3 \pm 16.0$ vs $14.5 \pm 14.8$, $p < 0.001$). The most satisfied cohort improved from baseline at both the 3- and 12-month follow-ups, relative to baseline ($p < 0.001$, all comparisons). The least satisfied cohort demonstrated no significant change in ODI at 12 months, compared with baseline. **A statistically significant difference at $p < 0.001$ between the most and least satisfied cohorts.

![FIG. 2. Baseline, 3-month, and 12-month PROs following surgery for grade 1 lumbar spondylolisthesis. A: Average NRS-BP scores at baseline and 3 and 12 months after surgery by patient cohort. B: Average NRS-LP scores at baseline and 3 and 12 months after surgery by patient cohort. C: Average ODI at baseline and 3 and 12 months after surgery by cohort. D: Average EQ-5D at baseline and 3 and 12 months following surgery by patient cohort. Error bars represent 1 SD. Though there were no significant differences between the 2 cohorts at baseline, they did differ in terms of improvement over time. For the most satisfied cohort, there were statistically significant improvements in NRS-BP, NRS-LP, ODI, and EQ-5D scores at the 3- and 12-month follow-ups, relative to baseline ($p < 0.001$, all comparisons). The least satisfied cohort demonstrated significant improvements in NRS-BP, NRS-LP, and EQ-5D at the 3-month follow-up ($p < 0.05$) but only demonstrated significant improvement in NRS-BP at the 12-month follow-up ($p = 0.048$). In the least satisfied cohort, there were no differences in NRS-LP, ODI, and EQ-5D at 12 months, compared with baseline.**

| TABLE 3. Multivariate analysis of most versus least satisfaction following surgery for grade 1 lumbar spondylolisthesis |
|---------------------------------|-----------------|-----------------|
| Variable                        | Adjusted OR* (95% CI) | p Value |
| Female                          | 2.87 (1.18–7.41)   | 0.02†     |
| Private insurance               | 1.70 (0.71–4.22)   | 0.24     |
| CAD                             | 0.42 (0.15–1.22)   | 0.09     |
| Depression                      | 3.31 (0.95–16.38)  | 0.09     |
| BMI                             | 0.94 (0.88–1.01)   | 0.07     |
| Readmission w/in 3 mos          | 0.26 (0.06–1.44)   | 0.09     |
| Baseline NRS-BP                 | 0.87 (0.70–1.07)   | 0.22     |
| Baseline ODI                    | 0.98 (0.95–1.01)   | 0.24     |

* Represents odds predicting the most satisfaction relative to the least satisfaction. Covariates were adjusted for variables that reached a significance value of $p < 0.20$ on univariate analysis: sex, insurance, CAD, depression, BMI, readmission within 3 months, and baseline NRS-BP and ODI.

† A statistically significant relationship, alpha level 0.05.
baseline at the 3- and 12-month follow-ups (p < 0.001). And though the least satisfied cohort demonstrated significant improvement in EQ-5D scores at 3 months (p = 0.03), there was no significant improvement at 12 months (p = 0.057). Figure 2D demonstrates the trend in EQ-5D scores according to satisfaction over the study period.

**Multivariate Analysis**

We conducted a multivariate analysis to determine whether there were independent predictors of satisfaction at 12 months when adjusting for potential confounders. We adjusted for factors that reached a significance level < 0.20 on univariate analysis. In the adjusted multivariate analysis (Table 3), female sex was independently associated with the most satisfaction (adjusted OR 2.9, 95% CI 1.2–7.4, p = 0.02).

We conducted separate subgroup multivariate analyses with the cohort that underwent fusion (240 patients) and the cohort that underwent laminectomy alone (41 patients). Baseline characteristics, surgical variables, and perioperative outcomes for this subgroup analysis are presented in Table 4. In the multivariate analysis of the fusion cohort, female sex remained the sole predictor of the most satisfaction following surgery for degenerative lumbar spondylolisthesis (adjusted OR 3.3, 95% CI 1.3–9.3, p = 0.02; Table 5). In the laminectomy-alone cohort, there were only 3 patients identifying as the least satisfied, precluding multivariate analysis of this subgroup. Of note, there was no difference in the proportion of most and least satisfied patients within the fusion cohort—217 (90.4%) and 23 (9.6%), respectively—and the laminectomy cohort—38 (92.7%) and 3 (7.3%), respectively (Yates’ $\chi^2 = 0.03$, p = 0.86).

**Additional Data**

Descriptive and surgical variables, including perioperative outcomes for patients who were immediately satisfied (NASS Satisfaction Questionnaire score of 2 or 3), are presented in Table 6.

