

# Clinical Outcomes of Minimally Invasive Versus Open TLIF: A Propensity-Matched Cohort Study

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## Abstract

In this study, we compare intermediate-term outcomes in minimally invasive surgical transforaminal lumbar interbody fusion (MISTLIF) to open TLIF. Sixty-four patients who underwent 1- to 2-level MISTLIF with baseline, 1-, and 2-year outcome measures were identified. These were propensity-matched to a cohort of open TLIF patients based on age, body mass index, sex, smoking status, workers' compensation status, and preoperative outcome measures. At 1 year, both groups had similar improvements in pain and Short-Form 36 (SF-36) Physical Composite Summary (PCS), but the MISTLIF group had a statistically significantly greater improvement in Oswestry

Disability Index (ODI) compared with the open TLIF group. At 2 years, the MISTLIF group had a statistically significantly greater improvement in pain and ODI compared with the open TLIF group, but no statistically significant difference in SF-36 PCS. Both MISTLIF and open TLIF lead to significant improvements in clinical outcomes. At 1 year after surgery, MISTLIF patients had greater improvements in ODI, and at 2 years after surgery, they had greater improvements in pain and ODI. This study showed that the perioperative advantages of MISTLIF, such as less muscle dissection and faster recovery, continue to be beneficial 1 to 2 years after surgery.

Transforaminal lumbar interbody fusion (TLIF) has become an increasingly popular method of lumbar fusion, since its introduction by Harms and Rolinger in 1982.<sup>1</sup> The procedure allows for a circumferential fusion through a posterior-only approach, with improved sagittal alignment<sup>2</sup> and minimal risk for iatrogenic nerve injury. In the past decade, a minimally invasive surgical method of TLIF (MIS TLIF) has been introduced<sup>3-5</sup> and involves neural decompression and interbody fusion through a tubular retractor, and percutaneous placement of pedicle-screw instrumentation. This technique uses muscle dilation rather than large-scale detachment of muscle. Proponents of the MIS technique have postulated that decreased muscle damage would lead to better short-term, and possibly long-term, clinical outcomes, because of less iatrogenic soft-tissue damage.

Studies that have compared results of MISTLIF with open TLIF have shown improved perioperative outcomes, but most have shown similar intermediate-term clinical outcomes.<sup>6</sup> In the short term, multiple studies demonstrate that MISTLIF is associated with decreased blood loss, less postoperative pain and narcotic requirements, and shorter hospital length of stay.<sup>7-13</sup> However, changes in pain score and disease-specific and generic health-related quality of life measures have been similar for the 2 procedures, beyond 6 months postoperatively.<sup>10,13-15</sup> These studies have generally involved retrospective reviews of unmatched patient groups, with small sample sizes and significant heterogeneity in surgical indications and case complexity. In our study, we compared intermediate-term clinical outcomes of MISTLIF with open TLIF, using propensity matching to optimize baseline similarity of the groups.

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### Methods

This retrospective study was conducted after receiving approval from the Institutional Review Board. Surgical and clinical databases of 2 centers from 2008 to 2012 were reviewed for eligible subjects. Cases in 2007 were excluded because this was the year that MIS was introduced as a new technique in the practice. Inclusion criteria consisted of patients who underwent 1- to 2-level MIS TLIF and had complete baseline, 1- and 2-year postoperative outcome measures. Patients who had surgery for trauma, tumor, or osteomyelitis were excluded. Outcome measures collected and reviewed in this study included the Oswestry Disability Index (ODI),<sup>16,17</sup> the Medical Outcomes Study Short-Form 36 (SF-36),<sup>18</sup> and numeric rating scales for back and leg pain (0-100 scale).<sup>19</sup> The Physical Composite Summary (PCS) and Mental Composite Summary of the SF-36 were reviewed separately. We recorded the following patient demographic data: age, gender, American Society of Anesthesiologists (ASA) grade, body mass index, indication for surgery, workers' compensation, and smoking status. Surgical data included number of levels fused, operative time, estimated blood loss, and length of hospital stay.

