Minimally invasive lateral retroperitoneal transpsoas interbody fusion for L4–5 spondylolisthesis: clinical outcomes

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Clinical article

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Object. In this study the authors report on the clinical outcomes, safety, and efficacy of lateral retroperitoneal transpsoas minimally invasive surgery–lumbar interbody fusion (MIS-LIF) at the L4–5 disc space in patients with spondylolisthesis. This approach has become an increasingly popular means of fusion. Its most frequent complication is lumbar plexus injury. Reported complication rates at the L4–5 disc space vary widely in the literature, bringing into question the safety of MIS-LIF for the L4–5 region, especially in patients with spondylolisthesis.

Methods. The authors retrospectively reviewed prospectively acquired multicenter databases of patients with Grade I and II L4–5 spondylolisthesis who had undergone elective MIS-LIF between 2008 and 2011. Clinical follow-up had been scheduled for 1, 3, 6, 12, and 24 months postoperatively. Outcome measures included estimated blood loss, operative time, length of hospital stay, integrity of construct, complications, fusion rates, visual analog scale (VAS), Oswestry Disability Index (ODI), and 36-Item Short Form Health Survey (SF-36).

Results. Eighty-four patients with L4–5 MIS-LIF were identified, 31 of whom met the study inclusion criteria: 26 adults with Grade I and 5 adults with Grade II L4–5 spondylolisthesis who had undergone elective MIS-LIF and subsequent posterior percutaneous pedicle screw fixation without surgical manipulation of the posterior elements (laminectomy, foraminotomy, facetectomy). The study cohort consisted of 9 males (29%) and 22 females (71%) with an average age of 61.5 years. The mean total blood loss was 94 ml (range 20–250 ml). The mean hospital stay and follow-up were 3.5 days and 18.2 months, respectively. The average score on the ODI improved from 50.4 preoperatively to 30.9 at the last follow-up (p < 0.0001). The SF-36 score improved from 38.1 preoperatively to 59.5 at the last follow-up (p < 0.0001). The VAS score improved from 69.9 preoperatively to 38.7 at the last follow-up (p < 0.0001). No motor weakness or permanent deficits were documented in any patient. Correction of deformity did not have any neurological complications. All patients had improvement in anterolisthesis. Residual postoperative listhesis across cases was noted in 4 patients (12.9%). Transient anterior thigh numbness (Sensory Dermal Zone III) was noted in 22.5% of patients.

Conclusions. With its established surgical corridors through the retroperitoneum and psoas muscle, the MIS-LIF combined with posterior percutaneous pedicle screw fixation/reduction is a safe, reproducible, and effective technique for patients with symptomatic degenerative spondylolisthesis at the L4–5 vertebral segment.

Key Words • lateral lumbar interbody fusion • retroperitoneal • transpsoas approach • minimally invasive surgery • spine fusion • spondylolisthesis • extreme lateral interbody fusion

Abbreviations used in this paper: ALIF = anterior lumbar interbody fusion; EMG = electromyography; LIF = lumbar interbody fusion; MIS-LIF = minimally invasive surgery–LIF; ODI = Oswestry Disability Index; PLIF = posterior LIF; SF-36 = 36-Item Short Form Health Survey; TLIF = transforaminal LIF; VAS = visual analog scale.

Axial back pain with radiculopathy, neurogenic claudication, or instability is associated with a varied degree of spondylolisthesis for which surgical intervention may be warranted. Treatment options have ranged from limited decompression to decompression with anterior and/or posterior fusion with or with-
out listhesis correction to multilevel fusion for deformity correction. In patients with spondylolisthesis and related neurological symptoms, the radiographic and clinical outcome of spinal fusion has been suggested to be superior to conservative treatment and decompression alone. Traditional posterior approaches in combination with anterior arthrodesis have been advocated and routinely used for spinal fusion in this population with satisfactory results. Prior to choosing a particular surgical technique, approach-related risks and complications should be considered. Posterior approaches necessitate relatively extensive muscle dissection and removal of posterior elements, which can further compromise spinal stability.

