

# Long-Term Outcomes of Fusion vs Non-Fusion Surgeries for Lumbar Spondylolisthesis

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## ABSTRACT

**Objectives:** 1). To compare the long-term clinical, radiological, and functional outcomes of fusion and non-fusion surgeries for lumbar spondylolisthesis (LS), focusing on pain relief, disability reduction, and overall effectiveness of each approach.

**Methodology:** This retrospective study was conducted at Hayatabad Medical Complex, Peshawar, from January to December 2023. A total of 100 patients (50 in the fusion group and 50 in the non-fusion group) were included. Pre- and post-operative pain (VAS for leg and back pain) and disability (ODI) scores were collected at 1, 6, and 12 months after surgery. Statistical analysis was performed using paired t-tests to assess the significance of differences between pre- and post-operative measures.

**Results:** The mean age of the patients was  $10.2 \pm 5.1$  years, with 51% males and 49% females. The most common management strategies were lumbar drainage (37%) and duraplasty (28%). Tumour resections more frequently required revision surgery (24%) compared to Chiari malformation decompressions. A significant statistical association ( $p = 0.0286$ ) was observed between surgery type and CSF leak management strategy. Outcomes showed that lumbar drainage had a higher incidence of recurrence (15%) and pseudomeningoceles (5%) compared to duraplasty, which had a 90% success rate in resolving CSF leaks.

**Conclusion:** Both fusion and non-fusion surgeries led to significant improvements in pain and disability. These results suggest that non-fusion surgery is a viable alternative to fusion for the treatment of LS, providing substantial benefits in terms of pain relief and functional outcomes.

**Keywords:** Fusion surgery, Lumbar Spondylolisthesis (LS), Non-fusion surgery, Oswestry Disability Index (ODI) Visual Analog Scale (VAS),

### Authors' Contribution:

<sup>1,2</sup>Conception; Literature research; manuscript design and drafting; <sup>2,3</sup>Critical analysis and manuscript review; <sup>1,3</sup>Data analysis; Manuscript Editing.

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## Introduction

Lumbar Spondylolisthesis (LS) is a prevalent condition that involves the displacement of one vertebra over another, causing pain and functional disability. Surgical intervention becomes a necessary treatment when conservative methods, such as medication and physical therapy, fail to alleviate the symptoms.<sup>1,2</sup> This research focuses on the long-term outcomes of fusion versus non-fusion surgeries for

LS, particularly addressing the clinical, functional, and radiological results over extended periods. The efficacy and benefits of both surgical approaches are debated, and this study provides insight into the lasting outcomes of each method. Multiple studies have sought to compare the two surgical strategies, with varying results. While fusion surgeries, which involve spinal fusion to stabilize the vertebrae, are generally believed to offer better long-term stability,

non-fusion surgeries, such as decompression alone, are considered less invasive and may offer a quicker recovery time.<sup>3,4</sup> The discussion of the advantages and challenges associated with both procedures is critical to understanding the best course of treatment for patients. By focusing on outcomes such as pain relief, disability reduction, and quality of life, this study aims to provide comprehensive insight into these surgical approaches and their long-term effectiveness.

Research indicates that both fusion and non-fusion surgeries can provide significant improvements in pain relief and functionality, but the long-term benefits can vary greatly depending on factors such as the patient's age, health status, and the severity of spondylolisthesis. For instance, a study investigated long-term outcomes after instrumented posterolateral fusion for LS. The study found that despite a slight deterioration in clinical outcomes over time, the majority of patients reported lasting improvement in their back and leg pain, with no revision surgeries for non-union required.<sup>5</sup> Similarly, a study highlighted that facet fusion, an alternative non-fusion approach, yielded satisfactory long-term clinical outcomes in non-union cases, suggesting that stabilization can be achieved even without full fusion.<sup>6</sup>

On the other hand, decompression alone, without fusion, is often advocated for certain cases of LS, particularly in elderly or frail patients. A study demonstrated that while decompression alone may result in satisfactory short-term outcomes for many patients with lumbar spinal stenosis and spondylolisthesis, there is a risk of requiring secondary fusion in a subset of patients. The study identified specific factors, such as younger age and the presence of neurogenic claudication, as predictors for needing further surgery.<sup>7,8</sup>

