

# Incidence of revision surgery and patient-reported outcomes within 5 years of the index procedure for grade 1 spondylolisthesis: an analysis from the Quality Outcomes Database spondylolisthesis data

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**OBJECTIVE** Some patients treated surgically for grade 1 spondylolisthesis require revision surgery. Outcomes after revision surgery are not well studied. The objective of this study was to determine how revision surgery impacts patient-reported outcomes (PROs) in patients undergoing decompression only or decompression and fusion (D+F) for grade 1 spondylolisthesis within 5 years of the index surgery.

**METHODS** Patients in the 12 highest Quality Outcomes Database (QOD) enrolling sites with a diagnosis of grade 1 spondylolisthesis were identified and the incidence of revision surgery between the decompression-only and D+F patients were compared. PROs were compared between cohorts requiring revision surgery versus a single index procedure.

**RESULTS** Of 608 patients enrolled, 409 had complete 5-year data available for this study. Eleven (13.3%) of 83 patients underwent revision in the decompression-only group as well as 32 (9.8%) of 326 in the D+F group. For the entire cohort, patients requiring revision had significantly worse PROs at 5 years: Oswestry Disability Index (ODI) 27.4 versus 19.4,  $p = 0.008$ ; numeric rating scale for back pain (NRS-BP) 4.1 versus 3.0,  $p = 0.013$ ; and NRS for leg pain (NRS-LP) 3.4 versus 2.1,  $p = 0.029$ . In the decompression-only group, the change in 5-year PROs was not impacted by revision status: ODI 31.9 versus 24.2,  $p = 0.287$ ; NRS-BP 1.9 versus 2.9,  $p = 0.325$ ; and NRS-LP 6.2 versus 3.7,  $p = 0.011$ . In the D+F group, the change in 5-year PROs was diminished if patients required revision: ODI 19.1 versus 29.1,  $p = 0.001$ ; NRS-BP 3.0 versus 4.0,  $p = 0.170$ ; and NRS-LP 2.3 versus 4.6,  $p = 0.001$ .

**CONCLUSIONS** The most common reasons for reoperation within 5 years in the decompression-only group were repeat decompression and instability, whereas in the D+F group the most common reason was adjacent-segment disease. The need for revision resulted in modestly diminished benefit compared with patients with no revisions. These differences

**ABBREVIATIONS** ASD = adjacent-segment disease; D+F = decompression and fusion; NRS = numeric rating scale; NRS-BP = NRS for back pain; NRS-LP = NRS for leg pain; ODI = Oswestry Disability Index; PRO = patient-reported outcome; QOD = Quality Outcomes Database.

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were greater in the fusion cohort compared with the decompression-only cohort. The mean PRO improvement still far exceeded minimal clinically important difference thresholds for all measures for patients who underwent a revision surgery.

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**KEYWORDS** revision; grade 1 spondylolisthesis; clinical outcomes; lumbar

**D**EGENERATIVE spine disease is a major cause of low-back pain and affects approximately 80% of the US population, with spinal stenosis and degenerative spondylolisthesis affecting approximately 20% of the population.<sup>1</sup> Surgical management of degenerative spondylolisthesis is considered in patients who are symptomatic and have experienced unsuccessful nonoperative measures. This management typically involves a decompressive laminectomy alone or a decompressive laminectomy and spinal fusion (D+F).<sup>2-5</sup> However, controversy remains as to whether a spinal fusion is necessary in patients undergoing decompression for grade 1 spondylolisthesis. There are concerns for instability in patients undergoing decompression only as well as concerns for adjacent-segment disease (ASD) in patients undergoing fusion.

A recent systematic review and meta-analysis of risk factors for reoperation after degenerative lumbar spondylolisthesis surgery found reoperation rates to be 11% after a decompression-only operation, 10% after a fusion only, and 9% after a D+F.<sup>6</sup> The overall reoperation rate in this study was 10%, which found that obesity, diabetes, and smoking increased the risk for reoperation. In a population-based analysis by Vorhies and colleagues, it was found that treatment of degenerative spondylolisthesis with fusion or decompression alone resulted in higher reoperation rates at 1 year in the decompression-only group but similar rates of reoperation at both 3 and 5 years.<sup>7</sup>

The Quality Outcomes Database (QOD) was developed by the AANS to investigate prospective longitudinal demographic, clinical, and patient-reported outcome (PRO) data to measure the safety and quality of spine surgery.<sup>3</sup> This database was developed with the goal of evaluating risk-adjusted expected morbidity and surgical outcomes to improve care for surgical spine patients.<sup>8</sup>

There is currently a gap in the literature regarding PROs in patients with grade 1 spondylolisthesis who have undergone revision surgery. The purpose of this study was to determine the incidence of revision surgery in patients undergoing decompression only and D+F for grade 1 spondylolisthesis and how the need for revision affects PROs within 5 years of the index surgery. The results of this study will allow surgeons to better educate patients on the relevant risks associated with their index operation for treatment of grade 1 spondylolisthesis and allow surgeons to discuss expected postoperative outcomes following revision surgery.

