Risk factors for adjacent segment degeneration after surgical correction of degenerative lumbar scoliosis

Kee-yong Ha, Jong-Min Son[1], Jin-Hyung Im[1], In-Soo Oh[1]

Abstract

Background: Degenerative lumbar scoliosis surgery can lead to development of adjacent segment degeneration (ASD) after lumbar or thoracolumbar fusion. Its incidence, risk factors, morbidity and correlation between radiological and clinical symptoms of ASD have no consensus. We evaluated the correlation between the occurrence of radiologic adjacent segment disease and certain imperative parameters.

Materials and Methods: 98 patients who had undergone surgical correction and lumbar/thoracolumbar fusion with pedicle screw instrumentation for degenerative lumbar scoliosis with a minimum 5 year followup were included in the study. We evaluated the correlation between the occurrence of radiologic adjacent segment disease and imperative patient parameters like age at operation, sex, body mass index (BMI), medical comorbidities and bone mineral density (BMD). The radiological parameters taken into consideration were Cobb's angle, angle type, lumbar lordosis, pelvic incidence, intercristal line, preoperative existence of an ASD on plain radiograph and magnetic resonance imaging (MRI) and surgical parameters were number of the fusion level, decompression level, floating OP (interlumbar fusion excluding L5-S1 level) and posterolateral lumbar interbody fusion (PLIF). Clinical outcomes were assessed with the Visual Analogue Score (VAS) and Oswestry Disability Index (ODI).

Results: ASD was present in 44 (44.9%) patients at an average period of 48.0 months (range 6-98 months). Factors related to occurrence of ASD were preoperative existence of disc degeneration (as revealed by MRI) and age at operation ($P = 0.0001$, 0.0364). There were no statistically significant differences between radiological adjacent segment degeneration and clinical results (VAS, $P = 0.446$; ODI, $P = 0.531$).

Conclusions: Patients over the age of 65 years and with preoperative disc degeneration (as revealed by plain radiograph and MRI) were at a higher risk of developing ASD.

Key words: Adjacent segment degeneration, degenerative lumbar scoliosis, lumbar/dorsolumbar fusion, risk factor

Introduction

Degenerative lumbar scoliosis (DLS) is defined as abnormal curvature of the spine in patients over the age of 18 years.[1] DLS surgery can lead to development of adjacent segment degeneration (ASD) after lumbar and thoracolumbar fusion.[2-8] However, there is no available critical consensus concerning incidence, period of occurrence, correlation between the clinical symptoms and radiographic ASD and the risk factors.

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The purpose of this study was to assess the incidence of radiological ASD, period of the radiological ASD occurrence, clinical, radiographic, surgical risk factors for ASD and the correlation between the clinical results and radiological ASD after spinal fusions for DLS.

Materials and Methods

98 patients, who underwent surgical correction and lumbar/thoracolumbar fusions with pedicle screw instrumentation for DLS from Aug 2003 to Dec 2005 were included retrospectively in this study. We evaluated the correlation between the incidence of radiologic adjacent segment disease and imperative patient parameters [age at operation, sex, medical comorbidities and body mass index (BMI)], radiological parameters [Cobb's

angle, angle type, lumbar lordosis, pelvic incidence, intercristal line, preoperative existence of an ASD as revealed by plain radiograph and magnetic resonance imaging (MRI)] and surgical parameters [number of the fusion levels, operation (OP) type, floating OP and posterolateral lumbar interbody fusion (PLIF)] in order to assess the risk factors of occurrence of radiographic ASD.[3,7,9-15] Inclusion criteria were age above 18 years at the time of surgery with at least one of the defined radiographic criteria. Exclusion criteria included diagnosis of scoliosis with other etiology (idiopathic, paralytic/neuromuscular, or congenital) and age less than18 years at the time of surgery. We defined radiologic ASD as translation greater than 4 mm, angular change greater than 10°, severe collapse of intervertebral disc space, herniated nucleus pulposus and stenosis, vertebral compression fracture and pedicle screw loosening and nonunion [Figures 1 and 2]. Lateral view of plain spine x-rays (standing) and MRI were taken before and after surgery. Full-length radiographs of the spine extending from the base of the skull to the proximal femur in the anteroposterior and lateral planes were obtained. Lumbar lordosis (L1–L5), lumbar scoliosis with Cobb's angle, pelvic incidence and position of intercristal line were measured [Table 1]. The ASD at the time of the procedure was graded using Pfirrmann grade on MRI [Table 2]. Hospital records were reviewed for patients' medical comorbidities and BMI. Clinical outcomes were assessed with the Visual Analogue Score (VAS) and Oswestry Disability Index (ODI).

