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Minimally Invasive Transforaminal Lumbar Interbody Fusion: Comparison of Two Techniques

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Rezumat

Sinteza lombară intercorporeală transforaminală minim invazivă: comparația a două tehnici chirurgicale

Scurt istoric: Sinteza lombară intercorporeală transforaminală minim invazivă (MI TLIF) este foarte populară în Statele Unite. Cele două tehnici MI TLIF folosite în mod curent utilizează fie un retractor tubular, fie un retractor atașat la șuruburile transpediculare.
Materiale și Metodă: Șaizeci de pacienți au fost operați MI TLIF între 2009 și 2012, folosind tehnica tubulară (43 pacienți) sau cea bazată pe șuruburile transpediculare (17 pacienți). Parametrii perioperatori și rezultatele la 1 an au fost analizate retrospectiv.
Rezultate: Pentru tehnica tubulară, timpul operator, sângerarea intraoperatorie, și durata spitalizării au fost 189 min, 170 ml și 3.37 zile, respectiv. Scala analogă vizuală (VAS) pentru durere s-a îmbunătățit de la 9.7 preoperator la 2.6 la 1 an postoperator. Au fost două durotomii incidentale, dar nici una nu a rezultat în fistula LCR. A fost o re-intervenție pentru repoziționarea unui șurub transpedicular. Pentru tehnica bazată pe șuruburi transpediculare, timpul operator, sângerarea intraoperatorie, și durata spitalizării au fost 223 min, 257 ml și 3.29 zile, respectiv. VAS s-a îmbunătățit de la 9.4 la 1.9. O pacientă care a suferit o durotomie incidentală a dezvoltat un hematom epidural compresiv postoperator, cu sindrom de coadă de cal, care a necesitat re-intervenție. Nu au fost re-intervenții pentru revizia implanturilor. Șapte pacienți nu s-au prezentat la vizita de 1 an postoperator. Rata fuziunii osoase la 1 an a fost de 100%.
Concluzie: Ambele tehnici pot fi folosite cu rezultate bune, dar fiecare tehnică are avantaje și dezavantaje care pot fi adaptate la caracteristicile pacienților.

Cuvinte cheie: chirurgie spinală minim invazivă, fuziune intercorporeală lombară transforaminală (TLIF), șuruburi transpediculare percutane

Abstract

Background: Minimally invasive transforaminal lumbar interbody fusion (MI TLIF) is very popular in the United States. Two techniques are commonly used, based on either tubular or pedicle-screw-based retraction.
Materials and Methods: Sixty patients underwent MI TLIF between 2009 and 2012, using the tubular technique (43 patients) or screw-based-retractor technique (17 patients). Perioperative parameters and 1-year outcomes were reviewed.
Results: For the tubular technique, the average operative time, blood loss, and hospital stay were 189 min, 170 ml, and 3.37 days, respectively. The visual analog scale (VAS) score improved from 9.7 preoperatively to 2.6 at 1-year postoperatively. There were two incidental durotomies, none resulting in a CSF leak. There was one re-intervention for removal of a misplaced pedicle screw. For the screw-based-retractor technique, the average operative time, blood loss, and hospital stay were 223 min, 257 ml, and 3.29 days, respectively. VAS improved from 9.4 to 1.9. One patient who had an incidental durotomy developed a postoperative compressive hematoma with

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resultant cauda equina syndrome requiring re-intervention. There were no re-interventions for revision of instrumentation. Seven patients were lost at the 1-year visit. The fusion rate at 1-year was 100%.
Conclusion: Both techniques can be used with good results, but each technique offers distinct advantages and challenges that can be tailored to individual patients.

Key words: minimally invasive, transforaminal lumbar interbody fusion, TLIF, percutaneous pedicle screws

Introduction

Transforaminal lumbar interbody fusion (TLIF) is the most frequently performed spine operation in the United States. While the overwhelming majority of indications are represented by degenerative disc disease, it can be occasionally used for stabilization of posttraumatic spondylolisthesis. Over the past 5 years, minimally invasive (MI) spinal surgery techniques have emerged (1) as favorable options to achieve the same fusion rates (2-4), but with significantly decreased blood loss, muscle disruption, length of hospital stay, postoperative infections (5-7), and cost (8,9). The minimally invasive transforaminal interbody fusion (MI TLIF) techniques are now used by 80% of the spine surgeons in advanced cities like Los Angeles and New York, and it is predicted that this figure will become representative for the entire United States over the next 5 years.

Two conceptually different MI TLIF techniques can be used. One involves performing the decompression and interbody cage insertion via a tubular retractor (the tubular technique), followed by insertion of the pedicle screws and rod. The other involves placing the pedicle screws first, with retractor blades attached to the screw posts, which maintain the exposure for the decompression and interbody cage insertion (the screw-based-retractor technique). While the end result is the same (i.e., interbody cage and pedicle screws / rod construct), each technique has unique advantages and risks, and many surgeons typically choose one technique or another, but not both. We retrospectively evaluate the results with these two techniques, with emphasis on surgical technique, operative parameters, postoperative pain level, perioperative complications, and fusion rates.

Materials and Methods

A total of 60 patients underwent an MI TLIF between Jan 2009 and June 2012. We used the tubular technique in 43 patients and the screw-based-retractor technique in the remaining 17 patients. The following parameters were retrospectively reviewed: age, sex, surgical indication, number and location of levels, placement of unilateral versus bilateral pedicle screws, operative time, estimated blood loss, length of hospital stay, complications related to surgery, and the visual analog scale (VAS) score preoperatively and at 1 year post-operatively.

