



EFFECTS ON ADJACENT SEGMENT AFTER MINIMUM FIVE-YEARS FOLLOWING INSTRUMENTED LUMBAR SPINAL FUSION IN INDIAN POPULATION

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ABSTRACT

Adjacent segment degeneration [ASD] after instrumented lumbar spinal fusion has been studied extensively in non-Indian population. Present study attempts to evaluate incidence of and factors predisposing to ASD in the Indian population. This was a retrospective study with the inclusion criteria being: patients who underwent lumbar spinal fusion for spondylolisthesis, trauma, infection or deformity with a minimum five-year follow-up. Exclusion criteria: postoperative iatrogenic surgical-site infections, revision surgeries, postoperative implant failure and pseudarthrosis. Radiographs reviewed immediate postoperatively, and at final follow-up. Global lumbar lordosis from L1-S1; and angulation and translation of spinal motion segment immediately adjacent [cranial and caudal] to fused segment were studied. ASD was defined using White and Panjabi's criteria. At final follow-up, VAS for lower back as well as lower limbs was noted separately along with walking distance. Twenty patients [49.4+17.4years] included [six males, fourteen females]. ASD was seen in 13 of 20 [65%] patients. Age>50years at the time of surgery and global lumbar lordosis <40° in the immediate postoperative period were identified as significant risk factors for ASD [p=0.02 and 0.03, respectively]. However, no significant correlation was noted between development of ASD and extension of fusion to sacrum. Nor was there any correlation between ASD and gender or length of fusion. It was also notable that no significant differences were identified in VAS scores and walking distance between patients with and without ASD. To conclude, among the various factors studied, age>50years at the time of surgery and immediate postoperative global lumbar lordosis <40° were significantly associated with development of ASD after a minimum follow-up of five years.

KEYWORDS : lumbar, adjacent segment, adjacent segment degeneration, adjacent segment disease

INTRODUCTION

Degeneration of motion segments immediately adjacent to a fused segment is a phenomenon noted quite commonly¹. There has been some debate as to whether these changes represent physiological age-related changes or whether these are secondary to abnormal biomechanics induced by the adjacent fusion¹. In fact, Pellisé F et al noticed that these kinds of changes occur universally across the lumbar spine segments, including in those that are farther off from the fused areas². Adjacent segment disease has also been noted in patients undergoing non-fusion surgeries, calling into question the incrimination of fusion as a causative agent³. However, increased pressure and motion in discs immediately adjacent to fusion have been clearly demonstrated in biomechanical experiments in vitro⁴. A lot of other clinical studies too, echo a similar viewpoint^{1, 5}. Asymptomatic adjacent segment degeneration [ASD] has also been considered to be a harbinger of symptomatic adjacent segment disease [ASDis]. In a meta-analysis, Zhang et al quoted a pooled annual incidence of 5.9% for ASD and 1.8% for ASDis⁵.

Numerous parameters ranging from age, segmental lumbar lordosis, global lumbar lordosis, pre-existing adjacent segment degeneration, preoperative bone mass density, body mass index [BMI], radiological sagittal parameters, osteoporosis, length of fusion and extension of fusion to sacrum have been incriminated as predisposing factors for ASD as well as ASDis^{1, 5}. Although these aspects have been studied extensively, the authors are not aware of any study pertaining to this problem in the Indian population. Hence, the present study was carried out to study incidence and risk factors for ASD and to elucidate association between radiographic ASD and clinical outcome.

MATERIALS AND METHODS

A retrospective study was conducted at a tertiary care referral center for spine surgery between September 2012 to October 2013 after appropriate IRB approval. Inclusion criteria were patients who underwent lumbar spinal fusion for spinal instability due to varied etiology: degenerative, spinal trauma, infection and deformity. Exclusion criteria were patients with postoperative iatrogenic surgical site infections,

previous multiple surgeries, postoperative implant failure or pseudarthrosis and functional overlay.

All patients were operated by a single spine surgeon [YKP]. All patients were operated in the prone position with a standard midline open surgical approach. Care was taken not to violate the facet joint while inserting the cranial pedicle screw. However, the supraspinous attachment between the cranial instrumented vertebra with the immediate cranial vertebra was not retained in any of the patients. No surgical decompression was done at the cranial unfused segment. All patients were treated with posterolateral fusion with additional posterior fusion in areas where laminectomy was not found necessary. Titanium pedicle screws and rods were used in all patients.