The period of the disease-free survival in radiological adjacent segment disease was analyzed using the Kaplan–Meier survival analysis with its end point being the occurrence of ASD. We selected the statistically significant parameters for further correlation of the parameters with the occurrence of radiological adjacent segment disease by the logrank test for univariate analysis and the Cox proportional hazards model for multivariate analysis. Correlation between clinical symptoms and radiographic ASD was analyzed using repeated measures analysis of variance (ANOVA) test. P value of less than 0.05 was considered as significant.

Results

44 (44.9%) of the 98 patients had radiographic ASD. The average length of followup was 75.4 months (range 60-102 months). The average age of the patients was 64.4 ± 5.1 years (range 52-78 years). There were 18 men and 80 women.

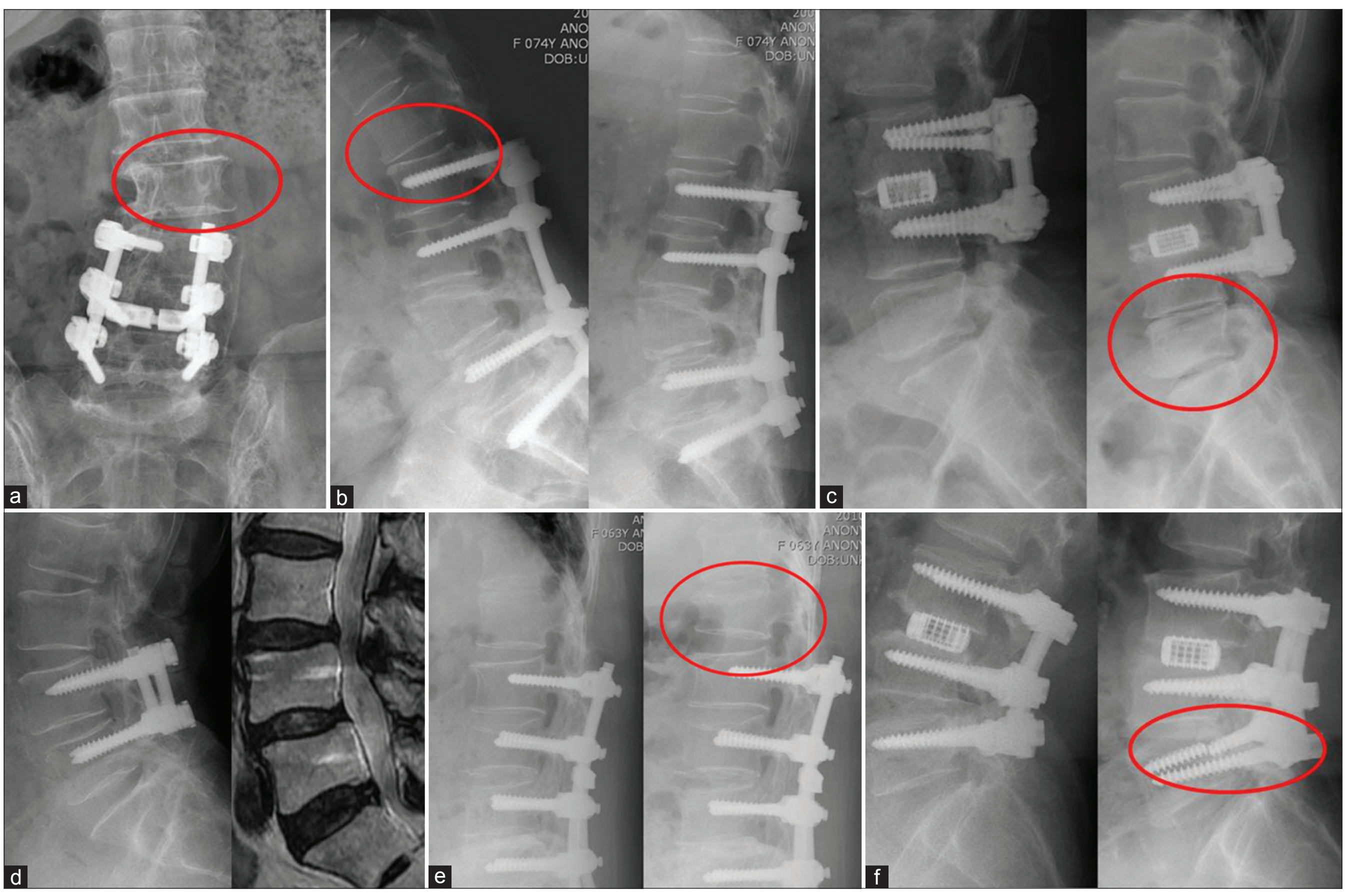

Figure 1: Radiologic ASD: (a) translation greater than 4 mm, (b) angular change greater than 10°, (c) severe collapse of intervertebral disc space, (d) herniated nucleus pulposus and stenosis, (e) vertebral compression fracture and (f) pedicle screw loosening and broken pedicle screws

