Effectiveness of Reoperations for Adjacent Segment Disease Following Lumbar Spinal Fusion

AUSTIN DRYSC; REMI M. AJIBOYE, MD; AKSHAY SHARMA, BA; JESSE LI, BS; TARA REZA, BS; DUSHAWN HARLEY, BS; DON Y. PARK, MD; SINA POURTAHERI, MD

Abstract

Although several options are available to address adjacent segment disease (ASD), the most effective surgical treatment has not been determined. In addition, it is important to subdivide ASD into stenosis with or without instability to determine if a decompression alone vs an extension of fusion is necessary. A systematic search of multiple medical reference databases was conducted for studies on surgical treatment of ASD. The primary outcome measures used were radiographic and clinical success rates. Meta-analysis was completed to determine effect summary values, 95% confidence intervals, and Q statistic and P values, using the random effects model for heterogeneity. The search yielded 662 studies, of which 657 were excluded. A total of 5 (level IV) studies with a total of 118 patients were included in this review. In 2 studies (46 patients), stenosis without instability was the indication for reoperation for ASD. However, extension of fusion was the modality of choice for the treatment of ASD in all studies. Overall clinical improvement (in back and/or leg pain scores) was noted in 71.3% of patients (95% confidence interval, 37.4-100), while radiographic fusion was noted in 89.3% of patients (95% confidence interval, 51.2-100). Following reoperation for ASD, revision surgery rates ranged from 4.5% to 23.1% at last clinical follow-up. There is variability in the clinical improvement following lumbar fusion for ASD. In addition, little literature exists regarding the optimal treatment options for patients with ASD for stenosis with or without instability. [Orthopedics. 201x; xx(x):xx-xx.]

Because the number of lumbar fusions performed in the United States has been increasing since the turn of the century, understanding the clinical outcomes and results associated with this procedure is important. Although short-segment lumbar fusions are associated with high union rates, adjacent segment disease (ASD; symptomatic adjacent segment pathology) is a common complication in the years following surgery.1,2 The surgical options for ASD can be a decompression alone vs an extension of fusion. Furthermore, there are several options to extend the fusion. Interestingly, the optimal surgical option has not been reported.

The exact cause of adjacent segment pathology is not known, but there are several explanations for it. The literature supports an increase in load bearing and pressure in adjacent segments along with increased mobility as being responsible for degenera-
The dissection of the paraspinal muscles during surgery has been mentioned as a possible cause. Some authors contend that the natural process of disk degeneration contributes to adjacent segment pathology and there is an inherent predisposition for adjacent segment pathology at the adjacent disks prior to surgery. The frequency of ASD development among patients who undergo lumbar fusion has varied widely, ranging from 5% to 77%. Lehmann et al. reported findings from a median follow-up of 33 years. Forty-two percent of patients developed adjacent segment stenosis and 45% presented with adjacent segment instability on radiographic evaluation. This study showed that not all adjacent segment pathology will become symptomatic.

Due to the high incidence of long-term degeneration following a lumbar fusion, insight into the effectiveness of reoperation is imperative. Furthermore, insight into the most effective surgical treatment for ASD is important. Finally, it is important to subdivide ASD into adjacent segment stenosis and adjacent level instability to determine if a decompression alone vs an extension of fusion is necessary. The purpose of this review was to determine the overall outcomes of surgical intervention for ASD following lumbar fusion regarding both decompression alone and extension of the spinal fusion to the adjacent level.

**Materials and Methods**

**Search Strategy**

A review of the literature was performed to identify studies that reported on ASD after lumbar fusions. The PubMed, SCOPUS, EMBASE, CINAHL, and Web-of-Science databases were independently searched by 2 of the authors (R.M.A., S.P.) to identify all relevant reports of patients undergoing lumbar spine surgery. The search terms used were “adjacent segment disease,” “adjacent segment degeneration,” “adjacent segment pathology,” and “lumbar fusion.” Only English-language full-text manuscripts or abstracts that had quantified outcomes were reviewed. All study designs were included in the search query. Following review of all relevant reports, the references of articles selected for review were further assessed to identify studies that were not captured by the initial database search.

**Selection of Studies**

Studies, regardless of the level of evidence, on ASD related to a lumbar fusion and studies with reported follow-up were included. Case reports, studies with less than 6 months of follow-up, studies not in English, and studies not about the lumbar spine were excluded.

