Retrospective Analysis of Clinical Indicators of 522 Patients Undergoing the ALIF Surgical Technique Using PEEK Cages

ABSTRACT
This review discusses the anterior lumbar interbody fusion (ALIF) procedure combined with a polyetheretherketone (PEEK) cage to treat degenerative diseases of the lumbar spine such as disc degeneration, spondylolisthesis, and pseudarthrosis, as well as their possible complications and benefits. A systematic literature review to identify, select, and analyze articles on ALIF for treating degenerative or traumatic disorders of the lumbar spine, published from 1988 until March 2021, was performed in the Public/Publisher MEDLINE database. In nine articles selected, 522 patients underwent ALIF surgery. Among all the patients surveyed, 17% had intra- and extra-operative complications and due to them, 11 (2.1%) needed reoperation. The mean Patient Satisfaction Index was 82.93% in three articles evaluating 210 patients after the surgery. Satisfactory clinical-functional improvement, considering postoperative time and patients’ total recovery, was based on the Visual Analogue Scale (VAS), Oswestry Disability Index (ODI), and follow-up (mean of 18.55 months). Although standardization between studies was difficult because different types of material and methods were used in the articles surveyed, the ALIF technique has been proven to be an effective surgical procedure. Further studies are needed to standardize the variables to effectively establish response predictors of candidates for the ALIF procedure.

Keywords: ALIF; Anterior lumbar interbody fusion; PEEK cage; Low back pain; Lumbar spine; Neurosurgery
INTRODUCTION

The surgical technique named anterior lumbar interbody fusion (ALIF) was initially described by Capner, in the 1930s, and was developed to treat Pott’s disease, the tuberculous vertebral column involvement caused by Koch’s bacillus (Mycobacterium tuberculosis)\(^1,2\). Such a surgery consists of fostering arthrodesis between the bodies of two contiguous vertebrae by replacing the intervertebral disc with a cage, using the abdomen as an access route. Due to the possibility of restoring the biomechanical and structural integrity of the spine\(^1,3\) this procedure had also become a new treatment option for more prevalent diseases such as disc degeneration, spondylolisthesis, and pseudarthrosis\(^2\).

In the United States, a total increase by 168.5% was observed in ALIF completion rate between 2007 and 2014, i.e., 24.07% per year\(^4\). Although Brazil lacks studies dedicated to this theme to establish a national portrait, it is likely to have similar percentages.

It is important to emphasize that no significant difference was found between the arthrodesis rate promoted for the fusion of vertebral bodies of the lumbar spine using the ALIF approach and any other similar techniques\(^5\). However, the ALIF technique offers certain advantages, namely a shorter surgery time\(^6\), less blood loss\(^5\), less postoperative pain, and reduced surgical trauma to the paraspinal muscles\(^5\). The anterior approach allows complete re-section of the degenerated disc and contributes to eliminate the source of pain. Simultaneously, it leads to distracting and reshaping of the disc space that is affecting the regional and local spine alignment, including disc height/angle and lumbar lordosis\(^5\).

By contrast, the anterior approach implies exposure and manipulation of structures such as the great vessels, sympathetic plexus, peritoneal contents, and ureters\(^5\), which can provoke vascular traumas such as arterial wall dissection or venous injury\(^5\), in addition to complications not considered serious, which tend to resolve spontaneously, such as lower limb paresthesia, retrograde ejaculation, and sympathetic dysfunctions\(^7\). It is worth mentioning that, in Brazil, since the surgical access is performed by a vascular surgeon, such complications have become extremely rare\(^6\).

The main implantable option for ALIF is the polyetheretherketone (PEEK) cage. This material has been widely used for fixation, given that it is a non-absorbable, radiolucent, biocompatible compound that displays physical properties similar to those of human bone\(^8\). These characteristics make it more attractive compared to metal cages, in addition to allowing better image control\(^10\).

