Percutaneous lumbar interbody fusion results in less perioperative opioid usage compared to minimally invasive transforaminal lumbar interbody fusion: a single institution, multi-surgeon retrospective study

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Background: Ultra-minimally invasive percutaneous lumbar interbody fusion (percLIF) has been demonstrated to further minimize tissue trauma and has been associated with improved clinical outcomes including decreased blood loss, post-operative pain and length of stay when compared to minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF) surgery. A single-institution retrospective study was conducted to investigate whether 1-level percLIF is associated with decreased narcotic consumption compared to 1-level MIS-TLIF in the first 24-hour following surgery.

Methods: A retrospective study of patients undergoing either single-level percLIF or MIS-TLIF from January 2018 to December 2021. Opioid consumption in the 24-hour following surgery was converted into total morphine milligram equivalents (MME). The primary outcome used univariate and multivariate regression analysis to compare MME consumption between the MIS-TLIF and percLIF groups. Secondary outcome variables included, estimated blood loss, total intraoperative MME, MME at discharge, MME at 30 days post-op, exiting nerve root injury, post-anesthesia care unit (PACU) visual analogue scale (VAS) score at handoff, time to first ambulation, distance ambulated post-operative day one and hospital length of stay.

Results: A total of 51 patients (21 percLIF *vs.* 30 MIS-TLIF) were included in the study. Univariate regression analysis revealed that on average patients who underwent percLIF had a 24-hour postoperative MME –50.8 mg (95% CI: –91.6, –10) lower than those who had MIS-TLIF (P=0.02). On multivariable analysis, after adjusting for sex and age, 24-hour postoperative MME closely failed to meet statistical significance (P=0.06) with an average of –40.8 mg (95% CI: –83.2, 1.6) MME in percLIF patients compared to MIS-TLIF. There was no statistically significant difference in MME between MIS-TLIF and percLIF at the time of discharge and at 30 days post-op.

Conclusions: In the setting of the current opioid epidemic in the United States and increased numbers of patients undergoing lumbar interbody fusion, spine surgeons must continue to do their part helping reduce the need for opioid prescriptions for postoperative pain management. New "ultra-MIS" techniques such as percLIF allow surgeons to further decrease tissue trauma, which should lead to reduced need for post-operative narcotic requirements.

Introduction

Lumbar interbody fusion surgery is a workhorse technique to treat degenerative diseases of the spine, including degenerative disc disease and its spondylolisthesis as well as spinal deformity. In the United States over 100,000 lumbar fusion surgeries occur annually. This number is increasing with 122,000 cases in 2004 and over 190,000 cases in 2015 with the greatest increases among patients 65 years and older (1). Unsurprisingly, there has also been an increase in the number of surgical patients presenting with chronic back pain managed with long-term opioid therapy, which creates challenges in pain management during the perioperative period (2,3).

Minimally invasive lumbar fusion surgery, specifically minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF), reduces tissue dissection and has demonstrated benefits to patients by reducing intraoperative blood loss, faster recovery times, shorter length of hospital stay, reduced costs and decreased opioid consumption as compared to traditional open spine surgery (4,5). Recently, an ultra-minimally invasive procedure, percutaneous lumbar interbody fusion (percLIF) has been demonstrated to further minimize tissue trauma and has been associated with improved clinical outcomes including decreased blood loss, post-operative pain and length of stay when compared to MIS-TLIF surgery (6-9). However, it has not yet been shown if this ultra-minimally invasive technique provides any benefit to postoperative analgesia requirements.

The percLIF technique is described in Wang *et al.*, but briefly is characterized by percutaneous entrance into the disc space through Kambin's triangle obliquely and without facetectomy followed by discectomy and placement of interbody cage. While there is literature to suggest that percLIF may be associated with improved postoperative clinical outcomes, there is a paucity of data on the effect of percLIF versus MIS-TLIF on postoperative narcotic consumption in the acute setting (9).

In this study we seek to investigate whether 1-level percLIF is associated with decreased narcotic consumption compared to 1-level MIS-TLIF in the first 24-hour following surgery. We also measured secondary outcomes including the first PACU visual analogue scale (VAS), PACU VAS handoff, distance ambulated on post-op day 1, and hospital length of stay in hours, time to first ambulation (hours), and total intraoperative narcotic consumption, exiting nerve root injury, narcotic consumption at discharge and 30 days post-op, stratified by procedure type. Defining the relationship between approach and these patient outcomes is important for continuing to innovate improvements in MIS spine surgery. We present this article in accordance with the STROBE reporting checklist (available at https://jss.amegroups.com/article/view/10.21037/jss-23-132/rc).

