Clinical analysis of percutaneous facet screw fixation after anterior lumbar interbody fusion

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Object. The authors performed a retrospective study to evaluate the results of percutaneous facet screw fixation (PFSF) after anterior lumbar interbody fusion (ALIF) in comparison with the gold standard, post-ALIF pedicle screw fixation (PSF).

Methods. Of 84 patients treated for degenerative spondylolisthesis or degenerative disc disease at the authors’ institution, 44 underwent PFSF (Group 1) and 40 underwent PSF (Group 2 [control population]) after ALIF. Function was assessed using the Oswestry Disability Index (ODI) scoring system, and outcome was measured using the Macnab criteria. At 3, 6, 12, and 24 months after surgery, dynamic lateral (flexion-extension) radiography and computerized tomography scanning were conducted to evaluate the osseous union status. After a minimum follow-up period of 2 years, analysis showed no intergroup statistical difference in terms of ODI score and Macnab outcome criteria (p > 0.05).

Excellent or good outcome was obtained in 40 (90.9%) of the 44 patients in Group 1 and 37 (92.5%) of the 40 patients in the control Group 2 (p > 0.05). No patient required a blood transfusion in either group. At 24 months after surgery fusion rates were 95.8% in Group 1 and 97.5% in Group 2.

Conclusions. The results of PFSF following ALIF appear to be clinically equivalent to those achieved after PSF, and the procedure represents a safe and minimally invasive modality with which to achieve solid fusion in the lumbar spine.

Key Words: • anterior lumbar interbody fusion • percutaneous facet screw fixation • pedicle screw fixation

The potential advantages of ALIF include the avoidance of epidural scarring, the preservation of posterior spinal elements, and the diminished risk of neural injury; however, concerns have been expressed regarding the low fusion rate observed when ALIF is conducted as a stand-alone procedure. The authors of several biomechanical studies have shown that anterior cage-augmented stabilization alone does not ensure solid fixation, especially in the directions of extension and axial rotation.\(^6,19,20\) Supplementary posterior fixation is needed to promote solid fixation, such as that obtained with translaminar or pedicle screws after ALIF. Pedicle screw fixation has been the most popular method of stabilization since the late 1980s; however, the chances of screw malpositioning, with the potential risk of neurological and vascular injury and suboptimal fixation, has been reported in the literature.\(^2,4,8,16,24\) Moreover, extensive paraspinous muscle injury arising from pedicle screw insertion can lead to an increased incidence of infection and other related complications. The availability of a less invasive and equally efficacious method of fixation would be of great interest to spine surgeons. The authors of several biomechanical studies have shown that facet screws may be useful for stabilizing segments after ALIF reconstruction.\(^5,20,22,23\) Therefore, in this study we present our clinical experience with PFSF in comparison with PSF after ALIF and evaluate the effects of PFSF.

Clinical Material and Methods

Patient Population

This study cohort consisted of 84 patients with degenerative spondylolisthesis or DDD. Of these 84 patients, degenerative spondylolisthesis and foraminal stenosis were diagnosed in 51 patients, and DDD, either alone or combined with foraminal stenosis, was diagnosed in 33 patients. Rather than collecting sequentially, they were collected simultaneously. Patients with lytic spondylolisthesis, osteoporosis, kyphotic deformity, and high-grade spondylolisthesis (> Grade 1) were excluded from both groups.