## Methods

The QOD has been enrolling patients since 2012, with 80 participating sites across the US.<sup>3</sup> Twelve of the sites participate in the lumbar spondylolisthesis module organized by the AANS/CNS Joint Section on Disorders of the Spine and Peripheral Nerves, as first reported by Mummaneni and colleagues.<sup>3,9</sup>

After obtaining approval from the University of Louisville IRB, we queried the QOD to obtain information about patients with degenerative grade 1 spondylolisthesis who underwent revision surgery following a decompression-only procedure or a D+F procedure within 5 years of the index operation. PROs were compared between cohorts requiring revision surgery versus a single index procedure.

## Study Criteria

The diagnosis of degenerative grade 1 spondylolisthesis was determined by surgeons at participating sites using preoperative plain radiographs (standing or dynamic) as defined by the Meyerding classification.<sup>10</sup> Patients were included who underwent anterior-only, posterior-only, lateral-only, or two-stage surgery at the index level of lumbar spondylolisthesis (decompression only or D+F). Patients were included who underwent single-segment surgery (single-level decompression) or a two-level spinal fusion (e.g., L4–5 posterior spinal fusion). Patients were excluded who had 1) grade 2 or higher spondylolisthesis, or 2) surgery that included more than 1 level.

## Demographic, Clinical, and Surgical Variables

The QOD registry collects data on demographic variables (age, sex, smoking status), patient comorbidities (American Society of Anesthesiologists classification, diabetes mellitus, osteoporosis), clinical characteristics, socioeconomic factors (employment status, return-to-work status, discharge location), baseline PROs, and surgical variables (reason for reoperation, estimated blood loss, length of stay, length of surgery).

## Study Outcomes

Primary outcomes included the reason for reoperation at 30 days and 1, 2, 3, and 5 years postoperatively. PROs included the numeric rating scale for back pain (NRS-BP), NRS for leg pain (NRS-LP), and Oswestry Disability Index (ODI).<sup>11</sup> With regard to the NRS, extreme scores of 0 and 10 reflect no pain and unbearable pain, respectively.

## Statistical Analysis

Patients were separated into two groups based on whether they had a decompression-only procedure or a D+F procedure for all analyses. Continuous variables were compared using the Student t-test, and categorical variables were compared using chi-square analysis. Significance was defined in all cases as  $p < 0.05$ . All calculations were performed using SPSS software (version 22.0, IBM Corp.).

## Results

Of the 608 patients enrolled, 409 (67.3%) who under-

**TABLE 1. Demographic data of patients who underwent decompression only and D+F**

Variable	Decompression Only	D+F	p Value
No. of patients	83	326	
Mean age (SD), yrs	68.42 (11.98)	60.17 (10.56)	<b>0.001</b>
Mean BMI (SD), kg/m <sup>2</sup>	28.62 (5.48)	30.80 (6.90)	<b>0.003</b>
Females, n (%)	40 (48.2)	204 (62.6)	
Smoker, n (%)	8 (9.6)	35 (10.7)	
Diabetic, n (%)	14 (16.9)	45 (13.8)	
Osteoporotic, n (%)	5 (6.0)	24 (7.4)	
Workers' compensation, n (%)	2 (2.4)	21 (6.4)	
Revision, n (%)	11 (13.3)	32 (9.8)	0.271
Mean baseline PROs (SD)			
NRS-BP	5.37 (3.31)	6.91 (2.61)	<b>0.001</b>
NRS-LP	6.25 (2.85)	6.66 (2.76)	0.249
ODI	41.49 (17.50)	49.35 (14.86)	<b>0.001</b>

Boldface type indicates statistical significance.

went surgery for degenerative grade 1 spondylolisthesis had PROs and revision data available at 5 years postoperatively. There were 11 (13.3%) of 83 patients who underwent a decompression only who eventually underwent a revision, compared with 32 (9.8%) of 326 patients who underwent a D+F who ultimately underwent a revision.

