INTRODUCTION

Lumbar spinal decompression and fusion was introduced approximately 70 years ago and has evolved as a treatment option for symptomatic spinal instability, spinal stenosis, spondylolisthesis, and degenerative scoliosis. Over time, indications have been expanded to recurrent disk herniation, trauma and degenerative disk disease (DDD). Lumbar spinal fusion is often performed after a posterior decompressive procedure when there is evidence of lumbar spinal deformity or instability that could worsen with revision laminectomy alone.\(^1\)

In 1982, Harms & Rolinger introduced transforaminal lumbar interbody fusion (TLIF) as a lateral approach to the disk space,\(^2\) reducing the amount of thecal sac and nerve root retraction. Furthermore, during the unilateral approach, the contralateral interlaminar surface and facet joint are preserved.

Foley et al. were among the first to describe this novel technique,\(^3\) which utilized tubular retractors, inserted serially under radiological guidance via a muscle-dilating approach, thus reducing the amount of iatrogenic muscle and soft tissue injury. Subsequently, the approach also facilitated the avoidance of epidural scar tissue encountered in revision surgery where midline decompression had previously been performed. The resultant reported advantages of decreased intraoperative blood loss, decreased postoperative analgesic requirements; early postoperative ambulation and decreased length of hospital stay have made minimally invasive spine transforaminal lumbar interbody fusion (MIS-TLIF) an attractive option when treating degenerative lumbar spine disease.

In 2000, Morgenstern described placement of an interbody fusion cage through a transforaminal approach using a bullet type expandable cage.\(^4\) This cage was later discontinued and never received FDA approval in the US. The authors’ experience with this device was positive, but good clinical outcomes depended heavily on adding bone graft anteriorly to the cage to better stabilize the motion segment and minimize cage migration.

The advantages of using this cylindrical cage having a plurality of tines that could expand radially by shortening the cage via an internal thread mechanism were multiple. Most importantly, it would pass through a small tubular retractor and minimize the need for a complete facetectomy, reducing surgical time and intraoperative bleeding. Moreover, visualization of the intervertebral disk space and endplate preparation was significantly improved when implantation was assisted by an endoscope.

In this chapter, the pros and cons of both endoscopically assisted and open transforaminal interbody fusion approaches are examined, and the clinical evidence is discussed in conjunction with the authors’ clinical experience.

ANATOMY

Understanding lumbar anatomy and its variations is highly relevant when planning an endoscopic procedure. Kambin’s triangle is an important anatomic landmark (Figure 19.1) and its common anatomic variations are listed in Table 19.1.

The great anatomic variability that exists in the fifth lumbar vertebra (L5) is of clinical significance when considering the range of motion in the lumbar spine. Therefore, anatomic variations in this vertebra may not only affect the range of motion but may also be an important factor determining lower back pain.\(^5\)

The presence of a sixth lumbar vertebra (transition vertebrae) may suggest a potentially weaker than normal spine. In this situation, muscles have been found to no longer be flexible enough to maintain...
lumbar lordosis, which tends to increase under gravity. When muscle balance is altered, the physiological curve increases to the point at which the ligaments are under tension, being more prone to create instability.5

Anatomic variations in segmental lumbar spinal nerve arrangement have to be considered as an important source of variation when it comes to lumbar interbody fusion techniques. Conjoined nerve roots are a normal anatomic variant. They are most commonly discovered incidentally on routine sagittal or axial MRI, or even just in surgery without any prior knowledge of their existence. In this case, two nerve roots emerge at the same level and can be traced to their shared origin.

In patients with only four lumbar vertebrae, this problem is typically less clinically relevant. In contrast, a sacralized fifth lumbar vertebra typically produces normal range of motion between the fourth and the sacralized fifth vertebrae as the last caudal functional motion segment.6

A high iliac crest (Figure 19.2) typically makes direct lateral access to the L5–S1 level impossible. Alternative access can be achieved via the transiliac approach or paraspinal posteriorly oblique placed transforaminal approach. The latter approach is commonly used during endoscopically assisted ‘outside-in’ foraminoplasty decompression and microdiscectomy surgeries. An endoscopically assisted approach under X-ray surveillance allows the introduction of the endoscopic working cannula and a foraminoplasty under strict visualization of the L5 exiting root. Additionally, a high-riding iliac crest can rarely block lateral access to the L4–L5 level, requiring a similar technique to achieve interbody fusion.7

### SURGICAL TECHNIQUE

The use of an endoscope during the authors’ preferred surgical technique is crucial for the visualization of the foramen, in the same way as it is for transforaminal discectomy and foraminoplasty, which is performed prior to the cage insertion. The authors consider the endoscope to be a useful tool to directly visualize and release the exiting and traversing nerve root. This is of particular importance when faced with conjoined nerve roots or a furcal nerve (intraforaminal spinal nerve division overlaying the disk space). The patient should be operated on in a prone position and in lumbar flexion. The patient should be prepared and draped using a standard surgical sterile technique.

