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To Include S1 Screws or Not in Fixation of L4-5 Spondylolisthesis Associated with L5-S1 Degenerative Disc Disease

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Abstract

Background: The main goal of management of L4-5 spondylolisthesis is reduction and fixation of the mobile vertebrae to reduce back pain and relief neurological compression. If the patient has in addition, L5-S1 degenerative disc, there is always a debate about including S1 vertebra in the fusion surgery or not.

Aim of Study: To compare the L4-5 fusion (floating fusion) and the L4-5-S1 fusion (sacral fusion) in the surgical management of L4-5 spondylolisthesis associated with degenerative L5-S1 disc as regard outcome and complications of both techniques.

Patients and Methods: The study included 60 patients having L4-5 spondylolisthesis associated with L5-S1 degenerative disc. Patients were followed-up clinically and radiologically for at least 6 months. Data were collected and statistically calculated.

Results: Thirty patients were operated for L4-5 fusion and 30 patients were operated for L4-5-S1 fusion. Sacroiliitis was highly significant in group that underwent sacral fusion than group with floating fusion. 40% of patients operated for sacral fusion were complicated by sacroiliitis, while only 16% in patients operated for floating fusion. The group that had sacral fusion reported higher adjacent segment disease 30% than the group that had floating fusion 23%. Sacroiliitis was reported more in female patients where 70% of sacroiliitis cases were females. Adjacent segment disease occurred more in females, 62.5% of cases with adjacent segment disease are in female patients. Sacroiliitis was significantly affected by Body mass index, as the mean BMI among patients with sacroiliitis was 31±2 compared to 29±2 among patients without sacroiliitis. The mean BMI for patients with adjacent segment disease was 31.44±1.22, while the mean BMI for patients without adjacent segment disease was 28.67±2.73, this significantly indicates a relation between increasing in body mass index and occurrence of ASD.

Conclusion: L4-5-S1 fixation carries more risk of occurrence of sacroiliitis and ASD than isolated L4-L5 fixation.

Key Words: Floating fusion – Sacral fusion – Sacroiliitis – Adjacent segment disease.

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Introduction

THE two predominant types of adult spondylolisthesis are degenerative spondylolisthesis, which stems from disc degeneration and facet joint arthropathy, and isthmic spondylolisthesis, which involves defects in the pars interarticularis. Surgical treatment primarily aims to decompress the neural elements and stabilize the affected vertebral segments, which are often compromised by instability and nerve compression. Among the various surgical techniques available, segmental fusion is one of the most widely adopted and well-researched methods. However, this approach may contribute to biomechanical stress on adjacent spinal segments, potentially accelerating degenerative changes in these areas **[1,2]**. Therefore, it has been proposed that a major contributing factor to the development of adjacent segment disease (ASD) following fusion is biomechanical stress on the disc and facet joints at the neighboring segments **[1,2]**. Such stress is considered a significant factor in the development of adjacent segment disease (ASD), a complication that can lead to additional surgeries and negatively affect patient outcomes, despite its partial association with natural aging. Several studies have identified risk factors for ASD beyond segmental fusion itself, including laminectomy, advanced age, existing degeneration in neighboring segments, and the overall length of the spinal fusion **[3,4]**. Notably, degeneration at the L5-S1 level appears to be linked with spondylolisthesis at the L4-L5 level, particularly among older individuals, where L5-S1 changes are often more prominent than other types of degeneration. When spinal fusion is planned for L4-L5 spondylolisthesis in patients who already exhibit L5-S1 degeneration, this factor can influence surgical planning and long-term outcomes, as unresolved symptoms at L5-S1 may necessitate further intervention **[7]**. Despite its clinical relevance, only

limited research has focused on the progression of caudal segment degeneration after fusion of upper segments, especially above L5-S1. Most existing studies emphasize cranial adjacent segment degeneration **[8]**. Furthermore, investigations into L5-S1 disc height variability following isolated L4-L5 fusion have not demonstrated a strong correlation with clinical outcomes **[8-10]**. Determining whether to include L5-S1 in fusion procedures remains a challenging decision, particularly when attempting to distinguish between pathological degeneration and age-related changes **[8]**. Additionally, the involvement of the sacrum in spinal fusion may have biomechanical stresses on the sacroiliac joint. Fusion at or near this joint has been associated with increased stress and may contribute to sacroiliac joint pain, especially as the number of fused vertebral segments increases **[11]**.

Patients and Methods

This study represents prospective and retrospective study of clinical and radiological outcomes in 60 patients admitted to the Neurosurgery Department of Alexandria Main University Hospital From November 2023 – November 2024 and operated for L4-L5 spondylolisthesis associated with L5-S1 degenerative disc disorders either by Posterior Lumbar Interbody Fusion (PLIF) with pedicle screw fixation L4-L5 or L4-L5-S1.

