Outcome of the L5-S1 Segment after Posterior Instrumented Spinal Surgery in Degenerative Lumbar Diseases

Jen-Chung Liao, MD; Wen-Jer Chen, MD; Lih-Huei Chen, MD; Chi-Chien Niu, MD

Background: Posterior decompression, instrumentation, and posterolateral fusion are surgical procedures for the treatment of degenerative lumbar diseases. Solid fusion usually causes adjacent problems. This study investigated the clinical outcome and radiographic fate of the L5-S1 segment in patients who underwent posterior instrumented surgery for degenerative lumbar diseases.

Methods: From January 1999 to December 2000, 181 patients (average age 59.4 years, range 45-79 years) underwent posterior decompression, posterior instrumentation, and posterolateral fusion for degenerative lumbar diseases (including degenerative spondylolisthesis and degenerative lumbar scoliosis) with spinal stenosis. Modified Brodsky's criteria and the Oswestry disability index were used to evaluate patients before surgery and at the final follow-up. Degenerative changes in the L5-S1 intervertebral disc were evaluated with the University of California at Los Angeles (UCLA) grading scale. Adjacent L5-S1 segmental instability was defined as the appearance of retrolisthesis, anterolisthesis, or lateral listhesis in the static or dynamic radiographs at the final follow-up.

Results: Only 1 of these 181 patients developed inferior adjacent instability, but there were no symptoms related to this instability. The mean pre-operative L5-S1 disc degenerative score was 1.73 ± 0.66 and at the last follow-up, 1.87 ± 0.72 ($p = 0.006$). There was no symptomatic disc degeneration necessitating further L5-S1 fusion during follow-up. One hundred fifty-six patients (86%) exhibited satisfactory results (good or excellent). The mean Oswestry score was 21.8 ± 6.0 preoperatively, which improved to 9.6 ± 7.4 at the last follow-up ($p = 0.001$).

Conclusions: The L5-S1 disc degenerated more after posterolateral lumbar floating fusion. However, there was no symptomatic inferior adjacent instability or symptomatic L5-S1 disc degeneration requiring further L5-S1 fusion at a mean 5.1 years follow-up.

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Key words: degenerative lumbar diseases, lumbar floating fusion, L5-S1 disc degeneration

With increasing life expectancy, there are more people presenting with degenerative lumbar disease (including degenerative spondylolisthesis and degenerative lumbar scoliosis). There are two

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major problems in degenerative lumbar diseases, segmental instability or deformity, and spinal stenosis. In the 1970s, some authors recommended decompression only for symptomatic patients.[1,2] However further postoperative instability usually occurred in these cases. Later studies showed that decompression with a concomitant arthrodesis for degenerative spondylolisthesis provided better clinical results than decompression alone.[3,4]

Kornblum et al performed a prospective study comparing fusion and pseudoarthrosis in degenerative lumbar spondylolisthesis, and showed that solid fusion provided better long-term clinical results.[5] In order to achieve solid union, posterior instrumentation has been widely applied in degenerative lumbar spondylolisthesis during the last two decades. The instrumentation provides immediate stability, reduces olisthesis, and enhances posterolateral fusion rates. Decompression, pedicle screw instrumentation, and posterolateral fusion have become popular for treating degenerative lumbar disease with spinal stenosis.[6,7]

Theoretically, solid fusion increases the stress on both adjacent segments. Clinically, superior adjacent stenosis or instability after lumbar fusion requiring further decompression and fusion can occur. The incidence and surgical treatment of superior adjacent instability have been well reported.[8-11] But only sporadic reports mention about the condition of the L5-S1 segment after lumbar floating fusion. Degenerative lumbar diseases are often associated with L5-S1 disc degeneration, however, the need to extend the fusion to the L5-S1 segment remains controversial.

The purposes of this study were to evaluate the outcome of the L5-S1 segment in patients with degenerative lumbar disease after posterior instrumentation with fusion and to determine the need to extend the fusion to the sacrum in patients with preoperative L5-S1 disc degeneration.

METHODS

From January 1999 to December 2000, 216 patients with degenerative lumbar scoliosis or degenerative spondylolisthesis underwent posterior decompression, instrumentation, and lumbar floating fusion. The definition of lumbar floating fusion was posterolateral fusion terminating at the L5 level without extension to the sacrum. Thirty-five patients were excluded because of inadequate clinical and radiographic data, or because they developed superior adjacent instability which might interfere with the final clinical results. There were 181 patients enrolled into this retrospective study. Sex, age, fusion level, pre-operative and post-operative disc degenerative grading, and pre-operative and post-operative clinical results were recorded and analyzed.

