

## Comparing perioperative and postoperative outcomes and complications of ALIF and LLIF

Comparación de resultados y complicaciones perioperatorias y postoperatorias de ALIF y LLIF

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### ABSTRACT

**Purpose:** This paper compares anterior lumbar intercorporeal fusion (ALIF) and lateral lumbar intercorporeal fusion (LLIF). LLIF is an approach through the lateral retroperitoneal corridor, transpsoas. ALIF is a described alternative to interbody fusion with approach variations described as retroperitoneal, transperitoneal, open, and laparoscopic. Our objective is to compare complications can occur in both approaches the ALIF and the LLIF, to see what the advantages and disadvantages are during the perioperative and postoperative.

**Methods:** This is a literature review article. A MEDLINE search was conducted through PubMed, google scholar, science direct, and Cochrane to identify

articles that reported the differences between ALIF, LLIF and other lumbar interbody fusion approaches focusing the complications, cost and length of surgery, length of hospitalization, narcotic use, sagittal balance and surgical technique.

**Results:** There was no overall significant difference in the postoperative narcotic use, fusion rate, and disc height. However, ALIF was seen to have better postoperative sagittal balance. Although long-term complication rates between ALIF and LLIF are not statistically even though the procedures have procedure-specific complications. Intraoperative blood loss and operative time were relatively higher in ALIF than in LLIF. The risk of injury to the lumbar plexus and iliac vessels is relatively higher than ALIF.

**Conclusions:** ALIF and LLIF they are considered safe, effective and non-invasive. Both procedures present their pearls and pitfalls, but LLIF is associated with more complications than ALIF, although they do not present great differences of clinical outcomes. There is a need more extensive research to determine the best approach.

**Keywords:** anterior lumbar interbody fusion; ALIF vs LLIF; lumbar interbody fusion.

## RESUMEN

**Propósito:** Este trabajo compara la fusión intercorpórea lumbar anterior (ALIF, por sus siglas en inglés) y la fusión intercorpórea lumbar lateral (LLIF, por sus siglas en inglés). LLIF es una aproximación a través del corredor retroperitoneal lateral, con transpsoas. La ALIF es una alternativa a la fusión intercorporal con variaciones de abordaje descritas como retroperitoneal, transperitoneal, abierta y laparoscópica. Nuestro objetivo es comparar las complicaciones que pueden ocurrir en ambos abordajes de la ALIF y la LLIF, para ver cuáles son las ventajas y desventajas durante los procesos perioperatorio y postoperatorio.

**Métodos:** Este es un artículo de revisión de literatura. Se realizó una búsqueda MEDLINE a través de PubMed, Google Scholar, Science Direct y Cochrane para identificar artículos que reportaron las diferencias entre ALIF, LLIF y otros enfoques de fusión intercorporal lumbar enfocándose en las complicaciones, el costo y la duración de la cirugía, duración de la hospitalización, uso de estupefacientes, equilibrio sagital y técnica quirúrgica.

**Resultados:** No hubo diferencia significativa general en el uso posoperatorio de narcóticos, la tasa de fusión y la altura del disco. Sin embargo, se observó que la ALIF tenía un mejor equilibrio sagital postoperatorio. Aunque las tasas de complicaciones a largo plazo entre ALIF y LLIF no son estadísticamente

significativas a pesar de que los procedimientos tienen complicaciones específicas del procedimiento. La pérdida de sangre intraoperatoria y el tiempo operativo fueron relativamente más altos en ALIF que en LLIF. El riesgo de lesión en el plexo lumbar y los vasos ilíacos es relativamente mayor que la ALIF.

**Conclusiones:** ALIF y LLIF se consideran métodos seguros, eficaces y no invasivos. Ambos procedimientos presentan aciertos y desaciertos, pero el LLIF se asocia a más complicaciones que el ALIF, aunque no presentan grandes diferencias en los resultados clínicos. Se necesita una investigación más amplia para determinar el mejor enfoque.

