

# A New Method to Treat Severe Asymptomatic Pre-existing Degeneration of Adjacent Segment: a Retrospective Case-control Study

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# Abstract

**Background** Pre-existing degeneration of adjacent segment is an important risk factor for adjacent segment degeneration (ASD), but limited and controversial studies have addressed its management. **Methods** Patients with symptomatic degeneration of the L5/S1 segment warranting surgical interference and severe asymptomatic degeneration of the L4/5 segment were retrospectively analyzed. Among them, those who underwent interbody fusion in the causative (L5/S1) segment and distraction of the intervertebral space and facet fusion in the adjacent L4/5 segment were included as Group A (n=103). Patients who underwent interbody fusion in both L5/S1 and L4/5 segments were included as Group B (n=81). Clinical and radiographic outcomes were evaluated. **Results** Mean follow-up was 58.5 months (range, 48-75 m). No significant difference in clinical outcomes or the incidence of adjacent segment degeneration in L3/4 segment was found between Groups A and B. Compared with Group B, less bleeding ( $315\pm 84$  vs.  $532\pm 105$  ml), shorter operation time ( $107\pm 34$  vs.  $158\pm 55$  min) and lower costs ( $13,830\pm 2640$  vs.  $16,020\pm 3380$  US\$) were found in Group A ( $P<0.05$ ). In Group A, disc height ratio (DHR) of L4/5 segment was significantly increased from preoperative value of  $0.40\pm 0.13$  to last follow-up value of  $0.53\pm 0.18$  ( $P<0.05$ ), while the degree of canal stenosis (DCS) was decreased from preoperative value of  $34.3\pm 11.2\%$  to last follow-up value of  $15.9\pm 9.3\%$  ( $P<0.05$ ). **Conclusions** This new method could be effective in treating severe asymptomatic pre-existing degeneration of adjacent segment in lumbar spine.

## Background

Posterior lumbar interbody fusion (PLIF), which can provide posterior fusion concomitant with anterior column support, is an effective procedure for lumbar degenerative diseases such as lumbar disc herniation, degenerative spondylolisthesis, degenerative instability and spinal canal stenosis. However, with its wide applications, many complications emerge, including pseudarthrosis, loosening or breaking of the implant, and adjacent segment degeneration (ASD). Development of ASD has attracted increasing attention because it adversely affects long-term clinical outcome and sometimes requires surgery[1–3]. The exact cause of ASD remains controversial, yet some risk factors have been documented[4, 5]. Among them, pre-existing degeneration of the adjacent segment is one of the most important risk factors[1, 4, 6]. Studies concerning whether asymptomatic pre-existing degeneration of adjacent disc should be treated, and how to be treated are limited and controversial. If left untreated, clinical symptoms may appear, warranting a second operation, which was consistently associated with technical difficulties, poor outcomes, and psychological and economical burdens[6, 7]. A better therapeutic approach should be taken from the first surgery. Some surgeons may carry out a fusion of the causative segment and simultaneous extensive laminar or semi-laminar decompression surgery or augmenting the vertebral canal in a hidden-proceed manner without fusion at the adjacent segment with asymptomatic pre-existing degeneration, but this approach may not be so effective and may even induce symptomatic ASD[4]. Some suggest a complete PLIF at the adjacent level, which may increase not only the costs but also the surgical trauma[8]. Recently, some other surgeons prefer dynamic stabilization, but multiple studies showed that there is no significant advantages of dynamic stabilization on preventing ASD and

many issues have been reported for the use of dynamic stabilization such as limited indications, dissatisfactory long-term results, and high incidence of reoperation[9–11].

In this paper, we reported a new method to treat severe asymptomatic pre-existing degeneration of adjacent segment by performing a distraction of the intervertebral space and facet fusions in the adjacent segment with significant degeneration. To evaluate the effectiveness of this approach, a retrospective case-control study was conducted.

## **Methods**

### **Patient Characteristics**

This study was approved by the Ethics Committee of Honghui Hospital (No. XAHLLSP0901), and written consent was obtained from all of the patients. We retrospectively reviewed the records of all patients who underwent lumbar spinal fusion surgery in L4/5 and L5/S1 segments for lumbar disc herniation from September 2009 through November 2014. We included the patients who had received imaging examination and preoperative nerve electrophysiological test to confirm that S1 nerve root was causative of the neurological symptoms, and L5/S1 segment was the causative segment. And if confirmed diagnosis cannot be obtained in the above-mentioned examinations, nerve root block had been conducted.