Inclusion criteria:

- Adults aged 18 years old or older.
- Patients having L4-L5 instability associated with L5-S1 degenerative disc.
- Patients were willing to participate and were capable of providing informed consent.
- Patients with preoperative and postoperative imaging data are available for review.

Exclusion criteria:

- Normal looking L5-S1 disc in MRI.
- L5-S1 spondylolisthesis.
- Patients with systemic inflammatory or autoimmune disease that can affect the spine.

Ethical approval and consent to participate:

All procedures performed in the study involving human participants were in accordance with the ethical standards of the institution and approved by the Ethics Committee of Alexandria University.

Statistical analysis:

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp). Qualitative data were described using number and percent. The Shapiro-Wilk test was used to verify the normality of distribution Quantitative data were described using range (minimum and maximum), mean, standard deviation, median and interquartile range (IQR). Significance of the obtained results was judged at the 5% level.

The used tests were:

1- Chi-square test:

For categorical variables, to compare between different groups.

2- Fisher's Exact:

Correction for chi-square when more than 20% of the cells have expected count less than 5.

3- Student t-test:

For normally distributed quantitative variables, to compare between two studied groups.

4- Paired t-test:

For normally distributed quantitative variables, to compare between two periods.

Results

A total of 60 patients who underwent lumber spine fusion surgery either by L4 - L5 fusion (floating fusion) or L4 - L5 - S1 fusion (sacral fusion) in the Neurosurgery Department at Alexandria Main University Hospital are included in the study. All patients are diagnosed as having L4-L5 spondylolisthesis associated with L5-S1 degenerative disc.

Patients are divided into two groups each group consists of 30 patients, first group included the patients operated for L4-L5 fixation and interbody fusion, while second group patients included those operated for L4-L5-S1 fixation and interbody fusion.

The patients are followed clinically and radiologically after surgery and complications such as sacroiliitis and ASD are reported.

Sacroiliitis was highly significant in group that underwent sacral fusion than group with floating fusion. 40% of patients operated for sacral fusion were complicated by sacroiliitis, while only 16% in patients operated for L4 – L5, (Table 1).

Female patients accounted for more than 70% of sacroiliitis cases. The mean age of patients that developed sacroiliitis was significantly higher than the mean age of patients that did not develop sacroiliitis. (57±4 years compared to 51±8 years). Sacroiliitis was also significantly associated with Diabetes

as 58.0% of patients that developed sacroiliitis were diabetic compared to 28.0% of patients that did not suffer from sacroiliitis (Table 2).

Sacroiliitis was significantly affected by Body mass index, as the mean BMI among patients with sacroiliitis was 31±2 compared to 29±2 among patients without sacroiliitis.

The group that had sacral fusion reported higher adjacent segment disease than the group that had floating fusion. Compared to 23% of patients who had surgery for L4–L5, 30% of patients who had sacral fusion had adjacent segment disease (Table 3)

62.5% of cases with adjacent segment disease are in female patients. The mean age of patients those developed adjacent segment disease was higher than the mean age of patients did not developed adjacent segment disease (58.14±6.52 years compared to 50.47±6.11 years). The mean BMI for patients with adjacent segment disease was 31.44±1.22, while the mean BMI for patients without adjacent segment disease was 28.67±2.73, this significantly indicates a relation between increasing in body mass index and occurrence of ASD (Table 4).

Table (1): Relation between the type of fusion and occurrence of sacroiliitis.

Post-operative	L4–L5 fusion (n = 30)		L4–L5–S1 fusion (n = 30)		*p*
	No.	%	No.	%	
Sacroiliitis:					
No	25	83.3	18	60.0	0.045*
Yes	5	16.7	12	40.0	

Table (2): Relation between demographic criteria and associated diseases and occurrence of Sacroiliitis.

Total sample	Sacroiliitis (SIJP)				*p*
	No (n = 43)		Yes (n = 17)		
	No.	%	No.	%	
Age (years):					
Mean±SD	51.32±8.14		57.40±3.58		0.018*
Gender:					
Male	22	51.2	4	23.5	0.052
Female	21	48.8	13	76.5	
BMI (kg/m^2):					
Mean±SD	29.32±3.03		31.22±2.33		0.023*
DM	12	27.9	10	58.8	0.025*
Hypertension	13	30.2	4	23.5	^{FE}p=0.755

Table (3): Relation between the type of fusion and occurrence of ASD.

Post-operative	L4–L5 fusion (n = 30)		L4–L5–S1 fusion (n = 30)		*p*
	No.	%	No.	%	
ASD:					
No	23	76.7	21	70.0	0.559
Yes	7	23.3	9	30.0	

Table (4): Relation between demographic criteria and associated diseases and occurrence of ASD.

