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IDEAS AND TECHNICAL INNOVATIONS

Mini-open lateral retroperitoneal lumbar spine approach using psoas muscle retraction technique. Technical report and initial results on six patients

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Abstract
Purpose The main aim of this paper was to report reproducible method of lumbar spine access via a lateral retroperitoneal route.
Methods The authors conducted a retrospective analysis of the technical aspects and clinical outcomes of six patients who underwent lateral multilevel retroperitoneal interbody fusion with psoas muscle retraction technique. The main goal was to develop a simple and reproducible technique to avoid injury to the lumbar plexus.
Results Six patients were operated at 15 levels using psoas muscle retraction technique. All patients reported improvement in back pain and radiculopathy after the surgery. The only procedure-related transient complication was weakness and pain on hip flexion that resolved by the first follow-up visit.
Conclusions Psoas retraction technique is a reliable technique for lateral access to the lumbar spine and may avoid some of the complications related to traditional minimally invasive transpsoas approach.

Keywords Retroperitoneal approach · Interbody fusion · Psoas muscle · Lumbar plexus

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Introduction

Over the course of the last decade, there has been a significant technical progress in spine surgery, especially in interbody fusion techniques for degenerative disc disease. The concept of minimally invasive, extreme lateral interbody fusion (XLIF) technique was first reported in early 2000s by Pimenta [1] and has gained widespread acceptance among spine surgeons [2]. It is based on lateral retroperitoneal transpsoas approach and electrophysiological navigation inside the psoas major muscle to avoid damaging the lumbar plexus. Studies on nerve distribution along the lateral side of the lumbar vertebral column, inside the psoas muscle, showed relatively safe working "windows" to access the disc spaces from L1–2 to L4–5 [3, 4]. However, given the patient- and level-related variations, no standard surgical strategy can be used to access all levels. Monitoring of sensory branches such as the genitofemoral, iliohypogastric, ilioinguinal and lateral femoral cutaneous nerve is not feasible. Additionally, the inevitability of retracting the lumbar plexus creates risk for nerve injury. In some cases, the "safe window" is located between branches of the plexus and therefore anterior retraction is necessary [2]. Such retraction can cause nerve stretching and may lead to permanent injury. Therefore, placing the muscle opening as anterior as possible is advantageous in terms of avoiding lumbar plexus injury. In addition, the electrophysiologically optimal working window inside the muscle may not necessarily represent the radiologically optimal site for discectomy and cage implantation. Finally, there is inter- and intra-observer variability in the electrophysiologic monitoring itself, adding to the unpredictability of the outcome.

In this paper, we report an alternative to the traditional transpsoas technique with exposure of the anterior border

of the psoas major muscle close to the sympathetic chain and retraction of the psoas muscle from antero-medial to postero-lateral side under direct visualization to expose the lateral aspect of the disc space. This approach provides a slightly oblique trajectory to the disc and, in our opinion, minimizes the risk of lumbar plexus motor or sensory nerve injury. Surgical nuances as well as complication avoidance are discussed.

Materials and methods

Patient population

Six patients were operated between January and August 2012 using psoas muscle retraction technique. Demographic data and operated levels are shown in Table 1. In the patients who had preoperative degenerative coronal deformity, the approach was chosen from the concave side. Otherwise left side approach was utilized on routine basis.

