Comparison of anterior- and posterior-approach instrumented lumbar interbody fusion for spondylolisthesis

JUN-HONG MIN, M.D., PH.D.,¹ JEE-SOO JANG, M.D., PH.D.,¹ AND SANG-HO LEE, M.D., PH.D.²

¹Department of Neurosurgery, Gimpo Airport Wooridul Spine Hospital; and ²Department of Neurosurgery, Wooridul Spine Hospital, Seoul, Korea

Object. The purpose of this study was to compare the imaging and clinical outcomes obtained in patients with lumbar spondylolisthesis who have undergone either instrumented anterior lumbar interbody fusion (ALIF) or instrumented posterior LIF (PLIF), especially with regard to the development of adjacent-segment degeneration (ASD).

Methods. Forty-eight patients with preoperative spondylolisthesis and minimal ASD who underwent instrumented L4–5 fusion were divided into two groups according to the surgical approach. After ensuring the two groups’ comparability, the following variables were evaluated: postoperative segmental and lumbar lordosis, postoperative percentage of vertebral slippage, reduction rate, incidence of ASD, and clinical outcomes.

Results. Adjacent-segment degeneration was found in 44.0% of the patients in the ALIF group and in 82.6% of those in the PLIF group (p = 0.008). Clinical success rates were 92.0 and 87.0% in the ALIF and PLIF groups, respectively. There were no statistically significant intergroup differences in the postoperative segmental and lumbar lordosis, postoperative percentage of slippage, reduction rate, Japanese Orthopaedic Association score, and success rate.

Conclusions. Both ALIF and PLIF can produce good outcomes in treating lumbar spondylolisthesis, but ALIF is more advantageous in preventing the development of ASD. (DOI: 10.3171/SPI-07/07/021)

Keywords • adjacent-segment degeneration • anterior lumbar interbody fusion • posterior lumbar interbody fusion • spondylolisthesis
osis. If the patient’s primary symptom was back pain and neural compression was not severe, an ALIF was the preferred operation, whereas if the patient’s primary symptom was neurological and stenosis was severe, a PLIF was the preferred operation. Because most patients, however, had both mechanical and neurological symptoms, the surgeon’s preference and familiarity with a given approach played a decisive role in which operation was selected. To ensure that characteristics in the two groups were comparable, the following intergroup variables were examined: basic demographic data, body weight, body height, body mass index, bone mineral density, follow-up duration, preoperative segmental and lumbar lordosis, preoperative percentage of vertebral slippage, preoperative diameter spinal canal, and preoperative JOA score.

Radiological and Imaging Evaluation

Adjacent-segment degeneration was defined as imaging evidence of one or more of the following lesions adjacent to a fused segment, which was not present preoperatively: 1) disc degeneration such as loss of disc height of more than 10%; 2) some form of listhesis (anterolisthesis, retrolisthesis) greater than 4 mm; 3) angle change greater than 10° between adjacent vertebral bodies on flexion and extension radiographs; 4) occurrence of symptomatic disc herniation or spinal stenosis confirmed by CT or MR imaging; 5) hypertrophic facet joint arthropathy; 6) osteophyte greater than 3 mm; 7) spondylolisthesis; and 8) compression fracture. The aforementioned degenerative changes were identified by analyzing MR images, CT scans, and radiographs. Patients in whom these changes were demonstrated preoperatively at the adjacent segment were excluded from this study to simplify the study, to focus on the effect of fusion itself, and to reduce the effect of natural degenerative process.

To investigate the changes in lordosis, the Cobb angle was evaluated on pre- and postoperative standing lateral radiographs. Preoperative and postoperative segmental lordosis and lumbar lordosis were measured, and the differences in these variables between the pre- and postoperative periods were determined.

The percentage of vertebral slippage was determined by assessing pre- and postoperative standing lateral x-ray films, and the rate of reduction was calculated.

Union was defined as the presence of trabecular osseous continuity and/or less than 4° mobility between the segments on a flexion and extension radiograph or CT scan. Nonunion was defined as bilateral presence of a visible gap, graft collapse, and motion greater than 4° on the motion study.

