Asian Spine Journal
Clinical Study
Asian Spine J 2023;17(2):293-303 • https://doi.org/10.31616/asj.2022.0071

Single-Level Anterior Lumbar Interbody Fusion versus Minimally Invasive Transforaminal Lumbar Interbody Fusion at L5/S1 for an Obese Population

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Study Design: Retrospective study.

Purpose: To compare perioperative outcomes, patient-reported outcome measures (PROMs), and minimal clinically important difference (MCID) achievement rates for an obese patient cohort between single-level minimally invasive (MIS) transforaminal lumbar interbody fusion (TLIF) vs. anterior lumbar interbody fusion (ALIF).

Overview of Literature: To the best of our knowledge, no study has compared the outcomes of MIS TLIF and ALIF in an obese population.

Methods: Obese patients (body mass index [BMI] ≥30.0 kg/m^2) who underwent single-level MIS TLIF or ALIF at L5/S1 were included in the study. Demographic/perioperative variables, presenting patient pathology, and 1-year arthrodesis statistics were collected. PROM scores for Visual Analog Scale (VAS) back/leg, Oswestry Disability Index, 12-item Short Form Physical Composite Scale, and Patient-Reported Outcome Measurement Information System Physical Function (PROMIS-PF) were collected from preoperative and postoperative (6 weeks, 12 weeks, 6 months, 1 year, 2 years) PROMIS-PF. The obese patients were classified based on the procedure they underwent (MIS TLIF vs. ALIF).

Results: The criteria were met by 210 patients in total. After coarsened exact matching for Charlson comorbidity index score, degenerative spondylolisthesis, isthmic spondylolisthesis, degenerative scoliosis, foraminal stenosis, insurance, male, and ethnicity, 94 obese patients were included in the total cohort, with 59 receiving MIS TLIF and 35 receiving ALIF. ALIF recipients had higher PROMIS-PF scores at 6 weeks (p=0.014) and 12 weeks (p=0.030), as well as a higher VAS leg at 2 years (p=0.017). Following multiple regression accounting for differences in baseline BMI, only the 6-week PROMIS-PF significantly differed (p=0.028), with no other intergroup differences in mean PROMs between fusion types. Aside from a significantly higher 6-week MCID achievement rate for PROMIS-PF among ALIF recipients (p=0.006), no differences in attainment were observed.

Conclusions: There were no statistically significant differences in perioperative characteristics, fusion rates, PROMs, or MCID achievement between obese patients receiving MIS TLIF vs. ALIF. As a result, our findings indicate that MIS TLIF and ALIF at L5/S1 are equally effective in an obese patient population.

Keywords: Obesity; Spine, Lumbar vertebrae/surgery; Patient-reported outcome measures; Minimal clinically important difference

Received Feb 15, 2022; Revised Apr 15, 2022; Accepted Apr 24, 2022

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Introduction

Degenerative lumbar pathologies are among the common causes of disability, and they frequently cause significant pain (back and/or radicular) as well as disruption in function and quality of life (QOL) [1]. When conservative measures fail to relieve symptoms of lumbar degenerative disease, operative treatment may be required. Lumbar interbody fusion (LIF) is a common procedure used by spinal surgeons that is effective in lordotic correction and biomechanical stabilization.1 The anterior (anterior lumbar interbody fusion [ALIF]) and transforaminal (transforaminal lumbar interbody fusion [TLIF]) approaches are two important LIF techniques that have been extensively studied in the spinal literature. Numerous studies have also compared the two procedures, concluding that each has advantages and disadvantages, despite having similar arthrodesis rates [1-3]. In prior comparative studies, however, had a limitation in that they did not control for patient-specific factors. Obesity, a condition in which metabolic derangements and resulting inflammation may precipitate or exacerbate spinal disease, is an important patient characteristic that may play a role in outcomes [4]. While many authors have compared the outcomes of non-obese and obese (defined as body mass index [BMI] ≥30.0 kg/m^2) individuals undergoing spine surgery, none, to our knowledge, have attempted to answer the following question: Which procedure is best suited for an obese patient population? As a result, we present a longitudinal study comparing minimally invasive (MIS) TLIF and ALIF for perioperative safety and postoperative success (as measured by patient-reported outcome measures [PROMs] and minimal clinically important difference [MCID] achievement) in obese surgical recipients.

