Effects of Body Mass Index on Spondylolisthesis Surgery and Associated Patient-Reported Outcomes: A Retrospective Review

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Effects of Body Mass Index on Spondylolisthesis Surgery and Associated Patient-Reported Outcomes: A Retrospective Review

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ABSTRACT

Background: Obesity is often associated with worse outcomes after lumbar fusion surgery, but its impact on patient-reported outcomes in spondylolisthesis remains unclear. This study assesses the effect of body mass index (BMI) on outcomes for degenerative and isthmic spondylolisthesis patients undergoing lumbar fusion.

Methods: We conducted a retrospective analysis of 86 patients with low-grade lumbar degenerative and isthmic spondylolisthesis, categorized by BMI into nonobese (<30 kg/m²), obesity class I (30.0–34.9 kg/m²), obesity class II (35.0–39.9 kg/m²), and obesity class III (≥40.0 kg/m²). Outcomes were measured using the visual analog scale (VAS) for pain and the Oswestry Disability Index (ODI) at baseline and 12 months postoperatively. Statistical analyses included a 1-way analysis of variance, Bonferroni post hoc comparisons, and Kruskal-Wallis tests.

Results: Significant disability improvements (mean ODI improvement: 15.6 points, $P < 0.001$) were observed across all BMI categories, while pain improvements were less pronounced (mean VAS improvement: 2.1 points, $P < 0.001$). Nonobese and class II patients maintained improvements at 12 months. Degenerative spondylolisthesis patients showed better ODI outcomes compared with isthmic patients ($P = 0.019$), while VAS outcomes were similar ($P = 0.251$).

Conclusion: Lumbar fusion results in significant disability reduction across BMI categories, with sustained improvements in nonobese and obesity class II patients. These findings suggest that obesity should not be a contraindication for lumbar fusion in well-selected patients, as meaningful improvements can be achieved, particularly in disability outcomes.

Clinical Relevance: Clinically, this supports a more individualized approach to surgical candidacy, emphasizing functional goals and symptom burden over BMI alone, thereby promoting equitable access to care and helping guide preoperative counseling and shared decision-making.

Level of Evidence: 3.

Lumbar Spine

Keywords: spondylolisthesis, BMI, patient-reported outcomes, spinal fusion, pain, disability

INTRODUCTION

Obesity has become a significant public health challenge in recent decades, with the prevalence of obesity rising dramatically from 30.5% in 2000 to 42.4% in 2018 in the United States alone.[1,2] This condition is often associated with numerous comorbidities, including cardiovascular diseases, diabetes, and a variety of musculoskeletal disorders such as lower back pain and degenerative disc disease.[3] As the incidence of obesity increases, so does its impact on spinal pathologies, particularly in patients undergoing surgical interventions such as lumbar fusion for spondylolisthesis.[4]

Two types of spondylolisthesis include degenerative and isthmic. Lumbar fusion is frequently performed to manage these conditions, particularly when conservative treatments fail.[5] However, there is growing concern about the impact of obesity on both surgical outcomes and patient-reported outcomes (PROs) in individuals undergoing this procedure.[6,7]

While some studies suggest that higher body mass index (BMI) is associated with increased operative times, higher rates of complications, and poorer functional outcomes,[6,8–11] others have found no significant differences in postoperative recovery between obese and nonobese patients.[6,12] Although it is well documented that obesity can exacerbate lumbar spine conditions, its specific impact on PROs remains a subject of ongoing debate.[13,14]

The clinical relevance of obesity in the context of lumbar fusion for both degenerative and isthmic spondylolisthesis has not been well investigated, especially

regarding whether there is a BMI cutoff above which the benefit-risk ratio is low. The purpose of this study is to assess the impact of obesity on PROs in patients with spondylolisthesis after lumbar fusion.

METHODS

Case Ascertainment

Data for this study originated from patients with diagnosed low-grade degenerative and isthmic spondylolisthesis at a single institution between 2010 and 2023. Patients eligible for analysis (n = 271) were categorized into National Institutes of Health BMI classes by preoperative weight. The BMI classes were defined as <30 kg/m^2 nonobese, 30.0 to 34.9 kg/m^2 obesity class I, 35.0 to 39.9 kg/m^2 obesity class II, and ≥40.0 kg/m^2 obesity class III.

Patient Population

Eligibility criteria included the following: adult patients (aged ≥18 years) with a confirmed diagnosis of lumbar spondylolisthesis (L1–S1) due to degeneration or pars defect. Patients were classified using Meyerding's classification (grades 1 or 2) and had undergone 1 or multiple levels of lumbar fusion utilizing any surgical approach. Exclusion criteria included patients with other spinal conditions requiring surgical intervention (eg, scoliosis, trauma, iatrogenic conditions, or spondylosis) or those who had not undergone lumbar spinal fusion (ie, decompression-only surgery).

