Mini-open oblique lumbar interbody fusion (OLIF) approach for multi-level discectomy and fusion involving L5–S1: Preliminary experience

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A B S T R A C T
Study design: Technical description and single institution retrospective case series.
Objective: Evaluate technical feasibility and evaluate complications of mini-open retroperitoneal oblique lumbar interbody fusion (OLIF) at the L5–S1 level.
Summary of background: The mini-open retroperitoneal oblique lumbar interbody fusion (OLIF) approach was first described in 2012 as a surgical approach to achieve spinal fusion while limiting invasiveness of the exposure to the anterior lumbar spine. Surgeons who use this approach, along with those who described it in cadaveric studies describe it as a feasible approach in targeting the L2 down to the L5 level and recommend alternative approaches to the L5–S1 level due to the vascular challenges and possible complications.
Methods: Technical description and single institution case series of patients treated with the OLIF between 2013 and 2015 at the L5–S1 level. The previously described surgical approach was modified by identifying and ligating the iliolumbar vein before retracting the iliac artery and vein anteriorly instead of passing between the vessels.
Results: Six patients (3 males, 3 females, mean age 62 years) were operated between 2013 and 2015. There were no vascular injuries or peripheral nerve trauma associated with the surgical procedure. Complications associated with the procedure included: cage displacement immediately postoperative requiring re-operation in one patient, transient psoas weakness in one patient, extended hospital stay for pain control in one patient, and transfusion was required in one patient.
Conclusions: Mini-open retroperitoneal oblique lumbar interbody fusion is feasible at the L5–S1 level with limited vascular complications through a technical modification for safe mobilization of the iliac vessels by first ligating the iliolumbar vein.

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1. Introduction

Lumbar fusion is an efficient treatment for various degenerative conditions, such as degenerative disc disease, spondylolisthesis and deformity. Over the past decades, improvement in surgical techniques and spinal instrumentation allowed surgeons to perform safe and solid constructs. Moreover, the increasing use of cages and various graft materials has lead to a dramatically improved fusion rates and patients’ outcomes. Thus, epidemiological studies demonstrated that the number of lumbar fusion increased 2.4-fold (113%) between 1998 and 2008 in the United States, which is much greater than increases in other major orthopaedic procedures [1]. Although lumbar fusion is an effective and increasingly performed treatment, there is still no consensus regarding the ideal approach. Posterior lumbar interbody fusion (PLIF) and transforaminal lumbar interbody fusion (TLIF) are the most widely performed techniques as most surgeons are more familiar with the posterior approach [1–3]. With the recent development of minimally invasive techniques, many teams reported similar outcomes in comparison to open standard procedures, while decreasing the overall morbidity related to the approach and its consecutive muscle damage [4–6].

The anterior approaches have gained more popularity because it allowed the surgeon to insert larger cages and to achieve more lordosis with better alignment.

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The minimally invasive lateral transpsoas approach to the lumbar spine is also known as extreme lateral interbody fusion (XLIF) [7]. The advantages of XLIF include minimally invasive access to the lumbar spine, less blood loss compared with open surgery, decreased operative times, shorter hospital stays, and less postoperative pain [7]. XLIF is unique in that it can be used to gain access to the lumbar spine via a lateral approach by splitting the psoas major muscle. However, this poses a risk of injuring the neural structures of the lumbar plexus as they course through the psoas. And the approach to L5–S1 is extremely difficult because of the presence of the iliac crest, and the iliolumbar vein.

Mini-open oblique lumbar interbody fusion (OLIF) was reported in 2012 [8]. Those who described this approach mentioned that the approach to L2–L5 is feasible, but another approach is preferred to access the L5–S1 level because of the risks associated with mobilization of the iliatic vessels and because the presence of the iliac wing disturbed the insertion of the cage [8].

Silvestre et al. reported the complications and morbidities of mini-open anterior retroperitoneal lumbar interbody fusion in 179 patients and they concluded that it is a safe approach for accessing the L2 down to L5 and advised using another approach for the L5–S1 due to the danger of injuring the iliac vessels [8].