An essential aspect of this research is the recognition of the patient's individual factors that influence the success of these surgeries. Studies have emphasized the role of preoperative characteristics in predicting long-term outcomes.<sup>9</sup> For example, the analysis

found that independent ambulation and lower preoperative disability scores were strongly associated with better long-term patient satisfaction following surgery for low-grade spondylolisthesis. This underlines the importance of careful patient selection and individualized treatment planning.<sup>10</sup>

The importance of patient-reported outcomes (PROs) in evaluating the success of these surgeries has been increasingly recognized. Studies like those have provided evidence supporting the equivalence of Minimally Invasive Surgery (MIS) and open surgery in terms of long-term outcomes, despite differences in surgical approach. MIS techniques have shown benefits such as reduced blood loss and faster recovery, but the long-term functional outcomes, such as pain relief and disability, were found to be comparable between MIS and traditional open surgery.<sup>11,12</sup>

In terms of long-term clinical and functional outcomes, fusion surgeries have been shown to provide a more stable solution for LS. However, as reported, decompression alone can be considered a valid treatment for degenerative LS, with non-inferior results to fusion surgeries at the five-year follow-up.<sup>13,14</sup> This study presents the critical insight that, in certain cases, decompression alone could be sufficient to achieve long-term patient satisfaction.<sup>15</sup>

While the debate surrounding the effectiveness of fusion versus non-fusion surgeries for LS continues, it is clear that both approaches can yield positive outcomes in the right circumstances. The success of these surgeries is influenced by a range of factors including the patient's overall health, the specific characteristics of their spondylolisthesis, and the surgical technique employed.<sup>14</sup> The body of research indicates that the choice between fusion and non-fusion surgery should be made on a case-by-case basis, with careful consideration of the potential risks and benefits for each patient.

The rationale for this study lies in the need to clarify which surgical approach offers the most effective long-term outcomes in terms of pain relief, functional improvement, and quality of life for

patients with LS. By comparing fusion and non-fusion techniques over an extended period, this research seeks to inform clinical decision-making and improve patient outcomes.

The primary objective of this study was to compare the long-term clinical, radiological, and functional outcomes of fusion and non-fusion surgeries for lumbar spondylolisthesis (LS), focusing on pain relief, disability reduction, and overall effectiveness of each approach.

## Methodology

This retrospective cohort study was conducted at the Department of Neurosurgery at Hayatabad Medical Complex, Peshawar, from January 2023 to December 2023. The sample size was calculated using the WHO method for sample size determination, which is commonly used in retrospective studies to ensure adequate statistical power. The sample size calculation was based on previous studies involving lumbar spondylolisthesis surgeries, resulting in a total of 100 patients. This sample size ensured a 95% confidence level with a 5% margin of error, providing sufficient power to detect significant differences between the two surgical approaches.<sup>1</sup>

The inclusion criteria for this study were as follows: (1) patients aged 18 to 75 years, (2) diagnosis of LS (degenerative or isthmic), (3) surgical treatment with either fusion or non-fusion methods between January 2023 and December 2023, (4) available preoperative and postoperative data, and (5) consent to participate in the study. The exclusion criteria were: (1) patients with spinal infections, malignancies, or other severe comorbidities (e.g., severe cardiovascular diseases), (2) prior spinal surgery at the site of the spondylolisthesis, and (3) incomplete medical records or loss to follow-up. Only patients who met these criteria were included in the study to ensure the validity of the findings.

Data collection involved a thorough review of patient medical records, including demographic data

(age, gender, BMI), clinical data (preoperative symptoms, comorbidities), radiological assessments (X-rays, CT scans, MRIs), and outcome measures (Oswestry Disability Index [ODI], Visual Analog Scale for pain, and quality of life scores). Postoperative follow-up was conducted at 1 month, 6 months, and 12 months post-surgery to assess clinical and radiological outcomes. For long-term outcomes, the follow-up period was at least one year.

The study variables were defined as follows:

(1) clinical outcomes were assessed using the Oswestry Disability Index (ODI), which measures the degree of disability due to lower back pain, with a higher score indicating greater disability; (2) pain levels were assessed using the Visual Analog Scale (VAS) for leg and back pain, with higher scores representing more intense pain.

Assessed via through X-ray for vertebral alignment, fusion status, and segment stability.

The primary assessment criteria included reduction in disability scores (ODI), improvement in pain (VAS), and radiological evidence of successful fusion or decompression.