**Palabras clave:** fusión intercorporal lumbar anterior; ALIF vs LLIF; lumbar intercorporal.

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## Introduction

Degenerative disc disease and facet joint disease involving the lumbar spine are common in the aging population and are one of the most frequent causes of disability. It is known to affect about 40 % of people over 40years and as many as 80 % of people over 80years.<sup>(1)</sup> The common clinical features include mechanical back pain, radicular and claudication symptoms, reduced mobility, and poor quality of life. Many management techniques have been discussed in the literature however surgical interbody fusion of degenerative levels is the most commonly used. This technique is an effective treatment option to stabilize the spine and reduce the painful pathological motion and may provide indirect decompression of the neural elements while restoring lordosis and correcting the deformity.<sup>(1,2,3,4)</sup>

The general principle in lumbar interbody fusion involves placing an implant (cage, spacer, or structural graft) in the intervertebral space following discectomy and endplate preparation. Depending on the site of the approach to the vertebral column, various techniques have been described including posterior lumbar interbody fusion (PLIF), transforaminal lumbar interbody fusion (TLIF), minimally invasive transforaminal lumbar interbody fusion (MI-TLIF), oblique lumbar interbody fusion/anterior to psoas (OLIF/ATP), lateral lumbar interbody fusion (LLIF) and anterior lumbar interbody fusion (ALIF).<sup>(5)</sup>

Some authors have tried to compare the different types of Lumbar interbody fusion to try to determine the best approach to manage this ever-increasing problem.<sup>(6,7,8,9)</sup> Most authors have agreed that even though they may all have similar fusion rates, ALIF has shown the greatest amount of segmental and lumbar lordosis correction. However, a recent metanalysis of 12 studies, demonstrated significantly greater sagittal and coronal correction in patients receiving LLIF.<sup>(9)</sup>

Literature directly comparing anterior lumbar interbody fusion (ALIF) with XLIF for degenerative spondylolisthesis is insufficient.<sup>(6)</sup> To better inform the choice of surgical approach for the treatment of degenerative spondylolisthesis, the specific complications and outcomes associated with these approaches need to be delineated.<sup>(8)</sup>

The risk of injury to the lumbar plexus and the iliac vessels is relatively higher than in ALIF. The article reviews and compares the fusion rate, operative blood loss, operative time, length of hospital stay, cost of surgery, postoperative narcotic use, sagittal balance, and complication rates.

## Methods

This is a literature review article. A MEDLINE search was conducted through PubMed, google scholar, science direct, and Cochrane to identify articles that reported on the differences between ALIF, LLIF and other lumbar interbody fusion approaches focusing on the postoperative complications, cost and length of surgery, length of hospitalization, narcotic use, sagittal balance and surgical technique. The key words used included Anterior Lumbar interbody fusion, ALIF, ALIF vs LLIF, Lumbar Interbody Fusion, comparing ALIF and LLIF, postoperative complications in spinal fusion, Sagittal Balance in ALIF and LLIF.

The inclusion criteria included articles comparing ALIF and LLIF, articles published in the last 10 years, articles written in English language. The exclusion criteria included all articles written in any language other than English, all articles that did not compare ALIF with LLIF and or other types of spinal fusion, all papers not published in the last 10years, case reports, editorials and articles from the same author. The authors carefully reviewed the selected articles evaluating the title and abstract to see if they met the inclusion criteria, followed by revision of the full text if the article met the inclusion criteria. After careful evaluation, a summary was made for each of the aspects being analyzed in this literature review and a conclusion based on the data extracted from each article (table).

**Table - Summary of the articles used in this literature review**

Author	Type	Methods	Conclusion	Limitation
<i>Park et al.</i> 2019	Retrospective comparative study	40 patients LLIF/ 40 patients PLIF Clinical outcomes ODI/VAS and complications.	LLIF-related complications such as endplate fracture and lower leg also developed.	Retrospective analysis.
<i>Qureshi et al.</i> 2017	Retrospective Review	The Pearl Diver Database of Medicare records. ALIF patients' group, TLIF/PLIF patients' group. Complication and readmission in 30 and 90 days.	Complications, readmissions and cost of postoperative care were increased in ALIF, but may not have the best long-term outcomes and not be cost-effective compared with TLIF/ PLIF	Retrospective analysis, non-randomized.
<i>Pavan et al.</i> 2018	Retrospective/ Cohort	Database ACS-NSQIP From 2011-2014 patients undergoing elective ALIF or TLIF.	ALIF is associated with decreased operative time, decreased blood transfusions and increased incidence of respiratory complications.	Retrospective database studies have inherent limitations. Discrepancies between data collection and entry are of primary concern.
<i>Xu et al.</i> 2018	Retrospective review	Database Cases from 2012-2016 Patients with Meyerding grade II lumbar spondylolisthesis who underwent minimally ALIF or LLIF.	Low operative blood loss and no neurological deficits.	The retrospective study, treatment strategy is limited, the strategy is not viable in the setting of osteoporosis, overall duration of follow-up is short.
<i>Goodnough et al.</i> 2019	Retrospective Review	Cases from 2008-2012 XLIF (n=21) and ALIF (n=54) Complications peri-operative and 30-day complications	XLIF is associated with Low operative blood loss, similar clinical results. Not differences between complications.	Small sample size limited power to detect significant differences in multivariate analysis.
<i>Winder et al.</i> 2016	Literature review	Literature and authors clinical experience were reviewed about ALIF vs XLIF for L4/L5	ALIF and XLIF both offer safe, reliable and reproducible. ALIF appears to offer greater ability for segmental lordotic correction, XLIF offers lower risks or vascular and hypogastric plexus injury.	Literature review
<i>Kim et al.</i> 2020	Literature review	Literature and authors clinical experience were reviewed about Pearls and pitfalls on ALIF, PLIF, TLIF, LLIF and OLIF	Each approach has its own pearls and pitfalls.	Literature review
<i>Lee et al.</i> 2016	Prospective Observational study/ cohort	32 adult patients from 2012-2014 with spinal deformity	Mini- open ALIF compared with LLIF followed by PLIF may be reducing the necessity of more extensive surgery.	Small number of patients
<i>Kudo et al.</i>	Retrospective	Database of	LLIF is safe, effective,	Retrospective,