Surgical technique

The patient is placed on a lateral decubitus position with axillary and lumbar rolls. We found that it is unnecessary to overextend the gap between the T12 rib and iliac crest by breaking the table because this maneuver stretches the psoas muscle and lumbar plexus making retraction difficult and dangerous. The location of the disc of interest is first outlined by lateral fluoroscopy. An incision is made starting from anterior to mid-disc point. It creates an oblique working angle and decreases the need for psoas muscle retraction. The lateral abdominal muscles are opened parallel to their fibers. Mono polar cautery is not used since sensory and motor branches can be injured by spreading electricity. Dissection proceeds carefully to avoid injury to the subcostal, iliohypogastric and ilioinguinal nerves. It is essential to remember that the different muscle's fibers in the lateral abdominal wall are parallel neither to each other nor to the nerves. Therefore, one must work in between the nerves, gradually separating muscle fibers. Typical opening is about 5 cm and enough to access two levels. L1–2 and L2–3 are typically approached by removing the 12th rib and working above the subcostal nerve. L3–4 and L4–5 are usually located between the subcostal and iliohypogastric nerves, although sometimes L4–5 may be lower—between iliohypogastric and ilioinguinal nerves. For more than two levels, two separate abdominal muscular wall openings should be performed to avoid excessive retraction and obtain optimal angle for discectomy and cage placement. After opening the transversalis fascia, the retroperitoneal fat protrudes into the defect. Dissection continues in a blunt fashion inside the retroperitoneal fat, gradually retracting the peritoneal contents anteriorly. Initially, the dissection is directed posterio-medially—the first muscle to be exposed is the quadratus lumborum. Lateral abdominal nerves passing over the surface of the quadratus lumborum muscle can be found just between the muscle's fascia and the retroperitoneal fat. The dissection is performed anteriorly to keep them attached to the muscle's surface. Once the psoas muscle is found, the retroperitoneal fat is dissected away from it and retracted anteriorly for complete exposure. The genitofemoral nerve lies on the lateral surface of the psoas major muscle and is exposed. The nerve should be distinguished from the psoas minor muscle tendon that also runs on the lateral aspect of the muscle, which is usually whiter and has more bundle-type appearance. Direct visualization avoids the risks of blunt finger dissection that can avulse those nerves as the finger gets into the plane between the nerves and the muscle. Dissection is continued anteriorly to expose the anterio-medial border of the psoas major muscle where the sympathetic chain is found. At this point, a retractor frame is installed and a single retractor blade (SynFrame; Synthes; West Chester, Pennsylvania) is placed into the field to retract retroperitoneal fat anteriorly.

A dissection plane is developed between the sympathetic chain and the anterior border of the psoas muscle. Bipolar cautery and sharp dissection is used to cut attachments and the psoas muscle is retracted posteriorly. Also the sympathetic plexus is dissected from the spine and retracted anteriorly by placing the anterior retractor blade posterior and medial to it. This maneuver usually exposes the anterior longitudinal ligament which should be preserved. Segmental vessels are coagulated clipped and cut if access to mid-vertebral body is required to insert a plate or other anterior support instrumentation. During psoas muscle dissection, small nerve branches may come into view and are retracted posteriorly together with the body of the muscle. A 2-cm working space is enough to obtain adequate access (Video). Discectomy is performed in a routine fashion with contralateral annulotomy using a Cobb under AP fluoroscopic guidance.

Once the cage is implanted attention is given to adjacent levels. The anterior border of the psoas muscle serves as

Table 1 Patients' demographical and operative data

Patient	Sex	Age	Level	Blood loss	Follow-up
1	Female	73	3–4	200	33 weeks
2	Female	64	3–4, 4–5	100	35 weeks
3	Male	69	2–3, 3–4, 4–5	400	23 weeks
4	Female	63	1–2, 2–3, 3–4, 4–5	200	19 weeks
5	Female	68	2–3, 3–4	50	39 weeks
6	Female	61	1–2, 2–3, 3–4	200	11 weeks

