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Review Article
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Operative Technique and Literature Overview of the Lateral Access Surgery for Anterior Interbody Fusion

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Abstract

Based on the concept of minimally invasive spinal surgery, the retroperitoneal lateral transpsoas access was developed to approach the lumbar spine in a less invasive way. This technique allows access to the intervertebral disc laterally through the fibers of the psoas muscle. This approach is reported to offer adequate disc exposure, with the benefit of reduced iatrogenic injury to abdominal great vessels, sympathetic plexus (reducing incidence of retrograde ejaculation), and neural structures.

Here we minutely pass through the lateral interbody fusion technique, illustrate and highlight some hot points in the literature, while presenting clinical and radiological results and complications inherent to the technique.

Similarly to other minimally invasive approaches, learning curve consist a real barrier to accomplish surgery objectives. So, complete knowledge of the steps and tricks are primordial to perform and evolve this procedure. Patient positioning regards to a critical point of the surgery, when truly perpendicular way to the level has to be set. Safe crossing of the psoas muscle is assured with intraoperative use of EMG, avoiding lumbar plexus and direct neural damage. Ipsilateral and contralateral annulus release provides cortical bone support to the interbody cage at apophyseal ring to prevent cage subsidence.

The use of the lateral access has become popular and usual throughout the orthopedic and neurosurgery practice. However, as every incoming technology and technique, the users of it have to be attentive to its benefits and pitfalls.

Keywords: Spinal surgery; Intervertebral disc; Spondylolisthesis; Lordosis

Introduction

Chronic low back pain has been recognized as a complex disorder, and associated with wide-ranging adverse consequences [1-3]. Patients suffering from a painful lumbar motion segment not resolved with conservative management can gain benefit from lumbar arthrodesis [4].

Lumbar spine fusion has become a commonly performed surgery, and its use continues to rise, with the annual number of spinal fusion operations increasing every year [5]. Initially, reconstructive spinal fusion surgery was used for the management of infectious conditions, adolescent scoliosis and trauma. The indications for spinal fusion among these patients have remained largely unchanged. Moreover, based on these experiences the use of spinal arthrodesis has been extended to treat degenerative lumbar disorders, spondylolisthesis and disc-related problems [6].

Anterior lumbar interbody fusion (ALIF) is the technique commonly used to achieve large discectomy and lumbar interbody arthrodesis. ALIF allows restoration of disc space, lumbar lordosis and spinal alignment, without compromising posterior tension bands [6-9]. Besides, resection of the disc eliminates one of the possible causes of discogenic back pain. Disadvantages of ALIF include the necessity of an access surgeon, injury to the great vessels and retrograde ejaculation. In addition, ALIF is associated with increased operating time and blood loss, as well as prolonged recovery time [10,11].

Less invasive surgical techniques have been demonstrated to provide a large number of benefits, which include less tissue trauma, preservation of normal anatomical structures and faster recuperative period [12].

The true lateral retroperitoneal approach may offer same clinical advantages over more traditional techniques for lumbar fusion [13,14]. This less invasive procedure realigns the endplates to a parallel position through bilateral annular release, placement of a large implant across the disc space spanning the ring apophysis, and the effects of ligamentotaxis. The interbody grafting restores disc and foraminal heights, indirectly decompressing the neural elements and promotes stabilization through an anterior intervertebral fusion [15]. The complications related to this technique are mostly related to psoas traverse, including hip flexion weakness or numbness ipsilateral to the surgical access (psoas weakness), and less frequently sensory changes in the lower limb and abdominal wall, all resolved within 6 months [16,17]. Also, cage subsidence is frequently associated with standalone constructions or endplate injuries during discectomy. The implantation of wider interbody spacers has been proved to maximize the endplate support and allow a standalone construction with a lower incidence of severe cage subsidence, preventing its related complications [18].

