

Mini Review

## A Critical Review of the Current Trends in Lumbar Interbody Fusion Techniques

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### Abstract

Lumbar interbody fusion has been used extensively for tumors, spinal instability, deformity, and stenosis. The currently recommended surgical procedures are the anterior lumbar interbody fusion, the posterior lumbar interbody fusion and the transforaminal lumbar interbody fusion. As an alternative to them, lateral interbody fusion was introduced as a minimally invasive procedure for the management of lumbar spine disease. The literature to this date does not support a clear benefit of one main technique over others. However, many studies have compared MIS versus open interbody fusions and found similar improvements in both pain and function, but with less intraoperative blood loss, lower rates of transfusion, less postoperative narcotic use and significantly shorter hospitalization.

**Keywords:** ALIF, LLIF, XLIF, OLIF, PLIF, TLIF

### Introduction

Lumbar interbody fusion (LIF) is a surgical option for degenerative spinal pathologies, including spondylosis, spondylolysis, spondylolisthesis, pseudarthrosis, adjacent-segment disease (ASD), recurrent disc herniation and previous failed surgery [1]. Additional indications include trauma, infection and tumors. Traditionally, surgical intervention with lumbar fusion is associated with improved acute and long-term outcomes compared with nonoperative treatment [2]. Open LIF has been performed for many years with good results, however minimally invasive surgery (MIS) techniques for lumbar fusion have progressively increased in popularity in recent years.

The aim of this article is to review and summarize the current literature on the most common open and minimal invasive LIF techniques with their indications, advantages and disadvantages, and finally to compare them.

### Presenting the main techniques

The goal of the LIF surgery is to reduce pain and nerve irritation by stabilizing the painful motion segment. An implant, which can be a cage, a spacer or structural bone graft, is placed between the vertebrae after discectomy and preparation of the endplates. LIF is divided according to its approach into anterior lumbar interbody fusion (ALIF), lateral lumbar interbody fusion (LLIF) or extreme lateral interbody fusion (XLIF), oblique lateral interbody fusion (OLIF), transforaminal lumbar interbody fusion (TLIF) and posterior lumbar interbody fusion (PLIF). Each approach has its own theoretical advantages and disadvantages; however, the studies that compare them are limited.

### **The ALIF approach**

The ALIF has the longest track record. In this technique the patient is placed in the supine position and an inflatable bag is placed underneath the lumbar spine in order to exaggerate the lumbar lordosis and open the anterior disc space. A transverse incision has the advantage of better cosmetic effect and is performed between the umbilicus and the symphysis pubis. A midline or paramedian incision is also possible, especially for higher lumbar levels. The large blood vessels are mobilized via a retroperitoneal approach, often in conjunction with a vascular surgeon [3]. The L4/L5 and L5/S1 levels are particularly suitable for the ALIF approach due to the efficient access below the bifurcation of the aorta and inferior vena cava, but it should be avoided in higher levels due to extensive peritoneal and kidney retraction. ALIF provides high fusion rates and allows the use of implants of the right size; offering a satisfactory restoration of disc height & lordosis [4]. Dural injuries are not common, contrast to injuries of blood vessels, visceral organs and retrograde ejaculation [5,6].

### **The LLIF approach**

LLIF is a lateral approach between the retroperitoneal space and psoas muscle to allow access to the lumbar spine. The XLIF is a MI technique that allows the preservation of the anterior longitudinal ligament and posterior osteoligamentous complex, which are spine's major stabilizers. Contrast to the classic front or back approaches, the space between each spinal disc is accessed from the patient's side in this technique, thus ligaments, major back muscles and bones are spared. It corrects efficiently sagittal and coronal deformity; even multi-segmental correction can be performed with less blood loss and morbidity, and with rapid postoperative mobilization [7]. It is a very good option in lumbar degenerative scoliosis with latero-listhesis and it can be the treatment of choice in elderly patients in whom comorbidities increase the perioperative risk of complications [8]. It cannot treat conditions at the lowest level of the spine, L5/S1 or for some patients at L4/L5, due to the location of the iliac crest that obstructs lateral access. Complications include injury of lumbar plexus and psoas muscle, vascular and bowel injury. Complications in MI XLIF compare favorably with those from other MIS fusion procedures, with the duration of hospitalization being shorter than with any previously reported technique [9]. In addition a lower incidence of infection, visceral and neurologic injury, and a reduced need for transfusion were recorded in comparison with traditional open approaches.