Follow-Up

Outcome measures on pain and disability were collected at patient follow-up visits preoperatively and at 12 months. Back pain was assessed using a 0 to 10 visual analog scale (VAS). Dysfunction related to pain was assessed using the Oswestry Disability Index (ODI).[15] The minimum clinically important difference (MCID) represents the smallest change in a PRO measure that is of genuine clinical value to patients,[16] and the values used for MCID in the current study were 13 for ODI[17] and 2 for VAS.

Statistical Analysis

All analyses focused on patients diagnosed with low-grade degenerative and isthmic spondylolisthesis who underwent spinal fusion. PROs and changes from baseline were compared by BMI class using the paired Student t test and 1-way analysis of variance with post hoc Bonferroni pairwise comparisons at each time interval. For non-normally distributed data or unequal sample sizes, Kruskal-Wallis tests were used to assess differences between BMI groups. All statistical analyses were performed using SPSS version 29.0 (IBM Corporation, Armonk, NY). P values < 0.05 were considered statistically significant.

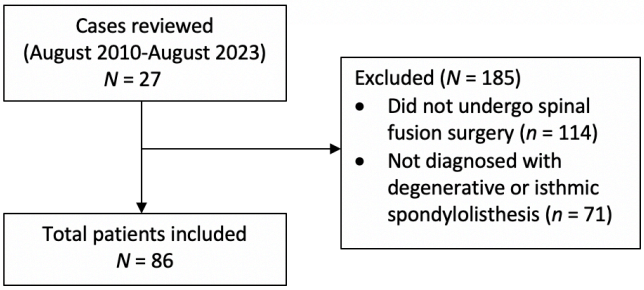

Figure 1. Study flow chart.

RESULTS

Baseline Characteristics

A total of 271 patients were eligible for analysis, but only 86 patients (50 women and 36 men) met the inclusion criteria and were included in the study (Figure 1). Patient and cohort characteristics are described in Table 1.

Primary Outcomes for All BMI categories

Overall, the mean VAS pain score improved from 5.9 at baseline to 3.8 at 12 months for the cohort, signaling a 2.1-point improvement (P < 0.001) with a moderate effect size (0.46). The BMI category did not impact the mean improvement in the VAS score (P = 0.93). The mean ODI score improved from 47.2 at baseline to 31.5 at 12 months, signaling a 15.6-point improvement (P < 0.001) with a larger effect size (0.69). BMI category did not impact the mean improvement in ODI score (P = 0.31; Tables 2 and 3; Figures 2A and 3A).

Primary Outcomes for <30 BMI Cohort

In the nonobese cohort, the mean VAS pain score improved from 5.29 at baseline to 3.66 at the 12-month follow-up, indicating a negligible 1.63-point improvement from baseline (P = 0.07). MCID was achieved at 1-year post-lumbar fusion by 14 of 40 patients (35%; Table 4). The mean ODI score improved from 44.42 at baseline to 25.35 at the 12-month follow-up, indicating a 19.07-point improvement (P = 0.003). MCID was achieved at 12-month follow-up by 16 patients 16/25 (64%; Table 4).

Table 1. Patient and characteristics and surgical outcomes (*N* = 86).

Characteristic	*n* (%)
Sex	
Female	50 (58.1%)
Male	36 (41.9%)
BMI	
<30	40 (46.5%)
30–34.9	25 (29.1%)
35–39.9	15 (17.4%)
≥40	6 (7.0%)
Mean ± SD	30.63 ± 6.99
Surgical Approach and BMI	
TLIF	
<30	21 (56.8%)
30–34.9	9 (24.3%)
35–39.9	6 (16.2%)
≥40	1 (2.7%)
Mean ± SD	28.55 ± 6.75
LLIF	
<30	9 (25.7%)
30–34.9	14 (40.0%)
35–39.9	8 (22.9%)
≥40	4 (11.4%)
Mean ± SD	33.63 ± 5.97
ALIF	
<30	7 (70%)
30–34.9	1 (10%)
35–39.9	1 (10%)
≥40	1 (10%)
Mean ± SD	28.53 ± 9.02
OLIF	
<30	0
30–34.9	2 (100%)
35–39.9	0
≥40	0
Mean ± SD	32.85 ± 1.06
Multi-approach	
<30	3 (75%)
30–34.9	1 (25%)
35–39.9	0
≥40	0
Mean ± SD	28.85 ± 3.44
Prior Lumbar Fusion	
Yes	3 (3.5%)
No	83 (96.5%)
History of Degenerative Disk Disease	
Yes	8 (9.3%)
No	78 (90.7%)
Type of Surgery	
TLIF	37 (43.0%)
LLIF	33 (38.4%)
ALIF	10 (11.6%)
OLIF	2 (2.3%)
Multiple	4 (4.7%)
Segment Level	
L3–4	9 (10.5%)
L4–5	44 (51.2%)
L5–S1	14 (16.3%)
Multilevel	19 (22.1%)
Spondylolisthesis	
Grade 1	56 (73.7%)
Grade 2	20 (26.3%)
Grade 3	0
Grade 4	0
Grade 5	0
VAS	
0, none	8 (9.3%)
1–3, mild	9 (10.5%)
4–6, moderate	23 (26.7%)
7–10, severe	46 (53.5%)
Mean ± SD	5.85 ± 2.83
ODI	
0–20, minimal	6 (7.0%)
21–40, moderate	18 (20.9%)
41–60, severe	46 (53.5%)
61–80, crippled	16 (18.6%)
81–100, bedbound	0
Mean ± SD	47.81 ± 16.32

