Chapter 27

Oblique Lateral Lumbar Interbody Fusion (OLIF)

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INTRODUCTION

Lumbar degenerative disease is a prevalent condition associated with aging, often leading to significant pain and disability. Recent research estimates the overall prevalence of degenerative spinal disease at 27.3%, with rates increasing progressively with age (1). As the global population continues to age, the frequency of lumbar spine surgeries has grown correspondingly, driven by their proven effectiveness in alleviating pain and enhancing patients' quality of life (2-3). Among the available surgical options, lumbar interbody fusion has become a cornerstone technique for managing lumbar degenerative disease, surpassing other fusion methods such as instrumented posterolateral fusion in utilization (4-5).

Different lumbar interbody fusion techniques vary based on the surgical approach to the intervertebral disc (IVD) space. These methods include posterior lumbar interbody fusion (PLIF), transforaminal lumbar interbody fusion (TLIF), anterior lumbar interbody fusion (ALIF), direct lateral interbody fusion (DLIF), and oblique lateral interbody fusion (OLIF) (Figure 1). For cases involving spinal stenosis, ALIF, DLIF, and OLIF are considered indirect decompression techniques. Indirect decompression achieves symptom relief by restoring disc height, reducing spondylolis-

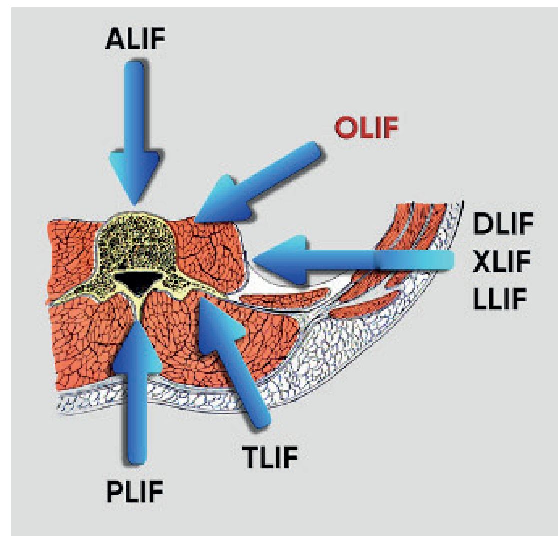

Figure 1: Lumbar interbody fusion techniques. ALIF, anterior interbody fusion; OLIF, oblique lateral interbody fusion; DLIF, direct lateral interbody fusion; XLIF, extreme lateral interbody fusion; LLIF, lateral lumbar interbody fusion; TLIF, transforaminal lumbar interbody fusion; PLIF, posterior lumbar interbody fusion. *(Modified from "Sobotta 1909 fig.237 - cross section of the back muscles - no labels" at AnatomyTOOL.org by Johannes Sobotta and Marco de Marco, AMC, license: Creative Commons Attribution-ShareAlike)*

thesis, stabilizing affected segments, and facilitating gradual remodeling of the spinal canal, rather than directly excising the compressive pathology. Previous studies have provided radiological evidence supporting the effectiveness of these approaches in achieving indirect decompression in lumbar interbody fusion procedures (6-8).

Traditional surgical interventions, such as PLIF and TLIF, have been associated with extensive muscle dissection, increased blood loss, and prolonged recovery periods. In recent years, minimally invasive techniques like OLIF have emerged as viable alternatives, offering the potential for reduced surgical morbidity and improved clinical outcomes.

Surgical Technique

a. Positioning and Exposure

OLIF technique employs a retroperitoneal oblique surgical corridor, creating an access pathway between the psoas major muscle and the great vessels for L2–5, and between the bifurcated iliac vessels for L5–S1. Patient positioning and correct surgical approach is of vital importance especially for those who are unfamiliar with this technique. This unique corridor allows for fusion without disrupting the psoas muscle and lumbar plexus. Numerous anatomical and radiological studies have explored the feasibility and safety of this oblique corridor (9-11). Molinares et al. (11), for instance, analyzed 133 MRI scans and found that a safe oblique corridor was identifiable in 90% of cases for L2–5 and in 69% for L5–S1. Notably, the corridor for L4–5 warrants additional scrutiny, as it is frequently obstructed by vascular structures or a high-riding psoas muscle. While positioning the patient in the lateral decubitus posture can expand the operative corridor at the L4–5 level, thorough preoperative evaluation of anatomical structures is imperative. Optimizing the surgical incision to ensure a secure oblique corridor is critical for reducing complications. For those who are unfamiliar with this approach, neuro-navigation may be utilized.