Indications and contra-indications

Indications for the lateral approach are the same as those for any interbody fusion, with the limitation of access only at disc levels above L5. Such patients typically suffer discogenic pain due to segmental instability, disc degeneration, degenerative scoliosis, and/or grade one or two spondylolisthesis [19-24]. It may also be applied to patients that have failed prior surgery and require interbody fusion, or in cases of adjacent level disease [25]. Pseudarthrosis and failed lumbar total disc replacements have also been treated using the lateral approach for retrieval and revision [26-28].

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The lateral approach has been successfully accomplished for levels above and including L4-5. Approaching the L5-S1 level using this technique is not recommended because the risk of iliac vessels injury as well as the difficulty of accessing the disc space due to the iliac crest. Other current indications for XLIF, with or without pedicle screw supplementation, are discogenic low back pain [29], trauma [30-34] infection [35-37] and sagittal alignment by anterior column realignment [38-42].

Contra-indications of this technique include symptomatic level at L5-S1, lumbar deformities with more than 30º of rotation, high grade degenerative sponylolisthesis (grade 3 or higher), bilateral peritoneal scarring, need for direct posterior decompression through the same approach, for example in congenital lumbar stenosis or if a second micro-decompression is not indicated [24].

Surgical Technique

Patient positioning

The lumbar plexus monitoring is mandatory during psoas traverse, and this is performed using surface electrodes from electromyography system (NeuroVision, NuVasive, CA, USA) that monitors four muscle groups per side: vastus medialis, anterior tibialis, biceps femoris, and medial gastrocnemius. The patient is attached into a radiopaque bendable surgical table in a direct lateral decubitus position (90°), perpendicular to the table, with the trochanter directly positioned over the table break and with legs and knees slightly bent. This configuration increases the space between iliac crest and ribs, especially relevant when accessing thoracolumbar junction or L4-L5 level (Figure 1a and 1b).

The ideal positioning is confirmed by fluoroscopy, ensuring that when at 0º, the C-arm provides a true anteroposterior (AP) image, and when at 90º, a true lateral image. It is substantial that the lateral fluoroscopic images show both vertebral plateaus and superior pedicles aligned, presented as a single line, and that the AP image reveals the spinous processes in a middle position, and pedicles as circumferences (Figure 1c and 1d).

Lateral Retroperitoneal Access

Over the skin, the iliac crest, the transition between the last rib and the posterior abdominal wall and the quadratus lumborum muscles must be marked. After skin asepsis, the central position of the targeted disc can be identified using two Kirschner wires and lateral fluoroscopic images (Figure 2), making a marking that covers the center of the affected disc space. After, a longitudinal skin incision is made, over the intersection between the posterolateral muscles of the abdominal wall (abdominal internal oblique, abdominal external oblique and transverse abdominus). A first fascia incision is made to permit the surgeon to introduce the index finger into the retroperitoneal space and gently create a pathway and releases all attachments of the peritoneum, providing a safe lateral entry. Once identified the retroperitoneal space, a second fascia incision in made below the first skin mark to introduce the initial dilator. The index finger will safely guide all dilators up to the psoas muscle, protecting abdominal structures.

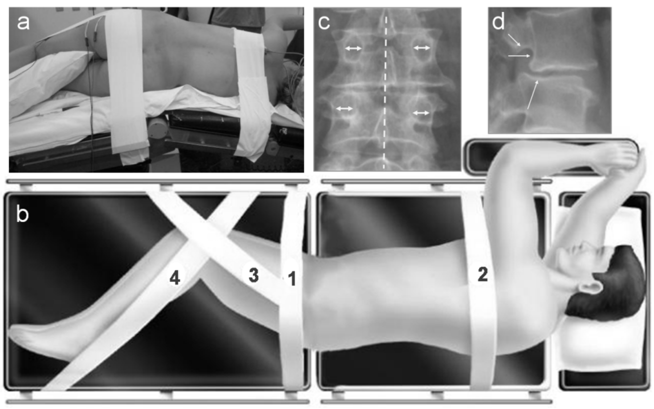

Figure 1: Patient positioning. **a.** True 90o lateral decubitus positioning. **b.** Patient is taped at the surgical table at: 1. just below the iliac crest. 2. over the thoracic region. 3. from the iliac crest to the knee, then to the table. 4. from the table to the knee, past the ankle, then to the table. **c.** Symmetrical pedicles on fluoroscopy. **d.** Spinous process at midline on fluoroscopy.