Methods

Study design and patient population

This is a single institution multi-surgeon retrospective study of patients undergoing single-level minimally invasive lumbar fusion from January 2018 to December 2021. All surgeries were done by board-certified neurosurgeons practicing in an academic tertiary care center. The electronic medical record was reviewed for pertinent clinical and demographic information. including pre-operative and

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Highlight box

Key findings
- Percutaneous lumbar interbody fusion (percLIF) is associated with less opioid consumption in the 24-hour following surgery.

What is known and what is new?
- Percutaneous lumbar interbody fusion has been associated with improved postoperative clinical outcomes compared to minimally invasive transforaminal lumbar interbody fusion.
- PercLIF is a less invasive technique that may reduce acute postoperative pain and analgesia demands.

What is the implication, and what should change now?
- In appropriate patients, surgeons may be able to use percLIF to provide a less invasive technique and reduce postoperative narcotic exposure.

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postoperative narcotic utilization, VAS pain assessment, progress notes, and physical therapy assessments. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by ethics board of Duke University School of Medicine (No. Pro00107600) and individual consent for this retrospective analysis was waived.

Clinical outcomes

Primary outcome

The primary clinical outcome of this study was the 24-hour post-operative narcotic consumption. This was evaluated using morphine milligram equivalents (MME) as outlined by the Center for Disease Control and Prevention (10). MME was calculated for each individual patient by multiplying quantity, dose, and conversion factor of any administered opioids administered.

Secondary outcomes

Secondary outcomes of this study included estimated blood loss, VAS score at hand-off, time to first ambulation (hours), distance ambulated (feet), hospital length of stay (hours), and intraoperative MME, MME at discharge, MME after 30 days post-op and evidence of exiting nerve root injury documented intraoperatively or during post-operative follow-up visits.

Inclusion and exclusion criteria

The inclusion criteria for this study were age ≥18 years and the diagnosis of single-level lumbar degenerative disc disease including lumbar stenosis and spondylolisthesis that was treated with either primary single-level percLIF or single-level MIS-TLIF, discharge ≥24 hours following the end of surgery, and documentation of post-operative opioid consumption. Patients were excluded if they underwent open, mini-open, or hybrid (open and minimally invasive), or revision lumbar spine surgeries and patients who had no values for 24-hour MME or were discharged before 24-hour following the end of surgery.

Covariates

Demographic data included: age, sex, body mass index (BMI), American Society of Anesthesiologists (ASA) level, MME at admission, diabetes status (yes or no), smoker status (yes or no).

Surgical procedures

Each patient underwent either a MIS-TLIF or a percLIF. MIS-TLIF patients underwent a traditional tubular approach, discectomy, and interbody insertion with bilateral percutaneous pedicle screws instrumentation under fluoroscopy or with intraoperative navigation.

Patients undergoing percLIF were intubated then flipped prone onto a Jackson table with the arms aimed 90° towards the head. The target disc space is then identified using fluoroscopy followed by a paramedian stab incision made 10 cm from the midline. A blunt electromyography (EMG) probe is used to pierce the fascia and aimed at Kambin's triangle (*Figure 1A*). Continuous EMG was used to ensure safe entry into the disc. Dilators were then inserted over the blunt EMG probe, and a working channel was placed just inside the annulus to protect surrounding structures (*Figure 1B*). Disc material is then removed using a combination of tools including a fan-blade shaver and articulating curette. Discectomy is confirmed by placing a balloon into the disc space and filling the balloon with radio-opaque dye (*Figure 1C*). Once discectomy is completed, patients received either an ELITE Expandable Cage or Optimesh bone allograft (Spineology, Minneapolis, MN, USA) placed into the disc space to create sufficient contact with inferior and superior endplates to provide indirect decompression (*Figure 1D*). The incision is closed at the skin and closed with either Monocryl suture or staples. Lastly, percutaneous pedicle screw instrumentation is completed via stab incisions with final fluoroscopy used to confirm appropriate placement of all hardware (*Figure 1E*).

