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Modified Mini-open Transforaminal Lumbar Interbody Fusion

Description of Surgical Technique and Assessment of Free-hand Pedicle Screw Insertion

Peyman Pakzaban, MD

Study Design. Retrospective case series.

Objective. To describe a modified technique for mini-open transforaminal lumbar interbody fusion (TLIF) that improves visualization for decompression, fusion, and freehand pedicle screw insertion. Accuracy of freehand pedicle screw placement with this technique was assessed.

Summary of Background Data. Mini-open TLIF is a minimally invasive technique that allows limited visualization of the bone and neural anatomy *via* an expandable tubular retractor inserted through the Wiltse plane. No significant modification that of this technique has been described in detail.

Methods. In this study, 92 consecutive patients underwent one-level modified mini-open TLIF (MOTLIF). MOTLIF modifications consisted of (i) transmuscular dissection through the multifidus muscle rather than intermuscular dissection in the Wiltse plane; (ii) microsurgical detachment of multifidus from the facet rather than muscle dilation; (iii) *en bloc* total facetectomy (unilateral or bilateral, as needed for decompression); (iv) facet autograft used for interbody fusion; and (v) solid pedicle screws placed bilaterally by a freehand technique under direct vision.

Results. The mean age was 53 years. Mean follow-up was 35 months (minimum 2 yrs). By 6 months, mean Visual Analog Scale for back and leg pain had improved from 51 to 19 and from 58 to 17, respectively, and mean ODI improved from 53 to 16. These improvements persisted at 2 years. Solid fusion, defined by computed tomography at 1 year, was achieved in 88.1%, whereas satisfactory fusion was achieved in 95.2% of patients. Pedicle screws were accurately placed in 335 of 336 imaged pedicles (pedicle breach grades: 91.1% grade 1; 8.6% grade 2; and 0.3% grade 3). Mean fluoroscopy time was 29.3 seconds.

Conclusion. MOTLIF is a safe and effective minimally invasive technique with a high fusion rate. It allows accurate pedicle screw placement by a freehand technique. By eliminating biplanar fluoroscopy, it helps reduce radiation exposure. This is the largest published report of mini-open TLIF to date.

Key words: facetectomy, fusion, local autograft, lumbar spine, minimally invasive, mini-open fusion, pedicle screws, radiation exposure, screw placement accuracy, spondylolisthesis, transforaminal lumbar interbody fusion.

Level of Evidence: 4

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Mini-open transforaminal lumbar interbody fusion (oTLIF), as described by Mummanemi,[1] is a minimally invasive fusion technique that utilizes expandable tubular retractors to permit insertion of pedicle screws and TLIF implants under direct vision. Unlike percutaneous TLIF (pTLIF),[2–9] there is no need for placement of K-wires, cannulated pedicle screws, or biplanar fluoroscopy, thus making the technique more accessible to surgeons who are accustomed to open instrumented fusion.

Although good clinical and radiographic results have been reported with oTLIF,[1,10–15] the accuracy of freehand pedicle screw placement through such limited exposures has not been assessed.

Here we describe a modification of oTLIF, named modified mini-open transforaminal lumbar interbody fusion (MOTLIF), in which we have assessed the accuracy of freehand pedicle screw placement guided by direct visualization of anatomical landmarks, lateral fluoroscopy, and electrophysiological monitoring. MOTLIF differs from oTLIF with regard to the location of the skin incision, the trajectory of the surgical corridor, exposure of bone anatomy by direct dissection rather than muscle dilatation, *en bloc* resection of facet processes, and reliance only on

From the Houston Microneurosurgery, Houston, TX.

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The device (s)/drug (s) is/are FDA-approved or approved by corresponding national agency for this indication.

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Address correspondence and reprint requests to Peyman Pakzaban, MD, Houston Microneurosurgery, 5388 Lynbrook Drive, Houston, TX 77056; E-mail: Pakzaban@live.com

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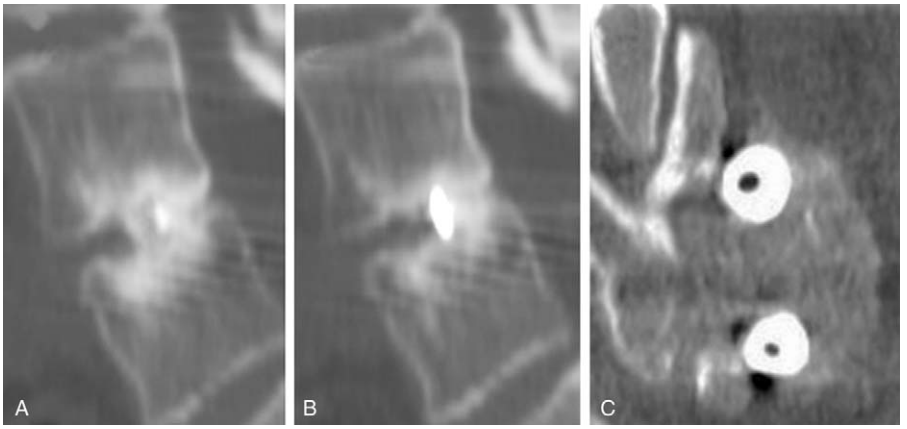

