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Original Article

A radiographic analysis of cage positioning in lateral transpsoas lumbar interbody fusion

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ABSTRACT

Direct Lumbar Interbody Fusion (DLIF) and eXtreme Lateral Interbody Fusion (XLIF) are the most common surgical platforms available for performing transpsoas spinal fusion but no study has been carried out to compare them. We evaluated 21 DLIF and 22 XLIF cage positions by measuring the distance between the posterior vertebral border and the centre of the cage normalised to the midsagittal length of the inferior end plate. We found that DLIF cages were significantly more anteriorly located than XLIF (0.65 vs 0.52, $p = 0.001$) at L4-5, suggesting that XLIF would permit implantation of wider cages than DLIF.

1. Introduction

The lateral transpsoas approach is a novel minimally invasive technique for accessing the anterior vertebral column of the lumbar spine. Characterised by a unique lateral line of attack, it allows placement of cages spanning the entire width of the vertebrae without disrupting the normal stabilising ligaments of the spine. This affords a unique capability for enabling the interbody cages to engage the dense cortical bone at the apophyseal rings, thus reducing the risks of graft subsidence and maintaining indirect decompression unparalleled by any traditional anterior or posterior approaches.

Nevertheless, one major caveat in exploiting the advantages of this approach is the proximity of the lumbar plexus. As the nerves of the plexus descend within the psoas muscle, they migrate progressively anteriorly towards the centre of the intervertebral disc.[1–3] As a result, the available operating window becomes increasingly narrow and shifted towards the anterior quadrants of the disc space as one approaches the lower lumbar segments. This in turn restricts the anteroposterior (AP) width of the cages implantable and potentially precludes a safe working zone particularly at L4-5.

To overcome this obstacle, specially designed surgical platforms incorporating tailor-made retractor and neuromonitoring system have been introduced in recent years to maximise access and promote safety. Conceivably systems that would allow positioning the working channel as close to the lumbar plexus as possible without risking neural injury would be most desirable in maximising the AP width of the operating window and the choice of larger cages. Currently there are two main surgical platforms known as eXtreme Lateral Interbody Fusion (XLIF, NuVasive Inc., San Diego, CA)[4] and Direct Lateral Interbody Fusion (DLIF, Medtronic, Memphis, TN)[5] for achieving this. While both systems similarly embrace the core techniques of triggered electromyographic (EMG) monitoring and the use of expandable tubular retractors to establish minimally invasive access through the psoas muscle, they differ significantly in their initial approach to the disc space and the establishment of the operating window.

In DLIF, the design is based on a pair of traditional two-blade expandable tubular retractors—the retractors were split into left and right halves allowing craniocaudal expansion (Fig. 1). The initial transpsoas approach targets at anchoring the muscle dilators to the centre of the disc space as guided by lateral fluoroscopy and evoked EMG monitoring. The retractor system (22 mm diameter) was then placed over the dilators and secured in place with a table-mounted arm assembly. In XLIF, the design is based on a three-blade system—the tubular retractors are split into left, right and centre blades. The initial approach aims to anchor the muscle dilators posterior to the centre of the disc space. The retractor system (12 mm diameter) was then inserted and fixed in

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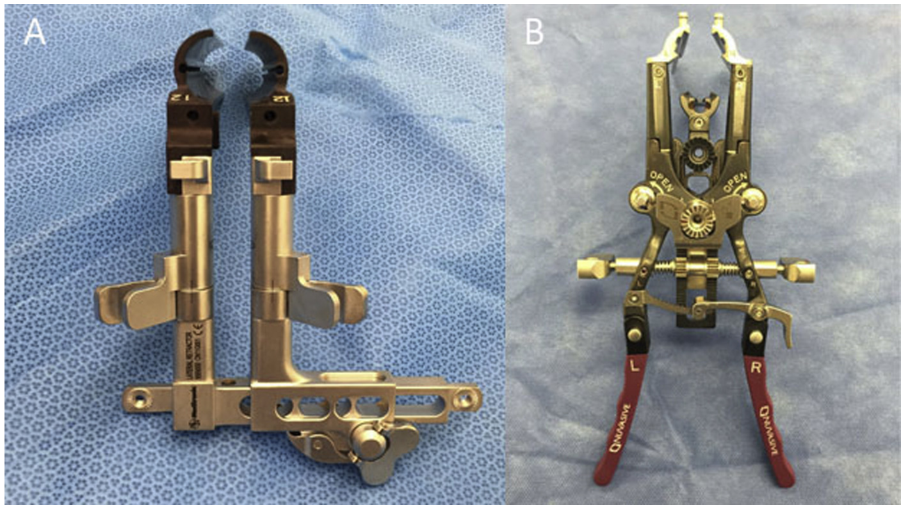