### **Inclusion and Exclusion Criteria**

Inclusion criteria were the following: 1) symptomatic degeneration of the L5/S1 segment warranting surgical interference; 2) asymptomatic degeneration of the L4/5 segment with equal or more than Pfirrmann Grade IV[12] causing equal or more than 25% spinal canal stenosis (the degree of canal stenosis was evaluated and calculated on preoperative MRI according to the method introduced by Imagama et al[13] as shown in Figure 2b).

Exclusion criteria were the following: 1) symptomatic disc herniation in L4/5 segment; 2) equal or more than Pfirrmann Grade IV disc degeneration, spondylolisthesis, spinal instability or stenosis in L3/4 segment; 3) history of spinal operation.

The patients who underwent interbody fusion in the causative (L5/S1) segment, and a distraction of the intervertebral space and facet fusions in the adjacent L4/5 segment were included as Group A, and those who underwent interbody fusions in both L5/S1 and L4/5 segments were included as Group B.

### **Surgical Technique**

For patients in Group A, standard PLIF was performed in the L5/S1 segment. For the distraction of the intervertebral space in L4/5 segment, disc space between L4 and L5 was moderately distracted using a

distraction device with the L4 and L5 pedicle screw caps as fulcrums. As a reference for the distraction distance, the height of the adjacent intervertebral space was used, and excessive distraction should be avoided to prevent excessively increased nerve root tension. For the facet fusions in L4/5 segment, V-shape osteotomy was carried out on the L4 inferior articular facet and L5 superior articular facet from top to bottom using an osteotome to create a V-shape groove on the both sides of L4/5 segment (Figure 1a, 1c). The autogenous bone chips from laminectomy were then implanted into the V-shape grooves (Figure 1b, 1d).

For patients in Group B, standard PLIFs were performed in both L5/S1 and L4/5 segments.

Assessment of Outcome

## Data Collection and Analysis

X-rays were obtained at 3, 6, 9, 12, 18, and 24 months and every 1 year thereafter to evaluate the position of the internal fixation, presence of loosening or migration and change in the adjacent L3/4 segment. Symptomatic and functional recovery was evaluated using the Visual Analogue Scale (VAS) and the Oswestry Disability Index (ODI). At the most recent follow-up, X-rays, computed tomography (CT) and MRI were performed.

In Group A, disc height ratio (DHR) of the L4/5 segment was measured according to the Farfan's method[14] on lateral radiograph as shown in Figure 2a. Briefly, DHR was defined as [anterior disc height (A) + posterior disc height (B)] / the distance between the anterior and posterior margins of the disc (C) [DHR = (A+B)/C]. The degree of disc degeneration in L3/4 and L4/5 segments was graded on MRI T2-weighted images according to the Pfirrmann grading system[12]. The degree of canal stenosis (DCS) in L3/4 and L4/5 segments was evaluated and calculated on MRI according to the method introduced by Imagama et al[13] as shown in Figure 2b. Briefly, DCS was defined as [the sagittal length of the spinal canal (A) - the maximal sagittal length of the hernia (B)] / the sagittal length of the spinal canal (A) ×100 [DCS = (A-B)/A×100]. Measurements were performed twice by two observers independently, and interobserver and intraobserver reliabilities of these data were greater than a correlation of 0.80. Radiographic ASD in L3/4 segment was defined as: 1) development of spondylolisthesis or spinal instability; 2) disc degeneration equal to or more than Pfirrmann Grade IV.

### *Statistical analysis*

Comparison between preoperative and postoperative values was performed using [paired t-test](#). The independent sample t-test was conducted to compare the outcomes between Groups A and B. Statistical analyses were conducted using SPSS 20.0 (IBM, Armonk, NY, USA). Two-sided  $P < 0.05$  was considered statistically significant.

## Results

## Follow-up of Patient Characteristics

A total of 103 patients (43 male and 60 female) were included in Group A, whose mean age was 61.5 years (range, 31–74 y). And 81 patients (37 male and 44 female) were included in Group B, whose mean age was 59.7 years old (range, 34–72 y). The mean follow-up was 58.5 months (range, 48–75 m).

## Clinical Results

As shown in Table 1, compared with Group B, less bleeding ( $315\pm 84$  vs.  $532\pm 105$  ml), shorter operation time ( $107\pm 34$  vs.  $158\pm 55$  min), and lower costs ( $13,830\pm 2640$  vs.  $16,020\pm 3380$  US\$) (all  $P<0.05$ ) were found in Group A. The preoperative and final follow-up VAS and ODI scores were presented also in Table 1, and the clinical symptoms in both groups were improved postoperatively ( $P<0.05$ ). But preoperatively or postoperatively there was no significant difference of VAS and ODI scores between Groups A and B (all  $P>0.05$ ). No implant loosening or breakage was found in all patients at the last follow-up.

