Navigation Makes Transforaminal Lumbar Interbody Fusion Less Invasive

Yu Wang, MD, PhD; Yongkai Hu, MD; Hong Liu, MD; ChunDe Li, MD; Hong Li, MD; Xiaodong Yi, MD

abstract

The current study presents a navigated transforaminal lumbar interbody fusion (TLIF) technique that requires only a 4-cm incision to accomplish a single-level TLIF. The authors compared its efficacy and efficiency with those of conventional TLIF. Forty patients who were indicated for single-level lumbar fusion were included and randomized to either the navigated-TLIF group or the conventional-TLIF group. Intraoperative blood loss, operative time, incision length, complications, bed rest period, and length of hospital stay were recorded. Oswestry Disability Index (ODI) scoring was also performed for each patient preoperatively and 3 months and 2 years postoperatively. Incision length was significantly shorter in the navigated-TLIF group than in the conventional-TLIF group (4.2 vs 8.3 cm, respectively; \(P=0.001\)). Accordingly, intraoperative blood loss was also significantly less in the navigated-TLIF group than in the conventional-TLIF group (122.5 vs 220.5 mL, respectively; \(P=0.049\)). There was no significant difference in total operative time between the 2 groups (134.4 vs 124.5 minutes; \(P=0.226\)). The navigated-TLIF group had a significantly shorter bed rest period and length of hospital stay compared to the conventional-TLIF group. Incision length decreased with time; at final follow-up, average incision length had decreased from 4.2 to 3.7 cm in the navigated-TLIF group and from 8.3 to 7.7 cm in the conventional-TLIF group. Average ODI score improved significantly in both groups immediately postoperatively and was maintained in the following 2 years. Navigation can make single-level TLIF less invasive. Compared with conventional TLIF, navigated TLIF proved to be superior with regard to incision length, intraoperative blood loss, bed rest period, and length of hospital stay. [Orthopedics. 2016; 39(5):e857-e862.]

With advances in navigation technology, navigated TLIF has become an option for spine surgeons. The current study presents a navigated TLIF technique that requires only a 4-cm incision to accomplish a single-level TLIF. Compared with conventional TLIF, navigated TLIF could result in smaller incisions, less intraoperative blood loss, and shorter hospital stay; however, it may increase operative time and incidence of complications. The authors performed the current study to examine the differences between conventional and navigated TLIF.

Techniques such as percutaneous pedicle screw placement and expandable retractor system have been applied in TLIF procedures in the past decade, with the goal of lessening approach-related morbidity. However, such minimally invasive TLIF procedures require 4 to 7 incisions, and one of these incisions must be approximately 4 cm in length so that an expandable retractor can be inserted.1-9

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Materials and Methods

The indication for navigated and conventional TLIF is the same: symptomatic single-level degenerative disk disease. Navigated TLIF uses 1 incision approximately 4 cm long. Through this incision, pedicle screw placement, decompression, disectomy, cage insertion, and bone grafting can be performed. Accordingly, because of the incision’s small size, intraoperative blood loss can be decreased. Another advantage of navigated TLIF is that the pedicle screws are inserted under the guidance of infrared navigators, which not only make the insertion more accurate but also completely avoids exposure to radiation by the operating room personnel.

Surgical Technique for Navigated Transforaminal Lumbar Interbody Fusion

Two senior surgeons (Y.W., H.L.) with more than 20 years of experience in spinal surgery performed all TLIF procedures.

Navigated TLIF is performed with the patient under general anesthesia and in the prone position on a carbon-fiber operating table. A 4-cm longitudinal median incision is made. Detachment of the paravertebral muscles and exposure of the laminae are performed bilaterally.

First, a patient tracker is fixed to the spinal process (Figure 1), followed by scanning using a 3-dimensional (3-D) C-arm (Figure 2). After scanning, the image data are transferred within 30 seconds.
from the 3-D C-arm to the navigation workstation, allowing the lumbar spine of the patient to be tracked by the navigation system in real time. Meanwhile, the navigated instruments are also being tracked.