Fluoroscopy is used to locate the spinal level that is being accessed. Anterior-posterior (AP) and lateral X-rays are performed to ensure a proper positioning of the needle that will guide the entry of the dilator through a 1.5-cm incision. A 7-mm working cannula is then placed to give space for the 20° endoscope, causing no muscle detachment.

Foraminoplasty is performed to release the exiting root from any compression at this level. This will allow the cage entry to the intervertebral space. As previously mentioned, the patient is under conscious sedation, so any nerve root irritation due this procedure will be felt and can be communicated. Foraminoplasty is performed using the ‘outside-in’ technique. Decompression starts on the facet joint, heading then to the pars articularis and ending toward the caudal pedicle. This endoscopic decompression allows a wide foraminoplasty and greatly improves access to the now exposed intervertebral disk. The endoscope and interbody fusion instruments are now widely movable in both the axial and sagittal planes (Figure 19.3 and 19.4).

After foraminoplasty is done and nerve root decompression and release is completed, a grasper punch is used to extract the disk fragments, after which vertebral endplates are prepared using a 4-mm round drill bit. Bipolar radiofrequency (RF) is then employed, physiological saline combined with antibiotics is then used to wash the area and the endoscope is then retrieved. Cancellous bone allograft is impacted on the anterior and lateral areas of the intervertebral space, leaving enough space to place the cage, which has also been filled with bone allograft. A guidewire is left in the intervertebral space to lead

### Table 19.1 Anatomic variations

<table>
<thead>
<tr>
<th>Variation</th>
<th>Consideration</th>
</tr>
</thead>
<tbody>
<tr>
<td>High iliac crest</td>
<td>To be considered together with angle of L5–S1 disk</td>
</tr>
<tr>
<td>Prominent facet joint</td>
<td>Orientation of facet screws, axial MR/TAC</td>
</tr>
<tr>
<td>Pedicle variations</td>
<td>Orientation of pedicle screws, axial MR/TAC</td>
</tr>
<tr>
<td>Obliquity of L5–S1 disk</td>
<td>Either horizontal or oblique</td>
</tr>
</tbody>
</table>

Figure 19.2  High iliac crest and disk obliquity. This anatomic variation has to be considered, particularly when treating the L5–S1 level. Preoperative planning is mandatory and has to be studied together with the obliquity of the L5–S1 disc.

Figure 19.3  Axial endoscope movement. Lines represent the start and end positions when performing an axial movement with the endoscope.
Surgical technique

the cage into position under fluoroscopic guidance. Posterior-anterior (PA) and lateral views are then used to check the position of the cage, which should now be in the midline.

After placement of the interbody fusion cage, a meticulous cleaning of the neural foramen is performed under direct visualization of the cage to check that no bone graft residues remain in the area and also to double check cage positioning.

Preoperative planning is done using MRI and CT scan to determine the best access approach and exact location of the clinically symptomatic foraminal or central stenotic lesions requiring decompression. The authors’ surgical times were significantly improved by employing this standardized preoperative planning program and a summary of the different surgical techniques can be found in Table 19.2.

### Decompressive laminectomy

In the authors’ experience, more reliable and significant clinical improvements can be achieved by performing a posterior decompressive laminectomy in patients with instability and severe central lumbar spinal lumbar stenosis. Sometimes, the mere placement of the interbody fusion cage causes an increase in the neuroforaminal volume and lateral recess by ligamentotaxis of the ligamentum flavum (LF). However, this is difficult to assess intraoperatively and may deteriorate postoperatively in cases of cage subsidence. Therefore, concomitant decompressive laminectomy proves more reliable in the long run.