Abbreviations: ALIF, anterior lumbar interbody fusion; BMI, body mass index; LLIF, lateral lumbar interbody fusion; ODI, Oswestry Disability Index; TLIF, transforaminal lumbar interbody fusion; VAS, visual analog scale.
Note: Data presented as *n* (%) unless otherwise noted.

Primary Outcomes for 30 to 34.9 BMI Cohort

In the class I obesity cohort, the mean VAS pain score demonstrated negligible improvement from 6.03 at baseline to 4.31 at 12-month follow-up, indicating a 1.72-point improvement from baseline ($P = 0.3$). MCID was not achieved at 12-month follow-up; however, 5 of 25 patients (20%), were able to maintain their clinical gains at 12 months postlumbar fusion (Table 4). The mean ODI score also showed some improvement from 45.60 at baseline to 32.76 at 12-month follow-up, indicating a 12.84-point improvement ($P = 0.003$). MCID was not achieved at the 12-month follow-up (Table 4). However, 8 of 25 patients (32%) were able to maintain their clinical gains at 1-year postlumbar fusion.

Primary Outcomes for 35 to 39.9 BMI Cohort

In the class II obesity cohort, the mean VAS pain score demonstrated modest improvement from 5.14 at baseline to 2.57 at 12-month follow-up, indicating a 2.57-point improvement from baseline ($P = 0.48$). MCID was achieved at 12-month follow-up (Table 4). Four of 16 patients (25%) were able to maintain their clinical gains at 1-year after lumbar fusion. The mean ODI score improved from 54.83 at baseline to 42.06 at 12-month follow-up, indicating a 12.77-point improvement ($P < 0.001$) from baseline. MCID was not achieved at 12-month follow-up (Table 4). Eight of 16 patients (50%), were able to maintain their clinical gains at 1-year postlumbar fusion.

Primary Outcomes for ≥40 BMI Cohort

In the class II obesity cohort, the mean VAS pain score demonstrated modest improvement from 7.40 at baseline to 5.00 at 12-month follow-up, indicating a 2.40-point improvement from baseline ($P = 0.06$). MCID was achieved at 12-month follow-up. Additionally, 3 of 6 patients (50%) were able to maintain their clinical gains at 1-year postlumbar fusion. The mean ODI score demonstrated little change from 57.20 at baseline to 50.00 at 12-month follow-up, indicating a 7.20-point improvement ($P = 0.12$). MCID was not

Table 2. Primary outcomes for the entire cohort (*N* = 86).

Scale	Baseline	12-Month Follow-Up	Mean Change	MCID	*P*[a]
VAS	5.9	3.8	2.1[b]	2	<0.001
ODI	47.2	31.5	15.6[b]	13	<0.001

Abbreviations: MCID, minimal clinically important difference; ODI, Oswestry Disability Index; VAS, visual analog scale.
[a]Dependent *t* test.
[b]MCID.

achieved at 12 months. Two of 6 patients (33.33%) were able to maintain their clinical gains at 1-year post-lumbar fusion (Table 4).

Additional Subanalysis

In the degenerative spondylolisthesis cohort, a total of 58 patients were analyzed. Patient and cohort characteristics are described in Table 5. When comparing the ODI and VAS outcomes across BMI categories, neither outcome reached statistical significance (P = 0.37 and P = 0.70, respectively; Figures 2B and 3B; Table 6). In the isthmic spondylolisthesis cohort, 28 patients were included. Patient and cohort characteristics are described in Table 5. When comparing ODI and VAS outcomes across BMI categories, neither outcome reached statistical significance (P = 0.59 and P = 0.99, respectively; Figures 2C and 3C; Table 7). To compare the overall outcomes between degenerative and isthmic cohorts, Kruskal-Wallis test was applied to analyze the nonparametric distribution. A significant difference in ODI mean change was present between the degenerative and isthmic groups, with the degenerative group demonstrating greater improvements (P = 0.019). However, there was no difference in VAS mean change between degenerative and isthmic groups (P = 0.280).