Radiographs were done maintaining a uniform distance of 6 feet between the source and the subject. These were taken before surgery, in immediate postoperative period as well as at last follow-up. Additional flexion and extension radiographs in the lateral plane were procured at last follow-up. Global lumbar lordosis from L1-S1 was noted in all radiographs in the standing position, with feet approximated and ensuring that hips and knees were straight, with fists clenched and kept on opposite clavicles. Additionally, angulation and translation of spinal motion segments immediately adjacent to fused spinal segment on the cranial and caudal aspect were studied on dynamic radiographs.

White and Panjabi's criteria [Table 1] were used to define radiographic ASD⁶.

Table 1: White And Panjabi's Criteria For Lumbar Spinal Instability On Dynamic Radiographs

	Inter-vertebral disc space	Angulation	Translation
Adjacent segment degeneration [ASD] is diagnosed if	L1-L2	>150	>4.5mm
	L2-L3	>150	>4.5mm
	L3-L4	>150	>4.5mm
	L4-L5	>200	>4.5mm
	L5-S1	>250	>4.5mm

Visual Analogue Scale [VAS] was used for clinical assessments at final follow up. A 10 mm VAS was used to evaluate outcome. Unbearable pain intensity was recorded as 10, and 0 indicated no pain at all. Scores were done independently for lower back as well as for radicular pain going down into the gluteal region or beyond. Walking distance at last follow-up was assessed for functional outcome⁷. Difference in ASD based on age of the patient at the time of surgery was assessed by grouping into those above and below 50 years of age.

Statistical analysis was done with the help of computer using Epidemiological Information Package [EPI 2010] developed by Centre for Degeneration Control, Atlanta. Chi square test was used to test the significance of difference between quantitative variables while Yate's and Fisher's chi square tests were used for qualitative variables. A two-tailed 'p' value less than 0.05 was considered to denote significant relationship.

RESULTS

Forty-two patients underwent lumbar fusion surgeries in the period mentioned above. Of these, twenty patients [48%] were available for study after a minimum five years following surgery. Mean age was 49.4 ± 17.4 years. There were six males [30%] and 14 females [70%]. Follow-up duration was 72.6 ± 9.8 months with a minimum of 60 months and maximum of 99 months. There were sixteen patients with degenerative spondylolistheses, two patients with degenerative scoliosis, one patient with tuberculosis and one with trauma. VAS Score for lower back at last follow up was 2.4 ± 1.6 [range: 0-5] while it was 0.3 ± 1.3 [range: 0-4] for radicular pain. Walking distance at last follow up was 1.45 ± 1.02 kilometers [range: 0.5-4 kilometers].

Radiological ASD, as per the criteria elaborated in Table 1 was seen in 13 [65%] out of 20 patients. Between angulation and translation, it was noted that the adjacent segments demonstrated instability only in the form of excessive angulation [Fig 1].

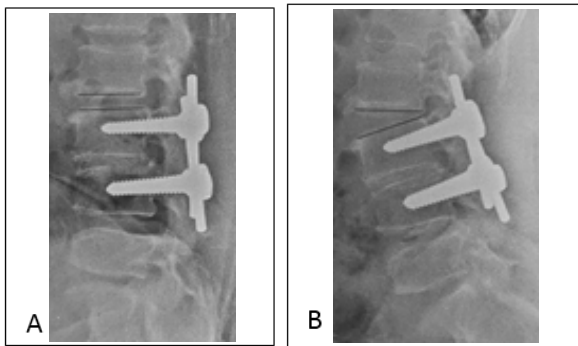


Figure 1: Radiographs Of A Patient Demonstrating Asd In The Form Of Angular Movement At L2-3 Level Exceeding 15°. A: Lateral Radiograph In Full Flexion At Five-years Follow-up. B: Lateral Radiograph In Full Extension At Five-years Follow-up

Eleven out of thirteen patients aged above 50 years at the time of surgery had adjacent segment degeneration whereas two out of seven patients below 50 years of age at the time of surgery had adjacent segment degeneration. This was found to be a statistically significant difference [$p=0.0223$].

