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Stand-Alone Lateral Lumbar Interbody Fusion (LLIF) in Patients with Aborted Second Stage Procedures: Case Series Results

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Abstract

Background: The lateral lumbar interbody fusion (LLIF), has gained significant popularity over the last decade. The LLIF is typically supplemented with posterior or lateral fixation and decompression when necessary. Herein, we report a case series of patients who underwent a stand-alone LLIF as part of the first of a planned two-stage procedure whose second stage was subsequently aborted due to anesthesia risks or patient's desire.

Methods: This study was approved by the Hughston Sports Medicine Center Institutional Review Board. Patients were those who had an aborted second stage with a resulting stand-alone LLIF between 2014-2020 were identified retrospectively. Charts and radiographs were evaluated for evidence of fusion, implant migration, implant subsidence, minor and major complications, revisions, and resolution of symptoms. Oswestry Disability Index (ODI) and Visual Analog Score (VAS) were assessed at the initial visit and one-year postoperatively.

Results: Seventeen patients, with procedures involving 31 levels and at least 12 months of clinical follow up, were identified for inclusion in this study. At final follow up, 28 levels (90.3%) have shown radiographic evidence of fusion with evidence of cage migration in one case (3.2%). The average disc height increased by 25.6%. Twenty-four levels (77.4%) demonstrated Grade 0 (0-24%) subsidence and 4 levels (12.9%) had Grade I (25-49%) subsidence. There were no revisions, no major complications, and no additional procedures were recommended. Pre- and post-operative VAS and ODI were 6.4/3.5 ($p < 0.0001$) and 39.9/24.8 ($p < 0.032$).

Conclusion: Stand-alone LLIF is a viable option in patients with refractory back and leg pain due to a lumbar spine condition and should be considered for patients with significant risk factors to decrease anesthetic time and complications.

Abbreviations: Lateral Lumbar Interbody Fusion (LLIF), Oswestry Disability Index (ODI), Visual Analog Scale (VAS), Estimated Blood Loss (EBL), Anterior Lumbar Interbody Fusion (ALIF)

Declarations:

• Ethics approval and consent to participate: This study was approved by the Hughston Sports Medicine Center Institutional Review Board.

• Consent to publish: Not Applicable

• Availability of data and materials: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

• Competing interests: BJC, DB, SV, CK, DWP have no competing interests.

• Funding: Not applicable

• Authors' Contributions: BJC collected and interpreted data and aided in completion of the manuscript. DB collected and interpreted data and aided in completion of the manuscript. SV edited and aided in completion of the manuscript. CK aided in interpretation of radiographs and edited manuscript. DWP was the primary surgeon, aided in data collection, interpreted radiographs and edited the manuscript.

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Background

Traditional anterior and posterior approaches to spinal decompression and arthrodesis can be associated with significant morbidity to patients, which has driven the development of minimally invasive solutions for degenerative spinal disease including the lateral transpsoas approach to the lumbar spine, also known as lateral lumbar interbody fusion (LLIF). [1-4] The LLIF technique was first described by Pimenta in 2001 and was later popularized by Ozgur et al. in 2006. [3] This approach has gained significant popularity over the last decade, particularly with respect to lumbar fusion. Lateral interbody devices are generally supplemented with posterior or lateral instrumentation; however, the use of stand-alone cages, without posterior or lateral instrumentation, has been reported in the literature. [2,5,6,8]

Although previous studies have demonstrated the viability of stand-alone cages in LLIF, there is a paucity of evidence to suggest stand-alone LLIF is a viable surgical strategy in the high-risk patient or in the instance of an aborted, planned two-stage procedure. Therefore, the purpose of this study was to elucidate the feasibility and outcomes of a series of patients with aborted second stage procedures after undergoing a staged LLIF. We hypothesized that these patients' radiographic and clinical outcomes would correlate with the existing literature describing stand-alone LLIFs. Herein, we demonstrate patients who underwent a stand-alone LLIF whose second stage procedure was subsequently aborted due to cardiopulmonary risks of anesthesia and patient preference not only demonstrated good fusion results, but also exhibited minimal subsidence and interbody cage migration with no subsequent procedures or revision surgeries. Collectively, our findings suggest that a stand-alone LLIF as part of an aborted two-stage procedure is safe and is reproducible in patients with comorbidities that may limit the intensive staging in conventional LLIF.