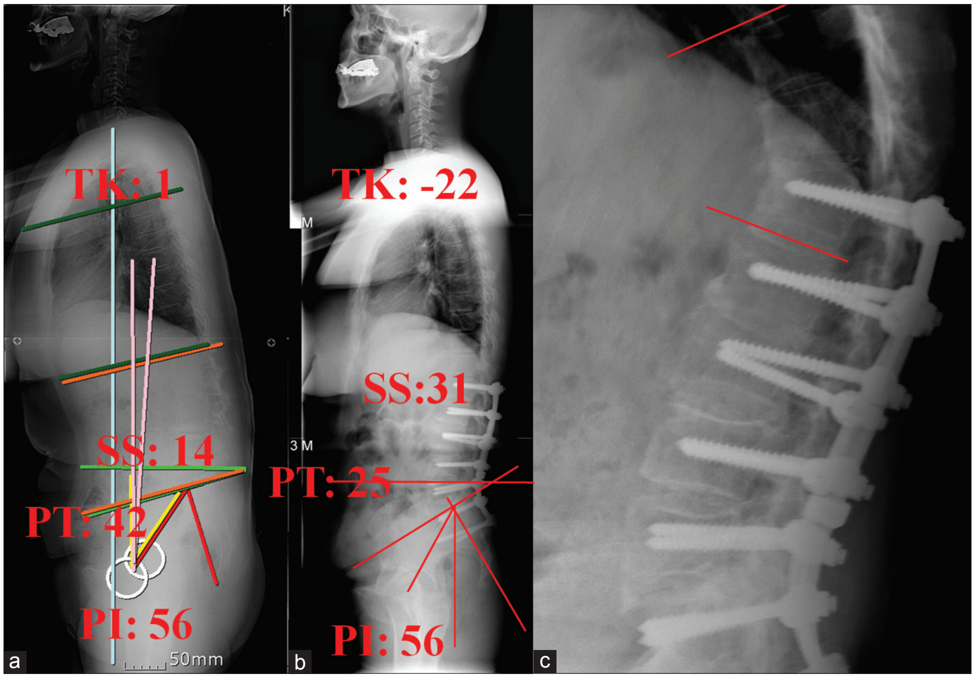

Figure 2: (a, b) Lateral standing radiograph of a 70-year-old woman who had undergone an L2 to sacrum posterior instrumented fusion. Patient presented with severe sagittal imbalance issues and osteoporosis. (c) Final lateral standing radiograph. At 3 years postoperatively, proximal junctional failure was developed

98 patients, 30 had a short fusion including only decompressive laminectomy site, 44 had a short fusion within deformity and not exceeding the end vertebra and 24 had long fusion exceeding end vertebra. The number of levels of fused segments was 3.54 ± 1.41. Disc level degeneration rather than deformity correction was the most relevant factor for us to decide the surgery level. The criteria to choose between short or long fusion was existence of instability besides the MRI findings. Patients' age and degree of osteoporosis were also considered. Before surgery, the average Cobb's angle was 16.83° (range 11.8-42.2°). 52 of 98 patients had additional PLIF. PLIF was used to correct severe deformities such as disc space collapse or instability. Three patients, who had severe sagittal imbalance, underwent additional subtraction osteotomy. Forty three patients had floating fusion excluding L5–S1 fusion and 55 patients were reported to have L5–S1 joint fusion. Among 44, 3 patients had to go through revisional operation.