Statistical methods

Demographic and clinical characteristics were summarized with descriptive statistics. Continuous variables were summarized with mean, standard deviation, median, Q1, Q3, and minimum/maximum. Categorical variables were summarized with frequency counts and percentages for non-missing values. To examine the difference in the distributions of variables between the two groups, Wilcoxon test for continuous variables and Chi-square test for categorical variables were performed. Multivariable linear regression analyses were performed to study the association of narcotic consumptions (24-hour MME) with the procedure type (MIS-TLIF *vs*. percLIF) adjusting for age and sex. In univariable analysis, the outcome was associated with each of the covariates and procedure type. The
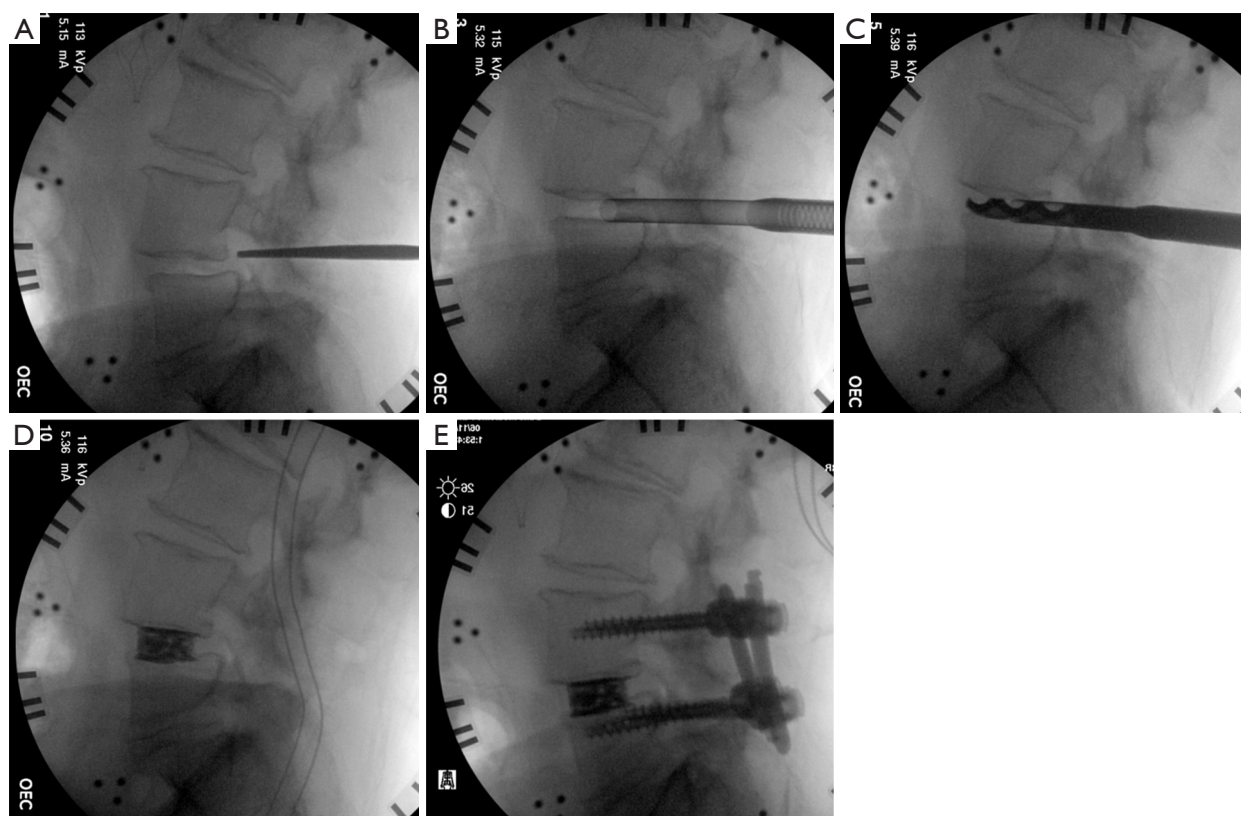
Figure 1 Serial fluoroscopy of the percutaneous lumbar interbody fusion. (A) Use of a blunt electromyography probe traverses through Kambin's triangle and is enters the disc space. (B) Next, after sequential dilation a working cannula is placed into the disc space to protect the surrounding structures. (C) A discectomy is completed and a balloon next inserted into the disc space and inflated with radio-opaque material to confirm complete discectomy. Following end plate preparation, an introducer is set at the center of the disc space and subsequently loaded with an expandable cage. (D) The cage is expanded as shown. (E) Finally percutaneous screws are placed to complete the procedure.

regression estimates and their 95% confidence intervals were reported. The significance of the tests was assessed at 2-sided alpha =0.05. All statistical analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA).

PercLIF vs. MIS-TLIF considerations

Here we highlight two surgical cases. In case 1 the patient underwent a MIS-TLIF and case 2 the percLIF was used. Criteria favoring percLIF over MIS-TLIF included patients with spondylolisthesis without central stenosis or the need for direct decompression. Criteria favoring MIS-TLIF over percLIF included patients with spondylolisthesis with central stenosis, radiculopathy and the need for direct decompression such as a symptomatic facet cyst or disc herniation.