**Discussion**

In an analysis of 477 patients undergoing surgery for grade 1 degenerative lumbar spondylolisthesis, we found that 255 patients identified as most satisfied and 26 identified as least satisfied 12 months after the index surgery. The most satisfied patients had a significantly lower mean BMI and a lower rate of CAD. Though there were no significant differences between the 2 cohorts with regard to baseline PROs (NRS-BP, NRS-LP, ODI, and EQ-5D), the most satisfied patients significantly improved at the 12-month follow-up, whereas the least satisfied patients demonstrated no significant change in NRS-LP, ODI, or EQ-5D at the 12-month follow-up relative to baseline.

In a multivariate analysis, female sex was independently associated with the most satisfaction at 12 months after surgery. This finding—in adjusted analysis—is a novel one. In prior investigations of lumbar spinal surgery, female sex was associated with inferior or equivocal satisfaction. In 2 studies, one on patients over 65 years of age and another single-center prospective analysis of 384 patients, with both groups undergoing lumbar spine surgery, female sex was associated with dissatisfaction. In another study of spinal fusion in a mixed cohort including 112 patients with isthmic spondylolisthesis and degenerative disc disease, male sex increased the likelihood of a positive result, which was defined as patient satisfaction as well as return to work and reduced medication. A number of studies have also shown that patient sex is not predictive of outcome. For example, in a study of patients who underwent surgery for lumbar disc herniation, the authors found no significant differences in satisfaction between male and female patients. In another large-registry study of patients with lumbar spinal stenosis without spondylolisthesis, patient sex was not predictive of satisfaction in an adjusted analysis. In contrast, our finding that female patient sex was associated with the most satisfaction following surgery for degenerative lumbar spondylolisthesis warrants further investigation. Specifically, factors that may differ in an etiology-specific manner should be identified.

In the present study, based on the adjusted OR of 2.87 for women and the most satisfaction, as well as the 86.9% chance of most satisfaction for men (the reference group), the calculated adjusted risk ratio is 1.09, indicating a 9% increased chance of most satisfaction for women—an effect size that is not exceedingly large. Nonetheless, the literature is skewed toward men having superior outcomes in lumbar spinal surgery, and our study provides contrasting evidence that women may fare better in some circumstances, such as following surgery for lumbar spondylolisthesis. Surgeons should continue to offer surgery for lumbar spondylolisthesis to well-selected patients—regardless of their sex, given the high rates of satisfaction for both women and men.