Propensity-scoring technique<sup>20,21</sup> was used to match the MIS TLIF patients to a control group of patients who underwent TLIF using an open approach (open TLIF), matching for multiple characteristics to produce 2 similar comparison groups. Propensity matching was performed to control for bias. In controlling for known confounders or biases, propensity matching, in theory, should also control for unknown confounders. Gender, age, body mass index, smoking status, indication for fusion, as well as preoperative ODI, SF-36 PCS, SF-36 Mental Composite Summary, and pain scores were used to generate a control open TLIF group.

### MIS TLIF Surgical Technique

Patients in the MIS TLIF group underwent neural decompression and interbody fusion through a tubular retractor system (METRx, Medtronic Inc.), followed by percutaneous pedicle-screw fixation under fluoroscopic guidance (Sextant, Medtronic Inc.). After successful induction of general endotracheal anesthesia, patients were positioned prone on a radiolucent table. Posteroanterior (PA) and lateral fluoroscopic images were used to localize 2 paramedian incisions, approximately 3-cm to 5-cm lateral to midline, over the pedicles of interest. Modified Jamshidi needles (Medtronic Inc.) were

used to cannulate the pedicles under PA, posterior-oblique, PA, and lateral fluoroscopic guidance. The pedicles were tapped with a cannulated tap. Pedicle screws and rods were introduced on the side contralateral to the TLIF and were used as needed to maintain intradiscal distraction during the TLIF portion of the procedure.

Decompression and TLIF were carried out on the side of the patient's radicular pain or bilaterally, according to the surgeon's discretion. A K-wire was advanced to the facet joint complex, after which sequential dilators were used to dilate through the muscles to establish an intramuscular corridor to the facet. A 26-mm fixed tubular retractor was docked over the facet and locked in place, using a post attached to the operating room table. Neural decompression was obtained by removal of the entire facet-joint complex and lamina to the base of the spinous process, using a combination of high-speed drills and Kerrison rongeurs. The ligamentum flavum was completely resected. The superior articular process of the caudal vertebra was removed all the way to the pedicle below. Ball-tipped probes were used to confirm that traversing and exiting nerve roots were completely free. An annulotomy was performed, and all disc material was removed from the disc through a combination of rotating shavers, serrated curettes, endplate scrapers, and rasps. Bone graft was placed anterior and contralateral to the interbody cage. (Bone grafts included autogenous iliac crest, local bone obtained from the decompression, recombinant human bone morphogenetic protein 2, or allograft demineralized bone matrix at the surgeon's discretion.) After placement of the interbody cage, the ipsilateral pedicle-screw instrumentation was put over the remaining guide wires and compression applied across the construct to lock the interbody cage and restore lordosis. Wounds were closed without drains.

### Open TLIF Surgical Technique

In patients undergoing open TLIF, a midline incision was made over the vertebrae of interest, and paraspinous muscles were subperiosteally dissected to the tips of the transverse processes. The appropriate level was confirmed with intraoperative radiograph. Pedicle screws were placed free-hand using anatomic landmarks, and appropriate placement was confirmed with intraoperative radiograph and evoked electromyography stimulation. Laminectomy and facetectomy were performed, and the disc was entered on the side

of the facetectomy. After thorough disc-space preparation, bone graft and an interbody cage were placed, rods inserted, and compression carried out. A supplemental posterolateral fusion was also performed after decortication of the transverse processes and cartilaginous surface of the contralateral facet. Layered wound closure was performed over drains.

**Analysis**

Statistical analysis was carried out using SPSS Statistics version 17.0 (IBM) with significance set at the *P* < .01 level. A small, conservative *P*-value threshold was used to minimize type II error that resulted from the multiple comparisons performed. Student *t* test was used to determine any significant differences between continuous demographic variables, and to compare preoperative and postoperative outcome measure scores within

and between study groups. Fisher’s exact test was used to compare categorical variables between the 2 groups.

**Results**

The MISTLIF group consisted of 64 patients (average age, 52 years), and included 22 patients with degenerative spondylolisthesis, 33 with disc pathology, 8 with postdecompression, and 1 nonunion patient. The open TLIF group consisted of 64 patients (average age, 54 years), and included 39 degenerative spondylolisthesis, 15 disc pathology, 7 postdecompression, and 3 nonunion patients (Table 1). All 64 open and 19 MIS cases were from a spine practice with 6 surgeons, and 45 MIS cases came from a spine practice with 2 surgeons. There was also an unequal distribution of the specific levels fused between the open and MIS groups.

