



Back Dominant Pain Has Equal Outcomes to Radicular Dominant Pain Following Posterior Lumbar Fusion in Adult Isthmic Spondylolisthesis: A CSORN Study

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Abstract

Study Design: Retrospective Cohort Study.

Objectives: This study aimed to determine how the surgeon-determined and patient-rated location of predominant pain influences patient-rated outcomes at 1-year after posterior lumbar fusion in adult isthmic spondylolisthesis.

Methods: We retrospectively reviewed consecutive patients prospectively enrolled in the Canadian Spine Outcomes and Research Network national registry between 2009 and 2017 that underwent posterior lumbar fusion for isthmic spondylolisthesis. Using longitudinal mixed-model repeated-measures analysis the change from baseline in patient-reported outcome measures (PROMs) at 1 year after surgery was compared between surgeon-determined groups (back vs. radicular) and between patient-rated pain groups (back, leg, and equal) derived from preoperative pain scores on the numerical rating scale (NRS).

Results: 83/252 (33%) patients had a surgeon-determined chief complaint of back pain, while 103 (41%) patients rated their back pain as the predominant pain location, and 78 (31%) rated their back and leg pain to be equal. At baseline patients in the surgeon-determined radicular group had worse NRS-leg pain than those in the back-pain group but equal NRS-back pain. At baseline patients in the patient-rated equal pain group had similar back pain compared to the patient-rated back pain group and similar leg pain compared to the patient-rated leg pain group. All PROMs improved post-operatively and were not different between the 2 groups at 1 year.

Conclusions: Our study found no difference in outcome, irrespective of whether a surgeon determines the patient's primary pain complaint back or radicular dominant, or the patient rates pain in one location greater than another.

Keywords

lumbar radicular pain, low back pain, isthmic spondylolisthesis, numerical rating scales, CSORN, posterior fusion

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Introduction

Isthmic spondylolisthesis is a common source of pain and disability and is believed to affect 8% of the general population being 2 times more common in males.¹ Symptoms vary from complaints of lower back pain, to complaints of radiating pain to the legs/buttock region or a combination of both.¹ Back or buttock pain is by far the most frequent finding, occurring in approximately 80% of the patients.² Many cases of isthmic spondylolisthesis respond well to non-operative treatment but for those patients that fail conservative management with persistent significant pain or neurological deficit, surgical decompression and stabilization offers beneficial outcomes.^{3,4}

For lumbar disc herniation, spinal stenosis and degenerative spondylolisthesis, preoperative predominant leg pain over back pain is associated with superior postoperative outcomes in decompressive surgery.⁵⁻⁸ Therefore, surgeons generally prefer to recommend surgical management when the predominant complaint is leg pain.⁹ In patients with isthmic spondylolisthesis, the inherent instability and secondary slip may be a cause of low back pain that is more amenable to surgical treatment. Whether surgical outcome varies according to the preoperative predominant pain location (back or leg) in patients who undergo lumbar fusion for isthmic spondylolisthesis has not been investigated. Understanding this relationship could assist in establishing reasonable expectations of treatment, and improve evidence-based surgical decision making.

Previous studies have relied on patient-rated methods of scoring back pain and leg pain intensity to identify the location of predominant pain; however, the patient's ability to assess their pain dominance using self-rating methods can be unreliable.¹⁰ Therefore, the aim of this study was to examine how the surgeon-determined chief complaint as well as the patient-rated predominant pain location, influence patient-rated outcomes at 1 year after posterior lumbar fusion for isthmic spondylolisthesis.

Materials and Methods

Study Design

This was a retrospective review of prospectively collected data from consecutive patients enrolled in the Canadian Spine Outcomes and Research Network (CSORN) national registry. CSORN is comprised of Neurosurgical and Orthopaedic spine surgeons across Canada and was created to answer research questions and facilitate the implementation of best practices. Details on the CSORN registry data set and data collection have been described elsewhere.¹¹

Study Population

The registry was queried (years 2009-2017) for consecutive patients 18 years and older who underwent posterior interbody fusion or posterolateral lumbar fusion for isthmic spondylolisthesis. Patients were excluded who did not have a surgeon-determined chief complaint of back pain or radicular pain; a

completed pre-operative patient rated back and leg pain score; had not attained a minimum of 1 year of follow-up; had associated deformities (i.e. scoliosis); no data at any follow-up time point; had undergone anterior fusions or previous lumbar surgery.

Demographic and Patient-Rated Outcome Measures

Patient-reported outcome measures (PROMs) were collected at baseline, and at 3 and 12 months post-operatively via a questionnaire. PROMs included the numeric rating scale for back pain (NRS-B) and leg pain (NRS-L; ranging from 0 to 10 with higher scores indicating worse pain), the Oswestry Disability Index (ODI; ranging from 0 to 100 with higher scores indicating more severe disability), and the Short Form 12 Health Survey physical component summary score (SF-12 PCS) and mental component summary scores (SF-12 MCS), with higher scores indicating a better quality of life. Post-operative satisfaction was assessed using a 5-point scale: extremely dissatisfied, somewhat dissatisfied, neither satisfied nor dissatisfied, somewhat satisfied, and extremely satisfied.