In this article, we report our experience in 6 patients who underwent discectomy and fusion, including the L5–S1 level using the mini-open retroperitoneal approach, and give a step by step description of the surgical technique including our modified technique in exposure of the L5–S1 level.

2. Material and methods

2.1. Population

A total of 6 consecutive patients (3 males, 3 females, mean age 62 years) were included in this series. Two patients had a preoperative diagnosis of isthmic spondylolisthesis, 1 patient had degenerative spondylolisthesis and 3 patients had degenerative scoliosis (Table 1). The patients have had their symptoms at least one year before being operated, and have exhausted all conservative means of management. The predominant symptoms in all patients were back pain, and bending forward posture during ambulation.

The levels operated were L1–L2 down to L5–S1 in 1 patient, L2–3 down to L5–S1 in 2 patients, L3–4 down to L5–S1 in 1 patient and L5–S1 in 2 patients. The neurological status of all patients was evaluated using the American Spinal Injury Association (ASIA) Classification and was intact in all patients.

All patients were operated by the senior author (DS), at our institution between the years 2013 and 2015.

2.2. Surgical technique

All patients were placed under general anesthesia with endotracheal intubation, in the lateral decubitus position, an Olympic Vac-Pac® mattress with the ipsilateral hip flexed to allow relaxation of the ipsilateral psoas muscle, and the ipsilateral arm placed on an arm rest. Intraoperative fluoroscopy was used to obtain anteroposterior and lateral views throughout the procedure. The Synframe (Depuy) retractor was used along with the Cougar LS (Depuy) cage system.

A 4–5 cm skin incision is made two fingerbreadths anterior to the anterior superior iliac spine (ASIS). The incision can be costumed according to desired level. The incision is made using 20 blade, and deepened with the help of the electrocautery until the fascia of the external oblique is identified. The fascia of the external oblique is opened and a muscle splitting technique is used along the direction of the muscle fibres till the fascia of the internal oblique is identified.

The fascia of the internal oblique is cut and opened along the incision and the muscle fibres are dissected deep till the fascia of the transversus abdominus is identified. The fascia of the transversus abdominus muscle is cut and opened and the fibers are retracted until the peritoneum is identified. The surgical procedure is shown schematically in Fig. 1.

The dissection is then continued along the retroperitoneal space directed towards the anterior superior iliac spine using large peanut gauze, and it is continued till the psoas muscle is identified laterally and the internal iliac artery and vein are identified medially.

The retractor is placed in the depth of the field, with the lateral blade retracting the psoas muscle and the medial one is retracting the peritoneum. A clamp is placed on disc space for radiological level confirmation. Once the level is confirmed, two other retractor blades are used to maintain a working channel.

For exposure of the L5–S1 level, gentle dissection is done in the fat surrounding that level lateral to the iliac vessels till the iliolumbar vein is identified. There are some variations in the anatomy in this region where more than one vein can be identified at this region, so careful inspection should be done before repositioning the retractor. Once the vein is located, careful dissection from surrounding tissue is done, and clips are placed after which it is coagulated and cut (Fig. 1). We advise that the iliolumbar vein be located coagulated and cut before starting the discectomy at this level because any injury later on will be difficult to control. The medial retractor blade is then placed lateral to the iliac vessels with gentle retraction, and the lateral blade is placed lower on the psoas major muscle. We do not go in between the iliac vessels to avoid injury of the superior hypogastric plexus, and to minimize distraction of the iliac vessels.

The discectomy is then completed in the regular manner, with proper preparation of the endplates, a proper sized cage is tried and placed after filling it with bone graft and bone marrow aspirated from the iliac crest. During the insertion of the cage, it is necessary to have a strict radiological anteroposterior (AP) and lateral radioscopic control. Indeed, the oblique approach must be taken into account to avoid impacting the cage too posterior toward the contralateral foramen. Thus, a strict AP and lateral radioscopic control.
was mandatory for every level to ensure an optimal positioning of the cage.

