Degenerative Change in the Adjacent Segments to the Fusion Site after Posterolateral Lumbar Fusion with Pedicle Screw Instrumentation: A Minimum 4-Year Follow-up

Hayashi, Tetsuo  
Department of Orthopaedic Surgery, Kyushu Central Hospital

Arizono, Takeshi  
Department of Orthopaedic Surgery, Kyushu Central Hospital

Fujimoto, Toshihiro  
Department of Orthopaedic Surgery, Kyushu Central Hospital

Morooka, Takaaki  
Department of Orthopaedic Surgery, Kyushu Central Hospital

他

https://doi.org/10.15017/11872

バージョン: published
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Degenerative Change in the Adjacent Segments to the Fusion Site after Posterolateral Lumbar Fusion with Pedicle Screw Instrumentation —A Minimum 4-Year Follow-up—

Tetsuo Hayashi, Takeshi Arizono, Toshihiro Fujimoto, Takaaki Morooka, Junichi Shida, Shinichi Fukumoto and Sachio Masuda

Department of Orthopaedic Surgery, Kyushu Central Hospital, Fukuoka, Japan

Abstract Background. Controversy remains regarding the subsequent degeneration of adjacent segments, and little reliable information could be found in the literature regarding long-term clinical results and adjacent segment degeneration. The objective of this study is to investigate the degenerative change of adjacent segments to the fusion site and clinical outcome after posterolateral lumbar fusion with pedicle screw instrumentation and identify the risk factors in degenerative change at adjacent segments.

Methods. Thirty-two patients who underwent posterolateral lumbar fusion and were able to be followed over four years were evaluated in this study. The intervertebral disc height, percent of slip, lumbosacral joint angle, lumbar lordosis and disc angle were all examined. The postoperative progression of degeneration at adjacent segments were defined as more than a 50% narrowing in the adjacent disc height or more than a 5% slip in adjacent segments in comparison to the preoperative neutral lateral radiographs. The clinical results were assessed using an evaluation scores for lumbar lesions proposed by the Japanese Orthopedic Association.

Results. Fifteen (46.8%) of the 32 patients had adjacent segment degeneration including slip or narrowing. No significant correlation was found between the adjacent segment degeneration and the recovery rate at the final follow-up. In addition, no significant correlation was observed between the adjacent segment degeneration at the lastest follow-up and postoperative radiographic measurements.

Conclusions. The rate of radiographic degeneration at the adjacent segments was 46.8%. No significant correlation was found between degenerative change in the adjacent segments and the clinical results. We could not identify any preoperative radiographic factors which might have influenced the segments adjacent to the fusion.

Key words: pedicle screw instrumentation, posterolateral lumbar fusion, adjacent segment degeneration, long term result, risk factor

Introduction

Posterolateral lumbar fusion (PLF) with pedicle screw instrumentation is a useful procedure for a variety of pathologic conditions, however, several disadvantages related to lumbar fusion have also been reported. One of the reasons for such disadvantages seems to be the degenerative change of adjacent segments to the fusion site. Pedicle screw fixation has been used to increase the fusion rate, to correct deformities, and to provide early stabilization. Whereas PLF with pedicle screw fixation has shown satisfactory clinical results, a solid fusion has been reported to accelerate the occurrence of degenerative change.
at unfused adjacent levels due to increased stress and motion\textsuperscript{4\textendash}7. Although the development of adjacent segment degeneration can be considered part of the normal aging and degenerative process, this phenomenon appears to be at least partly influenced by the altered stresses that arise as a consequence of lumbar fusion. The findings of clinical reports of radiographic changes after lumbar fusion for degenerative disease support the view that fusion is associated with an increased incidence of degeneration at adjacent levels\textsuperscript{1\textendash}2. Biomechanical studies in normal human cadaveric spines also support this view\textsuperscript{8\textendash}9. Controversy also still remains regarding the subsequent degeneration of adjacent segments, however, little reliable information has been reported in the literature on the long-term clinical results and adjacent segment degeneration.

The objectives of the present study were to investigate the degenerative change in adjacent segments to the fusion site and the clinical outcome after PLF with pedicle screw instrumentation and to identify the risk factors in degenerative change at adjacent segments.

