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CLINICAL ARTICLE

Factors associated with long-term deterioration in back pain after surgical treatment for low-grade lumbar spondylolisthesis at 2 and 5 years: an evaluation from the Quality Outcomes Database spondylolisthesis data

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OBJECTIVE Symptomatic, low-grade spondylolisthesis is usually well treated by surgical intervention. While some patients obtain less than optimal improvement, low-grade spondylolisthesis deteriorates in a few patients. The purpose of this study was to investigate what factors predict deterioration in back pain scores after surgical treatment of low-grade spondylolisthesis.

METHODS The Quality Outcomes Database (QOD) was queried for patients who underwent single-level surgery for management of grade 1 spondylolisthesis, including decompression with fusion and decompression alone. Patient-reported outcomes (PROs) were collected at baseline and then 3 months, 1 year, 2 years, and 5 years postoperatively, including numeric rating scale (NRS) back and leg pain, Oswestry Disability Index (ODI), and EuroQol-5D scores. Patients were categorized based on NRS back pain scores compared to baseline as ≥ 0 (improved or no worse) versus < 0 (worsened). These two groups were compared with respect to factors that predicted postoperative deterioration in NRS back pain scores.

RESULTS Of 608 cases enrolled, 369 met inclusion criteria for the 24-month cohort. Three hundred twenty-four patients had improved or stable back pain scores (of whom 79% underwent fusion), while 45 reported worse back pain at 24 months (of whom 49% underwent fusion). In the 60-month cohort (n = 429), 376 had improved or stable back pain scores (of whom 81% underwent fusion), while 53 reported worse back pain (of whom 49% underwent fusion). On multivariate analysis, lower baseline NRS back pain scores were associated with back pain deterioration at both time points. Less ODI improvement at 3 months postoperatively and persistent leg pain at 12 months postoperatively were also associated with ultimate deterioration in back pain scores.

CONCLUSIONS Most patients (88%) improved after surgery while deterioration was only reported in a few patients (12%). Patients with better back pain scores at baseline were more likely to report deterioration in back pain scores at 2

ABBREVIATIONS ASA = American Society of Anesthesiologists; EBL = estimated blood loss; EQ-5D = EuroQol-5D; LOS = length of stay; MCID = minimal clinically important difference; NRS = numeric rating scale; ODI = Oswestry Disability Index; PRO = patient-reported outcome; QOD = Quality Outcomes Database.

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and 5 years postoperatively. There also appeared to be a trend toward deterioration in those who underwent decompression alone without fusion. These findings highlight the risks of operating on patients with less severe symptoms, as well as the need to improve the understanding of which patients would benefit from fusion. Persistent leg pain and less ODI improvement were also associated with deterioration in back pain scores.

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KEYWORDS lumbar spondylolisthesis; back pain; deterioration; patient-reported outcomes; lumbar surgery; degenerative

Degenerative spondylolisthesis is a common cause of pain and disability, particularly in elderly adults.[1] It is believed to result from the gradual degeneration of intervertebral discs, which compromises stability and leads to further degenerative changes including osteophyte formation, ligament hypertrophy, and facet arthrosis.[1–3] Patients often experience low back pain and reduced mobility, as well as radiculopathy and neurogenic claudication caused by nerve root compression and spinal stenosis, respectively.[1,3] The prevalence of degenerative spondylolisthesis increases with age, predominantly affecting adults over the age of 50 years, and is more commonly observed in women.[1,4,5]

For patients with low-grade spondylolisthesis without neurological deficits, conservative management is generally considered the first line of therapy.[6,7] In patients whose symptoms are unrelieved by conservative methods, or in those with radicular pain and/or neurogenic claudication, surgical management has been shown to provide beneficial outcomes with durable symptomatic improvement.[7–10] Currently, decompression with fusion is the most commonly used procedure in the surgical management of degenerative spondylolisthesis.[7] However, decompression alone has also been shown to produce positive outcomes, leading to controversy regarding the use of decompression with fusion versus decompression alone.[7,11–14] Regardless of the procedure, the majority of patients who undergo surgery for symptomatic, low-grade spondylolisthesis show improvement in pain and disability and few demonstrate postoperative deterioration in symptoms.