No intraoperative monitoring was used, and no drain was inserted for all procedures.

In our series, all patients underwent posterior instrumentation with pedicular screws, the operation was performed the same day for 4 patients, and 1 week later for 2 patients. It was done via minimally invasive percutaneous pedicular screws in 3 patients and open posterolateral pedicular fixation for 3 patients, where a Smith Petersen osteotomy (SPO) was needed to achieve adequate lumbar lordosis and correction (Fig. 2).

2.3. Clinical and radiological follow-up

Operative time, blood loss, and length of hospital stay were prospectively recorded, all intraoperative and postoperative complications were reported. All patients underwent postoperative anteroposterior and lateral X-rays along with long cassette standing X-rays before their discharge to assure good alignment and proper placement of hardware, and then they were followed up in the outside clinic with similar X-rays at 2 months, 6 months and 1 year to reconfirm the previously mentioned criteria along with ensuring proper fusion. Spino-pelvic parameters, lumbar lordosis and sagittal vertical axis (SVA) have been measured preoperatively and at 2 months (Table 2).

A CT scan was ordered only if patient complained of radiculopathy postoperatively or fusion was suspected to be suboptimal after 6 months.

Fusion was defined as a continuous trabecular bony bridging along the instrumented surgical bed.

3. Results

Our series included 6 patients, 3 males and 3 females, 2 patients had isthmic spondylolisthesis, 3 patients had degenerative scoliosis, and 1 patient had degenerative spondylolisthesis. Levels operated were 5 in one patient, 4 in two patients, 1 in two patients, and 3 in one patient, operative time ranged from 142 minutes to 405 minutes (mean 274 minutes) in total time for the anterolateral approach only, mean blood loss was 283 mL for the combined anterior approach only. Results are tabulated in Table 1.

There were no intraoperative vascular incidents, or any breach of the peritoneum.

Postoperatively all patients were ambulated in a brace with the help of the physiotherapy team on day 1.

One patient developed anaemia postop, that required transfusion, and one patient had an S1 radiculopathy that was resistant to pain medications, a CT scan showed slippage of her cage and was re- operated same day for repositioning of the cage, and her symptoms resolved postoperatively.

Mean hospital stay was 14 days, with 2 patients discharged home and 4 sent to a rehabilitation center for continuous physiotherapy. All patients have been followed up and seen at their 2 months, 6 months and 1 year follow-up appointments at the clinic.

Table 1

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age</th>
<th>Sex</th>
<th>Preoperative diagnosis</th>
<th>Spinal levels</th>
<th>Time (min)</th>
<th>EBL (mL)</th>
<th>Complications</th>
<th>LOS (days)</th>
<th>F/U (months)</th>
</tr>
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<td>1</td>
<td>66</td>
<td>M</td>
<td>Degenerative spondylolisthesis</td>
<td>L2/3 to L5/S1</td>
<td>314</td>
<td>200</td>
<td>Anemia requiring transfusion</td>
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<tr>
<td>2</td>
<td>63</td>
<td>M</td>
<td>Lumbar kyphosis</td>
<td>L3/4 to L5/S1</td>
<td>295</td>
<td>400</td>
<td>Pain</td>
<td>23</td>
<td>2</td>
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<tr>
<td>3</td>
<td>62</td>
<td>F</td>
<td>Lumbar scoliosis</td>
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<td>250</td>
<td>None</td>
<td>15</td>
<td>2</td>
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<tr>
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<td>F</td>
<td>L5–S1 isthmic spondylolisthesis</td>
<td>L5/S1</td>
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<td>F</td>
<td>L5–S1 isthmic spondylolisthesis</td>
<td>L5/S1</td>
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<td>100</td>
<td>Slipped cagea</td>
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<td>6</td>
<td>68</td>
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<td>Lumbar scoliosis</td>
<td>L1/2 to L5/S1</td>
<td>405</td>
<td>550</td>
<td>None</td>
<td>19</td>
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</table>