**Materials and methods**

Between June 1994 and June 1998, 32 patients who underwent PLF with pedicle screw instrumentation and were able to be followed over four years were evaluated in this study. A retrospective review of medical records, including hospital records, office charts and radiographs was performed at a single institute and the findings were analyzed by an independent observer (T.H.) to determine the demographic characteristics, symptoms, preoperative and postoperative diagnosis, surgical method and clinical results. Bony fusion was observed by using X-ray and the patients whose implants were loose were defined as nonunion. Of the 32 patients evaluated, 15 were men and 17 were women. The mean age at surgery was 54 years (range, 39-75) and the average follow-up period was 5 years and 5 months (range, 4 years and 1 month -7 years and 3 months). Regarding the diagnosis, 15 cases had spondylolisthesis, 12 cases had lumbar spinal canal stenosis and 5 cases had spondylosis. All patients underwent posterolateral lumbar fusion with pedicle screw instrumentation. Regarding the fusion site, 18 cases were L4-L5, 11 cases were L5/S1 and 3 cases were multiple level fusions.

Intervertebral disc height and percent of slip at adjacent segments with preoperative and postoperative radiographs, and lumbosacral joint angle\textsuperscript{10}, lumbar lordosis\textsuperscript{10} measured between L1 and L5 and disc angle at fusion site with postoperative radiographs were examined. All radiographs were taken under identical conditions (at a source-to-film distance of 100cm), using the same radiograph machine and the same type of high-quality film. Each item was measured with a ruler or a protractor before surgery, within a month after surgery, and at the time of final follow-up. The intervertebral disc height was measured on lateral photographs in the neutral position and it was defined as the average of anterior disc height and posterior disc height.

The postoperative progression of degeneration at adjacent segments were defined as more than a 50% narrowing in the adjacent disc height or more than a 5% slip increase at adjacent segments in comparison to the preoperative neutral lateral radiographs. The patients were divided into two groups according to degenerative changes at the adjacent segments: Group 1 with no radiographic progression of degenerative changes at the adjacent segments, and Group 2 with radiographic progression at the adjacent segments.

The clinical results were assessed using an evaluation scores for lumbar lesions proposed by the Japanese Orthopedic Association (JOA score)\textsuperscript{18}. Briefly the JOA score consists of subjective symptoms, clinical signs, restrictions of activities of daily living, and the urinary bladder function. A normal score is 29 points. The recovery rate was evaluated using Hirabayashi’s method\textsuperscript{11}. The correlations between the degen-
operative changes at adjacent segments, the recovery rate at final follow-up and preoperative radiographic measurements were evaluated.

All radiographic data and clinical charts of these patients were reviewed by the first author. The findings of radiographic and clinical parameters were analyzed statistically using a simple regression analysis and Student’s t test. Statistical significance was set at the 95% confidence interval.

Results

Fifteen (47%) of the 32 patients had adjacent segment degeneration including vertebral slip or disc space narrowing. Eleven cases had only vertebral slip, one case had only disc narrowing and three cases had both slip and narrowing. Two cases (6%) had adjacent segment degeneration at two levels cephalad to the fusion level and were included in Group 2. A laminectomy at the one level cephalad segment to the PLF was performed in two cases, which had degenerative changes at the laminectomy level. Four (57%) of seven patients who had a correction loss had adjacent segment disease. Thirteen (45%) of the 29 patients who underwent single level fusion (L4/5 : 50%, L5/S : 45%) and one of three patients who underwent multiple fusion had adjacent segment disease (Table 1). Bony union after stabilization was obtained in all patients.

The average JOA score at initial presentation was 13.5 points (range, 9 to 19 points), and it improved to an average of 23.8 points (range, 13 to 29) at the final follow-up examination. The average recovery rate of JOA score was 64.4% (range, -60 to 100).

The average JOA score was significantly higher at final follow-up than before surgery (P < 0.001). No significant correlation was seen between the adjacent segment degeneration and the recovery rate at the final follow-up. In addition, no significant correlation was observed between the adjacent segment degeneration and the preoperative radiographic measurements such as percent of slip at fusion segments, lumbosacral angle, lumbar lordosis and disc angle at fusion segments (Table 2).