Reoperation within 12 months after lumbar fusion occurred in 9.3% (8/86) of the cohort, as detailed in Table 8. Among the patients who required reoperation, surgical approaches were distributed as follows: 50% underwent lateral lumbar interbody fusion, 37.5% transforaminal lumbar interbody fusion, and 12.5% anterior lumbar interbody fusion. Patients who required reoperation had a higher mean BMI (34.9 ± 5.07) compared with those who did not (30.1 ± 6.89).

DISCUSSION

Our findings indicate that across all BMI categories, significant improvements were observed in disability measures. However, despite diminished outcomes in the highest BMI category, improvements were substantial, suggesting that obesity does not preclude meaningful clinical benefit after lumbar fusion.

Class III patients exhibited early improvements in VAS and ODI scores, likely due to worse baseline measures, but these gains followed a parabolic trend, diminishing progress by 12-month follow-up. This aligns with other studies that reported that obese patients experienced significant initial improvements, which later diminished.[18,19] Rapid improvement may reflect preoperative weight loss, potentially reducing mechanical stress.[20] However, ongoing weight-related stress limits the long-term sustainability of outcomes. While disability significantly improved in 3 BMI groups, only 1 showed significant pain reduction, suggesting surgery was more effective in improving function than reducing pain. The divergence between pain and disability outcomes has not been widely discussed in other previous studies. It appears that while disability significantly improved, the persistence of pain may indicate unresolved mechanical stress or a delayed inflammatory response, particularly in higher BMI groups.

Following lumbar fusion surgery, patients may engage in rehabilitation programs that include physical therapy and progressive weight-bearing activities. In obese patients, these interventions

Table 3. VAS and ODI mean change from baseline to 12 months between BMI categories (*N* = 86).

	BMI					
Scale	<30 (*n* = 39)	30–34.9 (*n* = 25)	35–39.9 (*n* = 16)	>40 (*n* = 6)	MCID	*P*[a]
VAS mean change	1.8	1.7	2.5[b]	2.5[b]	2	0.93
ODI mean change	19.0[b]	12.8	15.3[b]	7.2	13	0.31

Abbreviations: ANOVA, analysis of variance; BMI, body mass index ; MCID, minimal clinically important difference; ODI, Oswestry Disability Index; VAS, visual analog scale.
[a]One-way ANOVA.
[b]Met MCID.

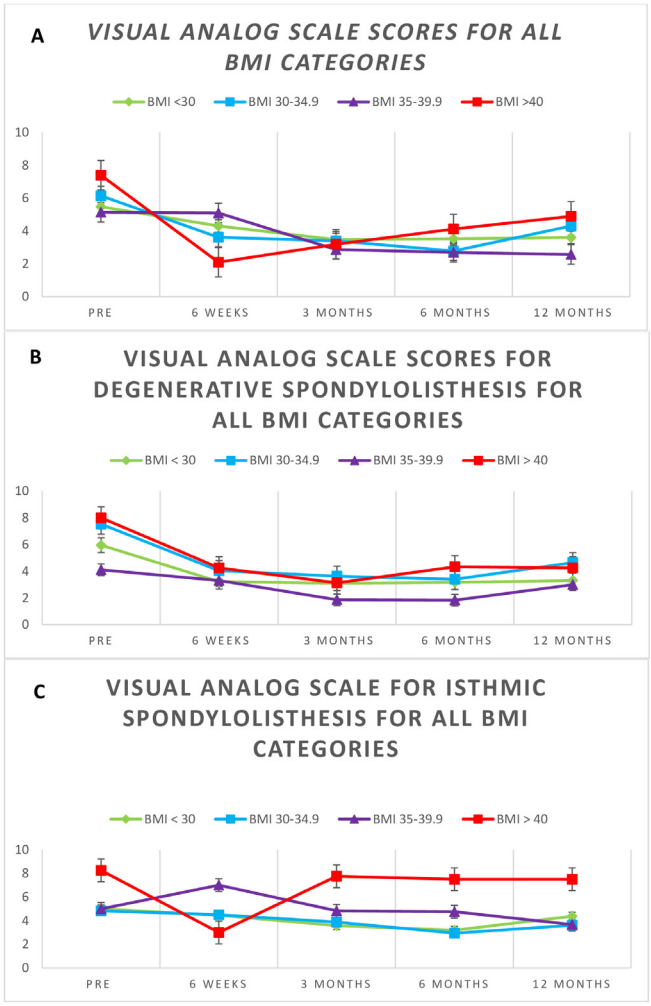

Figure 2. Visual analog scale scores for all body mass index (BMI) categories. (A) Entire cohort. (B) Degenerative cohort. (C) Isthmic cohort.