Fixation Procedures

Of the 84 patients, 44 underwent ALIF and PFSF (Group 1) and 40 underwent ALIF and PSF (Group 2 [control population]). The mean age of patients in Group 1 was 57.2 years (range 46–67 years) and that in Group 2 was 60.5 years (range 49–70 years). Group 1 was composed of 12 men and 32 women, whereas Group 2 com-
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TABLE 1
Summary of characteristics obtained in patients who underwent ALIF and PFSF or PSF

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>PFSF</th>
<th>PSF</th>
</tr>
</thead>
<tbody>
<tr>
<td>no. of cases</td>
<td>44</td>
<td>40</td>
</tr>
<tr>
<td>sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>F</td>
<td>32</td>
<td>29</td>
</tr>
<tr>
<td>mean age (yrs)</td>
<td>57.2</td>
<td>60.5</td>
</tr>
<tr>
<td>range</td>
<td>46-67</td>
<td>49-70</td>
</tr>
<tr>
<td>level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L4–5</td>
<td>29</td>
<td>24</td>
</tr>
<tr>
<td>L5–S1</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>L4–S1</td>
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<td>L3–S1</td>
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</table>

The main symptom was low-back pain that radiated to the lower extremities. In 28 of the 84 patients back pain was solely the result of painful DDD or instability. The anterior approach was performed by a single surgeon specializing in abdominal procedures. The posterior approach in both Groups 1 and 2 was performed by a single spine surgeon. Anterior lumbar interbody fusion and posterior procedures (facet and PSF) were performed during the same anesthesia session. The operative time for the posterior procedures was documented and compared between the groups.

Surgical Technique

In all cases an open minimal ALIF was performed using cages (Ostapek, Co-Ligne AG, Zurich, Switzerland; or OIC, Stryker, Cestas, France) filled with the allograft and autograft. In Group 1, following ALIF C-arm–guided facet screws were inserted percutaneously with the patient in the prone position. Preoperatively, we calculated the lamina angle and distance from the midline for the entry point of the facet screw on the axial magnetic resonance images (Fig. 1).

The ideal screw direction is from the base of the spinous process to the lateral margin of the midpedicle. The guide needle was inserted by calculating the lamina angle from the skin entry point until the tip reached the base of the spinous process cortex on the contralateral side. After confirmation of the ideal position for the guide needle on anteroposterior and lateral C-arm fluoroscopy, a pilot hole

Fig. 1. Axial magnetic resonance image on which the laminar angle and distance from the midline for the entry point of the facet screw are calculated.
was drilled to penetrate from the cortex at the base of the contralateral spinous process base to the lateral margin of the midpedicle; during continuous C-arm fluoroscopic guidance a K-wire was passed through the 14-gauge guide needle (Fig. 2). Care was taken that the K-wire did not penetrate the spinal canal. After confirmation of the ideal position of the K-wire (Fig. 3 upper left and right), a cannulated screw was inserted along the K-wire. The mean length and diameter of the translaminar facet screw was 46 and 5 mm, respectively, those of the transfacet screw were 32 mm and 5 mm, respectively.

These 5-mm-diameter partially threaded cannulated screws (Ace Medical, Inc., Waipahu, HI) utilize hollow instruments that were sequentially placed over the K-wire. The screw length was determined from the depth markers on the K-wire. The selected cannulated screw was inserted over the K-wire until the screw head reached the cortex of the contralateral spinous process, as observed on the continuous fluoroscopy monitor. An identical procedure was performed on the contralateral side at a slightly different position and angle to avoid any contact between the two screws (Fig. 3 lower left and right). In five patients only one translaminar facet screw was placed because the lamina was deficient due to previous laminotomy (Fig. 4). In two patients one translaminar facet screw and one direct transfacet screw were placed toward the pedicle because of a technical problem involving a previously placed translaminar facet screw that interfered with the insertion of an additional screw. In three cases, we performed transfacet pedicle screw fixation at L5–S1 (Fig. 5). Following the placement of the screws, CT scanning was con-
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In Group 2, a 3-cm longitudinal bilateral skin incision was made approximately 3 cm lateral to the midline at the proper site of incision (as confirmed with a needle and fluoroscopy). The multifundus and longissimus muscles were identified and dissected using the fingertips and scissors. The fingertip was used to identify the base of the transverse process and the lateral aspect of the facet joint. The pedicle screws were inserted and fixated under fluoroscopic guidance.