In cases with central spinal stenosis, surgery starts with central decompression, with the placement of progressive dilators and tubular retractors up to 13 mm. Placement of pedicle screws described below at this juncture can be considered and may help during decompression by achieving proper mobilization from pedicle to pedicle. In addition, the tubular retractor can be directed to the midline over the top, thereby reaching the contralateral nerve root and obviating the need to place another incision on the contralateral side.

In patients without severe central spinal stenosis, a foraminoplasty using the ‘outside-in’ transforaminal approach may be performed to decompress and release the exiting and traversing nerve roots from epidural adhesions or foraminal ligaments that can cause tethering to the disk or facet joint. Direct visualization of any anatomic abnormalities and complete exposure of the intervertebral disk, with preparation of the entry site as well as the interspace, should be achieved prior to insertion of the interbody fusion cage.

### Disk space management

Prior to preparing access to the disk space, local anesthesia with 1% lidocaine is achieved by injection in the skin and the entire intramuscular working tract down to the facet joint complex. Typically, 10 mL of anesthetic is sufficient. It is the authors’ preference to routinely perform discography to visualize the internal disk disruption, annular tears, or any extruded fragments. In patients treated under monitored...
anesthesia care (MAC) with local anesthesia and intravenous sedation, quantitative discometry may be performed on the compromised surgical lumbar level by documenting opening pressures and filling volumes.

With a standard dilation system, a 7-mm working cannula is inserted to start the foraminoplasty and to release and mobilize both the exiting and traversing nerve roots. Specifically, the exiting nerve root should be well mobilized to minimize the risk of postoperative neuropraxia and dorsal root ganglion (DRG) irritation.

Under high definition (HD) video-endoscopic visualization, a combination of motorized burrs and drills are employed to perform an expansile foraminoplasty, thereby preparing it for cage placement. The drill may also be used to improve endplate preparation and intertransverse fusion gutter preparation.

With the patient under MAC conscious sedation, nerve root mobility should be tested, making sure that the patient is not experiencing any pain when moving the nerve roots. In anticipation of some nerve root stretching during cage placement, this has been found to be the best predictor of any postoperative nerve root problems.

### Cage

Preoperative planning is aimed at achieving an oblique cage position in an approximate 45° relative to the posterior annulus across the interspace, to achieve optimal stability. Once the foramen is properly enlarged, disk preparation must be started, creating a space in which the cage and the bone graft will be placed.

To continue the endplate preparation for interbody fusion, 7 mm drill bits, reamers, and shavers are used. Disk fragments are extracted with rongeurs by tilting them toward the upper and lower endplates. Finally, the area is irrigated under pressure with antibiotic solution.

The authors’ preference is to use cancellous allograft with bone marrow concentrate (BMC) to fill the cage. The interspace is filled with the same graft material, using 4–7 mL anteriorly prior to cage insertion. Clinical experience has shown that this surgical technique improves the biomechanical stability of the reconstructed motion segment and decreases the incidence of cage subsidence.

Advancement of the implant and final positioning can be assessed during cage placement by following the tantalum markers on intraoperative fluoroscopy images, as well as on final PA and lateral X-ray views (Figure 19.5). Once the interbody fusion cage is satisfactorily placed between the two vertebral bodies, intervertebral height may be increased if an expandable implant is used. This produces indirect decompression of the nerve roots.

### Pedicle screws

Pedicle screw placement is planned using preoperative axial CT or MRI images through the surgical level. Medial-to-lateral and rostral-to-caudal screw trajectories are determined to avoid injury to nerve roots or the dural sac (Figures 19.6 and 19.7).

Using intraoperative fluoroscopy, MIS pedicle screws with connecting rods are placed with additional bone graft being placed in the intertransverse fusion bed. Bone marrow-enriched allograft is again preferred.

### Facet-pedicle screws

When planning using facet-pedicular screws, an MRI or CT scan is used to determine the facet joint orientation and possible trajectories across the facet joint and pedicle (Figures 19.8 and 19.9).

Furthermore, the bone must be in good condition and an established diagnosis of severe osteoporosis or a very deformed facet joint may be a contraindication. Transfacet or facet-to-pedicle screws are also contraindicated in the presence of spondylolysis.

The authors prefer to employ facet screw systems when there is a need to reduce surgical time in patients with complex medical comorbidities. In addition, there may also be less postoperative pain with facet screws. Transfacet or pedicle screws oppose the surgical access are often employed at the surgical level where the TLIF is performed. This type of 360° fusion obviates the need for contralateral incisions and approaches. Moreover, it is associated with less collateral damage to muscles, and lowers the risks inherent in pedicular screw placement.