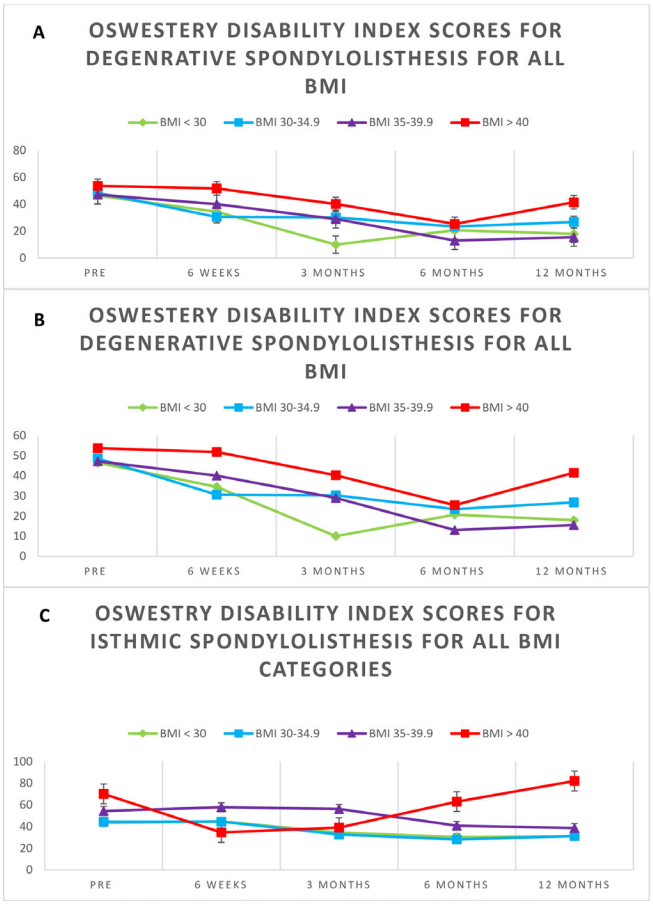

Figure 3. Oswestry Disability Index scores for all body mass index (BMI) categories. (A) Entire cohort. (B) Degenerative cohort. (C) Isthmic cohort.

can potentially improve functional mobility, reduce mechanical stress, and enhance quality of life as weight management efforts also progress. Studies suggest that sustained weight loss after bariatric or other interventions is associated with significant reductions in pain and disability measures.[21,22] Enhanced paravertebral muscle strength, potentially developed through targeted rehabilitation, could also contribute to better spinal stability and reduced pain over time. Studies support this by showing functional improvements in ODI and VAS scores in obese patients after spinal surgery.[23]

Only nonobese and class II patients reached the MCID for ODI at 12 months, consistent with the findings of Djurasovic et al, who noted that obese patients were less likely to achieve MCID following lumbar fusion.[7] However, in our study, higher BMI categories achieved MCID for pain, likely due to more severe baseline pain scores. The greater initial severity of pain in these groups could have made it more likely for them to experience a clinically significant improvement, even though their long-term outcomes tended to plateau or decline 6 weeks after surgery. The diminished likelihood of achieving MCID in higher BMI groups could be attributed to the increased biomechanical demands placed on the spine by excess body weight.

Surgical decision-making for the obese patient population remains a challenge for spine surgeons. Saini et al highlight the ethical dilemma of balancing surgical risks with access to care.[24] While some argue that obesity increases the risk of complications, multiple studies have demonstrated favorable clinical outcomes in obese populations. Vincent et al retrospectively found that morbidly obese patients (BMI ≥ 40 kg/m²) achieved similar improvements in PROs after arthroplasty as those with lower BMI.[22] Similarly, Stefanova et al revealed that BMI cutoffs (≥40 kg/m²) could significantly limit surgical access, with nearly 20 patients denied surgery to avoid the risk of 1 complication.[21]

Table 4. Mean change in VAS and ODI scores for each BMI category.

BMI Category	Outcome Measure	Baseline	12-Month Follow-Up	Mean Change	MCID	*P*
<30 (*n* = 39)	VAS	5.29	3.66	1.63	2	0.07
	ODI	44.42	25.35	19.07[a]	13	0.003
30–34.9 (*n* = 25)	VAS	6.03	4.31	1.72	2	0.03
	ODI	45.60	32.76	12.84	13	0.003
35–39.9 (*n* = 16)	VAS	5.14	2.57	2.57[a]	2	0.48
	ODI	54.83	42.06	12.77	13	<0.001
>40 (*n* = 6)	VAS	7.40	5.00	2.40[a]	2	0.06
	ODI	57.20	50.00	7.20	13	0.12

Abbreviations: BMI, body mass index ; MCID, minimal clinically important distance; ODI, Oswestry Disability Index; VAS, visual analog scale.
[a]Met MCID.

