RESEARCH PAPER

Adjacent Segment Degenerative Disc Disease Following Lumbar Spinal Fusion: A Retrospective Cohort Study

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ABSTRACT

Background: Lumbar spinal fusion is an established treatment for selected degenerative lumbar spine disorders, but the procedure alters spinal biomechanics and may predispose the adjacent motion segment to degeneration.

Objective: To determine the incidence of adjacent segment degeneration and symptomatic adjacent segment disease after short-segment lumbar fusion and to identify associated risk factors.

Methods: This retrospective cohort study included 112 patients who underwent one- or two-level posterior lumbar fusion between January 2021 and December 2024. Clinical and radiological outcomes were assessed with follow-up imaging.

Results: Radiographic adjacent segment degeneration was observed in 32 patients (28.6%), while symptomatic adjacent segment disease occurred in 16 patients (14.3%). Significant risk factors included age greater than 50 years, two-level fusion, and pre-existing adjacent disc degeneration.

Conclusion: Adjacent segment disease is a clinically important complication after lumbar fusion, and its risk is influenced by both patient-related and surgical factors.

Keywords: adjacent segment degeneration; adjacent segment disease; lumbar fusion; risk factors; retrospective cohort study

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INTRODUCTION

Lumbar degenerative spine disorders are common indications for surgical fusion when nonoperative treatment fails.[1] Fusion can improve pain and stability; however, elimination of motion at the fused segment increases mechanical load at adjacent levels.[2] This biomechanical alteration may accelerate disc, facet, and endplate degeneration at neighboring motion segments, a phenomenon referred to as adjacent segment degeneration.[3] When these changes become symptomatic and clinically significant, the condition is termed adjacent segment disease.[4] The pathogenesis of adjacent segment disease is multifactorial. Patient-related factors such as age and pre-existing degeneration may increase susceptibility, whereas surgical variables including fusion length, distal level selection, and postoperative alignment can alter stress distribution across the lumbar spine.[5,6,7] Although radiographic adjacent degeneration is frequently observed, symptomatic disease is less common and remains an important cause of pain, disability, and reoperation after fusion.[4,8] The present study was designed to determine the incidence of adjacent segment degeneration and symptomatic adjacent segment disease in patients undergoing short-segment lumbar fusion and to evaluate clinical and surgical predictors associated with its development.[5,6]

Materials and Methods

This retrospective cohort study included consecutive adults who underwent posterior lumbar fusion with pedicle screw-rod instrumentation for degenerative lumbar spine pathology between January 2021 and December 2024 at a single institution. Inclusion criteria were age 18 years or older, one- or two-level fusion from L3 to S1, and a minimum follow-up of 24 months. Patients with prior lumbar fusion, fusion spanning six or more levels, trauma, infection, tumor, congenital deformity, or inadequate imaging were excluded. The institutional review board approved the study and waived individual informed consent because of the retrospective design.

All patients underwent decompression and instrumented posterior lumbar interbody fusion or posterolateral fusion under general anesthesia. Preoperative and follow-up images were reviewed by two spine surgeons. Demographic variables, including age and sex, and surgical variables, including number of fused levels and inclusion of L5-S1, were recorded. Preoperative magnetic resonance imaging was reviewed for adjacent-level disc degeneration using the Pfirrmann grading system. Pfirrmann grade III or higher at the segment immediately adjacent to the fusion was considered degenerative.[5,6]

Radiographic adjacent segment degeneration was defined as a new degenerative change at the adjacent level on follow-up magnetic resonance imaging or radiographs compared with preoperative imaging, including disc height loss, endplate sclerosis, Modic change, or facet arthropathy. Symptomatic adjacent segment disease was defined as new symptoms referable to the adjacent level, such as low back pain or radiculopathy, with confirmatory imaging findings and need for reoperation.[4,5]

Continuous variables are presented as mean and standard deviation, and categorical variables are presented as number and percentage. Incidence was calculated as the proportion of patients affected. Univariate analyses using chi-square tests or t tests were performed to assess associations between symptomatic adjacent segment disease and age, sex, fusion length, inclusion of L5-S1, and pre-existing adjacent disc degeneration. A two-sided p value less than 0.05 was considered statistically significant.