Case Report

A 72-year-old woman with L4 degenerative spondylolisthesis underwent L4-L5 PLF. The preoperative percentage of slippage was 12% at L4-L5 (Fig. 1A). The postoperative percentage of vertebral slippage was 12%, and adjacent

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Ratio of adjacent segment degeneration in each item</th>
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<tbody>
<tr>
<td>Fusion segments</td>
<td>Number of patients operated</td>
</tr>
<tr>
<td>L4/5</td>
<td>18</td>
</tr>
<tr>
<td>L5/S</td>
<td>11</td>
</tr>
<tr>
<td>Multiple levels</td>
<td>3</td>
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</table>

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Comparison between Group 1 and Group 2 in each item</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group 1</td>
</tr>
<tr>
<td>Cases</td>
<td>17</td>
</tr>
<tr>
<td>Ages</td>
<td>55.6</td>
</tr>
<tr>
<td>Male/Female (cases)</td>
<td>7/10</td>
</tr>
<tr>
<td>Recovery rate of JOA score (points)</td>
<td>67.4</td>
</tr>
<tr>
<td>% slip of fusion segment (%)</td>
<td>7.5</td>
</tr>
<tr>
<td>Lumbosacral angle (°)</td>
<td>7.7</td>
</tr>
<tr>
<td>Lumbar lordosis (°)</td>
<td>26.8</td>
</tr>
<tr>
<td>Disc angle (°)</td>
<td>4.5</td>
</tr>
</tbody>
</table>

No significant correlation was seen between the adjacent segment degeneration and the recovery rate at the final follow-up. In addition, no significant correlation was observed between the adjacent segment degeneration and the radiographic measurements.
Superior disc (L3–4) narrowing and vertebral slip adjacent to the fusion was observed at 5 years after surgery (Fig. 1C). Her intervertebral disc heights before surgery at L3–L4, L4–L5, and L5–S1 were 12mm, 11mm, and 11mm, and those at 5 years after surgery were 6mm, 11mm, and 11mm, respectively. Her percent of slip before surgery at L3–L4, L4–L5, and L5–S1 was 0%, 12%, and 0%, and those at 5 years after surgery was 9%, 12%, and 0%, respectively. No loss of correction at the fusion level was observed. Her preoperative JOA score of 16 points was improved to 24 points and recovery rate of JOA score was 62% at 5 years after surgery. In spite of the disc narrowing and slippage at the segment adjacent to the fusion site, the clinical outcome resulted in a good recovery during the follow-up.

**Discussion**

Adjacent segment degeneration after spinal fusion has been recognized by many authors, and some previous reports have described the long-term rate of adjacent segment disease.\(^4\)\(^-\)\(^6\) Axelsson et al\(^1\) reported that 12 of 71 patients experienced progressive disc degeneration in the cranial segment above the level of posterolateral lumbar fusion without instrumentation, after an average follow-up of 4 years. Frymoyer et al\(^5\) reported that although there was a high percentage of residual clinical symptoms (14.8–94.6%) after posterior fusion with a minimum follow-up of 10 years, only 5 of 96 patients experienced degenerative disc disease at the segment above fusion. Ghiselli et al\(^6\) reported that the rate of symptomatic degeneration at an adjacent segments warranting either decompression or arthrodesis was predicted to be 16.5% at 5 years and 36.1% at 10 years. Cheh et al\(^12\) reported that radiographic adjacent segment disease occurred in 42.6% (80 of 188 patients) with a minimum follow-up of 5 years.

This study showed 15 of 32 cases (46.8%) to thus have radiographic adjacent segment degeneration with a minimum follow-up of 4 years.

The relationship between the clinical status and the radiographic adjacent segment degeneration has been discussed whether these results are due to aging or are secondary to stresses which occur after fusion. Van Horn and Bohnen\(^13\), in a retrospective matched-pair study of 16 patients with a minimum follow-up of 16 years after anterior spinal fusion, found that radiographic degenerative changes of the adjacent discs