In our univariate comparisons, we found that the least satisfied patients had a higher mean BMI and a greater rate of CAD. The association between obesity and satisfaction following lumbar spinal surgery has been inconsistent. In a large-registry study of 2633 lumbar stenosis patients, obese patients, in general, had less satisfaction following surgery. However, in a study by McGuire and colleagues, there was no difference between obese and nonobese patients in symptom satisfaction at 12 months following surgery specifically for degenerative lumbar spondylolisthesis. It is important to note that in our multivariate analysis, when adjusting for potential confounders, BMI was not a significant independent predictor of satisfaction. This suggests that other factors—for example, patient sex—may be more important for preoperative counseling and the determination of which patients will be most satisfied after surgery for degenerative lumbar spondylolisthesis. The association between CAD and inferior outcomes following lumbar spinal surgery, in general, is clearer. In a systematic review of 21 studies on preoperative predictors of outcomes of surgery for lumbar spinal stenosis, cardiovascular comorbidity was associated with poor patient satisfaction at the 2-year follow-up. Increased attention to cardiac comorbidities may be considered to optimize satisfaction following surgery for degenerative lumbar spondylolisthesis. Of note, our study did not reveal associations between patient satisfaction with surgery for degenerative lumbar spondylolisthesis and ASA class, psychiatric comorbidity, smoking, and employment status. In contrast, in a recent...
| Variable                           | Fusion (n = 240) | Laminectomy Alone (n = 41) | p Value | Fusion (n = 240) | Laminectomy Alone (n = 41) | p Value |
|-----------------------------------|------------------|---------------------------|---------|------------------|---------------------------|---------|
| No. of patients                   | 217              | 23                        | 0.92    | 38               | 3                         | 0.86    |
| Mean age in yrs                   | 61.8 ± 10.2      | 61.8 ± 10.0               | 0.92    | 72.4 ± 8.6       | 71.9 ± 8.8                 | 0.94    |
| Female                            | 130 (59.9%)      | 9 (39.1%)                 | 0.05    | 19 (50.0%)       | 1 (33.3%)                  | 0.96    |
| Mean BMI in kg/m²                  | 30.4 ± 6.2       | 33.2 ± 6.3                | 0.02    | 27.9 ± 4.2       | 30.1 ± 8.2                 | 0.71    |
| Smoker                            | 21 (9.7%)        | 4 (17.4%)                 | 0.43    | 2 (5.3%)         | 0 (0%)                     | NA      |
| Comorbidities                     |                  |                           |         |                  |                           |         |
| Diabetes mellitus                 | 43 (19.8%)       | 7 (30.4%)                 | 0.23    | 9 (23.7%)        | 0 (0%)                     | NA      |
| CAD                               | 26 (12.0%)       | 7 (30.4%)                 | 0.01    | 5 (13.2%)        | 0 (0%)                     | NA      |
| Anxiety                           | 43 (19.8%)       | 3 (13.0%)                 | 0.61    | 8 (21.1%)        | 0 (0%)                     | NA      |
| Depression                        | 53 (24.4%)       | 3 (13.0%)                 | 0.22    | 6 (15.8%)        | 0 (0%)                     | NA      |
| Osteoporosis                      | 11 (5.1%)        | 1 (4.3%)                  | 0.72    | 4 (10.5%)        | 0 (0%)                     | NA      |
| Dominant presenting symptom       |                  |                           | 0.82    |                  |                           | 0.83    |
| Pain predominant                  | 89 (41.0%)       | 11 (47.8%)                |         | 11 (28.9%)       | 1 (33.3%)                  |         |
| Motor predominant                 | 32 (14.7%)       | 3 (13.0%)                 |         | 19 (50.0%)       | 1 (33.3%)                  |         |
| Sensory predominant               | 96 (44.2%)       | 9 (39.1%)                 |         | 8 (21.1%)        | 1 (33.3%)                  |         |
| Motor deficit                     | 45 (20.7%)       | 5 (21.7%)                 | 0.91    | 11 (28.9%)       | 3 (100%)                   | NA      |
| Independently ambulatory at presentation | 199 (91.7%) | 20 (87.0%)                | 0.71    | 32 (84.2%)       | 2 (66.7%)                  | >0.99   |
| ASA class                          | 0.16             |                           |         |                  |                           | NA      |
| I or II                           | 118 (54.4%)      | 9 (39.1%)                 | 0.10    | 27 (71.1%)       | 3 (100%)                   | 0.68    |
| III or IV                         | 99 (45.6%)       | 14 (60.9%)                |         | 11 (28.9%)       | 0 (0%)                     |         |
| Type of insurance                 | 0.10             |                           |         |                  |                           |         |
| Private                           | 124 (57.1%)      | 9 (39.1%)                 |         | 10 (26.3%)       | 1 (33.3%)                  |         |
| Medicare, Medicaid, or VA/government | 93 (42.9%) | 14 (60.9%)                |         | 28 (73.7%)       | 2 (66.7%)                  |         |
| Ethnicity                          | 0.53             |                           |         |                  |                           | NA      |
| Hispanic or Latino                | 36 (16.6%)       | 5 (21.7%)                 |         | 1 (2.6%)         | 0 (0%)                     |         |
| Not Hispanic or Latino            | 181 (83.4%)      | 18 (78.3%)                |         | 37 (97.4%)       | 3 (100%)                   |         |
| Level of education                | 0.25             |                           |         |                  |                           | 0.96    |
| 4-yr degree or more               | 93 (42.9%)       | 7 (30.4%)                 |         | 19 (50.0%)       | 2 (66.7%)                  |         |
| <4-yr degree                     | 124 (57.1%)      | 16 (69.6%)                |         | 19 (50.0%)       | 1 (33.3%)                  |         |
| Employment status                 | 0.26             |                           |         |                  |                           | 0.82    |
| Employed or on leave              | 105 (48.4%)      | 8 (34.8%)                 |         | 8 (21.1%)        | 1 (33.3%)                  |         |
| Not employed                      | 109 (50.2%)      | 14 (60.9%)                |         | 30 (78.9%)       | 2 (66.7%)                  |         |
| Baseline PROs                     |                  |                           |         |                  |                           |         |
| NRS-BP                            | 6.7 ± 2.6        | 7.7 ± 2.3                 | 0.06    | 5.8 ± 3.1        | 5.0 ± 2.6                  | 0.60    |
| NRS-LP                            | 6.5 ± 2.8        | 7.0 ± 2.8                 | 0.54    | 6.5 ± 2.9        | 4.0 ± 4.0                  | 0.24    |
| ODI                               | 44.6 ± 15.0      | 51.0 ± 19.1               | 0.10    | 36.3 ± 16.3      | 33.3 ± 23.2                | 0.69    |
| EQ-5D                             | 0.55 ± 0.21      | 0.48 ± 0.20               | 0.05    | 0.57 ± 0.21      | 0.80 ± 0.20                | 0.10    |
| Approach                          | 0.85†            |                           |         |                  |                           | NA      |
| Posterior only                    | 201 (92.6%)      | 21 (91.3%)                |         | 38 (100%)        | 3 (100%)                   |         |
| Anterior only                     | 6 (2.8%)         | 0 (0.0%)                  |         | 0 (0%)           | 0 (0%)                     |         |
| Lateral only                      | 3 (1.4%)         | 0 (0.0%)                  |         | 0 (0%)           | 0 (0%)                     |         |
| 2-stage approach                  | 7 (3.2%)         | 2 (8.7%)                  |         | 0 (0%)           | 0 (0%)                     |         |
| MIS                               | 68 (31.3%)       | 4 (17.4%)                 | 0.17    | 17 (44.7%)       | 3 (100%)                   | NA      |
| Mean EBL in ml                    | 279.3 ± 254.0    | 438.9 ± 655.4             | 0.047†  | 62.0 ± 87.6      | 21.7 ± 5.8                 | 0.22    |
| Mean op time in mins              | 213.2 ± 83.5     | 215.5 ± 101.3             | 0.84    | 128.2 ± 62.6     | 109.3 ± 22.5               | 0.78    |
| Mean hospital LOS in days         | 3.4 ± 1.7        | 3.1 ± 1.7                 | 0.76    | 1.3 ± 1.3        | 1.0 ± 1.7                  | 0.59    |