Clinical Evaluation

The JOA evaluation system for measuring low-back pain syndrome (Table 1) was used to assess the outcome of subjective symptoms and clinical signs. We determined JOA scores preoperatively, 2 to 3 months postoperatively, 1 year postoperatively, and at the final follow-up examination. The recovery rate was determined, based on final JOA score, with the standard formula. Using this recovery rate, the surgical outcome was rated as excellent (100–75%), good (74–50%), fair (49–25%), unchanged (24–0%), and deteriorated (< 0%).

Surgical Methods

Posterior LIF. In the PLIF, a standard midline exposure was undertaken. Under the microscope, bilateral laminotomies with partial or complete facetectomies and foraminotomies were performed for decompression and to allow insertion of the interbody devices. After these procedures, pedicle screws were inserted through the wound under fluoroscopic guidance.

Anterior LIF. In the ALIF, a retroperitoneal approach was undertaken through a paramedian incision made by a general or vascular surgeon. After removing the disc material and posterior anulus fibrosus, decompression was confirmed by probing the foramen and anterior aspect of the spinal canal. The same interbody devices used for the PLIF were inserted in the ALIF procedure because large, wedge-shaped lordotic cages were not available at that time. After performing ALIF, pedicle screws were inserted percutaneously under fluoroscopic guidance. This percutaneous approach corresponded to the open transmuscular one described by Wiltse and Spencer. Separate posterior decompression was not performed, except in one patient who underwent bilateral decompressive laminotomy to treat severe stenosis.

Statistical Analysis

All of the statistical analyses were processed on a personal computer running commercially available software (SPSS, Inc.). Depending on the characteristics of the variables being compared, various tests were used. A probabili-
ity value of less than or equal to 0.05 was considered to indicate statistical significance. Mean data are presented ± the SDs.

**Results**

Group I (ALIF treatment) and Group II (PLIF treatment) included 25 and 23 patients, respectively. Table 2 provides a summary of the basic data. There were no statistically significant intergroup differences in the basic data.

**Adjacent-Segment Degeneration**

Adjacent-segment degeneration was found in 11 Group I patients (44.0%) and 19 Group II patients (82.6%). The radiographs shown in Figs. 1 and 2 are examples of ASD in both groups. There was a statistically significant intergroup difference in the rate of ASD development (p = 0.008). The ASD was mostly located at the cranial segment of the fused level in both groups. In Group I, ASD was found in eight patients (72.7%) at the cranial segment, in one patient at the caudal segment, and in two patients at both segments. In Group II, ASD was found in 17 patients (89.5%) at the cranial segment, in one patient at the caudal segment, and in one patient at both segments. The most common type of the ASD in both groups was angular instability. In ALIF-treated patients, angular instability was present in all cases, although in some simultaneous listhesis or stenosis was also noted. In PLIF-treated patients, angular instability was documented in 16 of 19 cases, although in some listhesis was also noted. The remainder of the patients had retrolisthesis or stenosis.

The mean postoperative periods required for the identification of ASD were 44.5 ± 16.1 months and 34.5 ± 13.0 months in Groups I and II, respectively (p = 0.1045). Reoperations for ASD were performed in two Group II patients (6.7%). Decompressive laminotomies were performed for spinal stenosis.

**Neuroimaging Evaluation**

Table 3 provides a summary of the postoperative imaging data. There was no statistically significant intergroup
difference in the data associated with lordosis. In particular, the mean differences in the degree of pre- and postoperative lumbar lordosis were negative values in both groups. With regard to percentage of VB slippage, the mean rate of reduction appeared to be higher in the ALIF group, although there was no statistically significant intergroup difference (p = 0.4038).

In all patients radiography and MR imaging revealed osseous union.

Clinical Evaluation

Table 4 provides a summary of the clinical outcomes in both treatment groups. There was a statistically significant intergroup difference in the JOA score at 2 to 3 months postoperatively (p = 0.0023). Group I had a slightly better score.

In Group I we observed four complications (16.0%), including two cases of anhydrosis on the unilateral foot caused by sympathetic dysfunction, one case of wound infection, and one case of an incisional hernia. We found no significant complications in Group II. There was a statistically significant intergroup difference in the rate of complications (p = 0.029), with a higher rate in Group I.