Methods

This study was approved by the Hughston Sports Medicine Center Institutional Review Board (IRB). IRB approval was obtained in March of 2018 for a retrospective and prospective chart review. Inclusion criteria included LLIF at one or more levels with no supplemental instrumentation or posterior decompression, greater than 12 months of clinical and radiographic follow up, and an aborted second stage procedure from 2014-2019 by a single surgeon at a single institution. Patients reported symptomatology rooted in refractory back and leg pain with a diagnosis of either neurogenic claudication, radiculopathy, and

lumbar spondylosis without spondylolisthesis. Patients were excluded if they had any supplemental instrumentation, either lateral or posterior, or history of prior surgery at the operative level. All patients underwent LLIF from a left lateral approach as part of a planned 2-stage procedure. Interbody spacers included polyetheretherketone (PEEK) cages (Medtronic Clydesdale) that were 18 mm wide in antero-posterior diameter and 45-55 mm wide. Cages were packed with demineralized bone graft (Medtronic Magnifuse™) and recombinant human bone morphogenetic protein-2 (rhBMP-2 Infuse™).

Patients did not undergo the second stage of the planned two-stage LLIF either due to potential cardiopulmonary risks of anesthesia or due to individual preference. Specifically, concerns for prolonged anesthesia time either during the first or second stage of the procedure in accordance with pre-existing comorbidities in our patient population such as obstructive sleep apnea (OSA), chronic obstructive pulmonary disease (COPD), and pre-existing cardiac conditions (i.e., atrial fibrillation) contributed to the decision to abort the second stage of the procedure.

Radiographic evaluation was conducted by a musculoskeletal-trained radiologist utilizing standing anteroposterior and lateral radiographs at preoperative and follow up clinical visits at 3 months, 6 months, and 1 year to assess for fusion, cage migration, subsidence, and change in disc heights. Cage migration was assessed by comparing intraoperative radiographs directly with follow-up radiographs. Fusion was determined by the surgeon and radiologist – considering successful evidence of radiographic fusion as evidenced by bone bridge formation between the entire fusion area, with no indication of pseudoarthrosis or area of lucency between graft bone and vertebral bone. A lack of fusion was defined by construct collapse, vertebral slip, and interbody cage displacement. Subsidence was determined using a grading system described by Marchi et al. [6] This classification describes subsidence based on the percentage of the cage that has subsided (grade 0 (0-24%), grade I (25-49%), grade II (50-74%), grade III (75-100%)). Disc height change was measured preoperatively and at the latest postoperative clinical visit using the Farfan method, which calculates the average of the anterior and posterior intervertebral space divided by the disc space diameter. [7]

Medical records were reviewed for major complications (death, infection, vascular injury, fracture, etc.) and the most common minor complications (psoas weakness, thigh pain, thigh numbness), as reported in the existing literature. Records were also evaluated to assess surgical time, potential revision surgeries, and patient-reported satisfaction with the procedure. The visual analog scale (VAS) and Oswestry Disability Index (ODI) were obtained preoperatively and at the one-year postoperative visit to quantify clinical improvement. Statistical analysis was performed using a paired student T-test.

Results

Fifty-four patients were identified during 2014 - 2019 who underwent LLIF with aborted second stage. Of these 54, 17 patients (12 males, 5 females) with an average age of 73.8 years (range 58 - 86 years) met the inclusion criteria. Average body mass index (BMI) was 29.2 kg/m^2. Only 2 out of the 17 patients were current tobacco users. Average surgical time was 27.5 minutes (range: 19-50) with an average estimated blood loss (EBL) of 43.5 (range 10-150). One patient underwent a one level standalone LLIF combined with anterior lumbar interbody fusion (ALIF) at an adjacent level, one patient had a three-level standalone LLIF, twelve underwent stand-alone LLIF at 2 levels while four underwent stand-alone LLIF at one level. There was a total of 31 stand-alone LLIF levels in these 17 patients. Most common levels fused were L3-4 (13), followed by L2-3 (12). This data is summarized in Table 1.