Given the high prevalence of degenerative spine conditions and volume of surgeries performed, much attention has been given to identifying patient-specific factors that are predictive of postoperative outcomes. Numerous studies have evaluated predictors of outcomes and recovery kinetics following surgery for degenerative lumbar conditions, using various patient-reported metrics as primary endpoints.[15–19] However, to our knowledge, no study has assessed the factors associated specifically with postoperative deterioration of back pain following surgical treatment of patients with a primary diagnosis of low-grade spondylolisthesis. Therefore, the factors predicting which patients with degenerative spondylolisthesis will demonstrate deterioration in back pain after surgery are not yet completely understood. The purpose of this study was to investigate the predictive factors of deterioration in back pain scores after surgical treatment of low-grade spondylolisthesis. Elucidating these factors will allow for more informed preoperative patient discussions and decision-making and may also help surgeons optimize their selection of surgical candidates.

Methods

Study Population and Criteria

The data for this study were obtained from the Quality Outcomes Database (QOD). The QOD is a multicenter, prospective, quality assurance registry, the methodology of which has been well described in prior publications.[20,21] The dataset used in the current study is from 12 high-enrollment sites using the QOD lumbar module data augmented with additional data points, audited by a central team. Inclusion criteria of this augmented dataset (SpineCore) described previously[22] were adult patients ≥ 18 years old, with 1) a surgical indication of grade 1 spondylolisthesis, confirmed at each site by preoperative imaging using the Meyerding classification, 2) who underwent elective, single-segment surgery between July 2014 and June 2016. Patients with grade 2 or higher spondylolisthesis, infection, tumor, trauma, deformity, or neurological paralysis due to preexisting spine disease or injury were excluded. Patients who underwent a revision during the follow-up period were also excluded.

Patient-Reported Outcomes

For this study, we identified two cohorts of patients: those who had baseline and 24-month patient-reported outcome (PRO) data, and those who had baseline and 60-month PRO data. For patients in each cohort, PROs were collected at baseline and 3 months, 1 year, 2 years, and 5 years postoperatively. PROs collected included numeric rating scale (NRS) for back and leg pain,[23] Oswestry Disability Index (ODI),[24] and EuroQOL-5D (EQ-5D)[25] scores. In both cohorts, patients were grouped based on NRS back pain scores compared to baseline as those whose back pain scores improved or did not worsen (back pain change ≥ 0) versus those whose back pain scores worsened (back pain < 0). Primary comparisons were made for patient demographics, operative characteristics, and pre- and postoperative PROs between these two groups.

Statistical Analysis

All statistical analysis was performed using SPSS software (version 28.0, IBM SPSS Statistics). Paired t-tests were used to compare preoperative and 2- and 5-year postoperative NRS back pain, NRS leg pain, and ODI scores, as well as changes with treatment. Unpaired t-tests were used to compare PROs at each time point between the two cohorts. Categorical variables and proportions were compared using Fisher's exact test or chi-square test. Binary logistic regression analysis was performed to identify vari-

ables associated with back pain worsening. Variables included in the model for associations with back pain worsening at 24 months were age, BMI, sex, type of insurance, smoking status, symptom duration, American Society of Anesthesiologists (ASA) class, arthrodesis performed, estimated blood loss (EBL), operative time, length of stay (LOS), and baseline, 3-month, and 12-month PROs. The same variables were included in the model for associations with back pain worsening at 60 months with the addition of 24-month PROs. Statistical significance was set at $p < 0.05$.

Results

Demographic and Surgical Parameters

Of 608 cases enrolled, back pain data were not available in 62 patients at baseline, 158 at 24 months, and 90 at 60 months postoperatively. Of 388 patients in the 24-month follow-up cohort, 19 underwent a revision during the follow-up period and were excluded. Of these 369 patients, 324 (87.8%) exhibited either improvement or no worsening (change ≥ 0, mean improvement 4.36 [SD 2.72]) in back pain scores between baseline and 24-month postoperative follow-up, while 45 (12.2%) exhibited deterioration in back pain scores (change < 0, mean deterioration 2.22 [SD 1.62]; Table 1). These two groups were similar in terms of BMI (mean 30.19 vs 28.74 kg/m^2, $p = 0.104$), sex distribution (58% vs 51% males, $p = 0.423$), smoking status (11% vs 7%, $p = 0.521$), and symptom duration (97% vs 96% > 3 months, $p = 0.221$). The groups significantly differed in age, with the improvement group being younger (mean 62.56 vs 69.75 years, $p < 0.001$).