In Group I the outcome was considered excellent in 16 patients (64.0%), good in seven (28.0%), and fair in two
Anterior and posterior LIF for spondylolisthesis

**Discussion**

The purpose of this study was to compare the imaging and clinical outcomes obtained in patients who had undergone instrumented ALIF or instrumented PLIF for lumbar spondylolisthesis, especially with regard to the development of ASD. Analysis of the results indicates that both imaging and clinical outcomes were generally good and that both procedures yielded similar results except for several outcome parameters: 1) the development of ASD was more prevalent in the PLIF group, although it did not necessarily correlate with a poor outcome; 2) JOA scores at 2 to 3 months postoperatively were somewhat better in the ALIF group; and 3) the minor complications were more prevalent in the ALIF group.

In the present study, imaging-documented ASD was found in 44.0% of patients in Group I (ALIF-treated) patients and in 82.6% in Group II (PLIF-treated) patients. Reported rates for various surgical approaches based on the aforedescribed imaging criteria vary from 8 to 100%. Also variable are the reported rates of ASD developing after ALIF and PLIF. The rates for ALIF range from 32 to 100%, whereas those for PLIF range from 31 to 100%. The results of the present study correspond relatively well with those reported in earlier studies, but the rate of post-PLIF ASD in our study was very high. To the best of our knowledge, there have been no reports of a comparative analysis of ALIF and PLIF with regard to postoperative ASD.

Many risk factors for ASD have been suggested, although they remain controversial. Posterior LIF itself is one of the operative approaches that is assumed to be a risk factor for ASD. In the present study, a separate posterior decompression was not performed in patients undergoing ALIF; except in one case in which bilateral decompressive laminotomy was conducted to treat spinal stenosis. In addition, pedicle screws were inserted percutaneously. This result suggests that ALIF may reduce damage to the integrity of the posterior complex, which is known to be an important risk factor for ASD. This fact may explain the different rates of ASD in our ALIF and PLIF treatment groups, but the actual reoperation rate in cases of ASD was low regardless of the very high rate of ASD. This means that imaging evidence of ASD does not necessarily correlate with a poor outcome, as several authors have asserted.

In addition, the aforementioned results may be supported by the findings that patients in the PLIF group with a higher rate of ASD did not experience poorer clinical outcomes than those in the ALIF group.

With regard to the radiological and neuroimaging evaluation, there were no statistically significant intergroup differences in lordotic changes. In particular, in both groups the mean difference in pre- and postoperative lumbar lordosis was represented by a negative value. This finding may be interpreted as operative failure to restore the preoperative standing lumbar lordosis, even in ALIF-treated patients. Originally, the advantages of ALIF were thought to include the ease with which it could restore normal lordosis and correct the spinal malalignment. We think that this discordance with ALIF may in part be caused by the interbody devices. At the time in our study when patients underwent ALIF, the large, wedge-shaped lordotic cages currently used were not available. Rather, the ordinary parallel double cages used in PLIF were also applied in ALIF. At present, large, wedge-shaped lordotic cages specifically designed for ALIF are used at our institution. Thus, we believe that the aforementioned results concerning lordosis may change.

Several authors have proposed the importance of postoperative sagittal alignment associated with ASD. Umehara and colleagues have indicated that postoperative hypolordosis in the instrumented segment may cause increased loads across the instrumentation and increased posterior-element stress at the adjacent segment. Oda and associates have reported that maintenance of physiological alignment in spinal fusion may minimize the acceleration of ASD. These authors, however, could not demonstrate clinical evidence to support this view. In the present study we found that neither surgical approach could reproduce the degree of preoperative lumbar lordosis, but we could not prove the exact relationship between the lumbar lordo-