## Radiographic Findings

In Group A, disc height ratio (DHR) in L4/5 segment was significantly increased from preoperative value of  $0.40\pm 0.13$  to last follow-up value of  $0.53\pm 0.18$  ( $P<0.05$ ), while the degree of canal stenosis (DCS) was decreased from preoperative value of  $34.3\pm 11.2\%$  to last follow-up value of  $15.9\pm 9.3\%$  ( $P<0.05$ ) (Table 2). Radiographic ASD in L3/4 segment has been found in 13 of 103 (12.62%) patients in Group A and 9 of 81 (11.11%) patients in Group B at the final follow up, but there was no significant difference in the occurrence of radiographic L3/4 ASD between the two groups ( $P=0.05$ ).

## Illustrative Case

A 54-years-old man with chief complaint of radiating pain to the left lower extremity was diagnosed as lumbar disc herniation. The causative segment had been confirmed to be L5/S1 segment by preoperative examination. Preoperative MRI demonstrated that 42.5% of spinal canal stenosis in L4/5 segment was caused by the degenerative disc (Pfirrmann Grade IV, Figure 3c, d). We performed a standard PLIF in L5/S1 segment, and distraction of the intervertebral space and facet fusion in L4/5 segment. At the 5-year follow-up assessment, CT showed that complete facet fusion in L4–5 facets was achieved (Figure 3a, 3b), and MRI demonstrated that the degree of spinal canal stenosis in L4/5 segment was decreased to 7.2% (Figure 3e, f), indicating that the disc herniation was retracted.

## Discussion

Our study demonstrated that a distraction of the intervertebral space and facet fusions in L4/5 segment with severe degeneration, could be effective in preventing ASD of L4/5 segment, and had several

advantages over interbody fusions in both L5/S1 and L4/5 segments, including decreased bleeding, shorter operation time and lower costs.

The incidence of ASD varies from 8.2% to 18.5% among studies, and about 2.7–20% patients with symptomatic ASD need surgical intervention[1–3, 5]. Patients with pre-existing degenerative changes at an adjacent motion segment would have a worse long-term clinical outcome and experience a higher rate of sequelae[1, 4, 6]. Anandjiwala et al. found that adjacent segments with Pfirrmann Grade IV or V degeneration constitute a significant risk factor for ASD and suggested that adjacent segments with Grade IV or V degeneration should be included in the primary fusion procedure to prevent subsequent ASD[15]. But complete interbody fusion at the adjacent level, not only markedly increases the overall operation costs, but also leads to more surgical trauma with related consequences[8]. Meanwhile, some surgeons choose to augment the vertebral canal in a hidden-proceed manner without fusion at the adjacent segment, but Hikata et al. reported that simultaneous decompression surgery without fusion at the adjacent level may not be effective in reducing the incidence of symptomatic ASD[4].

Interspinous distraction devices and dynamic stabilization across pedicle screws can theoretically prevent ASD by preserving some motion at the segment. Koroivessis et al. recommended the use of the Wallis interspinous implant in the unfused vertebral segment cephalad to instrumentation with mild arthritic changes to protect the adjacent segments[16]. In the present study, significant disc degeneration and spinal stenosis in the adjacent segment (L4/5 segment) were present; therefore, distracting the interspinous process is far from enough to retract the herniated disc and decompress the spinal stenosis. Graf ligament and Dynesys device are the mostly used devices for dynamic stabilization. Since there was severe disc degeneration at L4/5 segment, the Graf ligament was unsuitable for our patients[17]. The Dynesys system can resist both tensile and compressive forces and control motion of the segment in all the directions, but this system has a high incidence of screw loosening[18] and the incidence of ASD is similar to that of traditional method[10, 19].

The present study has several limitations. It was a retrospective study that limited the data to those available in the medical charts. Only a single center was involved, and a small sample size of cases were included. Patients with significant L3/4 degeneration were excluded to lower interindividual and intergroup variability, but it could result in lower generalizability. Additional prospective studies are necessary to confirm these results.

## Conclusions

Our outcomes indicate that distraction of the intervertebral space and facet fusions could be effective in treating severe asymptomatic pre-existing degeneration of adjacent segment in lumbar spine.

## Abbreviations

ASD: adjacent segment degeneration; PLIF: posterior lumbar interbody fusion; VAS: Visual Analogue Scale; ODI: Oswestry Disability Index; MRI: magnetic resonance imaging; CT: computed tomography; DHR: disc height ratio; DCS: degree of canal stenosis.