Minimally invasive surgery has been developed to potentially mitigate approach-related risk and surgical morbidity. Minimally invasive TLIF, mini-open TLIF/PLIF, and ALIF are common and effective techniques permitting direct decompression of neural elements, interbody fusion, and deformity correction through a single approach. However, these procedures still entail some degree of ligamentous and/or facet disruption.

The lateral retroperitoneal transpsoas MIS-LIF has become an increasingly popular means of fusion because it avoids disruption of the posterior stabilizing elements of the spine, provides indirect foraminal decompression, and allows placement of a larger interbody implant with satisfactory fusion rates. However, there has been some reservation among surgeons regarding the safety of MIS-LIF at the L4–5 disc space because of the risk of lumbar plexus injury, particularly the femoral nerve. Reported motor nerve complication rates vary widely, ranging from 0.7% to 33.6%, and there is concern that the risk may be greater with the presence of spondylolisthesis. The literature is limited as regards the minimally invasive lateral approach for patients with spondylolisthesis. However, with a thorough understanding of the regional anatomy, directionally intraoperative EMG, and a meticulous surgical technique, the L4–5 interspace can be safely accessed. In this study we report on the clinical and radiographic outcomes, safety, and efficacy of MIS-LIF combined with posterior percutaneous pedicle screw placement at the L4–5 disc space in patients with Grade I and II spondylolisthesis.

Methods

Study Design and Patient Population

We performed a retrospective multicenter database review of all patients with L4–5 spondylolisthesis (Grade I and II) who had undergone elective minimally invasive lateral retroperitoneal transpsoas LIF between 2008 and 2011. Initial patient selection for surgery was based on the presence of symptomatic L4–5 listhesis and the absence of improvement with conservative measures. Preoperative symptoms included radiculopathy, neurogenic claudication, and/or axial back pain. Study inclusion criteria were focal L4–5 listhesis, no history of previous lumbar spine surgery, no history of recent trauma, no significant sagittal or coronal imbalance, absence of degenerative disc disease at other lumbar levels, treatment with single-level lateral transpsoas LIF with percutaneous posterior short-segment instrumentation, and data from at least 2 of 3 selected outcome measures (VAS, ODI, or SF-36). Patients with stand-alone lateral fusion and open posterior instrumentation were excluded.

Outcome measures included estimated blood loss, length of hospital stay, integrity of construct, complications, fusion rates, VAS, ODI, and the SF-36. Responses to outcome questionnaires were obtained at each interval follow-up period. Clinical follow-up was scheduled for 1, 3, 6, 12, and 24 months postoperatively.

Fusion, deformity correction, and construct integrity were assessed with plain radiographs or CT scans. Descriptive statistical analysis was performed to compare outcome measures.

Surgical Procedure

Each patient in the database had undergone an extreme lateral interbody fusion (XLIF, NuVasive) only at L4–5 with a 10° lordotic cage 18–26 × 8–10 × 50–60 mm. The L-5 vertebral body was used to determine the docking landmark for the transpsoas retractor (Figs. 1 and 2). Great care was taken not to violate the L4–5 foramen. Directional EMG was used to ensure docking of the retractor was anterior to the femoral nerve. Subsequently, posterior percutaneous instrumentation was placed at corresponding levels. The restoration of disc height by the lateral cage provided partial reduction of listhesis (approximately 50%). The percutaneous posterior approach was performed with initial locking of the inferior pedicle screw (L-5) and thereby creating a cantilever to further reduce the remaining segmental listhesis.

Statistical Analysis

Preoperative and most recent follow-up clinical score averages were determined. The Shapiro-Wilk test was performed to confirm normally distributed data. The paired t-test was used to compare means. The p values were determined for each clinical outcome measure. Statistical significance was defined with a p < 0.05.