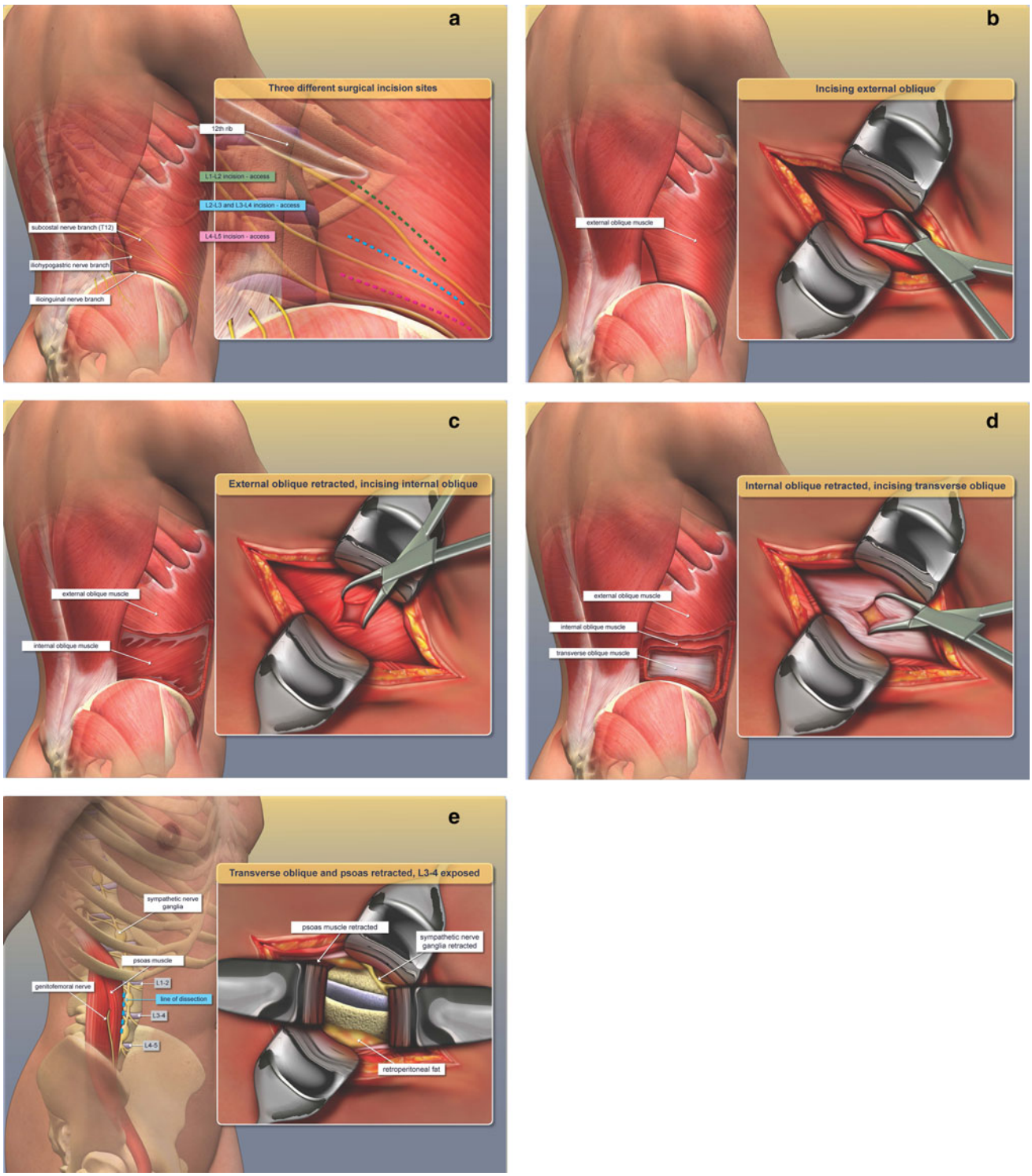

Fig. 1 Anatomical step-by-step demonstration of the approach. **a** Postero-lateral abdominal wall with different incision marks for different levels. **b** Opening of the external oblique muscle. **c** Opening of the internal oblique muscle. **d** Opening of the transverse muscle and fascia and exposing retroperitoneal fat. **e** The dissection between the sympathetic plexus and psoas muscle. *Inset* The muscle has been retracted posteriorly and plexus anteriorly

the major landmark to extend the dissection inferiorly or superiorly. The same surgical corridor between the sympathetic chain and the muscle is developed further up or down. At the L4–5 level, the genitofemoral nerve comes close to the anterior psoas muscle border and therefore should be preserved by strict adherence to muscle

detachment technique. Also at this level for a left-sided approach, the iliolumbar vessels should be ligated and sectioned to adequately retract the muscle. No EMG monitoring is necessary but could be used for reassurance.

Results

Postoperatively all patients showed mild pain with ipsilateral hip flexion that was attributed to psoas major muscle manipulation. There were no new sensory or motor neurological deficits. All patients showed return to preoperative psoas muscle function by the first postoperative visit (6 weeks). Postoperative direct radiographs showed optimal placement of hardware in all cases.

Illustrative case

A 63-year-old Caucasian female (Patient 2) presented with chief complaint of low back and bilateral leg pain. On neurological examination, she was found to have right great toe dorsiflexion weakness. Radiographic assessment revealed grade 1 degenerative changes in L3–4 and L4–5 levels with coronal deformity and spondylolisthesis at L4–5 level (Fig. 1). After discussion of all treatment options, she chose lateral retroperitoneal interbody fusion. However, the patient insisted on keeping the number of fused levels as few as possible and did not consent to two-stage procedure. Therefore, the decision was made to perform fusion at symptomatic levels—namely, L3–4 and L4–5. The patient underwent left lateral retroperitoneal interbody fusion at L3–4 and L4–5 levels with expandable interbody cages, supplementary screw rod fixation and polymethylmethacrylate cement augmentation (Fig. 2). She had an uneventful postoperative course and was neurologically intact at 6 weeks follow-up. Both back and leg pain vanished at that point.