A summary of the some of the steps related to this surgical technique can be found in Figure 19.10.

### INDICATIONS AND CONTRAINDICATIONS FOR OPEN VERSUS ENDOSCOPICALLY ASSISTED TLIF

#### Indications

Surgical indications for endoscopically assisted TLIF closely compare to those of open TLIF and are determined, in part, by the surgeon’s experience and level of comfort with these procedures. It is recommended, before attempting an endoscopically assisted TLIF, to start with more simple minimally invasive procedures such as L4–L5 discectomies or foraminal decompressions. It is also crucial that the surgeon has gained sufficient experience of the open procedure before attempting the endoscopic approach.

One of the most relevant indications for endoscopically assisted TLIF is the treatment of mechanical low back and radicular pain associated with spondylolisthesis. Grade I or II spondylolisthesis is normally suitable for this technique: high-grade slips are technically very challenging and are optimally treated by most surgeons via an open approach.

In cases of bilateral radiculopathy, contralateral decompression can be achieved after graft placement and once foraminal height has been restored. Patients with severe contralateral lateral recess stenosis may be successfully treated with contralateral minimally invasive decompression through a separate incision using a tubular retractor.

Patients who have suffered recurrent disk herniations are also good candidates for this procedure. This could be a definitive treatment for patients with or without low-back pain who have suffered multiple recurrent disk herniations. The technique is also suitable for revision surgeries as the transforaminal approach can be placed lateral to previous incisions, thus avoiding scar tissue.
Other indications may include severe discogenic low-back pain caused by DDD, postlaminectomy instability, spinal trauma or the treatment of pseudoarthrosis.

### Contraindications

Conjoined nerve roots within the neuroforamen typically make transforaminal cage placement impossible. This should be closely analyzed on the preoperative MRI since attempts to mobilize conjoined roots carry an unacceptable risk of neurological injury. If found intraoperatively, a contralateral TLIF should be considered.

This approach is not recommended for more than two intervertebral levels. A high-riding iliac crest and horizontal L5–S1 disk may present a relative contraindication and it may be advisable to proceed with a conventional MIS-TLIF in such cases.

A summary of the indications and contraindications for this procedure are listed in Table 19.3.

Relative contraindications to lumbar interbody fusion surgery may exist and are no different in this respect from open lumbar fusion surgery. As such, surgical treatment should be considered in context with the patient’s psychosocial disposition. Negative prognostic factors, such as depression, hypochondria, hysteria, hostility and anxiety should all be considered. Moreover, secondary gain factors should be taken into account. The latter problem has been found to correlate with less favorable surgical outcomes in workman compensation patients.

### CLINICAL EXPERIENCE

The authors’ study included 50 patients who underwent a TLIF surgery between 2010 and 2013. Preoperatively, the patient’s functioning was assessed using Oswestry Disability Index (ODI) and the lumbar visual analog scale (VAS) score specific to gluteal, leg and foot pain. Postoperatively, patients were evaluated at 1 month, 3 months, 1 year and 2 years. Data collection was performed by a staff member in...
the outpatient clinic who was not involved in the clinical care of the patient. A certified statistician then analyzed the data.

 Patients and outcome analysis

Twenty-six of the 50 patients reached 2-year follow up postoperatively. In 26 patients, an endoscope was used during TLIF. All patients signed an informed consent form prior to being included in the study and four additional patients were excluded from the study because of having missed intermittent follow-up visits. The clinical outcomes of the remaining 22 TLIF patients (84.62%) were analyzed: 11 males and 11 females, with a median age of 50 years.

The variables measured were pain intensity, daily living activities, lifting up objects, walking, sitting down, standing up, sleeping, sexual
activity, social activities and travel. All were measured on a 0–5 scale, 0 being no pain or disability and 5 being severe pain and disability. In this longitudinal cohort study, there were no replicates and no control group.

Different multivariate analysis of variance methods were employed including Wilks’ lambda, Pillai’s trace, Hotelling trace and Roy’s largest root. Bonferroni correction was used to correct for multiple comparisons. Mauchly’s sphericity test was used to validate a repeated measures analysis of variance. Greenhouse-Geisser and Huynh-Feldt corrections were used to alter the degrees of freedom and produce an F-ratio to reduce the type I error. The actual F-ratio does not change as a result of applying the corrections; only the degrees of freedom.