**Data Extraction**

Two of the authors (R.M.A., S.P.) reviewed and extracted data from the included studies. Disagreements were
resolved when a consensus was reached between the 2 authors. The following variables were extracted from each study: average interval between the index surgery and the reoperation for ASD, clinical and radiographic success rates, leg pain scores, back pain scores, and revision rate following surgical treatment of ASD. The primary outcome measures used were radiographic and clinical success rates.

Assessment of Level of Evidence and Methodological Quality of the Studies

Two authors (A.S., S.P.) performed a quality assessment of all studies included in the final analysis. Level of evidence ratings were assigned to each study using criteria set by the Journal of Bone and Joint Surgery for therapeutic studies (Table 1).12 Quality assessment of all of the selected reports was conducted by using the 12-point Methodological Index for Nonrandomized Studies (MINORS) criteria (Table 1). These criteria have been previously reported to have high test–retest reliability, external and internal validity, and interobserver reliability.13-15 The risk of bias was assessed using a modified 5-point assessment score of the Cochrane Back Review Group tool for noncomparative studies as previously described (Table 2).16 Inconsistencies in methodologic quality assessment were reconciled through discussion with a third author (A.D.).

Data Analysis

The data were analyzed using the random effects model with inverse variance weighting. Meta-analyses and forest plots were constructed as described by Neyeloff et al.17 Summary effects and 95% confidence intervals (CIs) were the primary summary measures. Individual studies were compared via 95% CIs and forest plots. Meta-analysis was completed to determine the success rates for reoperation following ASD, as determined by clinical and radiographic outcomes. Rates of success were determined by dividing the number of patients noted with successful outcomes by the total patient cohort size in each study. Heterogeneity was evaluated between individual studies with a Q statistic and a $I^2$ value for each meta-analysis. $I^2$ heterogeneity less than 25% generally indicates consistent results and homogeneous studies, 25% to 75% indicates moderate heterogeneity, and greater than 75% indicates severe heterogeneity, as reported by DeLong et al.18

### RESULTS

#### Studies

The search yielded 662 studies, of which 657 were excluded. A total of 5 (level IV) studies with a total of 118 patients were included in this review (Figure). Characteristics for each of the 5 studies are listed in Table 3. Indications for surgery for ASD included stenosis in 3 studies,19-21 instability in 1 study,22 and stenosis or instability in 1 study.23 The surgical treatments for ASD included minimally invasive lateral fusion,19 decompression and posterior lumbar interbody fusion,20 decompression and posterolateral lumbar fusion,21,22 and decompression with instrumented and noninstrumented posterolateral lumbar fusion.23

Three studies reported on the average interval between initial fusion and surgical treatment for ASD, which was 8.2 years (range, 5.2-11.5 years).21-23 All of the studies reported on success rates following reoperation, both clinically and radiographically, and 4 of the studies reported revision rates following surgical treatment of ASD.19-22

#### Quality Assessment of Included Studies

All studies were published as level IV evidence (Table 1). The MINORS scores

<table>
<thead>
<tr>
<th>Study (Year)</th>
<th>Patient Selection/Inclusion Described</th>
<th>Dropout Rate Described</th>
<th>Independent Assessor</th>
<th>Co-interventions Described</th>
<th>Timing of Outcome Assessment Similar</th>
<th>Total</th>
<th>Risk of Bias</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wang et al (2014)</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>Low</td>
</tr>
<tr>
<td>Miwa et al (2013)</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>Low</td>
</tr>
<tr>
<td>Phillips et al (2000)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>Low</td>
</tr>
<tr>
<td>Chen et al (2001)</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>Low</td>
</tr>
<tr>
<td>Whitecloud et al (1994)</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>Low</td>
</tr>
</tbody>
</table>

*The items are scored 0 (no or unclear) or 1 (yes).
of the studies ranged from 7 to 11 (mean, 8.4; SD, 1.52) (Table 1). All studies included in this review were of low methodologic quality but had low risk of bias (Table 2).

Demographics
There were a total of 118 patients included across all 5 studies. Patients' average age was 61 years. Forty-three (36.4%) of the patients treated for ASD were male, while 75 (73.4%) were female (Table 3).

