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# Surgical Management of Lumbar Degenerative Spondylolisthesis: A Brief Review

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## Abstract

Lumbar degenerative spondylolisthesis (LDS) is a common spinal abnormality that occurs when a vertebrae bone is relatively subluxate onto the bone underneath. It often causes the symptoms of low back pain, radiculopathy, and neurogenic claudication. Surgical management is recommended for patients who do not respond to initial conservative approaches. However, published articles regarding the most favorable and optimal surgical methods of LDS remain controversial. Surgeons commonly perform surgical decompression alone; however, interbody fusion may improve surgical outcomes and can be executed by various surgical approaches. On the other hand, minimally invasive techniques continue to develop. Proper consideration in choosing the surgical management of LDS is necessary given the growing numbers of the elderly population. Evidence-based research must be taken into account with established clinically beneficial surgical practices while simultaneously being cost-effective.

**Keywords:** Lumbar spondylolisthesis, Degenerative, Surgical, Low back pain, Radicular pain.

## INTRODUCTION

Spondylolisthesis is the anterior slippage of one vertebral bone relatively onto the adjacent vertebra [1]. Lumbar degenerative spondylolisthesis (LDS) is one of the most common cases of spondylolisthesis and is known to cause lumbar stenosis resulting in disability as a complication. Vertebral levels of L4-L5 and L5-S1 are the typical sites to be affected [2]. Epidemiologically, LDS occurs more frequently in the female population, with a male to female ratio of 1:6. Degenerative spondylolisthesis is a unique disease, with most cases are predominantly in patients over 40-50 years of age [3]. Its origin is multifactorial, such as intervertebral disc degeneration, facet joint degeneration, iliolumbar configuration, ligament hyperlaxity, physical overactivity, anterolisthesis, and loss of disc height at affected level, which may lead to central, lateral recess, and foraminal stenosis [4]. Hence, those pathological conditions cause several clinical manifestations of LDS, including weakness, low back pain (LBP) of varying levels of severity, and lower extremity pain, resulting in reduced life quality [5]. Treatment of LDS is initiated by conservative treatments, including pharmacological therapy, physical therapy, lifestyle modification, and comprehensive pain management [6]. However, a surgical approach with spinal decompression of neural encroachment and stabilization of the spinal column in LDS patients is highly recommended if the conservative treatment fails [7]. Many studies remain controversial about the most favorable surgical technique for LDS patients. This study evaluates different techniques in LDS surgical management to prevent any further complications or unexpected treatment goals when the surgical approach is considered.

### Surgical Modalities

Some experts recommended that surgery be considered the best option for the patient with conservative management failure within three months [8]. Although there are some considerations for the surgical approach, including the degree of facet resection needed for decompression, grade of vertebral spondylolisthesis, dynamic segmental instability, spinal alignment, the severity of LBP, spinopelvic balance [9]. Certain surgical techniques in the management of LDS have increased in the past decade. Decompression laminectomy with partial medial facetectomy and instrumented fusion remains the standard; however, the development of several novel techniques is also worth comparing to evaluate the superiorities and weaknesses of the various available approaches.

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*Surgical Decompression*

According to the North American Spine Society (NASS) guideline, it is recommended that surgical decompression may be considered for low-grade DS and symptomatic spinal stenosis LDS patients with failure of conservative therapy [2]. Laminectomy is the most common procedure of decompression. This method allows direct decompression of the central canal, lateral recess, and neural foramen. Hence, laminectomy is an alternative approach to decompression in which the vertebral arch is preserved. Unfortunately, several studies reported that post-operative spinal instability becomes a major concern for surgeons performing decompression alone in the presence of LDS. However, some other research mentioned that simultaneous arthrodesis along with decompression is not required [10-12].

A prospective study by Ahmad *et al*. reported that lumbar decompression procedure without arthrodesis in patients with lumbar spinal stenosis with DS had significant post-operative improvements, based on the Oswestry Disability Index (ODI) and Visual Analogue Scale (VAS) pain score. Additionally, the study showed a low rate of post-operative instability and subsequent fusion. Among ten patients, only one individual ended up needing a subsequent joint fusion at a mean follow-up of 36 months. This finding concluded that arthrodesis procedure is not always necessary in their patients [11].