The feasibility of accessing the L5–S1 segment using an oblique corridor is inherently more challenging than for L2–5, primarily due to the overlying major abdominal vessels. When the patient is positioned in the right lateral decubitus posture for OLIF at L5–S1, the bare surgical window may further narrow because of the downward displacement of the left common iliac vein (LCIV). Preoperative imaging assessments, including axial and sagittal MRI scans, are indispensable for evaluating vascular structures in this region. Additionally, abdominal CT angiography or innovative techniques such as MRI–CT fusion imaging can enhance preoperative planning (Table 1).

If the vascular corridor is particularly narrow, the LCIV crosses the midline, and no discernible fat plane exists between the LCIV and the IVD, an alternative surgical approach should be considered due to the elevated risk of vascular injury (Figure 2). Furthermore, OLIF at the L5–S1 level is contraindicated when the sagittal orientation of the L5–S1 IVD extends below the symphysis pubis, rendering the oblique approach unviable. This comprehensive anatomical and imaging-based planning is essential for ensuring the safety and efficacy of OLIF procedures, particularly in challenging segments like L5–S1.

Table 1: Critical Vascular Factors for anterolateral access to L5-S1.

(1) the size of the vascular corridor
(2) the anatomical position of the left common iliac vein (LCIV)
(3) the presence of a fat plane separating the LCIV and the intervertebral disc

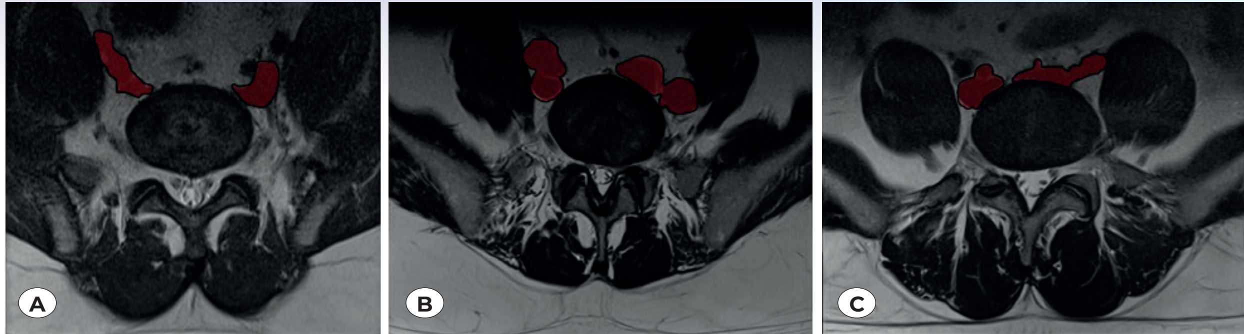

Figure 2: Various vascular corridors to be evaluated before OLIF at L5–S1. (A) A broad vascular pathway offering unobstructed access to the L5–S1. (B) A challenging vascular pathway where the left common iliac vein overlaps the left portion of the L5–S1, with no fat plane separating the vessel from the disc. (C) Another complex vascular pathway, lacking any accessible window along the entire length of the L5–S1.

Early studies introduced OLIF as a surgical technique performed with the patient in the lateral decubitus position. However, the necessity of strict lateral decubitus positioning has diminished with the advent of stereotactic navigation systems in OLIF. Previous research has examined the importance of optimal hip positioning in the lateral decubitus position. While there is debate about whether hip positioning affects the expansion of the surgical corridor, maintaining a neutral hip position is generally advised to minimize the psoas muscle volume during the procedure. Especially in cases where ADS (adult degenerative scoliosis) is observed along with other pelvic abnormalities, obtaining a true lateral decubitus and optimal hip positioning may not be viable. Thus surgeons should first evaluate the patients both anatomically and radiologically and be prepared to tailor the approach according to need (12-13).

b. Fixation and Decompression

While a limited number of studies propose the stand-alone OLIF procedure as a safe and effective option for managing lumbar degenerative diseases, multiple biomechanical investigations highlight the advantages of additional stabilization in enhancing the stability of the OLIF construct (14-15). These studies indicate that stand-alone OLIF, without supplementary fixation, often fails to ensure adequate stability to prevent cage subsidence. Among the various stabilization techniques evaluated, bilateral pedicle screw and rod fixation have consistently demonstrated superior biomechanical stability in finite element analysis studies. Conversely, alternative fixation strategies, such as lateral plate fixation, have shown no significant clinical advantage over stand-alone OLIF in mitigating cage subsidence. Anterolateral screw and rod fixation, when combined with OLIF, have yielded favorable early clinical outcomes. When dealing with adult degenerative scoliosis (ADS), posterior fixation combined with OLIF has given better results in terms of correcting Cobb angle and restoring IVD height (16). While comparing OLIF plus fixation to other intervertebral fusion techniques, OLIF has shown equal correction and fusion rates while causing less trauma and reducing the number of levels needed for fusion (17).

