Lateral Transpsoas Interbody Fusion: Mini-Open Technique

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Learning Objectives: After participating in this CME activity, the neurosurgeon should be better able to:
1. Evaluate the advantages of the mini-open technique for lateral transpsoas interbody fusion (LTIF).
2. Illustrate the essential steps of the mini-open technique for LTIF.
3. Analyze the advantages and disadvantages of alternative surgical strategies and techniques for approaching lumbar spine pathology.

Lateral transpsoas interbody fusion (LTIF) is an increasingly popular approach to lumbar interbody fusion, offering several advantages over traditional posterior lumbar interbody fusion, transforaminal lumbar interbody fusion, and anterior lumbar interbody fusion in selected patients. Recent studies have demonstrated that LTIF may confer the benefits of smaller incisions, less blood loss, less postoperative pain, and less time spent in the hospital compared with traditional open approaches to the lumbar spine. Use of LTIF enables robust interbody fusion, indirect spinal canal and neural foraminal decompression, and access to adjacent segment disease in patients who have had prior lumbar fusion. This may obviate the need for posterior removal of hardware in some revision cases.

Lateral access to the disc space can be limited superiorly by the ribs and diaphragm and inferiorly by the iliac crest and lumbosacral plexus—particularly at L4–L5 and when spondylolisthesis is present, causing the plexus to be situated relatively anteriorly on the L5 body. The iliac crest can also prevent access to the caudal levels in some patients. Anatomic studies have demonstrated that the lumbar plexus is situated in a cleft between the transverse processes and the posterior border of the psoas muscle. The position of the plexus migrates from dorsal to ventral as it progresses caudally. This puts the plexus in “harm’s way” with a posteriorly situated retractor at more caudal levels.

Intraoperative neuromonitoring and fluoroscopy are mandatory during LTIF procedures. Intraoperative monitoring with electromyography (EMG) is imperative to protect the lumbosacral plexus during transpsoas retractor placement. Monitoring modalities used during LTIF typically include somatosensory-evoked potentials (SSEPs), spontaneous electromyography (s-EMG), and triggered electromyography (t-EMG). During placement of the retractor system, the dilator is rotated while stimulating directionally. The response is typically monitored in the vastus medialis, tibialis anterior, biceps femoris, and medial gastrocnemius. Depending upon the amplitude required to elicit a response, the surgeon can estimate his or her proximity to the nerves of interest to avoid injury.
allow for the use of c-arm fluoroscopy. Our practice is to use the reverse position to allow for the use of c-arm fluoroscopy. The OR table is used in the reverse position to ensure safe patient positioning (Figure 1). A standard SSEPs of the dependent upper extremity are monitored to indicate before retractor docking, which allows for the identification of the genitofemoral nerve. The genitofemoral nerve therefore can be dissected, retracted, and protected if necessary.

Mini-Open Technique for LTIF

Patient Positioning

The patient is positioned in true lateral decubitus position, with an axillary roll placed and all pressure points padded. SSEPs of the dependent upper extremity are monitored to position the patient with the right side down when possible. However, patients with degenerative scoliosis are positioned with the convexity of the curve pointed upward. This situates the more open side of the disc space toward the surgeon to allow for better access to the disc space. The patient’s hips are placed at the break in the bed, such that flexing the bed will open the disc space, move the iliac crest caudally, and move the rib cage rostrally. This position maximizes the potential for rostral-caudal exposure. Bed flexion is minimized, if possible, to avoid putting the psoas muscle under stretch during the dissection.

The bed is adjusted such that the patient is in a true lateral position and such that the disc space is perpendicular to the floor. The c-arm is set to neutral, and the bed is rotated such that the disc space is perpendicular to the floor. The Bed is adjusted such that the patient is in a true lateral position and such that the disc space is perpendicular to the floor. The c-arm is set to neutral, and the bed is rotated such that the disc space is perpendicular to the floor. The c-arm is set to neutral, and the bed is rotated such that the disc space is perpendicular to the floor. The c-arm is set to neutral, and the bed is rotated such that the disc space is perpendicular to the floor.

