Minimally Invasive Transforaminal Lumbar Interbody Fusion in the Outpatient Setting

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Abstract: Minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF) has been shown to have long-term clinical outcomes similar to those with open TLIF and decreased perioperative morbidity. This study assessed whether this procedure can be safely performed in outpatient settings. Ninety-six consecutive patients undergoing 1- or 2-level MIS-TLIFs were retrospectively reviewed. They were divided into inpatient and outpatient cohorts (36%). All had a minimum of 2 years of follow-up. Patient demographics, comorbidities, complications, and readmissions were examined. Early postoperative complications were stratified into wound related, infection, neurologic, implant related, and vascular injuries. Patients in the outpatient cohort were significantly younger, had lower American Society of Anesthesiologists physical status scores, and had lower Charlson Comorbidity Index scores than patients in the inpatient cohort. There were no statistically significant differences in overall postoperative complication rates, readmission rates, or final Oswestry Disability Index or visual analog scale scores between the 2 cohorts. The clinical outcomes of the outpatient TLIF procedure were similar to those of the inpatient procedure and it had an acceptable complication rate. [Orthopedics. 2016; 39(6):e1218-e1222.]
knowledge, there are currently no data in the literature on the safety and complication rates of instrumented MIS-TLIF performed in an outpatient setting. Thus, the purpose of this study was to identify patient selection criteria for safe performance of MIS-TLIF in an outpatient setting. Specifically, the authors compared (1) patient characteristics, including age, sex, and comorbidities; (2) complications; (3) readmission rates; and (4) clinical outcomes measured by the Oswestry Disability Index (ODI) and pain levels measured by the visual analog scale (VAS) between patients who had received MIS-TLIF in the inpatient vs outpatient setting.

**Materials and Methods**

After obtaining appropriate institutional review board approval for this study, the authors reviewed the database of all 108 consecutive patients who had undergone a MIS-TLIF at a single high-volume institution between January and December 2012. All medical records, including history and physical examinations, operative notes, discharge summaries, and follow-up office visits, as well as all appropriate radiographs were carefully reviewed. Patients with complete medical records, both clinical and radiographic, were included in the analysis. All patients were evaluated at a mean of 29 months of follow-up (range, 24-36 months) and no patient was lost to follow-up. The main indications for surgery included degenerative disk disease, lumbar spinal stenosis, spondylolisthesis (grades 1 and 2), prior failed decompression for herniated disk, stenotic radiculopathy requiring complete facetectomy, and iatrogenic instability. Exclusion criteria included infection, tumor, prior instrumentation, high-grade spondylolisthesis, and workers’ compensation (n=12).

All MIS-TLIF procedures were performed with the patient in the prone position on a radiolucent table and using standard dual planar fluoroscopy. Percutaneous guide-wires used for pedicle screw instrumentation were placed according to the standard technique and used as guides for approach to the facet joint. Next, Jamshidi trocars (Becton, Dickinson, and Company, Franklin Lakes, New Jersey) were used to obtain the correct trajectory of the pedicle screws above and below the level that needed decompression. The trocars were placed at the junction of the facet lamina and gently impacted transpedicularly into the vertebral body in a converging fashion. Anteroposterior and lateral radiographs were obtained once the correct trajectories of the pedicle screws were obtained. Pedicle screws and rods were placed after the decompression was completed. The side for decompression was selected based on the patient’s primary symptoms. A roughly 2.5-cm incision was made approximately 4 to 5 cm off midline in a paramedian fashion. Once the facial layer was incised, a tubular retractor system was used and sequential dilation of the paraspinal soft tissue was completed in a Wilse fashion. A tube was inserted and docked over the facet joint for the planned decompression. Microscopic technique was used to perform an en bloc facetectomy; a high-speed burr was used to remove the inferior articular facet of the cephalad level and superior articular facet of the caudal level. Once completed, the traversing nerve root was identified and retracted medially. A radical disectomy was performed and interbody fusion was carried out using morselized autograft from the harvested lamina and facet mixed with corticocancellous allograft and demineralized bone matrix. Somatosensory and motor evoked potentials were monitored throughout the procedure and each percutaneous tap and screw was stimulated to monitor electromyography potentials.