Surgeon-Determined Chief Complaint

On initial clinical assessment from the surgeon indicated the "chief complaint for which surgical intervention is required" by selecting one of the following options: back pain, neck pain, radiculopathy, myelopathy, neurogenic claudication, deformity, or other. The surgeon determined the patient's chief complaint to be back dominant if the pain was localized into the central lumbosacral region with potential referral into the buttocks but not into the leg. Radicular pain was defined as following primarily a lower leg dermatomal distribution. Although radicular pain may include both back/buttock and leg pain, the patient has predominant radicular pain as their chief complaint if the pain followed a dermatomal distribution down the leg. If both back pain and radicular pain was present the surgeon had to choose the predominant symptom for which the patient required surgery.

Patient-Rated Predominant Pain Location

The patient-rated predominant pain location was calculated by subtracting the preoperative NRS-B score from the preoperative NRS-L. The patient-rated back pain group had at least 2 points more back pain than leg pain on the NRS, and a patient-rated leg predominant group had at least 2 points more leg pain than back pain on the NRS.¹² Patients that had a back and leg pain score within 2 points were designated into a third group of equal leg and back pain.

Statistical Analysis

Data analysis was performed using PASW Statistics version 24 (SPSS Inc., Chicago, IL, USA). Patients were subdivided

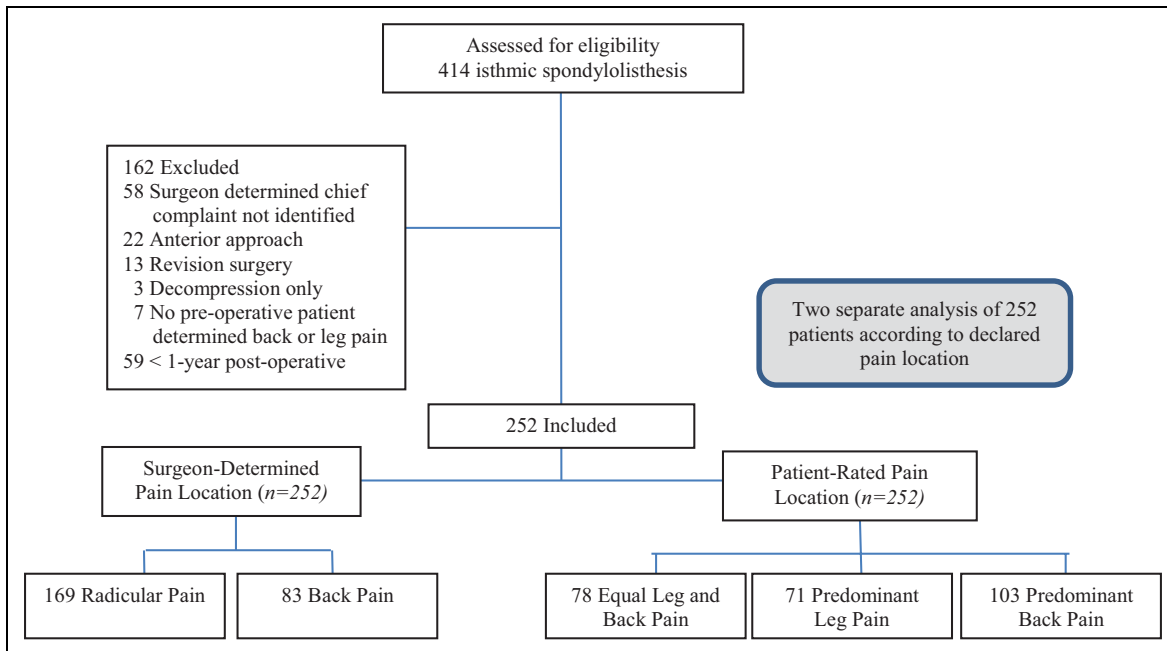


Figure 1. Patient inclusion flow diagram.

into back pain or radicular pain groups. To compare baseline characteristics and surgical parameters the Student's t test or 1-way ANOVA was used for continuous parametric variables or the Mann-Whitney U test or Kruskal Wallis test was used for continuous nonparametric variables. Comparisons for categorical variables including satisfaction with treatment were made using the Chi-square test or the Fisher's exact test.

For analysis of PROMs the change from baseline to the 3 month and 1-year follow-up times were used. The main effects of time and group and time x group interactions were assessed using a mixed-effects model of longitudinal regression that included a random individual effect to account for the correlation between repeated measures. Group and time (3 months and 1 year) were included as fixed variables and subject was included as a random variable. Confounding baseline variables and variables associated with missing data at the 1-year time point were included if they were $P < 0.05$ or were considered clinically relevant. Pairwise comparisons were performed at the 1-year time point. Group in the aforementioned model was either the surgeon-determined (back pain vs. radicular pain) or patient-rated pain (leg pain vs. back pain vs. equal back and leg pain). To adjust for the possible effect of missing data a comparative analysis was performed using the same mixed-model repeated measures analysis with a multiple imputation procedure with 10 iterations assuming the data was missing at random.

Surgeon-determined chief complaint was compared to patient-rated predominant pain location using a dot plot, and a subgroup analysis was conducted whereby patients who rated their back and leg pain as equal at baseline were stratified by

surgeon-determined predominant pain location. The analysis used the same mixed-models approach as described above. Statistical significance was defined as $P < 0.05$.

Results

Study Population

414 patients met the inclusion criteria of which 162 were excluded based on the exclusion criteria and 252 patients were included in the final analysis (Figure 1). 83 (33%) had a surgeon-determined chief complaint of back pain, while 103 (41%) had back pain as the patient-rated predominant pain location (Table 1). 78 (31%) rated their back and leg pain to be equal. The follow-up rate was 79% at the 3-month visit and 73% at the 12-month visit. Patients with missed visits at the 12-month follow-up visit were not different from the cohort with complete data.