### Results

Observing the critical levels for statistical significance associated with each comparison, significant ODI differences between preoperative and 1-year postoperative assessments were noted. Patients improved 94.25% of the time (Figure 19.11).

Evaluating the lumbar VAS and gluteal VAS results, postoperative improvements of 86.36% were found. The average improvement in leg VAS was 95.65%. The study results are summarized in Figure 19.12.

The results with endoscopically assisted MIS-TLIF showed ODI reductions from 50.9 preoperatively to 25.7 at 6 weeks postoperatively, 16.3 at 6 months postoperatively, and 17.9 at 1 year postoperatively.

### Complications

Complications observed in this series of patients are listed in Table 19.4. One patient suffered neurological complications with L5 neuropraxia and foot drop. Function returned 3 months postoperatively with excellent results. In another patient, facet-pedicular screws had to be converted to a nonsegmental pedicle screw construct due to loosening. An additional patient had an asymptomatic medially placed pedicle screw shown on a postoperative CT scan. The patient underwent revision surgery within 24 hours to reposition the pedicle screw. A dural tear was encountered in one patient and treated with a collagen patch (Duragen). This patient was discharged 24 hours later and advised to observe an additional 5 days of bed rest at home. They had an otherwise uneventful recovery without headaches or development of a CSF fistula.

In patients with complications requiring revision surgery, it became clear that revision of MIS pedicle screw instrumentation is suitable for percutaneous reattachment of pedicle screws to extension tabs.

---

**Table 19.3** Summary of indications and contraindications of open and endoscopically assisted transforaminal lumbar interbody fusion (TLIF)

<table>
<thead>
<tr>
<th>Indications</th>
<th>Contraindications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endoscopically assisted TLIF</td>
<td>● Degenerative disk disease (DDD)</td>
</tr>
<tr>
<td></td>
<td>● Spondylosis (no response to 6 months of conservative treatment)</td>
</tr>
<tr>
<td></td>
<td>● Spondylolisthesis (no response to 3 months of conservative treatment)</td>
</tr>
<tr>
<td></td>
<td>● Radiologically and clinically confirmed vertebral instability</td>
</tr>
<tr>
<td></td>
<td>● Recurrent disk herniation (third episode)</td>
</tr>
<tr>
<td></td>
<td>● Scoliosis of four levels or more</td>
</tr>
<tr>
<td></td>
<td>● Tethered spinal cord syndrome</td>
</tr>
<tr>
<td></td>
<td>● Congenital abnormalities</td>
</tr>
<tr>
<td></td>
<td>● Severe osteoporosis (relative contraindications)</td>
</tr>
<tr>
<td>Open TLIF</td>
<td>● Herniated disk with instability and disabling low-back pain</td>
</tr>
<tr>
<td></td>
<td>● Foraminal herniated disc that requires foraminotomy for treatment</td>
</tr>
<tr>
<td></td>
<td>● Extruded disk herniations that need bilateral facetectomy for proper decompression</td>
</tr>
<tr>
<td></td>
<td>● Recurrent herniation associated to disabling low-back pain</td>
</tr>
<tr>
<td></td>
<td>● Nonresponsive conventional treatment with no results</td>
</tr>
<tr>
<td></td>
<td>● Radiologically and clinically confirmed vertebral instability</td>
</tr>
</tbody>
</table>

---

**Figure 19.11** Lumbar Oswestry Disability Index score (ODI).

**Figure 19.12** Summary of study results.

---

**Figure 19.13** Time course of lumbar Oswestry Disability Index score (ODI).
and tubular retractors. However, reattachment of extension tabs and delivery tools onto the pedicle screw construct may present a degree of difficulty and may require some practice.

During the pedicle screw repositioning maneuver, progressive dilation tubes are used to access the area with an endoscope. Reattachment of the delivery instrumentation to the pedicle screw can be monitored under direct visualization on the video screen. Reattachment of the pedicle screw rod construct may considerably increase surgical time, even in the hands of an experienced surgeon.