## **Declarations**

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## **Availability of data and materials**

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

## **Authors' contributions**

All authors contributed to the analysis and interpretation of data. WJG and DJH has been involved in conception and design. XLZ and JWZ has been involved in drafting the manuscript. ZC, YBL and XDW contributed to the acquisition of data. All authors gave final approval of the version to be published.

## **Ethics approval and consent to participate**

This study was approved by the Ethics Committee of Honghui Hospital (No. XAHLLSP0901), and written consent was obtained from all patients.

## **Consent for publication**

Not applicable

## **Competing interests**

The authors declare that they have no competing interests.

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## Tables

**Table 1.** Clinical outcomes in Groups A and B

	Group A	Group B
Bleeding (ml) #	315±84	532±105
Operation time (min) #	107±34	158±55
Total cost (US\$) #	13,830±2640	16,020±3380
VAS*		
Preoperative	7.7±2.1	7.5±1.6
Final Follow-Up	1.4±0.7	1.6±0.8
ODI*		
Preoperative	65.3±11.6	62.2±8.2
Final Follow-Up	13.5±5.7	14.7±7.3

#  $P < 0.05$  between Groups A and B

\*  $P < 0.05$  between preoperative score and final follow-up score in both Groups A and B

VAS: Visual Analog Scale; ODI: Oswestry Disability Index

**Table 2.** Radiologic Outcomes of L4/5 Segment in Group A

	Preoperative	Final Follow-Up
DHR #	0.40±0.13	0.53±0.18
DCS #	34.3±11.2%	15.9±9.3%