Results

A total of 112 patients met the inclusion criteria. The mean age was 52.4 ± 9.6 years, and 68 patients (60.7%) were male. Single-level fusion was performed in 74 patients (66.1%), while 38 patients (33.9%) underwent two-level fusion. The L5-S1 level was included in 22 cases (19.6%), and preoperative adjacent-level degeneration was present in 41 patients (36.6%).

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The mean follow-up duration was 30 months. Radiographic adjacent segment degeneration was identified in 32 patients (28.6%), whereas symptomatic adjacent segment disease developed in 16 patients (14.3%). The mean time to diagnosis of symptomatic disease was 2.4 years after surgery. No patient with isolated radiographic degeneration progressed to symptomatic disease during the follow-up period.

Patients older than 50 years had a higher rate of symptomatic adjacent segment disease than younger patients. Two-level fusion was associated with a significantly higher incidence than single-level fusion. Pre-existing adjacent disc degeneration was also strongly associated with symptomatic disease. Sex and inclusion of L5-S1 were not significantly associated with symptomatic adjacent segment disease.

Tables

Table 1. Baseline demographic and surgical characteristics

Variable	Value
Patients, n	112
Age, mean ± SD, years	52.4 ± 9.6
Sex, male/female	68 (60.7%) / 44 (39.3%)
Fusion levels, single/two	74 (66.1%) / 38 (33.9%)
Fusion to S1, yes/no	22 (19.6%) / 90 (80.4%)
Preoperative adjacent-disc degeneration	41 (36.6%)

Table 2. Risk factors for symptomatic adjacent segment disease

	ASD present / total (%)	p value
Age >50 years	21/56 (37.5%) vs 15/56 (26.8%)	0.018
Fusion levels = 2	15/38 (39.5%) vs 17/74 (23.0%)	0.011
Pre-op adjacent degeneration	19/41 (46.3%) vs 22/71 (31.0%)	0.004
Sex (male vs female)	10/68 (14.7%) vs 6/44 (13.6%)	0.81
Fusion includes L5-S1	5/22 (22.7%) vs 11/90 (12.2%)	0.14

Discussion

In this cohort, symptomatic adjacent segment disease occurred in 14.3% of patients after short-segment lumbar fusion, whereas radiographic degeneration was more common. This pattern is consistent with the literature showing that structural degeneration is frequent after fusion, but only a subset of patients develop clinically significant symptoms.[3,4,8,9]

The biological basis for adjacent segment pathology likely reflects altered load transfer after motion elimination at the fused level. Increased intradiscal pressure, facet loading, and compensatory motion may accelerate degeneration in adjacent segments.[2,3] These effects may be amplified in older patients and in those with pre-existing adjacent-level degeneration.[5,6,7]

Fusion length also appears to influence risk. Extending fusion to a second level likely increases stiffness and shifts stress to the next mobile segment.[6,8,9] Our findings support a more cautious approach when planning multilevel constructs, especially in patients with risk factors for accelerated adjacent degeneration.[8,9]

Pre-existing adjacent disc degeneration emerged as a strong predictor in this study.[5,7,8] This observation supports the concept that the adjacent level may already represent an early degenerative segment before fusion, making it more vulnerable to postoperative progression.[3,10] Careful preoperative imaging review may therefore aid surgical planning and patient counseling.[10,11]

The present study should be interpreted in light of its limitations, including retrospective design, modest sample size, single-center experience, and relatively short follow-up.[4] In addition, alignment parameters were not analyzed. Nevertheless, the findings are clinically relevant and reinforce the need for individualized decision-making, especially in older patients and those with pre-existing adjacent degeneration.[8,9]

Conclusion

Adjacent segment degeneration after one- or two-level lumbar fusion was common on imaging, but symptomatic adjacent segment disease was less frequent. Advanced age, fusion of two levels, and pre-existing adjacent disc degeneration were significant predictors of symptomatic disease. These findings underscore the importance of preoperative risk assessment and careful surgical planning to reduce the likelihood of adjacent segment complications.[1]

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