Materials and Methods

1. Patient population

The institutional review board at Rush University Medical Center approved the study before it began (ORA #14051301), and patients gave their consent. A retrospective database of an attending orthopedic spine surgeon was searched to identify patients who met the inclusion criteria: obesity (BMI ≥30.0 kg/m^2) undergoing single-level MIS TLIF or ALIF at L5/S1. Patients receiving fusion for trauma, infection, or malignancy were excluded. All procedures were carried out by a single surgeon (K.S.) at Rush University Medical Center. During the planning stage, the surgeon made a patient-by-patient decision on ALIF versus MIS TLIF based on patient characteristics, individual needs/preferences, and radiographic factors such as the amount of lordotic correction required.

2. Data collection

Demographic/perioperative variables, presenting patient pathology, and 1-year arthrodesis statistics were collected. PROM scores for Visual Analog Scale (VAS) back and leg, Oswestry Disability Index (ODI), 12-item Short Form (SF-12) Physical Composite Scale (PCS), and Patient-Reported Outcome Measurement Information System Physical Function (PROMIS-PF) were collected preoperative and postoperative (6 weeks, 12 weeks, 6 months, 1 year, 2 years). Based on the procedure used, the obese patients were divided into two groups (MIS TLIF versus ALIF).

3. Statistical analysis

Stata ver. 16.0 (Stata Corp., College Station, TX, USA) software was used to analyze all data. Coarsened exact matching was used to match cohorts based on Charlson comorbidity index (CCI) score, degenerative spondylolisthesis, isthmic spondylolisthesis, degenerative scoliosis, foraminal stenosis, insurance, male, and ethnicity among patients who met inclusion/exclusion criteria. Student *t*-tests for independent samples for continuous variables and chi-square analysis for categorical variables were used to determine between-group differences in demographic, perioperative, and mean PROM variables. Multiple regression analysis was used to determine differences in mean PROMs between groups while controlling for baseline BMI. The achievement of MCID was defined by predetermined threshold values for ΔPROMs (change in score from preoperative to postoperative) and compared between groups using chi-square analysis. Threshold values that were utilized from existing literature include: VAS back=2.1 [5]; VAS leg=2.8 [5]; ODI=14.9 [5]; SF-12 Mental Composite Scale=9.1 [6]; SF-12 PCS=2.5 [7]; and PROMIS-PF=4.5 [8].

Table 1. Patient demographics: unmatched

Characteristic	Total (n=210)	MIS TLIF (n=156)	ALIF (n=54)	*p*-value[a]
Age (yr)	47.4±11.3	46.5±10.7	49.8±12.8	0.064
Body mass index (kg/m^2)	35.6±4.6	35.2±4.6	36.7±4.7	0.051
Gender				**0.003**
Female	31.9 (67)	26.3 (41)	48.2 (26)	
Male	68.1 (143)	73.7 (115)	52.9 (28)	
Ethnicity				0.065
Caucasian	63.2 (132)	59.4 (92)	74.1 (40)	
African-American	16.8 (35)	18.1 (28)	13.0 (7)	
Hispanic	16.8 (35)	20.0 (31)	7.4 (4)	
Asian	0.5 (1)	0	1.9 (1)	
Other	2.9 (6)	2.6 (4)	3.7 (2)	
Diabetic status				0.897
Non-diabetic	85.7 (180)	85.9 (134)	85.2 (46)	
Diabetic	14.3 (30)	14.1 (22)	14.8 (8)	
Smoking status				0.389
Non-smoker	81.3 (170)	82.7 (129)	77.4 (41)	
Smoker	18.7 (39)	17.3 (27)	22.6 (12)	
Hypertension status				0.978
Non-hypertensive	61.0 (128)	60.9 (95)	61.1 (33)	
Hypertensive	39.1 (82)	39.1 (61)	38.9 (21)	
American Society of Anesthesiologists classification				0.789
<2	76.8 (159)	77.3 (119)	75.5 (40)	
≥2	23.2 (48)	22.7 (35)	24.5 (13)	
Charlson comorbidity index score	1.6±1.6	1.6±1.7	1.6±1.4	0.938
Insurance				**0.001**
Medicare/Medicaid	4.8 (10)	4.5 (7)	5.6 (3)	
Workers' compensation	48.1 (101)	55.8 (87)	25.9 (14)	
Private	47.1 (99)	39.7 (62)	68.5 (37)	

Values are presented as mean±standard deviation or % (number). Boldface indicates significance.
MIS-TLIF, minimally invasive transforaminal lumbar interbody fusion; ALIF, anterior lumbar interbody fusion.
[a]Calculated using Student *t*-test for continuous variables and chi-square analysis for categorical variables.