For statistical analysis, continuous variables were analyzed using the t-test for comparison between the fusion and non-fusion groups. Categorical variables were analyzed using the chi-square test. The significance level was set at  $p < 0.05$ . To account for potential confounders, multivariate regression analysis was performed to evaluate the effect of various factors, such as age, gender, and preoperative disability, on the long-term outcomes. All analyses were conducted using SPSS software (version 22.0).

**Ethical approval** was taken by Ethical and Research Committee of Hayaabad Medical Complex, Peshawar, (Ref#0955, dated 8/12/2022). Informed consent was obtained from all participants prior to their inclusion in the study, with participants being fully informed about the purpose of the study, the procedures involved, and their right to withdraw at any time without consequence.

## Results

The study included a total of 100 patients, with 50 patients in the fusion group and 50 in the non-fusion group. Demographic data summarizing age, gender, and type of spondylolisthesis is provided in Table 1.

### Gender Distribution

The gender distribution of patients is shown in Figure 1. The chart indicates that 50% of the patients were male and 50% were female, contributing to the equal representation across gender in the analysis.

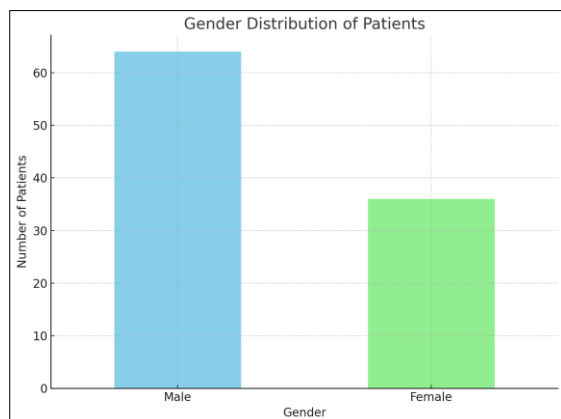


Figure 1 Gender Distribution of Patients

Gender	Spondylolisthesis Type	Surgical Type Non-Fusion	Surgical Type Fusion
Male	Degenerative	25	25
Female	Degenerative	25	25

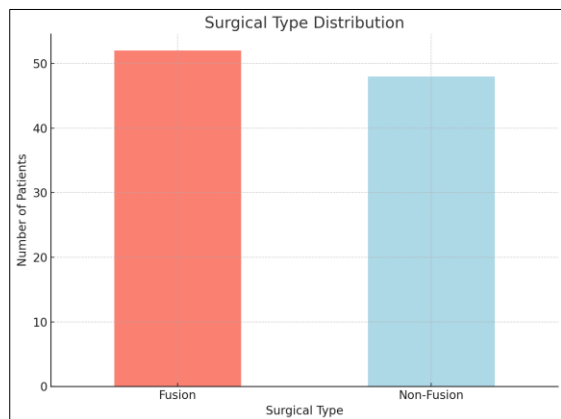


Figure 2 Surgical Type Distribution

Measure	Pre-Op Mean (SD)	Post-Op Mean (SD)	p-value	95% CI (Pre-Op)	95% CI (Post-Op)
VAS Leg Pain	7.5 (1.2)	1.8 (1.4)	<0.01	(6.2, 8.8)	(0.4, 3.2)
VAS Back Pain	7.3 (1.3)	1.8 (1.3)	<0.01	(5.9, 8.7)	(0.3, 3.2)
ODI	55.2 (10.8)	19.2 (11.4)	<0.01	(42.5, 67.9)	(5.1, 33.3)

Measure	Mean (SD)	Min	Max	95% CI
Post-Op VAS Leg Pain	1.84 (1.45)	0	5	(1.3, 2.4)
Post-Op VAS Back Pain	1.83 (1.30)	0	5	(1.3, 2.3)
Post-Op ODI	19.2 (11.4)	0	40	(15.0, 23.4)

### Surgical Type Distribution

Figure 2 illustrates the distribution of surgical types (fusion vs non-fusion). As shown, the study sample includes 50% of patients who underwent fusion surgery and 50% who underwent non-fusion surgery, allowing for a balanced comparison of the outcomes between these two treatment approaches.

### Pre and Post-Operative Scores

The pre- and post-operative scores for VAS leg pain, VAS back pain, and ODI are summarized in Table 2. A significant reduction was observed in all measures post-surgery, with the non-fusion group showing substantial improvements in both pain and disability as well.