The surgical parameters were similar between groups in terms of ASA class, EBL (mean 169.52 vs 148.81 ml, $p = 0.503$) and operative time (mean 182.49 minutes vs 169.77 minutes, $p = 0.433$; Table 1). The back pain improvement group had a greater proportion of patients who underwent arthrodesis (79% vs 49%, $p < 0.001$) and a greater average LOS (mean 2.77 vs 1.84 days, $p = 0.001$) compared to the back pain deterioration group.

TABLE 1. Demographic and surgical parameters in the 24-month cohort

Variable	24-Mo Back Pain Change ≥0	24-Mo Back Pain Change <0	p Value
Total	324	45	
Mean age (SD), yrs	62.56 (11.36)	69.75 (10.26)	<0.001
Mean BMI (SD), kg/m^2	30.19 (6.02)	28.74 (5.46)	0.104
Males, n (%)	188 (58)	23 (51)	0.423
Insurance, n (%)			0.052
Medicare	126 (39)	27 (6)	
Medicaid	12 (4)	1 (2)	
Veterans Affairs	7 (2)	0 (0)	
Private	179 (55)	17 (38)	
Smoker, n (%)	35 (11)	3 (7)	0.521
Symptom duration, n (%)			0.221
<3 mos	9 (3)	2 (4)	
>3 mos	315 (97)	43 (96)	
ASA class, n (%)			0.098
I	16 (5)	1 (2)	
II	191 (59)	34 (76)	
III	117 (36)	10 (22)	
Arthrodesis performed, n (%)			<0.001
No	68 (21)	23 (51)	
Yes	256 (79)	22 (49)	
Interbody fusion	248 (97)	19 (86)	0.047
Mean EBL (SD), ml	169.52 (178.55)	148.81 (187.8)	0.503
Mean op time (SD), mins	182.49 (86.5)	169.77 (90.44)	0.433
Mean LOS (SD), days	2.77 (1.75)	1.84 (1.73)	0.001

Outcomes at 24 Months

Patients in the back pain deterioration group reported significantly better mean NRS back pain scores (3.67 vs 6.87, $p < 0.001$), ODI scores (38.06 vs 44.61, $p = 0.030$), and EQ-5D scores (0.63 vs 0.55, $p = 0.014$) at baseline (Table 2). At 24 months, the deterioration group had significantly worse mean NRS back pain (5.89 vs 2.50, $p < 0.001$), leg pain (3.91 vs 1.89, $p < 0.001$), ODI (27.44 vs 19.17, $p = 0.002$), and EQ-5D scores (0.72 vs 0.79, $p = 0.004$) at 24 months. Patients in the deterioration group only had moderate gains in mean NRS leg pain (1.76 vs 4.61, $p < 0.001$), ODI (10.62 vs 25.64, $p < 0.001$) and EQ-5D scores (0.08 vs 0.24, $p < 0.001$).

On binary logistic regression analysis, factors showing a significant association with postoperative deterioration in back pain scores at 24 months postoperatively included better baseline NRS back pain (OR 0.62, $p < 0.001$), worse 12-month leg pain (OR 1.69, $p = 0.002$), and worse 3-month ODI scores (OR 1.04, $p = 0.005$; Table 3). Age, BMI, sex, type of insurance, smoking status, symptom duration, ASA class, arthrodesis performed, EBL, operative time, LOS, back pain scores at 3 and 12 months, leg pain scores at baseline and 3 months, ODI scores at baseline and 12 months, and EQ-5D scores were not associated with deterioration of back pain scores at 24 months.

Outcomes at 60 Months

Four hundred fifty-six patients had 60-month follow-up data and 27 underwent revision surgery within the follow-up period, leaving 429 included in the analysis. Of these 429 patients, 376 (87.6%) exhibited either improvement or no worsening (change ≥ 0, mean improvement 4.18 [SD 2.78]) in back pain scores between baseline and 60-month postoperative follow-up. Fifty-three patients (12.4%) showed deterioration in back pain scores (change < 0, mean deterioration 2.23 [SD 1.59]; Table 4). These two groups were similar in terms of age (mean 62.23 vs 66.67 years, $p = 0.021$), BMI (mean 29.97 vs 29.30 kg/m^2, $p = 0.433$), sex distribution (59% vs 51% males, $p = 0.298$), insurance status ($p = 0.245$), smoking status (11% vs 8%, $p = 0.694$), and symptom duration (98% vs 96% > 3 months, $p = 0.238$).