Results

1. Patient selection

The initial selection criteria were met by 210 patients. Following coarsened exact matching for CCI score, degenerative spondylolisthesis, isthmic spondylolisthesis, degenerative scoliosis, foraminal stenosis, insurance, male, and ethnicity, 94 obese patients were retained in the total cohort, with 59 receiving single-level MIS TLIF and 35 receiving single-level ALIF.

2. Demographic and perioperative characteristics

The mean age was 45.1 years, with the majority of people being male (63.8%). ALIF patients had a significantly higher mean baseline BMI than MIS TLIF recipients (35.9 kg/m^2 versus 34.1 kg/m^2, p=0.040), with no other intergroup differences observed for demographic characteristics (Tables 1, 2). The majority of patients (80.9%)

Table 2. Patient demographics: matched

Characteristic	Total (n=94)	MIS TLIF (n=59)	ALIF (n=35)	*p*-value[a]
Age (yr)	45.1±10.8	44.8±10.0	45.6±12.3	0.635
Body mass index (kg/m^2)	34.8±4.0	34.1±3.8	35.9±4.2	**0.040**
Gender				0.054
Female	36.2 (34)	28.8 (17)	48.6 (17)	
Male	63.8 (60)	71.2 (42)	51.4 (18)	
Ethnicity				0.880
Caucasian	90.4 (85)	91.5 (54)	88.6 (31)	
African-American	2.1 (2)	1.7 (1)	2.9 (1)	
Hispanic	7.5 (7)	6.8 (4)	8.6 (3)	
Diabetic status				0.052
Non-diabetic	92.6 (87)	96.6 (57)	85.7 (30)	
Diabetic	7.5 (7)	3.4 (2)	14.3 (5)	
Smoking status				0.183
Non-smoker	78.7 (74)	83.1 (49)	71.4 (25)	
Smoker	21.3 (20)	17.0 (10)	28.6 (10)	
Hypertension status				0.969
Non-hypertensive	66.0 (62)	66.1 (39)	65.7 (23)	
Hypertensive	34.0 (32)	33.9 (20)	34.3 (12)	
American Society of Anesthesiologists classification				0.839
<2	78.3 (72)	79.0 (45)	77.1 (27)	
≥2	21.7 (20)	21.1 (12)	22.9 (8)	
Charlson comorbidity index score	1.1±0.9	1.1±0.9	1.1±0.9	0.995
Insurance				0.142
Workers' compensation	35.1 (33)	40.7 (24)	25.7 (9)	
Private	64.9 (61)	59.3 (35)	74.3 (26)	

Values are presented as mean±standard deviation or % (number). Boldface indicates significance.
MIS-TLIF, minimally invasive transforaminal lumbar interbody fusion; ALIF, anterior lumbar interbody fusion.
[a]Calculated using Student *t*-test for continuous variables and chi-square analysis for categorical variables.

had central stenosis, while approximately half (45.7%) had foraminal stenosis, the latter of which was present in a significantly higher proportion in the ALIF group (62.9% versus 35.6%, p=0.010) (Table 3). Of the patients, 46.8% had isthmic spondylolisthesis, 14.9% had recurrent herniated nucleus pulposus, and 10.6% had degenerative spondylolisthesis (Table 3). The mean operating time for MIS TLIF was 128.3 minutes and 142.7 minutes for ALIF. The mean estimated blood loss (EBL) for MIS TLIF was 63.6 mL, while ALIF had a value of 66.2 mL (Table 3). Both groups' average length of stay (LOS) was 40.2 hours (Table 3). The postoperative narcotic consumption on day 0 (POD0) was 88.9 oral morphine equivalents (OME) for MIS TLIF and 67.0 OME for ALIF (Table 3). The postoperative narcotic consumption on day 1 (POD1) was 71.8 OME for MIS TLIF and 47.6 OME for ALIF (Table 3). There were no intergroup differences in other perioperative characteristics or 1-year arthrodesis rates, which were 86.9% in the total study population (88.9% for MIS TLIF and 81.3% for ALIF) (Table 3).