2020	Review	patients undergoing revision interbody fusion surgery between 2014-2018	and less invasive. LLIF can be an alternative to PLIF / TLIF for restenosis	Small sample size.
Hartl et al. 2016	Systematic literature review / Retrospective cohort/ Randomized controlled trials	34 patients ELIF/ ALIF Database MEDLINE (from 1966) EMBASE (from 1980) COCHRANE LIBRARY (Through February 2013)	Complications rate for ELIF was lower compared to ALIF, ELIF is associated with a greater risk of neurological complications.	The type and timing of complications and the inconsistent use of neuromonitoring.
Malham et al. 2016	Retrospective analysis of prospectively collected registry data/Comparative cohorts	90 patients ALIF (n=50) LLIF (n=40) 45 to 70yrs old with degenerative disk disease or grade 1 to 2 spondylolisthesis and single- level pathology from L1 to S1.	No significant differences in clinical outcomes, complication rates, or fusion rates.	The relative heterogeneity between the groups. The small numbers of patients.
Smith et al. 2012	Clinical Study/ Retrospective chart review	Database 2004-2008 ALIF vs XLIF. Patients who had undergone either a Mini-open lateral or an open anterior approach for 1 or 2 level discectomy and interbody fusion with bilateral posterior pedicle screw fixation.	Clinical and cost effectiveness of XLIF shown significant advantages over ALIF.	Retrospective/ non randomized/
Teng et al. 2017	Systematic review article/ Meta-analysis	Database Through December 2015 Guidelines for systematic review ALIF, PLIF, TLIF and LLIF.	ALIF is associated with better outcome regarding restored disc height and segmental lordosis, higher incidences of cage migration.	Little data overall regarding the comparison of different lumbar interbody fusion approaches, especially with LLIF.
Watkins et al. 2014	Retrospective radiographic analysis	220 Patients were compared in terms of lordosis, disk height and spondylolisthesis 3 types of surgery: ALIF, LLIF and TLIF	The ALIF group had significantly improved lordosis compared to other groups. The ALIF and LLIF groups had significantly increased disk height compared to the transforaminal group.	Retrospective, small numbers of patients
Bolh et al. 2017	Retrospective analysis of a prospectively maintained surgical registry	Database review 2007-2014 Patients who underwent either an ALIF or LLIF. Inpatient narcotic consumption.	A total of 169 patients, no differences in risk for continued narcotic use between ALIF and LLIF surgery.	Small numbers of patients.
Rao et al. 2017	Prospective	Reviewing scans of 147 patients Radiographic scans taken pre-operatively in	The subsidence rate at follow-up was low following standalone ALIF.	Heterogeneity in the study due to usage of different graft materials. The patient series was

		addition to post operatively at 6 weeks and 18 months.		also from a single spine surgeon.
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## Approach considerations