Results

We initially identified 84 patients with L4–5 lateral MIS fusions between 2008 and 2011. Thirty-one patients (9 males and 22 females) met the study inclusion criteria (Table I). Twenty-six patients had Meyerding Grade I listhesis, and 5 patients had Grade II listhesis. The mean combined blood loss was 94 ml (range 20–250 ml). The average hospital stay and follow-up were 3.5 days and 18.2 months, respectively.

There were no anesthesia-related intraoperative complications or surgical adverse events. Postoperatively, 7 patients (22.5%) experienced transient postoperative anterior thigh numbness that resolved by 3 months. There were no permanent neurological deficits. Neither were there any hardware failures or pseudarthrosis in the follow-up period (Table 2 and Fig. 3). All patients exhibited radiographic and clinical evidence of fusion as determined by static and dynamic radiographs, or CT scans.
when available, at 6 months. The single intraoperative implant complication consisted of a broken guidewire during percutaneous posterior pedicle screw placement but had no clinical consequence.

The average ODI improved from 50.4 preoperatively to 30.9 at the last follow-up (p < 0.0001). The average SF-36 score improved from 38.1 preoperatively to 59.5 at the last follow-up (p < 0.0001). The average VAS score improved from 69.9 preoperatively to 38.7 at the last follow-up (p < 0.0001). All patients had improvement in anterolisthesis. Twenty-seven patients had complete reduction of the listhetic deformity; 4 patients (12.9%) had residual postoperative listhesis.

**Discussion**

The minimally invasive lateral transpsoas approach to the L4–5 disc involves navigating nerves of the lumbar plexus and therefore has a higher risk of nerve injury than more cephalad levels. Moreover, the presence of a spondylolisthesis at this level may alter the regional anatomy and, intuitively, surgery at this level is more difficult. Data in the present study demonstrate that surgery at L4–5 with listhesis is feasible, safe, and efficacious.

The goal of surgical intervention in patients with lumbar listhesis includes not only neural decompression and stabilization of the motion segment, but also the
restoration of sagittal alignment and the maintenance of lumbar lordosis. The restoration of disc height and anterior interbody fusion in combination with posterior instrumentation allows for the opportunity to favorably alter spinopelvic parameters such as segmental lumbar lordosis. Challenges with traditional techniques, such as posterior interbody fusion and transforaminal interbody fusion, can include anterior placement of the interbody cage, which can be crucial to the restoration of segmental lordosis. Segmental lumbar lordosis is improved through the restoration of disc height with larger lordotic interbody cages such as is possible in both ALIF and MIS-LIF. Marchi et al. presented their case series on stand-alone lateral interbody fusion for lumbar listhesis with a significant improvement in lumbar lordosis and disc height, although their subsidence rate and revision surgery rate were 17% and 13%, respectively.

Transient Sensory Deficits

Approach-related neural complications of the retroperitoneal transpsoas approach, despite directional EMG monitoring, have been well established in the literature. Injury to sensory components of the plexus is not well predicted by nerve monitoring; fortunately, isolated sensory deficits tend to be transient. Understanding the mechanism of nerve injury and the anatomical properties of peripheral nerves can help to determine a nerve’s susceptibility to injury. Most nerves of the lumbar plexus have both sensory and motor components with varied degrees of axonal diameter and myelination. Sensory fibers, which are smaller in diameter, are more susceptible to manipulation than are motor fibers. Iatrogenic nerve traction has been associated with focal ischemia of the involved nerve. However, transient sensory deficits (that is, those lasting <3 months) most likely represent mild neurapraxia (Sutherland Grade I) of the sensory fibers. In our study, all of the sensory deficits were noted in the femoral nerve distribution (Sensory Dermal Zone III) without a motor component. The incidence of transient sensory deficits in patients with L4–5 listhesis is similar to that in patients without such displacement, although there is great variability in reported motor and sensory complications.