Surgical technique for MI TLIF based on tubular exposure (the tubular technique)

The patient is placed in prone position with the arms tucked to the sides and with adequate padding for all pressure points. The perfect prone position is verified on the AP image, with the spinous process of the level of interest midline between the two pedicles. The level of interest is then identified on the lateral image by placing a spinal needle in perfect alignment with the intervertebral disc to be removed (*Fig. 1*). The skin incision is centered on the spinal needle entry point, and is typically 2-2.5 cm in length, parallel to the midline and about 4-5 cm lateral to it. In patients with larger body habitus, the incision has to be placed further laterally (*Fig. 2*). After local hemostasis for the skin edges, the incision of the subcutaneous fat and the lumbar fascia is continued with the 10-blade in a lateral to medial direction, and maintaining the same cranial to caudal angulation as the localizing spinal needle. We prefer to continue the paraspinous muscle dissection with the index finger, or with one of the smaller tubular dilators if the finger cannot fit through the skin incision. The bony landmark to be identified with either the finger or the dilator is the junction between the spinous process and the lamina of the level of interest (e.g., the L4 lamina if the L4-5 fusion is to be performed). This should be confirmed with lateral fluoroscopy, since it is easy to land on the level above or below, particularly in large patients. Once that junction is identified, the paraspinous muscles can be gently detached from the underlying lamina with the tubular dilator, with great care not to fall in the space between the laminae and injure the spinal

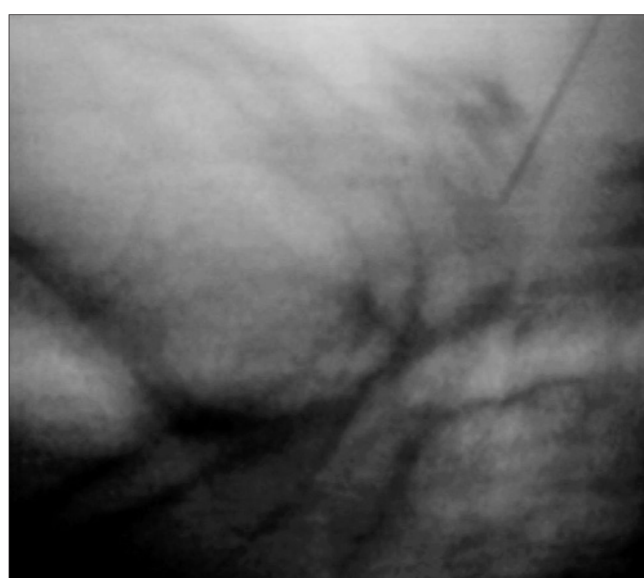

Figure 1. *Intraoperative radiograph showing the localizing spinal needle inserted in perfect alignment with the targeted L5-S1 disc*

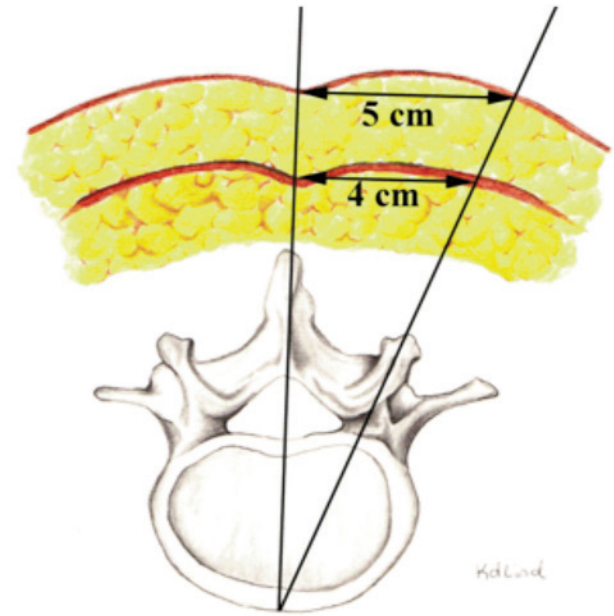

Figure 2. *Artist's depiction illustrating the need for a more lateral skin incision in obese patients*

Figure 3. *Intraoperative photograph illustrating the tubular retractor inserted over the tubular dilators at the required depth*

sac. The tubular dilators of increasing size are then used to insert the final tubular retractor of the appropriate height, as read on the side of the tubular dilators (*Fig. 3*). The correct placement of the tube, in line with the intervertebral disc of interest, is confirmed with lateral fluoroscopy (*Fig. 4*) and then the retractor is locked in place with a rigid arm (*Fig. 5*). Most surgeons prefer the 26 mm diameter retractor, although with experience, a 22 mm diameter tube can be used instead.

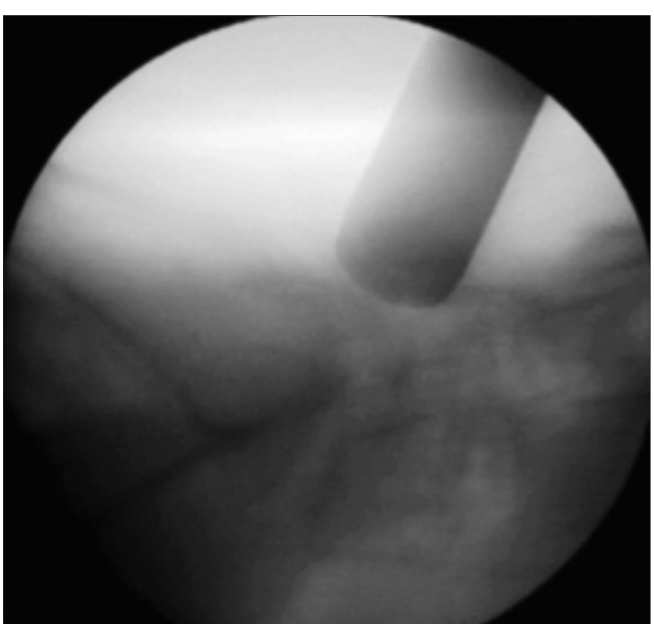

Figure 4. *Intraoperative radiograph showing the tubular dilators and retractor centered on the disc of interest, locked in the desired position*

At this point, the microscope is brought into the operative field. There is always some amount of muscle left between the bottom of the tube and the lamina; this is due to the fact that the tube rides on the high lip of the facet joint (*Fig. 6*). This muscle must be removed with the Bovie cautery and / or pituitary rongeurs, in order to expose the underlying bony anatomy. Typically, the medial edge of the tube rests against the base of the spinous process, the caudal edge of the tube is at the level of the caudal edge of the lamina, the cranial edge of the tube is just above the pars interarticularis, and the lateral edge of the tube rests on the lateral facet joint (*Fig. 7*).