3. Patient-reported outcomes

The following were the mean preoperative scores among obese MIS TLIF recipients: PROMIS-PF=34.8; SF-12 PCS=31.1; VAS back=6.8; VAS leg=5.5; and ODI=48.3. The following were the mean preoperative scores among obese ALIF recipients: PROMIS-PF=34.9; SF-12

Table 3. Perioperative characteristics

Characteristic	Total (n=94)	MIS TLIF (n=59)	ALIF (n=35)	*p*-value[a]
Spinal pathology				
Dspond	10.6 (10)	11.9 (7)	8.6 (3)	0.617
Ispond	46.8 (44)	42.4 (25)	54.3 (19)	0.263
rHNP	14.9 (14)	17.0 (10)	11.4 (4)	0.467
Central stenosis	80.9 (76)	84.8 (50)	74.3 (26)	0.213
Foraminal stenosis	45.7 (43)	35.6 (21)	62.9 (22)	**0.010**
Operative time (min)	133.7±49.7	128.3±40.6	142.7±61.6	0.178
Estimated blood loss (mL)	64.5±42.8	63.5±41.6	66.2±45.2	0.775
Length of stay (hr)	40.2±25.0	40.8±28.0	39.2±19.3	0.774
Postoperative VAS pain				
POD 0	5.5±2.0	5.7±2.1	5.1±1.6	0.274
POD 1	5.1±2.1	5.2±2.2	4.7±1.7	0.360
Postoperative narcotic consumption				
POD 0	80.6±59.3	88.9±72.1	67.0±22.4	0.085
POD 1	63.8±62.1	71.8±72.2	47.6±35.3	0.067
1-Year arthrodesis (%)	86.9 (53)	88.9 (40)	81.3 (13)	0.437

Values are presented as % (number) or mean±standard deviation. Boldface indicates significance.
MIS-TLIF, minimally invasive transforaminal lumbar interbody fusion; ALIF, anterior lumbar interbody fusion; Dspond, degenerative spondylolisthesis; Ispond, isthmic spondylolisthesis; rHNP, recurrent herniated nucleus pulposus; VAS, Visual Analog Scale; POD, postoperative day.
[a]Calculated using Student *t*-test for continuous variables and chi-square analysis for categorical variables.

PCS=27.7; VAS back=6.7; VAS leg=5.4; and ODI=42.5 (Table 4). Obese ALIF recipients reported higher PROMIS-PF scores at 6 weeks (p=0.014) and 12 weeks (p=0.030) and higher VAS leg at 2 years (p=0.017). Only the 6-week PROMIS-PF significantly differed (p=0.028) after multiple regression accounting for differences in baseline BMI, with no other intergroup differences in mean PROMs between fusion types (Table 4). Using a paired samples *t*-test to compare baseline to postoperative points, SF-12 PCS significantly differed at 6 months (p=0.008) and 2 years (p=0.048) for MIS TLIF and 12 weeks (p=0.027) for ALIF. Using the Student *t*-test for independent samples to compare mean PROMs between both cohorts, SF-12 PCS significantly differed at 12 weeks (p=0.027) (Table 4). VAS back significantly improved from baseline to all postoperative points (p≤0.021, all) in the MIS TLIF cohort (Table 4). The ALIF cohort's VAS back improved from baseline to 6 weeks through 6 months (p<0.001, all) (Table 4). Except for 1-year (p≤0.006, all), the VAS leg MIS TLIF cohort showed significant improvements from baseline to all postoperative time points (Table 4). The ALIF cohort improved the VAS leg significantly from baseline to 2 years only (p=0.017) (Table 4). The MIS TLIF cohort's ODI improved significantly from baseline at all postoperative time points (p≤0.010, all) (Table 4). The ALIF cohort only significantly improved from baseline to 12 weeks (p=0.004) and 6 months (p=0.019) for ODI (Table 4). Aside from a significantly higher 6-week MCID achievement rate for PROMIS-PF among ALIF recipients (p=0.006), no other between-group differences in attainment rates were observed (Table 5).