Ten patients had global lumbar lordosis less than 40° in the immediate postoperative period. Nine out of these ten patients had ASD as compared to only four out of the other group with global lumbar lordosis more than 40° . This difference was statistically significant [$p=0.0286$].

Four out of six male patients and nine out of fourteen female

patients had ASD. This difference was not statistically significant [$p=0.6641$]. Mean VAS score for back pain in patients with ASD was 2.23 ± 1.64 whereas it was 2.71 ± 1.5 in those without ASD. This difference was not statistically significant [$p=0.4906$]. Mean VAS score for radiculopathy in patients with ASD was 0.46 ± 1.2 whereas it was zero in all those without ASD. This difference too, was not statistically significant [$p=0.287$].

Seven patients had extension of fusion till sacrum while thirteen had at least one motion segment spared caudally. Six out of the former and seven out of the latter group had radiological ASD. This difference too, was statistically insignificant [$p=0.3916$].

Twelve out of sixteen patients with fusion upto three motion segments had ASD. On the other hand, one out of four patients with fusion exceeding three motion segments had ASD. Analysis of this data did not reveal any significant correlation between length of fusion and development of ASD [$p=0.1531$].

DISCUSSION

Data analysis has revealed a 276% increase in elective lumbar fusions in the US for degenerative conditions from 2002 to 2014⁸. Given this increase in the number of fusions, it would be essential to bear in mind the long-term consequences of this procedure in the form of ASD and ASDis.

Kumar MN et al noted that 38% [31 of 83] patients had cranial ASD at an average of 5.2 years following lumbar fusion surgery⁹. Soh J et al also noted ASD in 38% [21 of 55] patients at the end of minimum five years of follow-up¹⁰. Cheh G et al noted ASD in 42.6% [80 of 188] of patients at minimum five-year follow-up¹¹. At the end of a mean follow-up of 4.6 years, Hikata et al noted ASD in 57.4% [31 of 54] patients¹². In a comparative study over a mean follow-up of 3.7 years between lumbar fusion surgery through anterior versus posterior approach, Min JH et al noted ASD in 82.6% [19 of 23] patients who underwent fusion through posterior approach¹³. After a minimum follow-up of five years, Kim KH et al noted ASD in 72.7% [33 of 44] patients with isthmic spondylolisthesis and in 84% [22 of 25] patients with degenerative spondylolisthesis¹⁴.

The present study was carried out to ascertain data related to radiological ASD, based on dynamic flexion-extension radiographs following lumbar fusion surgery in the Indian scenario. Patients were studied over a minimum follow-up period of five years. Assessment of ASD and its correlation to various parameters were studied. Our study revealed ASD in thirteen [65%] out of twenty patients. Between abnormal angulation and translation, patients demonstrated ASD primarily in the form of abnormal angulation in the present cohort.

There can be various reasons for such widely varying incidence of ASD in literature. One of the likely reasons is variation in parameters used to define ASD. Sakaura H et al considered translation more than three millimeters along with posterior opening of more than 5° as criteria for ASD¹⁵. Chen BL et al defined ASD on the basis of dynamic angulation $>5^\circ$ and anteroposterior translation more than three millimeters¹⁶. In a study of 73 patients over fifteen years, Maruenda JI et al considered dynamic angulation greater than ten degrees and anteroposterior translation more than three millimeters as indicators of ASD¹⁷. However, physiological angular motion is not uniform across all the lumbar motion segments⁵. Hence, we felt it more appropriate to apply the radiological instability criteria of White and Panjabi in our study⁶.

It may be argued that ASD incidence was relatively on the higher side in our study because of sacrifice of supraspinous ligament at the cranial adjacent level. In fact, Lai PL et al

suggested that removal of supraspinous ligament at the cranial adjacent level can indeed spike the incidence of ASD¹⁸. However, Yu CH et al carried out a study to identify difference in ASD development between patients who had undergone complete laminectomy with sacrifice of supraspinous ligament at the cranial adjacent level versus those in whom a partial laminectomy was done with retention of this ligament¹⁹. These authors could not identify any difference in the incidence of ASD between the two groups.