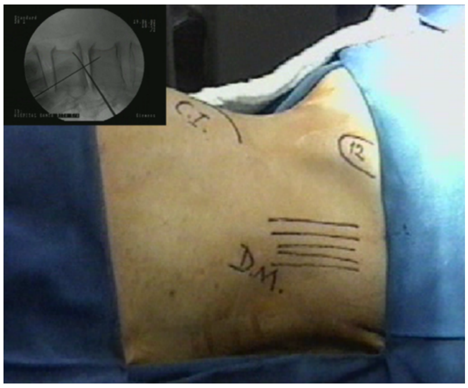

Figure 2: Targeted disc space. A K-wire and lateral fluoroscopy are used to identify the mid-position of the disc. C.I. Iliac crest. 12. 12th rib. D.M. Dorsal muscles.

Psoas traverse

The first dilator is placed upon the posterior third of the disc, as confirmed by AP and lateral fluoroscopy. Then, the fibers are gently separated by the initial blunt dilator with concomitant EMG monitoring for assessing the closeness to the lumbar plexus and allowing determining the proximity of neural structures that are adjacent to the surgical field by using a probe. The dilator must be rotated in position to determine proximity and spatial distribution of nerves. The dilators in sequence are placed over the previous, always checking the EMG, until the final placement of the retractor, still closed. The working portal is connected to a suspension arm in order to prevent unwanted movement. After confirming the ideal position by fluoroscopy, a shim goes down on the posterior blade and inserted inside the posterior portion of the disc in order to stable the position of the retractor system. Therefore, the blades can be selectively open and adjusted to the desired diameter. A bifurcated optical fiber cable is attached to the retractor for optimal direct visualization of the exposure (Figure 3). Moreover, the retractor opening must be minimal, with the shorter duration of muscle spreading as possible to prevent lack of blood flow to the nerves of the plexus and then, prevent plexopaties following the access.

Disc space preparation

The discectomy is performed using standard instruments under direct visualization. The anterior and posterior portions of the disc containing the longitudinal ligaments must be preserved in order to keep intact the anterior and posterior longitudinal ligaments, responsible for ligamentotaxis and indirect decompression of the neural structures [15,43]. Laterolateral disc removal and contralateral ring release with a Cobb are essential to ensure symmetrical distraction, properly bilateral decompression and avoid coronal iatrogenic changes. Furthermore, this maneuver allows the placement of an implant that covers both side edges of the cortical apophyseal ring, maximizing the

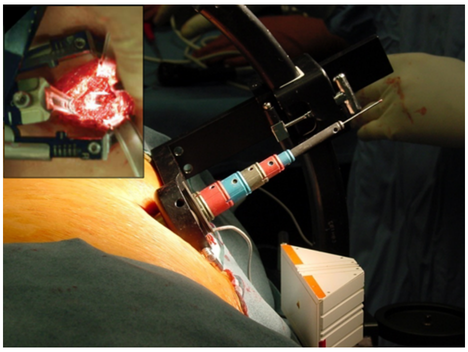

Figure 3: Working portal with positioned dilators and retractor. Upper left is possible to see the direct visualization of the disc space provided by the opened retractor.

Figure 4: Case example of a 62 year-old female that underwent seven level degenerative scoliosis surgery achieved by two small incisions, with minimal blood loss and muscle damage. Patient was discharged 48 hs after surgery, without the need of drains or referral to intensive care unit.

spinal plateau support. The complete removal of cartilage and rasping the cortical bone layer provides blood precursor cells and bone growth factors that facilitate bone ingrowth.