Clinical and Radiographic Outcomes
The method of determining radiographic success, defined as radiographic fusion, was not described in 4 studies. Only 1 study mentioned the method used to assess fusion, which was by computed tomography scan. Overall radiographic success was 89.3% (95% CI, 51.2-100), while overall clinical success was 71.3% (95% CI, 37.4-100) (Table 4).

Pain Differences and Japanese Orthopedic Association Scores
Wang et al reported the preoperative and postoperative back and leg pain, with noticeable decreases evident following reoperation. The study by Miwa et al was the only one to provide Japanese Orthopedic Association scores, with mean values of 7.7 and 11.4 preoperatively and postoperatively, respectively. At final follow-up, the mean Japanese Orthopedic Association score had declined to 10.2. Chen et al reported that back soreness was common in the patient cohort, although lower back pain showed general improvement. Phillips et al divided their respective patient cohort into success (n=15) and failure (n=11) groups, with significantly higher back and leg pain being reported for the failure group. Specifically, the success and failure groups reported 3.1 vs 7.6 (P=.001) for low back pain and 2.8 vs 4.6 (P=.09) for leg pain, respectively. The strongest predictive factor for a poor outcome in that study was ongoing postoperative lower back pain, followed by decreased ability to perform daily activities.

Reoperation Following Surgical Treatment for ASD
Reoperation following the surgical treatment for ASD varied among the 4 studies that reported this metric. Rates of 4.5%, 5.1%, 16.7%, and 23.1% were reported at the last clinical follow-up (Table 4).

Discussion
Adjacent segment disease is prevalent among patients who undergo lumbar fusion. Given the reported incidence of approximately 2% to 3% annually, it is imperative to understand the best treatment option for ASD. However, the literature is limited regarding successful treatment options for the various types of ASD (ie, adjacent level instability or adjacent level stenosis). To the authors’ knowledge, no previous review has been performed regarding surgical treatment of ASD after lumbar fusion.
fusion. In the current study, the authors included 5 studies involving 118 patients undergoing reoperation following a lumbar spine fusion. They found a wide range of results regarding success rates for reoperation following lumbar fusion across the 5 studies. However, the available data did support general decreased lower back pain following reoperation. There are several potential reasons why the current study did not find consensus within the literature. First, there were few published studies on which to base this review. Second, the studies spanned different decades in terms of the data collected. Finally, each study had a different definition for ASD and subsequently addressed ASD with different surgical procedures.

### Table 3

**Patient Demographics and Characteristics of the 5 Studies**

<table>
<thead>
<tr>
<th>Study</th>
<th>Study Period</th>
<th>No. of Patients</th>
<th>Male/Female</th>
<th>Mean Age, y</th>
<th>Interval Between Index Surgery and Reoperation, Mean, y</th>
<th>Indication for ASD Surgery</th>
<th>Surgical Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wang et al^19</td>
<td>Published 2014</td>
<td>21</td>
<td>57.1%/42.9%</td>
<td>61</td>
<td>-</td>
<td>Adjacent segment stenosis and spondylosis failing conservative measures</td>
<td>Minimally invasive lateral interbody fusion</td>
</tr>
<tr>
<td>Miwa et al^20</td>
<td>2005-2009</td>
<td>18</td>
<td>33.3%/66.7%</td>
<td>71</td>
<td>-</td>
<td>Neurologic symptoms compatible with lesions in the adjacent motor segment</td>
<td>Posterior lumbar interbody fusion with instrumentation</td>
</tr>
<tr>
<td>Phillips et al^21</td>
<td>1980-1992</td>
<td>26</td>
<td>34.6%/65.4%</td>
<td>57</td>
<td>7.8</td>
<td>Spinal stenosis</td>
<td>Surgical decompression and extension of the posterolateral fusion</td>
</tr>
<tr>
<td>Chen et al^22</td>
<td>1990-1997</td>
<td>39</td>
<td>23.1%/76.9%</td>
<td>61</td>
<td>5.2</td>
<td>Adjacent instability</td>
<td>Autogenous posterolateral arthrodesis with transpedicle screw fixation and decompressive laminectomy</td>
</tr>
<tr>
<td>Whitecloud et al^23</td>
<td>1985-1989</td>
<td>14</td>
<td>50.0%/50.0%</td>
<td>52</td>
<td>11.5</td>
<td>Degenerative spinal or lateral recess stenosis or segmental instability</td>
<td>Fusion with instrumentation (n=9) Uninstrumented fusion (n=5)</td>
</tr>
</tbody>
</table>

Abbreviation: ASD, adjacent segment disease.