Discussion

Low back pain (LBP) is a common condition that affects approximately 80% of people at some point in their lives [9]. While conservative measures are frequently tried when LBP is presented, non-operative management has variable outcomes, with up to 62% of patients experiencing recurrence [10]. Patients experiencing refractory symptomatology may require surgical intervention with LIF. The predominant approaches for fusion at L5/S1 are transforaminal (TLIF) and anterior (ALIF) [11,12]. These procedures were pioneered to improve patient outcomes and demonstrate efficacy in achieving lumbar arthrodesis while alleviating signs and symptoms of lumbar spondy-

Table 4. Mean patient-reported outcomes

PROM	MIS TLIF		ALIF		*p*-value[c]	*p*-value[d]
	Mean±SD	*p*-value[a]	Mean±SD	*p*-value[b]		
PROMIS-PF						
Preoperative	34.8±6.4	0.452	34.9±6.5	0.088	0.947	0.305
6 Weeks	34.2±7.4	0.452	40.2±3.9	0.088	**0.014**	**0.028**
12 Weeks	37.0±7.9	0.068	45.0±10.4	0.200	**0.030**	0.087
6 Months	42.4±6.7	**<0.001**	43.3±4.1	**0.006**	0.744	0.467
1 Year	39.2±6.4	**<0.001**	43.6±7.3	0.229	0.260	0.542
2 Years	40.0±9.8	0.089	53.0±10.3	0.447	0.117	0.128
SF-12 PCS						
Preoperative	31.1±10.7	-	27.7±6.9	-	0.247	0.467
6 Weeks	30.3±6.9	0.670	35.0±9.5	0.171	0.073	0.197
12 Weeks	32.9±10.6	0.227	40.6±9.7	**0.027**	**0.027**	0.068
6 Months	37.6±11.2	**0.008**	40.0±10.1	0.161	0.612	0.664
1 Year	33.3±10.1	0.073	36.8±10.6	0.393	0.505	0.501
2 Years	36.4±12.1	**0.048**	46.0±10.6	0.482	0.317	0.574
VAS back						
Preoperative	6.8±2.0	-	6.7±2.2	-	0.841	0.888
6 Weeks	4.3±2.4	**<0.001**	3.7±2.5	**<0.001**	0.261	0.244
12 Weeks	3.0±2.5	**<0.001**	3.5±2.7	**<0.001**	0.430	0.713
6 Months	4.0±2.7	**<0.001**	3.5±3.0	**<0.001**	0.543	0.827
1 Year	4.2±2.6	**0.007**	4.5±6.4	-	0.892	0.954
2 Years	4.0±3.3	**0.021**	7.9±2.3	0.230	0.088	0.106
VAS leg						
Preoperative	5.5±2.9	-	5.4±2.8	-	0.863	0.380
6 Weeks	3.8±2.7	**<0.001**	3.9±3.0	0.202	0.902	0.773
12 Weeks	3.2±3.2	**<0.001**	3.0±3.3	0.147	0.825	0.397
6 Months	3.3±3.3	**<0.001**	2.8±2.7	**0.025**	0.647	0.788
1 Year	4.1±3.5	0.073	3.9±5.5	-	0.930	0.688
2 Years	3.2±2.8	**0.006**	7.8±0.5	-	**0.017**	0.059
ODI						
Preoperative	48.3±17.0	-	42.5±19.0	-	0.250	0.087
6 Weeks	39.6±18.6	**0.010**	30.1±19.0	0.247	0.095	0.130
12 Weeks	32.9±21.0	**<0.001**	23.5±15.9	**0.004**	0.127	0.215
6 Months	28.1±19.6	**<0.001**	22.3±19.7	**0.019**	0.382	0.506
1 Year	32.8±22.0	**0.004**	44.0±33.9	-	0.512	0.177
2 Years	29.5±24.1	**0.001**	27.3±17.0	-	0.890	0.745

Boldface indicates significance.
PROM, patient-reported outcome measure; MIS TLIF, minimally invasive transforaminal lumbar interbody fusion; ALIF, anterior lumbar interbody fusion; SD, standard deviation; PROMIS-PF, Patient-Reported Outcome Measurement Information System Physical Function; SF-12 PCS, 12-item Short Form Physical Composite Scale; VAS, Visual Analog Scale; ODI, Oswestry Disability Index.
[a]Calculated using paired sample *t*-test to determine preoperative to postoperative improvement in MIS TLIF cohort. [b]Calculated using paired samples *t*-test to determine preoperative to postoperative improvement in ALIF cohort. [c]Calculated using Student *t*-test for independent samples to compare mean PROMs between both cohorts. [d]Calculated using multiple regression to evaluate differences in mean PROMs between cohorts while accounting for baseline body mass index.

