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BACKGROUND: The Oswestry Disability Index (ODI) is a widely used patient-reported outcome instrument in lumbar spine surgery, but its relationship to the increasingly scrutinized but still heterogeneous patient satisfaction metrics has not been well described. One popular metric is the North American Spine Society (NASS) patient satisfaction index. This study aimed to determine whether change in ODI predicts patient satisfaction.

METHODS: Adult patients at a neurosurgery spine clinic completed the ODI and NASS questionnaires at various times in their care between September 2014 and November 2018. Scores were retrospectively analyzed using ordinal logistic regression.

RESULTS: One thousand thirty-seven patients were identified (mean age 59.3 ± 14.7 years, 54.2% male). At 3, 12, and 24 months postoperatively, 684 (84.5%), 400 (83.3%), and 215 (80.9%) patients, respectively, expressed satisfaction (NASS score 1 or 2). Mean ± standard deviation improvements in ODI at 3, 12, and 24 months postoperatively were 16.8 ± 17.5 (n = 675), 18.4 ± 17.5 (n = 396), and 19.7 ± 17.7 (n = 213). For every unit improvement in ODI, the odds of selecting the next most satisfied NASS score at 3, 12, and 24 months postoperatively increased by 6.8% (95% confidence interval [CI] 5.6%–8.1%), 5.8% (95% CI 4.4%–7.1%), and 6.0% (95% CI 4.2%–7.9%), respectively. Every 10-unit improvement increased the odds, respectively, by 93.8% (95% CI 73.2%–117.0%), 75.0% (95% CI 53.8%–99.1%), and 79.4% (95% CI 50.3%–114.1%).

CONCLUSIONS: Improvements in ODI are predictive of increased patient satisfaction as defined by the NASS index. A 10-point improvement in ODI nearly doubled the odds of increased satisfaction 3 months postoperatively.

INTRODUCTION

The unsustainable and escalating costs of American health care have led to increased scrutiny of value and to prominence of patient-reported outcomes (PROs) as metrics for reimbursement. The Oswestry Disability Index (ODI) is one of the most widely used PROs to assess pain and disability due to spinal pathology as well as to evaluate functional outcomes after lumbar spine surgery.1-3 Although ubiquitous, validated, and responsive, the ODI can be cumbersome for patients to complete and costly for institutions to record.4,5 Patient satisfaction metrics, although not rigorously validated in the spine domain, have become commonplace in determining value and quality due to their general ease of use, collection, and analysis.6,7

Although theoretically, postoperative functional improvement as reflected in ODI should lead to patient satisfaction, such an association has not been consistently demonstrated in the literature.8-11 Some authors have advocated for keeping discussions regarding patient satisfaction and functional PROs separate, not only providing data that improvements in metrics like ODI and Short Form-12 fail to predict satisfaction, but also arguing from a pragmatic standpoint that perception of service cannot be a proxy for perception of health.9,12 Furthermore, not only in the...
neurosurgical literature,\textsuperscript{11} but also in the general surgery literature, data have shown that perceived satisfaction with care relates more strongly to present state of health—which could be due to a variety of unrelated issues—than to the degree of improvement afforded by the intervention in question.\textsuperscript{15}

To assess the relationship between improvement in ODI and patient satisfaction, we employed the North American Spine Society (NASS) patient satisfaction index. This popular and brief instrument is measured on a scale of 1 to 4 with the choices as follows: “The treatment met my expectations” (1); “I did not improve as much as I had hoped, but I would undergo the same treatment for the same outcome” (2); “I did not improve as much as I had hoped, and I would not undergo the same treatment for the same outcome” (3); and “I am the same or worse than before treatment” (4).\textsuperscript{14} As functional status can be influenced by myriad factors other than surgery, we hypothesized that improvement in ODI would fail to predict postoperative patient satisfaction as defined by the NASS index.

METHODS

This study was approved by the University of Michigan institutional review board. Patient consent was unnecessary, given that all medical records were in existence at the time of institutional review board application submission and the final dataset was devoid of identifiable patient information.