Regarding the surgical indication, it should be considered as the main symptom reported by patients who are candidates for surgery is low back pain. This problem affects 80% of the adults at some moment in life, and it is among the top 10 causes of consultation with internists. Every year, 5% to 10% of workers miss more than seven days of work due to this condition\(^11\). Chronic spinal disorders have a prevalence of around 18.5% in the Brazilian population\(^9\) and are one of the main causes of absenteeism\(^12\), resulting in significant economic impacts. It has been estimated that back pain affects more than 100 million individuals and costs over $200 billion per year\(^13\). Therefore, the ALIF technique becomes more relevant considering that the surgical procedure is the last step in an attempt to relieve suffering, in clinical-functional improvement, for those who did not obtain satisfactory solutions with the conservative treatment, to restore patients’ productive capacity, and to improve quality of life\(^6,7\).

Based on these considerations, this systematic literature review aimed to compare pre- and postoperative parameters of patients that underwent ALIF using a PEEK cage, analyze variables such as functionality, pain, and patients’ satisfaction rate according to validated scales, and discuss possible complications.

MATERIALS AND METHODS

A systematic literature review was carried out in the Public/Publisher MEDLINE (PubMed) database on the use of the surgical technique ALIF for the treatment of degenerative or traumatic disorders of the lumbar spine with the use of PEEK cage. The search was conducted by five independent researchers following the steps proposed in the protocol of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)\(^14\).
Aiming to increase the specificity of the systematic review, filters were applied contiguously to the Boolean descriptor, combined as follows: “ALIF” [Medical Subject Headings (MeSH) Major Topic] OR “anterior lumbar interbody fusion”. For the selection of articles, the following inclusion criteria were adopted: 1) studies in English; 2) studies performed in patients over 19 years old; 3) studies that included patients who underwent autonomous single-level or multilevel ALIF using a PEEK cage; and 4) studies involving humans. The exclusion criteria were: 1) studies that used any fixation methods other than PEEK cage; 2) studies in which ALIF was used concomitantly with other lumbar interbody fusions (ALIF combined with posterior lumbar interbody fusion (PLIF), transforaminal lumbar interbody fusion (TLIF), lateral lumbar interbody fusion (LLIF), extraforaminal lumbar interbody fusion (ELIF), and oblique lateral interbody fusion (OLIF); 3) cohorts including cadavers; 4) studies that could not be traced; 5) studies whose author’s last name was “Alif”; and 6) meta-analyses and systematic reviews.

**RESULTS**

In this systematic review in the PubMed database, 307 papers were initially selected. After applying the abovementioned inclusion and exclusion criteria, nine articles were fully analyzed, encompassing 522 patients who underwent ALIF surgery (Figure 1, Table 1). The mean follow-up period was 23.18 months (minimum of 12 months and a range of 12–59 months). All patients completed a period of conservative treatment before the surgical intervention using ALIF was necessary.

As an outcome, in most studies selected, the clinical improvement of pain after the ALIF procedure was analyzed using the Oswestry Disability Index (ODI) and the Visual Analogue Scale (VAS), employed by clinicians and researchers to quantify disability due to low back pain and one-dimensional quantification of pain intensity, respectively. Additionally, the Patient Satisfaction Index (PSI) was used for the self-assessment of postoperative results.
On one hand, 345 patients (45.05% male, mean age of 53.7 years) were evaluated pre- and postoperatively applying ODI, whereas 107 patients (55.7% male, mean age of 55.7 years) were evaluated pre- and postoperatively using VAS. On the other hand, in only three articles PSI was used to evaluate 210 patients (49% male) after the surgical procedure.