The next step is to remove the medial facet. This is started by drilling a vertical cut through the lamina (similar to the one for a microdiscectomy) until the insertion of the yellow ligament is encountered. This typically coincides

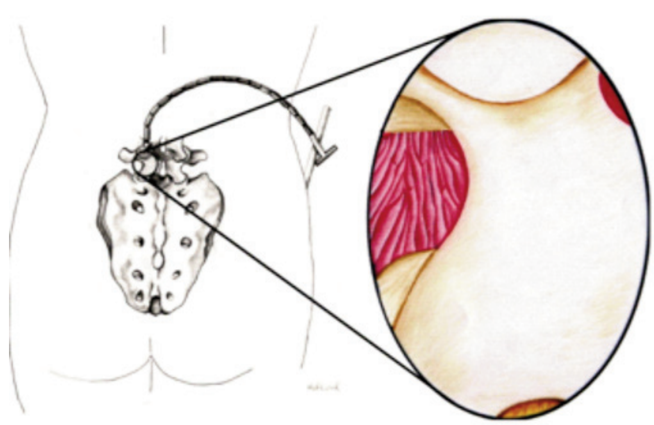

Figure 5. *Artist's depiction of the minimally invasive exposure for a left L5-S1 transforaminal interbody fusion (TLIF). The tubular retractor is immobilized via an adjustable arm and, after removal of the muscle fiber remnants, exposure of the bony elements is achieved*

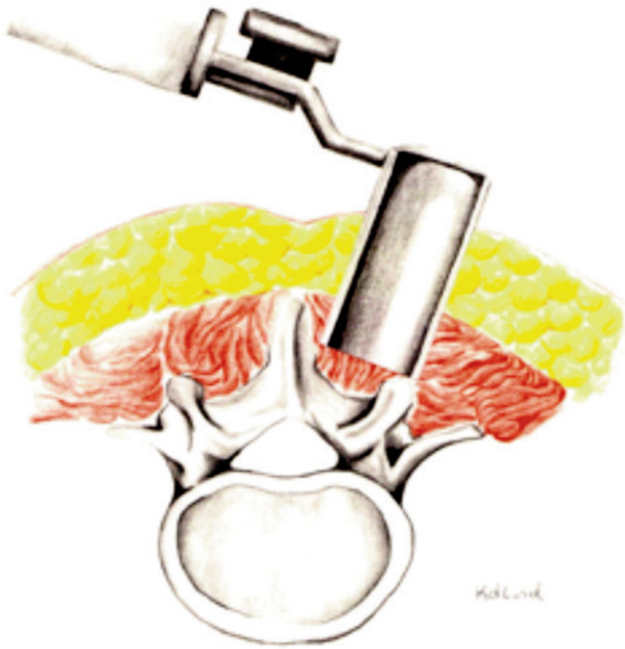

Figure 6. *Artist's depiction illustrating the amount of muscle underneath the tip of the tubular retractor that has to be removed in order to expose the bony landmarks (lamina and facet)*

with the caudal edge of the cranial pedicle on the lateral fluoroscopic image, and marks the cranial-most point of the exposure. The second, horizontal cut is made through the pars interarticularis and allows for detachment of the medial facet; it is sometimes necessary to cut through the facet capsule in order to completely free up the medial facet and remove it with a pituitary rongeur. The medial facet can be morselized and later used as fusion material.

The next step is to remove the tip of the lateral facet. This is done with the high-speed drill and is continued until the upper edge of the caudal pedicle is encountered (this can also be verified with lateral images). The bony removal has to be completed all the way laterally, where the lumbar artery is frequently encountered and can be easily controlled with bipolar cautery.

It is not usually necessary to expose the upper nerve root (traveling under the cranial pedicle), unless there is a high-grade spondylolisthesis and the root is more medial than usual, in which case the high-speed drill is used to remove the pars interarticularis flush with the caudal edge of the cranial pedicle and the nerve root is then unroofed under the pedicle.

Once the bony work is done, the next step is to remove the yellow ligament. This can be easily performed with a Kerrison rongeur, since the cranial edge of the ligament has already been exposed. The removal of the ligament exposes the lateral edge of the spinal sac and the take-off of the inferior nerve root. If the patient has spinal stenosis at that level, the yellow ligament removal can be continued under the spinous process until the entire spinal canal and the opposite foramen are decompressed.

After the removal of the yellow ligament, the epidural venous plexus is exposed (*Fig. 8*) and the annulus fibrosus and the exiting spinal nerve are visualized (*Fig. 9*). An annulotomy may be generated with a bayoneted, retractable scalpel blade. We place the lateral edge of the annulotomy medial enough so that the spinal nerve remains at a safe distance (*Fig. 10*). When larger cages are required, the thecal sac may be gently mobilized and retracted medially, if an adequate laminotomy has been performed. A common error is to place the annulotomy too far laterally, which may lead, at the time of cage