Case 1

The patient is a 79-year-old female who underwent MIS-TLIF at L3–L4 due to long-lasting back pain and radiating left lower extremity pain from the back into the hip and anterolateral thigh. This was disabling and interfered significantly with completing her activities of daily living. She completed a course of lumbar physical therapy and underwent hip as well as lumbar epidural steroid injections with little relief. Pre-operative imaging showed a mobile grade 1 anterolisthesis L3 on 4 and a large left central and foraminal disc extrusion with cranial migration measuring up to 10 mm (*Figure 2A,2B*). Complete effacement of the left lateral recess with mass effect on both the exiting left L3 nerve root and descending left L4 nerve root was observed intraoperatively. We also encountered a synovial cyst at L3–4 on the left. Due to hyponatremia the patient
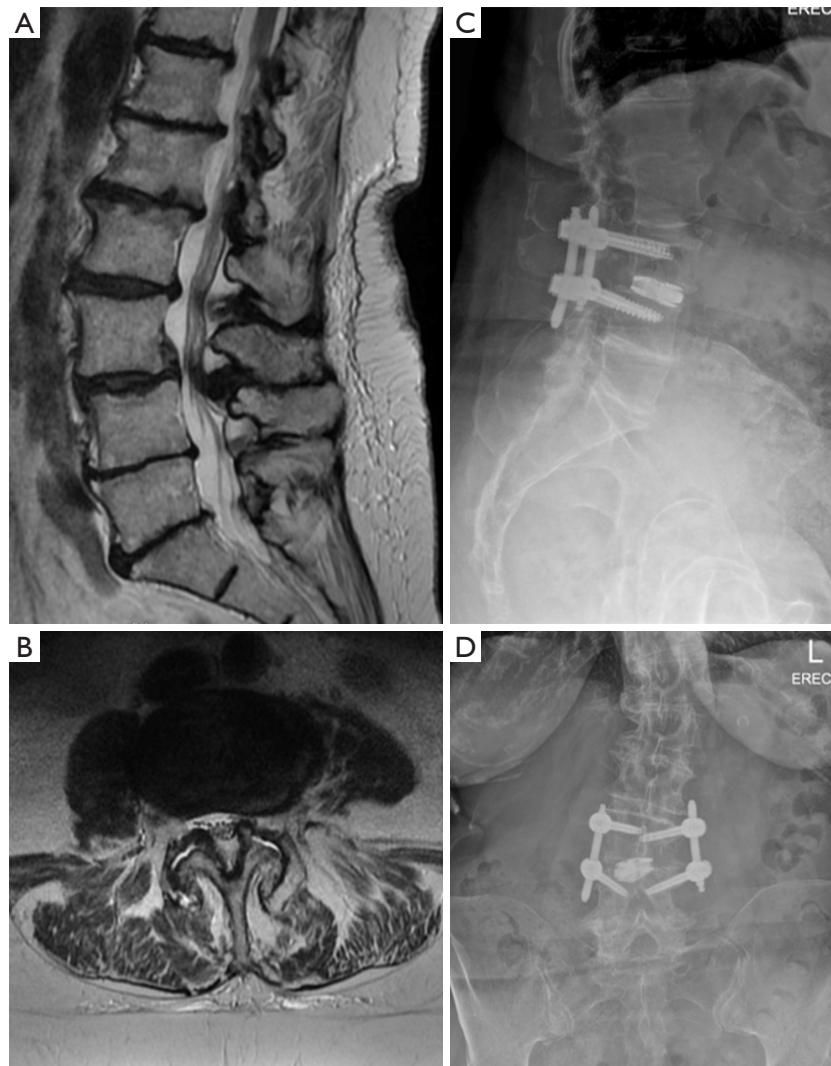
Figure 2 Example figure of intraoperative imaging during MIS-TLIF. Preoperative imaging prior to undergoing MIS-TLIF includes MRI sagittal (A) and transverse (B). Postoperative X-ray imaging lateral (C) and anteroposterior (D). MIS-TLIF, minimally invasive transforaminal lumbar interbody fusion; MRI, magnetic resonance imaging.

was discharged on postoperative day 6 and returned for follow-up six weeks later with resolution of their symptoms (*Figure 2C,2D*).

Case 2

This patient is a 65-year-old female who underwent a L4–5 percLIF due to ten years of worsening low back pain that radiated down into the hip and calf, right worse than left. This was associated with tingling and numbness of her feet. She underwent several rounds of physical therapy and three facet joint injections. Pre-operative imaging showed grade 1 anterolisthesis of L4 on L5 and severe bilateral facet

disease with a 5 mm right sided intra-articular facet cyst (*Figure 3A,3B*). She was discharged on postoperative day two. She did well at her 6 week follow up visit (*Figure 3C,3D*).

Results

Patient demographic data and comorbidities

A total of 59 patients (26 percLIF and 33 MIS-TLIF) were identified in this study. Of these 59 patients, 8 were excluded (5 percLIF *vs.* 3 MIS-TLIF patients) due to a hospital length of stay less 24-hour, leaving 51 patients

Figure 3 Example figure of intraoperative imaging during percLIF. Preoperative imaging prior to undergoing percLIF includes MRI sagittal (A) and transverse (B). Postoperative X-ray imaging lateral (C) and anteroposterior (D). percLIF, percutaneous lumbar interbody fusion; MRI, magnetic resonance imaging.

