Classification of Minimally Invasive Techniques for Transforaminal Lumbar Interbody Fusion

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Abstract
Several techniques have been described for minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF), offering varying degrees of direct visualization versus reliance on fluoroscopy. In addition, the techniques differ with respect to the extent of neural decompression, choice of fusion substrates, and methods for pedicle screw insertion. Here we classify and contrast these techniques and highlight the features of a recently-described technique known as modified mini-open TLIF (MOTLIF).

Keywords: Fluoroscopy; Tubular retractor; Boney anatomy; Morphogenic protein

Literature Review and Commentary
Minimally-invasive techniques for transforaminal lumbar interbody fusion have been shown to reduce intra-operative blood loss, muscle injury, post-operative pain and length-of-stay and expedite recovery compared to the open technique [1-11]. The main drawback has been increased intra-operative radiation exposure due to reliance on bi-planar fluoroscopy that is required to compensate for diminished surgical exposure and visualization [12-18]. There are several surgical techniques for MIS-TLIF that provide a spectrum of exposures, ranging from minimal to moderate [3-11,19-25]. These are classified as percutaneous techniques, variously described at p-TLIF or MI-TLIF [3-11], and mini-open techniques, known as o-TLIF [19-25]. Recently, we described a modified mini-open technique, named MOTLIF, which offers an enhanced surgical exposure on par with the open exposure, thereby reducing the need for fluoroscopy [26]. An illustrated technique guide for MOTLIF is available at www.pakzaban.com/MOTLIF_technique_manual [27]. The distinguishing features of p-TLIF, o-TLIF and MOTLIF are outlined in Table 1. Here we compare and contrast these techniques with regard to exposure, decompression, interbody fusion, and pedicle screw placement.

Exposure
In p-TLIF and o-TLIF, the incisions are placed lateral to the parasagittal plane of the pedicles and the soft tissues are expanded with the aid of tubular dilators in the cleavage plane between the multifidus and longissimus muscles (inter-muscular approach) to reach the boney anatomy. In MOTLIF, by contrast, a 3 cm incision is placed directly in the parasagittal pedicle plane and a trans-muscular dissection is carried out through the multifidus muscle. Rather than relying on tissue dilators, in MOTLIF the multifidus attachments to bone are cauterized and cut to provide an expansive exposure of the facet joint, pars interarticularis, lateral aspect of lamina and medial aspect of transverse processes. This exposure is then maintained with an expandable tubular retractor that provides a conical field of view that is about 3 cm wide at the skin level and about 6 cm wide at bone level (Figure 1).

In p-TLIF and o-TLIF, the oblique approach trajectory in the inter-muscular plane generally requires that the tubular retractor be fixed to the operating table to maintain the approach angle. In addition, the strong attachments between the multifidus and the underlying bone often lead to muscle creep in the field of view if boney exposures beyond 2 cm to 3 cm are required. In MOTLIF, the vertical trans-muscular trajectory obviates the need for table fixation and allows the expandable retractor to “float” over the boney anatomy as screw drivers and implant inserters are passed through the incision (Figure 1). Furthermore, the expansive boney exposure eliminates muscle creep into the field of view.

Decompression and interbody fusion
In p-TLIF, K-wires are first inserted percutaneously to mark the locations of the pedicles; then a piecemeal lateral facetectomy is carried out to get access to the disc space. This lateral
MOTLIF, the vertical trans-muscular trajectory obviates the need for table fixation and allows the expandable retractor to “float” over the boney anatomy as screw drivers and implant inserters are passed through the incision.

Table 1 Comparison of Techniques for MIS-TLIF.