Table 5. Minimum clinically important difference

PROM	MIS TLIF	ALIF	*p*-value[a]
ODI			
6 Weeks	23.5	28.6	0.714
12 Weeks	51.6	41.7	0.558
6 Months	68.6	37.5	0.101
1 Year	66.7	100.0	0.486
2 Years	66.7	0	0.197
Overall	69.4 (25)	47.1 (8)	0.117
PROMIS-PF			
6 Weeks	11.1	58.3	**0.006**
12 Weeks	26.7	50.0	0.263
6 Months	64.7	83.3	0.394
1 Year	72.7	33.3	0.207
2 Years	44.4	50.0	0.887
Overall	71.4 (15)	91.6 (11)	0.171
SF-12 PCS			
6 Weeks	42.3	50.0	0.658
12 Weeks	52.2	66.7	0.457
6 Months	57.9	57.1	0.973
1 Year	50.0	50.0	1.000
2 Years	70.0	50.0	0.584
Overall	75.0 (21)	92.3 (12)	0.193
VAS back			
6 Weeks	50.0	65.4	0.201
12 Weeks	57.8	54.2	0.773
6 Months	54.6	50.0	0.766
1 Year	30.8	100.0	0.164
2 Years	55.6	0	0.091
Overall	70.6 (36)	72.4 (21)	0.862
VAS leg			
6 Weeks	35.3	35.7 (5)	0.978
12 Weeks	38.7	33.3 (4)	0.744
6 Months	40.0	42.9 (3)	0.865
1 Year	28.6	100.0	0.143
2 Years	66.7	0	0.197
Overall	62.9 (22)	56.3 (9)	0.654

Values are presented as % or % (number). Boldface indicates significance.
PROM, patient-reported outcome measure; MIS TLIF, minimally invasive transforaminal lumbar interbody fusion; ALIF, anterior lumbar interbody fusion; ODI, Oswestry Disability Index; PROMIS-PF, Patient-Reported Outcome Measurement Information System Physical Function; SF-12 PCS, 12-item Short Form Physical Composite Scale; VAS, Visual Analog Scale.
[a]Calculated using chi-square analysis.

lolysis [3].

Certain patient factors, such as age, smoking status, and BMI have been shown to increase the risk of developing LBP [13]. One meta-analysis found that obese patients (≥30.0 kg/m^2) were significantly more likely to experience LBP than overweight (25.0 kg/m^2–29.9 kg/m^2) and non-overweight (<25.0 kg/m^2) individuals, even after controlling for publication bias and confounding covariates [14]. One explanation for the higher prevalence of LBP is that obese patients are at a higher risk of developing degenerative disc disease and spinal stenosis secondary to adipose-induced inflammation and/or biomechanical instabilities [15,16].

When providing surgical care to this patient population, providers must consider the effects of obesity on perioperative and postoperative outcomes. While previous studies have compared perioperative and postoperative outcomes in non-obese and obese lumbar procedures cohorts, no study to our knowledge has directly compared two LIF procedures specifically for this patient population. The current study compares perioperative characteristics, PROMs, and MCID achievement in obese patients undergoing single-level MIS TLIF versus ALIF at L5/S1. We hope that by conducting this study, we will be able to provide evidence-based findings that will assist spine providers in selecting an appropriate surgical method for this patient group.