Patients who underwent D+F had statistically significantly more back pain on the NRS than patients who underwent a decompression only (p = 0.001). Patients who underwent D+F had a higher ODI than patients in the decompression-only group (p = 0.001). Descriptive variables are presented in Table 1. Frequencies and percentages of the entire cohort are presented in Table 2.

**Reoperation Rates and Reasons for Reoperation**

There were no revision surgeries in the decompression-only group at 30 days. The most common reason for reoperation at 30 days was irrigation and debridement (4/8) in the D+F group. The most common reason for reoperation at 1 year was repeat decompression (2/5) and instability (2/5) in the decompression-only group and ASD (4/6) in the D+F group. At 2 years, the most common reason for reoperation was instability (1/1) in the decompression-only group and ASD (2/5) and implant removal (2/5) in

**TABLE 2. Frequency and percentages for entire cohort**

Procedure	Frequency	Percentage
Decompression only, no revision	72	17.6
Fusion, no revision	294	71.9
Decompression only, revised	11	2.7
Fusion, revised	32	7.8
Total	409	100

**TABLE 3. Reason for reoperation in patients who underwent decompression only (n = 11)**

Reason for Reop	30 Days	1 Yr	2 Yrs	3 Yrs	4 Yrs	5 Yrs
ASD		1*			1*	1*
Repeat decompression		2		1	1	
Instability		2	1			1

\* Cephalad-level ASD.

the D+F group. At 3 years, the most common reason for reoperation was repeat decompression (1/1) in the decompression-only group and nonunion (2/5) in the D+F group. The most common reason for reoperation in the decompression-only group at 5 years was ASD (1/2) and instability (1/2). The most common reason for reoperation in the D+F group at 5 years was equal between ASD nonunion (1/3), nonunion (1/3), and extension (1/3). The reoperation data are presented in Tables 3 and 4 for decompression-only and D+F patients, respectively.

**PROs**

Entire Cohort Stratified by No Revision Versus Revision

For the overall cohort, there were no differences in ODI, NRS-BP, or NRS-LP at baseline (Table 5). At the 5-year follow-up, patients requiring revision were significantly worse in terms of the ODI (27.4 vs 19.4, p = 0.008), NRS-BP (4.1 vs 3.0, p = 0.013), and NRS-LP (3.4 vs 2.1, p = 0.029; Table 5).

Decompression-Only Cohort

For patients who had decompression only as an index procedure, baseline leg pain was higher in the revision group (7.9 vs 6.0, p = 0.005) but 5-year PROs were equivalent in the two groups (Table 6). For those in the decompression-only cohort, there were no statistically significant differences in the NRS-BP or ODI at baseline (Table 7).

**TABLE 4. Reason for reoperation in patients who underwent D+F (n = 32)**

Reason for Reop	30 Days	1 Yr	2 Yrs	3 Yrs	4 Yrs	5 Yrs
I & D	4	1				
Evacuation of hematoma	1					
Endplate collapse	1					
Implant revision	2					
Implant removal			2	1		
Repeat decompression		1			1	
ASD		4*	2†	1‡		
ASD nonunion			1‡	1‡	3	1
Nonunion				2	1	1
Extension						1

I & D = irrigation and debridement.

\* 3 cephalad-level and 1 caudal-level ASD.

† 1 cephalad-level and 1 caudal-level ASD.

‡ Cephalad-level ASD.

**TABLE 5. PROs for entire cohort stratified by no revision versus revision**

PRO	No Revision, n = 366	Revision, n = 43	p Value
<b>Mean NRS-BP (SD)</b>			
Baseline	6.60 (2.83)	6.29 (3.06)	0.581
5-yr/latest	2.96 (2.95)	4.10 (2.69)	<b>0.013</b>
Change	3.78 (3.40)	2.70 (2.94)	0.053
<b>Mean NRS-LP (SD)</b>			
Baseline	6.56 (2.79)	6.70 (2.73)	0.756
5-yr/latest	2.13 (2.85)	3.36 (3.41)	<b>0.029</b>
Change	4.46 (3.69)	3.26 (3.22)	<b>0.029</b>
<b>Mean ODI (SD)</b>			
Baseline	47.52 (15.82)	49.79 (14.93)	0.354
5-yr/latest	19.42 (17.65)	27.42 (17.96)	<b>0.008</b>
Change	28.10 (17.13)	22.36 (16.82)	<b>0.039</b>

Boldface type indicates statistical significance.