(21 percLIF *vs.* 30 MIS-TLIF). The percLIF group consisted of more female patients 16 (76.2%) *vs.* 14 (46.7%) (P=0.04). In terms of age both groups compared similarly with a median age of 64.0 years in the percLIF group *vs.* 62.5 years for MIS-TLIF (P=0.39). Medical comorbidities were also similar between the two groups with a median BMI of 32.5 *vs.* 28.8 (P=0.42), Smoker 28.6% *vs.* 23.3% (P=0.67), diabetic 23.8% *vs.* 33.3% (P=0.46), median ASA 3.0 *vs.* 2.0 (P=0.44) in the percLIF groups *vs.* MIS-TLIF respectively. Baseline narcotic consumption was also similar between groups with a mean MME 8.8 *vs.* 4.3 mg (P=0.67) in the percLIF *vs.* MIS-

TLIF group (*Table 1*).

Regression analysis on the association between narcotic consumption and procedure type

Univariable regression analysis

The percLIF group had a lower mean total MME as compared to those in the MIS-TLIF group 78.1±54.4 *vs.* 128.9±81.0 mg (*Table 2*). PercLIF patients experienced a mean reduction in MME of 40% when compared to the MIS-TLIF group. On average patients who underwent percLIF had a 24-hour postoperative MME −50.8 mg

Table 1 Demographic and clinical characteristics

Baseline demographic variable	PercLIF (N=21)	MIS-TLIF (N=30)	Total (N=51)	P value
Sex, n (%)				0.04[a]
Male	5 (23.8)	16 (53.3)	21 (41.2)	
Female	16 (76.2)	14 (46.7)	30 (58.8)	
Age (years)				0.39[b]
Mean (SD)	62.5 (9.4)	59.3 (13.0)	60.6 (11.6)	
Median	64.0	62.5	63.0	
Q1, Q3	54.0, 72.0	51.0, 68.0	52.0, 69.0	
Range	(49.0–76.0)	(23.0–79.0)	(23.0–79.0)	
BMI (kg/m^2)				0.42[b]
Mean (SD)	32.1 (5.2)	30.6 (5.5)	31.2 (5.4)	
Median	32.5	28.8	31.0	
Q1, Q3	27.7, 36.0	26.0, 35.5	26.9, 36.0	
Range	(22.2–41.8)	(21.9–40.5)	(21.9–41.8)	
Smoker, n (%)				0.67[a]
No	15 (71.4)	23 (76.7)	38 (74.5)	
Yes	6 (28.6)	7 (23.3)	13 (25.5)	
Diabetes, n (%)				0.46[a]
No	16 (76.2)	20 (66.7)	36 (70.6)	
Yes	5 (23.8)	10 (33.3)	15 (29.4)	
MME at admission				0.67[b]
Mean (SD)	8.8 (25.4)	4.3 (17.7)	6.2 (21.1)	
Median	0.0	0.0	0.0	
Q1, Q3	0.0, 0.0	0.0, 0.0	0.0, 0.0	
Range	(0.0–90.0)	(0.0–40.0)	(0.0–90.0)	
ASA				0.44[b]
Mean (SD)	2.6 (0.5)	2.5 (0.7)	2.5 (0.6)	
Median	3.0	2.0	2.0	
Q1, Q3	2.0, 3.0	2.0, 3.0	2.0, 3.0	
Range	(2.0–3.0)	(1.0–4.0)	(1.0–4.0)	

[a], Chi-square; [b], Wilcoxon. percLIF, percutaneous lumbar interbody fusion; MIS-TILF, minimally invasive transforaminal lumbar interbody fusion; SD, standard deviation; BMI, body mass index; ASA, American Society of Anesthesiologists; MME, morphine milligram equivalents.

(95% CI: –91.6, –10) lower than those who had MIS-TLIF (P=0.02) (*Table 3*). Although patient sex did not meet statistical significance (P=0.08), female sex was associated with a –37.7 mg (95% CI: –79.6, 4.3) in MME compared to male patients. Age at the time of surgery also did not meet statistical significance (P=0.08) and each year increase in age was associated with a –16 mg (95% CI: –33.9, 2) in MME (*Table 3*).

Table 2 24-hour MME by surgical procedure

24-hour oral MME (mg)	PercLIF (N=21)	MIS-TLIF (N=30)	PercLIF + MIS-TLIF (N=51)
Mean (SD)	78.1 (54.4)	128.9 (81.0)	108.0 (75.0)
Median	68.5	125.5	103.0
Q1, Q3	45.0, 103.0	62.0, 152.5	52.5, 133.5

MME, morphine milligram equivalents; percLIF, percutaneous lumbar interbody fusion; MIS-TLIF, minimally invasive transforaminal lumbar interbody fusion; SD, standard deviation.