Pre-operative and final follow-up radiographs were blindly evaluated by an independent reviewer who did not view the surgery. L5-S1 disc height, spur formation, and appearance of endplate sclerosis were recorded on pre-operative and final lateral lumbosacral spine radiographs. A normal disc height was defined as a distance between the L5 lower endplate to the S1 upper endplate ≥ 10 mm.[12] The sum of the length of the anterior spurs of both endplates on lateral L-S radiographs was calculated, with values ≥ 3 mm representing obvious osteophyte formation.[13] The UCLA modified arthritis grading scale was used to evaluate the pre-operative and post-operative L5-S1 disc degeneration grade.[14] A grade I disc was a normal disc. Grade II, III, and IV discs were degenerative. A grade II disc has disc space narrowing. Combined disc space narrowing and obvious osteophyte formation occurred in grade III discs and grade IV discs (Fig. 1) had disc endplate sclerosis. Adjacent L5-S1 segmental instability was defined as retrolisthesis, anterolistheis, or lateral listhesis in the static or dynamic radiographs at the final follow-up.

All clinical data were obtained from clinic interview, by mail or by telephone interview. Modified Brodsky's criteria and the Oswestry disability index were used to evaluate patients' clinical results. The modified Brodsky's criteria evaluated the patients' conditions on the basis of pain, activity, analgesic use, and overall satisfaction. Clinical results were categorized as excellent, good, fair, or poor.[15] The Oswestry disability index questionnaire had 10 items including pain intensity, personal care, lifting, walking, sitting, standing, sleeping, sex life, social life, and traveling. Scores for each item were from 0 to 5. Higher scores indicated more severe lower back disability.[16] Survivorship of the L5-S1 segment was defined as lack of any surgery over the L5-S1 segment subsequent to the initial lumbar floating fusion.

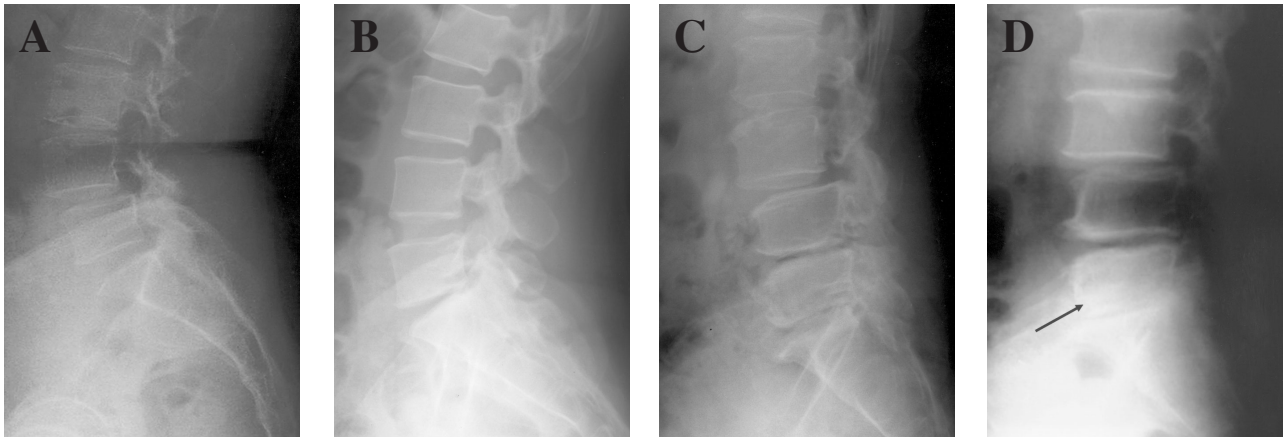

Fig. 1 L5-S1 disc degeneration grading: (A) Grade I: normal disc height, no osteophyte formation; (B) Grade II: narrowing disc without osteophyte formation; (C) Grade III: narrowing disc with obvious osteophyte formation; (D) Grade IV: appearance of subchondral sclerosis (arrow).

Statistical analysis

The Mann-Whitney test was used for group comparisons. The pre-operative and post-operative disc grade and Oswestry scores within the patient group were compared using the Wilcoxon sign rank test. A $p < 0.05$ was considered statistically significant.