In a study of 131 people, Maragkos GA et al noted that there was a lower incidence of ASD in older people²⁰. However, this finding was contradicted in another study of 188 patients by Cheh G et al who found out a higher risk of development of ASD in patients than 50 years¹¹. Aota et al and Rahm et al too, regarded patient's age as a major risk factor for development of ASD^{21,22}. In our study too, we noted similar findings of higher incidence of ASD in patients over the age of 50 years.

Etebar and Cahill suggested that the rate of degeneration at adjacent segments was higher in females after menopause²³. However, Kumar MN et al and Anandjiwala J et al showed no significant influence of gender on ASD in their studies^{3,24}. Our study too, could not identify any difference in the incidence of ASD between males and females.

Cheh G et al as well as Masevmin S et al noted that length of fusion, particularly beyond three lumbar motion segments was a significant risk factor in the development of ASD^{11, 25}. However, Penta M et al performed a radiologic study using plain films and MRI in 52 patients to evaluate relationship between adjacent level disease and fusion length²⁶. At ten-year follow-up, the authors found that 32% of these 52 patients had degenerative changes and that this percentage was not influenced by length of fusion. Wiltse LL et al too, found that length of fusion was not significant in the development of ASD²⁷. Ghiselli et al too, came up with similar findings in their study²⁸. In our study too, we found no significant relationship between adjacent segment degeneration and length of fusion.

In an analysis of 511 patients, Bydon M et al noted that patients who had floating fusion [leaving L5-S1 segment unfused] had a higher likelihood to develop ASD as compared to those with fusion extending upto sacrum²⁹. Similar opinion was expressed by Disch AC et al as well³⁰. However, Liao JC et al conducted a study on 107 patients with degenerative spondylolisthesis at L4-5 level³¹. These patients had pre-existing asymptomatic L5-S1 disc degeneration. The authors, however, could not find any advantage in extending fusion to S1 as compared to performing floating fusion³¹. Similar views of avoiding L5-S1 fusion for the sake of minimizing ASD were expressed by Miyakoshi N et al as well by Ghiselli G et al as well^{32, 33}. In current study too, we found no significant relationship between incidence of ASD and fusion done upto sacrum versus lumbar floating fusion.

Lai PL et al noted no correlation between lumbar lordosis and development of ASD³⁴. Liao JC et al and Chen BL et al too, could not identify any correlation between these two parameters^{16, 31}. However, Umehara S et al reported a human cadaveric study in which they noted increased posterior element stress at the adjacent levels in patients with instrumentation with loss of lordosis³⁵. Bagheri SR et al carried out a retrospective study on 630 patients and noted that patients with ASD had a significantly lower postoperative global lumbar lordosis as compared to the others³⁶. In our study too, it was noted that ASD was more common in patients with global lumbar lordosis [L1-S1] less than 40°.

It is intuitive logic to expect radiological ASD to lead to some form of clinical symptoms³⁷. Yang JY et al noted significant correlation between ASD and clinical outcomes³⁷. However, a study of 98 patients by Ha KY et al led them to conclude that

there is no correlation between ASD and clinical outcome³⁸. Our study too, could not identify any correlation between radiological ASD and clinical parameters in terms of VAS scores for lower back or lower limbs nor with the walking capacity of patients at last follow-up.

The present study, however, has its limitations. The study population has diverse etiology. However, ASD as a phenomenon is being studied to note the effects of fusion on segment adjacent to fusion. In view of this, the authors feel that the same may not be of relevance since fusion as a surgical method was the same in all cases. While patient-reported outcome scores are ideal, we do not have validated outcome scores in local Indian languages making it difficult for patients to fill up these of their own³⁹. Being a retrospective study, full length standing radiographs were not routinely ordered for all patients. Hence, we could not analyze radiological sagittal parameters such as pelvic tilt and sagittal vertical axis nor could we analyze other parameters such as segmental lordosis over the fused segment or spinal stenosis and disc degeneration on MRI. Also, the sample size is small. However, the present study can certainly provide the springboard for further studies in this direction in the Indian population.

CONCLUSIONS

To conclude, radiological ASD is a fairly common phenomenon following lumbar spinal fusion in the long term. It is more commonly observed in patients aged more than 50 years at the time of surgery. It is also more commonly observed in patients in whom the immediate postoperative global lumbar lordosis [L1-S1] was less than 40°. However, the present study could not identify any correlation of ASD to other factors such as gender, length of fusion and extension of fusion till sacrum.

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