Table 3 Regression analysis of 24-hour MME (mg)

Covariate	Univariable regression		Multivariable regression (procedure + sex + age)	
	Estimate (95% CI)	P value	Estimate (95% CI)	P value
Sex				
Female	−37.7 (−79.6, 4.3)	0.08	−20.8 (−63.4, 21.9)	0.33
Male	Reference		Reference	
Age at surgery (with 10-year increase)	−16 (−33.9, 2)	0.08	−12.1 (−29.6, 5.5)	0.17
Procedure type				
PercLIF	−50.8 (−91.6, −10)	0.02	−40.8 (−83.2, 1.6)	0.06
MIS-TLIF	Reference		Reference	

MME, morphine milligram equivalents; CI, confidence interval; percLIF, percutaneous lumbar interbody fusion; MIS-TLIF, minimally invasive transforaminal lumbar interbody fusion.

Multivariable regression analysis

In multivariable analysis, MME was regressed on procedure type adjusting for sex and age. There was no significant association between procedure type and 24-hour postoperative MME use after adjusting for sex and age, though it appeared to almost reach significance (P=0.06) and an average of −40.8 mg (95% CI: −83.2, 1.6) MME in percLIF patients compared to MIS-TLIF (*Table 3*). Sex (P=0.33) or age (P=0.17) were not significant in this multivariable analysis.

Secondary outcome variables

There was a significantly lower median estimated blood loss among patients that underwent percLIF (median volume: 25 *vs.* 100 mL, P<0.001) and an increase in the median total intraoperative MME (median dose: 192.0 *vs.* 88.8 mg, P<0.01) for patients that underwent percLIF (*Table 4*). There was no statistical significance in the median MME at discharge (median dose: 90.0 *vs.* 90.0 mg, P=0.23), MME at 30 days post-op (median dose: 0 *vs.* 0 mg, P=0.80), patients with exiting nerve root injury [2 in the percLIF group (10%) *vs.* 1 in the MIS-TLIF group (3%), P=0.75], PACU

VAS score at handoff (median: 5 *vs.* 5, P=0.94), time to first ambulation (median hours: 20.5 *vs.* 19 hours, P=0.76), distance ambulated post-operative day one (median: 100 *vs.* 100 feet, P=0.99), and hospital length of stay (median: 50.5 *vs.* 50.8 hours, P=0.87) hours in percLIF *vs.* MIS-TLIF respectively.

Secondary analysis: no intraoperative methadone vs. 24-hour narcotic consumption

A total of 8 patients (38%) percLIF patients received intraoperative methadone *vs.* 1 of 30 (3%) MIS-TLIF patients. Among the 13 percLIF and 29 MIS-TLIF patients who did not receive methadone, there was a significantly lower 24-hour postoperative MME among percLIF patients (median MME: 77.5 *vs.* 126 mg, P=0.049, *Table 5*).

Discussion

Previous studies have demonstrated MIS-TLIF compared to open lumbar fusion has been associated with a reduction in postoperative opioid consumption and improved perioperative clinical outcomes (5,11-14). However there

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Table 4 Secondary outcome variables

Secondary outcome variable	PercLIF (N=21)	MIS-TLIF (N=30)	Total (N=51)	P value
Estimated blood loss (mL)				<0.001[a]
N missing	2	1	3	
Mean (SD)	52.9 (70.1)	124.5 (119.1)	96.1 (107.7)	
Median	25.0	100.0	50.0	
Q1, Q3	20.0, 50.0	50.0, 150.0	27.5, 112.5	
Range	(10.0–300.0)	(25.0–660.0)	(10.0–660.0)	
Total intraoperative MME (mg)				<0.01[a]
Mean (SD)	193.6 (101.0)	132.4 (89.6)	157.6 (98.3)	
Median	192.0	88.8	153.6	
Q1, Q3	140.8, 237.9	60.0, 181.6	75.0, 222.1	
Range	(66.5–427.1)	(45.0–353.0)	(45.0–427.1)	
PACU VAS handoff				0.94[a]
N missing	3	3	6	
Mean (SD)	4.7 (2.0)	4.8 (2.1)	4.8 (2.1)	
Median	5.0	5.0	5.0	
Q1, Q3	4.0, 6.0	4.0, 6.0	4.0, 6.0	
Range	(0.0–8.0)	(0.0–9.0)	(0.0–9.0)	
Time to first ambulation (hours)				0.76[a]
N missing	1	2	3	
Mean (SD)	20.2 (13.9)	26.3 (21.1)	23.8 (18.5)	
Median	20.5	19.0	19.6	
Q1, Q3	11.3, 23.0	15.3, 37.5	13.1, 23.7	
Range	(4.1–64.7)	(3.4–89.6)	(3.4–89.6)	
Distance ambulated POD 1 (feet)				0.99[a]
N missing	4	5	9	
Mean (SD)	160.0 (138.7)	173.8 (218.4)	168.2 (188.4)	
Median	100.0	100.0	100.0	
Q1, Q3	60.0, 300.0	60.0, 200.0	60.0, 240.0	
Range	(15.0–400.0)	(10.0–1000.0)	(10.0–1000.0)	
MME at discharge (mg)				0.23[a]
Mean (SD)	100.1 (55.2)	79.4 (46.3)	88.0 (51.0)	
Median	90.0	90.0	90.0	
Q1, Q3	46.5, 135.0	48.8, 90.0	46.5, 128.0	
Range	(0.0–225.0)	(0.0–180.0)	(0.0–225.0)	