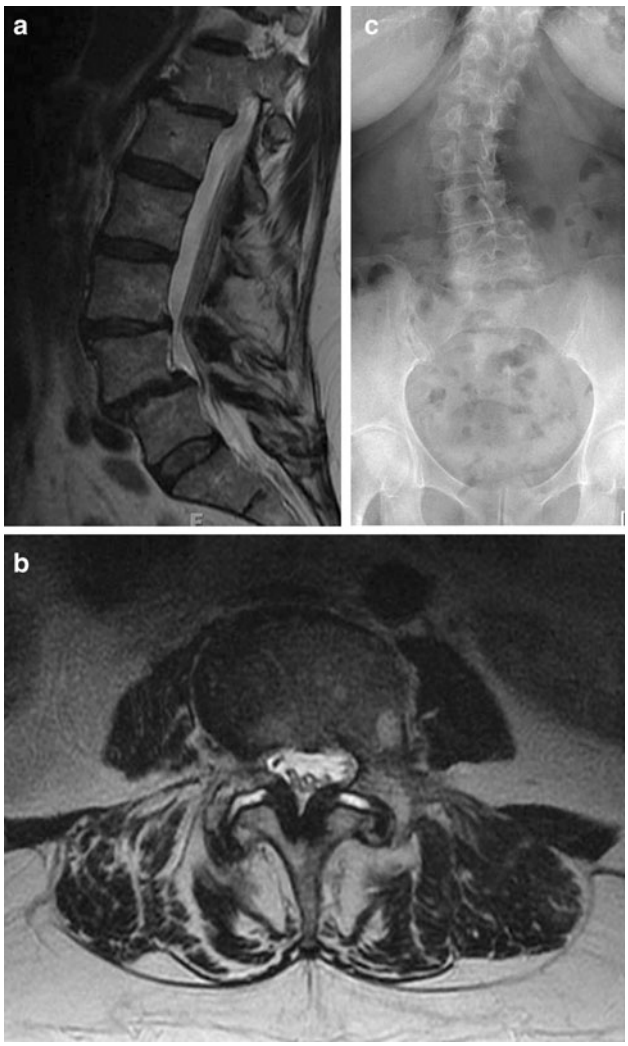

Fig. 2 Preoperative radiographic data of illustrative case. **a** Midline sagittal T2W. **b** Axial T2W image through L4–5 level. Note fluid accumulation inside facet joints. **c** Antero-posterior plain radiograph, demonstrating scoliosis

Discussion

Minimally invasive lateral retroperitoneal transpsoas interbody fusion technique has become a popular technique for lumbar degenerative disc disease treatment. There are several advantages of this technique over anterior and posterior fusion techniques. It gives a surgeon the ability to place relatively large cages which decrease the possibility of subsidence [5]. The cages are rested at the apophyseal rings providing stability in the coronal plane. Also approaching the spine purely from a lateral direction decreases the risk of vascular injury. From a biomechanical standpoint, lateral retroperitoneal approach is minimally destabilizing interbody fusion option as anterior longitudinal ligament, posterior longitudinal ligament, facet joints, inter- and supraspinous ligaments are all preserved. However, the risk of ipsilateral lumbar plexus injury is still its main disadvantage. Traditionally, a working window is created inside the muscle by means of electrophysiological monitoring to avoid lumbar plexus injury. However, monitoring may not be absolutely reliable especially for sensory branches and injuries may occur [6]. Banagan et al. [7] in their anatomical study found that K wire placement to the midpoint of the disc leads to direct nerve injury in 25 % of cases. Also it was found that K wire placed to the disc midpoint at the L3–4 level is posterior to the nerve roots in 25 % and at L4–5 level in 50 % of cases. It is assumed that posterior nerve retraction is safer due to less stretching. At lower levels, especially at L4–5, there is no safe working window anterior to all nerves. Guerin et al. [3] performed an

anatomical study on the safe working zones inside the psoas muscle and found that at L3–4 and L4–5 levels, the "safest" zone is always posterior to genitofemoral nerve.

Anterior lumbar interbody fusion is another alternative to XLIF [8–19]. However, there are several limitations associated with this ALIF. Deep surgical field, the possibility of vascular injury, the possibility of sympathetic chain damage with retrograde ejaculation, anterior longitudinal ligament compromise are handicaps of anterior lumbar interbody fusion technique.