The genitofemoral nerve typically is not monitored with traditional neuromonitoring techniques. The mini-open technique for LTIF permits direct visualization of the psoas muscle before retractor docking, which allows for the identification of the genitofemoral nerve.

The patient is positioned in true lateral decubitus position, with the patient’s hips at the break in the bed. The OR table is used in the reverse position to allow for the use of c-arm fluoroscopy. A true lateral approach to the disc

Figure 1. A, The patient is positioned in a true lateral decubitus position with the patient’s hips at the break in the bed. The OR table is used in the reverse position to allow for the use of c-arm fluoroscopy. B, View from above. The patient is in a true lateral position such that the disc space is perpendicular to the floor.

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space reduces the risk of vascular and nerve injury. Having the disc space situated perpendicular to the floor gives the surgeon another reference point to ensure that he or she is working in line with the disc space and avoiding injury to the end plates during discectomy, end plate preparation, and cage insertion. The importance of patient positioning for successful LTIF cannot be overemphasized.

**Placement of the Retractor System**

The key difference between the mini-open and traditional percutaneous approaches to LTIF involves placement of the retractor system. In the mini-open approach, the retractor is opened superficial to the psoas muscle, allowing the surgeon direct visualization of the surface of the psoas muscle and genitofemoral nerve. Using fluoroscopic guidance, a skin incision is made over the disc space of interest. Monopolar cautery is used to achieve hemostasis, and dissection proceeds through the subcutaneous fat until the external oblique muscle and fascia are encountered. A self-retaining retractor is inserted, and the muscle fibers are dissected bluntly by use of a hemostat until the transversalis fascia is reached. The transversalis fascia is opened bluntly with the hemostat, and a finger is inserted through the defect and into the retroperitoneal space. The peritoneum is swept anteriorly, and the psoas muscle and lumbar transverse processes can then be palpated.

At this time, the smallest dilator is inserted, using the finger as a guide, and placed just superficial to the psoas muscle. The distance from the skin edge to the tip of the dilator is measured, and retractor blades 2 cm longer than this distance are selected. Sequential dilators are then inserted, and then the retractor system is inserted over the dilator tubes. The retractor is connected to the articulating arm, and a lateral fluoroscopic image is acquired. There has been no role for t-EMG up to this point in the procedure, as the dilators and retractor system have remained superficial to the psoas muscle and the nerves of the lumbosacral plexus.

To this point, the psoas muscle and nervous tissue have not been violated. Once the surgeon is satisfied on visual inspection that the genitofemoral nerve is not at risk and is satisfied by t-EMG stimulation that the retractor is well anterior to the lumbosacral plexus, psoas dissection can be performed. This step may also be reassuring to surgeons who are comfortable with traditional retroperitoneal approaches to the lumbar spine but are relatively new to minimally invasive techniques.

There are 2 options for dealing with the psoas muscle using the mini-open technique. The first option involves inserting the K-wire into the disc space, followed by the tubed dilators. Each dilator is insulated and has a stimulator channel. The probe can then be stimulated directionally to ensure that the plexus is not at risk, as described by Uribe et al. Directional t-EMG is performed for each sequential dilator. Provided no nerves are at risk, the retractor is then advanced over the dilator and secured in this position for the discectomy. Occasionally, despite negative t-EMG responses at a 5-mV threshold, s-EMG activity may occur once the retractors have been placed. s-EMG firing from a root that was quiet at baseline should raise concern for the surgeon that local nerves may be under traction, and repositioning of the retractor system should be considered.

Alternatively, once the psoas under the retractor system is stimulated and found to be free of nerves, a Freer elevator (modified Penfield #4) can be used, along with a nerve root retractor, to create and maintain a small working channel.
through the muscle. In many cases, it is possible to carry out the discectomy and cage placement through this small working channel without placing the entire retractor system through the psoas muscle. The surgeon must reserve the option to abort the procedure if the patient’s anatomy is unfavorable. In some cases, access to the disc space will not be possible due to the position of the lumbar plexus. This more often occurs at caudal levels and in patients with degenerative spondylolisthesis.