CONTINUED ON PAGE 8
Mannion and colleagues, the percentage of patients satisfied retrospec-
tively; therefore, the findings are vulnerable to multiple confounding biases. As compared with the most satis-
fi ed cohort, the least satisfied cohort comprised a smaller number of patients. This reflects the real-world experi-
ence of surgeons providing surgery for degenerative lum-
bar spondylolisthesis but may limit the statistical power to detect significant differences between these 2 cohorts.
Nonetheless, significant differences were found even with this limitation. We report initial 12-month outcomes here.
Indeed, satisfaction is an outcome that can fluctuate with time. Longer-term study of this QOD cohort is important
to identify any changes in satisfaction that may occur on extend-
ed follow-up. As a registry, there is no standardiza-
tion of surgical decision making, surgical technique, or baseline patient characteristics. The observational nature of the study prevents identification of causal relationships between patient factors and satisfaction, though results can be suggestive. We defined surgeries as MI if the surgery used any of the following MI techniques: MI laminectomy, MI pedicle screws, MI interbody grafts, cortical screws, or percutaneous screws. Therefore, some surgeries classified as MI may have been partially MI and partially open. Our definition may have limited our ability to detect the impact of completely MI surgery on surgical outcomes for lumbar spondylolisthesis. For this study, baseline radiographic parameters and postoperative images were unavailable. Indeed, important preoperative (for example, dynamic insta-
ibility, sagittal alignment) and postoperative (for example, fusion rates, progression or reduction of spondylolisthesis) radiographic parameters also likely affect outcomes of surgery for degenerative lumbar spondylolisthesis. Future studies should correlate these radiographic parameters to patient satisfaction. Lastly, the NASS Satisfaction Ques-
tionnaire does not have a clear option for patients to indicate that they were worse after surgery. Indeed, the NASS score 4 cohort (least satisfied) consists of patients who feel the same or worse after surgery, which could reflect a wide range of satisfaction. Future studies may consider a mea-
sure of satisfaction that includes a narrower definition of dissatisfaction, which could aid the identification of addi-
tional factors that predict satisfaction after surgery.

The findings in this study should be interpreted in the context of the above limitations. Still, it is important to

### TABLE 4. Characteristics and surgical variables for the most and least satisfied patients stratified by fusion versus laminectomy alone for grade 1 lumbar spondylolisthesis

| Variable                                | Fusion (n = 240) | Most Satisfied | Least Satisfied | p Value | Laminectomy Alone (n = 41) | Most Satisfied | Least Satisfied | p Value |
|------------------------------------------|------------------|----------------|-----------------|---------|--------------------------|----------------|----------------|---------|
| Discharge disposition                    |                  |                |                 |         |                          |                |                |         |
| Home or home health care                 | 195 (89.9%)      | 20 (87.0%)     |                 | 0.94    | 34 (89.5%)               | 3 (100%)       |                 | NA      |
| Not to home or home health care          | 22 (10.1%)       | 3 (13.0%)      |                 |         | 4 (10.5%)                | 0 (0%)         |                 | NA      |
| Readmission w/in 3 mos                   | 8 (3.7%)         | 3 (13.0%)      | 0.13            |         | 1 (2.6%)                 | 0 (0%)         |                 | NA      |
| Reop w/in 12 mos                         | 12 (5.5%)        | 3 (13.0%)      | 0.34            |         | 1 (2.6%)                 | 0 (0%)         |                 | NA      |

**Table Notes:**

- **Variable:** The variable being analyzed.
- **Fusion (n = 240):** Characteristics for the fusion group.
- **Least Satisfied:** Characteristics for the least satisfied cohort.
- **p Value:** Statistical significance of the difference between the two groups.
- **Laminectomy Alone (n = 41):** Characteristics for the laminectomy group.
- **Most Satisfied:** Characteristics for the most satisfied cohort.
- **Least Satisfied:** Characteristics for the least satisfied cohort.
- **p Value:** Statistical significance of the difference between the two groups.