RESULTS

Of these 181 patients, 37 were men, and 144 were women. The average age at surgery was 59.4 ± 9.4 years (range, 45 to 79 years). The mean follow - up period was 5.1 ± 0.5 years (range, 4 to 6 years). There were 92 patients with one level fusions, 46 with two level fusions, 23 with three level fusions, and 20 with fusions of four or more segments in this study. There was an average of 1.9 ± 1.2 segments (range, 1 to 7) fused.

The pre-operative L5-S1 disc grade was grade I in 69 patients, grade II in 93 patients, grade III in 18 patients, and grade IV in 1 patient. After surgery, 57 patients had grade I, 92 patients grade II, 28 patients grade III, and 4 patients grade IV discs. The average L5-S1 disc grade was 1.73 ± 0.66 (range, 1 to 4) before surgery and 1.87 ± 0.71 (range, 1 to 4) at the final follow-up (p = 0.006). One patient was diagnosed with L5-S1 spondylolisthesis on lateral L spine radiography at the clinic 5.5 years after surgery, but there were no symptoms related to this adjacent instability. The incidence of inferior adjacent instability in this study was 0.5% (1/181). Two patients received revision surgery at the L5-S1 segment. One patient underwent L3-5 instrumentation and fusion initially and developed lower back pain with progressive leg soreness 2 years after the first surgery. Magnetic resonance imaging of the L spine showed L5-S1 stenosis, and he received a subsequent L5 laminectomy because of this inferior adjacent stenosis. The other patient underwent L4-5 instrumenation and fusion during the first surgery and suffered from acute left side sciatica 3 years later. A herniated intervertebral disc (HIVD) of the left L5-S1 disc was diagnosed, and an L5-S1 discectomy was performed for this patient. No patient underwent extension of fusion and instrumentation to the sacrum, and the L5-S1 segment survivorship was 99% (179/181).

Using modified Brodsky's criteria, 48 patients had excellent outcomes, 108 had good outcomes, 14 had fair outcomes, and 11 had poor outcomes. One hundred fifty-six patients (86%) exhibited satisfactory results (good or excellent outcomes). The mean Oswestry score of these 181 patients was 21.8 ± 6.0 preoperatively (range, 10 to 39), which improved to 9.6 ± 7.4 (range, 2 to 31) at the last follow-up (p = 0.001) (Table 1).

In 69 patients with normal pre-operative L5-S1 discs, the average pre-operative Oswestry score was 21.8 ± 6.2 (range, 11 to 36), which improved to 9.3 ±8.6 (range, 2 to 31) at the final follow-up. However, in the other 112 cases with degenerative

Table 1. Patient Data and Radiographic and Clinical Results

Characteristic	Total (N = 181)	
Gender		
M	38	
F	144	
Age (years)	59.4 ± 9.4 (45-79)	
Period of follow up (years)	5.1 ± 0.5 (4-6)	
Fusion length		
1 Level	92	
2 Level	46	
3 Level	23	
≧ 4 Level	20	
Radiographic results		
Development of L5-S1 adjacent instability	1	
L5-S1 disc degeneration grade		
Preoperative	1.73 ± 0.66 (1-4)	$p = 0.006$
Postoperative	1.87 ± 0.71 (1-4)	
Clinical results		
Satisfactory results (Brodsky's criteria)	86%	
Oswestry score		
Preoperative	21.8 ± 6.0 (10-39)	$p = 0.001$
Postoperative	9.6 ± 7.4 (2-31)	
Revision surgery at L5-S1 segment	2	
Survivorship of L5-S1 segment	99% (179/181)	

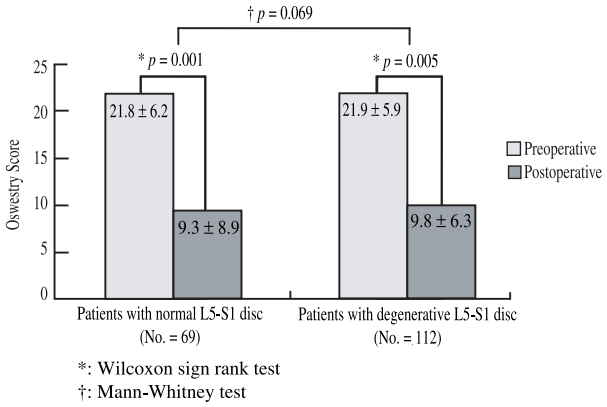

Fig. 2 Comparison of preoperative and final Oswestry scores between patients with and without preoperative L5-S1 disc degeneration. Degeneration of the L5-S1 disc preoperatively had an insignificant influence on the final functional result.

