Nearby Segment Disease in the Lumber Spine

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Abstract: Background: Between January 2006 and December 2010, Nintey two patients with posterior lumbar fusion(PLF) had the potential for nearby segment (NSD) disease cephalic or caudal to the fusion segment. There is controversy regarding the subsequent degeneration of adjacent segments, and we are aware of no long-term studies that have analyzed both cephalic and caudal degeneration after (PLF). Patients and Methods: The mean age of the patients was 55 (45-65) years, 60 females and 32 males. The average duration of follow-up was 36 to 48 Months. A retrospective investigation was performed to determine the rates of degeneration and survival of the motion segments adjacent to the site of (PLF) .Radiographs were analyzed with regard to arthritic degeneration at the adjacent levels both preoperatively and at the time of the last follow-up visit. Disc spaces were graded on a 4-point arthritic degeneration scale and assessed symptoms from the adjacent segment. Results:. 18 patients of 92 patients included in this study is found to have (NSD) at the cephalic adjacent segment after 3 to 4 years of the (PLF),10 of them met radiologic criteria for (NSD) which defined by; Development of spondylolisthesis >4 mm, Segmental kyphosis >10°, Complete collapse of disc space, or more than 2 grades worsening of Weiner classification and the remeaning 8 patient had symptomatic (NSD) which defined as; symptomatic spinal stenosis, Intractable back pain, or Subsequent sagittal or coronal imbalance ,2 of them had been treated only by decompression and the other 6 with decompression and extension of (PLF) up to the affected segment Conclusion: Symptomatic degeneration at an adjacent segment with (PLF) was after about 36 to 48 months from time of operation, no correlation with the preoperative arthritic degeneration of the adjacent segment but patients whose facet joint at the adjacent segment had a more sagittal orientation had postoperative anterior listhesis, which caused symptomatic (NSD).
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1. Introduction

Lumbar spinal fusion has become a common technique for treating traumatic and degenerative instability of the lumbar spine [(1)]. The clinical feature of degenerative spondylolisthesis is segmental instability with symptomatic compression of a neural element.

Posterior lumbar fusion (PLF) can provide posterior fusion concomitant with no anterior column support, and is a common surgery for degenerative spondylolisthesis. Unfortunately, spinal fusion alters the normal biomechanics of the spine, and a loss of motion at the fused levels is compensated for by increased motion at the unfused segments. The additional stress on the normal segments above and below the fusion leads to degenerative changes [(2,3,4,5,6)]. Biomechanical studies have documented the increased prevalence of degenerative disease adjacent to the fusion [(7,8,9,10,11)]. Recently, The objectives of the present study were to estimate the incidence, prevalence and rate of degeneration of the adjacent Segments in the lumbar spine following posterior lumbar arthrodesis, both radiographically and symptomatically, and to determine which lumbar segments are at the greatest risk for new symptoms.

2. Patients and methods

This was a retrospective study of 92 patients who underwent PLIF for lumber degenerative spondylolisthesis between 2006 and 2010. The follow-up rate was 100%. The patients were 32 men and 60 women, with a mean age of 55 years at surgery (range, 45–65y), and an average follow-up period of 42 months (range, 36–48 mo). All patients underwent only one level lumber spine fusion.63 patients underwent L4-5 ,19 L5-S1,6 L3-4 and 4 L2-3 level. All patients undergo evaluation to the cephalic disc space according to university of California at los Anglos grading scale for intervertebral space degeneration. None of those patients had an acute fracture, dislocation, a neoplasm, or were scheduled to have an additional anterior surgical procedure. Patients were not included in the radiographic analysis if preoperative radiographs from the time of the index arthrodesis were not available. The indication for the index posterior lumbar arthrodesis include:

1- Progressive spondylolisthesis in 42 patients.
2- Degenerative in 23.
3- Progressive lumbar scoliosis in 2.
4- Iatrogenic instability resulting from an extensive decompression in 18.

5- The occurrence of two or more episodes of disc herniation at the same level in7.

The arthrodesis was performed at all levels associated with clinical signs and symptoms and at which neural element compression was demonstrated on neuroradiographic images. The diagnosis of (NSD) was based on the presence of The instability, radiculopathy, or spinal stenosis that was symptomatic enough for the patient to elect revision surgery. The criteria for arthrodesis as opposed to decompression at an adjacent segment were the same as those previously listed for the index arthrodesis.

All patients returned for regular postoperative visits that involved a radiographic assessment and an examination by the author. The persistence of symptoms, work status, functional status, the use of pain medication, and the findings of a complete neurological examination were documented.

The outcome at each follow-up visit was rated as excellent, good, fair, or poor on the basis of a modified function scale of Whitecloud TS and Hilibrand AS (Table I).