Device insertion

Implant proofs determine the proper cage height, length and angle that must be utilized to reach the stipulated objectives. The entire process must be guided by fluoroscopic imaging. The ideal placement is the device centered across the disc space from an AP view, and between the anterior third and middle third of the disc space from a lateral view. The ideal implant positioning also restores focal lordosis, especially at L4-L5 24.

The use of synthetic bone grafts instead of autologous bone is recommended, avoiding major postoperative morbidity. The final position of the implant must be checked by AP and lateral fluoroscopy.

Closure

The surgical site is washed and the retractor is closed. The portal must be slowly removed in order to observe the psoas muscle closure and confirm hemostasis. The incisions are closed in a standard fashion. No drain is required. The construct may be supplemented with the internal fixation system of choice, if indicated (Figure 4).

Postoperative care

Patients are encouraged to walk the same day accelerating their recovery and muscle function, also avoiding deep venous thrombosis and pulmonary thromboembolism. Postoperative pain tends to be minimal, and patients are usually discharged after only an overnight hospital stay.

Current Results

Since its first description [13], the published literature into lateral access surgery brought to light greater knowledge regarding applications and outcomes of the procedure. This includes dozens of peer-reviewed articles, and hundreds of abstracts and posters presented at the most important scientific meetings all over the world. These scientific evidences have allowed the expansion of surgical applications. Currently, the applications of lateral approach include discogenic low back pain [29], degenerative back and leg pain [44], trauma [30,33,45], infection [36], tumor [46,47] coronal and sagittal alignment [41,48-51] revision [26,27], spondylolisthesis [43,52-54], motion preservation [55], adjacent level disease [25], and others that require access to the anterior column of the thoracolumbar spine [38,56-58].

Until now, there is no prospective comparative cohort studies using minimally invasive approach for the specifically treatment of ASD. Rodgers et al. [25] conducted the only specific study regarding lateral access surgery for the treatment of ASD. They prospectively treated a series of 100 patients with adjacent segment degeneration after prior lumbar fusion using the lateral approach. From them, 79 had undergone prior instrumented posterior fusion procedures, 15 had undergone prior uninstrumented posterior fusion procedures, and 6 had undergone anterior lumbar interbody (ALIF) fusion procedures. The authors have found little intraoperative blood loss, and mean length of hospital stay was only 1.13 days. There were gains in disc height and slippage reduction in cases of spondylolisthesis. Lenke score showed good progression of fusion while clinical outcomes improved significantly in all follow up points.

Differently, literature presents several studies regarding XLIF that include patients with degenerative deformities like adult degenerative scoliosis [41,48,49,51,59-64], also including spondylolisthesis in partially or total cohort [43,52-54]. As featured, is possible to mention Rodgers et al. [54] that has operated 63 patients by lateral approach for the treatment of spondylolisthesis grade 2 using posterior supplementation, showing good clinical and radiological results. The hospital stay averaged 1.2 days, with no infections or persistent neurologic deficits. All patients achieved fusion at last follow up, with improvement in self-assessment questionnaires. They have found complications in only 3.4% of total cohort, one patient with ileus and second having a broken pedicle screw in consequence of a car accident 14 months after surgery. Marchi et al. [43] followed 52 patients that underwent XLIF surgery for the treatment of low grade spondylolisthesis, with all undergoing standalone constructions. The authors have achieved a mean surgical duration of 73.2 ± 31.4 minutes (mean ± standard deviation), with less than 50ml of blood loss and no intraoperative complications or infection. Symptoms of psoas weakness were found in 10 patients (19.2%), while 5 patients (9.6%) had anterior thigh numbness, both conditions resolved within 6 weeks after surgery without any special care. Clinical results of Visual Analogue Scale (VAS) and Oswestry Disability Index (ODI) were significantly improved. Radiological results have shown statistical significance in olisthesis reduction and improvement in global lordosis. Fusion was seen in 86.6% of total cases at last follow up, with no signals of pseudoarthrosis. Revision surgery to perform direct decompression and to place pedicle screws was necessary in 7 levels (13.5%), 5 cases in consequence of high-grade subsidence with instability/restenosis and 2 cases in which indirect decompression was not achieved. Other 4 cases of severe subsidence did not require surgical intervention.