Ha *et al.* prospectively conducted a five-year follow-up study of 36 LDS patients who underwent decompression without fusion (conventional lumbar laminectomy). The study found a reduction in VAS and ODI score, respectively, from the average of 7.8 points and 57 points throughout pre-operative evaluation to 1.4 points and 19 points after the five-year post-operative evaluation. Moreover, the degree of radiological displacement improved from an average of 5.1 mm preoperatively to 6.4 mm at the final followed-up [12].

A study by Yin Cheung *et al*. evaluated LDS patients with Meyerding classification's grade 1 DS of lumbar spine stenosis who underwent laminotomy and medial facetectomy at the involved levels. They assessed some parameters, such as residual or recurrence of symptoms, revision surgery performed, VAS pain score, modified Barthel index, which was completed over several follow-up periods, including the short-term (<5 years), mid-term (5–10 years), and long-term (>10 years). The authors concluded that decompression procedure alone provides good long-term results despite the presence of instability, specifically for low-grade degenerative spondylolisthesis [13].

Joelson *et al*. assessed reoperations following decompression with or without fusion in 6.532 patients who underwent surgery for L4-L5 spinal stenosis with or without DS (defined as vertebral slippage more than 3 mm on pre-operative radiographs). The authors concluded that single-level lumbar fusion surgery is associated with the increased reoperation rate at the adjacent level compared with decompression only. When reoperations at the index level are included, there is no difference in reoperation rates between fusion and decompression only (without fusion). In addition, for single-level DS that is symptomatic, low grade, with only central stenosis (no foraminal stenosis), decompression provides equivalent outcomes compared to decompression with fusion [14].

Inose *et al.* performed a prospective randomized study comparing different surgical techniques, i.e., decompression alone (group 1), decompression plus fusion (group 2), and decompression plus stabilization (group 3) for degenerative spondylolisthesis at the L4-L5 level. Surgery outcomes were assessed by using the Japanese Orthopaedic Association (JOA) and VAS pain scores. The study found no significant difference between decompression plus fusion or stabilization vs. decompression alone at one- and five-year post-operative follow up, particularly in patients with 1 level lumbar spinal stenosis with low grade (<30%) degenerative spondylolisthesis at the L4-L5 level [15].

Contrarily, Herkowitz *et al*. reported that most patients with LDS are treated with lumbar fusion and neural decompression. Laminectomy and fusion were more superior to laminectomy alone. Patients with LDS who underwent laminectomy and arthrodesis had significantly less leg and back pain ($p$-value <0.01) and a significantly higher proportion of excellent overall based on clinical results ($p$-value=0.0001) than other patients who underwent laminectomy procedure alone [16].

*Lumbar Interbody Fusion (LIF)*

In LDS patients with spinal instability and spondylolisthesis, lumbar interbody fusion (LIF) can be an alternative choice of surgical technique performed by surgeons. However, the rationale and precise technique for spinal fusion remain controversial [17]. Lumbar interbody fusion is preceded by discectomy and endplate preparation, followed by the placement of an implant, such as a spacer, structural graft, or cage within the intervertebral space. This technique consists of five different surgical approaches (Figure 1) [17]. Conventional method generally uses the anterior LIF (ALIF) approach; however, a modified approach has recently been developed, known as lateral LIF (LLIF) [9,17]. LLIF is acknowledged as a novel and less invasive method because it is done using a retroperitoneal trans-psoas or para-psoas approach. Other options include the posterior LIF (PLIF), transforaminal LIF (TLIF), and oblique lumbar interbody fusion/anterior to psoas (OLIF/ATP) approach. Each approach has some advantages and disadvantages, depending on the techniques and application of instrumentation. The preferable choice of LIF technique is left to the discretion of the treating surgeons (Table 1) [9].