Although the operative time was similar in both

Table 1. Summary of Demographic Data and Surgical Indications

	Open	MIS	<i>P</i> value
<b>N</b>	64	64	
Men	22	31	.106
Age, years, mean (SD)	54.25 (10.81)	51.92 (14.15)	.298
Workers’ compensation	1	5	.208
Diagnosis			.006
Degenerative spondylolisthesis	39	22	
Disc pathology	15	33	
Nonunion	3	1	
Postdecompression	7	8	
Levels			.000
L2-L3	1	0	
L2-L4	1	1	
L3-L4	5	0	
L3-L5	6	6	
L4-L5	26	10	
L4-S1	6	24	
L5-S1	19	23	

Abbreviations: MIS, minimally invasive surgery; N, number.

Table 2. Summary of Surgical Data<sup>a</sup>

	Open	MIS	<i>P</i> value
Estimated blood loss, mL	614.06 (409.65)	262.42 (182.09)	.000
Operative time, min	278.69 (93.79)	263.55 (108.09)	.399

<sup>a</sup>Mean (SD)  
Abbreviation: MIS, minimally invasive surgery.

groups, the MIS TLIF group had a statistically significantly lower blood loss compared with the open TLIF group (**Table 2**). Both MIS TLIF and open TLIF lead to significant improvements in pain, ODI, and SF-36 PCS ( $P < .01$ ) (**Table 3**). At 1 year, both groups had similar improvements in pain (36.9 vs 30.8,  $P = .178$ ) and SF-36 PCS (9.9 vs 7.5,  $P = .231$ ), but the MIS TLIF group had a statistically significantly greater improvement in ODI compared with the open TLIF group (30.4 vs 15.1,  $P < .000$ ). At 2 years, both groups had similar improvements in SF-36 PCS (12.1 vs 7.5,  $P = .033$ ), but the MIS TLIF group had a statistically significantly greater improvement in pain (40.2 vs 27.0,  $P = .005$ ) and ODI (33.1 vs 15.4,  $P < .000$ ) compared with the open TLIF group (**Table 4**).

## Discussion

The current study compared intermediate-term clinical outcomes of MIS TLIF to open TLIF. We

used propensity matching to identify a control group of open TLIFs that were comparable to the MIS TLIF group across a variety of covariates that are known to influence the results of lumbar fusion. This created comparison groups that were as closely matched at baseline as possible. We found that, at 2-year follow-up, MIS TLIF patients had less pain and less low-back pain–related disability as measured by ODI. There was also a trend toward better generic health-related quality of life in the MIS TLIF group.

These data suggest that the decreased soft-tissue trauma of the minimally invasive surgical technique, which leads to improved perioperative parameters in the short term, may also lead to some advantages that translate to improved intermediate-term clinical outcomes. Traditional lumbar fusion procedures have shown excellent clinical results when used for accepted clinical indications.<sup>22</sup> However, the procedure requires exten-

**Table 3. Clinical Outcomes**

	Open	MIS	P value
Preoperative			
Numeric Pain Scale	72.03 (18.62)	63.28 (19.77)	.011
ODI	45.13 (13.95)	52.75 (12.50)	.001
SF-36 PCS	28.97 (7.92)	30.17 (7.47)	.380
1 year after surgery			
Numeric Pain Scale	41.25 (29.52)	26.41 (27.10)	.004
ODI	30.02 (19.42)	22.38 (19.96)	.030
SF-36 PCS	37.01 (11.46)	40.66 (10.78)	.068
2 years after surgery			
Numeric Pain Scale	45.00 (28.73)	23.13 (29.97)	.000
ODI	29.74 (20.56)	19.69 (21.71)	.008
SF-36 PCS	37.65 (11.51)	42.90 (12.65)	.017

Abbreviations: MIS, minimally invasive surgery; ODI, Oswestry Disability Index; SF-36 PCS, Short-Form 36 Physical Composite Summary.