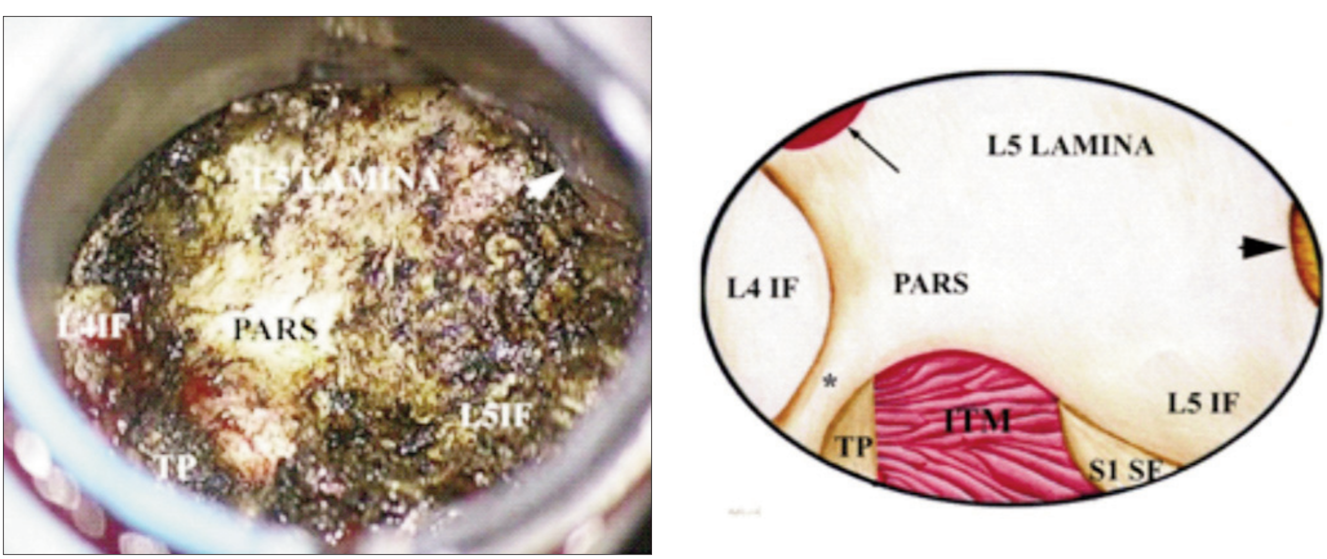

Figure 7. *The pars interarticularis is identified as the "valley between two hills" (L4IF = L4 inferior facet, TP = L5 transverse process, PARS = L5 pars interarticularis, ITM = intertransverse membrane and muscle, S1SF = S1 superior facet, L5IF = L5 inferior facet). Left, intraoperative image, Right, Artist's depiction*

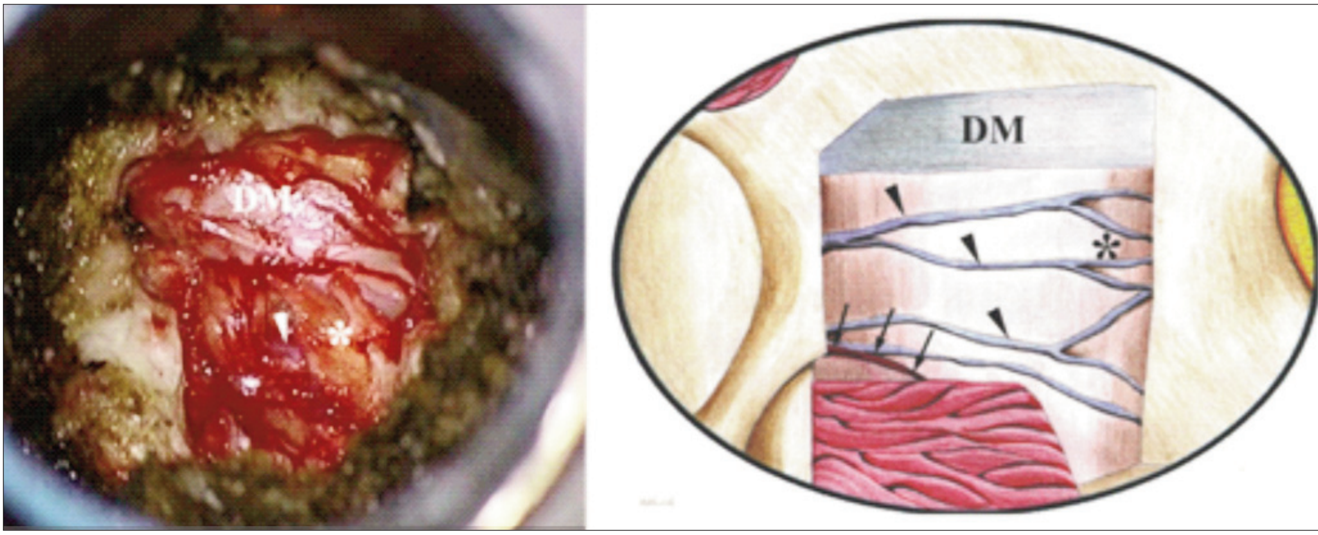

Figure 8. *Anatomic exposure after the initial bony removal with the high-speed drill. Once the bone and yellow ligament are removed, dura mater (DM) of the thecal sac is exposed medially, the arterial arcade of Dunsker (arrows) overlie the exiting spinal nerve, and multiple epidural veins (arrowheads) obscure the exposure. Bipolar coagulation of these veins is safest to start in the medial caudal quadrant (*). Left, intraoperative image, Right, Artist's depiction*

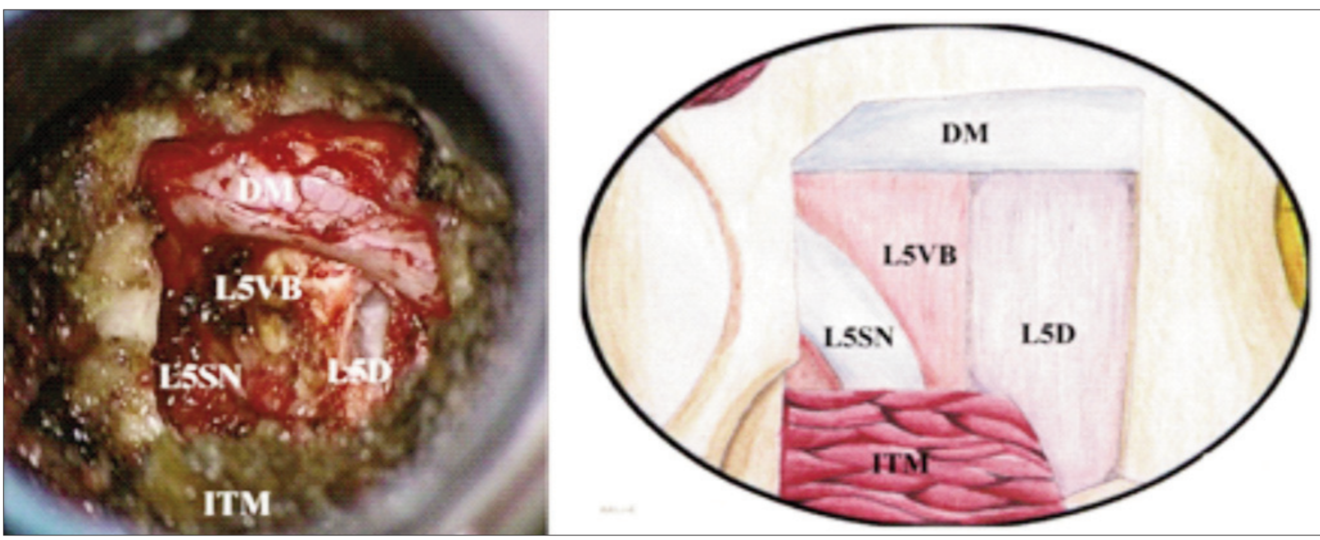

Figure 9. *Anatomic exposure after discectomy. The exiting spinal nerve runs underneath the corresponding pedicle. The annulotomy can be extended medially by retracting the dura. Left, intraoperative image, Right, Artist's depiction.*