Table 4 (*continued*)

Table 4 (*continued*)

Secondary outcome variable	PercLIF (N=21)	MIS-TLIF (N=30)	Total (N=51)	P value
LOS (hours)				0.87[a]
Mean (SD)	71.3 (47.9)	69.7 (53.7)	70.4 (50.9)	
Median	50.5	50.8	50.7	
Q1, Q3	45.8, 96.3	44.9, 70.7	44.9, 78.7	
Range	(24.4–204.5)	(25.5–277.2)	(24.4–277.2)	
MME at POD 30 (mg)				0.80[a]
Mean (SD)	21.8 (45.0)	19.0 (45.4)	20.1 (44.8)	
Median	0.0	0.0	0.0	
Q1, Q3	0.0, 0.0	0.0, 0.0	0.0, 0.0	
Range	(0.0–180.0)	(0.0–90.0)	(0.0–180.0)	
Exiting nerve root injury				0.75[b]
Yes	2	1	3	
No	19	29	48	

[a], Wilcoxon; [b], Chi-square. percLIF, percutaneous lumbar interbody fusion; MIS-TLIF, minimally invasive transforaminal lumbar interbody fusion; SD, standard deviation; MME, morphine milligram equivalents; PACU, post-anesthesia care unit; VAS, visual analogue scale; POD, postoperative day; LOS, length of stay.

Table 5 24-hour MME by no intraoperative methadone

24-hour oral MME (mg)	PercLIF (N=13)	MIS-TLIF (N=29)	Total (N=42)	P value
Mean (SD)	92.2 (61.2)	132.6 (79.8)	120.1 (76.2)	0.049[a]
Median	77.5	126.0	107.3	
Q1, Q3	52.5, 105.0	79.5, 152.5	62.0, 147.0	
Range	(30.5–270.0)	(21.0–385.0)	(21.0–385.0)	

[a], Wilcoxon. MME, morphine milligram equivalents; percLIF, percutaneous lumbar interbody fusion; MIS-TLIF, minimally invasive transforaminal lumbar interbody fusion; SD, standard deviation.

has been limited research describing the difference in opioid consumption between patients undergoing MIS-TLIF compared to percLIF. To our knowledge, this is the first study comparing the narcotic consumption postoperatively between patients undergoing MIS TLIF versus percLIF.

PercLIF is a newer ultra-minimally invasive surgical technique that has gained popularity in the management of spinal decompression and interbody fusion. Preliminary results from published literature on the use of percLIF have demonstrated both feasibility and improved clinical outcomes including blood loss, faster recovery, and reduced soft tissue injury (15-18). Several published studies directly comparing percLIF to MIS-TLIF demonstrate faster recovery, reduced blood loss, and reduced postoperative pain in percLIF patients (6,7).

Our study suggests that percLIF is associated with a reduction of postoperative opioid utilization when compared to more traditional approaches. On univariate regression, we found a significant reduction in opioid consumption (P=0.02), while multivariate regression failed to reach significance by a small margin (P=0.06) possibly due to the small sample size. Additionally, it has been reported that a twenty-eight percent reduction in MME among spine surgery patients is the minimal clinically important difference (MCID) (19). MCID is the smallest change required in an outcome variable for an intervention

to be deemed beneficial based on patient self-reporting. Our results demonstrate nearly a forty-percent reduction in MME among the percLIF group, suggesting that these patients experience the MCID needed to support a clinically relevant improvement in the patient experience. Given these promising results, despite a small sample size, we are cautiously optimistic that for appropriate patients, the percLIF approach should be considered for patients utilizing ERAS protocols and for patient and physician teams seeking to limit the need for postoperative opioids.