Giori et al further demonstrated that BMI criteria result in many patients being denied complication-free surgery compared with those spared complications.[25] Despite these challenges, quantitative assessments can guide surgeons on the appropriateness of BMI criteria. For example, coverage policies for lumbar fusion, total hip arthroplasty, and total knee arthroplasty frequently exclude patients above specific BMI thresholds. However, no such policy exists for lumbar or SIJ fusion, and studies indicate that functional improvements in ODI and VAS scores are comparable between obese and nonobese groups. These findings challenge the exclusion of patients based solely on BMI, particularly when meaningful clinical improvements can still be achieved.

While our study focused on lumbar fusion, parallels can be drawn to the findings of Goyal et al, who reported that obesity did not significantly impact PROs, finding obese patients could achieve similar functional outcomes after lumbar fusion as their nonobese counterparts.[1,23] These results mirror our findings, in which BMI did not significantly alter the magnitude of improvement in PROs. The relationship between BMI and surgical outcomes may be similar across various types of spinal surgeries, reinforcing the notion that elevated BMI should not serve as a blanket contraindication for surgical intervention. The use of BMI cutoffs in surgical decision-making, particularly for lumbar fusion, has been a topic of considerable debate. Many insurance providers impose strict BMI limits as part of preapproval processes, with BMI ≥ 35 often serving as a threshold for denying coverage. Our findings challenge the appropriateness of such rigid criteria. Therefore, BMI should not be used as a strict exclusion criterion for lumbar fusion, as it may unfairly restrict access to surgery for patients who could still derive significant benefits.

Table 5. Patient characteristics for the type of spondylolisthesis.

Characteristics	*n* (%)
Type of spondylolisthesis	
Degenerative	58 (67.4%)
Isthmic	28 (32.6%)
BMI category, degenerative	
<30	29 (50%)
30–34.9	16 (27.6%)
35–39.9	9 (15.5%)
≥40	4 (6.9%)
BMI category, isthmic	
<30	11 (39.3%)
30–34.9	9 (32.1%)
35–39.9	6 (21.4%)
≥40	2 (7.2%)
Yes	3 (3.6%)
No	83 (96.5%)

Abbreviation: BMI, body mass index.

Degenerative spondylolisthesis patients demonstrated a statistically significant greater difference in disability outcomes than those with isthmic spondylolisthesis ($P = 0.019$). However, no statistically significant difference was found in pain outcomes ($P = 0.280$). These findings contrast with some previous literature that has suggested that outcomes between these 2 spondylolisthesis subtypes are generally comparable.[26,27] Discrepancy in our findings may be attributed to factors such as pathophysiological mechanisms, as degenerative spondylolisthesis is often associated with progressive facet and disc degeneration, which may respond differently to decompression and stabilization procedures than the more structural defect seen in isthmic cases.

Several limitations of this study must be acknowledged. First, the retrospective nature of the data limits the ability to establish causality between BMI and surgical outcomes. While our study was conducted at a single institution, which may limit the generalizability of findings to other populations, the results provide valuable insights for clinical practice. BMI was used as the primary measure of obesity; however, it does not account for other important factors such as muscle mass, fat distribution, or sarcopenia, which may influence surgical outcomes. The sample sizes between the

Table 6. VAS and ODI mean change from baseline to 12 months between BMI categories for the degenerative cohort.

	BMI					
Scale	**<30 (*n* = 39)**	**30–34.9 (*n* = 25)**	**35–39.9 (*n* = 16)**	**>40 (*n* = 6)**	**MCID**	***P*[a]**
VAS mean change	2.2[b]	2.7[b]	0.88	3.75[b]	2	0.70
ODI mean change	28.74[b]	21.81[b]	31.67[b]	12.20	13	0.37

Abbreviations: ANOVA, analysis of variance; BMI, body mass index ; MCID, minimal clinically important difference; ODI, Oswestry Disability Index; VAS, visual analog scale.
[a]One-way ANOVA.
[b]Met MCID.

degenerative and isthmic cohorts were disproportionate, potentially reducing the statistical power to detect differences. Despite this, significant differences in disability outcomes were observed between these groups. Another limitation is the relatively short follow-up period of 12 months. Longer-term studies are needed to assess the durability of the observed improvements, particularly in higher BMI groups, where outcomes may plateau or decline over time. While surgical technique was detailed in Table 1, a deeper analysis of the influence of specific approaches on outcomes was beyond the scope of this study.