Of 522 patients, a total of 89 complications were found within the articles analyzed, i.e. 17% of them had intra and extra operative complications, of which 11 (2.1%) required reoperation. Among the complications, seven patients complained of bladder dysfunction; seven had paralytic ileus; seven reported pseudarthrosis; five had superficial infections of the surgical scar, which improved after antibiotic therapy; five reported post-surgical hematomas; four had sympathetic dysfunction; three had intraoperative iliac vein injuries, which resolved without further damage; three complained of paresthesia of the lower limbs, extending to the L5 dermatome; three complained of motor complications; three reported sexual complications; two had peritoneal tears; one had an incisional hernia; one had anterior dural tear; one had abdominal wall insufficiency caused by the anterior approach, which required revision surgery; one reported temporary sensitivity disturbance in the region of the left flank correlated to the retroperitoneal approach, but the symptom disappeared spontaneously within 1 year; one had deep vein thrombosis; one reported recurrent radicular pain at L5; one had neurogenic claudication; one had lateral stenosis; one had phlebitis; one reported a sensory complication; and one had a sacral fracture.

Additionally, one patient died one day after surgery due to a previous heart problem.

Furthermore, 21 complications were attributed to the material used in the ALIF surgery: 15 patients underwent cage subsidence after a given period of cage implantation; three patients needed posterior fixations, requiring reoperations; two migrations of the plate were observed; and in one patient the screw was improperly placed.

Detailing the 11 reoperations, four patients underwent screw and rod removal due to discomfort attributed to posterior equipment after evidence of bone fusion; one required revision surgery, given the insufficiency of the abdominal wall; one required adjacent-level fusion within a 34-month observation period; one required reoperation by posterior approach due to another disease of the lumbar spine; one required reoperation to place a posterior pedicle screw percutaneously, due to constructive failure confirmed by imaging tests; one suffered a non-traumatic fracture of the upper endplate of L5, requiring posterior fixation with a pedicle screw; one underwent posterior decompression and uninstrumented fusion after imaging revealed nonunion, lateral stenosis, and residual spondylolisthesis; and one underwent revision surgery due to the detachment of the proximal hooks from their fixation points, which caused prominence of the rods and hooks.

### Table 1. Characterization of the studies selected in this systematic literature review.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Experimental design</th>
<th>Patients (n)</th>
<th>Follow-up duration (months)</th>
<th>Age at surgery (mean ± SD; years)</th>
<th>Male patients (%)</th>
<th>Complication</th>
<th>Reoperation</th>
<th>Preoperative (mean; mean ± SD)</th>
<th>Postoperative (mean; mean ± SD; %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afain et al.</td>
<td>Prospective study</td>
<td>65</td>
<td>12</td>
<td>57.1 ± 11.1 [35–82]</td>
<td>24.6</td>
<td>17</td>
<td>1</td>
<td>48.4</td>
<td>21.8</td>
</tr>
<tr>
<td>Jägersberg et al.</td>
<td>Retrospective cohort</td>
<td>46</td>
<td>34</td>
<td>48 ± 10</td>
<td>47.8</td>
<td>11</td>
<td>6</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Wan et al.</td>
<td>Retrospective radiographic study</td>
<td>48</td>
<td>17</td>
<td>56.3</td>
<td>20.8</td>
<td>0</td>
<td>0</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Ni et al.</td>
<td>Retrospective radiographic study</td>
<td>68</td>
<td>27.5</td>
<td>67 ± 9</td>
<td>7.3</td>
<td>1</td>
<td>1</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Mobb et al.</td>
<td>Clinical study</td>
<td>15</td>
<td>18</td>
<td>54 [33–62]</td>
<td>60.0</td>
<td>3</td>
<td>0</td>
<td>–</td>
<td>7.9</td>
</tr>
<tr>
<td>Phan et al.</td>
<td>Prospective observational study</td>
<td>137</td>
<td>24</td>
<td>56.82</td>
<td>47.4</td>
<td>30</td>
<td>0</td>
<td>59.75 ± 24.36</td>
<td>–</td>
</tr>
<tr>
<td>Norotte and Barrio</td>
<td>Retrospective study</td>
<td>65</td>
<td>24</td>
<td>48 ±10</td>
<td>55.3</td>
<td>12</td>
<td>0</td>
<td>61.7 ± 9.4</td>
<td>22.3 ± 14.3</td>
</tr>
<tr>
<td>Kapustka et al.</td>
<td>Retrospective analysis</td>
<td>51</td>
<td>12–59</td>
<td>41.7 ± 8.4 [24–59]</td>
<td>52.9</td>
<td>5</td>
<td>0</td>
<td>58</td>
<td>24</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>522</td>
<td>89</td>
<td>11</td>
<td></td>
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</tbody>
</table>