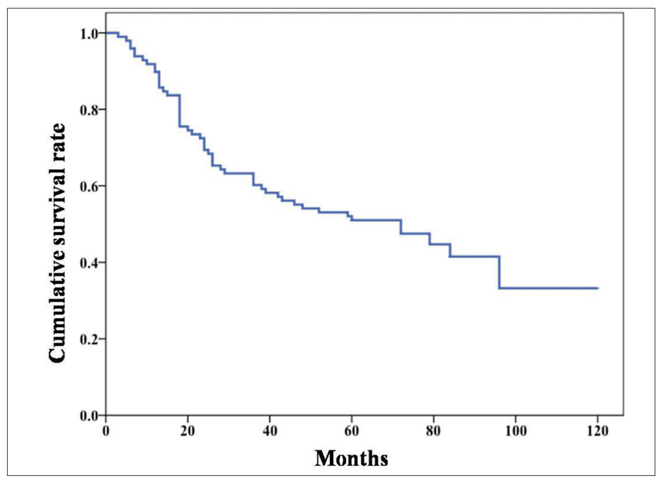

Figure 3: Kaplan–Meier survival curves of patients with adjacent segment degeneration after surgery

Kaplan–Meier survivorship analysis revealed a 1-year "ASD free" rate of 72.0%, a 2-year survival rate of 63.0% and a 4-year survival rate of 52% [Figure 3]. The mean ASD free period of ASD patients was 66.81 ± 5.01 months (95% CI: 56.987-76.631) and the median implant failure free period of ASD patients was 72.00 ± 16.76 months (95% CI: 36.152–104.848). Based on the logrank test, we selected the statistically significant parameters for correlation with the incidence of radiological adjacent segment disease. Factors that were related to ASD occurrence were preoperative existence of an ASD on plain radiograph, disc degeneration on MRI and age at operation ($P = 0.0001, 0.0364$). The mean ODI improved from 65.3 preoperatively to 48.6 at the last visit in the ASD group and in the Non ASD from 71.0 preoperatively to 47.8 at the last visit. The mean VAS improved from 7.8 preoperatively to 4.6 at the last visit in the ASD group and in the Non ASD from 7.3 preoperatively to 4.8 at the last visit. There were no statistically significant differences between the radiological ASD and clinical results (repeated measures ANOVA test: VAS, $P = 0.446$; ODI, $P = 0.531$).

Table 1: Prognostic factors for survival in patients with adjacent segment degeneration after surgery-univariate analysis

Variables	Group	No. of patients	A mean of survival (median, months)	*P* value[a]
Age (years)	<60	57	66.46±6.65 (72.00)	0.0364[b]
	≥65	41	42.85±5.32 (26.00)	
Sex	Male	18	44.71±9.40 (23.0)	0.3031
	Female	80	60.96±5.64 (59.00)	
BMI (kg/m^2)	≥30	58	52.16±5.98 (36.0)	0.0543
	<30	40	61.97±5.45 (73.0)	
Medical comorbidities	Absent	61	66.87±6.49 (72.0)	0.2766
	Present	47	50.65±6.39 (46.0)	
BMD	<3.0	32	66.06±10.51 (96.0)	0.2370
	≥3.5	66	51.29±5.46 (48.0)	
Cobb's angle	<15.0	55	53.97±6.41 (38.0)	0.1480
	≥15.0	43	56.64±4.76 (72.0)	
Lumbar lordosis	<25	34	57.13±6.70 (72.0)	0.3085
	≥25	64	66.09±10.92 (96.0)	
Pelvic incidence	<50	48	42.44±46.30 (21.0)	0.1129
	≥50	50	66.72±6.28 (72.00)	
Intercristal line	≤L4	36	43.68±5.34 (36.0)	0.1544
	L4 level	39	67.19±7.92 (84.0)	
	≥L5	23	52.60±6.72 (72.0)	
Cephalad disc (Pfirrmann grade)	≤Grade 2	47	69.30±5.14 (48.0)	0.0001[b]
	≥Grade 3	51	38.77±4.66 (28.0)	
Caudal disc (Pfirrmann grade)	≤Grade 2	29	70.28±4.80 (76.0)	0.0000[b]
	≥Grade 3	14	33.07±6.41 (23.0)	
No. of the fusion level	≤2	30	59.25±8.79 (38.00)	0.7749
	≥3	68	56.21±14.76 (59.00)	
Decompression level	≤2	54	65.32±6.51 (42.0)	0.7677
	≥3	44	57.13±6.70 (72.0)	
Floating OP	Performed	55	65.32±6.51 (42.0)	0.8936
	Not performed	43	56.85±6.19 (72.0)	
Posterolateral interbody fusion	Not performed	46	54.32±5.22 (42.0)	0.0539
	Performed	52	67.28±7.87 (72.0)	

[a]Statistical significance test was done by logrank test, [b]*P* <0.05 is significant and shown in bold, BMI=Body mass index, BMD=Bone mineral density, BMI=Body mass index, OP=Operation

Table 2: Prognostic factors for survival in patients with adjacent segment degeneration after surgery-multivariate analysis