Radiological Evaluation

At 3, 6, 12, and 24 months after surgery, dynamic lateral flexion-extension radiography was performed. The minimum follow-up period was 24 months (mean 27.4 months, range 24–38 months).

Bone union was defined as solid when there was osseous trabecular continuity and the absence of motion between the fusion segments demonstrated on flexion-extension lateral radiography; nonunion was defined as a visible gap and angular motion on dynamic lateral radiography. When the osseous trabecular continuity was not clearly present or there was angular motion between the adjacent fused segments, the bone union was evaluated using CT reconstructions.

Outcome Evaluation

Before and after surgery, function was assessed using ODI scoring. Outcome was categorized using the Macnab criteria as excellent (no pain and no restriction of activity), good (occasional back or leg pain of sufficient severity to interfere with normal work or leisure), fair...
(handicapped by intermittent pain of sufficient severity to curtail work or leisure activity, but improved functional capacity), and poor (unimproved symptoms, insufficient improvement to allow increased activity, or requirement of reoperation at the same level). Clinical data were collected by a trained nurse employed at the hospital. Patients in whom outcome was categorized as excellent or good were regarded as being satisfied with the outcome. The data were analyzed using the Fisher exact test, paired t-test, chi-square test, and independent t-test to determine any statistical difference between the two groups. A probability value of less than 0.05 determined statistical significance.

Results

The minimum follow-up period in each group was 24 months. The mean follow-up period for Group 1 was 28 months (range 24–38 months), whereas that for Group 2 was 26 months (range 24–35 months).

There were nine (10.7%) of 84 cases of ALIF-related complication, of which four involved left iliac vein injury that was repaired, one case involved an incisional herniation that required operation, and two cases involved deep venous thrombosis resulting in lower-extremity edema. In two cases dural injury occurred during anterior decompression. All nine cases were successfully treated (Table 2). The mean operative time for posterior procedures was 18 minutes in Group 1 and 47 minutes in Group 2 (p < 0.05) (Table 2). In this study, there was no infection in any case in either group. In Group 1, all the screws purchased the facets and spinous processes. Nine of 81 screws did not purchase the laminas; however, no screws penetrated the spinal canal or injured the neural structures. No screw failure was noted at the last follow-up examination. In Group 2, no screws penetrated the spinal canal or injured the neural structures. No screw failure was noted at the last follow-up examination. No patient required a blood transfusion in either group.

In Group 1, subsidence of the cage was noted at four fusion sites. At one fusion site, radiography later revealed a collapsed nonunion (Fig. 7). Forty-six of 48 fusion sites exhibited osseous union. There was no hardware breakage in any patient. At the 24-month follow-up study, ODI scores were better in 43 of 44 patients than preoperatively. In Group 2, subsidence of the cage was noted at two fusion sites; these fusion sites showed later radiographically documented collapsed union. In Group 1, the fusion rate was 95.8% (46 of 48 levels), whereas in Group 2 it was 97.5% (39 of 40 levels) (p > 0.05). Reoperation was not performed in any cases of nonunion. The results were tolerable despite the nonunion.

There was an improvement in the function after surgery in both groups, according to the ODI. In Group 1, the mean ODI score improved from 68.4 before surgery to

<table>
<thead>
<tr>
<th>Complication</th>
<th>No. of Cases</th>
</tr>
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<tbody>
<tr>
<td>iliac vein injury</td>
<td>4</td>
</tr>
<tr>
<td>incisional herniation</td>
<td>1</td>
</tr>
<tr>
<td>dural injury</td>
<td>2</td>
</tr>
<tr>
<td>deep venous thrombosis</td>
<td>2</td>
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</tbody>
</table>

Table 2 Summary of postoperative complications related to ALIF in nine patients
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28.6 after surgery (p < 0.05). In Group 2, the mean ODI score improved from 64.8 before surgery to 32.2 after surgery (p < 0.05). There was no intergroup statistical difference in ODI scores (p > 0.05). Satisfactory outcome, defined as excellent or good according to the Macnab criteria, was achieved in 40 (90.9%) of the 44 patients in Group 1 and 37 (92.5%) of the 40 patients in Group 2. This difference was not statistically significant (p > 0.05) (Table 3).