Table 1: Patient demographics

Variable	Value
Age, years	73.76 (range: 58– 86)
Sex, number	
Male	12 (70.6%)
Female	5 (29.4%)
BMI, kg/m^2	29.2
Follow-up duration (months)	13.3 (range: 12 – 14.5)
Surgical time (minutes)	27.5 (19-50)
Estimated blood loss (EBL)	43.5 (10-150)

The average follow up was 13.3 months, with all 17 patients having follow up greater than one year. Definitive fusion was identified in 28 levels (90.3%) on postoperative radiographs and ongoing fusion at 3 levels. Patients with fusion have a follow up of 13.7 months, while those with an ongoing fusion only have a follow up of 12.2 months. Grade 0 subsidence was identified in 24/31 levels (77.4%), Grade I in 4/31 levels (12.9%), Grade 2 in 2/31 levels (6.5%) and Grade 3 in 1/31 levels (3.2%). One patient had appreciable radiographic evidence of cage migration into the superior and inferior endplates when comparing intraoperative radiographs to the most recent follow up radiographs. (Table 2.) Preoperative disc height for all levels was 5.81 mm, postoperative disc height was 7.27 mm, with an average change of 1.46 mm (p=0.028) across all levels which represents a 25% increase. (Table 3 and Figure 1).

Table 2: Radiographic Results

Number of levels	
1	4 (23.5%)
2	12 (70.6%)
3	1 (5.9%)
Total	31
Level of treatment	
L1-2	2
L2-3	12
L3-4	13
L4-5	4
Subsidence	
Grade 0	24 (77.4%)
Grade 1	4 (12.9%)
Grade 2	2 (6.5%)
Grade 3	1 (3.2%)
Fusion	
Yes	28 (90.3%)
Ongoing	3 (9.6%)
Migration	
Yes	1 (3.2%)
No	30 (96.8%)

Table 3: Change in Disc Height

Disc Height (P = 0.028)	(mm)
Preoperative	5.81
Postoperative	7.27
Change	1.46 (25%)

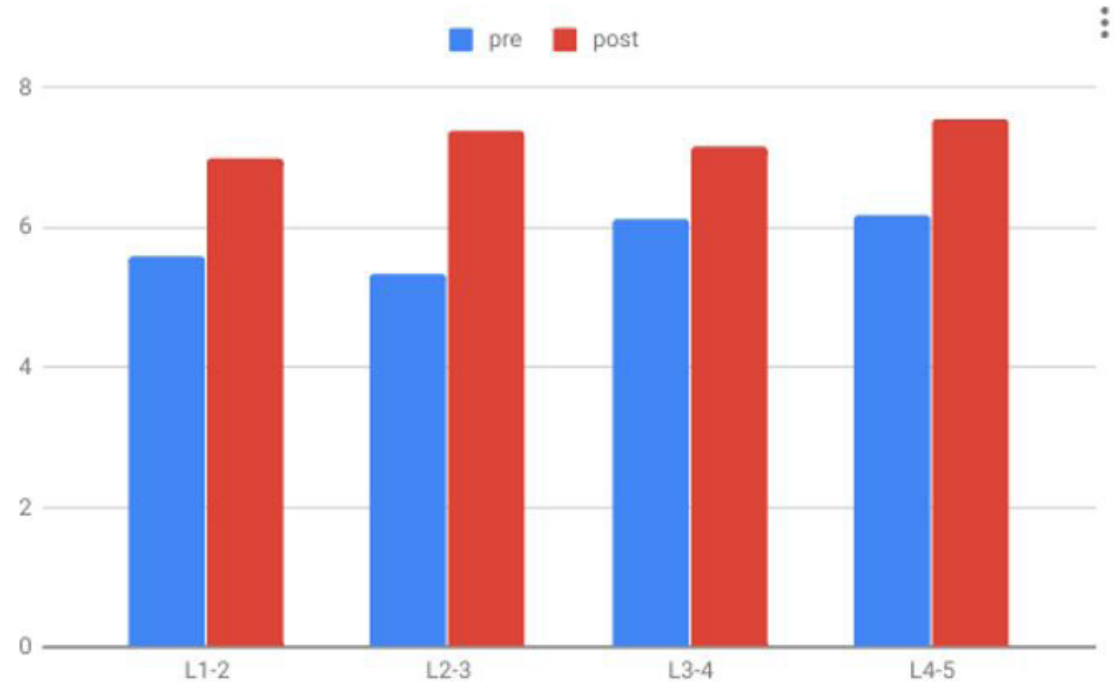

Figure 1: Change in disc height across levels (mm)

There were no major complications exhibited in our patient population. Four patients (12.9%) experienced minor complications - numbness (2 patients) and thigh pain (2 patients) which resolved within 3 months postoperatively. There were no revisions. Sixteen out of seventeen patients (94.1%) reported satisfaction with surgery. Fourteen patients had preoperative and also one-year postoperative VAS and ODI assessments. In these patients, the VAS and ODI scores both improved from 6.4 and 39.4 to 3.5 ($p < 0.0001$) and 26.2 ($p < 0.032$) at one year postoperatively. (Figure 2)