**D+F Cohort**

Baseline NRS-BP, NRS-LP, and ODI were similar between the no-revision cohort and the revision cohort in patients who underwent D+F as their baseline procedure (p = 0.999, 0.446, and 0.628, respectively). NRS-BP, NRS-LP, and ODI at the latest follow-up at 5 years was significantly greater in the revision group compared with the no-revision group (p = 0.022, 0.006, and 0.002, respectively). There was significantly less improvement in the NRS-LP and ODI in the revision group (p = 0.001 and 0.001, respectively).

**Discussion**

In this study, we used a prospective longitudinal registry (the QOD) to assess reasons for reoperation in patients with degenerative grade 1 spondylolisthesis who underwent a decompression-only operation or a D+F operation.

**TABLE 6. PROs in the decompression-only cohort**

PRO	No Revision, n = 72	Revision, n = 11	p Value
<b>Mean NRS-BP (SD)</b>			
Baseline	5.43 (3.34)	5.00 (3.19)	0.685
5-yr/latest	2.48 (2.73)	3.50 (2.59)	0.277
Change	2.88 (3.43)	1.90 (2.69)	0.325
<b>Mean NRS-LP (SD)</b>			
Baseline	6.00 (2.92)	7.91 (1.64)	<b>0.005</b>
5-yr/latest	2.42 (3.04)	1.50 (2.17)	0.262
Change	3.66 (3.76)	6.20 (2.35)	<b>0.011</b>
<b>Mean ODI (SD)</b>			
Baseline	40.50 (16.85)	47.99 (21.04)	0.282
5-yr/latest	16.33 (16.90)	16.04 (13.95)	0.951
Change	24.17 (18.18)	31.95 (22.06)	0.287

Boldface type indicates statistical significance.

**TABLE 7. PROs in the D+F cohort**

PRO	No Revision, n = 294	Revision, n = 32	p Value
<b>Mean NRS-BP (SD)</b>			
Baseline	6.91 (2.60)	6.91 (2.86)	0.999
5-yr/latest	3.05 (2.99)	4.28 (2.74)	<b>0.022</b>
Change	3.98 (3.37)	3.04 (3.04)	0.171
<b>Mean NRS-LP (SD)</b>			
Baseline	6.70 (2.75)	6.28 (2.92)	0.446
5-yr/latest	2.07 (2.81)	3.94 (3.54)	<b>0.006</b>
Change	4.62 (3.66)	2.34 (2.90)	<b>0.001</b>
<b>Mean ODI (SD)</b>			
Baseline	49.24 (15.10)	50.40 (12.55)	0.628
5-yr/latest	20.17 (17.77)	31.34 (17.67)	<b>0.002</b>
Change	29.07 (16.76)	19.07 (13.51)	<b>0.001</b>

Boldface type indicates statistical significance.

We demonstrated that repeat decompression and instability were the most common reasons for reoperation within 5 years in the decompression-only group and ASD was the most common reason for reoperation within 5 years in the D+F group. Despite the need for revision surgery, surgical treatment for grade 1 spondylolisthesis generated significant improvement in PROs at 5 years' follow-up. We found that patients requiring revision had a modestly diminished PRO improvement at 5 years' follow-up, with the impact of revision being greater in the D+F cohort.

In this study, we found an overall 13.3% (11 of 83) reoperation rate in the decompression-only group. Repeat decompression and instability were the most common reasons for reoperation within 5 years. Brodke and colleagues conducted a retrospective cohort analysis that compared early treatment failures, survivorship, and clinical outcomes of interspinous process spacers, laminectomy only, and laminectomy and fusion.<sup>11</sup> They defined early failure as a return to the operating room for either recurrent stenosis of the index-level or adjacent-segment pathology within 2 years. In the laminectomy-only group, 2 (8.3%) of 24 patients required revision surgery for recurrent symptoms at the index level, similar to the reoperation rate found in the present study. The ability to identify preoperative risk factors that may increase the likelihood of subsequent instability after a decompression-only procedure would be valuable to the treating spine surgeon. Blumenthal and colleagues have previously reported on risk factors for instability after laminectomy for degenerative spondylolisthesis, including motion at the site of listhesis > 1.25 mm, disc height > 6.5 mm, and facet angle > 50°.<sup>12</sup> Consideration of these risk factors while determining a surgical plan may help the treating surgeon choose the best operation for the patient.