Variables	HR	95% CI	*P* value[a]
Age	2.027	0.800-5.084	0.132
Cephalad disc (Pfirrmann grade)	2.872	0.809-10.201	0.103
Caudal disc (Pfirrmann grade)	2.929	0.953-9.003	0.061

[a]Statistical significance test was done by Cox proportional hazards model, HR = Hazard ratio, CI = Confidence interval

Discussion

ASD is a debatable late complication of spinal fusion. Nevertheless, the amount and biomechanical factor of ASD and its clinical relevance still remains unclear. Various biomechanical data have shown that posterior lumbar fusion increases the mobility and stress at the adjacent segment and varying incidence of occurrence of ASD after lumbar fusion has been reported in several reports.[2-8] While many *in vivo* animal studies have proposed an important role of biomechanical changes in ASD, clinical studies are still controversial. Based on radiographic analysis, several investigators have argued that ASD is a spontaneously degenerative process rather than a consequence of biomechanical stress.[16-18] On the basis of MRI analysis carried out to evaluate 81 patients, who had undergone anterior interbody fusion, Penta *et al.* suggested that factors relevant to age-dependent degeneration led to development of ASD rather than it occurring as a complication of spinal fusion.[16]

The definition of ASD can be broadly defined as any abnormal process that develops in the mobile segment next to a spinal fusion. A number of studies have provided incidence data for ASD with rates ranging from 5.2% to 100%.[18] Such a broad range of incidence is reflective of the retrospective nature of the studies as well as differing methodologies, definitions of ASD and variable patient population. In many studies, the criteria used to determine ASD were solely based on radiographic findings rather than symptomatology. In our study, we found that 44.9% (44 of 98) of patients who underwent a lumbar or thoracolumbar spinal fusion with pedicle screw instrumentation developed radiographic evidence of ASD on an average of 44 months after surgery. There were no statistically significant differences between radiological ASD and clinical results (repeated measures ANOVA test: VAS, $P = 0.446$; ODI, $P = 0.531$).

The risk factors of ASD include old age, female gender, high BMI, osteoporosis, rigid fusion such as PLIF and pedicular screw system, fusion length, sagittal malalignment and pre-existing adjacent level degeneration.[3,7,9-15,19] Cheh *et al.*[20] stated that patients over the age of 50 years, length of fusion and fusion up to L1-L3 increased the risk of ASD following lumbar/thoracolumbar fusion with pedicle screw instrumentation. However, Ghiselli *et al.*[21] stated that there appeared to be no correlation with the length of fusion or the preoperative degeneration of the adjacent segment. In addition, a few studies have been carried out to evaluate the correlation amongst various other parameters.

In the current study, the incidence of ASD was higher, when patients over the age of 65 years had preoperative cephalad and caudal segment degeneration as revealed by MRI. This implies that the most important parameter associated with determining the extent of the fusion level for DLS to prevent ASD is the amount of adjacent segment disc degeneration with aging process. The condition of the adjacent disc has been considered as another factor implicated in ASD, based on the assumption that an already degenerated disc is more likely to deteriorate.[11,13] Age has been shown to be a significant risk factor and is again likely to be related with the decreased ability of the older spine to accommodate the biomechanical alterations imposed by a fusion. Aota *et al.* observed that the incidence of ASD was much higher in patients older than 55 years of age.[22] Several other clinical studies have further corroborated a trend of increasing ASD as the age progresses.[12,14,15,22] However, if older patients have multiple ASD, it is controversial to perform long fusion to prevent adjacent segment problem. Based on MRI predictions, Balderston *et al.*[23] stated that surgeons who manage deformity might have to consider altering fusion levels at the time of fusion. Moreover, Cho *et al.*[24] stated that short fusion is sufficient for patients with small Cobb's angle and good spinal balance; for patients with severe Cobb's angle and rotatory subluxation, long fusion should be carried out to minimize adjacent segment disease. As long as fusion is likely to increase early perioperative complications, intensive postoperative care should be taken in the case of high-risk patients to avoid complications. We found that all the patients with over Pfirrmann grade IV developed changes in the radiographic adjacent segment. We believe that it is very important to obtain accurate information about adjacent segment before surgery.

The limitations of this study are the relatively short duration of followup and not taking into consideration the scoliotic curve type and sagittal imbalance. The number of patients was limited, retrospective nature and it was not a randomized controlled design.

In conclusion, the presence of disc degeneration and age greater than 65 years seem to be the most significant risk factors for ASD after surgical correction of DLS and should be primarily considered before recommending spinal fusions. Further investigations with respect to determination of the importance of the individual risk factors, particularly risk factors that are modifiable, are required to reduce the development of ASD.

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