At the L5–S1 level, supplemental screw fixation can be employed to prevent anterior cage migration following OLIF. This technique was initially introduced in stand-alone ALIF, where it demonstrated promising radiological outcomes. Chung et al. (18) conducted a retrospective review of 61 patients who underwent OLIF combined with pedicle screw fixation at the L5–S1 level. Their findings indicated a significant reduction in anterior cage migration when supplemental screw fixation was utilized. Notably, in this context, the primary function of the supplemental screw was

to prevent anterior cage migration rather than to enhance segmental stability or mitigate cage subsidence. Further investigations are required to determine the cost-effectiveness of supplemental screw fixation in L5–S1 OLIF procedures.

In cases with severe stenosis or sequestered discs, additional posterior direct decompression may be performed alongside indirect decompression. A recent systematic review compared clinical outcomes between isolated indirect decompression and a combination of indirect and direct decompression. It suggested a trend toward greater improvement in the Oswestry Disability Index (ODI) in the isolated indirect decompression group (21.3% vs. 17.1%, $p=0.053$). However, other clinical outcomes, including overall complication and revision rates, showed no statistically significant differences between the two groups (19).

Due to the limited quantity and quality of available studies, specific cases where additional posterior direct decompression might be beneficial is still controversial as there are studies favoring direct and indirect decompression (20-21).

Radiological Outcomes

a. Correction of Spinal Deformity

OLIF has become one of the effective approaches that yield significant correction of spinal deformity, especially in cases with adult degenerative scoliosis. While evaluating the addition of lateral instrumentation to OLIF in terms of sagittal and coronal balance, significant improvements in Cobb angles were recorded, demonstrating improved overall spinal alignment (22). Complementarily, OLIF was able to manage sagittal imbalance with increased segmental lordosis, further benefiting the restoration of spinal alignment (21).

b. Cage Subsidence and Segmental Stability

One of the main issues that has so far concerned the field of spinal fusion surgery is maintaining segmental stability and avoiding cage subsidence. OLIF, supplemented with unilateral pedicle screw fixation through the Wiltse approach, provided significant segmental stability with minimal cage subsidence. The study concluded that rigid fixation methods must be incorporated to maximize the biomechanical performance of OLIF constructs (23). This becomes highly relevant, especially in patients with degenerative scoliosis, for whom stability attainment and maintenance are critical.

c. Restoration of Disc Height

Another significant radiological outcome of OLIF is the restoration of the disc height. In a retrospective observational study, OLIF was able to significantly increase the disc height and through indirect decompression increased the foramen diameter (24). These improvements likely play a crucial role in relieving nerve compression and contributing to better neurological and clinical outcomes. This radiological improvement has been instrumental in alleviating pain and improving the quality of life for patients.

Clinical Outcomes

a. Reduction in Pain and Disability

One of the main goal of deformity surgery is to reduce pain and disability associated with ADS. OLIF combined with percutaneous pedicle screw fixation was able to significantly reduce pain and decrease ODI scores. Both coronal and sagittal parameters were improved with this approach

as well. The minimal invasive approach also proved to be effective in reducing complication and re-operation rate.

b. Reduced Surgical Trauma and Enhanced Recovery

OLIF's minimally invasive approach provides a substantial advantage in terms of surgical morbidity. By preserving the posterior musculature and reducing the extent of dissection, OLIF minimizes intraoperative blood loss and reduces the risk of postoperative complications such as infections. OLIF contributes to quicker recovery times and shorter hospital stays compared to traditional open spinal fusion techniques (21, 25).

c. Sustainability of Long-term Outcomes

While immediate improvements in alignment and pain relief are well-documented, the long-term sustainability of OLIF outcomes remains an area of active research. Preliminary findings suggest that OLIF offers promising long-term benefits, including sustained pain relief and functional improvement however, larger cohort studies with extended follow-up periods are needed to comprehensively evaluate the durability of these outcomes (21, 24).

OLIF and Adult Degenerative Scoliosis

OLIF has emerged as a widely accepted approach for addressing ADS (26). Research has consistently highlighted OLIF as a safe and effective surgical method for managing ADS, demonstrating reduced intraoperative blood loss and fewer complications compared to alternative techniques (27–29). Recent meta-analyses have confirmed OLIF's capability to correct both sagittal and coronal deformities, with or without the addition of posterior column osteotomies (PCOs) (30). Additionally, in cases of severe sagittal malalignment, OLIF can facilitate anterior column realignment (ACR) by incorporating circumferential annulotomy and resection of the anterior longitudinal ligament into the standard procedure (31). Depending on the deformity's severity, ACR may also be performed alongside PCO (32).