insertion, to compression of the exiting spinal nerve against the superior pedicle. After the annulotomy is completed, disc material is removed using a variety of straight and angled curettes, disc space shavers, and paddle distractors of progressively larger sizes (*Fig. 11*). The disc and endplate preparation must be thorough; fusion rate will depend upon adequate endplate decortication. An implantable cage or bone graft provides substrate for the interbody fusion. Due to the naturally concave shape of the vertebral endplates, often compounded by large osteophytes, it is often difficult to insert an appropriately sized cage through the narrow opening at the level of the annulotomy. Several maneuvers can be used to facilitate appropriate cage sizing. Use of "bullet nose" shaped cages allows for progressive distraction of the two endplates by the cage itself, as it is inserted. Distraction of the opposite side of the vertebral elements via percutaneous pedicle instrumentation may maintain open the ipsilateral annulotomy, allowing for positioning of a larger intervertbral device. Intervertebral distraction may be garnered via rotation of blunt paddle distractors within the vertebral interspace. The distraction may be maintained via provisional tightening of contralateral percutaneous fixators. Small osteotomes can be used to remove part of the bony edges of the annulotomy; however this maneuver may presidpose to cage retropulsion. Finally, we prefer to make the final turn with the largest part of the shaver paddle at the superficial level of the annulotomy, while protecting the thecal sac and exiting spinal nerve, so that a cage of the same size will easily fit through the opening. An

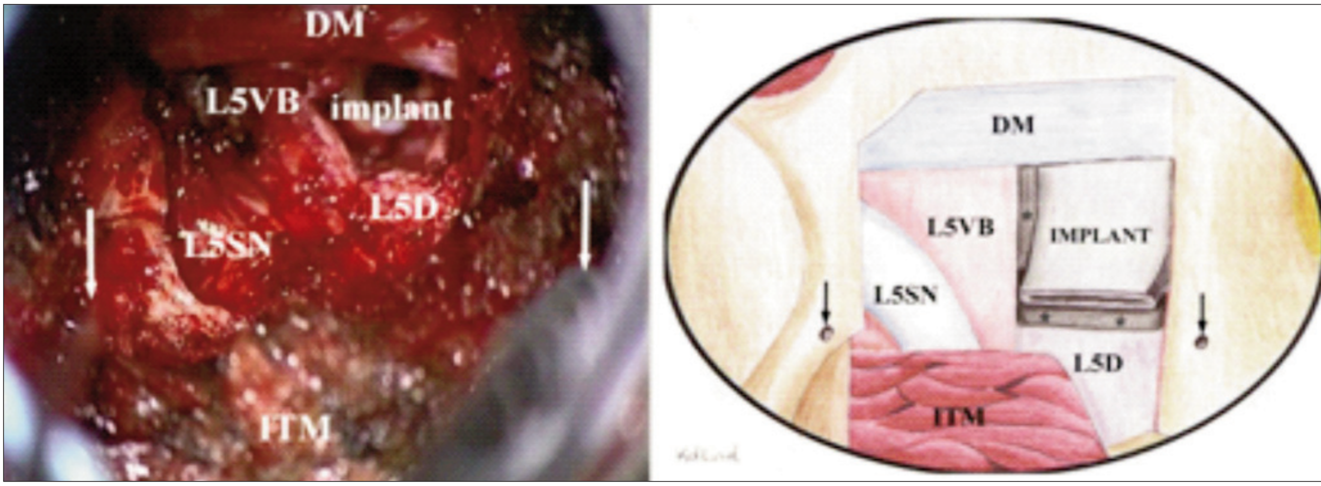

Figure 10. *The largest size implant should be inserted in the interspace (*). Pedicle screw insertion points (arrows) can be identified by directly palpating the pedicles. (DM = dura mater, L5VB = L5 vertebral body, IMPLANT = interbody implant, L5SN = L5 spinal nerve, L5D = L5 disc, ITM = intertransverse membrane and muscle). Left, intraoperative image, Right, Artist's depiction*

interbody spacer provides substrate for arthrodesis. Commercial vertebral body replacement devices, allograft spacers, or autograft bone may be used. These agents may be mixed with locally harvested bone obtained during the laminotomy. The interbody spacer is inserted in the disc space. The largest technically feasible spacer should be used. The size of the spacer can be inferred from the largest diameter shaver or distractor paddle used to prepare the endplates and distract the vertebral bodies. Optimal distraction of the interbody space may be confirmed via fluoroscopic images. According to the surgeon preference, either a PLIF or TLIF cage can be used, depending on the angle of insertion. Protection of the thecal sac and the inferior spinal nerve during this step is mandatory.

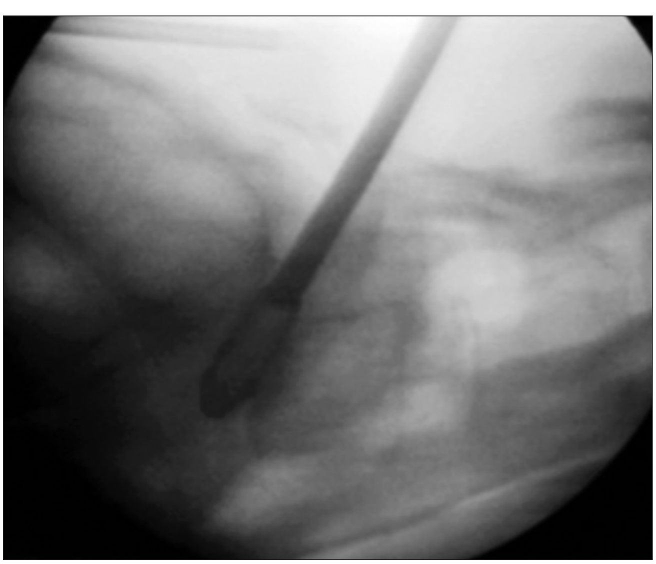

Figure 11. *Intraoperative radiograph showing the widest shaver inserted into the intervertebral space to remove the disc material and assess the height of the interbody spacer to be subsequently inserted*