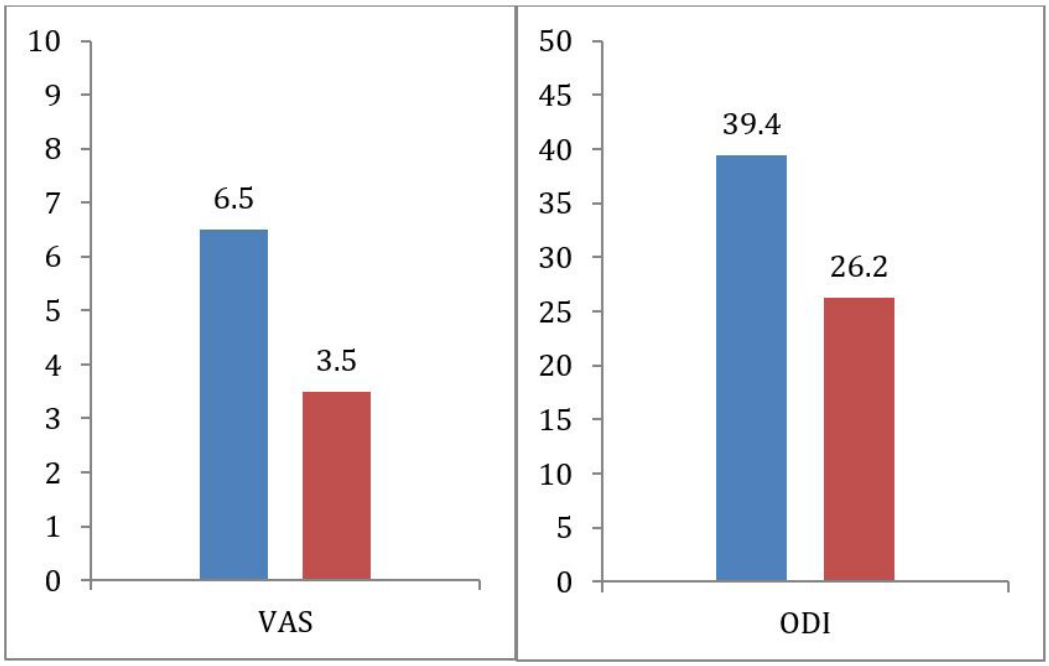

Figure 2: Visual Analogue Scale and Oswestry Disability Index Scores Before and After Surgery (VAS $p < 0.0001$; ODI $p < 0.032$)

Discussion

There are several advantages to the lateral lumbar interbody fusion technique – including direct access to the disc space, minimal soft tissue dissection, shorter operative times, avoidance of damage to the posterior structures, preservation of anterior and posterior ligamentous structures, accessibility for larger implant options, decreased blood loss, shorter hospital stays, and lack of necessity for an access surgeon. Disadvantages include inability to visually assess decompression of the thecal sac due to reliance on an indirect decompression and limited access to the upper and lower lumbar spine levels due to the anatomic constraints from the iliac crest (L5-S1) and pulmonary structures (L1-L2). [1-4] Risk of injury to the lumbar plexus with reports of minor motor weakness and sensory complications may also occur in up to 75% of cases. [4,8,9,10,11,12] These motor and sensory complications are usually transient, but can cause significant discomfort to the patient.

The existing literature describing stand-alone LLIF primarily consists of retrospective reports. Although the use of stand-alone LLIF has shown promising results, additional studies and data are needed to compare the clinical and radiographic outcomes with the current standard of lateral interbody devices with supplemental fixation. Our study demonstrates that stand-alone LLIF is a viable treatment option for patients in whom longer anesthetic times and multiple inductions of anesthesia is contraindicated or not desired, and the findings of this study reflect successful clinical outcomes with an attenuated complication profile, standard operative time, consistent clinical fusion rates, and no revisions to date.