Second, under the guidance of the navigator, 4 pedicle screws (multi-axial, 6.5-mm diameter) are inserted one by one. When a screw is being inserted, the muscles are pulled laterally, and the operator always has the visual of the entry point (Figure 3). When all 4 pedicle screws have been inserted, another 3-D scan is performed to check the position of each screw. If all the screws are shown to be well placed, the patient tracker is removed from the spinal process.

Finally, a retractor is inserted to give the operator a visual of the laminae, through which decompression, discectomy, cage insertion, bone grafting, rod instrumentation, and screw nut locking are performed (Figure 4).

Navigated Versus Conventional Transforaminal Lumbar Interbody Fusion

A comparative study was performed between navigated and conventional TLIF. Forty patients who were indicated for single-level fusion were included and randomized to either the navigated-TLIF group or the conventional-TLIF group. Blinded randomization was done using Filemaker Pro (Filemaker Inc, Santa Clara, California), a commercially available database package. Exclusion criteria included previous lumbar surgery, severe osteoporosis, motor deficit, cauda equina syndrome, or spondylolisthesis greater than grade I. Intraoperative blood loss, operative time, incision length, complications, bed rest period, and length of hospital stay were recorded. Oswestry Disability Index (ODI) scoring was also performed for each patient preoperatively and 3 months and 2 years postoperatively.

Statistical Analysis

Distributions of variables were presented as mean±SD. A t test and chi-square test were used to detect differences in each parameter between the 2 groups. A P value of less than .05 was considered significant. Statistical analyses were performed using STATA 11.0 software (Stata Corp, College Station, Texas).

RESULTS

All 40 patients were followed for at least 24 months. Demographic data were compared between the navigated-TLIF and conventional-TLIF groups (Table 1). The results showed no significant differences between the 2 groups in terms of patient age, height, and weight.

Operative data were compared between the groups (Table 2). Incision length was significantly shorter in the navigated-TLIF group than in the conventional-TLIF group (4.2 vs 8.3 cm, respectively; P=.001). Accordingly, intraoperative blood loss was significantly less in the navigated-TLIF group.

Table 1

<table>
<thead>
<tr>
<th>Patient Demographics</th>
<th>Navigated-TLIF Group</th>
<th>Conventional-TLIF Group</th>
<th>P&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients, No.</td>
<td>20</td>
<td>20</td>
<td>.846</td>
</tr>
<tr>
<td>Age, mean±SD, y</td>
<td>50.6±12.7</td>
<td>51.5±10.0</td>
<td>.16</td>
</tr>
<tr>
<td>Sex, M/F, No.</td>
<td>7/13</td>
<td>10/10</td>
<td>.854</td>
</tr>
<tr>
<td>Height, mean±SD, cm</td>
<td>166±8.2</td>
<td>165.4±7.0</td>
<td>.831</td>
</tr>
<tr>
<td>Weight, mean±SD, kg</td>
<td>70.3±14.3</td>
<td>69.3±11.4</td>
<td>.851</td>
</tr>
<tr>
<td>ODI score, mean±SD</td>
<td>0.52±0.11</td>
<td>0.34±0.10</td>
<td>.08</td>
</tr>
<tr>
<td>Fusion level, No.</td>
<td>L4-L5 12</td>
<td>17</td>
<td>.06</td>
</tr>
<tr>
<td></td>
<td>L5-S1 8</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: F, female; M, male; ODI, Oswestry Disability Index; TLIF, transforaminal lumbar interbody fusion.

<sup>a</sup>P<.05 significant; t test or chi-square test.

Table 2

<table>
<thead>
<tr>
<th>Operative Data</th>
<th>Navigated-TLIF Group</th>
<th>Conventional-TLIF Group</th>
<th>P&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incision length, mean±SD, cm</td>
<td>4.2±0.2</td>
<td>8.3±1.5</td>
<td>.001&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Blood loss, mean±SD, mL</td>
<td>122.5±100.0</td>
<td>220.5±191.0</td>
<td>.049&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Operative time, mean±SD, min</td>
<td>Total time 134.4±27.9</td>
<td>124.5±23.0</td>
<td>.226</td>
</tr>
<tr>
<td></td>
<td>Exposure 24.4±10.4</td>
<td>26.7±6.2</td>
<td>.399</td>
</tr>
<tr>
<td></td>
<td>Screw placement 23.5±7.6</td>
<td>21.4±8.4</td>
<td>.413</td>
</tr>
<tr>
<td></td>
<td>3-D scanning 9.7±3.0</td>
<td>0±0</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Decompression 64.2±22.1</td>
<td>53.6±16.6</td>
<td>.095</td>
</tr>
<tr>
<td></td>
<td>Closure 12.8±5.2</td>
<td>22.9±4.8</td>
<td>.001&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Abbreviations: 3-D, 3-dimensional; N/A, not applicable; TLIF, transforaminal lumbar interbody fusion.