Once the disc space has been exposed, annulotomy, discectomy, and end plate preparation are performed. A Cobb elevator is used to break through the contralateral annulus fibrosus under fluoroscopic guidance to minimize the risk of end plate injury. Releasing the contralateral annulus enables the cage to be seated evenly across the apophyseal ring and to release the disc space to allow for distraction across the disc space—presumably increasing the likelihood of indirect decompression. An interbody cage is inserted into the disc space and packed with allograft, autograft, or bone substitute according to surgeon preference. AP fluoroscopic images are acquired to ensure that the interbody graft sits squarely in the disc space and to ensure that the end plates are not violated.

**Anterior Instrumentation**

Historically, placement of interbody grafts using LTIF has been performed in conjunction with posterior segmental instrumentation, either during the same OR visit or as a staged procedure. However, LTIF can be used successfully in patients who have developed adjacent segment disease or with a history of multilevel lumbar fusion. In these cases, a posterior approach would necessitate opening of the entire previous incision, removal of hardware, and reinstrumentation to include the level of interest. An intervention of this kind includes substantial postoperative pain and increased risk of cerebrospinal fluid leak associated with reoperative exposure.

As an alternative to posterior segmental instrumentation, anterior instrumentation may be preferable. By use of a tubular lateral retractor system, pedicle screws can be placed through the vertebral body. Screw length should be taken into account such that bicortical purchase is achieved. By creating an anterior screw–rod construct through the tubular retractor system, the need for posterior revision may be obviated for selected patients. The use of a pediatric pedicle screw set with fixed heads can allow for a low-profile construct that minimizes psoas muscle irritation.

**Conclusions**

LTIF is a minimally invasive alternative technique that offers several advantages over traditional approaches to lumbar fusion in selected patients. LTIF enables a wide cage to be placed on the apophyseal ring and inserted into the intervertebral space without disrupting the anterior or posterior longitudinal ligaments. Furthermore, indirect spinal canal and neural foraminal decompression can be achieved in patients with adjacent segment disease and prior lumbar fusion.

During LTIF, the lumbar plexus and genitofemoral nerve are at risk for injury with retractor placement, and the genitofemoral nerve is difficult to monitor. We think the risk of genitofemoral nerve injury may be reduced by identifying the nerve on the border of the psoas muscle and retracting it gently or repositioning the retractor system if necessary. The mini-open technique for LTIF may confer genitofemoral nerve protection, and it may also be a more comfortable transition for surgeons who are familiar with open retroperitoneal approaches to the lumbar spine but are new to LTIF. LTIF is a useful procedure for the spine surgeon, particularly in the setting of mild degenerative scoliosis and adjacent segment disease, when indirect decompression and interbody fusion are desired. Careful use of fluoroscopy and neuromonitoring is mandatory to ensure patient safety during the LTIF procedure.

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**Readings**


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1. Anatomically, the lumbar plexus is positioned in a cleft between the transverse processes and the posterior border of the psoas muscle.

   True or False?

2. LTIF technique puts the lumbosacral plexus at risk of damage with a posteriorly situated retractor at more caudal levels.

   True or False?

3. Neuromonitoring is optional during LTIF.

   True or False?

4. With the mini-open approach for LTIF, the genitofemoral nerve can be identified on the border of the psoas and then retracted.

   True or False?

5. Bed flexion is maximized during patient positioning for LTIF.

   True or False?

6. During LTIF, t-EMG is used before the retractor system is situated over the disc space of interest.

   True or False?

7. The key difference between the mini-open and traditional percutaneous approaches to LTIF involves placement of the retractor system.

   True or False?

8. LTIF can be limited superiorly by the ribs and diaphragm and inferiorly by the lumbosacral plexus.

   True or False?

9. Lateral instrumentation is an option during LTIF.

   True or False?

10. LTIF can be used in patients with adjacent segment disease or a history of multilevel lumbar fusion.

    True or false?