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Case study

Lateral lumbar interbody fusion at the lumbosacral junction

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ABSTRACT

Due to the obstruction of the iliac crest and the retroperitoneal vessels, lateral lumbar interbody fusion (LLIF) is generally considered contraindicated at the lumbosacral junction (LSJ). In particular the 'rise' of the psoas from the vertebral column in the lower lumbar segments has been associated with significant overlap of the lumbar plexus with the vertebral body and exclusion of a safe transpsoas entry. However in selected individuals anatomical variations may help circumvent the difficulties and the anatomical corridor posterior to the lumbar plexus may provide an alternative to the conventional anterior approach. Currently there is a dearth of information in informing the feasibility. We therefore reviewed the records of three patients in whom LLIF was successfully conducted at the LSJ. The patients' spinopelvic parameters and psoas anatomy were analysed by whole spine standing X-rays and MRI respectively. Intraoperative findings and postoperative outcome were examined. We found that in keeping with published morphometric data, low pelvic incidence (40–50°) appeared associated with 'low-lying' iliac crests which had facilitated lateral access to the LSJ in all cases. Patients with scoliosis provided added advantage when the concave side of the curve was utilised for the approach. A very high 'rising' psoas was found conducive to a novel posterior surgical corridor. No significant neurovascular sequelae were noted. In conclusion, LLIF can be safely performed at the LSJ in selected cases. To our knowledge this is the first report to describe the possibility of a safe LLIF working zone posterior to the lumbar plexus.

1. Introduction

Lateral lumbar interbody fusion (LLIF) is a minimally invasive surgical approach designed to allow placement of interbody cages across the whole width of the vertebral interspace without disrupting the stabilising ligaments of the spine. It confers a unique capability for surgeons to distract lost disc space, correct deformity and achieve indirect decompression with reduced level of invasiveness and complications associated with conventional techniques [1–3]. However due to the obstruction of the iliac wing, LLIF is generally considered infeasible for treatment of disease at the lumbosacral junction (LSJ) [4]. This is because the 'rise' of the iliac wing lateral to the LSJ precludes an orthogonal lateral access to the vertebral column and thus renders a direct lateral exposure important for performing interbody surgery generally infeasible. In addition, the lumbar plexus and the retroperitoneal great vessels as they descend across the LSJ can traverse directly over the lateral surface of the vertebral interspace and thus limit the possibility of establishing a safe working channel [5].

In our experience, however, we have found that the limitations posed on the direct lateral approach to the LSJ are not always insurmountable. Due to individual variations in spinopelvic parameters, and with the aid of angled instruments, the lateral craniocaudal interval between the iliac crest and the sacral endplate may be quite small in some individuals and overcoming the obstruction of the iliac wing can be technically feasible. In addition, in patients with lumbar scoliosis, the resultant altered coronal orientation of the sacral endplate could facilitate an orthogonal access to the vertebral column when the concave side of the curve is selected for the approach. Similarly the psoas and vascular anatomy can exhibit considerable variations and the retroperitoneal great vessels in general tend to move away from the lateral operating window in a lateral decubitus position [6]. Preoperative axial magnetic resonance imaging (MRI) can help verify the relevant anatomical relationships and ensure appropriate case selection [5,7].

Currently in the literature there is a dearth of data in informing the feasibility of LLIF for the LSJ. Shirzadi et al. claimed that they reported the first case of applying LLIF to L5–S1 [4]. In the report, the patient's imaging demonstrated a lumbarised sacrum and the L5–S1 disc appeared anatomically equivalent to a normal L4–5. The procedure was performed successfully without causing any

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vascular or lumbar plexus injury. In another study, Smith et al reported a series of 10 patients with lumbarised sacrum in whom LLIF was attempted between L5 and the lumbosacral transitional vertebra (LSTV) designated as L6 [8]. In their experience despite the advantages of having the L5-6 disc space levelling at the iliac crests similar to L4–5, the neuromonitoring findings were mostly unfavourable, leading to conversion of the procedure to an alternative approach in all but two cases [8]. In the study by Khajavi and Shen, they evaluated 21 patients who had undergone LLIF for degenerative scoliosis in which L5–S1 LLIF was successfully performed in three patients whose spinal curve and neuromonitoring findings rendered the approach feasible [9]. However no specific case selection criteria or operative details concerning these cases were given.

In view of these, we conducted a retrospective study to reflect on our experience in performing LLIF at the LSJ. We described our techniques and sought to determine the patient parameters and surgical strategies that would favour such endeavour.