Patient Demographics and Baseline PROMs

Patient baseline demographic variables and PROMs are presented in Table 1. On average, the overall cohort was 49 ± 12 years of age and tended to be overweight with a body mass index of 28 ± 6 Kg/m². 135 were female (54%) and 111 patients (44%) were employed. 224 patients (89%) had Grade I or II spondylolisthesis at L5-S1. Comparison of patients who had a surgeon-determined chief complaint of back pain to radicular pain revealed no between-group differences in any of the baseline demographic variables ($P < 0.05$ for all comparisons). Three-way comparison for the patient-rated predominant pain

Table 1. Patient Baseline Demographic Characteristics.

Parameter	Surgeon-determined			Patient-rated			
	Radicular pain (n = 169)	Back pain (n = 83)	P Value	Leg (n = 71)	Back (n = 103)	Equal (n = 78)	P Value
Age, mean ± SD, years	49.6 ± 11.8	48.0 ± 13.6	0.331	51.6 ± 11.2	47.2 ± 12.6	49.3 ± 13.0	0.071
Female, n (%)	89 (52.7)	46 (55.4)	0.689	32 (45.1)	64 (62.1)	39 (50.0)	0.064
Body mass index, mean ± SD, kg/m ²	28.6 ± 6.9	27.3 ± 5.5	0.110	28.4 ± 5.3	27.7 ± 6.2	28.8 ± 5.8	0.409
Employed, n/total n (%)	79/166 (47.6)	32/83 (38.6)	0.223	43/71 (60.6)	39/101 (38.6)	29/77 (37.7)	0.006
Current smoker, n/total n (%)	56/168 (33.3)	30/83 (36.1)	0.674	20/71 (28.2)	38/103 (36.9)	28/77 (36.4)	0.441
Condition over 1 year, n/total n (%)	141/145 (97.2)	62/62 (100)	0.319	53/54 (98.1)	88/88 (100)	62/65 (95.4)	0.122
Does not exercise, n/total n (%)	74/165 (44.8)	40/83 (48.2)	0.686	32/71 (45.1)	43/101 (42.6)	39/76 (51.3)	0.505
Level involved, n (%)							
L3-4	3 (1.8)	0 (0.0)		2 (2.8)	1 (1.0)	0 (0.0)	
L4-5	27 (16.0)	8 (9.6)		10 (14.1)	11 (10.7)	14 (17.9)	
L5-S1 or L6-S1	112 (66.3)	63 (75.9)	0.266	49 (69.0)	71 (68.9)	55 (70.5)	0.506
L3-L4-L5	1 (0.6)	0 (0.0)		1 (1.4)	0 (0.0)	0 (0.0)	
L4-L5-S1 or L5-L6-S1	21 (12.4)	7 (8.4)		7 (9.9)	15 (14.6)	6 (7.7)	
≥ 3 levels involved	5 (3.0)	5 (6.0)		2 (2.8)	5 (4.9)	3 (3.8)	
Spondylolisthesis grade, n/total n (%)							
Grade I	84/168 (50.0)	39/83 (47.0)		40/71 (56.3)	45/103 (43.7)	38/77 (49.4)	
Grade II	71/168 (42.3)	30/83 (36.1)	0.126	23/71 (32.4)	48/103 (46.6)	30/77 (39.0)	0.482
Grade III	12/168 (7.1)	13/83 (15.7)		8/71 (11.3)	9/103 (8.7)	8/77 (10.4)	
Grade IV	0/168 (0.0)	1/83 (1.2)		0/71 (0.0)	0/103 (0.0)	1/77 (1.3)	
Spondyloptosis	1/168 (0.6)	0/83 (0.0)		0/71 (0.0)	1/103 (1.0)	0/77 (0.0)	
ODI, mean ± SD, score§	45.7 ± 13.9	46.5 ± 14.5	0.708	42.5 ± 13.3	46.7 ± 13.4	48.4 ± 15.3	0.034
NRS-B, mean ± SD, score‡	6.9 ± 2.2	7.4 ± 1.8	0.102	5.4 ± 2.2	7.7 ± 1.4	7.8 ± 1.9	<0.001
NRS-L, mean ± SD, score‡	7.3 ± 1.9	5.8 ± 2.5	<0.001	8.0 ± 1.6	5.3 ± 1.9	7.8 ± 1.9	<0.001
SF-12 PCS, mean ± SD, score	32.9 ± 8.3	33.9 ± 7.4	0.381	34.7 ± 7.9	32.7 ± 7.8	32.4 ± 8.4	0.160
SF-12 MCS, mean ± SD, score	47.1 ± 8.7	46.6 ± 8.7	0.618	48.9 ± 7.9	47.3 ± 8.0	44.9 ± 9.9	0.018

Abbreviations: ODI = Oswestry Disability Index; SF-12 PCS = Short Form-12 general health survey physical component score; SF-12 MCS = Short Form-12 general health survey mental component score; NRS-L = numerical rating scale leg pain; NRS-B = numerical rating scale back pain. Varying denominators indicate missing data for patients in some categories. For body mass index, data was available for n = 85 in the back-pain group and n = 180 in the radicular pain group. ‡ NRS-L and NRS-B scores range from 0 to 10, with lower scores indicating less severe symptoms. § In the ODI, the range of scores is 1 to 100, with high scores indicating worse disability and pain. ¶ SF-12 MCS and SF-12 PCS mean summary scores, with lower scores indicating worse functioning.

location revealed the cohort of predominant leg pain tended to be older ($P = 0.071$), male ($P = 0.064$), and more were employed compared to the patient-rated back predominant or equal back and leg pain groups.