We found an overall reoperation rate of 9.8% (32 of 326) in the D+F group; ASD was the most common reason for reoperation within 5 years. The rate of early adjacent-segment pathology in the Brodke study was 13% in the laminectomy and fusion cohort.<sup>11</sup> ASD accounted for all of the early failures seen in this group of patients, which is

similar to other studies found in the literature.<sup>13–15</sup> The reoperation rate found in that study is similar to the reoperation rate observed in the Spinal Laminectomy versus Instrumented Pedicle Screw (SLIP) trial (14%) and the Spine Patient Outcomes Research Trial (SPORT; 11%).<sup>4,16</sup> The increased incidence of ASD after laminectomy and fusion operations can be explained by the increased amount of stress at the adjacent intervertebral disc. This adjacent-segment stress is amplified if the magnitude and shape of lumbar lordosis are not restored.<sup>13,16</sup> Surgeons should aim to restore both the shape and magnitude of lumbar lordosis corresponding to the patient's pelvic incidence. Failure to do so may result in increased odds of failure at the adjacent segment.

There is a gap in the literature regarding PROs in patients with grade 1 spondylolisthesis who have undergone revision surgery. The present study demonstrated that patients with grade 1 spondylolisthesis requiring revision were significantly worse at 5 years in terms of ODI, back pain, and leg pain. For patients who underwent decompression only as an index procedure, the change in 5-year PROs was unchanged by revision status with respect to ODI (31.9 vs 24.2,  $p = 0.287$ ) and back pain (1.9 vs 2.9,  $p = 0.325$ ). However, the change in leg pain in patients who underwent a revision after a decompression-only procedure was significantly greater in the revision group compared to the no-revision group (6.2 vs 3.7,  $p = 0.01$ ). This information suggests that patients who require revision surgery after a decompression-only operation are expected to have similar clinical improvement in overall disability and back pain compared with patients who underwent decompression only without revision. That is, our findings suggest that revision surgery in this subset of patients when clinically warranted is beneficial for patients. In the D+F cohort, the change in 5-year PROs was diminished by revision (ODI 19.1 vs 29.1,  $p = 0.001$ ; NRS-BP 3.0 vs 4.0,  $p = 0.17$ ; NRS-LP 2.3 vs 4.6,  $p = 0.001$ ). This information suggests that less improvement in back pain, leg pain, and overall disability is expected in this subset of patients who undergo a revision following an index fusion operation, although the mean PRO improvement still far exceeded minimal clinically important difference thresholds for all measures. These findings can be used clinically when counseling patients preoperatively and in establishing patient expectations during the preoperative period. Surgeons can use this information to discuss expected clinical outcomes with respect to back pain, leg pain, and disability after a revision operation is performed.

### Limitations of the Study

We recognize this study has several limitations that are similar to those in other studies that have used the QOD.<sup>3</sup> The findings found in this study are reported from patients with only 1-level grade 1 spondylolisthesis and thus may not be generalizable to patients with multiple levels of disease or patients with grade 2+ spondylolisthesis. They also may not be generalizable to patients with other types of spondylolisthesis such as isthmic spondylolisthesis. We only used a subset of the complete QOD registry. The spondylolisthesis subgroup findings used in this study may differ from those of the entire QOD registry. We are

unable to comment on patients who may have had indications for revision but were not revised. A subanalysis of the outcomes based on the indication for revision was not performed because the sample size within each cohort was too small to provide valid conclusions. The type and extent of decompression was also not included in the data collection. Revision rates in the 199 patients lost to follow-up are unknown. Radiographic parameters including angulation and degree of mobility of the spondylolisthesis, degree of stenosis or grade of disc degeneration at the adjacent segment, and regional and global sagittal alignment were not collected. Lastly, because this is a prospective longitudinal registry, no attempt was made to homogenize surgical decision-making, which may leave our findings subject to selection bias.

### Conclusions

This study assessed reasons for reoperation following grade 1 spondylolisthesis surgery within 5 years of the index operation utilizing a prospective longitudinal registry (the QOD). Repeat decompression and instability were the most common reasons for reoperation within 5 years in the decompression-only group. ASD was the most common reason for reoperation within 5 years in the D+F group. At 5 years postoperatively, the need for revision surgery resulted in modestly diminished benefit compared to patients with only an index procedure. These differences were greater in the fusion cohort compared to the decompression-only cohort. Surgeons can use this information to educate patients on the relevant risks associated with their index operation for treatment of grade 1 spondylolisthesis and to help establish patient expectations during the postoperative period.

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## Disclosures

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## Author Contributions

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

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