The ALIF (also called the anterior retroperitoneal approach) is performed with the patient in a supine position via a midline, paramedian, or mini-Pfannenstiel abdominal incision. Following a retroperitoneal corridor and vascular mobilization and dissection, this approach facilitates adequate access to the entire ventral surface of the exposed disc, allowing comprehensive discectomy and direct implant insertion.<sup>(10,11)</sup> This approach is most suitable for L4/L5 and L5/S1 levels. Higher levels are not ideal indications due to the presence of kidneys and other vascular structures.<sup>(12)</sup> Contraindications reported in the literature include prior abdominal surgery with adhesions or adverse vascular anatomy, severe peripheral vascular disease, solitary kidney on the side of exposure, spinal infection, and high-grade (Grade 2+) degenerative spondylolisthesis in the absence of posterior fusion. Isthmic spondylolisthesis at L5/S1 is a relative contraindication and should include posterior fixation in combination with the ALIF technique.<sup>(10)</sup>

ALIF has several advantages that have made it a popular approach to the lower lumbar spine. Firstly, this technique allows a direct midline view of the disc space with extensive lateral exposure of the vertebral bodies, permitting efficient disc space and rapid endplate preparation. This access allows maximization of the implant size and surface area, facilitating aggressive correction of lordosis and foraminal height restoration. ALIF spares posterior spinal muscles and anterolateral psoas muscles, which reduces postoperative pain and disability.<sup>(10,12)</sup> However, the risk of visceral and vascular injury should be considered and discussed. Viswanathan et al. reported up to 40 % of general surgery-related complications during ALIF.<sup>(13)</sup> Other authors have reported a complication rate as low as 1-3 %.<sup>(12)</sup>

LLIF is an approach through the lateral retroperitoneal, transpsoas corridor. This is suitable for conditions that require access to T12/L1 to L4/5-disc spaces.<sup>(10)</sup> The L5/S1 level is not ideal because the iliac crest obstructs lateral access. Many authors have suggested that LLIF is suitable for all degenerative indications and is an excellent option for sagittal and coronal deformity correction, especially for lumbar degenerative scoliosis with laterolisthesis. The risk of injury to the lumbar plexus and the iliac vessels is relatively higher than in ALIF.<sup>(10,11,14)</sup> A systematic review by Hartl et al also showed a higher rate of nerve injury in LLIF. However, they argued that this information is based on class III evidence and prospective randomized or cohort studies are



needed to compare the safety of the minimal surgical ELIF approach with the traditional open surgical ALIF approach.<sup>(15)</sup>

## Fusion

Malham et al.<sup>(16)</sup> compared clinical and radiological outcomes in ALIF and LLIF. They analyzed 50 patients ALIF and 40 LLIF patients managed for single-level listhesis or disc disease between L1-S1. The mean follow-up in these patients was 34.1 months. The differences in fusion rates and correction of the lordosis were statistically insignificant. The fusion rate was 100 % for ALIF and 95 % for LLIF (pValue 0.1948). ALIF added 6 degrees of lordosis and 3 mm of height, primarily measured at L5-S1, and LLIF added 3 degrees of lordosis and 2 mm of height between L1 to L5. The difference in complication rates was also insignificant. This is similar to results published by Smith et al.,<sup>(17)</sup> who concluded that by using a mini-open lateral, as compared to a conventional open anterior approach, significant clinical, as well as cost benefits, are seen with similar long-term outcomes. However, it should be noted that Smith et al.,<sup>(17)</sup> compared standard ALIF to mini-open LLIF

## Blood loss

Limited tissue injury and incision size allow for earlier patient mobilization. As shown by Goodnough et al.,<sup>(6)</sup> the lateral approach is characterized by a smaller incision, indirect decompression of neural elements, and unlike the anterior approach, does not require mobilization of vascular structures with ligation or sacrifice of the middle sacral or iliolumbar veins. Their results show significantly less blood loss from the lateral approach, even after adjusting for posterior decompression, which was performed more frequently in the ALIF group. Estimated blood loss has been studied in the literature. Sembrano et al.<sup>(18)</sup> demonstrated less EBL in XLIF compared to posterior approaches at L4-5 for degenerative spondylolisthesis.

However, Teng et al.,<sup>(19)</sup> noted that the lateral and posterior approaches are associated with more blood loss compared to ALIF as they dissect through the paraspinal muscles and epidural veins. Some authors have further concluded that ALIF has minimal blood loss with 200-300mls for single-level surgeries unless there is associated vessel damage which can cause torrential hemorrhage of more than 700ml.<sup>(7,19)</sup>

However, the perioperative average blood loss described by Xu et al was significantly lower i.e., LLIF 60 ml and 106ml for ALIF.<sup>(9)</sup> The significant difference could be because Xu *et al*<sup>(9)</sup> reviewed only minimally invasive approaches to the lumbar spine.