### Table 4

**Clinical and Radiographic Outcomes of the 5 Studies Following the Surgical Treatment of ASD**

<table>
<thead>
<tr>
<th>Study</th>
<th>JOA Score Improvement</th>
<th>Clinical/Radiographic Success Rate</th>
<th>Revision Rate</th>
<th>Preoperative/Postoperative Back Pain Score</th>
<th>Preoperative/Postoperative Leg Pain Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wang et al^19</td>
<td>-</td>
<td>100%/100%</td>
<td>4.5%</td>
<td>7.5/2.9</td>
<td>6.3/1.9</td>
</tr>
<tr>
<td>Miwa et al^20</td>
<td>31.6%</td>
<td>94.4%/100%</td>
<td>16.7%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Phillips et al^21</td>
<td>-</td>
<td>57.6%/73.1%</td>
<td>23.1%</td>
<td>Overall decrease</td>
<td>Overall decrease</td>
</tr>
<tr>
<td>Chen et al^22</td>
<td>-</td>
<td>76.9%/94.9%</td>
<td>5.1%</td>
<td>Overall decrease</td>
<td>-</td>
</tr>
<tr>
<td>Whitecloud et al^23</td>
<td>-</td>
<td>28.6%/78.6%</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Abbreviations: ASD, adjacent segment disease; JOA, Japanese Orthopedic Association.
Across all studies, it was clear that radiographic outcomes were not representative of symptomatic outcomes for patients following reoperation. In all studies, radiographic outcomes were at best equal to clinical outcomes, with the largest disparity between the two measured at 50% by Whitecloud et al. However, overall success rates did improve with time, likely because improved surgical techniques and technology became available.

The study performed by Wang et al had the most promising data for surgical treatment of ASD, which may be related to their providing a minimally invasive surgical treatment to their patient cohort. Their results may also be attributable to a stricter definition of ASD as stenosis or spondylosis only after failure of conservative measures. Further, because the lack of follow-up data beyond 2 years could also account for the positive results, a study that extends follow-up would be beneficial.

To date, there is no consensus on which symptoms warrant reoperation and which procedure best addresses ASD following lumbar fusion. Regarding the 5 studies, each provided different descriptions of what conditions constitute ASD and thus require surgical intervention. Adjacent segment disease is an overarching general term to describe symptomatic changes to the adjacent level following lumbar fusions; however, different presentations of ASD may or may not improve with revision surgery.

Given their review of the literature regarding treatment options for ASD, the authors believe that a prospective study analyzing different treatment options for reoperation following a lumbar fusion is needed. A clear definition of and classification system for ASD are necessary to allow continuity and consensus in future studies. A treatment-based classification has been proposed (Table 5). It is possible, in types of ASD without stenosis or instability, that noninvasive treatment options will have better long-term outcomes than revision surgery. Similarly, other types of ASD may have improved outcomes with revision surgery (eg, laminectomy only in the presence of adjacent segment stenosis without instability).

**Limitations**

This systematic review had some limitations. The main limitation involved the lack of literature (only 5 studies) on which to base this analysis. Furthermore, none of the included studies were randomized controlled trials or comparative studies with high levels of evidence. Also, the data were heterogeneous due to the different methods of diagnosing and treating ASD used in the studies. Because the reporting methodologies were not unified, the generalizability of the results is limited.

**Conclusion**

Variability exists in the clinical results following lumbar fusion for ASD. Literature is lacking regarding the optimal treatment options for patients with ASD for stenosis with or without instability. This study highlights the clear need for a comprehensive randomized controlled trial using strict definitions and criteria for treatment to determine the most effective treatment options for ASD in the lumbar spine.

**Table 5**

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>ASD without stenosis or instability</td>
</tr>
<tr>
<td>II</td>
<td>ASD with stenosis alone, no instability</td>
</tr>
<tr>
<td>III</td>
<td>ASD with instability alone, no stenosis</td>
</tr>
<tr>
<td>IV</td>
<td>ASD with both stenosis and instability</td>
</tr>
</tbody>
</table>

*Abbreviation: ASD, adjacent segment disease.*

**References**


14. Khan M, Adamich J, Simunovic N, Philippon MJ, Bhandari M, Ayeni OR. Surgical man-