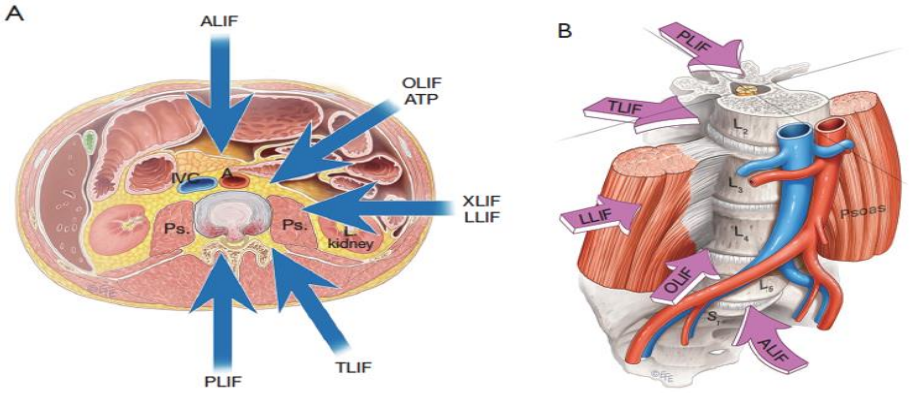


**Figure 1.** Anatomical sites for surgical approaches to the lumbar spine for inserted interbody fusion consisting of the anterior (ALIF), lateral or extreme lateral interbody fusion (LLIF or XLIF), oblique (OLIF/ATP), transforaminal (TLIF), and posterior (PLIF) approaches [17]

**Table 1:** Comparative evidence-based studies on the Lumbar Interbody Fusion technique

| No. | Author | Year | Study Design | Sample Size & Comparison | Results | Additional Findings |
|---|---|---|---|---|---|---|
| 1. | Thompson *et al* [23]. | 2013 | Prospective study | n = 519 patients ALIF vs. TLIF | Both ALIF and TLIF showed a similar long-term reduction in pain and functional disability in LDS patients. However, the ALIF group showed a faster reduction in one tear VAS back and leg pain score | TLIF more likely to experience post-operative complication (12.3% vs 7.8%, *p*-value =0.03), although visceral/ vascular injury was significantly higher in ALIF (*p*-value =0.002) |
| 2. | De Kunder *et al* [24]. | 2017 | Systematic review & Meta-analysis | Total of 192 studies (including 990 patients, consisting of 540 PLIF vs. 450 TLIF) | The clinical outcomes of TLIF and PLIF were similar. Although TLIF (8.7% range 0%-25%) showed advantages over PLIF (17.0% range 4.7%-28.8%) based on complication rate, blood loss, and operation time | A significant change in ODI scores was 3.46 points larger for TLIF, whereas the VAS score showed no significant difference between PLIF and TLIF |
| 3. | Teng *et al* [25]. | 2017 | Meta-analysis | Total of 30 studies (LLIF vs. ALIF/TLIF) | ALIF showed superior radiological outcome, better post-operative disc height (*p*-value=0.002 and *p*-value=0.005), post-operative segmental lordosis (*p*-value=0.013 and *p*-value= 0.000). Unfortunately, there was insufficient data to compare against LLIF | Both approaches had a similar fusion rates (*p*-value= 0.320 and *p*-value=0.703) |
| 4. | Watkins *et al* [26]. | 2014 | Retrospective study | 220 consecutive patients with 309 operative levels (184 ALIF, 86 LLIF, 39 TLIF | Improvement of lordosis was significant in both the ALIF and LLIF groups, but not the TLIF groups. The ALIF and LLIF groups had significantly increased disc height compared to the TLIF group | All these three groups had significantly reduced spondylolisthesis, with no difference between the groups |

Preceding studies regarding LIF surgery have not shown that one approach is superior to other approaches based on the fusion or clinical outcomes [10-14,17]. McAnany *et al*. reported a meta-analysis comparing the clinical outcomes from several LDS studies that were surgically treated by posterolateral fusion (PLF) and interbody fusion (PLIF). The analysis showed no significant difference in outcome parameters, including the fusion rate, surgery time, ODI, VAS pain score [18]. On the other hand, Baker *et al*. mentioned that there was not sufficient scientific evidence to support the recommendation for practicing or against the LIF procedure [19]. A retrospective subgroup analysis of 380 patients from the Spine Patients Outcomes Research Trial Group (SPORT) study showed no difference in clinical outcomes over four-year follow up between PLF and PLIF [20].

A randomized trial study by Farrokhi *et al*. compared the appliance of two groups, PLF and PLIF, among patients with LDS and degenerative instability. The authors reported a lower mean VAS pain score in the PLF group than the PLIF group (5.67 vs. 5.48, respectively), whereas the mean ODI score of the PLF group showed better improvement than the PILF group (42.75 vs. 40.94, respectively). A statistically significant difference was found between the pre-operative and post-operative sagittal balance, in addition to the mean Cobb angle among the two groups [21].