Discussion

Anterior lumbar interbody fusion appears to have some advantages over posterior fusion in terms of the avoidance of epidural scarring, the preservation of the posterior spinal elements, and the diminished risk of neural injury.7 Additionally, ALIF enables indirect decompression of the nerve root due to widening of the intervertebral space. Biomechanically, however, stand-alone anterior struts, although ideal for maintaining load-bearing capacity and proper disc height, have proved to be insufficient for neutralizing axial rotational and extensional forces.9,17,20,21,23

In light of these results, supplementary posterior fixation is needed after ALIF such as that provided by translaminar or pedicle screws. Pedicle screw fixation is widely used for the internal stabilization of the lumbar spine. Significant iatrogenic muscle and soft-tissue injury, however, occurs during routine lumbar pedicle screw insertion, which can lead to an increased incidence of infection and other related complications.2,8,10–13,17,22 Holte, et al.,11 determined that the fusion rate obtained with a posterior translaminar screw fixation in cases involving ALIF in which a femoral ring allograft surrounds autologous bone was 98%, compared with 75% in cases in which transverse screw fixation was not added. The combination of the excellent anterior cage–induced stabilizing effect in terms of axial compression, flexion, and lateral bending, as well as that provided by translaminar facet screw fixation in extension and axial rotation, seems optimal from a biomechanical perspective. Transfacet fusion is facet fixation performed on the same side as the site of insertion, whereas translaminar facet screw fixation is performed contralateral to the site of insertion. The screw crosses through the lamina before it traverses the facet joint. Both the transfacet screw fixation and the translaminar facet screw fixation insertions lead to adequate stabilization for a highly successful spinal fusion. Several authors have found no significant difference in biomechanical performance between translaminar facet fixation and transfacet pedicle fixation when interbody spacers are used.1,6,15

At L4–5, the facet joint and the laminae are more sagittally oriented, whereas at L5–S1 they are more anteriorly oriented. Because of these anatomical characteristics, direct transfacet pedicle fixation may be easier than translaminar facet fixation at this level. We performed transfacet pedicle screw fixation at L5–S1 in three cases.

By adding transverse screws, Oxland, et al.,20 reported the successful neutralization of the aforementioned remaining instability. Translaminar screw fixation offers immediate postoperative lumbar and lumbosacral stability and also enhances fusion.11,10–13,17,22 Holte, et al.,11 determined that the fusion rate obtained with a posterior translaminar screw fixation in cases involving ALIF in which a femoral ring allograft surrounds autologous bone was 98%, compared with 75% in cases in which translaminar screw fixation was not added. The combination of the excellent anterior cage–induced stabilizing effect in terms of axial compression, flexion, and lateral bending, as well as that provided by translaminar facet screw fixation in extension and axial rotation, seems optimal from a biomechanical perspective. Transfacet fusion is facet fixation performed on the same side as the site of insertion, whereas translaminar facet screw fixation is performed contralateral to the site of insertion. The screw crosses through the lamina before it traverses the facet joint. Both the transfacet screw fixation and the translaminar facet screw fixation insertions lead to adequate stabilization for a highly successful spinal fusion. Several authors have found no significant difference in biomechanical performance between translaminar facet fixation and transfacet pedicle fixation when interbody spacers are used.1,6,15

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Conclusions

To conclude, PFSF following ALIF produced clinically equivalent results as PSF and represents a safe and minimally invasive procedure with which to achieve solid fusion in the lumbar spine. In cases of anterior column height restoration and lumbar fusion, the use of ALIF in conjunction with C-arm–guided PFSF enhances the fusion rate and minimizes the morbidity associated with this kind of combined surgery.

References


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