<table>
<thead>
<tr>
<th>Technique Abbreviation</th>
<th>Percutaneous TLIF p-TLIF or MI-TLIF</th>
<th>Mini-Open TLIF o-TLIF</th>
<th>Modified Mini-Open TLIF MOTLIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incision Placement</td>
<td>Lateral to pedicles</td>
<td>Lateral to pedicles</td>
<td>Overlying pedicles</td>
</tr>
<tr>
<td>Incision Size</td>
<td>Multiple 1-2 cm incisions or single 3-4 cm incision</td>
<td>Single 3-4 cm incision</td>
<td>Single 3-4 cm incision</td>
</tr>
<tr>
<td>Muscle Handling or Dissection</td>
<td>Dilation</td>
<td>Dilation</td>
<td>Dissection and detachment from underlying bone</td>
</tr>
<tr>
<td>Dissection Plane</td>
<td>Inter-muscular</td>
<td>Inter-muscular</td>
<td>Trans-muscular</td>
</tr>
<tr>
<td>Retractor</td>
<td>Fixed tubular</td>
<td>Fixed or expandable tubular</td>
<td>Expandable tubular</td>
</tr>
<tr>
<td>Facetectomy</td>
<td>Piecemeal lateral facetectomy</td>
<td>Piecemeal subtotal facetectomy</td>
<td>En-bloc total facetectomy</td>
</tr>
<tr>
<td>Direct Visualization of Anatomy</td>
<td>Minimal</td>
<td>Moderate</td>
<td>Enhanced</td>
</tr>
<tr>
<td>Foraminal Decompression</td>
<td>Moderate</td>
<td>Enhanced</td>
<td>Enhanced</td>
</tr>
<tr>
<td>Access for Central Decompression</td>
<td>Minimal</td>
<td>Moderate</td>
<td>Enhanced</td>
</tr>
<tr>
<td>Pedicle Screw Insertion</td>
<td>Over K-wire</td>
<td>With or without K-wire</td>
<td>Without K-wire</td>
</tr>
<tr>
<td>Fluoroscopy</td>
<td>Biplanar</td>
<td>Usually Biplanar</td>
<td>Lateral only</td>
</tr>
<tr>
<td>Fusion substrate</td>
<td>High reliance on BMP</td>
<td>High reliance on BMP</td>
<td>No BMP. Relies on local autograft from en-bloc facetectomy</td>
</tr>
<tr>
<td>Additional postero-lateral fusion</td>
<td>No</td>
<td>No</td>
<td>Optional</td>
</tr>
</tbody>
</table>

Transforaminal approach allows decompression of the neural foramen but not the central canal. The location of the exiting nerve root in such a small transforaminal exposure limits the size of the interbody implant that can be inserted. Most p-TLIF techniques described in the literature rely on bone morphogenic protein (BMP) to achieve interbody fusion [3-11]. Issues regarding the use of BMP have been described extensively [28-33].

o-TLIF compensates for some of the above-mentioned limitations of p-TLIF by providing greater exposure of the boney anatomy which permits a subtotal facetectomy. There is better decompression of the neural foramen and lateral recess and better access for insertion of a properly-sized interbody implant and bone into the disc space. Many surgeons who initially used p-TLIF have developed personal technical variations that fall somewhere in the spectrum between p-TLIF and o-TLIF.

MOTLIF takes boney decompression one step further: a complete en bloc facetectomy is carried out in a systematic fashion (Figure 2). First, a transverse cut is made across the pars interarticularis with a drill or bone scalpel. Second, a sagittal cut is made across the lateral aspect of lamina, allowing removal of the inferior articular process. Third, a transverse cut is made to amputate the tip of the superior articular process. The resulting pedicle-to-pedicle exposure allows complete decompression of the exiting and traversing nerve roots, thorough evacuation of the disc space, and better preparation of endplates for fusion. Furthermore, the bone that has been harvested through en-bloc facetectomy is cleaned of its soft tissue attachments and used for interbody fusion. This technique yields abundant high-
quality bone with high cancellous ratio, especially in patients with hypertrophic facet joints, and obviates the need for BMP. We have reported high fusion rates with MOTLIF, relying only on local facet autograft [26].

**Pedicle screw insertion**

In p-TLIF, cannulated pedicle screws are inserted over K-wires under bi-planar fluoroscopy. Rod placement may require the use of screw-based guidance devices and a separate skin entry point. In o-TLIF, some authors have described placement of non-cannulated screws guided by boney anatomy and fluoroscopy, but most rely on K-wires and bi-planar fluoroscopy as in p-TLIF.

In MOTLIF, the pedicle-to-pedicle exposure and direct visualization of all relevant neural structures allow for free-hand placement of non-cannulated screws, guided only by lateral fluoroscopy, similar to the open technique (Figure 1). This minimizes radiation exposure and permits safe and accurate pedicle screw placement [26]. The rod is placed through the same exposure under direct vision.

**Conclusion**

Techniques for MIS-TLIF are classified as percutaneous (p-TLIF), mini-open (o-TLIF), and modified mini-open (MOTLIF), respectively offering increasing degrees of direct surgical visualization and decreasing reliance on intraoperative fluoroscopy.
References