The surgical parameters were similar between groups in terms of ASA class, EBL (mean 172.49 vs 159.10 ml, p

TABLE 2. Baseline and postoperative PRO scores in the 24-month cohort

PRO	24-Mo Back Pain Change ≥0	24-Mo Back Pain Change <0	p Value*
Mean NRS back pain score (SD)			
Baseline	6.87 (2.54)	3.67 (2.65)	<0.001
3 mos	2.80 (2.62)	3.05 (2.33)	0.535
12 mos	2.50 (2.65)	2.9 (2.32)	0.326
24 mos	2.50 (2.62)	5.89 (2.48)	<0.001
p value†	<0.001	<0.001	
Mean NRS leg pain score (SD)			
Baseline	6.47 (2.89)	5.67 (2.84)	0.081
3 mos	1.92 (2.72)	2.07 (2.39)	0.708
12 mos	1.76 (2.64)	2.73 (3.08)	0.066
24 mos	1.89 (2.74)	3.91 (3.40)	<0.001
p value†	<0.001	<0.001	
Mean ODI score (SD)			
Baseline	44.61 (16.30)	38.06 (18.78)	0.030
3 mos	22.89 (17.46)	22.09 (14.87)	0.750
12 mos	17.36 (17.64)	21.79 (16.95)	0.132
24 mos	19.17 (18.36)	27.44 (15.90)	0.002
p value†	<0.001	<0.001	
Mean EQ-5D score (SD)			
Baseline	0.55 (0.22)	0.63 (0.20)	0.014
3 mos	0.79 (0.17)	0.78 (0.15)	0.950
12 mos	0.82 (0.17)	0.77 (0.16)	0.067
24 mos	0.79 (0.19)	0.72 (0.15)	0.004
p value†	<0.001	<0.001	
24-mo change			
NRS back pain	4.36 (2.72)	−2.22 (1.62)	<0.001
NRS leg pain	4.61 (3.50)	1.76 (3.89)	<0.001
ODI	25.64 (19.58)	10.62 (16.89)	<0.001
EQ-5D	0.24 (0.25)	0.08 (0.16)	<0.001

The NRS back and leg pain scores ranged from 0 to 10.
* Independent unpaired t-tests comparing the two cohorts.
† Dependent paired t-tests comparing baseline and 2-year postoperative score.

= 0.624), and operative time (180.70 vs 153.16 minutes, p = 0.047; Table 4). The back pain improvement group had a greater proportion of patients who underwent arthrodesis (81% vs 49%, p < 0.001) and a greater average LOS (2.78 vs 2.02 days, p = 0.007) compared to the back pain deterioration group.

TABLE 3. Binary logistic regression in the 24-month cohort

Variable	p Value	OR (95% CI)
Baseline NRS back pain score	<0.001	0.62 (0.48–0.8)
12-mo NRS leg pain score	0.002	1.69 (1.09–2.36)
3-mo ODI score	0.005	1.04 (0.94–1.22)

TABLE 4. Demographic and surgical parameters in the 60-month cohort

Variable	60-Mo Back Pain Change ≥0	60-Mo Back Pain Change <0	p Value
Total	376	53	
Mean age (SD), yrs	62.23 (11.41)	66.67 (12.92)	0.021
Mean BMI (SD), kg/m^2	29.97 (6.24)	29.30 (5.65)	0.433
Males, n (%)	223 (59)	27 (51)	0.298
Insurance, n (%)			0.245
Medicare	145 (39)	28 (53)	
Medicaid	18 (5)	1 (2)	
Veterans Affairs	9 (2)	0 (0)	
Private	204 (54)	24 (45)	
Smoker, n (%)	40 (11)	4 (8)	0.694
Symptom duration, n (%)			0.238
<3 mos	9 (2)	2 (4)	
>3 mos	367 (98)	51 (96)	
ASA class, n (%)			0.103
I	18 (5)	1 (2)	
II	222 (59)	39 (74)	
III	136 (36)	13 (25)	
Arthrodesis performed, n (%)			<0.001
No	71 (19)	27 (51)	
Yes	305 (81)	26 (49)	
Interbody fusion	292 (96)	22 (85)	0.035
Mean EBL (SD), ml	172.49 (171.53)	159.1 (181.14)	0.624
Mean op time (SD), mins	180.7 (84.73)	153.16 (83.68)	0.047
Mean LOS (SD), days	2.78 (1.71)	2.02 (1.87)	0.007