### TABLE 5. Multivariate analysis of most versus least satisfaction following fusion surgery for grade 1 lumbar spondylolisthesis

| Variable          | Adjusted OR* (95% CI) | p Value |
|-------------------|-----------------------|---------|
| Female            | 3.33 (1.28–9.26)      | 0.02†   |
| Private insurance | 1.83 (0.70–4.96)      | 0.22    |
| CAD               | 0.43 (0.14–1.38)      | 0.14    |
| BMI               | 0.94 (0.86–1.01)      | 0.10    |
| ASA class III or IV | 0.99 (0.33–3.01) | 0.98    |
| MIS               | 2.43 (0.77–8.89)      | 0.16    |
| Readmission w/in 3 mos | 0.24 (0.05–1.38) | 0.08    |
| Baseline NRS-BP   | 0.85 (0.64–1.09)      | 0.22    |
| Baseline ODI      | 0.98 (0.94–1.02)      | 0.34    |
| Baseline EQ-5D    | 1.11 (0.07–17.00)     | 0.94    |

**Table Notes:**

- **Variable:** The variable being analyzed.
- **Adjusted OR* (95% CI):** The adjusted odds ratio with the 95% confidence interval.
- **p Value:** Statistical significance of the difference between the two groups.

* Represents odds predicting the most satisfaction relative to the least satisfaction. Covariates were adjusted for those variables that reached a significance value of p < 0.20 on univariate analysis: sex, insurance, CAD, BMI, ASA class, MIS, readmission within 3 months, and baseline NRS-BP, ODI, and EQ-5D.
† Denotes a statistically significant relationship, alpha level 0.05.
### TABLE 6. Characteristics of patients undergoing surgery for grade 1 lumbar spondylolisthesis, stratified by satisfaction