Table 19.4 Summary of study complications

<table>
<thead>
<tr>
<th>Complications</th>
<th>Referenced by published study*</th>
<th>Author’s experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infection</td>
<td>Minimally invasive 6.9%</td>
<td>Open 23.5%</td>
</tr>
<tr>
<td>Urinary tract infection</td>
<td>3.4%</td>
<td>11.8%</td>
</tr>
<tr>
<td>Neurological deficits</td>
<td>20.7%</td>
<td>11.8%</td>
</tr>
<tr>
<td>Screw/cage complications</td>
<td>44.8%</td>
<td>11.8%</td>
</tr>
<tr>
<td>CSK Leak</td>
<td>10.3%</td>
<td>5.9%</td>
</tr>
<tr>
<td>Blood transfusion/coagulation</td>
<td>3.4%</td>
<td>11.8%</td>
</tr>
<tr>
<td>Other</td>
<td>10.5%</td>
<td>23.4%</td>
</tr>
</tbody>
</table>


Level I data

There is no level I evidence addressing this topic.

Level II data

There is no level II evidence addressing this topic.

Level III data

In a study conducted from 2009 to 2012 by Wale et al., a total of 68 patients were enrolled in two groups comparing open TLIF with MIS-TLIF. The mean age was 56 years in the open TLIF group and 61 years in the MIS-TLIF group, respectively. All patients had low back and leg pain, with radiographic evidence of grades I to II spondylolisthesis. Patients in both groups showed a significant improvement in their functional outcome occurred between the open TLIF and MIS-TLIF groups ($P = 0.46$). However, open-TLIF was significantly more costly compared with MIS-TLIF ($P = 0.0002$).

In a prospective comparison study by Peng et al., no difference in clinical improvement between open TLIF and MIS-TLIF was found at 2 years postoperatively. The comparison studies from Dhall et al., showed similar results between open TLIF and MIS-TLIF.

Cheng et al, in a study published in 2013, stated that even though there was a slight improvement in the VAS score outcomes of minimally invasive TLIF when compared to open TLIF, it was not statistically significant.

Level IV data

Park et al. (2014) performed minimally invasive TLIF on 124 patients treated for spondylolisthesis and other degenerative lumbar diseases. Five-year follow up was available on 85 patients. The mean Oswestry Disability Index improved from 60 preoperatively to 24 postoperatively and 79 of 83 patients (95%) had an improvement > 10 points. At 5 years, 67 of 83 patients (81%) achieved radiographic fusion, including 64 of 72 patients (89%) who had single-level surgery. Perioperative complications occurred in 11 of 124 patients (9%), and another surgical procedure was performed in eight of 124 patients (6.5%) involving the index level and seven of 124 patients (5.6%) at adjacent levels.

Discussion

The open TLIF technique may be associated with extensive destruction of the paraspinal muscle group by requiring the dissection and retraction of these structures to access the pedicle and completely removing the facet joint. The damage to the musculature and surrounding tissues results in increased postoperative pain and a longer recovery time. In addition, it may negatively affect the biomechanical functioning of adjacent spinal motion segments.

The MIS-TLIF technique has been shown to reduce trauma to the paraspinal musculature, speed up postoperative recovery, shorten the length of hospital stay and reduce the risk of infection. It creates small surgical wounds resulting in minor bleeding. MIS-TLIF has also been shown to be less costly than open TLIF with respect to perioperative costs as well as postoperative costs and patient service utilization. Using these new methods, the authors usually discharge patients in less than 24 hours. By comparison, one study reported average discharge at 9.3 ± 2.6 days following conventional open TLIF.

General anesthesia with total intravenous anesthesia or in combination with minimal use of anesthetic gases may have some advantages over MAC. These include reduced postoperative nausea and a faster ‘wake-up’. However, MAC under local anesthesia and sedation offers the advantage of being able to communicate with the patient during surgery. Prevention of neural injury is obviously of concern and the ability to perform a quick wake-up test during surgery, rather than relying on intraoperative neuromonitoring with continuous EMG,
sensory or motor evoked potentials may prove useful, particularly to the novice surgeon. It is the preference of the authors, who consider performing endoscopically assisted MIS-TLIF to be risky under general anesthesia. However, each surgeon should discuss the appropriate choice of anesthesia with the patient and anesthetic team in the context of their own local standards and guidelines.

In the authors’ experience, one of the most relevant aspects of this new endoscopically assisted surgery is the ability to access the L5–S1 level. In an attempt to reduce tissue damage and improve the release of the compromised nerve root under direct endoscopic visualization, the posterior decompression is performed through a tubular retractor, which is placed via progressively wider dilation tubes.