EBL: estimated blood loss; LOS: length of stay; F/U: follow-up.
a Complication requiring revision surgery.
Table 2
Main radiological parameters.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Sacral slope</th>
<th>Pelvic tilt</th>
<th>Lumbar lordosis</th>
<th>SVA (mm)</th>
<th>L5–S1 lordosis</th>
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<tr>
<td>6</td>
<td>45°</td>
<td>18°</td>
<td>27°</td>
<td>21°</td>
<td>17°</td>
</tr>
</tbody>
</table>

SVA: sagittal vertical axis.

patients reported excellent progress in terms of pain, and ability to walk straight. Plan radiographs confirmed fusion for all patients at all treated levels at 1 year.

3.1. Case illustration

A 66-year-old male with past medical history of rheumatoid arthritis and cardiac disease presented with symptoms of progressive neurogenic claudication with pain radiating primarily to the right leg. He had significant back dominant pain and was no longer able to maintain an erect posture. On physical examination, no neurological deficits were noted; however, sagittal imbalance was evident. Lumbar stenosis from L2 down to S1, disk degeneration, and spondylolisthesis were noted on magnetic resonance imaging (MRI), and sagittal imbalance was noted on low cassette plain films (Fig. 2). The patient was operated with a combined retroperitoneal anterolateral approach with londotic cages placed from the L2/3 down to L5–S1 disc space and open instrumented fusion from the L2–S1 level with Smith Peterson osteotomies at the L2–3 and L4–L5 levels. There were no intraoperative complications, and he was ambulating on his first postoperative day. Pain was controlled with intravenous patient controlled anesthesia (PCA). Sagittal balance was improved postoperatively (Fig. 2). Postoperatively, he was noted to have grade 3/5 strength of his left psoas, which gradually recovered with physiotherapy.

4. Discussion

Genetic, mechanical, and chemical factors can influence degeneration of lumbar intervertebral discs [9–11] and these changes can lead to biomechanical and morphological stresses, causing pain and instability [12]. Spinal fusion procedures are one solution for pain relief and stabilization of affected segments, and spinal fusion can be performed through a variety of approaches [13,14]. Minilopen oblique approach that was first described in 2012 [8] is one of these approaches that can be used for fusion and stabilization of different segments of the spine. This approach offers the advantage of insertion of an adequate size cage, with sufficient anterior placement to obtain maximal lordosis of spinal segments, leading to better correction of spinal balance. Since the first description, this technique has become very popular, and several teams have reported their preliminary experience, emphasizing highly variable complication rates, especially at L4/L5, where the vascular anatomy is the most complex and more subject to variations, as reported recently by Orita et al. [15], Phan et al. [16] recently published a literature review focusing on complications following OLIF. Despite the methodological limitations of studies and the fact that they are mainly retrospective, they concluded that this technique is safe and that the complication rate is low. The main reported complications were transient incisional pain, transient lumbar plexopathy symptoms and sympathetic injury. Definitive complications were rare as well as retrograde ejaculation. The hypogastric plexus is subject to many anatomical variations, and as for ALIF, it is recommended to perform a careful subperiosteal dissection and to avoid the use of monopolar coagulation [8,16,17].

Silvestre et al. reported the largest retrospective study including 179 patients who underwent mini-open OLIF at one institution [8]. The patients were placed in a lateral decubitus position because they approached L1–S1 between the major vessels and the psoas muscle. The procedure was performed on the lumbar spine at L1–L2 in 4, L2–L3 in 54, L3–L4 in 120, L4–L5 in 134, and L5–S1 in 6 patients. The number of patients with OLIF at L5–S1 was small because of the difficulty of retracting the iliac vein and iliolumbar vein. Silvestre et al. concluded that another approach might be preferred at L5–S1 because of the risks associated with mobilization of the vessels and the presence of the iliac wing. Recent cadaveric study revealed that the OLIF method could approach the L2–S1 discs in patients at a lateral decubitus position [15]. However, in this cadaveric study, the approach to the L5–S1 disc space was approached in between the iliac vessels, which increases the chance of vascular injury along with injury to the superior hypogastric plexus and the resulting retrograde ejaculation.