_n_ = number; _SD_ = standard deviation; _ODI_ = Oswestry Disability Index; _VAS_ = Visual Analogue Scale; _PSI_ = Patient Satisfaction Index.
DISCUSSION

The non-experimental surgical procedure named ALIF using PEEK cage is already consolidated in the international surgical practice and has been progressively gaining ground as a therapeutic option worldwide. It has been used to treat diseases such as disc degeneration, spondylolisthesis, and pseudarthrosis, demonstrating its effectiveness through previous prospective studies, which was also confirmed in this systematic review.

Comparing ALIF with other intersomatic spinal approaches, such as PLIF and TLIF, the anterior retroperitoneal technique decreases the risk of iatrogenic trauma to the paravertebral muscles and spinal nerves and does not involve removal of posterior bone structures. It also allows the complete resection of the degenerated disc and the remodeling of the disc space using PEEK cages as well as the immediate decompression of the nerve root. Furthermore, this method allows the restoration of the lumbar lordosis angle, increases the height of the disc space, and improves sagittal balance, proposing an adequate alignment of the spine, thus making the reestablishment of the biomechanical integrity of the spine possible.

In contrast, the anterior approach requires exposure and mobilization of large blood vessels, peritoneal contents, ureter, and sympathetic plexus. Therefore, this technique may present risks and complications involving the aforementioned structures. The most frequent complication is venous injury and rupture of the arterial wall, considered the most serious iatrogenic damage, although extremely rare. Recognizing the risk, nowadays, the anterior access is performed by a vascular surgeon, which has resulted in considerable decrease in complications, reduced surgical time and bleeding, decrease in the rates of intra-operative and extra-operative complications, in addition to developing clinical-functional improvements that are beneficial to patients, especially in terms of pain relief.

Variables were analyzed within a study based on radiographic data from patients undergoing ALIF with PEEK, in which the anterior and posterior height of the disc, disc angle, lumbar lordosis, and foraminal dimensions were taken into account. According to this analysis, anterior lumbar fusion is an effective and safe procedure for the treatment of spinal pathologies, statistically improving pain, functionality, and measures of well-being in degenerative disc diseases. Thus, ALIF is an effective treatment both clinically and radiographically.

The nine studies selected did not use the same quantitative and qualitative analysis standards, which limits our discussion about the improvement of patients after ALIF. Nevertheless, given the significant clinical improvement expressed by the numerical decrease in the postoperative period compared to the pre-surgical index verified using ODI and VAS in most studies, the present systematic literature review confirmed that the improvements reported by the patients proved to be significantly expressive, confirming the effectiveness of the ALIF surgery in relieving patients' pain.

CONCLUSION

Low back pain is a prevalent spinal condition and one of the main causes of demand for medical care in the world, generating economic and health impacts at global level. Based on the studies analyzed, ALIF stands out as an effective option for the treatment of this condition, and it is evident that it is a safe technique that brings significant improvement in patients' pain and quality of life. However, further prospective studies are needed to provide a real and updated picture of the ALIF technique, especially in the Brazilian context, as well as its current rate of complications and indicators of improvement and satisfaction.

This study confirmed that the ALIF technique is a surgical procedure with proven efficacy. This systematic literature review encompassed a total of 522 patients, constituting the review with the largest number of patients analyzed for this surgery in the PubMed database. Nonetheless, the discussion was limited by the discrepancy between the different types of material and methods used in the articles surveyed, making standardization between studies difficult.

Therefore, further studies that can standardize the variables are needed to allow discussing the effectiveness of this surgical procedure and to effectively establish response predictors of candidates for the ALIF procedure.
REFERENCES


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