### **The OLIF approach**

OLIF has been proposed as a solution to access lumbar disc space by taking advantages of the surgical space between the aorta and psoas muscle [10]. In OLIF external oblique muscle, internal oblique muscle and transverse abdominal muscle are dissected along the direction of their fibers with a blunt muscle-splitting technique. Retroperitoneal space is accessed by blunt dissection along the retroperitoneal fat tissue. The peritoneal sac is mobilized anteriorly and the psoas muscle is dissected with the index finger and retracted posteriorly [11]. OLIF offers the solution to problems of ALIF and LLIF that have already been mentioned. However, potential risks involved with OLIF surgery still exist, and include sympathetic dysfunction and vascular injury [12].

### **The PLIF approach**

PLIF is one of the original approaches for LIF. In this technique the patient is positioned prone on an Andrews or Jackson table to decrease intraabdominal pressure. Upper extremities are well padded and placed on arm-boards in a "90-90" position [13]. A longitudinal incision is made in the midline of the low back, directly over the involved spinal levels. The fascia and muscles are divided in the midline, and retractors are used to allow the surgeon to visualize the posterior vertebral arches. After the retractor is in place, an x-ray is used to confirm that the appropriate spinal level is identified. The PLIF technique includes performing a wide laminectomy and bilateral partial facetectomy to allow visualization and removal of the intervertebral disc. The posterior technique is often favored when one or two spinal levels are being fused in conjunction with a posterior decompression (laminectomy) and instrumentation (use of metal

screws/rods). A PLIF fusion is often supplemented by a simultaneous posterolateral spine fusion surgery. PLIF is a familiar approach for spine surgeons, allowing neural decompression with adequate interbody height restoration. A 360-degree fusion through a single incision is also possible with this technique. Disadvantages of PLIF include paraspinal iatrogenic injury, retraction injury of nerve roots and inadequate lordosis restoration [14].

### **The TLIF approach**

This is another posterior surgical approach for fusion; consequently positioning, incision, and approach are the same as that of PLIF [13]. The difference between these 2 techniques is that in TLIF access to the intervertebral foraminal space is unilateral, causing less damage to spinal muscles and structural integrity, and reducing traction on the roots and thecal sac. On the other hand, the graft that can be accommodated in the TLIF approach is usually smaller compared to PLIF, and the surface area for fusion is limited.

### **MIS LIF techniques and intra operative navigation**

The aforementioned LIF operations can also be performed using mini-open or minimally invasive approaches with smaller incision sizes and magnification with the use of loupes or microscope. MIS techniques have been introduced in order to decrease perioperative complications. Their efficacy in the treatment of patients with adult scoliosis has been shown in several studies [15,16]. Their goals are to minimize iatrogenic muscle trauma, to reduce blood loss, to permit an earlier mobilization of the patient and to decrease hospital stay. On the other hand, the limited visualization may increase various surgical complications. The use of intra operative navigation in spine surgery, particularly the O arm, has increased rapidly in the past several years. The safety and efficacy of the CT/O arm in minimally invasive spine surgery has already been demonstrated. Their combination offers the potential to display the specific anatomic structures with optimal magnification, leading to less blood loss, shorter hospitalization stays, higher accuracy of pedicle screw placement and faster recovery period [17,18].

### **Comparison of the main techniques**

Despite the large number of studies, there is little data overall when comparing specific aspects of lumbar interbody fusions [5]. More recent studies did not show any significant difference in fusion rates between ALIF versus TLIF approaches [19-21]. In the meta-analysis of Phan et al the rate of dural tears was higher in the TLIF group, while blood vessel injury occurred more frequently in the ALIF group [22]. Radiological findings include higher disc height and better segmental lordosis and total lumbar lordosis in the ALIF group compared with TLIF [23]. The advantage of the PLIF and TLIF approaches in comparison to ALIF is that they avoid the morbidity of the transperitoneal dissection [13].

PLIF and TLIF are the most common LIF approaches. Comparative studies have shown that PLIF and TLIF had similar therapeutic effect in adult degenerative spondylolisthesis and comparable radiographic fusion rate [24,25]. In the meta-analysis of Zhang et al, which included 7 comparative observational studies, TLIF was shown to result in a lower complication rate and PLIF was associated with an increased risk of durotomy and longer time in surgery [25].