---

**TABLE 3**

Summary of the radiological and imaging data obtained in patients who underwent ALIF (Group I) and PLIF (Group II)*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group I (25 cases)</th>
<th>Group II (23 cases)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>rate of ASD (%)</td>
<td>44.0</td>
<td>82.6</td>
<td>0.008</td>
</tr>
<tr>
<td>mean duration to identify ASD (mos)</td>
<td>44.5 ± 18.0</td>
<td>34.5 ± 13.8</td>
<td>0.1045</td>
</tr>
<tr>
<td>sagittal angle (°)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean postop SL</td>
<td>17.7 ± 5.7</td>
<td>15.1 ± 5.5</td>
<td>0.1268</td>
</tr>
<tr>
<td>mean postop LL</td>
<td>42.3 ± 10.2</td>
<td>37.3 ± 8.5</td>
<td>0.0744</td>
</tr>
<tr>
<td>mean SL (postop – preop SL)</td>
<td>1.8 ± 4.9</td>
<td>1.6 ± 6.1</td>
<td>0.8976</td>
</tr>
<tr>
<td>mean LL (postop – preop LL)</td>
<td>−3.6 ± 9.1</td>
<td>−3.2 ± 13.5</td>
<td>0.5800</td>
</tr>
<tr>
<td>mean postop slippage rate (%)</td>
<td>6.8 ± 4.0</td>
<td>7.2 ± 3.4</td>
<td>0.6878</td>
</tr>
<tr>
<td>mean rate of reduction (%)</td>
<td>65.6 ± 22.9</td>
<td>59.1 ± 30.0</td>
<td>0.4038</td>
</tr>
<tr>
<td>union rate (%)</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

* Mean values are presented ± SDs. Abbreviations: LL = lumbar lordosis; SL = segmental lordosis.

---

**TABLE 4**

Summary of the clinical outcomes in patients who underwent ALIF (Group I) and PLIF (Group II)*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group I (25 cases)</th>
<th>Group II (23 cases)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>mean postop JOA score 2–3 mos</td>
<td>13.7 ± 0.6</td>
<td>12.8 ± 1.1</td>
<td>0.0023</td>
</tr>
<tr>
<td>1 yr</td>
<td>13.6 ± 1.3</td>
<td>13.6 ± 1.0</td>
<td>0.6247</td>
</tr>
<tr>
<td>final follow-up</td>
<td>13.6 ± 0.8</td>
<td>13.4 ± 1.1</td>
<td>0.5977</td>
</tr>
<tr>
<td>mean recovery rate (%)†</td>
<td>73.4 ± 17.1</td>
<td>65.0 ± 36.2</td>
<td>0.6638</td>
</tr>
<tr>
<td>success rate (%)</td>
<td>92.0</td>
<td>87.0</td>
<td>0.651</td>
</tr>
<tr>
<td>complication rate (%)</td>
<td>16.0</td>
<td>0.0</td>
<td>0.029</td>
</tr>
</tbody>
</table>

† Recovery rate % = \( \frac{\text{postop score} - \text{preop score}}{\text{1 yr} - \text{preop score}} \times 100. \)
sis and ASD, as there were no statistically significant intergroup differences in lordotic changes. In future studies this subject will need to be addressed.

The rate of reduction appeared higher in the ALIF treatment group than in the PLIF group, although there was no statistically significant intergroup difference. There have been no reported reduction rates associated with ALIF. The reported rates for posterolateral lumbar fusion and PLIF range from 34.6 to 62.9%. The results of the current study correspond well with those in the three aforementioned studies.

The clinical outcomes in our study also correspond well to those reported in earlier studies. The success rates have ranged from 74 to 100% for ALIF and PLIF. The authors of a comparative study of ALIF and PLIF for discogenic back pain indicated that both approaches afforded reliable treatment. In the case of spondylolisthesis, the procedures were also a reliable form of treatment in the current study. Patients who underwent ALIF, however, may experience a somewhat better outcome during the early postoperative period, as indicated by JOA scores in the early follow-up period in our study.

With regard to complications, the results of the present study corresponded well with those of earlier studies. In a study by Scaduto and coworkers, the overall complication rates were 14 and 41% for ALIF and PLIF, respectively, but minor postoperative complications were more prevalent in the ALIF group. In the present study, most of the complications were minor.

Conclusions

Both ALIF and PLIF can yield good outcomes in patients with lumbar spondylolisthesis, but ALIF is associated with better prevention of ASD.

References


Address reprint requests to: Jee-Soo Jang, M.D., Ph.D., Department of Neurosurgery, Gimpo Airport Wooridul Spine Hospital, 272-28, Gwahae-Dong, Gangseo-Gu, Seoul 157-822, Korea. email: spinejjs@yahoo.co.kr.