2. Methods

A retrospective chart review was conducted on all patients who underwent an LLIF from July 2013 to June 2016. Patients who had the LSJ (L5–S1, normal anatomy or L5–L6, lumbarised sacrum) operated on were identified and their records were evaluated to characterise the radiographic features, the operative findings and the clinical outcome. The position of the psoas muscles and the retroperitoneal vessels were evaluated on axial MRI. The operative records, neuromonitoring data and fluoroscopy images were analysed and correlated with the psoas anatomy identified. The spinopelvic parameters of these patients, including coronal cobb angle, pelvic incidence (PI), sacral slope (SS), sacral obliquity (SO) and lumbar lordosis (LL) were measured from preoperative whole spine standing X-rays (Fig. 1) and were compared with published data [10–12]. The projection of the iliac crest over the lumbar spine was evaluated on standing lateral radiographs. The postoperative motor and sensory physical findings were collected. The study was approved by local human ethics research committee.

2.1. Imaging analysis

Radiographs were analysed using validated software (Surgimap, Nemaris, New York, NY, USA) [13]. The presence of LSTV was ascertained from whole spine X-rays by counting caudally from C2. From the anteroposterior (AP) radiographs, the lumbar scoliosis curve was measured by the Cobb angle between the superior endplate of the upper end vertebra (tilting maximally toward the concavity of the curve) and the inferior endplate of the lower end vertebra. SO was measured by the angle between the horizontal reference line and a line drawn across the projected superior border of the sacral ala. From the lateral radiographs, PI was measured as defined by Legaye et al.[14] SS was measured from the angle between the sacral endplate and the horizontal line. LL was measured from the superior endplate of L1 and the caudal endplate of L5. The degree of cranial encroachment of the iliac crests was classified by determining the position of the midpoint between the highest points of left and right iliac crests relative to the L4–5 disc interspace. The highest point was determined by the point furthest from the sacral endplate[12]). The degree of ventral elevation of the psoas muscle was calculated by dividing the distance between the anterior border of the psoas and the anterior border of the vertebral body by the anteroposterior length of the psoas muscle at the level of the S1 (or L6) endplate on the side of the approach.

2.2. Surgical techniques

Our surgical techniques (NuVasive, San Diego, CA, USA) followed those described by Ozgur et al.[15] Importantly, for successful access to the LSJ, we paid particular attention in aligning the patient's greater trochanter with the hinge of the operating table (ProAxis, Mizuho OSI, Union City, CA, USA) and flexing the hinge to about 30 degrees to maximally reduce the obstruction of the iliac wing. Also, a dedicated 3–4 cm transverse incision immediately superior to the iliac crest was made over the vicinity of the surface projection of the LSJ for the approach, while separate incisions, if necessary, were made to access other levels. When negotiating a safe transpsoas entry with the muscle dilators, in addition to the traditional strategy of entering the psoas anterior to the lumbar plexus, we also explored the alternative of a posterior approach. Particular attention was paid in noting the direction of activation and the muscles that were activated, with the anticipation of proximity of the femoral nerve (vastus medialis) anteriorly and the L4 and L5 nerve roots (tibialis anterior) posteroinferiorly when the posterior approach was trialed. The midpoint of the disc space was the general target and the trajectory was adjusted until safe current thresholds (>10 mA) were maintained with the first dilator. Current thresholds reduction with subsequent dilators and retractors insertion was monitored though no revision was made as long as the first dilator insertion yielded safe current thresholds. After placement of the retractors, the surgical field was explored with a stimulation probe to ensure complete nerve clearance (>10 mA). To minimise undue traction to the adjacent nerves, the retractors were minimally expanded, particularly along the craniocaudal axis, so that a working channel just long and wide enough to expose the intervertebral disc was fashioned. Interbody work was then performed in a standard fashion. Angled instruments were used to improve access and avoid violation of the caudal endplate.

3. Results

Seventy-three patients underwent LLIF in the study period in whom surgery was performed at L5–S1 in two cases (Cases 1 and 2). One patient (Case 3) had surgery carried out at L5–6 (lumbarised sacrum) that appeared anatomically equivalent to a normal LSJ on lateral radiograph and was also included (Fig. 1). Their case histories were summarised in Table 1. A review of the relations between the iliac crests and the vertebral bodies on lateral radiographs revealed, as expected, that the iliac crests all appeared 'low-lying', caudal to the L4–5 disc, when comparing with reference data in the literature (Table 2). In addition, lower-than-average PI, LL and SS denoting an overall flat sagittal curve was also exhibited by all three patients (Table 2). The first two patients (Cases 1 and 2) harboured a degenerative scoliosis with the caudad end vertebra at L5 (Fig. 2). The sacral endplate was tilted towards the concave side of the curve, which was selected for the approach, thus further favouring a direct lateral access over the iliac crest on these two occasions.

Fig. 3 depicted the patients' axial MRI at the LSJ. The psoas muscles were noted to demonstrate the typical anterolateral 'rise' from the vertebral column in all three cases. This was particularly marked in Case 2 where more than 50% of the muscle bulk was seen completely anterior to the disc space as comparing with considerably less 'rise' in Case 1 and 3. They also appeared detached from the vertebral column, as indicated by the presence of a flat plane between the medial margin of the muscles and vertebrae, and exhibited a tear-drop configuration typical of LSJ in all three cases. These features, most evident in Case 2, contrast with the dome shaped, laterally located psoas normally encountered at