Spinal fusion can be performed in conjunction with an instrumented or non-instrumented approach to limit vertebral motion to prevent inherent spinal instability. A systematic review by Martin *et al*. reported the beneficial role of instrumented fusion in managing LDS. Posterior instrumentation procedure with fusion for LDS showed the promising result to reduce the risk of pseudarthrosis; however, any other correlated clinical outcomes remains unknown [22]. Study by Farrokhi *et al*. also supports the application of posterior instrumentation procedure with fusion, showing excellent clinical outcomes in terms of lower back and radicular pain, a better quality of life, well-corrected Cobb angle, well-restored sagittal alignment, improvement in Modic type 0 changes, decrease in Modic type 1 changes, despite the low fusion rate compared to PLIF [21].

*Minimally Invasive Decompression (MIS)*

Minimally invasive surgery (MIS) is one of the valuable options in the management of LDS patients. Numerous researchers have performed and analyzed this technique regarding its effectiveness and advantages. Harris *et al*. conducted a study in 21 patients undergoing standard PLF using a midline approach and 30 patients undergoing fusion with a mini-open technique to treat symptomatic DS. They found no significant difference in improvements in ODI or VAS pain score between groups or any difference in operative time, estimated blood loss (EBL), and length of stay (LOS) [27].

On the other hand, in a prospective cohort study, Kotani *et al*. divided the samples into two groups, involving 43 patients who underwent MIS-PLF with a percutaneous pedicle screw system and 37 patients who underwent open PLF. The study found rapid improvement among patients undergoing the MIS-PLF technique, based on the ODI and Roland-Morris Disability Questionnaire (RMQ) parameters at 24-month follow-up. However, no difference was found in the JOA score or VAS pain score [28].

A study by Wang *et al*. evaluated 85 patients with LDS who were randomly assigned to either MIS-TLIF or open TLIF. Surgical time, ODI score, and back pain VAS score were equivalent between the two groups at a mean follow-up of 26.3 months. The patients treated with MIS-TLIF had the added benefit of less total blood loss (*p*-value <0.01), a lower

post-operative back pain VAS score (*p*-value <0.05), and shorter hospital length of stay (*p*-value <0.05). Nevertheless, patients treated with MIS-TLIF had greater x-ray exposure due to the use of intraoperative fluoroscopy during surgery (*p*-value <0.05) [29].

Kim *et al*. measured the radiographic and clinical outcomes of MIS-TLIF with percutaneous pedicle screw fixation in 19 patients presented with DS and 25 patients presented with isthmic spondylolisthesis. A significant improvement was found based on the ODI score and VAS back and leg pain score (*p*-value <0.001). These findings were monitored at a minimum of five-year follow-up. The overall patient satisfaction rate was 80%. Dynamic radiography and/or CT demonstrated fusion in all patients with DS. Radiographic adjacent segment disease (ASD) was found in 13 patients (68.4%), and symptomatic ASD was found in only three patients (15.8%) [30]. Thus, the authors determined that MIS-TLIF be a safe and effective surgical technique.

Meanwhile, a recent meta-analysis by Scholler *et al*. analyzed 37 studies from 1156 patients, comparing outcomes after laminectomy and MIS-laminectomy for management of lumbar stenosis associated DS. They concluded that MIS-laminectomy was associated with reduced complications, improved patient satisfaction, slip progression, and secondary fusion [31].

**CONCLUSION**

Lumbar degenerative spondylolisthesis is one of the most frequently diagnosed in female patients with low back pain, older aged, radicular pain. Surgical management is suggested after the failure of three months of conservative therapy. Depending on the clinical and radiological findings, the surgical approach is carefully considered, either by the surgeon's preferences and experiences by the other experts. Furthermore, each surgical approach represents its advantages and disadvantages. It is essential to communicate and obtain informed consent from the patients. We propose a set of brief considerations from evidence-based research that may assist in deciding the most appropriate surgical approach for the patient. Hence, further research is still needed to re-evaluate surgical approach options in LDS patients.

**Conflict of Interest**

None declared.

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