<sup>a</sup>P<.05 significant; t test.
Postoperative data were also compared between the groups (Table 3). The navigated-TLIF group had a significantly shorter hospital stay and bed rest period compared with the conventional-TLIF group. There was no significant difference in postoperative blood loss between the 2 groups. Incision length decreased with time in both groups (Figure 5); at final follow-up, average incision length had decreased from 4.2 to 3.7 cm in the navigated-TLIF group and from 8.3 to 7.7 cm in the conventional-TLIF group.

Clinical outcomes were compared between the groups (Figure 6). Average ODI score improved significantly in both groups immediately postoperatively and was maintained in the following 2 years. The complications that occurred are listed in Table 4.

**Discussion**

According to this study’s results, navigated TLIF had several advantages compared with conventional TLIF. The navigated-TLIF group showed significantly less intraoperative blood loss and shorter hospital stay. These findings are in accordance with previous studies (Table 5). Most of these previous studies showed the superiority of minimally invasive TLIF over conventional TLIF. Operative time for navigated and conventional TLIF was comparable, which is also in agreement with previous studies (Table 5).

In the current study, average incision length in conventional TLIF was 2 times that in navigated TLIF (8.3 vs 4.2 cm, respectively; \(P=.001\)), which was a major advantage of navigated TLIF. Incision length decreased with time; at final follow-up, average incision length had decreased from 4.2 to 3.7 cm in the navigated-TLIF group and from 8.3 to 7.7 cm in the conventional-TLIF group.

Several minimally invasive TLIF procedures have been developed to lessen approach-related morbidity. Schwender et al presented the first clinical series reporting minimally invasive TLIF. A paramedian, muscle-sparing approach was performed through a tubular retractor. Facetectomy, diskectomy, and interbody cage insertion were performed through the tube. Bilateral percutaneous pedicle screw-rod placement was then accomplished with the Sextant system (Medtronic Inc, Minneapolis, Minnesota). Scheufler et al performed a clinical study on percutaneous TLIF. Decompression, diskectomy, and interbody cage insertion were performed through tubular retractors, followed by percutaneous pedicle screw-rod fixation. Isaacs et al developed microendoscopic TLIF. Hemilaminectomy, unilateral facetectomy, and microdiskectomy were performed using microendoscopy-assisted TLIF through a working channel. Bilateral percutaneous pedicle screws were then inserted.

All of these minimally invasive tech-
niques require 4 to 7 incisions, one of which must be approximately 4 cm (range, 3.5-4.5 cm) so that an expandable retractor can be accommodated. The technique reported in the current study requires only a single 4-cm incision, which is one of its advantages over other minimally invasive techniques. However, a small skin incision doesn’t necessarily mean a small muscle injury. Navigated TLIF still involves muscle detachment and ligamentous disruption, which should be improved in the future. A small skin incision may be a problem for navigation because the patient tracker might be moving when the wound is being retracted laterally. As such, the patient tracker must be fixed firmly, and care must be taken when retracting the wound.11,12

Incision length could be further decreased if the pedicle-screw direction is well designed.10 Another important advantage of navigated TLIF is that the pedicle screws are inserted under the guidance of infrared navigators, which not only make the procedure safer but also completely avoids exposure to radiation by the operating room personnel.

**CONCLUSION**

Navigation makes single-level TLIF less invasive. Compared with conventional TLIF, navigated TLIF proved to be superior with regard to intraoperative blood loss, length of hospital stay, and incision length.

**REFERENCES**


5. Dhall SS, Wang MY, Mummaneni PV.