Entry points for ipsilateral pedicle screws are easy to determine, since both pedicles can be palpated with a nerve hook or similar instrument (*Fig. 10*). The entry point for the superior pedicle should correspond to the junction between the pars, superior facet, and transverse process. We prefer to complete the preparation of both screw trajectories (including placement of the entry point using the high-speed drill, cannulation of the pedicle using the pedicle finder and tap, and palpation of the screw trajectory with the ball probe) before actually inserting the screws, since the working space is limited. Hemostasis after preparation of the first screw trajectory can be obtained through placement of a small piece of Gelfoam in the created screw path. Once both screws are inserted, the rod is placed on top of the screw heads and then tightened in position with the appropriate caps. Compression on the screw heads may be applied, if necessary. The tubular retractor is then removed and the wound is closed in anatomical layers. Final antero-posterior and lateral views of the construct can be obtained (*Fig. 12*).

Surgical Technique for MI TLIF based on pedicle screw – based retractor blades

The patient is placed in prone position, as described above. The patient's body must be adjusted to achieve as good of a neutral position as possible. The first step is to place the two pedicle screws bordering the level of interest (e.g., the L4 and L5 pedicles if the L4-5 level fusion is desired). The accurate placement of the pedicle screws is dependent of the quality of the radiologic images. Therefore, obtaining true AP and lateral images prior to skin incision is of utmost importance.

The AP image should be obtained first. The C-arm is

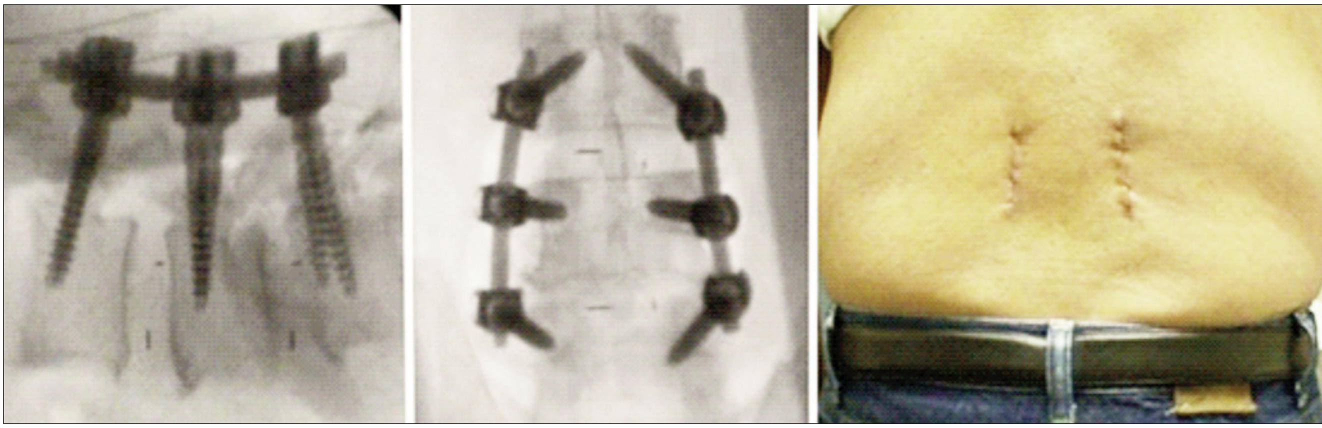

Figure 12. *Postoperative images at 1-year follow-up. Left and Middle, Antero-posterior lumbar radiographs showing the instrumented L4-L5-S1 fusion, Right, Well-healed minimally invasive incisions*

locked at 90 degrees, perfectly centered on the vertebral body of interest. This is particularly important if the patient has significant deformity, in which case the C-arm should be readjusted for each vertebral body. The spinous process of the vertebral body of interest should be dead centered between the two pedicle rings; otherwise, the table (NOT the C-arm) should be tilted left or right until the desired position is achieved. Then, the table is placed either in Trendelenburg or reverse Trendelenburg until the superior endplate of the vertebral body of interest becomes a single line. The lateral image is obtained next. If the AP image was perfect, now the posterior margin of the targeted vertebral body should appear as a single line. The perfect lateral image is obtained by "wagging" the C-arm until the two pedicles of the vertebral body of interest overlap. At this point, the superior and inferior endplates should also appear as a single line.

After this, the bony landmarks can be marked on patient's skin under AP fluoroscopy: the midline, the left and right pedicle lines, and the interpedicular line for the vertebral body of interest. The skin incision should be about 2-2.5 cm in length, vertical and centered on the interpedicular line, about 5 cm off the midline. This point typically corresponds to the tip of the transverse process on the AP image. In large patients, the skin incision has to be made further lateral, in order to maintain the same lateral-to-medial angle of insertion.

The lumbar fascia is then incised with the knife medial to the skin incision. It is important to remember that the fascia is the layer that limits the exploration of the deep bony landmarks. Continuing in the same lateral to medial direction, the index finger can be inserted to find the junction between the transverse process and the lateral facet. Typically, the lateral facet is first encountered (since it is the most superficial), and then the finger is allowed to slide lateral to it and land on the anterior aspect of the transverse process. If the incision is too small to accommodate a finger, the same landmarks can be identified with the tip of a Jamshidi needle, with the aid of frequent fluoroscopic images. The ideal docking point is at the junction of the transverse process with the lateral facet, as medial as allowed by the lateral facet. On the AP image, this point will appear just outside the pedicle ring; if it appears inside the pedicle ring, it is likely that the tip of the needle is actually riding high on the lateral facet, not on the transverse process. On the lateral image, the tip of the needle should be just above the ring of the transverse process, not high on the lateral facet, and the trajectory should pass through the upper half of the pedicle, parallel to the endplates. If fine adjustments are necessary, the tip of the Jamshidi needle can be moved with both hands (for maximal control) in millimeter increments, on the base of the transverse process, until the desired position is achieved.