Through the experience of more than 50 cases of MIS-TLIF to date, the authors recommend the use of an endoscope during the procedure for direct visualization at the L4–L5 and L5–S1 levels to achieve a proper release and decompression of the symptomatic nerve roots.

Accessing the intervertebral disk via Kambin’s triangle to perform the discectomy and endplate preparation for placement of an interbody fusion cage is novel in that it allows a direct and straightforward access to the interspace while producing minimal scarring around the neural elements and the lateral recess in particular.

In the authors’ opinion, direct root visualization (DV) of the L5 nerve root during extensile foraminoplasty and its mobilization by the release of adhesions due to foraminal ligaments and the intraforaminal venous complex is integral to accessing the interbody space to facilitate cage placement. The combination of nerve root exposure and mobilization during foraminoplasty lowers the risk of nerve root injury at this otherwise difficult-to-access level. Endoscopically assisted TLIF allows direct visualization of both the neural elements and vertebral endplates during discectomy and endplate preparation—a clear advantage when compared with traditional TLIF or a nonvisualized form of the procedure.

At the L5–S1 level, a foraminoplasty is necessary in almost every case given the narrow entry point into Kambin’s triangle that can be obliterated by a hypertrophic facet joint complex, the transverse process, and sacral alar. Transitional anatomy may pose an additional hindrance to accessing the foramen via an ‘outside-in’ technique. The foraminoplasty may greatly reduce the risk of postoperative neuropraxia, nerve damage and postoperative pain, which is frequently caused by irritation of the DRG.

In addition, foraminoplasty may facilitate better preparation of the endplates to achieve better interbody fusion. Besides the interbody fusion cage, the author advocates the use of additional bone graft, such as allograft, by placing it anterior to the cage and laterally to the sides such that the bone graft surrounds the cage. Posterior unilateral facet-pediculal screw fixation may reduce surgical time and postoperative pain.

Assessing the configuration of the iliac crest is of importance for both the L5–S1 and the L4–L5 level. The latter may also be problematic when there is a high-riding iliac crest. The surgeon should be wary of the feasibility of the transforaminal approach when the iliac wing projects above the L4–L5 disk level on the lateral X-ray projection, or if there is posterior pelvic tilt with a horizontal L5–S1 intervertebral disk. A conventional TLIF approach may be more appropriate for these patients. A significant learning curve may also be associated with endoscopically assisted MIS-TLIF, and this should be taken into consideration when selecting patients for this procedure.

The authors’ technique capitalizes on traditional TLIF. The combination of smaller incisions, reduced postoperative pain, blood loss, and MAC allows patients to be discharged within 24 hours. Early discharge home and mobilization has been shown to be associated with far fewer risks of developing deep vein thrombosis and other complications.16-19 This is especially important in the elderly patient.

A review of the published data in the literature with respect to complications, postoperative use of drugs, and length of stay has clearly shown the superiorit of MIS spinal fusion techniques, including the the endoscopically assisted TLIF used by the authors, when compared with open TLIF techniques. This has been corroborated by other authors.20,21

**CONCLUSION**

On the basis of the authors’ experience, the use of an endoscope to assist during MIS-TLIF, in combination with percutaneous pedicular screws, is recommended as an alternative to open TLIF. Our favorable clinical findings have been corroborated by others, who additionally also reported shorter hospital stays, fewer complications, reduced postoperative drug use, and lower costs with MIS-TLIF.4,10-15

The interbody fusion cage and the transpedicular screw fixation system employed in our patients have been extensively described in the literature.15 Endoscopically assisted TLIF via a posterolateral transforaminal approach occurs through the exiting neuroforamen, with minimal disruption of the supporting dynamic paraspinal muscles and minimal removal of bone. In contrast, during a classic TLIF, the inferior portion of the lamina, and superior and inferior articular processes – or some variation thereof – is typically resected with the LF.15 The latter may produce epidural fibrosis.22,23

In summary, the new endoscopically assisted TLIF approach seems to be an advanced, less invasive surgical technique that in most cases only requires partial removal of the lumbar facet joint – namely its anterior portion directly facing the lumbar intervertebral disk. The overall strain on the patient is significantly reduced, making this procedure more suitable for elderly patients or those with significant comorbidities. As a result, indications for TLIF may be more appropriate in higher-risk patients who would not normally consider surgery in spite of chronic pain syndromes because of the higher risks associated with open techniques.

---

**REFERENCES**