On average, patients in the surgeon-determined radicular pain group rated a higher baseline NRS-L score than those in NRS-B (7.3 ± 1.9 vs. 5.8 ± 2.5 ; $P < 0.001$; Table 1). In contrast, the intensity of back pain was not different between the 2 groups (back group: 7.4 ± 1.8 ; radicular group: 6.9 ± 2.2 , $P = 0.102$; Table 1). Average NRS-B in the patient-rated equal pain group was similar to the back pain group (7.7 ± 1.4 vs. 7.8 ± 1.9 respectively) but significantly greater than the patient-rated leg pain group (5.4 ± 2.2 ; $p < 0.001$). Likewise, average NRS-L in the patient-rated back and leg pain equal group was similar to the leg pain group (7.8 ± 1.9 vs. 8.0 ± 1.6) but significantly greater than the patient-rated back pain group (5.3 ± 1.9 ; $p < 0.001$). Baseline ODI, SF-12 PCS, and SF-12 MCS scores did not differ between the surgeon-determined groups, but significant differences existed between the patient-rated pain groups (Table 1). ODI and SF-12 MCS were significantly worse for the equal back and leg pain group

(ODI: 48.4 ± 15.3 ; SF-12 MCS: 44.9 ± 9.9) when compared to the patient-rated leg pain group (ODI: 42.5 ± 13.3 ; SF-12 MCS: 48.9 ± 9.9).

A comparison of the surgical details and adverse events are shown in Table 2. The majority of patients in both groups were treated with an interbody fusion (84%). Operative and perioperative parameters including minimally invasive approach, levels fused, ASA classification, blood loss, and length of stay as well as intraoperative, perioperative and postoperative adverse events did not differ between surgeon-determined groups or between patient-rated pain groups ($P > 0.05$ for all comparisons; Table 2).

Comparison of the PROMs at 1 Year After Surgery

As shown in Figure 2 the patient-rated outcome measures for both surgeon-determined pain groups and patient-rated pain groups improved after surgery. At 1 year after surgery the mean change in score for all PROMS did not differ between groups for either the surgeon-determined chief complaint groups or the patient-rated pain groups (Table 3). A sensitivity analysis

Table 2. Surgical Treatment, Complications and Events.

Parameter	Surgeon-determined			Patient-rated			P Value
	Radicular pain (n = 169)	Back pain (n = 83)	P Value	Leg (n = 71)	Back (n = 103)	Equal (n = 78)	
Type of fusion, n (%)							
Posterolateral fusion	23 (13.6)	19 (22.6)	0.073	9 (12.7)	23 (22.3)	10 (12.8)	0.134
Interbody fusion	146 (86.4)	64 (77.1)		62 (87.3)	80 (77.7)	68 (87.2)	
Minimally invasive approach, n (%)	55 (32.5)	24 (28.9)	0.665	22 (31.0)	27 (26.2)	30 (38.5)	0.212
Number of operated levels, mean (min –max)	2.2 (1-4)	2.2 (1-5)	0.614	2.2 (2-4)	2.3 (1-5)	2.2 (1-4)	0.373
Multiple-level fusion, n (%)	40 (23.7)	17 (20.5)	0.633	14 (19.7)	29 (28.2)	14 (17.9)	0.210
Level Fused, n (%)							
L3-4	2 (1.2)	0 (0.0)		2 (2.8)	0 (0.)	0 (0.0)	
L4-5	26 (15.4)	10 (12.0)		11 (15.5)	13 (12.6)	12 (15.4)	
L5-S1 or L6-S1	101 (59.8)	56 (67.5)	0.284	44 (62.0)	61 (59.2)	52 (66.7)	0.247
L3-L4-L5	1 (0.6)	0 (0.0)		1 (1.4)	0 (0.0)	0 (0.0)	
L4-L5-S1 or L5-L6-S1	34 (20.1)	1 (13.3)		12 (16.9)	22 (21.3)	11 (14.1)	
≥ 2 levels fused	5 (3.0)	6 (7.2)		1 (1.4)	7 (6.8)	3 (3.8)	
ASA classification, n (%)							
1	27/146 (18.5)	15/64 (23.4)		11/56 (19.6)	20/89 (22.5)	11/65 (16.9)	
2	87/146 (59.6)	34/64 (53.1)	0.369	37/56 (66.1)	48/89 (53.9)	36/65 (55.4)	0.433
3	32/146 (21.9)	14/64 (21.9)		8/56 (14.3)	21/89 (23.6)	17/65 (26.1)	
4	0/146 (0.0)	1/64 (1.6)		0/56 (0.0)	0/89 (0.0)	1/65 (1.5)	
Operating time, min mean ± SD	213.3 ± 68.1	209.9 ± 78.9	0.757	206.9 ± 71.6	214.2 ± 74.0	214.4 ± 67.7	0.820
Intraoperative blood loss, mL mean ± SD	417.1 ± 357.1	397.1 ± 374.9	0.690	435.6 ± 344.8	420.8 ± 397.2	374.7 ± 331.7	0.568
Length of stay, mean ± SD, days	3.8 ± 2.2	4.2 ± 2.1	0.243	3.8 ± 2.0	4.0 ± 1.9	4.0 ± 2.7	0.830
Intraoperative AE†, n (%)							
Dural Tear	7 (4.1)	8 (9.6)	0.095	4 (5.6)	6 (5.8)	5 (6.4)	0.978
Implant/instrument related	4 (2.4)	2 (2.4)	1.000	0 (0.0)	3 (2.9)	3 (3.8)	0.276
Revision intra-operative	2 (1.2)	2 (2.4)	0.600	0 (0.0)	1 (1.0)	3 (3.8)	0.139
Perioperative AE†, n (%)							
Delirium	4 (2.4)	1 (1.2)	1.000	2 (2.8)	1 (1.0)	2 (2.6)	0.628
Revision	4 (2.4)	2 (2.4)	1.000	2 (2.8)	2 (1.9)	2 (2.6)	0.926
Neurological deterioration	2 (1.2)	2 (2.4)	0.600	1 (1.4)	2 (1.9)	1 (1.3)	0.931
Pain new onset	5 (3.0)	2 (2.4)	1.000	0 (0.0)	3 (2.9)	4 (5.1)	0.163
Urinary retention	6 (3.6)	1 (1.2)	0.431	4 (5.6)	1 (1.0)	2 (2.6)	0.182
Postoperative AE < 12 weeks†, n (%)							
Implant/instrumentation related	2 (1.2)	0 (0.0)	1.000	1 (1.4)	1 (1.0)	0 (0.0)	0.605
Revision	2 (1.2)	0 (0.0)	1.000	1 (1.4)	0 (0.0)	1 (1.3)	0.496
Infection	4 (2.4)	1 (1.2)	1.000	1 (1.4)	2 (1.9)	2 (2.6)	0.879
Neurological deterioration	2 (1.2)	0 (0.0)	1.000	1 (1.4)	1 (1.0)	0 (0.0)	0.605
Pain new onset	2 (1.2)	0 (0.0)	1.000	1 (1.4)	1 (1.0)	0 (0.0)	0.605
Thromboembolic event	2 (1.2)	0 (0.0)	1.000	1 (1.4)	0 (0.0)	1 (1.3)	0.496
Urinary retention	0 (0.0)	1 (1.2)	0.329	1 (1.0)	0 (0.0)	0 (0.0)	0.278