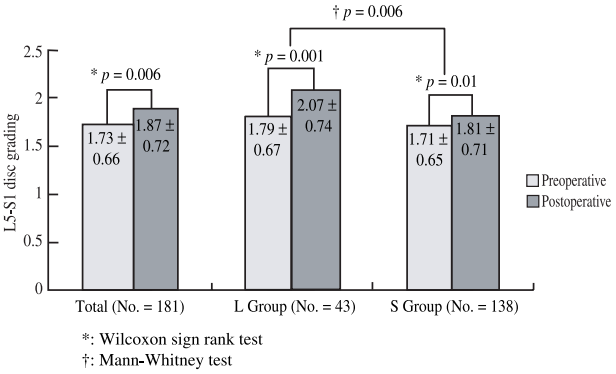

Fig. 3 Changes in the mean L5-S1 disc grade in all patients, long fusion patients (L group), and short fusion patients (S group). The L5-S1 disc degenerated more after lumbar floating fusion. The L5-S1 disc also degenerated more in the long fusion-length group than in the short fusion length group.

L5-S1 discs pre-operatively, the average Oswestry score was 21.9 ± 5.9 (range, 10 to 39) preoperatively and 9.8 ± 6.3 (range, 3 to 31) at the final follow-up. Both subgroups had statistically significant improvement ($p = 0.001$, 0.005 respectively) in the functional scores, but there was no significant difference between subgroups ($p = 0.069$) (Fig. 2).

The cases were grouped into the long fusion group (group L) if the fusion level was ≥ three motion segments, and the short fusion group (group S) with a fusion level ≤ two segments. There were 43 patients in group L, and 138 patients in group S. In group L, the mean L5-S1 disc grades were 1.79 ± 0.67 (range, 1 to 3) preoperatively and 2.07 ± 0.74 (range, 1 to 3) at the final follow-up. In group S, the mean L5-S1 disc grades were 1.71 ± 0.65 (range, 1 to 4) and 1.81 ± 0.71 (range, 1 to 4), respectively. The L5-S1 disc degenerated progressively on radiographs after lumbar floating fusion in both groups ($p = 0.001$, 0.01 respectively). The discs degenerated more in the long fusion group ($p = 0.006$) (Fig. 3).

In Group S, in 54 patients with normal pre-operative L5-S1 discs, the average Oswestry scores were 21.4 ± 5.8 (range, 11 to 34) pre-operatively, and 9.1 ± 7.7 (range, 2 to 31) at the final follow up. The other 84 cases with degenerative L5-S1 discs preoperatively had average Oswestry scores of 22.2 ± 5.7 (range, 10 to 39) preoperatively, and 9.0 ± 6.3 (range, 2 to 30) at the final follow-up. Both subgroups had statistically significant improvements ($p = 0.001$, 0.001 respectively) in their functional scores, but there was no significant difference between subgroups ($p = 0.49$) (Fig. 4).

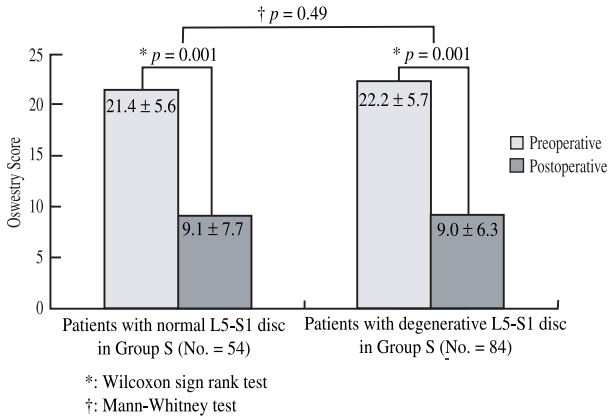

Fig. 4 Comparison of the preoperative and final Oswestry scores between patients with and without preoperative L5-S1 disc degeneration in Group S.