Patients were divided into 2 groups for comparative analysis. The outpatient group included patients undergoing MIS-TLIF who were discharged in less than 24 hours from admission. The inpatient group included those requiring inpatient admission and postoperative monitoring. All patients were assessed clinically at 2 weeks, 6 weeks, 3 months, 6 months, and annually thereafter. During each clinical visit, patients were thoroughly examined and VAS back and leg pain scores and ODI scores were recorded. Patients were also assessed for all potential relevant complications, which were stratified into wound related, infection, neurologic, implant related, and vascular injuries.

**Results**

In the outpatient cohort, there were 11 women and 21 men who had a mean age of 47 years (range, 27-66 years). In the inpatient cohort, there were 24 women and 40 men who had a mean age of 51 years (range, 21-76 years). The outpatient cohort was significantly younger (P=.04); however, there was no significant difference in the men to women ratio (P=.82).

A statistically significant difference did exist between the 2 groups regarding American Society of Anesthesiologists physical status score (mean, 1.4 vs 2.5; P<.01). A complete summary of the demographic data is found in Table 1. The rate of postoperative complications was similar between the 2 cohorts (9.4% vs 14%; P=.5). In the outpatient cohort, there were 3 surgery-related complications requiring revision: 2 cases of postoperative radiculopathy due to allograft malposition and 1 case of hardware failure from rod disengagement. In the inpatient cohort, there were 9 complications: 3 cases of postoperative radiculopathy due to bone graph displacement; 1 case of post-
operative radiculopathy due to hardware placement; 2 cases of wound dehiscence and hardware prominence; 1 case of headache due to incidental durotomy, which was self-resolved; and 2 cases of surgical site infections, which were treated by surgical washout and intravenous antibiotics (Table 2).

The overall rate of readmission was not statistically significantly different between groups (odds ratio, 5.08; 95% confidence interval, 0.26 to 97.5; \( P=0.28 \)). In the inpatient cohort, there were 3 readmissions (4.7%). Others in the inpatient cohort requiring revision surgery were identified in the early postoperative hospital stay prior to discharge. Readmissions included a late surgical site infection, a patient with hardware prominence and wound dehiscence, and a patient with progressive radiculopathy due to displaced bone graft nerve root compression. There was 1 readmission (3.1%) in the outpatient cohort because of new leg pain on the second postoperative day. Computed tomography confirmed isolated nerve root compression by displaced bone graft. The patient underwent revision decompression surgery on the following day and was discharged after an uncomplicated postoperative course. All patients who were readmitted had an uneventful recovery.

There were no significant differences in the final VAS or ODI scores between the 2 cohorts (\( P=0.05 \)). In the outpatient cohort, the mean ODI score had improved from 43 points (range, 35-61 points) to 22 points (range, 8-29 points); this was similar to the inpatient cohort, which improved from 45 points (range, 39-64 points) to 23 points (range, 8-29 points). The mean VAS back and leg pain scores had improved from 8.5 points (range, 7-10 points) and 8.2 points (range, 7-10 points) to 3.5 points (range, 3-5 points) and 2.5 points (range, 2-3 points), respectively, in the outpatient cohort. Similarly, the mean VAS back and leg pain scores in the inpatient cohort had improved from 8.6 points (range, 7-10 points) and 8 points (range, 7-10 points) to 3.5 points (range, 3-5 points) and 2.5 points (range, 2-3 points), respectively.

**DISCUSSION**

Open transforaminal lumbar interbody fusions have been performed for years with the goal of alleviating nerve compression and achieving stable arthrodesis with improved disk height and fusion rates.\(^3\)\(^4\) The TLIF procedure has reduced the complications of vessel injury, sympathetic nerve injury, and injury to retroperitoneal and peritoneal structures associated with anterior lumbar interbody fusion.\(^9\) Recent development of the MIS-TLIF technique has further reduced the risks associated with the conventional open technique.\(^1\)\(^2\)\(^10\)\(^12\)\(^14\) In MIS-TLIF, the tubular retractor system has been used to limit soft tissue trauma, blood loss, and postoperative pain and has increased the rate of recovery.\(^3\) Thus, the purpose of this study was to evaluate whether outpatient MIS-TLIFs would have safety and clinical outcomes comparable with those of inpatient MIS-TLIFs.