A study by Buell et al. compared the outcomes of OLIF with traditional surgical methods in patients with adult symptomatic thoracolumbar/lumbar scoliosis. The research demonstrated that OLIF provided comparable correction of spinal deformities with reduced operative time and lower complication rates. Specifically, patients undergoing OLIF experienced less intraoperative blood loss and shorter hospital stays compared to those receiving traditional posterior approaches. Furthermore, the study highlighted that OLIF facilitated significant improvements in health-related quality of life measures, including the Oswestry Disability Index and the physical component summary of the 36-item Short-Form Health Survey. These findings suggest that OLIF not only effectively addresses the structural aspects of ADS but also enhances patient-reported outcomes (33).

a. Clinical Outcomes

Recent studies have evaluated the efficacy of OLIF in the treatment of ADS. A comparative study between OLIF with posterior fixation and PLIF with fixation in ADS patients was conducted (17). The OLIF group demonstrated significantly less intraoperative blood loss and reduced need for blood transfusions compared to the PLIF group. Both groups achieved comparable improvements in spinal parameters and clinical symptoms, suggesting that OLIF with posterior fixation can achieve similar corrective outcomes with less surgical trauma.

Stand-alone OLIF in ADS patients has also been evaluated. Even without the addition of posterior instrumentation, improvements in the coronal Cobb angle, lumbar lordosis, and disc height were observed. Clinical outcomes, measured by VAS and ODI, also showed substantial improvement.

Table 2: OLIF Advantages.

Minimized Muscle Disruption	By accessing the spine through an oblique lateral corridor, OLIF reduces the need for extensive paraspinal muscle dissection, preserving muscle integrity and potentially decreasing postoperative pain.
Reduced Neurological Complications	Avoiding the psoas muscle during the approach minimizes the risk of injury to the lumbar plexus, which can lead to postoperative thigh pain or weakness.
Enhanced Deformity Correction	The anterior placement of interbody cages allows for better restoration of disc height and lumbar lordosis, contributing to improved sagittal and coronal balance.
Reduced Hemorrhage	Minimally invasive access results in less intraoperative blood loss compared to traditional open surgeries, as demonstrated in comparative studies.

The interbody fusion rate was 93.3%, indicating a high success rate for stand-alone OLIF in selected patients (24).

b. Radiological Outcomes

OLIF has been shown to effectively correct spinal deformities in multiple planes. Three-dimensional (3D) analysis of EOS images were used to evaluate intervertebral motion before and after staged OLIF in ADS patients (24). The study found significant reductions in wedge angles and axial rotation angles, along with improvements in lordosis angles postoperatively. These findings suggest that OLIF can simultaneously correct intervertebral rotation and scoliosis, contributing to overall spinal alignment.

Another study evaluated the use of OLIF at the functional curve (FC) in correcting alignment combined with open posterior instrumentation (35). Patients with a FC (L4 to S1) $\geq 10°$ were included in the study. The FC decreased from $16.9 \pm 7.3°$ preoperatively to $6.6 \pm 4.4°$. Coronal disc angle were also shown to improve dramatically. The advantages of OLIF are summarized in table 2.

Complications and Considerations

Although publications show that OLIF has a lower incidence of complications when compared with ALIF, it is not without potential complications.

- **Vascular Injury:** The proximity of the surgical corridor to major vessels like the aorta and iliac arteries poses a risk of vascular injury, necessitating careful surgical technique and preoperative planning. The vascular anatomy of the patient may even hinder the OLIF approach.
- **Iliopsoas Weakness:** Although the psoas muscle is avoided, retraction or manipulation during surgery can still lead to transient iliopsoas weakness or hip flexor pain.
- **Limited Direct Decompression:** OLIF relies on indirect decompression by restoring disc height and ligamentotaxis. In cases of severe central stenosis or significant coronal or sagittal imbalance, additional posterior decompression and instrumentation may be required.

Conclusion

Oblique Lateral Lumbar Interbody Fusion represents a significant advancement in the surgical management of adult degenerative scoliosis. Its minimally invasive nature, coupled with effective deformity correction and favorable clinical outcomes, makes it a compelling alternative to traditional posterior fusion techniques. However, patient selection is crucial, and surgeons must be adept with the anatomical considerations and potential complications associated with the OLIF approach. The use of OLIF in ADS surgery is very limited in terms of literature. Thus ongoing research and long-term outcome studies will further elucidate the role of OLIF in the comprehensive treatment of spinal deformities.

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