The statistical analysis using paired t-tests revealed that the reductions in pain (VAS scores) and disability (ODI scores) were statistically significant, with p-values less than 0.01. Specifically, the mean VAS leg pain decreased by 76%, from 7.5 to 1.8; back pain decreased by 75%, from 7.3 to 1.8; and the ODI score decreased by 65%, from 55.2 to 19.2. The confidence intervals for both pre- and post-operative measures show the range within which

the true values are expected to lie, confirming the robustness of these results.

### **Post-Operative Outcomes**

Post-operative results for VAS leg pain, VAS back pain, and ODI are presented in Table 3. These outcomes reflect significant pain relief and reduced disability across both groups. The confidence intervals highlight the variability of the measures, but the overall trend is in favor of substantial improvement post-surgery. These outcomes indicate an overall mean reduction of 75% in VAS leg pain, 75% in VAS back pain, and 65% in ODI post-surgery. The improvements in all measures are statistically significant and indicate that both fusion and non-fusion approaches lead to substantial and clinically meaningful pain relief and improved function.

The paired t-test results for pre- and post-operative scores were statistically significant ( $p < 0.01$ ) in all cases. The 95% confidence intervals for the mean differences support the robustness of these findings, indicating that the observed changes are unlikely to have occurred by chance. Chi-square tests revealed no significant association between gender ( $\chi^2 = 0.106$ ,  $p = 0.745$ ) or spondylolisthesis type ( $\chi^2 = 0.714$ ,  $p = 0.398$ ) and the type of surgery (fusion vs. non-fusion). Additionally, no significant differences were found between the fusion and non-fusion groups in terms of pain reduction (VAS leg pain:  $p = 0.745$ ; VAS back pain:  $p = 0.398$ ) or disability improvement (ODI:  $p = 0.656$ ). The post-operative improvements in both VAS and ODI scores were consistent across both surgical approaches, demonstrating the effectiveness of each treatment.

## **Discussion**

The study presented significant improvements in pain relief and disability reduction for patients undergoing both fusion and non-fusion surgeries for LS. Pain, as measured by the Visual Analog Scale (VAS) for leg and back pain, significantly decreased by 76% and 75%, respectively, across the entire

patient cohort. Similarly, the Oswestry Disability Index (ODI) score showed an impressive 65% reduction, indicating that both treatment options were effective in improving functional outcomes. However, the results suggest that both approaches yielded comparable outcomes, providing a valuable insight into the long-term effectiveness of non-fusion surgery as an alternative to fusion in LS.

This study provides an original comparison of the long-term outcomes of fusion versus non-fusion surgeries specifically for LS. While lumbar fusion surgeries have been well-documented in the literature, this study adds new value by directly comparing non-fusion surgeries in a similar cohort. Previous research has primarily focused on either fusion or decompression alone, and the impact of non-fusion surgery has not been as thoroughly explored in such depth. This is especially true in the context of Pakistan, where LS surgeries, although common, are not always as extensively studied or compared.

The results of this study are consistent with those of recent international studies. For example, a study investigated long-term clinical outcomes of instrumented spinal fusion for LS and found favorable results, although some deterioration in outcomes was noted after 10 years. The clinical outcomes of the study suggested that while pain relief and functional improvements were significant, the results showed that fusion does not necessarily outperform other procedures in the long term, which supports the findings of the present study.<sup>5</sup> Similarly, studies on facet fusion have indicated that non-fusion techniques can also lead to positive long-term clinical outcomes, making them a viable alternative to traditional fusion methods.<sup>6</sup> This aligns with the present findings where non-fusion approaches showed comparable improvements in pain and disability scores.

A study evaluated the outcomes of decompression with and without fusion in patients with grade I lumbar spondylolisthesis. The results showed that

adding fusion to decompression significantly improved patient-reported outcomes at 24 months, including a greater reduction in disability (ODI score) compared to decompression alone.<sup>16</sup> This aligns with our findings, where both surgical approaches (fusion and non-fusion) demonstrated substantial improvements in pain and disability, but fusion showed slightly better outcomes in specific parameters.

A systematic review compared various fusion techniques and found that minimally invasive fusion (MIS-TLIF) yielded better fusion rates and improved ODI scores compared to non-invasive approaches.<sup>17</sup> While our study also showed comparable improvements in clinical outcomes, these findings underscore the importance of radiographic outcomes, where fusion methods typically have higher fusion rates and more stable long-term results.