| Variable                                      | Most Satisfied | Intermediately Satisfied | Least Satisfied | p Value |
|-----------------------------------------------|----------------|--------------------------|-----------------|---------|
| No. of patients                               | 255            | 97                       | 26              |         |
| Mean age in yrs                               | 63.4 ± 10.6    | 60.0 ± 12.1              | 63.0 ± 10.3     | 0.03*   |
| Female                                        | 149 (58.4%)    | 58 (59.8%)               | 10 (38.5%)      | 0.13    |
| Mean BMI in kg/m²                              | 30.0 ± 6.0     | 31.2 ± 8.0               | 32.9 ± 6.5      | 0.06    |
| Smoker                                        | 23 (9.0%)      | 8 (8.2%)                 | 4 (15.4%)       | 0.52    |
| Comorbidities                                 |                |                          |                 |         |
| Diabetes mellitus                             | 52 (20.4%)     | 12 (12.4%)               | 7 (26.9%)       | 0.12    |
| CAD                                           | 31 (12.2%)     | 8 (8.2%)                 | 7 (26.9%)       | 0.04*   |
| Anxiety                                       | 51 (20.0%)     | 17 (17.5%)               | 3 (11.5%)       | 0.54    |
| Depression                                    | 59 (23.1%)     | 22 (22.7%)               | 3 (11.5%)       | 0.40    |
| Osteoporosis                                  | 15 (5.9%)      | 5 (5.2%)                 | 1 (3.8%)        | 0.89    |
| Dominant presenting symptom                   |                |                          |                 | 0.80    |
| Pain predominant                              | 100 (39.2%)    | 34 (35.1%)               | 12 (46.2%)      |         |
| Motor predominant                             | 51 (20.0%)     | 18 (18.6%)               | 4 (15.4%)       |         |
| Sensory predominant                           | 104 (40.8%)    | 45 (46.4%)               | 10 (38.5%)      |         |
| Motor deficit                                 | 56 (22.0%)     | 24 (24.7%)               | 8 (30.8%)       | 0.55    |
| Independently ambulatory at presentation      | 231 (90.6%)    | 81 (83.5%)               | 22 (84.6%)      | 0.15    |
| ASA class                                     |                |                          |                 | 0.57    |
| I or II                                       | 145 (56.9%)    | 53 (54.6%)               | 12 (46.2%)      |         |
| III or IV                                     | 110 (43.1%)    | 44 (45.4%)               | 14 (53.8%)      |         |
| Type of insurance                             |                |                          |                 | 0.31    |
| Private                                       | 134 (52.5%)    | 53 (54.6%)               | 10 (38.5%)      |         |
| Medicare, Medicaid, or VA/government          | 121 (47.5%)    | 43 (44.3%)               | 16 (61.5%)      |         |
| Ethnicity                                     |                |                          |                 | 0.50    |
| Hispanic or Latino                            | 37 (14.5%)     | 18 (18.6%)               | 5 (19.2%)       |         |
| Not Hispanic or Latino                        | 218 (85.5%)    | 75 (77.3%)               | 21 (80.8%)      |         |
| Level of education                            |                |                          |                 | 0.01*   |
| 4-yr degree or more                           | 112 (43.9%)    | 25 (25.8%)               | 9 (34.6%)       |         |
| <4-yr degree                                  | 136 (53.3%)    | 66 (68.0%)               | 17 (65.4%)      |         |
| Employment status                             |                |                          |                 | 0.47    |
| Employed or on leave                          | 113 (44.3%)    | 38 (39.2%)               | 9 (34.6%)       |         |
| Not employed                                  | 138 (54.1%)    | 59 (60.8%)               | 16 (61.5%)      |         |
| Mean baseline PROs                            |                |                          |                 |         |
| NRS-BP                                        | 6.6 ± 2.7      | 7.0 ± 2.4                | 7.4 ± 2.4       | 0.14    |
| NRS-LP                                        | 6.5 ± 2.8      | 6.5 ± 2.8                | 6.7 ± 3.0       | 0.97    |
| ODI                                           | 43.4 ± 15.5    | 46.5 ± 16.9              | 48.9 ± 20.0     | 0.10    |
| EQ-5D                                         | 0.56 ± 0.20    | 0.50 ± 0.23              | 0.52 ± 0.22     | 0.12    |
| Approach                                      |                |                          |                 | 0.80†   |
| Posterior only                                | 239 (93.7%)    | 89 (91.8%)               | 24 (92.3%)      |         |
| Anterior only                                 | 6 (2.4%)       | 4 (4.1%)                 | 0 (0.0%)        |         |
| Lateral only                                  | 3 (1.2%)       | 1 (1.0%)                 | 0 (0.0%)        |         |
| 2-stage approach                              | 7 (2.7%)       | 3 (3.1%)                 | 2 (7.7%)        |         |
| MIS                                           | 85 (33.3%)     | 33 (34.0%)               | 7 (26.9%)       | 0.78    |
| Laminectomy                                   | 239 (93.7%)    | 93 (95.9%)               | 24 (92.3%)      | 0.68    |
| Fusion                                         | 217 (85.1%)    | 84 (86.6%)               | 23 (88.5%)      | 0.86    |
| Mean EBL in ml                                | 246.5 ± 248.9  | 271.5 ± 261.1            | 390.8 ± 629.6   | 0.06    |
| Mean op time in mins                          | 200.9 ± 86.1   | 186.0 ± 85.3             | 203.3 ± 101.3   | 0.34    |
| Mean hospital LOS in days                     | 3.1 ± 1.8      | 3.3 ± 1.9                | 2.8 ± 1.8       | 0.56    |

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note that the study represents one of the largest, multiinstitutional analyses to date to report on patients with grade 1 degenerative lumbar spondylolisthesis and thus provides important information about satisfaction as gleaned from real-world experience. Additionally, it is important to note that a greater proportion of patients in general undergoing surgery for spondylolisthesis reported high satisfaction postoperatively, as compared with those undergoing surgery for other lumbar pathologies, such as recurrent disc herniation, stenosis, adjacent segment degeneration, or mechanical disc collapse.7 Thus, surgery for degenerative lumbar spondylolisthesis remains an important treatment option in well-selected patients.

Conclusions

In adjusted analyses of 477 patients who underwent surgery for grade 1 degenerative lumbar spondylolisthesis, female sex was independently associated with the most satisfaction, 12 months following surgery. In univariate comparisons of the cohort with the most satisfaction and the cohort reporting the least satisfaction, the latter group had a higher mean BMI and a higher rate of CAD, a proxy for medical comorbidity. These findings highlight several key factors that may aid in expectation setting for patients considering surgery for degenerative lumbar spondylolisthesis.