**Table 4. Change in Clinical Outcome Scores at 1 and 2 Years After Surgery**

	Open	MIS	P value
1-year change in score from preoperative			
Numeric Pain Scale	30.78 (28.97)	36.88 (21.37)	.178
ODI	15.11 (15.24)	30.37 (18.38)	.000
SF-36 PCS	7.46 (12.22)	9.85 (10.14)	.231
2-year change in score from preoperative			
Numeric Pain Scale	27.03 (28.21)	40.16 (22.85)	.005
ODI	15.39 (16.72)	33.06 (20.48)	.000
SF-36 PCS	7.50 (12.47)	12.06 (11.42)	.033

Abbreviations: MIS, minimally invasive surgery; ODI, Oswestry Disability Index; SF-36 PCS, Short-Form 36 Physical Composite Summary.

sive dissection of the paraspinal muscles, which causes significant muscle damage as evidenced by muscle breakdown products that can be detected in the bloodstream postoperatively.<sup>23,24</sup> The lateral dissection also transects the dorsal ramus of the segmental nerves, which innervate the paraspinal muscles, leading to significant scarring and atrophy on postoperative imaging studies.<sup>23</sup> Some authors have used the term “fusion disease” to describe the constellation of soft-tissue degradation seen after open lumbar fusion.<sup>5</sup>

An MIS version of the TLIF procedure that was described in 2003<sup>3</sup> avoids much of this iatrogenic soft-tissue trauma. It involves intramuscular dilation to approach the spine and to carry out neural decompression and interbody fusion, in conjunction with percutaneous pedicle-screw instrumentation. Proponents of this technique point to diminished iatrogenic soft-tissue and muscle damage as an advantage. Multiple studies have, in fact, confirmed improved short-term perioperative parameters, such as less blood loss, lower narcotic requirements, and decreased length-of-hospital stay.<sup>25</sup> Economic analyses have also shown lower direct and indirect costs with the MIS technique.<sup>26</sup>

Several studies have compared patient-reported outcome measures of MIS and open TLIF, and the results have been mixed. Most of these studies have shown similar improvement in clinical outcomes between the 2 procedures, but the MIS technique demonstrated short-term perioperative advantages, such as lower blood loss, less narcotic requirements, and shorter length of stay.<sup>7-15</sup> The authors of these studies conclude that the MIS technique can provide similar long-term results with lower short-term morbidity when compared with open TLIF. In contrast, some studies have shown better short- and intermediate-term clinical outcomes with the MIS technique.<sup>23,27-29</sup> As a whole, the literature comparing the 2 procedures consists of mostly small retrospective studies with nonrandomized patient samples, heterogeneous surgical indications, and differing surgical techniques, making it difficult to draw conclusions.

The current study suggests that MIS TLIF may lead to improved clinical results at 2-year follow-up, compared with open TLIF. Our study used propensity-score matching to minimize the effects of nonrandom assignment of subjects to MIS TLIF or open TLIF. A limitation of observational studies is that bias in assignment of subjects to treatment groups can lead to overestimation or underestimation of the effect of the treatment itself. Propen-

sity-score matching attempts to reduce this bias by accounting for several covariates that predict whether a subject will receive a certain treatment. These covariates are used in a logistic regression to produce a propensity score, which can be used to match subjects to controls across multiple dimensions, thus ensuring groups are as comparable as possible at baseline.

Our study still has several limitations. Sample size is relatively small, and follow-up is still only intermediate, at 2 years. There was unequal distribution of specific levels of surgery. Because patients were not blinded to the treatment they received, it is possible that patient perception of receiving a newer, less-invasive treatment method may influence their subjective improvement. The study sample was drawn from 2 different centers, with one center providing mostly MIS cases and the other providing mostly open cases. Because of this, undetected differences in how patients were selected for surgery could also affect outcomes. Any latent confounding variables, which are not identified a priori, will not be accounted for in the matching process. Only a prospective, randomized study with large numbers can control for observed and unobserved confounding patient characteristics.

In summary, our study shows that MIS TLIF is associated with improved low back pain and low back-related disability at 2 years compared with open TLIF. Other studies comparing the 2 techniques have come to different conclusions regarding whether the short-term benefits of MIS TLIF translate into long-term differences in clinical outcome. This study adds to this evidence and suggests there may be longer term advantages to the MIS approach, but prospective randomized trials are needed to confirm this finding and determine the true magnitude of these differences.

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