Intraoperative MME was significantly higher among percLIF compared to MIS-TLIF patients and reflects the limitations of retrospective analysis compared to randomized control trials. This study includes a small sample size in addition to heterogeneity in intraoperative anesthetic protocols used across patients including the use of methadone. Secondary analysis of the results demonstrated that a higher number of percLIF patients received intraoperative methadone more than MIS-TLIF (8 *vs.* 1 patient) respectively. Methadone not only increases the calculated intraoperative MME but has been published in multiple to studies to reduce acute post-operative pain following surgery (20-22). However, among the 13 percLIF patients and 29 MIS-TLIF patients where intraoperative methadone was not used, there was a significantly lower 24-hour postoperative MME among percLIF patients. In the absence of methadone use, the results continue to suggest an associated decrease in the 24-hour postoperative narcotic consumption between the two surgical procedures.

There was no statistically significant difference in opioid consumption at discharge and at 30 days post-operatively. These results suggest that reduced narcotic consumption in the percLIF group compared to the MIS-TLIF groups is restricted to the first 24-hour following surgery. The reduction of acute post-operative pain is critical for several reasons. Severe postoperative pain is a known predictor of the development of chronic pain and leads to patient discomfort and dissatisfaction. High postoperative pain also causes delayed ambulation, pulmonary complications, and long-term functional impairment (20-23). Thus, while percLIF and MIS-TLIF had similar opioid use at discharge and minimal at 30 days post-op, the acute reduction in opioid requirements is a clinically important by reducing acute pain and reducing an important risk factor in the development of chronic pain.

Traditionally opioid medication has been the gold standard in the United States for moderate to severe postoperative pain control. Given that postoperative narcotic utilization is associated with a variety of side effects that can prolong hospital stays (24,25), reducing and limiting the use of opioids in the management of postoperative pain is a major priority in spine surgery. Many surgical specialties have adopted enhanced recovery after surgery (ERAS) protocols to aid in postoperative pain management and reduced opioid use.

While theoretically less invasive, percLIF does have technical limitations when compared to standard MIS-TLIF. Currently, the indications for percLIF are primarily limited to patients with low-grade spondylolisthesis and degenerative disc disease, due to the inability to do direct decompression with percLIF. MIS-TLIF can be used for patients with low-grade spondylolisthesis and degenerative disc disease as well as those with central and foraminal stenosis. Additionally, percLIF requires a significant learning curve even for surgeons familiar with MIS techniques. Newer endoscopic techniques that allow for central and foraminal decompression with limited tissue dissection may prove to be helpful in bridging the gap between MIS-TLIF and percLIF (6,26-29). Understanding the differences in post-operative opioid consumption between these treatments could be important in informing approach.

Overall, percLIF represents ongoing MIS innovation to spare tissue trauma for patients, speeding recovery while achieving similar radiographic and patient reported outcomes. One of the advantages of percLIF is it further decreases tissue trauma, even below that of MIS TLIF. This provides an opportunity to further refine peri- and post-operative pain control, with the goal of decreasing narcotic usage to protect patients from harmful side effects and the risk of addiction or dependence.

This study was limited by retrospective chart study and small sample size. This study focused specifically on the period 24 hours following surgery to monitor and calculate opioid consumption. In turn, our findings, while important for understanding the impact of percLIF in opioid consumption in the acute perioperative phase, is unable to assess any differences outside of the 24-hour postoperative window. Additionally, anesthesia techniques, medication administration, and dosages in the perioperative period were non-standardized and varied between patients and providers. This could have an unforeseen impact on immediate postoperative narcotic usage. We observed that there was a slightly higher number of percLIF patients that were discharged in less than 24-hour following surgery though interpretation is limited by sample size.

Additionally, the insignificant result of multivariable regression could be due to the small sample size so the future study with a larger sample size should be performed to further address this scientific question. One source of bias we attempted to limit in this study is the influence of preoperative narcotic consumption on postoperative opioid use. Fortunately, both groups compared equally at baseline. Another source of bias is that percLIF is rarely used for large decompression and spinal fusions. To limit bias of percLIF being used for smaller fusions, we chose to only include 1-level fusions as these compare favorably between both groups. All surgeries occurred at a single institution with two primary surgeons limiting generalizability to other medical institutions. Prospective studies may be helpful by providing standardization of pre-operative, intraoperative and postoperative anesthetic protocols, in addition to a larger sample size.

Conclusions

In the setting of the current opioid epidemic in the United States and increased numbers of patients undergoing lumbar interbody fusion, spine surgeons must continue to do their part helping reduce the need for opioid prescriptions for postoperative pain management. New "ultra-MIS" techniques such as percLIF allow surgeons to further decrease tissue trauma, which should lead to reduced need for post-operative narcotic requirements. Here, we showed that MME decreased significantly with percLIF, well over the MCID. Together with innovations in anesthesiology such as erector spinae plane blocks, this technique may help to minimize postoperative need for opioids. Larger studies with standardized intraoperative and postoperative pain management would be useful to further investigate the relationship between ultra-minimally invasive spine surgery and postoperative narcotic utilization.

Acknowledgments

Footnote

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