Once the correct docking point is obtained, the needle is gently tapped through the pedicle. The direction is typically lateral to medial and cranial to caudal, but the angles vary with each level. As the needle is advanced through the pedicle, there should be no increased resistance (that would signify cortical bone and therefore pedicle wall breach). The most important images are obtained when the tip of the needle reaches the base of the pedicle on the lateral image; at this time, the tip of the needle should be still within the pedicle ring on the AP image.

At this time, neuromonitoring is usually employed. The shaft of the needle is stimulated, and a response of 10 mAmp or above signifies that the medial or inferior pedicle walls have not been breached.

Once the needle trajectory is deemed safe, the tip of the needle is advanced into the vertebral body for a couple of centimeters, and then the center part of the needle is removed and a K-wire is inserted for about another centimeter past the tip of the Jamshidi needle, in order to stabilize it to the cancellous bone and make it less likely to inadvertently come out during the placement of the tap and screw. Then, the Jamshidi needle is removed, while the K-wire is kept in place with the other hand.

After this, most systems have a series of tubular dilators that slide over the K-wire; the outer dilator and the K-wire are kept in place, whereas the inner dilators are removed to make room for the tap and screw. The tap is then advanced over the

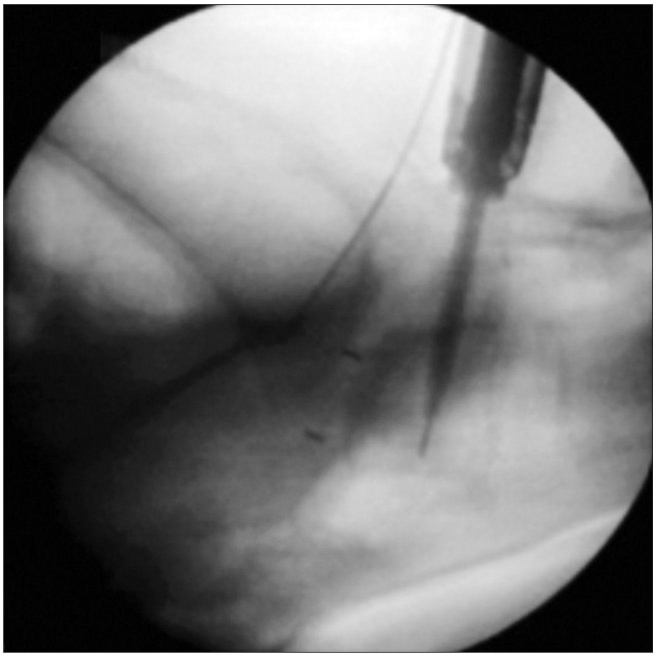

Figure 13. *Intraoperative radiograph showing the percutaneous insertion of L5 pedicle screw over the K-wire*

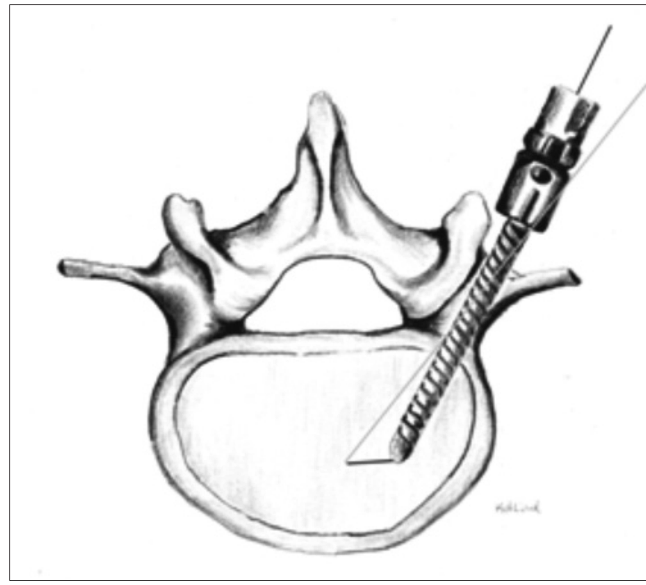

Figure 14. *Artist's depiction illustrating the risks of following a different direction than that of the guide wire. The tip of the wire gets bent and prevents the tap or screw from further advancement, thus stripping the pedicle*

K-wire into the pedicle of the vertebral body; it is sufficient (and recommended) to tap only past the base of the pedicle and not all the way into the vertebral body (*Fig. 13*). Most surgeons also prefer to undertap (i.e., use a 5.5 mm tap for a 6.5 mm screw), in order to maintain the good purchase of the screw into the bone. It is important to maintain the direction of the K-wire with the tap; if the tap is not aligned with the K-wire, the part of the K-wire in the vertebral body starts to bend at the tip of the tap, and when a critical angle is reached, the tap cannot advance any more, and any further turns of the tap do nothing but strip (and destroy) the pedicle (*Fig. 14*).

The tap is then removed and the screw (typically 6.5x45 mm for the average person) is inserted over the K-wire. The screw post has a retractor blade attached to its head and will permit the exposure for the remainder of the case. Once the tip of the screw passes the base of the pedicle, the K-wire can be removed, and the screw further inserted through the previously created trajectory. The screw insertion is stopped about 1 cm before its' final position, in order to maintain the retractor's poliaxial capabilities.

The second pedicle screw with its' attached blade are then inserted in a similar fashion. The two retractor blades are connected and then locked in place in the desired direction (as seen on the lateral fluoroscopic image) using a rigid arm that connects the retractor to the side of the bed.

At this point, the microscope is brought into the operative field. The cranial and caudal retractor blades can be opened to better expose the underlying structures, and the Bovie cautery is used to detach the paraspinous muscles from the lamina, in a lateral to medial fashion. The third (medial) blade is then used to retract these muscles and expose the facet joints and lamina of interest.

At this point, the anatomical exposure is similar to the one achieved with the tubular retractor; however, the angle of approach is typically more oblique, since the retractor blade location is dictated by the lateral position of the pedicle screw posts.

With that in mind, the next surgical steps are the same as in the tubular technique. The bony removal (medial facet, then lateral facet) is followed by the yellow ligament removal and exposure of the annulus fibrosus of the intervertebral disc of interest. The discectomy, endplate preparation, and cage insertion, are performed in a similar fashion as the tubular technique.