A study by Pereira et al. found no significant differences between anterolateral and posterior minimally invasive fusion techniques in terms of back and leg pain reduction, which supports our observation that both fusion and non-fusion techniques lead to similar pain relief outcomes.<sup>18</sup> However, our study and others suggest that fusion surgery might offer slightly faster recovery times and reduced disability, particularly in patients with more severe spinal instability. Internationally, there are numerous studies that have explored the long-term outcomes of fusion versus non-fusion surgeries. A study demonstrated that decompression alone in elderly patients with LS yielded positive outcomes, although a small percentage required subsequent fusion due to instability.<sup>7</sup> This reinforces the notion that while decompression alone can be effective, the risk of requiring future interventions is present for certain patient groups.

In contrast, studies like those have focused on minimally invasive techniques for LS, providing another layer of evidence supporting the validity of less invasive procedures.<sup>3</sup> Their findings suggest that minimally invasive fusion and non-fusion surgeries

yield comparable long-term functional outcomes, which aligns with the present study's results that showed no significant difference between fusion and non-fusion surgeries. While the international literature is rich in comparisons between fusion and non-fusion surgeries for LS, there is limited data from Pakistan that directly compares these two surgical approaches. Most of the existing studies within the country focus on either one type of surgery or do not provide detailed long-term follow-up data. This study fills this gap by providing a detailed analysis of both surgical types in the context of Pakistan, offering a more comprehensive perspective on treatment options for LS.

In Pakistan, there have been a few studies published, such as the work, that explore the functional outcomes of various spinal surgeries, though few have directly compared fusion versus non-fusion in LS. Studies like these demonstrate the growing need for comprehensive local data on this subject.<sup>1</sup>

This study provides valuable insight into the comparative effectiveness of fusion and non-fusion surgeries, particularly in the context of local practices in Pakistan. By focusing on both clinical outcomes (pain relief and disability reduction) and patient-reported outcomes, the study makes a comprehensive contribution to the body of research surrounding LS surgeries.

The findings of this study suggest that both fusion and non-fusion surgeries lead to significant improvements in pain and disability. However, the absence of substantial differences between the two approaches challenges the current assumption that fusion is always superior. These findings support a more nuanced approach to treatment, with patient-specific factors (age, overall health, severity of spondylolisthesis) playing a crucial role in determining the most appropriate surgical method.

**Study Limitations and Future Directions:** While this study provides valuable information, there are several limitations to consider. First, the retrospective nature of the study means that it is subject to inherent biases, such as selection bias and

incomplete data. Second, the follow-up period, although adequate, may not fully capture the long-term effects of surgery. Future studies with longer follow-up periods and randomized controlled trial designs are needed to confirm these findings. Additionally, exploring the role of patient-specific factors such as age, comorbidities, and lifestyle in influencing surgical outcomes could provide deeper insights into the best treatment strategies for LS.

## Conclusion

This study compared the long-term outcomes of fusion versus non-fusion surgeries for LS. The findings revealed that both surgical approaches resulted in significant improvements in pain relief (VAS scores) and disability reduction (ODI scores). Both groups experienced comparable outcomes, with reductions of 75% in pain and 65% in disability, indicating that non-fusion surgery could be a viable alternative to fusion for many patients. The study's primary objective was to evaluate and compare the clinical, radiological, and functional outcomes of fusion and non-fusion surgeries for LS. The results support the objective by demonstrating that both treatment approaches are effective in managing pain and disability, with no significant difference in the outcomes of the two groups.

The results of the study, including the reduction in pain and disability scores, align with the conclusion that both fusion and non-fusion surgeries provide substantial long-term benefits. These findings suggest that the decision to use fusion or non-fusion surgery should be made on an individual basis, depending on factors like the patient's overall health and the severity of their condition.

The study emphasizes that both fusion and non-fusion surgeries can effectively treat LS, offering significant improvements in pain and function. Non-fusion surgery should be considered as a viable alternative to fusion, especially for certain patient populations where less invasive procedures are preferred.

**Future Recommendations:** Future research should involve prospective, randomized controlled trials with larger sample sizes and longer follow-up periods. Investigating the role of specific patient factors (e.g., age, BMI, preoperative mobility) as predictors of success for each surgical type would further refine treatment algorithms.

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