The fusion was performed with autologous local bone and instrumentation with rods and pediclescrews. Bone union was achieved in 90 patients about(98%) only two cases (2%) show no bone union.We measured the lumbar lordosis at L1-S1, laminar inclination angle at lumber vertebrae above the level of fusion , facet sagittalization, facet tropism and lordosis at the cephalic level. Percent of listhesis at the fused segment and height of the fused segment [12,13].

The height at the fused segment was calculated from the midpoint of the upper line of the vertebra above to the midpoint of the lower line of vertebra below on the lateral radiograph (Fig. 1C)[15]. The distraction at fused segment was defined as (fused segment vertebral height after surgery)_(fused segment vertebral height before surgery).

Radiologic.

Standard biplanar anteroposterior, lateral, flexion, and extension radiographs of the lumbosacral spine from the pre- operative visit as well as from the last postoperative visit were reviewed for each patient, lateral radiographs demonstrating neutral, flexion, and extension views were measured for anteroposterior translation and intervertebral disc height at each lumber segment The amount of lumbar degeneration was classified, according to the University of California at Los Angeles grading scale.

The findings from the measurements were analyzed statistically using simple regression analysis, Student test, the w2 test, and Fisher exact test. A *P*-value<.05 was defined as statistically significant

3. Results

Eighteen patients of the 92 patients involved in this study are found to have(NSD) at the cephalic adjacent segment after 36 to 48 months of the PLF. 10 patients of the 18 met radiologic criteria for (NSD) showed radiographic evidence of (NSD) at the level above the fusion. 8 patients of the 18 patient had symptomatic NSD. Clinically and radiographically NSD was manifested in the vertebra above the fusion as anterolisthesis in 1 patients and retrolisthesis in 2 and as narrowing of the disk space by more than 3mm in 5 patients.

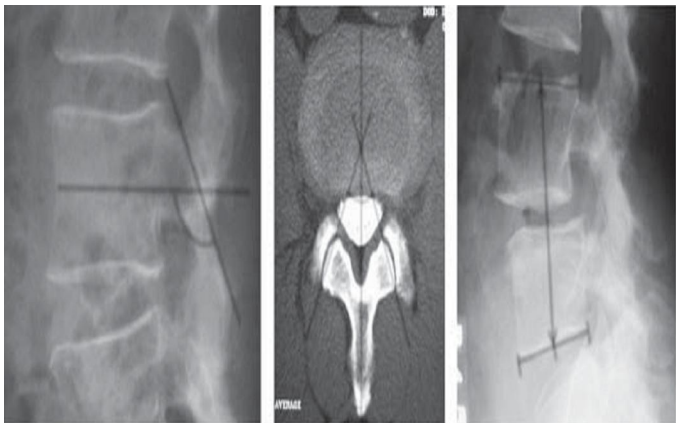
Successful fusions with no instrument failure were demonstrated in all 8 patients. six patients had radiculopathy, and the other 2 had cauda equina syndrome. The average period between the primary surgery and neurologic deterioration was 42 months (range,36-48 mo). A second operation was performed for all of them after trial of conservative treatments, such as medication, epidural block, and nerve root block, were ineffective. The second operation was PLF for 6 patients and additional laminectomy for 2.

New-onset disease at. the L2-L3 interspace was 2.7 times lower than that at the L4-L5 level, which had the highest prevalence. The L5-SI interspace had a relatively low risk of subsequent degeneration, with a prevalence .of 7.2%.

Cox regression analysis showed no significant correlation between adjacent segment disease and diagnosis (p = 0.34), age at the time of surgery (p = 0.13), gender (p = 0.92), or instrumentation (p = 0.47), with the numbers available. The Fisher exact test showed a trend but no significant correlation between preexisting radiographic degeneration and (NSD) (p = 0.115). Contrary to our hypothesis, segments that were adjacent to a single-level fusion had a three times higher risk for the development of disease than did those that were adjacent to a multiple level fusion (Cox proportional hazards model, 3.4; 95% confidence interval, 1.83 to. 6.23; $p < 0.001$).

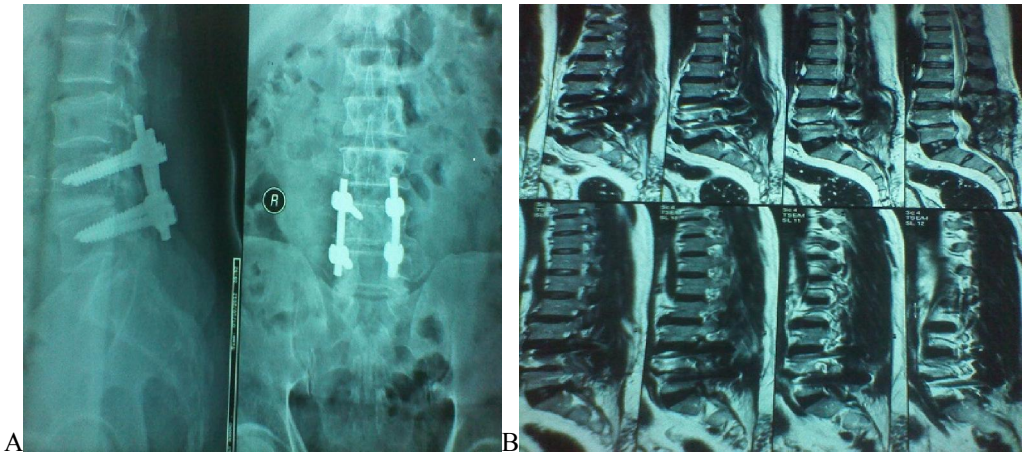
Table I: criteria for the assessment of the out come.