Figure 2. CT reconstructions demonstrating a Grade 1 fusion. Sagittal reconstructions show bridging bone within (**A**) and behind (**B**) the TLIF implant and coronal reconstructions (**C**) show bridging posterolateral fusion mass surrounding the pedicle screws.

repaired intraoperatively: None had a postoperative cerebrospinal fluid leak. Five patients (5.4%) had wound erythema, which was treated with oral and topical antibiotics. One patient (1.1%) had a deep wound infection, which was successfully treated surgical debridement and 4 weeks of intravenous antibiotic therapy without removal of the hardware. No patient required a blood transfusion.

Eighty-four (91.3%) of the 92 patients had a follow-up CT at 12 to 15 months after surgery. The reasons for failing to have a follow-up CT consisted of insurance refusal because of lack of justifying symptoms (3 patients), patient refusal caused by absence of symptoms (2 patients), and inability to reach the patient to schedule CT (3 patients). In the 84 patients who had CT, solid fusion (CT grade 1) was achieved in 74 patients (88.1%). Within this group (CT grade 1), all patients had bridging interbody bone, but only 72% had bridging posterolateral bone. An additional 6 patients had acceptable fusion (CT grade 2 with less than 5 degrees of angulation and no translation on dynamic radiographs), yielding a satisfactory fusion rate of 95.2%. None of these patients developed hardware loosening during the minimum 2-year follow-up period. All of the patients who did not have a CT had satisfactory fusion by dynamic radiographic criteria

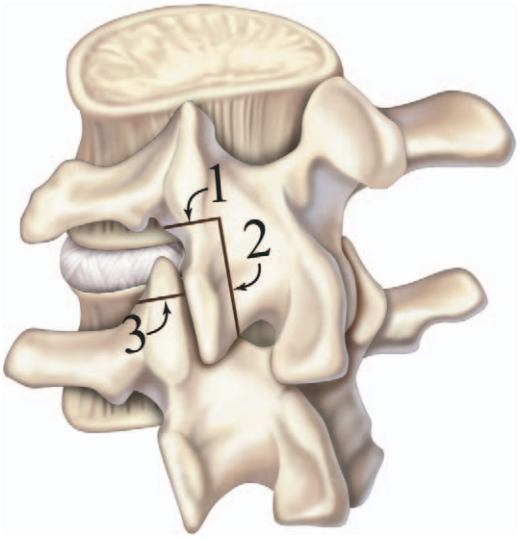

Figure 3. Artist's representation of *en bloc* facetectomy. A transverse cut (1) across the *pars* is joined with a second cut (2) along the lateral margin of the lamina. After removing the inferior articular process, a third cut (3) amputates the superior articular process. ©2010 Anatomical Justice, LLC.