Approaching the spine between the sympathetic chain and the anterior border of the psoas muscle has several advantages. First, it eliminates the risk of permanent direct lumbar plexus injury. It decreases the risk of retractional injury since the distance from the retracting point is further anterior. Electrophysiological monitoring is of minimal significance and may be omitted. On the other hand, it provides the same access as the traditional minimally invasive retroperitoneal transpsoas approach. The anterior longitudinal ligament is preserved during this approach, which provides additional segmental stability and prevents cage migration anteriorly. The working direction is slightly oblique, especially at lower levels (Fig. 3). The psoas muscle is bulky and overlays the majority of the lateral spine surface. At the L4–5 level, it almost reaches the most anterior point of the disc space. Starting the incision anteriorly and attacking the spine obliquely decrease the amount of retraction necessary for discectomy (Fig. 4). Bulky psoas muscles are relatively hard to retract. This issue is usually encountered with over-weighted male patients. In those cases, muscle requires more force to be retracted and the surgical field is deeper, requiring longer retraction blades. Small psoas muscle is almost ideal for our technique. First, it is easy to separate the muscle and retract it. Also smaller muscle has higher density of lumbar plexus nerves in it. Therefore, traditional transpsoas technique has higher risk of nerve injury.

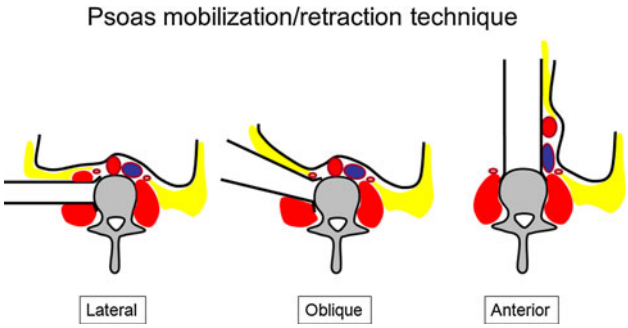

Fig. 4 Schematic representation of pure lateral (*left*), slightly oblique (*middle*) and anterior (*right*) retroperitoneal approaches

Having vertebral body surfaces available is also advantageous for supplemental hardware placement. During traditional lateral retroperitoneal transpsoas approach muscle is opened parallel to fibers. However, because lumbar plexus nerves are not parallel to muscle fibers exposure is limited. Therefore, placement of multilevel plate/screws constructs are not feasible and separate plate/screw combinations are used for each level or posterior approach is employed, requiring second surgery. Our technique is advantageous since it allows the placement of a single anterio-lateral supplemental construct.

Abdominal and thigh numbness after traditional minimally invasive lateral retroperitoneal interbody fusion are common complications [20]. It may be due to direct or indirect nerve injuries during either abdominal wall dissection or psoas major manipulation. The ideal approach from a theoretical standpoint to avoid abdominal wall nerve injury as well as lessen psoas muscle manipulation is a midline anterior retroperitoneal approach. However, vascular manipulation or retraction with a possibility of

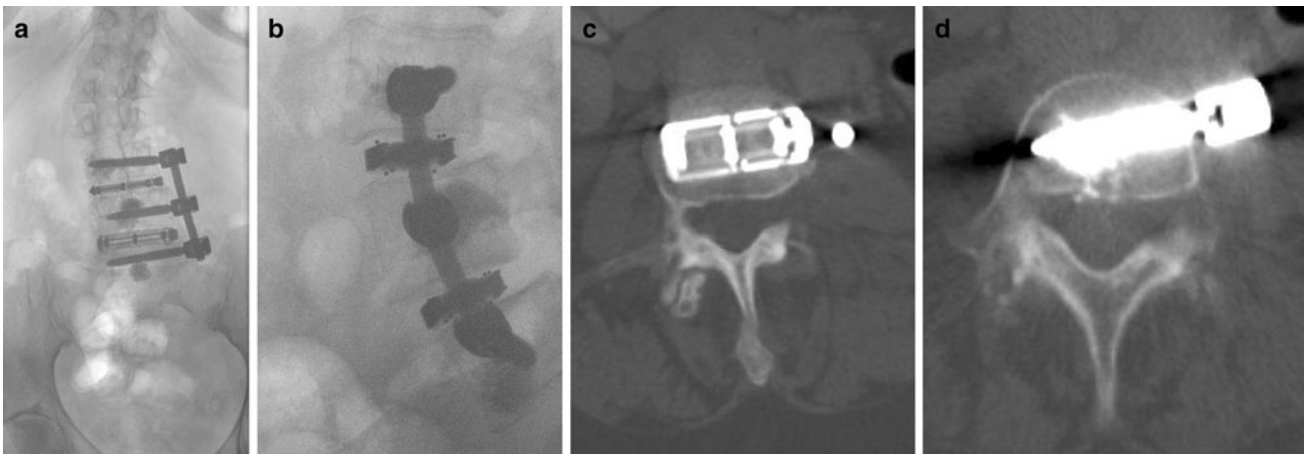

Fig. 3 Postoperative plain antero-posterior (**a**) and lateral (**b**) plain radiographs. **c** An axial CT picture demonstrating interbody cage. **d** An axial CT picture demonstrating a screw placement with PMMA cement around it