Outcome	Pain	Medication	Activity	Work Status
Excellent	None except for occasional back pain	None	Normal	Normal
Good	Markedly improved, occasional pain	Occasional use of pain medication	Minimal functional limitations	Return to work, although not at the same job activity
Fair	Some improvement	Frequent use of pain medication	Restricted	Limited
Poor	No change in symptoms or a worsening of the patient's condition	Oral use of narcotics	Incapacitated	Disabled



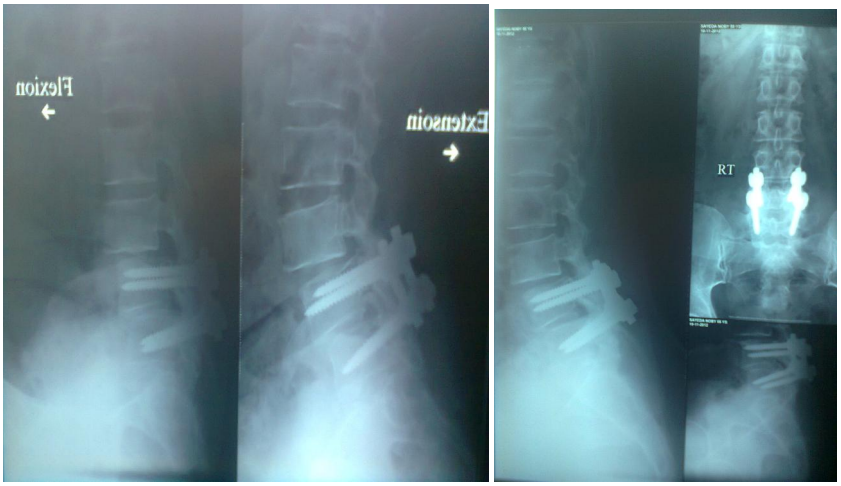
A B C

Figure 1. Measurement of radiographic parameters. A, The L3 laminar inclination angle (a) was defined as the angle formed by a straight line connecting the base of the superior facet with the base of the inferior facet and a straight line connecting the midpoints of the anterior and the posterior vertebral cortices. B, Facet sagittalization and facet tropism at L3/4 were, respectively, defined as the sum of the right and the left facet angles (b + c) and the difference between these angles (b_c), respectively. C, The L4-5 height (d) was measured from the midpoint of the upper edge of the L4 vertebra to the midpoint of the lower edge of the L5 vertebra.



A B

Figure 2: Anteroposterior and lateral radiographs and MRI of a 55-year-old man showing. a) PLIF 3yrs ago at L4-5 lumber spine with ASD of L3-4 level. b) MRI shows LCS at L3-4 level.



A

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Figure 3: Antero-posterior,lateral ,dynamic radiographs and MRI pre and post operative of 53-years-old female showing. a) anteroposterior,lateral ,dynamic flexion and extension views preoperative with PLIF L4-5 level of lumber spine 4 years ago with Lithesis L3-4 level. b) MRI preoperative. C) Postoperative plain x ray antroposterior and lateral views after decompression and PLIF of the L3-4 level.

4. Discussion

The continued degeneration of motion segments adjacent to lumbar spinal fusions is a potential concern for both patients and surgeons and accounts for a substantial percentage **o**f revision spine surgery._AIthough the development of adjacent segment degeneration can be considered part of the normal aging and degenerative process, this phenomenon appears to be at least partly influenced by the altered stresses that arise as a consequence of lumbar fusion [(14)].

NSD after spinal (PLF) has become one of the most common postoperative problems. NSD is a condition in which the motion of the segment adjacent to the fused segment degenerates because of hypermobility and increased biomechanical stress. Recently, Ekman *et al.* [(14)] showed that fusion accelerates degenerative changes at the adjacent level compared with the natural history, in a long-term randomized clinical trial. Here, we examined the risk factors for radiographic and symptomatic NSD after Lumber (PLF).