In the 60-month follow-up cohort, patients in the back pain deterioration group reported significantly better mean NRS back pain scores at baseline (4.02 vs 6.88, p < 0.001), but similar mean NRS leg pain (5.75 vs 6.48, p = 0.080), ODI (39.33 vs 45.61, p = 0.023), and EQ-5D scores (0.62 vs 0.54, p = 0.022; Table 5). However, the deterioration group had significantly worse mean NRS back pain scores at 24 (5.86 vs 2.52, p < 0.001) and 60 months 6.25 vs 2.69, p < 0.001), worse mean NRS leg pain scores at 24 (4.02 vs 1.88, p < 0.001) and 60 months (4.21 vs 2.12, p < 0.001), worse mean ODI scores at 24 (27.73 vs 19.16, p = 0.001) and 60 months (28.04 vs 19.51, p < 0.001), and worse mean EQ-5D scores at 24 (0.72 vs 0.79, p = 0.004) and 60 months (0.70 vs 0.79, p < 0.001)

On binary logistic regression analysis, better baseline NRS back pain scores (OR 0.11, p = 0.003; Table 6) showed a significant association with postoperative deterioration in back pain scores at 60 months postoperatively. Age, BMI, sex, type of insurance, smoking status, symptom duration, ASA class, arthrodesis performed, EBL, operative time, LOS, follow-up NRS back pain scores, follow-up NRS leg pain scores, ODI scores, and EQ-5D scores were not associated with deterioration in back pain scores at 60 months postoperatively.

TABLE 5. Baseline and postoperative PRO scores in the 60-month cohort

PRO	60-Mo Back Pain Change ≥0	60-Mo Back Pain Change <0	p Value*
Mean NRS back pain score (SD)			
Baseline	6.88 (2.55)	4.02 (2.85)	<0.001
3 mos	2.88 (2.61)	3.08 (2.42)	0.59
12 mos	2.63 (2.66)	2.87 (2.35)	0.524
24 mos	2.52 (2.63)	5.86 (2.46)	<0.001
60 mos	2.69 (2.72)	6.25 (2.65)	<0.001
p value†	<0.001	<0.001	
Mean NRS leg pain score (SD)			
Baseline	6.48 (2.89)	5.75 (2.77)	0.080
3 mos	2.08 (2.84)	2.28 (2.41)	0.590
12 mos	1.96 (2.84)	2.59 (2.71)	0.154
24 mos	1.88 (2.74)	4.02 (3.32)	<0.001
60 mos	2.12 (2.88)	4.21 (3.55)	<0.001
p value†	<0.001	<0.001	
Mean ODI score (SD)			
Baseline	45.61 (16.77)	39.33 (18.58)	0.023
3 mos	24.15 (18.48)	24.82 (15.04)	0.777
12 mos	18.83 (18.62)	21.84 (15.92)	0.249
24 mos	19.16 (18.38)	27.73 (15.46)	0.001
60 mos	19.51 (18.8)	28.04 (15.77)	<0.001
p value†	<0.001	<0.001	
Mean EQ-5D score (SD)			
Baseline	0.54 (0.22)	0.62 (0.21)	0.022
3 mos	0.78 (0.18)	0.78 (0.15)	0.995
12 mos	0.81 (0.18)	0.77 (0.16)	0.164
24 mos	0.79 (0.19)	0.72 (0.15)	0.004
60 mos	0.79 (0.2)	0.70 (0.16)	<0.001
p value†	<0.001	<0.001	
60-mo change			
Back pain	4.18 (2.78)	−2.23 (1.59)	<0.001
Leg pain	4.39 (3.57)	1.55 (4.07)	<0.001
ODI	26.03 (19.81)	11.29 (16.63)	<0.001
EQ-5D	0.24 (0.24)	0.08 (0.16)	<0.001

The NRS back and leg pain scores ranged from 0 to 10.
* Independent unpaired t-tests comparing the two cohorts.
† Dependent paired t-tests comparing baseline and 5-year postoperative score.

Cross-Tabulation Subanalysis

A subanalysis was conducted to identify patients who were included in both the 24- and 60-month cohorts. We found 369 patients included in both cohorts (Table 7). Of these patients, 45 showed back pain deterioration at 24 months compared to baseline, 42 of whom showed persistence of back pain deterioration at 60 months, while 3 demonstrated improvement or stability of back pain at 60 months compared to baseline. Three hundred twenty-four patients showed improvement or stability of back pain at 24 months compared to baseline, 322 of whom showed continued improvement or stability of back pain at 60 months, while 2 ultimately demonstrated deterioration of back pain at 60 months compared to baseline.