Complications and Management

Literature mostly shows low rate of complications in the immediate postoperative period, including hip flexion weakness or numbness ipsilateral to the surgical access (psoas weakness), and less frequently sensory changes in the lower limb, all resolved within 6 months [15,29,65]. Transient plexopaties (motor or sensory) and hip flexor weakness are the most commonly reported complication associated with lateral access surgery. Sensory deficits are more prevalent than motor abnormalities, and transient psoas weakness is more prevalent than both. 40-90% of these cases can expect resolution of their symptoms within 90 days, very few patients have symptoms lasting more than 12 months [66,67]. Manipulation of the psoas muscle is an obvious cause of hip flexor weakness in the absence of neurological etiologies. Thus, inhibition of the muscular contraction is expected postoperatively even without any intraoperative neural damage. Otherwise, the reports did not find a higher prevalence of thigh symptoms based on the number of levels that underwent transpsoas approach, or with the utilization of multiple procedures and approaches to achieve positive outcomes.

Subsidence is another well described complication related to anterior fusion surgery. It is usually related to standalone constructs, and has been correlated to instability at the index level, possibly due to resectioning of the anterior and posterior longitudinal ligaments. Subsidence decreases distraction of the disc space and the indirect decompression of the neural structures. Also, it can cause a spinal imbalance, not reaching the proper correction of sagittal alignment. The implantation of wider interbody spacers by lateral approach has been proved to maximize the endplate support and allow a standalone construction with a lower incidence of severe cage subsidence, preventing acute pain onset, and preserving surgical gains such as disc space distraction, sagittal alignment, and their effects on neural decompression [18].

Ahmadian et al. [68] showed a literature review of lumbar plexus-related complications in 2310 patients and the most seen were thigh pain and/or numbness [16,44,55,66,69-77], hip flexior weakness [50,55,66,70-73] and quadriceps weakness [16,50,72,73,77,78]. These complications were probably secondary to direct mechanical compression, laceration, stretch, traction, or in ischemia during the procedure.

Final Considerations

One of the biggest advantages of the lateral approach is the opportunity to insert larger implants into the densest area of the vertebral endplate, reaching both sides of the ring apophysis that enhances primary fusion. Despite its minimally invasive features, the maintenance of the longitudinal ligaments, particularly ALL, associated with the implantation of a large device results in the correction of the rotational deformity in addition to the coronal and sagittal deformities, without the risks, comorbidities and complications related to standard open surgeries. Disc height restoration has been proven to indirect decompress the neural structures, without the need of posterior laminectomy or pedicle screw supplementation, minimizing muscle splitting, blood loss, hospital stay and operative time, improving patient´s recovery and satisfaction with the procedure [79].

The older patients with significant comorbidities who are unable to tolerate large, disruptive surgeries are the biggest beneficiaries of lateral access surgery [80]. The most rewarding indications for these patients are adjacent segment degeneration and degenerative scoliosis. For adjacent level disease, the lateral approach avoids the previously operated approach pathway, either dorsally or ventrally, preventing access to scarred tissues. Moreover, the reconstruction of the anterior column is accomplished by the large interbody cage implanted laterally, that avoids injury to muscle groups accessed during the posterior approach [81], and abdominal organs and vasculature vulnerable in anterior approach [10,11].

Conclusions

The surgical, clinical and radiological results have shown that the technique is a feasible, safe and effective approach to the lumbar spine. The complication rate has been satisfactory when compared to other surgical methods. Psoas weakness is the most common complication and results usually don't show permanent neural deficits as consequence of an adverse event. For one decade the technique has been successfully performed worldwide to achieve spinal fusion through a lateral minimal invasive approach, decreasing pain, indirectly decompressing neurological structures, restoring disc height and stopping the progression of degenerative scoliosis. However, all the benefits only would be achieved with surgeon's evolution along the procedure learning curve, which must be carefully respect.

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