CONCLUSION

Our study demonstrates that lumbar fusion surgery leads to significant improvements in disability across all BMI categories, particularly for nonobese patients, who exhibited the most sustained benefits over time. Our findings suggest that obesity should not be considered a strict contraindication for lumbar fusion surgery, as meaningful improvements in disability were observed across all BMI groups. Our findings challenge the appropriateness of rigid BMI cutoffs in surgical decision-making, advocating instead for a more nuanced, patient-centered approach to lumbar fusion surgery.

REFERENCES

1. Dat KO, Cher D, Polly DW. Effects of BMI on SI joint fusion outcomes: examining the evidence to improve insurance guidelines. *Spine J*. 2024;24(5):783–790. doi:10.1016/j.spinee.2023.11.015

2. Beckmann M, Odland K, Polly DW. A retrospective cohort review of BMI on SI joint fusion outcomes: examining the evidence to improve insurance guidelines. *Eur Spine J*. 2025;34(1):140–147. doi:10.1007/s00586-024-08475-4

3. Goh GS-H, Liow MHL, Yeo W, et al. The influence of body mass index on functional outcomes, satisfaction, and return to work after single-level minimally-invasive transforaminal lumbar interbody fusion. *Spine (Phila Pa 1986)*. 2019;44(11):809–817. doi:10.1097/BRS.0000000000002943

4. Park C, Garcia AN, Cook C, Shaffrey CI, Gottfried ON. Long-term impact of obesity on patient-reported outcomes and patient satisfaction after lumbar spine surgery: an observational study. *J Neurosurg Spine*. 2021;34(1):73–82. doi:10.3171/2020.6.SPINE20592

5. Mulvaney G, Rice OM, Rossi V, et al. Mild and severe obesity reduce the effectiveness of lumbar fusions: 1-year patient-reported outcomes in 8171 patients. *Neurosurgery*. 2021;88(2):285–294. doi:10.1093/neuros/nyaa414

6. Soroceanu A, Burton DC, Diebo BG, et al. Impact of obesity on complications, infection, and patient-reported outcomes in adult spinal deformity surgery. *J Neurosurg Spine*. 2015;23(5):656–664. doi:10.3171/2015.3.SPINE14743

7. Djurasovic M, Bratcher KR, Glassman SD, Dimar JR, Carreon LY. The effect of obesity on clinical outcomes after lumbar fusion. *Spine (Phila Pa 1986)*. 2008;33(16):1789–1792. doi:10.1097/BRS.0b013e31817b8f6f

8. Buerba RA, Fu MC, Gruskay JA, Long WD, Grauer JN. Obese class III patients at significantly greater risk of multiple complications after lumbar surgery: an analysis of 10,387 patients in the ACS NSQIP database. *Spine J*. 2014;14(9):2008–2018. doi:10.1016/j.spinee.2013.11.047

9. Jiang J, Teng Y, Fan Z, Khan S, Xia Y. Does obesity affect the surgical outcome and complication rates of spinal surgery? A meta-analysis. *Clin Orthop Relat Res*. 2014;472(3):968–975. doi:10.1007/s11999-013-3346-3

10. Marquez-Lara A, Nandyala SV, Sankaranarayanan S, Noureldin M, Singh K. Body mass index as a

Table 7. VAS and ODI mean change from baseline to 12 months between BMI categories for the isthmic cohort.

	BMI					
Scale	**<30 (*n* = 39)**	**30–34.9 (*n* = 25)**	**35–39.9 (*n* = 16)**	**>40 (*n* = 6)**	**MCID**	***P*[a]**
VAS mean change	1.63	1.22	0.83	1.5	2	0.99
ODI mean change	17.33[b]	13.23[b]	12.85	–4.0	13	0.59

Abbreviations: BMI, body mass index ; MCID, minimal clinically important difference; ODI, Oswestry Disability Index; VAS, visual analog scale.
[a]One-way ANOVA.
[b]Met MCID.

Table 8. Return to the operating room, imaging modality, and surgical approach distribution.