Study Design and Population

We performed a cross-sectional study. Patients who presented to our spine clinic between September 2014 and November 2018 completed paper forms of the ODI and the NASS satisfaction index. Data were reviewed retrospectively from the initial clinic visit and standard follow-up visits at 3, 12, and 24 months postoperatively. Follow-up is typically attained within a month of these stated time points. Eligible patients were 18 years or older and underwent lumbar spine surgery for degenerative pathologies. Patients evaluated for tumor, trauma, or deformity were excluded.

Data Collection

Each of the ODI items was scored from 0 to 5, with greater values signifying greater disability. The scores for each item were then summed and doubled, resulting in a total score range from 0 to 100. For forms with missing responses, total scores were generated using the algorithm proposed by Mehr et al.\textsuperscript{13} The NASS satisfaction index was scored from 1 to 4, with lower numbers indicating greater levels of satisfaction.\textsuperscript{14}

Statistical Analysis

Descriptive data were analyzed with univariate instruments. Continuous variables were described with the mean and categorical variables with frequency. Ordinal multivariable logistic regression was used to evaluate the relationship between the ODI and NASS index and to determine the effect of covariates. Satisfaction also was evaluated as a binary outcome in logistic regression models, with a satisfied outcome defined as a NASS score of 1 or 2 and an unsatisfied outcome as a NASS score of 3 or 4.

RESULTS

One thousand thirty-seven unique patients were identified. Mean ± standard deviation (SD) age was 59.3 ± 14.7 years, mean ± SD body mass index (BMI) was 30.8 ± 6.2 kg/m\(^2\), 54.2% were male, and baseline ODI ± SD was 44.7 ± 15.6. At 3, 12, and 24 months postoperatively, 84.5% (n = 684), 83.2% (n = 400), and 80.6% (n = 215) of patients, respectively, expressed satisfaction with surgery (NASS score 1 or 2) (Table 1). Mean ± SD improvements in ODI from baseline at 3, 12, and 24 months postoperatively were 16.8 ± 17.5 (n = 675), 18.4 ± 17.5 (n = 396), and 19.7 ± 17.7 (n = 213).

Patients with both NASS and ODI data available for regression analysis numbered 674 at 3 months, 396 at 12 months, and 213 at 24 months postoperatively. Using univariate ordinal logistic regression and considering the NASS scores 1 through 4 individually, every unit improvement in ODI increased the odds of selecting the next most satisfied NASS score by 6.8% (95% confidence interval [CI] 5.6%–8.1%) at 3 months, 5.8% (95% CI 4.4%–7.1%) at 12 months, and 6.0% (95% CI 4.2%–7.9%) at 24 months postoperatively. Effect plots of these relationships are displayed in Figure 1. Every 10-unit improvement in ODI increased the odds of selecting a more satisfied NASS score by 93.8% (95% CI 73.2%–117.0%) at 3 months, 75.0% (95% CI 53.8%–99.1%) at 12 months, and 79.4% (95% CI 50.3%–114.1%) at 24 months (Table 2). Improvement in ODI remained independently associated with increased satisfaction at all time points after controlling for age, BMI, sex, and baseline ODI in multivariate analysis; however, each unit increase in baseline ODI was associated with a decreased odds of satisfaction by 4.0% (95% CI 3.7%–6.1%) at 3 months, 5.2% (95% CI 3.7%–6.8%) at 12 months, and 4.2% (95% CI 2.2%–6.1%) at 24 months.

Using univariate ordinal logistic regression and a binary satisfaction outcome, each unit improvement in ODI increased the odds of a satisfied NASS score by 8.1% (95% CI 6.2%–10.0%) at 3 months, 5.8% (95% CI 4.0%–7.7%) at 12 months, and 6.5% (95% CI 3.9%–9.1%) at 24 months. Effect plots of these relationships are displayed in Figure 2. A 10-unit improvement in ODI increased the odds of a satisfied NASS score by 117.7% (95% CI 83.2%–158.7%) at 3 months, 76.4% (95% CI 47.6%–110.7%) at 12 months, and 87% (95% CI 46.0%–139.8%) at 24 months postoperatively (Table 3). The binary satisfaction outcome remained independently associated with ODI improvement after controlling for age, BMI, and sex in multivariate analysis.