## Operation time

In a retrospective study by Xu *et al.*,<sup>(9)</sup> 24 patients with spondylolisthesis managed by mini-ALIF and LLIF were analyzed. The operative times were 199.1 minutes and 282.1 minutes for LLIF and ALIF respectively. The long operative times were attributed to the repositioning prone of the patient for pedicle screw following ALIF and LLIF.

## Hospital stay

Hospital stay in this case is defined as the time the patient spends in the hospital from the day of the operation. This is an important factor to consider in choosing the best operative technique as longer stays are associated with a high risk of hospital-acquired infections. Longer hospital stays are also very costly to the patient and caregivers. The hospital length of stay following minimally LLIF and ALIF have been reported as 2.2 days and ALIF 4.3 days respectively.<sup>(9)</sup>

## Cost

The cost of the operation is another important factor to consider. The cost of surgery is not commonly indicated in the literature. We found in the literature one study that compared the cost of ALIF and LLIF in Australia. The cost of an ALIF (with a vascular surgeon) was A\$10,296 for a stand-alone and A\$17,422 for instrumented versions. LLIF cost A\$6,800 for stand-alone and A\$13,926 for instrumented versions.<sup>(9)</sup>

## Sagittal balance

Whether ALIF is superior to LLIF in the restoration of sagittal balance has been met with varying expert opinions and research conclusions. Watkins *et al.* analyzed 220 consecutive patients with 309 operative levels managed with either ALIF or LLIF. They concluded that ALIF and LLIF significantly improve lordosis. ALIF was superior to LLIF and TLIF in the restoration of lordosis. ALIF and LLIF are superior to TLIF in disk height restoration.<sup>(20)</sup>

## Narcotic use in ALIF and LLIF patients

In a study by Bohl *et al.*,<sup>(21)</sup> where 169 patients undergoing ALIF or LLIF were studied. They concluded that there were no differences in risk for continued

narcotic use between ALIF and LLIF procedures. Their work suggested that while patients with greater body mass index had increased narcotic consumption as inpatients, preoperative narcotic consumption and worker's compensation payment status<sup>(22)</sup> are the best predictors of continued narcotics usage during the months following surgery. They suggested that these patients should be targeted to reduce the overuse of narcotics postoperatively.

## Complications

Lateral lumbar interbody fusion (LLIF) is associated with an increased risk to the lumbar plexus. Anatomically, descends on the most anterior part of the psoas muscles. Xu et al.,<sup>(9)</sup> states that as a rule, when placing the retractor at the disc space, the bottom vertebra should be used for target referencing, to place the center of the retractor at 50 % of the lateral endplate length without breaching the neuroforamen with the posterior retractor blade. Their results showed that EMG stimulation before placement of retractors allows a safe approach to avoiding damage to the plexus. However, even though when assessed separately, ALIF and LLIF have several complications and risks associated with the surgical approach, many authors in the literature have found no significant long-term difference in the complication rates.<sup>(6,9,16)</sup>

The limitations of our study include its literature review nature, more additional studies are needed to examine in depth the long-term clinical advantages and disadvantages of both ALIF and LLIF approaches. Another important limitation is the small number of studies found in the LLIF and ALIF databases. Many of the studies reviewed did not compare similar cohorts of patients making it difficult to make a meaningful comparison of ALIF and LLIF approaches to the lower lumbar spine.

## Results

There was no overall significant difference in the postoperative narcotic use, fusion rate, and disc height. However, ALIF was seen to have better postoperative sagittal balance. Although long-term complication rates between ALIF and LLIF are not statistically even though the procedures have procedure-specific complications. Intraoperative blood loss and operative time were relatively higher in ALIF than in LLIF. The risk of injury to the lumbar plexus and the iliac vessels is relatively higher than in ALIF. However, it should be noted that there are very few studies comparing similar patient cohorts undergoing ALIF or LLIF.

## Conclusion

ALIF and LLIF are two procedures commonly performed on the lumbar spine. They are considered safe, effective and non-invasive. Both procedures present their pearls and pitfalls, but LLIF is associated with more complications than ALIF, although they do not present great differences in terms of clinical outcomes. There is a need for more extensive research to determine the best approach. However, the choice between these two procedures must be tailored to the patients' anatomy, age, affected segmentation, and other relevant factors of the patient and surgeon.

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### Conflict of interest

The authors declare that there is no conflict of interest.