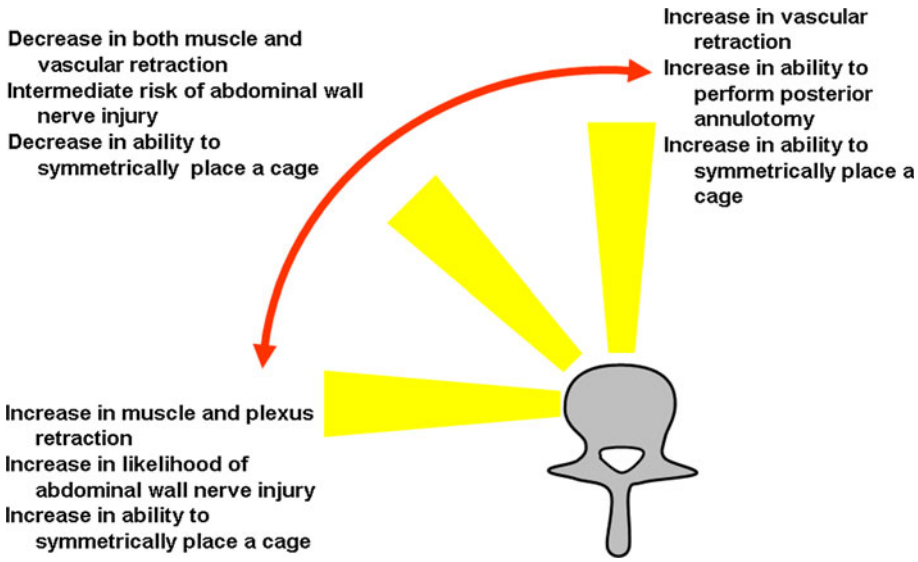

Fig. 5 Schematic comparison of three retroperitoneal routes to lumbar spine with corresponding advantages and disadvantages

catastrophic injury is the main handicap of this approach [21]. A slightly oblique approach, i.e., starting skin incision a few centimeters anterior to the classic lateral retroperitoneal seems to be a good alternative to avoid both vascular and muscle/plexus injury (Figs. 4, 5). Strict adherence to our technique led to the elimination of hypoesthesia in the postoperative period. However, given the small patient sample in our study, more patients need to be followed to substantiate this observation. Early postoperative thigh flexion weakness and pain are inevitable in our experience especially with multiple level discectomy. It is a response to psoas muscle detachment, retraction and manipulation. Again not a single patient in this small series had permanent muscle weakness on follow-up.

The oblique trajectory of cage placement may seem to endanger the contralateral intervertebral foramen and compromise the exiting nerve root. Therefore, it is important to confirm the trial and final cage position not only on anterior–posterior but also on lateral intraoperative X-rays. However, since discectomy site is located in the anterior third of the disk space and the working angle is not very steep, the cage naturally occupies anterior/mid third of the disk space (Fig. 3). Placing the cage in an oblique direction (Fig. 3) is a disadvantage of our technique. It may not be able to restore coronal deformity as it would be done with straight coronal placement. We think that this disadvantage may be handled in two ways. Currently available cage inserters hold the cage in a parallel manner. Having an inserter that grabs the cage at a slight angle will help place the cage properly. Another way is adjusting the cage itself. Banana type of cages has been employed for transforaminal interbody fusions for a long time. However, there are no commercially available curved cages for lateral transpsoas approach. Having a banana shaped cage available will allow the surgeon to slide it in the disc space in a curvilinear fashion. This would encompass proper coronal balance restoration, as well as decrease the risk of the contralateral foraminal injury.

The sympathetic chain should be considered different from the lumbar plexus nerves. It is not traveling in the muscle and can be dissected and retracted anteriorly. Damage to it can lead to anhidrosis, warmness of the leg as well as sexual dysfunction [21, 22]. None of these complications were observed in our patients—however, a larger series is required to confirm the safety of this approach.

Conclusion

Preliminary results with this small sample of patients show that psoas muscle retraction technique is feasible.

Conflict of interest None.

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