Anatomical Considerations

The importance of a thorough understanding of the regional paraspinal anatomy to successfully navigate through the psoas muscle without injuring the lumbar plexus cannot be overstated. Directional EMG monitoring is a critical adjunct for determining a safe trajectory through the psoas muscle. Establishing a safe corridor through the psoas muscle at the L4–5 disc space requires imaging, real-time EMG, understanding of the regional anatomy with its variations, and surgeon experience. In an approach to a nonlisthetic L4–5, the usual access corridor is slightly more anterior than that at rostral levels. In a patient with anterolisthesis, however, the regional anatomy may be altered, underscoring the importance of directional EMG as a navigational tool. Preservation of the anterior and posterior longitudinal ligaments and avoidance of the neural foramen are of particular importance in patients with moderate-grade listhesis. As a general rule, in a patient with L-4 on L-5 anterolisthesis, the L-5 vertebral body should be used to determine radiographic docking landmarks. Depending on the degree of listhesis, the radiographic docking region may be further anterior on the L-5 vertebral body and more posterior on the L-4 vertebral body—hence the importance of real-time directional EMG. We suspect that even though in anterolisthesis the vertebral body is translated ventrally, the lumbar plexus maintains its position within the psoas muscle.

Clinical Outcomes

Clinical outcomes in our study, as measured using the ODI, VAS, and SF-36, indicated significant clinical improvement in preoperative symptoms and satisfaction with MIS-LIF. There were no motor complications, and transient sensory deficits resolved within 3 months. In patients...
with preoperative radicular symptoms, indirect decompression with MIS-LIF and correction of listhesis resolved leg symptoms. The correction was maintained until fusion, with fusion rates comparable to those with traditional approaches. Deformity corrections were done without direct foraminotomy. There were no incidents of weakness or foot drop related to correction. In all patients, there was a trend toward improvement in health-related quality of life (SF-36), pain (VAS), or related disability (ODI).

Conclusions

A minimally invasive lateral transpsoas approach to L4–5 involved navigating the lumbar plexus, particularly the femoral nerve. With the use of intraoperative directional EMG and a detailed understanding of regional anatomy, one can safely and effectively access L4–5, even in patients with anterolisthesis.

Disclosure

Dr. Uribe is a consultant for NuVasive. Dr. Mundis is a consultant for NuVasive and DePuy. Dr. Oskouian is a consultant for NuVasive and Stryker; receives royalties from and is a consultant for Globus; and has ownership in DePuy.

Author contributions to the study and manuscript preparation include the following. Acquisition of data: all authors. Analysis and interpretation of data: Ahmadian, Verma. Drafting the article: Ahmadian, Uribe. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Ahmadian. Statistical analysis: Ahmadian. Study supervision: Uribe.
TABLE 2: Radiographic and clinical outcomes in 31 adults who underwent MIS-LIF

<table>
<thead>
<tr>
<th>Factor</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>transient numbness</td>
<td>7 (22.5)</td>
</tr>
<tr>
<td>permanent deficit</td>
<td>none</td>
</tr>
<tr>
<td>aborted cases</td>
<td>none</td>
</tr>
<tr>
<td>fusion rate*</td>
<td>100%</td>
</tr>
<tr>
<td>males/ ( % ) females</td>
<td>29/ 22 (71)</td>
</tr>
<tr>
<td>mean age in yrs</td>
<td>61.5</td>
</tr>
<tr>
<td>mean follow-up in mos</td>
<td>18.2</td>
</tr>
<tr>
<td>mean hospital stay in days</td>
<td>3.5</td>
</tr>
<tr>
<td>complication intraop (%)</td>
<td>1 (3.2)</td>
</tr>
<tr>
<td>postop</td>
<td>none</td>
</tr>
<tr>
<td>Meyering anterolisthesis grade</td>
<td>I 26</td>
</tr>
<tr>
<td></td>
<td>II 5</td>
</tr>
<tr>
<td>mean ODI score</td>
<td>19.5†</td>
</tr>
<tr>
<td>mean VAS score</td>
<td>31.3†</td>
</tr>
<tr>
<td>mean SF-36 score</td>
<td>-21.4†</td>
</tr>
</tbody>
</table>

* Fusion as determined by radiograph, or CT when available, and absence of pseudarthrosis.
† p < 0.0001, paired t-test.

References


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