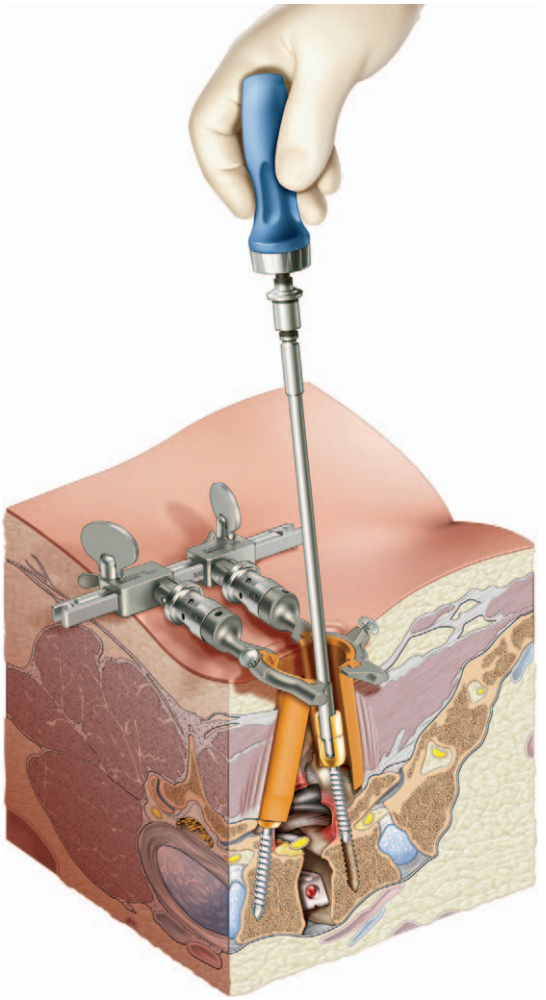

Figure 4. Artist's representation of freehand pedicle screw insertion under direct vision in a MOTLIF procedure. A complete facetectomy has provided exposure of the margins of the pedicles and the adjacent nerve roots, permitting insertion of pedicle screws without the need for K-wires or biplanar fluoroscopy. ©2010 Anatomical Justice, LLC.

more cranial segments), thus making it difficult to find the dissection plane through skin incisions that are made at an arbitrary distance from the midline.

To overcome these difficulties, in MOTLIF the skin incision is made precisely in the parasagittal plane bisecting the pedicles and a transmuscular surgical corridor is developed through the multifidus muscle to center the exposure on the facet joint. We have found that the transmuscular corridor provides superior exposure for facetectomy, lateral recess decompression, and TLIF, whereas still providing good exposure for pedicle screw insertion and intertransverse fusion. Furthermore, the retractor remains stable in the wound in vertical orientation, does not need to be tilted medially, and is not constantly displaced by the medial mass of the multifidus muscle. Because the retractor is not attached to the table at a fixed angle, it readily "floats" over the target whereas maintaining the exposure, thus facilitating the introduction of implant inserters and screwdrivers at optimal trajectories.

Another feature that distinguishes it from oTLIF and pTLIF is that MOTLIF does not rely on tubular dilators. The musculotendinous attachments of the multifidus to the facet joint are too strong to be detached by tubular dilators. In MOTLIF, these attachments are visualized under magnification, bipolar-coagulated, and cut flush with the bone before insertion of the expandable retractor, providing superior exposure and stable retractor placement.

In MOTLIF, the facet joint is resected *en bloc*. This technique yields large pieces of cortico-cancellous bone from the hypertrophic articular processes that can be thoroughly cleared of their soft tissue attachments and used for fusion. By contrast, piecemeal facetectomy with drills and rongeurs wastes bone and yields a low-quality fusion substrate contaminated with soft tissue attachments. In the current study, high fusion rates were achieved with local autograft, comparable with studies that relied on the use of BMP or iliac crest bone graft.[1–15,21] The cost and potential complications associated with the use of BMP are well-known[19,20,27–30] and are best avoided, if possible.

The use of stereotactic navigation and intraoperative computed tomography to enhance the accuracy of minimally invasive pedicle screw placement and reduce radiation exposure has been extensively described. [16–18,31–34] In the current study, we have demonstrated highly accurate pedicle screw placement by freehand technique without image guidance. We relied only on lateral fluoroscopy, which reduces radiation exposure compared to biplanar fluoroscopy. Our mean fluoroscopy time of 29.3 seconds compares favorably with other studies that report means times ranging from 38.7 seconds to 3.7 minutes for one-level operations.[35–38] Recently, a low-dose radiation protocol has been described that combines direct exposure and visualization of pedicle landmarks and avoidance of biplanar fluoroscopy (as in our technique) with pulsed low-dose fluoroscopy (that produces lower resolution images) to push mean fluoroscopy time to 10.4 seconds.[39]

In conclusion, MOTLIF differs from oTLIF in that it uses a transmuscular surgical corridor, requires manual detachment of multifidus from the underlying bone, and relies on an *en bloc* facetectomy to achieve decompression and provide high-quality local autograft. High fusion rates were achieved without the use of BMP or iliac crest autograft. The MOTLIF exposure allowed highly accurate pedicle screw placement by a freehand technique. It avoids biplanar fluoroscopy, thereby reducing radiation exposure. MOTLIF is a safe and effective minimally invasive technique, which may appeal to spine surgeons who are proficient in microsurgery but unfamiliar with percutaneous techniques. This represents the largest published report of mini-open TLIF and its variations to date.

➢ Key Points

- ❑ A modified technique for oTLIF is presented in detail.
- ❑ MOTLIF provides good exposure for interbody fusion and freehand pedicle screw insertion.
- ❑ Good clinical results and high fusion rates were achieved with use of local autograft from *en bloc* facetectomy.
- ❑ Highly accurate pedicle screw placement was achieved by a freehand technique. Biplanar fluoroscopy was avoided and low fluoroscopy times were recorded.
- ❑ This minimally invasive technique may appeal to surgeons who are proficient in microsurgery but unfamiliar with percutaneous techniques.

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