DISCUSSION

Increasing levels of scrutiny have been placed on PROs and patient satisfaction metrics in spine surgery to assess quality of care and inform reimbursement. Developed by Fairbank et al.\textsuperscript{1} in 1980, the ODI has become arguably the most widely used PRO in assessing pain and disability related to lumbar spine pathology and the effectiveness of surgery. As the ODI questionnaire can be cumbersome to complete and record, simpler patient satisfaction measures have been prioritized or even used as proxies for PROs in health care value determination.\textsuperscript{10} This has understandably generated both pragmatic and philosophical debates on the relationship between perception of outcome and perception of care.
Extant data are inconsistent regarding the association of the ODI and the NASS index, which is a validated, concise, single-item metric that ranges from 1 to 4, with lower scores representing greater levels of satisfaction. In addition, studies have tended to focus on either absolute preoperative ODI or postoperative ODI as potential predictors of postoperative NASS satisfaction rather than degree of ODI improvement. We argue that the latter is equally important to establish responsiveness of the satisfaction metric. Furthermore, the highly cited studies that do incorporate ODI improvement, such as those by Yamashita et al., Soroceanu et al., Bouras et al., and Lee et al., use satisfaction measures other than the NASS index.

Among the few studies of both ODI improvement and NASS index, Godil et al. found that improvements in Neck Disability

<p>| Table 1. Distribution of North American Spine Society Patient Satisfaction Scores at 3, 12, and 24 Months Postoperatively |
|---------------------------------------------------------------|-----------------|-----------------|-----------------|</p>
<table>
<thead>
<tr>
<th>Score</th>
<th>Outcome</th>
<th>No. of Patients (%)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The treatment met my expectations</td>
<td>413 (60.4)</td>
<td>224 (56)</td>
<td>115 (53.5)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>I did not improve as much as I had hoped, but I would undergo the same treatment for the same outcome</td>
<td>165 (24.1)</td>
<td>109 (27.3)</td>
<td>59 (27.4)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>I did not improve as much as I had hoped, and I would not undergo the same treatment for the same outcome</td>
<td>39 (5.7)</td>
<td>26 (6.5)</td>
<td>18 (8.4)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>I am the same or worse than before treatment</td>
<td>67 (9.8)</td>
<td>41 (10.3)</td>
<td>23 (10.7)</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1. Effect plots describing the probability of each of the 4 North American Spine Society (NASS) patient satisfaction index scores by changes in Oswestry Disability Index (ODI) at (A) 3 months, (B) 12 months, and (C) 24 months postoperatively.
Index and ODI at 3 months postoperatively were unable to differentiate satisfaction versus dissatisfaction by NASS questionnaire with good accuracy in receiver operating curve analyses (area under the curve 0.76). However, the study considered both cervical (32% of patients) and lumbar (68% of patients) spine surgery data together and included only the single 3-month follow-up point. Although we acknowledge that the 3-month time point has been shown to improve performance of prognostic models of functional outcomes at later time points, it is not a surrogate for them. In a retrospective study, Chotai et al. reported that inability to achieve minimal clinically important difference (MCID) for ODI and Neck Disability Index predicted dissatisfaction by NASS index 12 months postoperatively. Again, cervical and lumbar surgery patients were analyzed together, and only a single follow-up time point was presented. Furthermore, the ODI MCID can vary with surgical indication, and its use reduces the granular ODI to a binary covariate. Macki et al. reported similar results regarding dissatisfaction at 1 and 2 years postoperatively; this study again relied on MCID, and it considered only dichotomous NASS outcomes (1 or 2 vs. 3 or 4). A Quality Outcomes Database study by Chotai et al. of 5443 patients who exclusively underwent elective lumbar spine surgery found that improvement in ODI was associated with greater NASS satisfaction scores at a single 12-month follow-up point. They also found that patients with greater baseline ODI scores were less likely to achieve satisfaction.