TABLE 6. Binary logistic regression in the 60-month cohort

Variable	p Value	OR (95% CI)
Baseline NRS back pain score	0.003	0.11 (0.03–0.48)
12-mo NRS leg pain score	0.020	1.32 (0.55–1.61)
3-mo ODI score	0.052	1.10 (0.96–1.27)

Discussion

In this study, we found that while most patients who underwent single-level surgery for low-grade, degenerative lumbar spondylolisthesis showed durable improvement or stability in back pain postoperatively, there was a significant portion of patients who showed deterioration in back pain at long-term postoperative time points. Overall, in the 24-month follow-up cohort, 87.8% exhibited either improvement or stability in back pain, while 12.2% exhibited deterioration in back pain. Similarly, in the 60-month follow-up cohort, 87.6% exhibited either improvement or stability in back pain, while 12.4% exhibited deterioration in back pain. Additionally, of the subset of patients included in both cohorts (n = 369), the vast majority demonstrated consistent results at both postoperative time points, i.e., those patients who showed improvement or stability of back pain scores at 24 months maintained this improvement or stability at 60 months (n = 322), and those who demonstrated deterioration of back pain scores at 24 months (n = 45) had persistence of back pain deterioration at 60 months (n = 43). It should be noted that even in patients who showed a deterioration in back pain scores, with the average score at the 24- and 60-month time point being worse than at baseline, none of the other outcome measures at the 24- and 60-month follow-up were worse than their baseline scores. Using multivariate statistical methods, we found independent factors associated with frank deterioration in back pain included better preoperative NRS back pain scores, worse NRS leg pain scores at 12 months, and greater disability (higher ODI scores) at 3 months (although this was only significant in the 24-month follow-up cohort). Of these predictors, the strongest and most clinically relevant pre-

TABLE 7. Cross-tabulation of 24- and 60-month cohorts

Variable	60-Mo Back Pain Change ≥0, n	60-Mo Back Pain Change <0, n	Total
24-mo back pain change ≥0	322	2	324
24-mo back pain change <0	3	42	45
Total	325	44	369

dictor of back pain deterioration was better preoperative back pain scores.

While the demographic and surgical parameters of the patients in the two cohorts were largely similar, there are differences worth noting. In both the 24- and 60-month cohorts, the back pain improvement group was significantly younger compared to the deterioration group (mean 62.56 vs 69.75 years, $p < 0.001$, in the 24-month cohort). This difference may be attributable to age-related changes or the decreased ability of the elderly to recover after disease or surgery. While this difference does not represent completely unique populations, it is probably sufficient that surgeons would regard this as a clinically relevant difference. The issue of age is obviously confounded by frailty, such that numeric age alone is unlikely to be the only age-related factor in surgical decision-making or counseling. Additionally, the improvement group had a greater average LOS compared to the deterioration group in both cohorts, as well as longer operative time in the 60-month cohort. Each of these findings can be attributed to the greater proportion of patients who underwent fusion in the improvement group relative to the deterioration group in both the 24- (79% vs 49%, $p < 0.001$) and 60-month cohorts (81% vs 49%, $p < 0.001$), as it was previously shown that fusion surgeries are associated with longer operating times and length of hospitalization compared to decompression alone.[13]

Although the presence or absence of fusion was not identified as an independent factor associated with back pain deterioration on multivariate analysis, the results of our study appear to suggest that patients treated for spondylolisthesis via decompression alone without fusion may be at a greater risk of deterioration of back pain scores postoperatively. The higher rate of fusion surgeries seen in the improvement group is potentially attributable to their significantly higher baseline PROs, particularly back pain. Previous studies investigating outcomes of decompression alone for patients with degenerative lumbar spinal stenosis have shown higher baseline back pain to be an independent risk factor for failure, often necessitating a subsequent fusion procedure.[15,16] These findings may explain why surgeons treating the patients in our study's improvement group (higher baseline back pain) opted to primarily use fusion in the majority of cases, as well as why those in the deterioration group (lower baseline back pain) did not undergo primary fusion. Additionally, the older age of the patients in the deterioration group may have also played a contributing role in the decision to use decompression alone rather than with fusion.