Finally, the retractor blade connections are removed from the screw posts, the screw heads are attached to the screw posts, and then a short rod is locked in place with the appropriate caps. Final AP and lateral XRays are obtained to confirm the correct placement of the instrumentation, and then the retractor is removed and the wound is closed in anatomical layers.

Results

Of the initial 60 patients, 7 were lost at the 1-year follow-up visit (4 in the tubular technique, 3 in the screw-based-retractor technique).

In the 43 patients undergoing MI TLIF using the tubular technique, there were 23 females and 20 males, with an average age of 48.2 (range: 23 - 88). Surgical indication was degenerative disc disease, with (13) or without (30) spondylolisthesis. Most patients (n=31) had a single level fusion, with the remainder (n=12) having 2 levels fused. We used unilateral pedicle screw / rod fixation in 16 patients and bilateral fixation in 27 patients. The average operative time was

189 min (range: 135-290) and the average estimated blood loss was 170 (range: 50 - 500). The length of hospital stay was 3.37 days (range: 1 -7). The visual analog scale (VAS) score improved from 9.7 (range: 8 - 10) preoperatively to 2.6 (range: 1 - 10) postoperatively at 1 year. The fusion rate at 1 year was 100% in the followed patients. There was one re-intervention for removal of a misplaced pedicle screw. There were two incidental durotomies, none resulting in a cerebrospinal fluid leak. One patient had a postoperative superficial wound infection that resolved with antibiotic treatment alone.

In the 17 patients undergoing MI TLIF using the screw-based-retractor technique, there were 9 females and 8 males, with an average age of 55.9 (range: 32 - 78). Surgical indication was degenerative disc disease, with (n=6) or without (n=11) spondylolisthesis. Most patients (n=11) had a single level fusion, with the remainder (n=6) having 2 levels fused. We used unilateral pedicle screw / rod fixation in 4 patients and bilateral fixation in 13 patients. The average operative time was 223 min (range: 129 - 354) and the average estimated blood loss was 257 ml (range: 50 - 600). The length of hospital stay was 3.29 days (range: 2-8). The visual analog scale (VAS) score improved from 9.4 (range: 8 - 10) preoperatively to 1.9 (range: 1 - 8) postoperatively at 1 year. The fusion rate at 1 year was 100% in the followed patients. One patient who had an incidental durotomy developed a postoperative compressive hematoma with resultant cauda equina syndrome requiring re-intervention; she did not present for the follow-up visits and presumably was subsequently seen by another physician. There were no re-interventions for revision of instrumentation.

Discussion

The MI TLIF is likely to become the most frequently performed spinal operation in the United States in the next 5 years (10). Other minimally invasive operations can only be used at specific levels: the extreme lateral interbody fusion (XLIF) can be used at L4-5 and above, but not at L5-S1, and the axial presacral interbody fusion (Axialif) can only be used at L5-S1 or L4-S1. In contrast, the MI TLIF can be used at any lumbar level, and offers the additional advantage of directly exposing and decompressing the neural structures. Moreover, the MI TLIF allows for removal of large disc herniations, a feature not available with either the XLIF or Axialif, which rely on indirect decompression of the central canal and foramina by increasing the disc height with appropriate size interbody grafts.

Most surgeons performing MI TLIF use the tubular retractor technique. This is a natural extension of the microdiscectomy tubular technique, in which the laminotomy is followed by yellow ligament removal and discectomy. Of course, in the MI TLIF technique, the laminotomy is followed by pars interarticularis division, medial and then partial lateral facetectomy, as well as a much more extensive discectomy, but the local anatomy remains very familiar to the spine surgeon who has previously performed tubular microdiscectomies. Moreover, after cage insertion, the tubular retractor can be angled slightly lateral from its' original position and thus expose the junction between the transverse process and lateral facet for both the cranial and caudal pedicles, thus allowing for accurate placement of the pedicle screw entry points under direct visualization, with only minimal fluoroscopic guidance. One of the disadvantages of this technique is the need for removal of some of the paraspinous muscles (between the tip of the tubular retractor and the lamina), which may increase postoperative pain. Another disadvantage is the inability to distract on the pedicle screws at the time of cage insertion, although with adequate technique, this distraction is rarely necessary.

The pedicle screw-based-retractor technique has become popular recently and offers several advantages. First, the insertion of the pedicle screws is performed in a percutaneous fashion, which is familiar to most spine surgeons using minimally invasive techniques. Second, the initial placement of the cranial and caudal retractor blades allows for exposure and detachment, without removal, of the paraspinous muscles, thus potentially decreasing postoperative pain. Third, this system allows for distraction on the pedicle screw posts prior to cage insertion, thus facilitating insertion of a larger size graft. Fourth, during the bony removal, the pedicle screw posts offer anatomic landmarks that can be used to determine the cranial and caudal extent of the decompression, thus decreasing the use of fluoroscopy. Finally, this system works well on two-level fusions, since the retractor blades can be placed on the top and bottom pedicle screws, thus exposing both levels at the same time (although at different angles) and obviating the need to reinsert the retractor for the second level. One of the few disadvantages of this system is the more acute angle of approach to the disc space, which may lead an inexperienced surgeon to allow the cage to slide between the annulus fibrosus and the dural sac, instead of in the pre-created space; this error can be avoided by starting the cage insertion in an almost vertical fashion, until the tip of the cage is engaged into the disc space, followed by dropping the hand laterally and allowing the cage to follow the pre-created path across the midline to reach its final position.

Our retrospective analysis suggests that there are no major differences between the results of the two techniques and that both achieve good pain relief and fusion rates, with minimal complications. Most surgeons embrace one or the other of the two techniques. For those who use both, the choice of one technique versus the other may be dictated by the particular anatomical characteristics of each patient, which may be easier to approach with one of the two techniques (for example, a patient with a narrow and sclerotic L5 pedicle may be better treated with the tubular retractor technique, since the entry point and initial trajectory can be determined more accurately under direct visualization rather than fully relying on fluoroscopy).

Conclusions

Both tubular retractor and pedicle screw-based-retractor techniques for MI TLIF can be used with good results. Each technique presents specific challenges and offers distinct advantages and disadvantages that can be tailored to the individual patient needs, although our results were similar in the two study groups. Further prospective randomized trials may detect subtle differences in outcome.

Conflicts of interest and source of funding

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