Abbreviations: ASA = American Society of Anaesthesiologists; AE = adverse event; †only adverse events with an incidence of ≥ 1% are reported.

using multiple imputation confirmed no significant mean differences with respect to all outcome measures (Supplementary Table 1).

Satisfaction

Patient satisfaction with treatment at 1 year after surgery did not differ between the patients with a surgeon-determined chief complaint of back pain versus radicular pain or between the patient-rated predominant pain location groups. The majority of patients were satisfied with treatment at 1 year (Table 4).

Patient-Rated Equal back to Leg Pain Group Stratified by Surgeon-Determined Chief Complaint at 1 Year After Surgery

Figure 3 demonstrates that for only 18/78 (23%) patients who rated their pain as equal back to leg pain, the surgeon-determined chief complain was back dominant. The majority of patients were in the surgeon-determined radicular pain group whereas the minority of patient’s rated their predominant pain location to be leg. Both baseline and mean improvement in scores from baseline to 1-year was similar between group for all PROMs (Table 5).

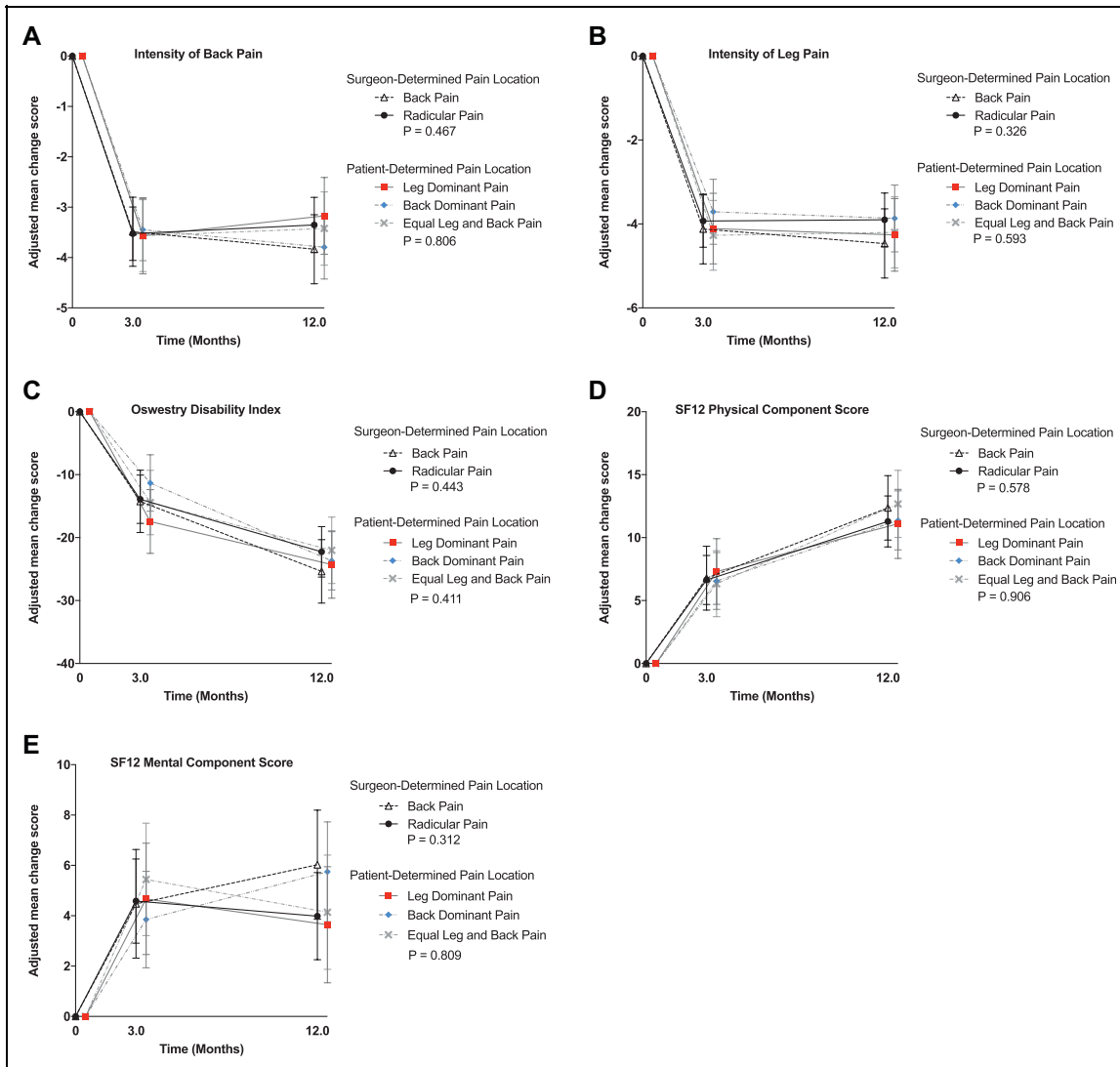


Figure 2. Change in patient-rated outcome scores from baseline to 3 months and 1 year after surgery. Scores over time on the A) numeric rating scale (NRS) for back-pain intensity; B) numeric rating scale for leg-pain intensity; C) Oswestry Disability Index (ODI); D) SF12 physical component (PCS); and E) SF12 mental component (MCS). The error bars are 95% confidence intervals. The data are derived from a longitudinal mixed-model repeated-measures analysis with adjustment baseline score, type of fusion (posterolateral or interbody), surgery at L5-S1, gender, age, and employment status. P-values denote the main effect for group (surgeon-determined back pain vs. radicular pain and patient-rated back pain, leg pain and equal pain groups). For ODI, NRS-leg pain and NRS-back pain a negative change in score indicates improvement and for PCS and MCS a positive change in score indicates improvement.

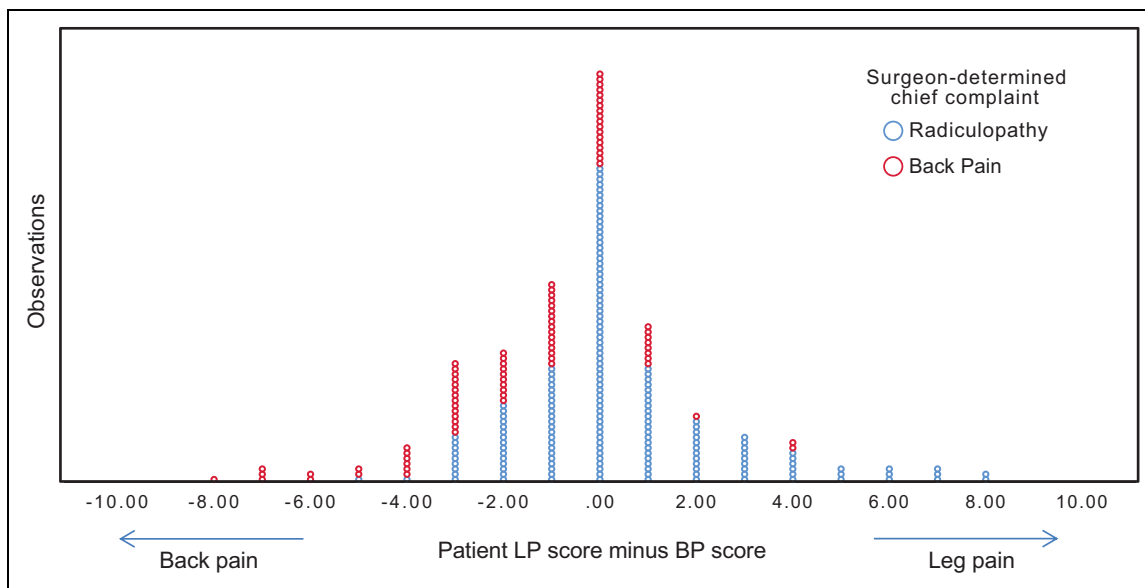
Table 3. Change in Patient Health-Reported Outcomes Scores From Baseline to 1 Year After Surgery Stratified by the Surgeon-Determined Predominant Pain Location and the Patient-Determined Predominant Pain Location⁺.