Fig. 1. (A) A DLIF retractors are composed of a pair of left and right retractor blades. The operative field is fashioned by expanding the retractor blades craniocaudally. (B) An XLIF retractors consist of a centre blade that acts as a posterior fixation point. It can be anchored to the disc space with a shim. The surgical field is established by expanding the left and right blades craniocaudally and anteriorly.

position by anchoring the centre blade to the vertebral interspace with an intradiscal shim and also to a table mounted arm assembly. The surgical field can then be expanded by retracting the muscle with the right and left blades craniocaudally and anteroposteriorly.

Whilst these two systems are similarly based on the principles of tubular surgery, the difference in the design of the retractors implies an important distinction in their strategies for establishing the initial transpsoas entry. In DLIF, because of the concentric design, the centre of the operative window coincides with the initial docking position of the muscle dilators. Thus when searching for an initial safe passage through the psoas, good clearance of the lumbar plexus is mandatory as subsequent advancement of muscle dilators and retractors may unduly displace and stretch the lumbar plexus located posteriorly. In contrast, for XLIF, the initial entry is designed to be a posterior fixation point. The operative window is established by winding the left and right retractor blades anteriorly and craniocaudally. The final expanse of the operative window is anterior to the initial entry point.

Thus, collectively, when applying the DLIF retractors there may exist a tendency to place the initial dilator more anteriorly to safely avoid the lumbar plexus than when applying the XLIF retractors as the initial dilator marks the posterior fixation point in the latter and the lumbar plexus will be protected behind it. Currently no study has been performed to compare which system would favour wider operative window and cages. We therefore performed a radiographic study to evaluate quantitatively cage positioning in a cohort of patients who had undergone either a DLIF or XLIF procedure and conducted a multiple regression analysis to determine whether a difference exists between these two systems.

2. Methods

We performed a retrospective chart review to identify patients who had undergone either a DLIF or XLIF procedure from October 2012 to January 2015. During this period these two systems were used non-selectively by a single surgeon (TS) at our institution. The indications for surgery included spondylolisthesis, degenerative scoliosis, degenerative disc disease, canal and lateral recess stenosis, and adjacent segment disease. Patient parameters including treatment level, the presence of spondylolisthesis and postoperative neurological deficits were included in the analysis. The study was approved by local institutional human research ethics committee.

2.1. Surgical techniques

The techniques used in this study followed those described by Ozgur et al. and the details can be found in their publication.[4] The same surgical protocol was applied for either system and all procedures were supplemented by pedicle screw instrumentation secured under cantilever compression. In addition, several technical points pertinent to this study are as follows. First, we used the midpoint of the disc space as our standard target for docking the muscle dilators when establishing the initial transpsoas corridor. This was applied for either system. Second we accepted current thresholds of greater than 10 mA as safe during the initial entry but if it fell below this limit the trajectory would be revised and a more anterior target would be trialled until safe current thresholds were reached. As neural monitoring is available for each dilator insertion in XLIF but not in DLIF, the current thresholds generally would drop progressively (sometimes down to less than 5 mA) as larger dilators were inserted during XLIF cases. However, we adopted a strategy that no revision of the dilator position would be made as long as the first dilator was above the safe threshold (10 mA). Third, to enhance safety and accuracy, a true lateral trajectory was strictly adhered to during cage implantation. To this end, anteroposterior and lateral fluoroscopy was used repeatedly to ensure the coronal axis of the vertebrae was orthogonal to the horizontal plane.

2.2. Imaging analysis

The primary outcome measure is cage positioning in the midsagittal plane along the inferior end plate as determined by postoperative CT scans (Fig. 2). The position was quantified by the distance between the posterior vertebral border (PVB) and the centre of the cage, normalised to AP width of the inferior end plate (IEP). The centre of the cage was defined as the midpoint between the anterior and posterior radiomarkers of the cage. A Digital Imaging and Communications in Medicine viewer (Inteleviewer, Intelerad, Westminster, CO) was used for all imaging analysis. Measurements were performed independently by two authors (TS and EN) on two occasions and intraobserver and interobserver reliability was assessed by intraclass correlation coefficient.