The lateral technique, especially when used in a stand-alone manner, relies on indirect decompression. In a prospective study using preoperative and 2-week postoperative MRIs Oliveira et al. demonstrated the propensity of the LLIF to indirectly increase disc height, foraminal height and area, and central canal diameter in 21 patients (43 levels). The average increase in disc height was 41.9%, foraminal height of 13.5%, foraminal area of 24.7%, and central canal diameter of 33.1%, all of which were statistically significant. [13]

Marchi et al. studied 53 patients who underwent single level stand-alone LLIF for treatment of low-grade degenerative spondylolisthesis. In their retrospective case series, they noted an 86% fusion rate at 24 months with a 55% increase in disc height. VAS and ODI scores showed lasting improvements in clinical outcomes with 60% and 54.5% improvement ($p < 0.05$). Cage subsidence was reported in 9/52 cases, with the majority being low grade subsidence: grade 20 (55.8%) and grade I (26.9%), grade II (11.5%), Grade III (5.8%). There were 7 revisions, 5 of which were for subsidence and 2 for inadequate indirect decompression. Patients with high grade (grades I and II) subsidence had statistically less improvement than those with low grade (grades 0 and I) subsidence, and elderly (average 71.7 years) and female patients tended to develop more severe subsidence.[6]

In a retrospective multicenter study, Ahmadian et al. evaluated the clinical outcomes of stand-alone LLIF in 59 patients (96 levels). At one year follow up they reported a 95% fusion rate, with 70% grade 0 subsidence and 30% grade I and II. VAS and ODI improved from 69.1 and 51.8 to 37.8 and 31.8 respectively. They noted no statistical difference in VAS and ODI improvement between patients with grade 0 and grade I subsidence. There was one cage migration which required revision. Forty seven percent of the patients experienced a minor complication including sensory or motor deficits, but the majority were transient.[4]

Nemani et al. retrospectively reviewed the rate of revision surgery after stand-alone LLIF. In 117 patients they showed a 10.3% revision rate at an average of 10.8 months postoperatively. The most common reasons for revision were persistent radiculopathy and symptomatic subsidence. They did not report any cage migration. Revision consisted of posterior decompression and posterior instrumentation.[8] Subsidence in stand-alone constructs after fusion has been correlated with increased instability in the interbody construct and also decreases the effect of indirect decompression of the neural foramina.[14] In the literature, risk factors for increased subsidence correlate with osteoporosis, increased age, female sex and multilevel procedures. [15-17] Machi et al. examined the difference in the rate of subsidence in 28 patients undergoing stand-alone short segment (1- or 2-level) LLIFs. They found that use of a wider cage, 22 mm instead of 18 mm, resulted in decreased cage subsidence and increased gains in lordosis and disc heights with no change in fusion rate.[6]

Nonunion rate in patients with stand-alone constructs is also a concern. Watkins et al. examined the nonunion rate in 23 patients (37 levels) undergoing stand-alone procedures. Nonunion was reported in 7 out of 37 levels (19%), whoever it is im-

portant to note that in their study that all patients with nonunion were either smokers or had a prior diagnosis of osteoporosis.[18] Our results, and the results of the previous studies, demonstrate a much high union rate (90.3%).

Our study has a few limitations. Notably, we acknowledge a smaller sample size than previous studies, however, these patients were not selected to undergo stand-alone fusion. Rather, the patients in our study underwent a stand-alone procedure as part of a planned two-stage plan. We also recognize the limited data surrounding our clinical outcomes as there are only 14 patients who have preoperative and one-year postoperative VAS and ODI scores in the medical record. Additionally, the average BMI of our patient population was 29.2 – although it is unlikely that results of our study were affected by variability in BMI, given the access granted by the lateral approach to interbody fusion, we acknowledge that future studies are necessary to corroborate our results. In our study, an orthopaedic spine surgeon and musculoskeletal fellowship-trained radiologist assessed radiographs fusion using radiographs. The use of computed tomography may provide more reliable imaging to determine extent of fusion. Continued follow-up is essential, and patients in this study will continue to be followed for any radiographic changes and clinical outcomes.

Conclusion

Stand-alone lateral lumbar interbody fusion is a viable consideration in patients with refractory back and leg pain secondary to lumbar conditions and is an option to consider for patients with significant cardiopulmonary risk in order to decrease anesthetic time. Furthermore, we demonstrate that, even in consideration of a high-risk patient population, stand-alone LLIF as part of an aborted two-stage procedure may show radiographic and clinical improvements consistent existing literature describing stand-alone LLIF, which relies on indirect fusion and decompression. Our study suggests that this procedure may present an alternative operative plan for patients with limited instability who may not be candidates for longer procedures.

References

1. Kepler, Christopher K., et al. "Indirect Foraminal Decompression after Lateral Transpsoas Interbody Fusion." *Journal of Neurosurgery: Spine*, vol. 16, no. 4, 2012, pp. 329–333., doi:10.3171/2012.1.spine11528.