Outcome	Surgeon-determined pain location			Patient-rated pain location			Mean difference (95% CI)		
	Radicular Pain	Back Pain	Mean difference (95% CI)	Equal Pain	Predominant leg pain	Predominant back pain	Leg vs. back	Leg vs. equal	Back vs. equal
ODI	-22.3 ± 1.9	-25.4 ± 2.6	3.1 (-2.2, 8.4)	-22.0 ± 2.7	-24.3 ± 2.7	-23.7 ± 2.4	-0.6 (-8.1, 6.9)	-2.3 (-10.1, 5.6)	-1.7 (-9.0, 5.6)
NRS-L	-3.9 ± 0.3	-4.5 ± 0.4	0.6 (-0.3, 1.4)	-4.2 ± 0.4	-4.2 ± 0.4	-3.9 ± 0.4	-0.4 (-1.6, 1.0)	-0.06 (-1.3, 1.2)	0.3 (-0.9, 1.6)
NRS-B	-3.8 ± 0.3	-3.5 ± 0.3	0.5 (-0.2, 1.2)	-3.4 ± 0.4	-3.2 ± 0.4	-3.8 ± 0.3	0.6 (-0.5, 1.7)	0.2 (-0.9, 1.4)	-0.4 (-1.4, 0.6)
SF12-PCS	11.3 ± 1.0	12.4 ± 1.3	-1.1 (-3.8, 1.6)	12.7 ± 1.3	11.1 ± 1.4	11.4 ± 1.2	-0.3 (-4.1, 3.6)	-1.6 (-5.6, 2.3)	-1.3 (-5.0, 2.4)
SF12-MCS	3.9 ± 0.9	6.0 ± 1.1	-2.0 (-4.3, 0.2)	4.1 ± 1.1	3.6 ± 1.2	5.7 ± 1.0	-2.1 (-5.3, 1.1)	-0.5 (-3.8, 2.9)	1.6 (-1.6, 4.7)

Abbreviations: CI = confidence interval; ODI = Oswestry Disability Index; SF-12 PCS = Short Form-12 general health survey physical component score; SF-12 MCS = Short Form-12 general health survey mental component score; NRS-L = numerical rating scale leg pain; NRS-B = numerical rating scale back pain. Values are mean change in score ± standard error of the mean and are derived from a mixed-model repeated-measures analysis. For ODI and NRS-L and NRS-B a negative change in score indicates improvement and for SF12-PCS and SF12-MCS a positive change in score indicates improvement. ⁺Values have been adjusted for baseline score, type of fusion (posterolateral or interbody), surgery at L5-S1, gender, age, and employment status.

Table 4. Level of Satisfaction With Treatment at 1 Year After Surgery.

Outcome	Surgeon-determined			Patient-rated			P value
	Radicular pain N = 124	Back pain N = 58	P value	Leg N = 53	Back N = 73	Equal N = 56	
Extremely satisfied	n (%) 79 (63.7)	n (%) 36 (62.1)	0.655	n (%) 33 (2.3)	n (%) 44 (60.3)	n (%) 38 (67.9)	0.850
Somewhat satisfied	21 (16.9)	12 (20.7)		10 (8.9)	14 (19.2)	9 (16.1)	
Neither	6 (4.8)	5 (8.6)		4 (7.5)	5 (6.8)	2 (3.6)	
Somewhat dissatisfied	13 (10.5)	4 (6.9)		4 (7.5)	9 (12.3)	4 (7.1)	
Extremely dissatisfied	5 (4.0)	1 (1.7)		2 (3.8)	1 (1.4)	3 (5.4)	

**Figure 3.** Simple dot plot showing the distribution of surgeon-determined back pain (solid circle) and surgeon-determined radicular pain (open circle) versus patient-rated NRS-leg pain score (LP) minus patient-rated NRS-back pain score (BP).

Discussion

Our study found no difference in PROMs (NRS-B, NRS-L, ODI, SF-12 PCS and SF-12 MCS), irrespective of whether a surgeon considers the patient's primary pain complaint back dominant or radicular dominant or the patient rates pain greater in one location over the other. This is an important finding as it is contrary to the conventional opinion that back pain dominant patients have a lesser degree of improvement and are less satisfied post-operatively versus leg pain dominant patients.⁵⁻⁷ The Spine Tango registry reported that higher baseline back pain relative to leg pain was associated with a poorer overall outcome at 1 year after decompression for lumbar disc herniation.⁷ Similar findings were found for lumbar degenerative spinal stenosis.⁶ A Swedish Spine Register study reported that predominant back pain was associated with inferior pain, quality of life and function.⁵ The Spine Patient Outcomes Research Trial for surgically treated degenerative spondylolisthesis showed a greater improvement in patients with predominant leg pain compared with back pain

and intermediate levels of improvement in those with equal back and leg pain.⁸ We speculate that our study for isthmic spondylolisthesis differs from this literature because the inherent instability and secondary slip may be a cause of low back pain that is more amenable to surgical treatment such as a lumbar fusion procedure. However, other differences in demographics, such as average age which was relatively lower than the cohorts in the above mentioned studies, may define a population difference apart from differing pathology, as a potential explanation for our result compared to the previous studies.⁵⁻⁸

Our study differentiated patients into back or radicular pain groups based on the surgeon-determined chief complaint which is unique from previous studies that differentiate subjects based on the patient-rated back and leg pain scores.⁵⁻⁸ Although the surgeon-determined chief complaint represents the surgeon's inherent bias, it is advantageous in that it allows the differentiation of patients that have similar back and leg pain scores, or have predominant buttock pain which is difficult for a patient to differentiate. A surgeon's opinion of the

Table 5. Subgroup Analysis: Comparison of Patients Who Rated Their Back and Leg Pain as “Equal” Prior to Surgery Stratified by Surgeon-Determined Predominant Pain Location.