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**Fig. 1** Radiographs in a 72-year-old woman obtained before surgery (A) and just after surgery (B) and 5 years after surgery (C). Disc narrowing and slipping superior to the fusion was observed during the follow-up. The recovery rate of the JOA score was 62% at 5 years after surgery.
occurred at a rate similar to that in the corresponding levels of the control group. In addition, degenerative changes occur not only in the intervertebral discs adjacent to the fusion, but also in the discs of nonsurgical patients, and the frequency increases in an age-dependent manner. Penta et al., in their report regarding the incidence of disc degeneration adjacent to interbody fusion, as detected by magnetic resonance imaging, concluded that anterior spinal fusion does not cause an accelerated degeneration of the adjacent intervertebral discs. Macnab and Dall, who first reported segmental instability, observed that it did not necessarily correlate with the symptoms. Miyakoshi et al. reported that no significant correlation was seen between the clinical results as estimated by the recovery rate and postoperative narrowing in L4/5 PLIF. Okuda et al. described that there was no correlation between radiologic degeneration of cranial adjacent segment and clinical results in a retrospective study of 87 patients who underwent PLIF at L4–L5. On the other hand, Rahm and Hall reported that adjacent segment degeneration occurred in 17 of 49 patients and it was a significant clinical problem as 44% of the patients who experienced it underwent subsequent surgical intervention. In this study, we found clear evidence that the radiographic degenerative change of adjacent level to the fusion site did not significantly correlate with the clinical status at minimum 4-year follow-up after PLIF with pedicle screw instrumentation.

The risk factors for segment degeneration have been described by several authors. Okuda et al. described that the risk factors for postoperative radiologic degeneration could not be detected in terms of each preoperative radiologic factor in L4/5 PLIF, however, the coexistence of the horizontalization of lamina and facet tropism may be one of the risk factors for neurologic deterioration resulting from the accelerated L3–L4 degenerative change which occurs after L4–L5 PLIF.

Etebar and Cahill reported that the risk of adjacent segment failure appears to be especially high in postmenopausal women. This study could not identify the risk factors among the percentage of vertebral slip at the fusion segments, lumbosacral angle, lumbar lordosis and disc angle at fusion segments, however, a laminectomy at adjacent segments induced the degenerative change of the segment, although the number of such cases was very small in our series.

There are several potential limitations in this study. The first limitation is that the study was a retrospective review of a heterogeneous patient population and small number of cases. A more homogenous population might have provided a stronger correlation between adjacent segment disease and independent variables such as age and preoperative diagnoses. Second, the adjacent segment degeneration may occur as a function of aging. This report would have greater strength if we could include a control group of age or gender matched patients who were treated non-operatively for a low back condition and then radiographed 4 years later. Future research with more patients and longer follow-up periods may shed some light on the risk factors of adjacent segment disease.

Conclusion

- A minimum four-year clinical study of posterolateral lumbar fusion with pedicle screw instrumentation was conducted in 32 patients.
- The rate of radiographic degeneration at the adjacent segments was 46.8% (15/32 cases).
- No significance was found between the degenerative change of the adjacent segments and the clinical results.
- We could not identify any factors which may have influenced the segments adjacent to the fusion.

References


(Received for publication April 10, 2008)
腰椎後側方固定術後の隣接椎間障害
—4年以上の経過観察における検討—

九州中央病院 整形外科

林 哲生, 有薗 剛, 藤本俊博, 諸岡孝明,
福元真一, 時任 毅, 志田純一, 増田祥男

腰椎後側方固定（以下 PLF）術後の長期において、X 線上の不安定性が見られ、隣接椎間障害が考えられる症例も少なくな。また固定隣接椎間障害の長期成績について様々な報告があるが、いまだに議論されているところである。

pedicle screw を併用して PLF を行った症例のうち、4年以上経過観察可能であった 32 症例を対象とした。術前後と最終経過観察時の椎間板腔の高さ・% slip、および術前の lumbosacral joint angle、腰椎前弯角、固定椎間の disc angle を全例計測した。臨床症状の評価として術前後の腰痛疾患治療成績判定基準（JOA）を用いて検討した。

32 例中 15 例（46.8%）で隣接椎間のすべりや狭小化を認めた。隣接椎間障害の有無と最終経過観察時の JOA スコア改善率の間に有意な相関関係は認められず、X 線上の隣接椎間の変性と臨床症状は相関関係がないと思われた。隣接椎間に影響を及ぼす因子について隣接椎間障害のある群とない群で検討を行ったが、術前単純 X 線像として固定椎間の % slip・lumbosacral joint angle・腰椎前弯角・disc angle について比較検討を行った結果、いずれの項目も有意な差は認められなかった。