This study had several limitations. The retrospective nature of the study could have introduced potential biases, such as selection or information biases, that would otherwise be reduced with a prospective, randomized study. Selecting outpatient MIS-TLIF procedures based on the surgeon’s analysis of individual medical comorbidities may have introduced further bias, and broader quality of life measures such as patient activity or satisfaction were not evaluated. This same design bias may be seen in the significant difference in American Society of Anesthesiologists scores. Criteria for clearance for discharge by anesthesia were not analyzed in particular. However, the desire to observe a patient postoperatively and the suspicion of complication by the anesthe-

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**Table 1**

Comparison of Patient Demographics Between the 2 Cohorts

<table>
<thead>
<tr>
<th>Demographic</th>
<th>Outpatient Cohort</th>
<th>Inpatient Cohort</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men:women, ratio, No.</td>
<td>21:11</td>
<td>40:24</td>
<td>.8</td>
</tr>
<tr>
<td>Age, mean (range), y</td>
<td>47 (27-66)</td>
<td>51 (21-76)</td>
<td>.04</td>
</tr>
<tr>
<td>ASA comorbidity index, mean (range)</td>
<td>1.4 (0-2)</td>
<td>2.5 (2-4)</td>
<td>.01</td>
</tr>
<tr>
<td>Length of stay, mean (range), d</td>
<td>0.6 (0-2)</td>
<td>2.6 (0-9)</td>
<td>.01</td>
</tr>
<tr>
<td>Levels fused, mean (range), No.</td>
<td>1.1 (1-2)</td>
<td>1.2 (1-2)</td>
<td>.9</td>
</tr>
<tr>
<td>Revision cases, No.</td>
<td>9</td>
<td>11</td>
<td>.71</td>
</tr>
<tr>
<td>Readmission rate</td>
<td>3%</td>
<td>4.7%</td>
<td></td>
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</tbody>
</table>

Abbreviation: ASA, American Society of Anesthesiologists.

**Table 2**

Comparison of Complications Between the 2 Cohorts

<table>
<thead>
<tr>
<th>Complication</th>
<th>Outpatient Cohort</th>
<th>Inpatient Cohort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurological(^a)</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Postoperative hematoma</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Incidental durotomy</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Surgical site infection</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Instrumentation(^b)</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

\(^a\)Allograft malposition or persistent nerve root compression. 
\(^b\)Pedicle screw malposition, hardware prominence, and rod disengagement.
sociologist cannot be separated. Nevertheless, the authors believe that the outcomes are valuable because this is the first study to evaluate the safety of performing MIS-TLIF as an outpatient surgical procedure.

The lower morbidity profile and faster recovery with MIS-TLIF have introduced the possibilities of performing this procedure within an outpatient setting. However, to the authors’ knowledge, no previous study has evaluated the complication rates and safety profile of outpatient MIS-TLIFs. Nevertheless, the authors’ findings are comparable with those of previous studies evaluating inpatient MIS-TLIFs.

Chin et al15 reviewed 16 consecutive patients (56% male; mean±SD age, 42.81±3.05 years; mean±SD body mass index, 28.95±1.04 kg/m²) who underwent outpatient direct open, single-level, posterior lumbar interbody fusions. At a mean follow-up of 15 months (range, 5.52-34.2 months), the mean±SD VAS lower back pain score had decreased from 8.4±0.37 preoperatively to 4.96±0.73 postoperatively (P=.001). The mean±SD ODI score had improved from 52.71±0.04 preoperatively to 37.43±0.06 postoperatively (P=.04). One patient experienced worse back pain postoperatively, with clinical and radiological signs of possible aseptic diskitis. Mean±SD estimated blood loss was 161±32 mL and mean±SD operative time was 124.85±7.10 minutes. The overall fusion rate was 87.5%. The authors concluded that their procedures had been performed safely and that there was a statistically significant reduction in mean pain and ODI scores, with patients discharged the same day as surgery without a drain.

Perez-Cruet et al10 conducted a prospective clinical study examining the quality of life outcomes in 304 consecutive patients undergoing MIS-TLIF. The study population included 120 men and 184 women who had a mean age of 62.4 years (range, 19-93 years) at the time of surgery. At a mean follow-up of 47 months (range, 2-8 years), the mean VAS pain score decreased significantly from 7 points to 3.5 points (P<.001), the mean ODI score decreased significantly from 43 points to 28 points (P<.001), and the Short-Form 36 physical component score increased significantly from 30.6 points to 39.6 points (P<.05). These patients also had a spinal fusion rate greater than 95% and a low rate of fusion failure requiring reoperation (3.9%; n=12).