Outcome	Baseline			Change score from baseline to 1 year			
	Back pain N = 18	Radicular pain N = 60	P value	Back pain N = 10	Radicular pain N = 46	Mean difference (95% CI)	P value
ODI	51.1 ± 16.1	47.5 ± 15.1	0.388	-18.2 ± 6.6	-18.1 ± 4.1	0.1 (-12.1, 12.3)	0.988
NRS-L	7.6 ± 2.5	7.9 ± 1.7	0.548	-4.0 ± 1.0	-4.1 ± 0.6	-0.1 (-2.0, 1.8)	0.895
NRS-B	7.6 ± 2.5	7.9 ± 1.7	0.548	-2.1 ± 0.9	-3.5 ± 0.6	-1.3 (-3.1, 0.4)	0.118
SF-12 PCS	32.5 ± 7.8	32.4 ± 8.6	0.973	8.4 ± 2.8	11.4 ± 1.7	3.0 (-2.5, 8.5)	0.287
SF-12 MCS	42.1 ± 10.0	45.7 ± 9.8	0.200	2.9 ± 3.1	5.4 ± 2.0	2.6 (-3.3, 8.4)	0.387

Values are mean change in score ± standard error of the mean and are derived from a mixed-model repeated-measures analysis. ODI = Oswestry Disability Index; SF-12 PCS = Short Form-12 general health survey physical component score; SF-12 MCS = Short Form-12 general health survey mental component score; NRS-L = numerical rating scale leg pain; NRS-B = numerical rating scale back pain. For ODI and NRS-L and NRS-B a negative change in score indicates improvement and for SF-12 PCS and SF-12 MCS a positive change in score indicates improvement. +Values have been adjusted for baseline score, type of fusion (posterolateral or interbody), lumbosacral level involvement, gender, age, and employment status.

dominant pain location is founded on patho-anatomy and an understanding of potential pain generators and pain referral patterns. Consideration to the etiology of a patient's pain is essential every time a surgeon determines the treatment options. Our opinion that NRS pain scores are less effective at differentiating radicular pain from back pain is illustrated by the group with equal back and leg pain. Importantly, in this study patients were not asked to specifically differentiate their pain dominant location. Agreement between the patients' and surgeons' declared location of predominant pain has previously been shown when patients are forced to select only one pain location (back or leg) as being more troublesome than the other.¹³

Both surgeon-determined cohorts were similar in baseline demographics and function. While, the patient-rated leg pain predominant group tended to be older and male, and have significantly better ODI and MCS compared to the patient-rated back predominant or equal back and leg pain groups. As expected, the surgeon-determined radicular pain cohort had a greater degree of baseline NRS-leg pain than did the surgeon-determined back pain cohort. However, both surgeon-determined cohorts had similar mean scores of baseline NRS-back pain and the surgeon-determined back pain group had similar severity of NRS-back and NRS-leg pain. This suggests that disproportionately more leg pain was most influential to the surgeon in determining the chief complaint of radicular pain while significant back pain, irrespective of the amount of associated leg pain, prompted a surgeon to focus on back pain as the chief-complaint. The majority of patients in our study were in the surgeon-determined radicular pain group whereas the minority of patient's rated their predominant pain location to be leg. This further suggests that patients and surgeons often consider the pain problem differently. The discrepancy might be due to surgeon selection bias that patients complaining of radicular pain are predictive of successful outcome following fusion surgery. This may also illustrate the difference in how a patient and surgeon attributes buttock pain to either back or radicular in origin. For the large group of patients that rated their back

and leg pain as equal, we performed a post-hoc analysis stratifying this cohort by surgeon-determined chief complaint. Sixty of 78 in this group were designated to have surgeon-determined radicular pain. The baseline and improvement from baseline to 1-year PROMs were similar between subgroups as well. Importantly, for all analyses performed, PROMs substantially improved following surgery. This finding complements previous studies demonstrating post-operative improvement in PROMs.¹⁴⁻¹⁶

Strengths of the study include: the large sample size, prospectively collected PROMs, multi-centered nature of the study improves generalizability, and the patient groups were defined by the surgeon-determined chief complaint that mirrors the surgeon's considerations when determining and educating surgical candidates. Limitations to this study include potential selection bias of the participating surgeons' discretion in determining surgical candidacy, chief complaint, and the surgical technique for fusion. Our study was not designed to account for the surgical fusion technique, such as MIS, which could have a variable impact on PROMs, however, there was no difference between groups for the use of MIS or an inter-body device (Table 2). Furthermore, other important clinical characteristics such as myotomal weakness or dermatomal sensation change that may influence the surgeon's decision-making process were not accounted for in our methodology. It should be recognized that very few patients in this cohort had isolated back pain; most had some component of leg pain (Figure 3). The follow-up rate of 73% at 12 months is another study limitation; however, replacing the missing data with multiple imputation confirmed our observed findings.

In conclusion, the study demonstrated similar improvement in PROMs at 1-year for both the back pain and radicular pain dominant cohorts following posterior lumbar fusion for patients with isthmic spondylolisthesis. This finding was irrespective of whether a surgeon determines the patient's primary pain complaint back or radicular dominant, or the patient rates pain in one location greater than another.

Abbreviations

CSORN = Canadian Spine Outcome and Research Network; ODI = Oswestry Disability Index; PROMs = patient-reported outcome measures; NRS = numerical rating scale; SF-12 PCS = Short Form-12 Health Survey physical component score; SF-12 MCS = Short Form-12 Health Survey mental component score.

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Supplemental Material

Supplemental material for this article is available online.

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