In our paper, we aim to show the feasibility of approaching the lumbar spine from L2 down to S1 through the mini-open retroperitoneal approach without the need for another approach (ALIF) to access the L5–S1 level. We also show a modification of the surgical approach described by Davis et al. [18] in accessing the L5–S1 level by finding and clipping the iliolumbar vein, before retracting the iliac artery and vein anteriorly instead of going in between the iliac vessels, which will also decrease the chance of injuring the superior hypogastric plexus, and also decrease the incidental injury of the ascending lumbar vein, which can be very difficult to find and control once injured. It seems legitimate to question the effectiveness of this technique to achieve adequate lordosis and reduce the sagittal alignment. Indeed, the anterior longitudinal ligament is not incised, which could constitute a limit for obtaining an optimal lordosis. However, the cage is inserted as far forward as possible to increase the lordosis. So in our experience, we believe that this approach does not limit the segmental correction. A comparative assessment of a larger cohort remains necessary to confirm this.

In our preliminary experience, the approach was always feasible and we encountered no difficulty that forced us to change the approach during the procedure. We had no intraoperative vascular injuries, and no cases where the peritoneum was breached, and no other intraoperative complications. Note that, we have not performed angiogram for the patients included in this study. The vascular anatomy was appreciated only on the preoperative MRI. However, many teams advocate the systematic implementation of an angio-CT to help with surgical planning, which should be considered. Similarly, we have not controlled the preoperative blood flow in the lower limbs, because our patients presented no sign of arteritis. However, this should be considered in patients at risk. Moreover, none of our patients reported sexual dysfunction related to an injury of the hypo gastric plexus.

In our study, we performed posterior fixation with pedicle screws in a second approach to increase stability and fusion in
all patients. The procedure was done either through a minimally invasive approach or an open approach whensmith Petersen osteotomies were needed to obtain adequate lumbar lordosis, especially in patients with high pelvic incidence and hypolordosis of the lumbar spine. The need for a posterior approach is still disputed. However, many studies suggest that the use of a standalone cage is associated with a higher rate of impaction and pseudarthrosis [19–22]. Deformity, spondylolisthesis, low bone mineral density and obesity are important risk factors to consider, justifying the implementation of a systematic posterior stabilization especially if several levels are fused [21,22]. For this reason, in our series, all patients underwent posterior approach to perform pedicle screw fixation as they were operated on for spondylolisthesis or spinal deformity. Percutaneous approach was used for three patients, and open approach was used for three patients who needed a SPO for a better correction.

The postoperative course was smooth for all the patients with no mortalities or significant morbidities and except for only one patient that needed a reoperation to reposition her displaced cage, and the patient did well post operatively. Noted that the hospital stay is long in our series, especially for a minimally invasive technique. There are two main reasons for this. First, all patients in this series underwent a posterior approach which is likely to have influenced more significantly the length of hospital stay. Second, most patients lived alone and even though they were fully ambulatory, they decided to stay in the hospital till a vacant place was found for them in the rehabilitation centre.

5. Conclusion

The mini-open retroperitoneal approach seems to be a possible surgical alternative in patients with degenerative changes, and sagittal imbalance and a safe way to access the disc spaces from L2 down to L5–S1 level; however, the surgeon has to be familiar with the complex anatomy of the region, to avoid injuring the lumbar plexus and the vascular structures.

Also in exposing the L5–S1 level, going lateral to the iliac vessels after controlling the iliofemoral vein instead of going in between the iliac vessels makes it a safer and more feasible approach. The main limitation of this study is related to the small number of patients, and a short follow-up period, and a wider series with a longer follow-up is needed.

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Disclosure of interest

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