In Group L, 15 patients with normal pre-operative L5-S1 discs, had average Oswestry scores of 23.4 ± 7.5 (range, 14 to 36) preoperatively and 10.2 ± 8.1 (range, 2 to 28) at the final follow up. The other 28 cases with degenerative L5-S1 discs preoperatively had average Oswestry scores of 20.8 ± 6.5 (range, 12 to 38) preoperatively, and 12.2 ± 5.7 (range, 4 to 31) at the final follow-up. Both subgroups had statistically significant improvement (p = 0.001, 0.018 respectively) in functional scores, but there was no significant difference between subgroups (p = 0.076) (Fig 5).

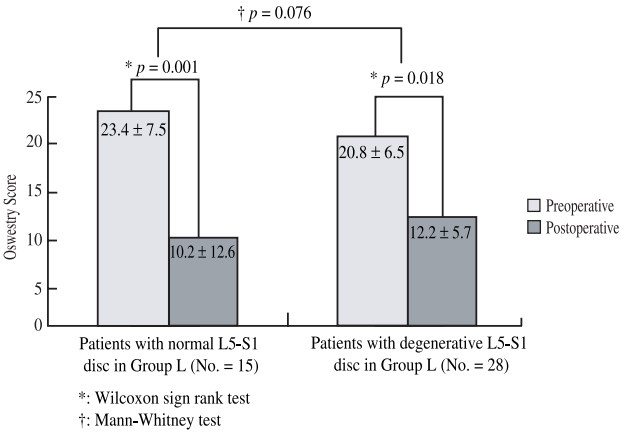

Fig. 5 Comparison of the preoperative and final Oswestry scores between patients with and without preoperative L5-S1 disc degeneration in Group L.

DISCUSSION

After failure of conservative treatment, lumbar fusion is thought to be a good method to treat lumbar instability. The satisfactory rate is about 76% to 93% for patients with degenerative lumbar disease after posterior instrumentation and fusion.[6,7] In the current study, 86% of patients exhibited excellent or good clinical results which is compatible with previous studies. But after long-term observation, solid spinal fusion may cause adjacent segment problems. Biomechanical study showed that the motion and facet load of the superior adjacent segment increases after lumbar immobilization.[17] From the finite element study, a larger increase in stress was estimated in the upper disc adjacent to the anterior interbody fusion than in the lower disc adjacent to the anterior interbody fusion.[18] Development of superior adjacent instability is a time-related process, and the incidence is reported to increase from 7% at 2.4 years to 45% at 33 years.[19,20] Other risk factors related to superior adjacent instability include loss of lumbar lordosis and destruction of the superior interspinal ligament.[21,22] Iatrogenic superior facet joint destruction when inserting the pedicle screw could be another reason for the development of superior adjacent instability.

The inferior segment is also influenced by spine fusion and instrumentation. Cunningham et al performed biomechanical tests of the lumbosacral spine of 11 human cadavers. Spinal destabilization and instrumentation significantly altered the distal intradisc pressure significantly when applying extension loading.[23] Clinically, Ghiselli et al retrospectively investigated 32 patients with L4-5 fusion. At an average 7.3 years follow up, there was neither increased symptomatic L5-S1 disc degeneration nor symptomatic stenosis or instability at the L5-S1 segment.[14] Edwards et al retrospectively analyzed 34 patients with long thoracolumbar fusion. Sixty-one percent of the L5-S1 discs had further disc degeneration. The risk factors related to L5-S1 disc degeneration were pre-operative position, sagittal balance, young age, and pre-operative degenerative disc.[24] In this study, at an average 5.1 years follow -up, lumbar floating fusion indeed caused further L5-S1 disc degeneration. The fusion length was a risk factor which hastened degeneration after lumbar floating

fusion in this study. The L5-S1 discs in the long fusion group degenerated more than those in the short fusion group.

L5-S1 degeneration after lumbar fusion may be due to adjacent stress after fusion, may be induced by sagittal imbalance, or it could just be a natural course. However, the motion of the L5-S1 segment is reduced after lumbar floating fusion in the elderly.[25] The L5-S1 disc is usually located below the iliac crest line, protected by the iliolumbar band, so the L5-S1 segment can be kept in a stable condition. In addition, the L5-S1 facet joint is seldom damaged when performing lumbar floating fusion with instrumentation because a sacral pedicle screw is not applied, and the decompression area is usually not wide enough to injure the joint level. These are reasons why the incidence of adjacent L5-S1 instability is low compared with results in the superior adjacent level after lumbar fusion and instrumentation. Only two patients in this study received revision surgery at the L5-S1 segment due to adjacent stenosis and HIVD. The opportunity for problems to occur adjacent to L5-S1 was low (2/181) and symptoms developed years after initial surgeries in these two patients. We thought the problems in these cases were sporadic and followed a natural course, and we were unable to analyze the risk factor possibilities.