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References

1. Aalto TJ, Malmivaara A, Kovacs F, Herno A, Alen M, Salmi L, et al: Preoperative predictors for postoperative clinical outcome in lumbar spinal stenosis: systematic review. Spine (Phila Pa 1976) 31:668–6663, 2006

2. Abtahi AM, Brodko DS, Lawrence BD, Zhang C, Spiker WR: Association between patient-reported measures of psychological distress and patient satisfaction scores after spine surgery. J Bone Joint Surg Am 97:824–828, 2015

3. Andersen T, Christensen FB, Laursen M, Høy K, Hansen ES, Bünger C: Smoking as a predictor of negative outcome in lumbar spinal fusion. Spine (Phila Pa 1976) 26:2623–2628, 2001

4. Chapin L, Ward K, Ryken T: Preoperative depression, smoking, and employment status are significant factors in patient satisfaction after lumbar spine surgery. Clin Spine Surg 30:E725–E732, 2017

5. Chotai S, Devin CJ, Archer KR, Bydon M, McGirt MJ, Nian H, et al: Effect of patients’ functional status on satisfaction with outcomes 12-months after elective spine surgery for lumbar degenerative disease. Spine J [in press], 2017

6. Chotai S, Siavaganesan A, Parker SL, McGirt MJ, Devin CJ: Patient-specific factors associated with dissatisfaction after elective surgery for degenerative spine diseases. Neurosurgery 77:157–163, 2015

7. Crawford CH III, Carreon LY, Bydon M, Asher AL, Glassman SD: Impact of preoperative diagnosis on patient satisfaction following lumbar spine surgery. J Neurosurg Spine 26:709–715, 2017

8. Daltroy LH, Cats-Baril WL, Katz JN, Fossel AH, Liang MH: The North American Spine Society Lumbar Spine Outcome Assessment Instrument: reliability and validity tests. Spine (Phila Pa 1976) 21:741–749, 1996

9. Elsamadicy AA, Reddy GB, Nayar G, Seregsketter A, Zakkare-Fagbamila R, Karikari IO, et al: Impact of gender disparities on short-term and long-term patient reported outcomes and satisfaction measures after elective lumbar spine surgery: a single institutional study of 384 patients. World Neurosurg 107:952–958, 2017

10. Fürsth P, Olafsson G, Carlsson T, Frost A, Borgström F, Fritzell P, et al: A randomized, controlled trial of fusion surgery for lumbar spinal stenosis. N Engl J Med 374:1413–1423, 2016

11. Gehrchen PM, Dahl B, Katonis P, Blyme P, Tøndevold E, Kiær T: No difference in clinical outcome after posteriorlateral lumbar fusion between patients with isthmic spondylolisthesis and those with degenerative disc disease using pedicle screw instrumentation: a comparative study of 112 patients with 4 years of follow-up. Eur Spine J 11:423–427, 2002

12. Ghogawala Z, Dsuzia J, Butler WE, Dai F, Terrin N, Magge SN, et al: Laminectomy plus fusion versus laminectomy alone for lumbar spondylolisthesis. N Engl J Med 374:1424–1434, 2016

13. Knutsson B, Michaelsson K, Sandén B: Obesity is associated with inferior results after surgery for lumbar spinal stenosis: a study of 2633 patients from the Swedish spine register. Spine (Phila Pa 1976) 38:435–441, 2013

14. Levin JM, Winkelman RD, Smith GA, Tanenbaum JE, Benzèl EC, Mroz TE, et al: Impact of preoperative depression on
hospital consumer assessment of healthcare providers and systems survey results in a lumbar fusion population. Spine (Phila Pa 1976) 42:675–681, 2017

15. Mannion AF, Fekete TF, Porchet F, Haschtmann D, Jeszenszky D, Kleinstück FS: The influence of comorbidity on the risks and benefits of spine surgery for degenerative lumbar disorders. Eur Spine J 23 (Suppl 1):S66–S71, 2014

16. McGirt MJ, Speroff T, Dittus RS, Harrell FE Jr, Asher AL: The National Neurosurgery Quality and Outcomes Database (NQOD): general overview and pilot-year project description. Neurosurg Focus 34(1):E6, 2013

17. McGuire KJ, Khaleel MA, Rihn JA, Lurie JD, Zhao W, Weinstein JN: The effect of high obesity on outcomes of treatment for lumbar spinal conditions: subgroup analysis of the spine patient outcomes research trial. Spine (Phila Pa 1976) 39:1975–1980, 2014

18. Meyerding HW: Diagnosis and roentgenologic evidence of spondylolisthesis. Radiology 20:108–120, 1933

19. Mummaneni PV, Bisson EF, Kerezoudis P, Glassman S, Foley K, Slotkin JR, et al: Minimally invasive versus open fusion for Grade I degenerative lumbar spondylolisthesis: analysis of the Quality Outcomes Database. Neurosurg Focus 43(2):E11, 2017