Total sample	ASD				*p*
	No (n = 44)		Yes (n = 16)		
	No.	%	No.	%	
Age (years):					
Mean±SD	50.47±6.11		58.14±6.52		0.517
Gender:					
Male	20	45.5	6	37.5	0.582
Female	24	54.5	10	62.5	
BMI (kg/m^2):					
Mean±SD	28.67±2.73		31.44±1.22		0.003*
DM	16	36.4	6	37.5	0.936
Hypertension	13	29.5	4	25.0	^{FE}p=1.000

Discussion

Instrumented lumbar fusion is widely regarded as the gold standard in managing lumbar spine instability. However, the biomechanical changes that follow this procedure may influence adjacent intervertebral discs and facet joints **[7]**. Patients commonly present with symptoms such as lower back pain, sciatica, and neurogenic claudication, frequently linked to L4-L5 spondylolisthesis and L5-S1 disc degeneration. Initial management typically involves conservative measures, which benefit a significant proportion of patients. Surgery is usually reserved for cases where symptoms become disabling and interfere with daily functioning.

When treating patients with L4-L5 spondylolisthesis alongside L5-S1 degeneration, surgical decision-making becomes particularly challenging, as outcomes following isolated L4-L5 fusion may be compromised by unresolved issues at the L5-S1 level. In the present study, sacroiliitis was observed in 40% of patients who underwent fusion at L4-L5-S1, aligning with findings from previous research reporting incidence rates between 16% and 43%. Studies have demonstrated a significantly higher

risk of sacroiliac joint degeneration in patients with sacral involvement compared to those with "floating" fusions that exclude the sacrum. The sacroiliac joint, being in close proximity to the fusion site, may contribute to persistent low back pain postoperatively [12].

Furthermore, fusing multiple spinal segments increases the risk of sacroiliac joint dysfunction, regardless of sacral inclusion. This is likely due to reduced spinal flexibility, which heightens biomechanical stress on the sacroiliac joint [13].

In this study, we compared sacroiliac joint pain after fusion surgeries involving and excluding the sacrum. We found that patients who underwent fusion including the sacrum had a significantly higher incidence of postoperative sacroiliac joint pain (40%) compared to those with fusion limited to L4-L5 (16.7%).

Age-related spinal changes such as disc height loss and increased rigidity may make older individuals more vulnerable to postoperative complications. In our analysis, patients who developed sacroiliitis had a higher average age (57.40±3.58 years) compared to those without this complication (51.32±8.14 years). Additionally, those with sacroiliac joint pain had a higher mean body mass index (BMI 31.22±2.33) compared to unaffected patients (BMI 29.32±3.03). Increased spinal loading due to obesity may exacerbate stress on adjacent joints, ligaments, and muscles, contributing to disc height reduction and impaired shock absorption [14].

Comorbid conditions such as diabetes also appear to elevate the risk of sacroiliitis. In our cohort, 58.8% of patients who developed sacroiliitis were diabetic, compared to 27.9% in the non-complicated group, suggesting a significant association [15].

Age also emerged as a key factor in the development of adjacent segment disease (ASD). According to Wang et al., natural degenerative changes associated with aging such as decreased disc elasticity and increased stiffness may predispose older patients to [14]. In our sample, those who developed ASD had a mean age of 58.14±6.52 years, whereas the unaffected group averaged 50.47±6.11 years. Although female representation was relatively high in both groups (62.5% in the ASD group vs. 54.5% in the non-ASD group), this difference was not statistically significant. Notably, patients with ASD also had a higher average BMI (31.44±1.22) compared to those without (28.67±2.73), further reinforcing the role of mechanical stress in adjacent segment degeneration.

Conclusions:

Sacral fusion carries more risk of occurrence of sacroiliitis and ASD than isolated L4-L5 fusion.

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اشراك الفقرة العجزية الأولى أو لا فى تثبيت التزحلق الفقارى بين الفقرة الرابعة والخامسة القطنية والتى يصاحبها مرض القرص التنكسى بين الفقرة الخامسة القطنية والأولى العجزية

فى هذه الدراسة قمنا بعرض نتائج التدخل الجراحى لمرضى التزحلق الفقارى بين الفقرة الرابعة والخامسة القطنية والتى يصاحبها مرض القرص التنكسى بين الفقرة الخامسة القطنية والأولى العجزية وذلك عن طريق تقسيم المرضى إلى مجموعتين : المجموعة الأولى وتشمل ثلاثين مريض تم لهم إجراء الجراحة عن طريق تثبيت الفقرة الرابعة والخامسة القطنية والمجموعة التانية وتشمل ثلاثين مريض تم لهم إجراء الجراحة عن طريق تثبيت الفقرة الرابعة والخامسة القطنية والأولى العجزية وتمت متابعة المرضى اكلينيكياً والأشعات لمدة ستة اشهر، أوضحت الدراسة وجود أفضلية للعلاج عن طريق تثبيت الفقرة الرابعة والخامسة القطنية فقط حيث انها أقل فى نسب حدوث المضاعفات وخاصة التهاب المفصل العجزى الحرقفى وكذلك مرض القرص المجاور.