In patients with pre-operative L5-S1 disc degeneration combined with lumbar instability or deformity, lumbar floating fusion alone can achieve satisfactory functional results. The same phenomenon was also observed by other researchers. Miyakoshe reviewed 45 patients who received L4-5 posterior lumbar interbody fusion due to L4-5 spondylolisthesis. There was no difference in clinical results between patients with normal L5-S1 discs and those with narrow L5-S1 disc heights. This shows that pre-operative narrowing of the L5-S1 disc does not affect the clinical outcome of L4-5 posterior lumbar interbody fusion.[26]

Another question is whether lumbosacral fusion is better than lumbar floating fusion in lumbar instability with pre-operative L5-S1 disc degeneration. Some authors feel posterior instrumentation with posterolateral fusion is suitable for resolving pain induced by spinal instability, but not for discogenic pain.[27] However, lumbosacral fusion in the treatment of lumbar scoliosis with L5-S1 disc degeneration is supported in some reports. L5-S1 disc degeneration is thought to be a contributing factor in the development of lower back pain in adult lumbar scoliosis, and solid lumbosacral fusion could overcome problems from severe L5-S1 disc degeneration or instability.[28] We recommend extensive fusion to the sacrum with existing L5-S1 segment instability. More case-controlled studies are needed to solve the debate about the results of lumbosacral fusion and lumbar floating fusion for degenerative lumbar disease associated with pre-operative L5-S1 disc degeneration.

Conclusions

The present study showed that posterior instrumentation with posterolateral lumbar floating fusion can provide satisfactory clinical results in degenerative lumbar diseases even with concomitant L5-S1 disc degeneration at a mean 5.1 years follow-up. The incidence of adjacent L5-S1 segment instability after lumbar floating fusion was very low (0.5%), and there was no symptomatic inferior adjacent instability requiring further L5-S1 fusion. Although the L5-S1 disc degenerated more after lumbar floating fusion, L5-S1 segment survivorship was high (99%).

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退化性腰椎疾病在接受後位內固定融合手術後，第五腰椎第一薦椎活動節的命運

廖振中 陳文哲 陳力輝 牛自健

背 景： 後位減壓，鋼釘內固定，後外側骨融合是治療退化性腰柱疾病的手術方法。但堅實的融合常引起鄰近活動節的問題。本篇研究是去探討退化性腰椎疾病的病人在接受後位鋼釘內固定融合手術後，第五腰椎第一薦椎活動節的變化以及臨床意義。

方 法： 從 1999 年 1 月到 2000 年 12 月，181 位病人因爲退化性腰椎疾病 (包括退化性腰椎滑脫，退化性腰椎側彎) 合併脊椎狹窄症接受後位減壓，鋼釘固定，後外側融合手術。使用 Modified Brodsky's criteria 以及 Oswestry disability index 去評估病人術前，以及最後的臨床結果。使用 UCLA grading scale 去評估第五腰椎第一薦椎椎間盤退化的情形。在最後追蹤的靜態或動態的 X 光上，第五腰椎第一薦椎活動節若出現有後滑脫，前滑脫，或側滑脫的現象，即定義爲第五腰椎第一薦椎鄰近節不穩定。

結 果： 在這 181 位病人中，只有一位病人在追蹤時發展出下鄰近節不穩定。術前第五腰椎第一薦椎椎間盤的退化分數平均爲 1.73 ± 0.66，在最後追蹤時平均退化分數改變成 1.87 ± 0.72 (p = 0.006)。在這段追蹤期間，沒有病人因爲此椎間盤的退化而必須做延長融合至薦椎的手術，156 位病人 (86%) 表示滿意手術結果。術前 Oswestry 分數爲 21.8 ± 6.0，在最後追蹤時進步至平均 9.6 ± 7.4 分 (p = 0.001)。

結 論： 在腰椎進行融合手術後，第五腰椎第一薦椎椎間盤會變得更加退化。然而在這平均 5.1 年的追蹤期間，沒有病人因爲此種下鄰近節不穩定或是椎間盤退化，需要做進一步的第五腰椎第一薦椎的融合手術。

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關鍵詞： 退化性腰椎疾病，腰椎漂浮融合，第五腰椎第一薦椎椎間盤退化

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