LLIF and OLIF are relatively new approaches; therefore only a few comparative studies between them and ALIF/PLIF/TLIF exist. Sembrano et al. in their radiographic comparison of four approaches (ALIF, LLIF, TLIF and posterior spinal fusion) reported that LLIF had the ability to improve sagittal contour as well as other interbody approaches and was superior to the posterior only approach in disc height restoration; however, ALIF provided the greatest amount of segmental and overall lumbar lordosis correction [26]. Watkins et al. compared ALIF, LLIF and TLIF approaches. All the 3 groups significantly reduced spondylolisthesis, with no difference between the groups, but they found that the ALIF and LLIF groups had significantly increased disc height and improved lordosis compared to the TLIF group [27]. LLIF however has unique complications, that include transient neurologic symptoms, motor deficits, and neural injuries [28].

The current literature of MIS vs. open techniques is composed mainly of retrospective studies. It suggests that MIS procedures are as effective at relieving pain and improving function as the open alternatives. Their advantages include less blood loss, shorter length of hospitalization and less perioperative pain [29]. On the other hand, MIS interbody fusions were associated with a higher rate of neurologic complications including hyperesthesia, numbness and hip flexor weakness in some studies [13]. More studies, especially randomized controlled trials, are needed to further explore this topic.

## Conclusion

Each approach has its own risks and benefits but similar fusion rates. There is no clear definitive evidence for one approach being superior to another in terms of fusion or clinical outcomes. MIS LIF techniques present more favorable results compared to the corresponding open approaches in the current literature.

## Conflict of Interest

The authors declare that they have no conflict of interest related to this article.

## References

1. Resnick DK, Choudhri TF, Dailey AT, Groff MW, Khoo L, et al. (2005) Guidelines for the performance of fusion procedures for degenerative disease of the lumbar spine. Part 7: intractable low-back pain without stenosis or spondylolisthesis. *J Neurosurg Spine* 2: 670-672.
2. Allen RT, Rihn JA, Glassman SD, Currier B, Albert TJ, et al. (2009) An evidence-based approach to spine surgery. *Am J Med Qual* 24: 15S-24S.
3. Mobbs RJ, Lennox A, Ho YT, Phan K, Choy WJ (2017) L5/S1 anterior lumbar interbody fusion technique. *J Spine Surg* 3: 429-432.
4. Malham GM, Parker RM, Ellis NJ, Chow FY, et al. (2014) Anterior lumbar interbody fusion using recombinant human bone morphogenetic protein-2: a prospective study of complications. *J Neurosurg Spine* 21: 851-860.
5. Teng I, Han J, Phan K, Mobbs R (2017) A meta-analysis comparing ALIF, PLIF, TLIF and LLIF. *J Clin Neurosci* 44: 11-17.
6. Giang G, Mobbs R, Phan S, Tran TM, Phan K (2017) Evaluating Outcomes of Stand-Alone Anterior Lumbar Interbody Fusion: A Systematic Review. *World Neurosurg* 104: 259-271.
7. Dangelmajer S, Zadnik PL, Rodriguez ST, Gokaslan ZL, Sciubba DM (2014) Minimally invasive spine surgery for adult degenerative lumbar scoliosis. *Neurosurg Focus* 36: E7.
8. Paterakis KN, Brotis AG, Paschalis A, Tzannis A, Fountas KN (2018) Extreme lateral lumbar interbody fusion (XLIF) in the management of degenerative scoliosis: A retrospective case series. *J Spine Surg* 4: 610-615.
9. Rodgers WB, Gerber EJ, Patterson J (2011) Intraoperative and early postoperative complications in extreme lateral interbody fusion: an analysis of 600 cases. *Spine (Phila Pa 1976)* 36: 26-32.
10. Silvestre C, Mac-Thiong JM, Hilmi R, Roussouly P (2012) Complications and morbidities of mini-open anterior retroperitoneal lumbar interbody fusion: oblique lumbar interbody fusion in 179 patients. *Asian Spine J* 6: 89-97.
11. Jin C, Jaiswal MS, Jeun SS, Ryu KS, Hur JW, et al. (2018) Outcomes of oblique lateral interbody fusion for degenerative lumbar disease in patients under or over 65 years of age. *J Orthop Surg Res* 13: 38.
12. Phan K, Mobbs RJ (2015) Oblique Lumbar Interbody Fusion for Revision of Non-union Following Prior Posterior Surgery: A Case Report. *Orthop Surg* 7: 364-367.