Aota *et al.,* and Kumar *et al.* [(15,16)] demonstrated that retrolisthesis was the most frequent type of radiologic (NSD) after spinal (PLF) without decompression surgery at the adjacent level. Tuite *et al.* [(18)] demonstrated that disc-space collapse was a more pronounced change after laminectomy, compared with the progression of spondylolisthesis and disc-space angle change. In contrast, Lai and colleagues [(19)] showed that damaging the integrity of the posterior complex between the fused segment and the neighboring motion segments may jeopardize lumbar spine stability. Sacrificing either the supraspinous ligament or the tendon insertion points on the spinous processes leads to the accelerated development of adjacent instability.

We found that the risk factors for symptomatic (NSD) after (PLF) were loss of lordosis at the fused segment and a more sagittal orientation of the facet

joint at cephalic segment. Schlegel *et al.* [6] hypothesized that the imbalance of the sagittal alignment caused by lumbar fusion induces degeneration at the adjacent segment by excessive motion at that level. Oda *et al.* [20] indicated that a kyphotic fusion may lead to degenerative changes in the cranial adjacent facet joints. Akamaru *et al.* [21] demonstrated in human cadavers that hypolordotic alignment at L4-5 causes the greatest amount of flexion extension motion at L3-4. sagittal realignment and maintenance of lordosis during fixation have been documented in clinical studies, and clinical experience suggests that lumbar fusion in a non-anatomic sagittal alignment can be deleterious at the adjacent segment level .Grober et al [12] demonstrated that patients with degenerative spondylolisthesis showed a significantly more sagittal facet orientation compared with both the normal population and spinal stenosis patients. They hypothesized that patients are predisposed to develop degenerative spondylolisthesis by a developmental sagittal orientation of the facet joints. Our radiologic assessment showed that anterior listhesis often developed in the symptomatic (NSD). Therefore, we hypothesize that patients with a more sagittal orientation of the facet joint at cranial level are predisposed to anterior listhesis (PLF), and develop symptomatic (NSD). Patients showing mild degeneration of the adjacent segments may be treated with a wider decompressive procedure, because the myelogram or magnetic resonance imaging will display mild stenosis at the adjacent segment. Levels that are decompressed but not included in the fusion could, theoretically, be more susceptible to stress and more likely to degenerate.(5) The motion segment just above the fused segment is the most common level of adjacent instability [21,22,24]. Aota *et al.* [15] showed that the incidence of post fusion instability was 24.6% at the last follow-up (average 39 mo), and that instability developed more frequently at the adjacent segment above the fusion.

In contrast, Aiki *et al.* (24) showed that decompression of the adjacent segment is not a significant risk factor for subsequent instability. Imagama and colleagues showed that artificial ligamentous stabilization is preventive for upper adjacent segment impairment after (PLF). Soft stabilization therefore might be able to prevent disk degeneration and spinal canal stenosis[25]. Tomohiro Hikata et al. [25] found that simultaneous decompressive surgery at the adjacent level (L3-4) when fused level was(L4-5) in patients with a more sagittal orientation of the (L3-4) facet joint tended to result in anterior listhesis at (L3-4), and the development of symptomatic NSD. Therefore, the simultaneous decompression surgery without fusion at the adjacent level was not effective for these patients, burather it seemed likely that it induced symptomatic (NSD). The presence of a circumferential fusion, which increases the stiffness of the fused segment compared with a posterior-only fusion, did not increase the incidence of NSD. Similar results were found by Penta *et al*.[12] who also found that anterior lumbar interbody fusions did not increase the rate of adjacent segment degeneration in a study of 52 patients (with a normal adjacent disc on discography) who were followed for a minimum 10 years following surgery. Specifically, they found that the prevalence of disc degeneration was 32% adjacent to a fusion compared with 30.7% in the discs of unoperated patients. The findings that anterior fusion does not increase (NSD) has been again confirmed at the 20-year follow-up study of the same institution [26].

In this study, we included new-onset substantial mechanical back pain and sagittal and/or coronal imbalance as possible symptoms of NSD. Other studies, however, sometimes do not consider back pain as a possible symptom of NSD since it is difficult to differentiate back pain from NSD to that from generalized spondylosis. Second, the severity of spinal stenosis has a wide spectrum, and some patients require no treatment at all, some nonoperative treatment such as medication and/or injections, and others surgical intervention due to severe symptoms. The need for revision surgery is a good indicator of severe spinal stenosis symptoms. In our analysis, we used revision surgery as a marker for severe spinal stenosis, which may underestimate the incidence of NSD.

Conclusions

The rate of symptomatic degeneration at an adjacent segment with (PLF) was about 19.5% after about 36 to 48 months from time of operation. There appeared to be no correlation with the preoperative arthritic degeneration of the adjacent segment. Patients whose facet joint at the adjacent segment had a more sagittal orientation had postoperative anterior listhesis, which caused symptomatic NSD.

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