The relationship between obesity and perioperative characteristics during spine surgery is not well established in the literature. A meta-analysis by Goyal et al. [17] included 23,415 patients from 32 studies to compare such metrics between obese and non-obese patients. Obese patients had higher EBL and operative time during lumbar spine surgery, according to their findings. However, the authors point out that, while their findings were statistically significant, the effect sizes were quite small and may not have been clinically meaningful. One possible explanation for their findings is that larger dissections are required when operating on obese patients. Nonetheless, such perioperative characteristics in the context of ALIF and MIS TLIF remain unknown because Goyal et al. [17] included a variety of surgical techniques with varying degrees of fusion. In contrast, Jacob et al. [3] compared the perioperative characteristics of MIS TLIF and ALIF. Their analysis of a large patient cohort revealed that patients undergoing MIS TLIF had shorter operative times and EBL than those undergoing ALIF [3]. When we restricted the

selection criteria to an obese patient population, we found contrasting results. There was no difference in EBL, operative time, or LOS between obese patients undergoing MIS TLIF or ALIF. As a result, spinal surgeons performing lumbar fusion may be reassured that the perioperative safety of MIS TLIF and ALIF in the operative treatment of obese individuals is comparable. Furthermore, prior research has found comparable fusion rates between the two procedures, a finding supported by our study of an obese patient population [2].

In terms of clinical outcomes, tools like the VAS are commonly used to measure pain intensity. As pain is the most common presenting symptom for those undergoing MIS TLIF or ALIF, postoperative pain measures are a useful metric for determining treatment success. Furthermore, scores can be restricted to specific areas of the patient's body, such as the back and leg [18]. A study conducted by Kotani et al. [19] on 550 patients found that ALIF resulted in greater VAS leg improvement when compared to TLIF. Furthermore, Jacob et al. [3] found that those who received an ALIF had a significantly greater rate of MCID achievement for the VAS leg when compared to those who received a TLIF. Those who had ALIF showed significantly higher VAS leg scores at the 2-year mark (p=0.017) in our study. This finding, however, may be limited because a 2-year gap in follow-up may have resulted in selection bias. Furthermore, MCID achievement varied over time, including at the 2-year mark. There was no difference in mean scores or MCID between the two cohorts based on VAS back measurements. Our findings are inconsistent with those of Kotani et al. [19] and Jacob et al. [3] but they are consistent with those of Ajiboye et al. [20]. In their meta-analysis, they pooled 811 patients from seven studies and found no significant mean differences in VAS scores between TLIF and ALIF. In terms of VAS score improvements from baseline, ALIF patients did not improve significantly at 2 years for VAS back or 6 weeks/12 weeks for VAS leg. Meanwhile, MIS TLIF patients improved at nearly every time point for both VAS scores (except for 1 year postoperatively for the VAS leg). A plausible explanation would be that there was a smaller sample size for ALIF versus MIS TLIF patients at these time points, requiring a greater magnitude of recovery for the former cohort to reach statistical significance. Furthermore, only one patient had postoperative as well as preoperative VAS scores at 1 year (for VAS back/leg) and 2 years for VAS back. As a result, at those time points, the significance of improvement among ALIF patients could not be calculated. Nonetheless, because we found no difference in MCID achievement at any time point for VAS leg and VAS back, our findings generally indicate that patients in these cohorts experience comparable pain levels. As a result, obese patients who are concerned about pain relief after surgery will experience similar results whether they undergo MIS TLIF or ALIF.

Patients considering spine surgery should consider postoperative functional levels because LBP can impair physical function (PF). Assessing postoperative PF after spinal surgery is an important clinical tool for determining surgical success [21]. The PROMIS and the SF-12 PCS were used in our study to assess PF [22,23]. PF can be assessed within the PROMIS system to assess a patient's physical well-being [22]. When compared to MIS TLIF patients, obese ALIF recipients had higher PROMIS-PF scores at 6 weeks (p=0.014) and 12 weeks (p=0.030), according to our functional outcomes analysis. This difference, however, did not persist for later time points and did not affect MCID achievement. As a result, we believe it is a unique finding for our cohort and is not generalizable, especially since the 12-week difference dissipated after adjusting for baseline intergroup differences in BMI. Our findings at the majority of postoperative time points are thus broadly consistent with the findings of Jacob et al. [3], who found no difference in PROMIS-PF following MIS TLIF when compared to ALIF. Our SF-12 PCS analysis followed a similar pattern, with no clinical difference in mean scores between the two cohorts. This finding is also consistent with the literature. A study conducted by Divi et al. [24] retrospectively reviewed 391 patients undergoing lumbar fusion and found that surgical technique made no difference in short-term SF-12 PCS mean scores or MCID achievement. While their study compared multiple surgical techniques, MIS TLIF and ALIF were both included in their analysis [24]. At the 1-year time point, Jacob et al. [3] found that the ALIF cohort had higher mean PCS than the MIS TLIF cohort. However, the authors concluded that there was no difference in MCID achievement between the two LIF approaches. Finally, our findings indicate that clinically meaningful physical health recovery among obese patients receiving MIS TLIF or ALIF is comparable. This finding may encourage surgeons because it broadens the scope of available options for improving physical health in obese LIF patients. Evidence-based findings from other PROMs, patient characteristics,