Seng et al11 conducted a retrospective analysis comparing the midterm clinical and radiologic outcomes of minimally invasive vs open TLIF procedures in 40 matched paired cases. Patients were followed at 6 months, 2 years, and 5 years after surgery. Minimally invasive procedures had less blood loss (mean, 127 vs 405 mL; P<.001) and had less morphine use (mean, 8.5 vs 24.2 mg; P=.006) and the patients were able to ambulate in a mean of only 1.5 days compared with those who underwent open fusion (3 days; P<.001). Although no significant difference was noted in complication rates, the rate was lower in the MIS-TLIF cohort (15%) and higher in open fusions (20%). Both cohorts had shown improvement in ODI, neurogenic symptoms, VAS back and leg pain, and Short-Form 36 scores until 5 years with no significant difference. Thus, open and MIS-TLIF were comparable in fusion rates and clinical outcomes, but the latter showed significantly reduced blood loss and postoperative pain, earlier rehabilitation, and shorter hospital stay.

In addition to the above benefits of MIS-TLIF, Cheng et al14 assessed postoperative functional mobility and use of pain medications in MIS-TLIF vs open TLIF procedures. Fifty patients underwent MIS-TLIF while 25 underwent open TLIF. Patients had a mean follow-up of 5.05 years. The authors concluded that MIS-TLIF achieved improved functional mobility as physical therapy on postoperative day 1 showed higher function in transfer-related tasks, ambulatory ability, and distance walked when compared with open TLIF (P<.05). This, in effect, resulted in shorter hospitalizations (mean, 4.8 vs 6.05 days for MIS-TLIF vs open TLIF; P=.006) and an average cost reduction of $3885 per patient. The 2 groups had similar fusion rates (92% vs 100% in the MIS-TLIF and open TLIF groups, respectively; P=.09). Furthermore, the 2 groups were similar in their preoperative medication use; however, postoperative administration of morphine equivalent pain medication was decreased in patients undergoing MIS-TLIF.

Although the benefits of MIS-TLIF are appealing as an outpatient procedure, studies have shown a complex learning curve associated with this procedure.16-18 Lee et al18 conducted a prospective cohort study in which 90 patients underwent single-level MIS-TLIF to evaluate the learning curve by assessing surgical competence. They determined the asymptote of the surgeon’s learning curve for MIS-TLIF was achieved at the 44th case. Silva et al16 determined that 90% of the learning curve could be achieved by the 40th case. In another study, the asymptote was reached after the 30th case.19

Although the learning curve has varied in the literature, likely because of differences in study design and surgical experience, most studies have reported proficiency after the 30th case. In all of these cases, the surgeon’s experience was associated with reduced operative time and intraoperative blood loss. Less experience was associated with a higher complication rate. In the current study, the outpatient cohort had significantly lower Charlson Comorbidity Index scores when compared with the inpatient cohort. In addition, the senior authors (A.E., K.S.H.) had extended experience in performing MIS-TLIFs, all of which had a complication rate of 9% in this study.

Ultimately, this study showed that patients requiring postoperative inpatient monitoring had more medical morbidities. Although older patients tend to have more medical comorbidities, age alone
may not prove to be a selection criterion for MIS-TLIF in the outpatient setting. Although this study did not quantify pre- or postoperative narcotic intake, proper preoperative patient assessment and postoperative pain control planning are necessary for successfully performing the procedure in the outpatient setting. The authors acknowledge that the readmission rate was numerically higher in the inpatient group, although statistical significance was not reached. The authors believe that the study design biases this statistic in that patients undergoing revision surgery in the inpatient group had complications identified in the immediate postoperative inpatient period and thus did not require readmission.

**CONCLUSION**

Minimally invasive transforaminal lumbar interbody fusion is a technically complex surgical procedure that has the advantages of reduced blood loss, decreased postoperative pain, reduced hospital stay, faster recovery, and similar efficacy when compared with its open counterpart. In this study, the authors found comparable clinical outcomes and safety profiles between outpatient and inpatient MIS-TLIFs. The results suggest that with appropriate patient selection and an experienced surgeon, MIS-TLIF may be safely performed as an outpatient procedure for patients with minimal medical comorbidities without compromising postoperative outcomes. More prospective, randomized studies are necessary to better evaluate these outcomes.

**REFERENCES**