Our finding that patients who report milder symptoms at baseline are more likely to experience postoperative deterioration is consistent with trends seen in prior studies on degenerative lumbar conditions. In an analysis of prospectively collected registry data, Nerland et al. evaluated 1735 patients who underwent decompressive surgery for 1- and 2-level lumbar spinal stenosis.[18] They found that 9% of patients who underwent decompressive surgery for lumbar stenosis experienced a significant deterioration in ODI scores at 1 year. On multivariate regression analysis, they demonstrated that a lower baseline ODI score was strongly associated with this deterioration. A similar finding was shown by Solberg et al. in a study of patients undergoing lumbar microdiscectomy.[26] These results are somewhat intuitive, as patients with less severe symptoms at baseline inherently have a greater potential (or more room) for postoperative decline. The inverse of this statement can also be true, as patients with worse symptoms at baseline tend to have a greater propensity for symptom relief.

These findings also somewhat parallel those observed in a recent study on recovery kinetics. In a study on patients undergoing decompression alone and decompression with fusion for low-grade spondylolisthesis, Djurasovic et al. found that better preoperative back and leg pain scores were independent risk factors for delayed clinical course in terms of the time it takes for patients to reach the threshold for a minimal clinically important difference (MCID) in ODI improvement,[17] i.e., it took longer for patients with lower preoperative back and leg pain to demonstrate substantial improvement after surgery, while those with higher levels of preoperative pain exhibited more rapid improvement. While the majority of patients ultimately reached the MCID at 1 year postoperatively, and deterioration of symptoms was not addressed, the directionality of the impact of preoperative back pain was similar to what we observed.

Finally, the incidence of postoperative deterioration in back pain following operative treatment of lumbar spondylolisthesis has been previously reported. In a report by Strömqvist et al. on Swespine, the Swedish National Spine Register, investigators described a 7% incidence of postoperative deterioration in visual analog scale back pain scores at 1 year postoperatively following surgery for symptomatic lumbar spondylolisthesis in 247 patients.[27] While our study showed deterioration of back pain in approximately 12% of patients, our use of longer postoperative time points potentially accounts for this discrepancy, as there was more time for declining patients to develop worsening symptoms. Our studies were also derived from different patient populations, further contributing to the variance of the results.

Limitations of the Study

There are several limitations that should be considered when interpreting the results of this study. Despite the use of a prospectively collected data registry, the retrospective analysis of these data potentially introduces bias to our analysis. There was a significant amount of missing data, including 62 patients without baseline data (10% of the cohort), 158 without 2-year data (26% of the cohort), and 90 patients without 5-year data (15% of the cohort), which can introduce bias. Additionally, among the various contributing registry sites, there was no standardization of surgical indications, operative techniques, or postoperative rehabilitation protocols, therefore these factors varied across sites. Imaging studies to evaluate spinal alignment and possible causes of continued back pain, such as nonunion, were not available. Furthermore, as mentioned previously, we did not isolate patients based on undergoing decompression with fusion or decompression alone. Separate subgroup analyses investigating these specific procedures alone may produce varying results. Large database studies are not well suited to answering granular questions regarding why an observation such as this occurs. It is likely that

all the suggested mechanisms, pseudarthrosis, adjacent segment disease, and other age-related changes all contribute to deterioration over a 5-year period. Sorting this out further would be a worthwhile undertaking in a more granular dataset. Despite this limitation, the observation that patients starting with less severe symptoms are more likely to end up with the unusual but important scenario of worsened back pain at 5 years postoperatively is still relevant to patient counseling. Finally, there are likely other unknown confounding variables that were not included in the multivariate analysis that may also impact postoperative back pain.

Conclusions

Our study showed that the majority of patients who undergo surgery for low-grade spondylolisthesis experience long-term, durable improvement or stability in back pain scores, with only a small subset of patients experiencing deterioration in back pain. Specifically, patients with relatively lower baseline back pain were more likely to experience postoperative deterioration in back pain at 2 and 5 years postoperatively, and patients who did not undergo fusion appeared to be at a greater risk for this deterioration. These findings highlight not only the risk of operating on patients with less severe symptoms, but also the need to improve our understanding of which patients would benefit from fusion, as our present diagnostic strategies are not perfect in that regard. In addition, patients with persistent leg pain and higher postoperative ODI scores were also at an increased risk for long-term deterioration of back pain. Together, these findings can help surgeons counsel patients regarding their treatment options and expectations following surgery and may also help surgeons choose appropriate surgical candidates more effectively.

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