2. Marchi, Luis, et al. "Stand-Alone Lateral Interbody Fusion for the Treatment of Low-Grade Degenerative Spondylolisthesis." *The Scientific World Journal*, vol. 2012, 2012, pp. 1–7., doi:10.1100/2012/456346.

3. Ozgur, Burak M., et al., "Extreme Lateral Interbody Fusion (XLIF): a Novel Surgical Technique for Anterior Lumbar Interbody Fusion." *The Spine Journal*, vol. 6, no. 4, 2006, pp. 435–443., doi: 10.1016/j.spinee.2005.08.012.

4. Wang, Michael Y., et al., "Minimally Invasive Lateral Interbody Fusion for the Treatment of Rostral Adjacent-Segment Lumbar Degenerative Stenosis without Supplemental Pedicle Screw Fixation." *Journal of Neurosurgery: Spine*, vol. 21, no. 6, 2014, pp. 861–866., doi:10.3171/2014.8.spine13841.

5. Ahmadian, Amir, et al. "Stand-Alone Minimally Invasive Lateral Lumbar Interbody Fusion: Multicenter Clinical Outcomes." *Journal of Clinical Neuroscience*, vol. 22, no. 4, 2015, pp. 740–746., doi:10.1016/j.jocn.2014.08.036.

6. Marchi, Luis, et al., "Radiographic and Clinical Evaluation of Cage Subsidence after Stand-Alone Lateral Interbody Fusion." *Journal of Neurosurgery: Spine*, vol. 19, no. 1, 2013, pp. 110–118., doi:10.3171/2013.4.spine12319.

7. Kirkaldy-Willis WH, Farfan HF. Instability of the lumbar spine. Clin Orthop Relat Res.1982;(165):110-23.

8. Nemani, Venu M., et al., "Rate of Revision Surgery After Stand-Alone Lateral Lumbar Interbody Fusion for Lumbar Spinal Stenosis." *Spine*, vol. 39, no. 5, 2014, doi:10.1097/brs.0000000000000141.

9. Alimi, Marjan, et al., "Radiological and Clinical Outcomes Following Extreme Lateral Interbody Fusion." *Journal of Neurosurgery: Spine*, vol. 20, no. 6, 2014, pp. 623–635., doi:10.3171/2014.1.spine13569.

10. Alimi, Marjan, et al., "Extreme Lateral Interbody Fusion for Unilateral Symptomatic Vertical Foraminal Stenosis." *European Spine Journal*, vol. 24, no. S3, 2015, pp. 346–352., doi:10.1007/s00586-015-3940-z.

11. Tempel, Zachary J., et al., "Graft Subsidence as a Predictor of Revision Surgery Following Stand-Alone Lateral Lumbar Interbody Fusion." *Journal of Neurosurgery: Spine*, vol. 28, no. 1, 2018, pp. 50–56., doi:10.3171/2017.5.spine16427.

12. Towers, Wendy S, and Khalid H Kurtom. "Stand-Alone LLIF Lateral Cage Migration: A Case Report." *Cureus*, 2015, doi:10.7759/cureus.347.

13. Oliveira, Leonardo, et al. "A Radiographic Assessment of the Ability of the Extreme Lateral Interbody Fusion Procedure to Indirectly Decompress the Neural Elements." *Spine*, vol. 35, no. Supplement, 2010, doi:10.1097/brs.0b013e3182022db0.

14. Le TV, Baaj AA, Dakwar E, Burkett CJ, Murray G, Smith DA, et al: Subsidence of polyetheretherketone intervertebral cage in minimally invasive lateral retroperitoneal transpsoas lumbar interbody fusion. Spine (Phila Pa 1976) 37:1268–1273, 2012

15. Cheung KMC, Zhang YG, Lu DS, Luk KDK, Leong JCY: Reduction of Disc Space Distraction After Anterior Lumbar Interbody Fusion with Autologous Iliac Graft. Spine (Phila Pa 1976) 28: 1385-1389, 2003.

16. Choi JY, Sung KH: Subsidence after anterior lumbar interbody fusion using paired stand-alone rectangular cages. Eur Spine J 15:16–22, 2006.

17. Hou Y, Luo Z: A study on the structural properties of the lumbar endplate: histological structure, the effect of bone density, and spinal level. Spine (Phila Pa 1976) 34:E427–E433, 2009.

18. Watkins, Robert, and Robert Hanna. "Non-Union Rate With Stand-Alone Lateral Lumbar Interbody Fusion." *Medicine*, vol. 93, no. 29, 2014, doi:10.1097/md.0000000000000275.