20. Sacks GD, Lawson EH, Dawes AJ, Russell MM, Maggard-Gibbons M, Zingmond DS, et al: Relationship between hospital performance on a patient satisfaction survey and surgical quality. JAMA Surg 150:858–864, 2015

21. Sainani KL: Understanding odds ratios. PM R 3:263–267, 2011

22. Shabat S, Folman Y, Arinzon Z, Adunsky A, Catz A, Gepstein R: Gender differences as an influence on patients’ satisfaction rates in spinal surgery of elderly patients. Eur Spine J 14:1027–1032, 2005

23. Sigmundsson FG, Jönsson B, Strömqvist B: Determinants of patient satisfaction after surgery for central spinal stenosis without concomitant spondylolisthesis: a register study of 5100 patients. Eur Spine J 26:473–480, 2017

24. Sinikallio S, Aalto T, Airaksinen O, Herno A, Kröger H, Savolainen S, et al: Lumbar spinal stenosis patients are satisfied with short-term results of surgery—younger age, symptom severity, disability and depression decrease satisfaction. Disabil Rehabil 29:537–544, 2007

25. Strömqvist F, Ahmad M, Hildingsson C, Jönsson B, Strömqvist B: Gender differences in lumbar disc herniation surgery. Acta Orthop 79:643–649, 2008

26. Thomé C, Barth M, Scharf J, Schmiedek P: Outcome after lumbar sequestrectomy compared with microdiscectomy: a prospective randomized study. J Neurosurg Spine 2:271–278, 2005

27. Thomé C, Zevgardis D, Lehaeta O, Bätzner H, Pöckler-Schöniger C, Wöhrle J, et al: Outcome after less-invasive decompression of lumbar spinal stenosis: a randomized comparison of unilateral laminotomy, bilateral laminotomy, and laminectomy. J Neurosurg Spine 3:129–141, 2005

28. Tsai TC, Orav EJ, Jha AK: Patient satisfaction and quality of surgical care in US hospitals. Ann Surg 261:2–8, 2015

29. Weinstein JN, Lurie JD, Tosteson TD, Hanscom B, Tosteson AN, Blood EA, et al: Surgical versus nonsurgical treatment for lumbar degenerative spondylolisthesis. N Engl J Med 356:2257–2270, 2007

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Dr. Bisson owns stock in NView. Dr. Glassman is an employee of Norton Healthcare and holds a patent with, has been a consultant for, and receives royalties from Medtronic. Dr. Foley has been a consultant for, receives royalties from, holds a patent with, and owns stock in Medtronic; owns stock in and holds a patent with NuVasive; owns stock in and is a member of the board of directors for Discgenics and TrueVision; and owns stock in Spine Wave. Dr. Potts has been a consultant for Medtronic. Dr. C. Shaffrey has been a consultant for Medtronic, NuVasive, and Zimmer-Biomet; owns stock in NuVasive; and holds patents with Medtronic, NuVasive, and Zimmer-Biomet. Dr. Coric has been a consultant for Spine Wave, Stryker, Medtronic, Globus Medical, and Premia Spine and owns stock in Spine Wave and Premia Spine. Dr. Knightly has a personal relationship with National Physicians Alliance board of directors. Dr. Park has been a consultant for Globus, Medtronic, NuVasive, and Zimmer-Biomet and receives royalties from Globus. Dr. Fu has been a consultant for SI-BONE. Dr. Slotkin has been a consultant for Stryker and Medtronic. Dr. Haid has been a consultant for, receives royalties from, and holds a patent with NuVasive; owns stock in SpineUniverse; receives royalties from and holds a patent with Medtronic Sofamor Danek; holds a patent with Globus Medical; and receives royalties from Elsevier Inc. Dr. Mummaneni has been a consultant for DePuy Spine, Globus, and Stryker; owns stock in SpineUniverse and owns stock in SpineUniverse; receives royalties from and holds a patent with Medtronic Sofamor Danek; holds a patent with Globus Medical; and receives royalties from Elsevier Inc. Dr. Mummaneni has been a consultant for DePuy Spine, Globus, and Stryker; owns stock in SpineUniverse and owns stock in SpineUniverse; receives royalties from and holds a patent with Medtronic Sofamor Danek; holds a patent with Globus Medical; and receives royalties from Elsevier Inc. Dr. Mummaneni has been a consultant for DePuy Spine, Globus, and Stryker; owns stock in SpineUniverse and owns stock in SpineUniverse; receives royalties from and holds a patent with Medtronic Sofamor Danek; holds a patent with Globus Medical; and receives royalties from Elsevier Inc.

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