13. Spiker WR, Goz V, Brodke DS (2019) Brodke. Lumbar Interbody Fusions for Degenerative Spondylolisthesis: Review of Techniques, Indications, and Outcomes. *Global Spine J* 9: 77-84.
14. Mobbs RJ, Phan K, Malham G, Seex K, Rao PJ (2015) Lumbar interbody fusion: techniques, indications and comparison of interbody fusion options including PLIF, TLIF, MI-TLIF, OLIF/ATP, LLIF and ALIF. *J Spine Surg* 1: 2-18.
15. Kanter AS, Tempel ZJ, Ozpinar A, Okonkwo DO (2016) A Review of Minimally Invasive Procedures for the Treatment of Adult Spinal Deformity. *Spine (Phila Pa 1976)* 8: S59-65.
16. Anand N, Baron EM, Khandehroo B, Kahwaty S (2013) Long-term 2- to 5-Year Clinical and Functional Outcomes of Minimally Invasive Surgery for Adult Scoliosis. *Spine (Phila Pa 1976)* 38: 1566-1575.
17. Epstein NE (2014) Commentary: Utility of the O-Arm in spinal surgery. *Surg Neurol Int* 30: S517-S519.
18. Chen K, Chen H, Zhang K, Yang P, Sun J, et al. (2019) O-arm Navigation Combined With Microscope-assisted MIS-TLIF in the Treatment of Lumbar Degenerative Disease. *Clin Spine Surg* 32: E235-E240.
19. Faundez AA, Mehbod AA, Wu C, Wu W, Ploumis A, et al. (2008) Position of interbody spacer in transforaminal lumbar interbody fusion: effect on 3-dimensional stability and sagittal lumbar contour. *J Spinal Disord Tech* 21: 175-180.
20. Kim JS, Lee KY, Lee SH, Lee HY (2010) Which lumbar interbody fusion technique is better in terms of level for the treatment of unstable isthmic spondylolisthesis? *J Neurosurg Spine* 12: 171-177.
21. Dorward IG, Lenke LG, Bridwell KH, O'Leary PT, Stoker GE, et al. (2013) Transforaminal versus anterior lumbar interbody fusion in long deformity constructs: a matched cohort analysis. *Spine (Phila Pa 1976)* 38: E755-E762.
22. Phan K, Thayaparan GK, Mobbs RJ (2015) Anterior lumbar interbody fusion versus transforaminal lumbar interbody fusion-systematic review and meta-analysis. *Br J Neurosurg* 29: 705-711.
23. Hsieh PC, Koski TR, O'Shaughnessy BA, Sugrue P, Salehi S, et al. (2007) Anterior lumbar interbody fusion in comparison with transforaminal lumbar interbody fusion: implications for the restoration of foraminal height, local disc angle, lumbar lordosis, and sagittal balance. *J Neurosurg Spine* 7: 379-386.
24. Yan DL, Pei FX, Li J, Soo CL (2008) Comparative study of PILF and TLIF treatment in adult degenerative spondylolisthesis. *Eur Spine J* 17: 1311-1316.
25. Zhang Q, Yuan Z, Zhou M, Liu H, Xu Y, et al. (2014) A comparison of posterior lumbar interbody fusion and transforaminal lumbar interbody fusion: a literature review and metaanalysis. *BMC Musculoskelet Disord* 15: 367.
26. Sembrano JN, Yson SC, Horazdovsky RD, Santos ER, Polly DW Jr (2015) Radiographic Comparison of Lateral Lumbar Interbody Fusion Versus Traditional Fusion Approaches: Analysis of Sagittal Contour Change. *Int J Spine Surg* 9: 16.
27. Watkins RG 4th, Hanna R, Chang D, Watkins RG 3rd (2014) Sagittal alignment after lumbar interbody fusion: comparing anterior, lateral, and transforaminal approaches. *J Spinal Disord Tech* 27: 253-256.
28. Patel VC, Park DK, Herkowitz HN (2012) Lateral transposas fusion: indications and outcomes. *ScientificWorldJournal* 2012: 893608.
29. Goldstein CL, Macwan K, Sundararajan K, Rampersaud YR (2014) Comparative outcomes of minimally invasive surgery for posterior lumbar fusion: a systematic review. *Clin Orthop Relat Res* 472: 1727-1737.