Variable	*n* (%)
Return to OR	
Yes	8 (9.3%)
No	78 (90.7%)
Imaging used	
Radiography	79 (91.0%)
Computed tomography	55 (64.0%)
Magnetic resonance imaging	9 (10.5%)
Surgical approach for patients who returned to OR	
LLIF	4 (50%)
TLIF	3 (37.5%)
ALIF	1 (12.5%)
BMI, mean ± SD	
Returned to OR	34.9 ± 5.07
No return to OR	30.1 ± 6.89

Abbreviations: ALIF, anterior lumbar interbody fusion; BMI, body mass index; LLIF, lateral lumbar interbody fusion; OR, operating room; TLIF, transforaminal lumbar interbody fusion.

predictor of complications and mortality after lumbar spine surgery. *Spine (Phila Pa 1986)*. 2014;39(10):798–804. doi:10.1097/BRS.0000000000000232

11. Seicean A, Alan N, Seicean S, et al. Impact of increased body mass index on outcomes of elective spinal surgery. *Spine (Phila Pa 1986)*. 2014;39(18):1520–1530. doi:10.1097/BRS.0000000000000435

12. Naik A, Moawad C, Harrop JS, Dhawan S, Cramer SW, Arnold PM. Influence of body mass index on surgical and patient outcomes for cervical spine surgery. *Clin Spine Surg*. 2023. doi:10.1097/BSD.0000000000001531

13. Sielatycki JA, Chotai S, Stonko D, et al. Is obesity associated with worse patient-reported outcomes following lumbar surgery for degenerative conditions? *Eur Spine J*. 2016;25(5):1627–1633. doi:10.1007/s00586-016-4460-1

14. Koerner JD, Glaser J, Radcliff K. Which variables are associated with patient-reported outcomes after discectomy? Review of SPORT disc herniation studies. *Clin Orthop Relat Res*. 2015;473(6):2000–2006. doi:10.1007/s11999-014-3671-1

15. Copay AG, Cher DJ. Is the Oswestry Disability Index a valid measure of response to sacroiliac joint treatment? *Qual Life Res*. 2016;25(2):283–292. doi:10.1007/s11136-015-1095-3

16. Copay AG, Subach BR, Glassman SD, Polly DW, Schuler TC. Understanding the minimum clinically important difference: a review of concepts and methods. *Spine J*. 2007;7(5):541–546. doi:10.1016/j.spinee.2007.01.008

17. Copay AG, Glassman SD, Subach BR, Berven S, Schuler TC, Carreon LY. Minimum clinically important difference in lumbar spine surgery patients: a choice of methods using the Oswestry Disability Index, medical outcomes study questionnaire short form 36, and pain scales. *Spine J*. 2008;8(6):968–974. doi:10.1016/j.spinee.2007.11.006

18. Sharma A, Tanenbaum JE, Hogue O, et al. Predicting clinical outcomes following surgical correction of adult spinal deformity. *Neurosurg*. 2019;84(3):733–740. doi:10.1093/neuros/nyy190

19. Knutsson B, Michaëlsson K, Sandén B. Obesity is associated with inferior results after surgery for lumbar spinal stenosis. *Spine (Phila Pa 1986)*. 2013;38(5):435–441. doi:10.1097/BRS.0b013e318270b243

20. Keeney BJ, Austin DC, Jevsevar DS. Preoperative weight loss for morbidly obese patients undergoing total knee arthroplasty: determining the necessary amount. *J Bone Joint Surg Am*. 2019;101(16):1440–1450. doi:10.2106/JBJS.18.01136

21. Stefanova I, Currie AC, Newton RC, et al. A meta-analysis of the impact of bariatric surgery on back pain. *Obes Surg*. 2020;30(8):3201–3207. doi:10.1007/s11695-020-04713-y

22. Vincent HK, Vincent KR, Lamb KM. Obesity and mobility disability in the older adult. *Obes Rev*. 2010;11(8):568–579. doi:10.1111/j.1467-789X.2009.00703.x

23. Goyal A, Elminawy M, Kerezoudis P, et al. Impact of obesity on outcomes following lumbar spine surgery: a systematic review and meta-analysis. *Clin Neurol Neurosurg*. 2019;177:27–36. doi:10.1016/j.clineuro.2018.12.012

24. Holt G, Nunn T, Gregori A. Ethical dilemmas in orthopaedic surgical training. *J Bone Joint Surg Am*. 2008;90(12):2798–2803. doi:10.2106/JBJS.H.00910

25. Giori NJ, Amanatullah DF, Gupta S, Bowe T, Harris AHS. Risk reduction compared with access to care: quantifying the trade-off of enforcing a body mass index eligibility criterion for joint replacement. *J Bone Joint Surg Am*. 2018;100(7):539–545. doi:10.2106/JBJS.17.00120

26. Kim JY, Park JY, Kim KH, et al. Minimally invasive transforaminal lumbar interbody fusion for spondylolisthesis: comparison between isthmic and degenerative spondylolisthesis. *World Neurosurg*. 2015;84(5):1284–1293. doi:10.1016/j.wneu.2015.06.003

27. Endler P, Ekman P, Ljungqvist H, Brismar TB, Gerdhem P, Möller H. Long-term outcome after spinal fusion for isthmic spondylolisthesis in adults. *Spine J*. 2019;19(3):501–508. doi:10.1016/j.spinee.2018.08.008

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