#  $P < 0.05$  between preoperative score and final follow-up score

DHR: Disc Height Ratio

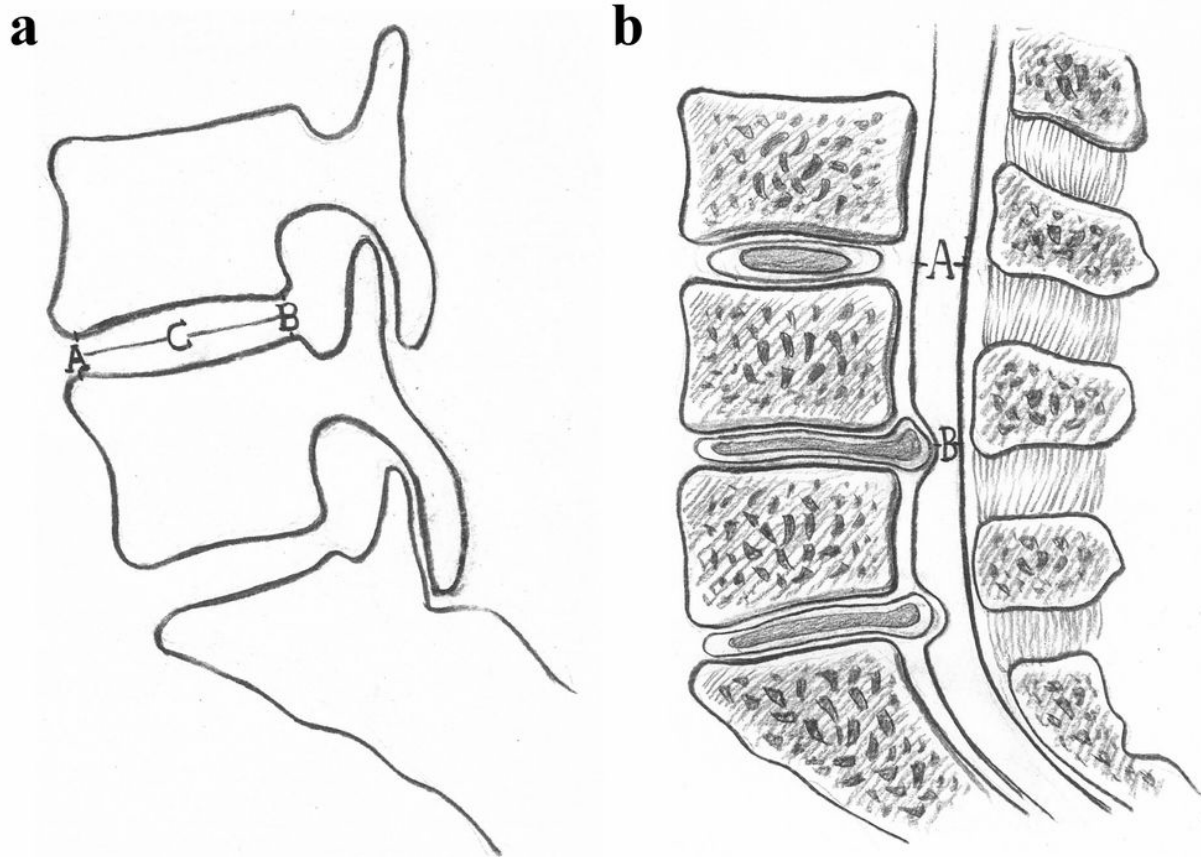
DCS: Degree of Canal Stenosis

## Figures



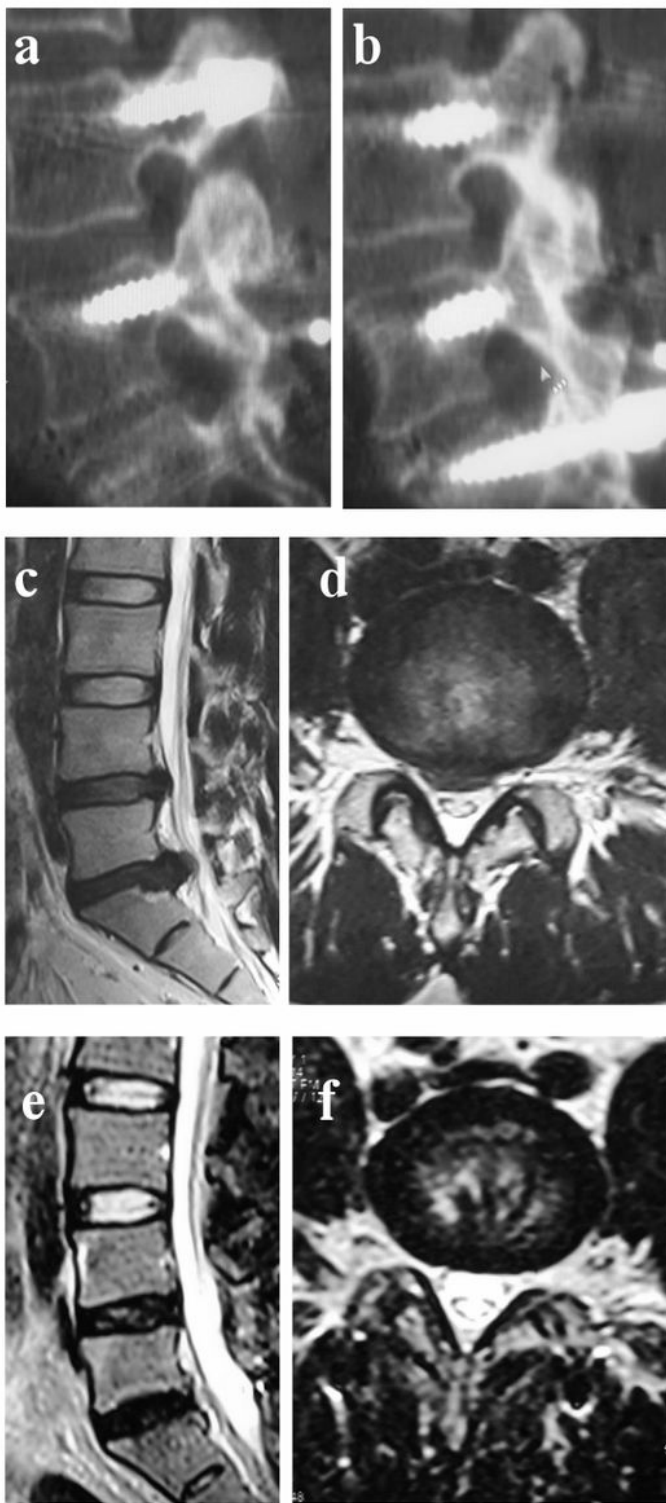
### Figure 1

Figure 1. V-shape osteotomy was carried out on the L4 inferior articular facet and L5 superior articular facet from top to bottom using an osteotome to create a V-shape groove on the both sides of L4/5 segment (a, c). The autogenous bone chips from laminectomy were then implanted into the V-shape grooves (b, d).



**Figure 2**

Schematic drawings of the calculations of disc height ratio (DHR) and degree of canal stenosis (DCS). a,  $DHR=(A+B)/C$ ; b,  $DCS=(A-B)/A \times 100$ .



**Figure 3**

A 54-year-old patient included in Group A was followed up for 5 years. Preoperative MRI demonstrated severe disc degeneration in L4/5 segment (c, d). A standard PLIF in L5/S1 segment (the causative segment), and a distraction of the intervertebral space and facet fusions in L4/5 segment was performed. At the final follow-up, CT showed that complete fusion in L4-5 facets was achieved (facet of the left side,

a; right side, b), and MRI demonstrated that the degree of canal stenosis in L4/5 segment was decreased (e, f).