and patient preferences should all be taken into account when deciding between approaches.

The ODI is a patient-reported functional disability assessment. The ODI assessment consists of 10 sections, and patients are given a maximum score of 50, with a higher score indicating a worse condition [25]. Ajiboye et al. [20] found no statistically significant pooled mean differences in ODI between MIS TLIF and ALIF. Furthermore, Phan et al. [26] conducted an eight-study meta-analysis and found that TLIF and ALIF resulted in similar postoperative ODI scores. While these studies encompass the general population, others do postulate ODI in obese patients. Djurasovic et al. [27] retrospectively compared 109 obese patients and 161 non-obese patients who received lumbar fusion. There was no difference in ODI scores between the cohorts, according to their findings [27]. Our study examined slightly different parameters but found no differences in ODI at any time point among obese patients undergoing MIS TLIF or ALIF at L5/S1. While ALIF patients did not significantly improve at 6 weeks (and there was no data on PROM improvements beyond 6 months), MIS TLIF patients improved significantly from 6 weeks to 2 years. The relatively smaller sample size of ALIF recipients may have made it more difficult to achieve statistical significance, especially since the mean ODI score was still >10.0 points lower at 6 weeks compared to preoperative for this group. Furthermore, at the 1-year and 2-year time points, there was only 1 ALIF patient who had a postoperative score as well as preoperative data. As a result, an improvement from preoperative to postoperative ODI score for ALIF at these time points could not be calculated. Despite this, there were no statistical differences in MCID achievement between the two cohorts at any time point. Patients who already have debilitating LBP due to obesity should not expect dissimilar ODI scores after either MIS TLIF or ALIF.

A significant limitation of our study is the small sample size, which was reduced by more than half after performing a coarsened exact match analysis to eliminate confounders. More studies with a larger number of subjects provide more statistical power. All operations were performed in an academic setting by one orthopedic spine surgeon, limiting the external validity of the results presented. As longitudinal outcomes were assessed, loss to follow-up at later timepoints resulted in limited available data at 1-year and 2-year intervals which may have contributed to selection bias in our presented results. Furthermore, radiographic measures such as sagittal alignment parameters were not assessed, which is an important direction for future research. Finally, because PROM questionnaires are subjective, response bias may have had a significant impact on our findings.

Conclusions

MIS TLIF and ALIF had comparable operative times, EBL, LOS, and 1-year arthrodesis rates among obese recipients, with no difference in acute postoperative pain or narcotic consumption. Obese patients also improved for both procedures at the majority of time points. When mean PROM scores were compared after adjusting for differences in baseline BMI, only one difference was observed across all time points studied (PROMIS-PF at 6 weeks), with the higher score among ALIF recipients also translating to greater PROMIS-PF MCID achievement at this timepoint. Nonetheless, no other postoperative PROMs or MCID achievement rates differed significantly between procedures at any other timepoint. As a result, we conclude that MIS TLIF and ALIF appear to be equally effective in terms of perioperative safety, 1-year fusion, and QOL patient-perceived outcomes of pain, disability, and physical health.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Author Contributions

Madhav R. Patel: analysis of data, drafting manuscript, critical revision; Kevin C. Jacob: analysis of data, drafting manuscript, critical revision; Cameron Zamanian: analysis of data, drafting manuscript, critical revision; Hanna Pawlowski: analysis of data, drafting manuscript, critical revision; Michael C. Prabhu: administrative support, critical revision; Nisheka N. Vanjani: administrative support, critical revision; and Kern Singh: conception and design, data acquisition, critical revision, supervision.

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