To our knowledge, we conducted the first cross-sectional study quantifying the relationship between improvement in ODI and

<table>
<thead>
<tr>
<th>Time Point</th>
<th>Odds Ratio</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 months (n = 674)</td>
<td>1.9</td>
<td>1.7–2.2</td>
</tr>
<tr>
<td>12 months (n = 396)</td>
<td>1.8</td>
<td>1.5–2.0</td>
</tr>
<tr>
<td>24 months (n = 213)</td>
<td>1.8</td>
<td>1.5–2.1</td>
</tr>
</tbody>
</table>

**Table 2. Odds of Increased Satisfaction for Each 10-unit Improvement in the Oswestry Disability Index at Various Time Points Postoperatively**

**Figure 2.** Effect plots describing the probability of a binary satisfied North American Spine Society patient satisfaction index score (1 or 2) by changes in Oswestry Disability Index (ODI) at (A) 3 months, (B) 12 months, and (C) 24 months postoperatively.
satisfaction by the NASS index at 3, 12, and 24 months postoperatively. Contrary to our hypothesis, we found a strong association at all time points. Indeed, a 10-unit ODI improvement was associated with nearly twice the odds of a more satisfied outcome at 3 months and 75% or greater odds at 12 and 24 months postoperatively. Like the aforementioned Quality Outcomes Database study by Chotai et al.,6 we also report that greater preoperative disability reduced the odds of satisfaction. Although our results suggest association of perceptions of outcome and of care itself, we maintain that they represent discrete domains and do not advocate for use of one as a substitute for the other. The relationship likely depends on how expectations are set in the preoperative clinic,18,24 although we do not have corroborating data at this time. The strengths of our study include the number of follow-up time points, our analysis of both single- and 10-unit improvements of ODI on satisfaction, and our analysis of both the ordinal (i.e., 1–4) and dichotomous outcomes of NASS. Our study has several limitations. As the ODI and NASS questionnaires were administered at the same visit, reporting bias by patients could theoretically generate a spurious association between the measures. In addition, as patients were 1) naturally at different stages of care (i.e., preoperative or 3-, 12-, or 24-month postoperative) and 2) incompletely compliant during our data collection window, our findings should be interpreted in a cross-sectional fashion and limited conclusions should be drawn regarding the predictive nature of associations at one time point on later ones. In contrast, 1-year PROs have been shown to reliably predict 2-year PROs, and return visits at 2 years in the face of stable clinical and radiographic findings can be onerous for patients.15–17 More complete data may be achievable in the future with integration of automated follow-up methods.

### CONCLUSIONS

Improvements in the ODI are associated with increased patient satisfaction at 3, 12, and 24 months postoperatively. Further studies are needed to evaluate the magnitude of other contributors to the increasingly valued satisfaction metric.

### CRediT AUTHORSHIP CONTRIBUTION STATEMENT

**Timothy J. Yee**: Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Validation, Visualization, Writing - review & editing. **Kelsey J. Feerer**: Data curation, Formal analysis, Project administration, Software, Validation, Writing - review & editing. **Mark E. Oppenlander**: Investigation, Writing - review & editing. **Osama N. Kashlan**: Investigation, Writing - review & editing. **Nicholas Szerlip**: Investigation, Writing - review & editing. **Martin J. Buckingham**: Investigation, Writing - review & editing. **Kevin Swong**: Investigation, Writing - review & editing. **Victor Chang**: Conceptualization, Data curation, Investigation, Writing - review & editing. **Jason M. Schwalb**: Conceptualization, Data curation, Investigation, Writing - review & editing. **Paul Park**: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing - review & editing.

### REFERENCES


Conflict of interest statement: The authors declare that the article content was composed in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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