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Pure Decompression versus Decompression with Fusion in Degenerative Lumbar Spondylolisthesis: A Meta-Analysis of Long-Term Outcomes

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Abstract

Degenerative lumbar spondylolisthesis is a common spinal problem seen in everyday practice, especially in older adults, and it often presents with ongoing low back pain, neurogenic claudication, and radicular symptoms. Although decompression surgery is generally considered effective for relieving neural compression, whether fusion should be added at the same time is still controversial, particularly when long-term results and resource use are taken into account. This meta-analysis followed PRISMA guidelines. We systematically searched PubMed, the Cochrane Library, and Google Scholar for randomized controlled trials involving adults with degenerative lumbar spondylolisthesis. The main outcomes were functional disability measured by the Oswestry Disability Index (ODI), along with separate assessments of low back pain and leg pain. Data were pooled in Review Manager 5.4 using fixed- or random-effects models as appropriate, and results were reported with 95% confidence intervals. Across the three included trials, the two surgical strategies performed similarly overall. There were no meaningful differences in ODI scores or in reported back and leg pain. Decompression alone was linked to a slightly higher reoperation rate, but the difference was not statistically significant. In contrast, adding fusion led to longer operative times and longer hospital stays, without providing a clear clinical benefit. Taken together, these findings suggest that decompression without fusion may be a simpler, more resource-efficient choice for carefully selected patients with degenerative lumbar spondylolisthesis who do not have instability or major deformity. That said, the evidence is still limited by the small number of trials and relatively short follow-up. Larger, well-designed studies with longer observation are needed to better determine how durable the outcomes are and what the true reoperation risk is.

Keywords: *Decompression, Degenerative Lumbar Spondylolisthesis, Oswestry Disability Index, Instrumented Fusion, Spinal Fusion.*

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INTRODUCTION

Degenerative lumbar spondylolisthesis (DS) represents one of the key clinical manifestations of spinal degeneration in older adults. It develops when a vertebral body shifts forward relative to the one beneath it, usually as a result of progressive disc degeneration, facet joint hypertrophy, and weakening of the ligamentous structures that normally stabilize the segment. DS often occurs together with lumbar spinal stenosis (LSS), and the two conditions commonly produce the hallmark symptoms of chronic low back pain, neurogenic claudication, and radiculopathy. These complaints frequently impose meaningful restrictions on walking distance, posture, and routine daily activities, ultimately diminishing quality of life in this age group (Austevoll et al., 2021). Epidemiologically, DS shows a consistent female predominance and a clear rise in prevalence with advancing age. As a result, the disorder has become an increasingly salient public health issue in societies experiencing rapid population aging. The growing clinical burden of degenerative spinal conditions is closely intertwined with broader demographic changes most notably extended life expectancy and the expanding proportion of older individuals worldwide.

Degenerative spondylolisthesis remains one of the most prevalent spinal disorders among older adults, with reported prevalence rates ranging from 25% to 43% in elderly women and 19% to 31% in elderly men. The anterior vertebral displacement, arising from facet joint arthritis accompanied by ligamentous instability and intervertebral disc degeneration, results in lumbar spinal stenosis (LSS) through progressive narrowing of the spinal canal (Mazurek et al., 2023). As the global elderly population continues to rise, the incidence of symptomatic DS requiring surgical intervention is also expected to increase substantially. From an applied epidemiological perspective, this trend indicates a future escalation in the demand for spinal decompression and fusion procedures, thereby imposing a considerable burden on healthcare systems, health insurance providers, and hospital resource allocation. Consequently, identifying effective yet economically sustainable surgical strategies has become increasingly important for maintaining healthcare system efficiency in both developed and developing countries.

This pathology commonly produces chronic lower back pain together with neurogenic claudication and radiculopathy, for which conservative therapies afford only minimal relief while surgical approaches yield markedly superior clinical outcomes (Pranata et al., 2022). While decompression alone removing hypertrophic facet joints and the ligamentum flavum to ease neural compression while maintaining spinal stability is generally the least invasive option, whether adding instrumented fusion is beneficial remains debated, particularly in terms of disease progression and the risk of reoperation. In light of this, the present review compares the effectiveness and safety of decompression with instrumented fusion versus decompression alone for degenerative lumbar spondylolisthesis (Kaiser et al., 2023; Arimbawa et al., 2022).

Therapeutic approaches for DS include conservative management and surgical intervention. In patients with persistent neurological symptoms or functional disability unresponsive to non-operative treatment, surgery becomes the preferred therapeutic option. Neural decompression through laminectomy or minimally invasive decompressive techniques aims to relieve pressure on neural structures and has demonstrated superior clinical outcomes compared with conservative therapy (Forsth et al., 2016). Nevertheless, clinical practice increasingly incorporates spinal fusion as an adjunctive procedure to prevent postoperative instability and further vertebral slippage. Although fusion is theoretically intended to improve spinal stability, its routine addition to decompression procedures remains controversial because the additional clinical benefit may not always justify the increased procedural complexity and healthcare expenditure.

The utilization of spinal fusion in combination with decompression has increased substantially over recent decades, although its additional benefits remain controversial (Martin et al., 2026). Some studies suggest that fusion enhances spinal segment stability and reduces the risk of reoperation; however, it is also associated with longer operative time, increased blood loss, extended hospitalization, and higher healthcare costs(Karlsson et al., 2024; Wei et al., 2022). Systematic reviews and meta-analyses further affirm that decompression alone yields comparable long-term clinical outcomes while demonstrating superior perioperative profiles relative to fusion-augmented procedures (Guo et al., 2025). From a macroeconomic perspective, spinal fusion has been identified as one of the most costly surgical procedures within healthcare systems, thereby raising critical concerns regarding service efficiency and resource allocation (Ghogawala et al., 2016; Martin et al., 2026). This issue is particularly relevant for national health insurance systems, including the Indonesian Social Security Administering Agency for Health (BPJS Kesehatan), where unnecessary utilization of costly fusion procedures may contribute to overtreatment, financial inefficiency, and unsustainable healthcare expenditure.

The economic implications of surgical overtreatment are becoming increasingly significant in the context of aging societies. As the prevalence of degenerative spinal disorders continues to rise, healthcare systems will face growing pressure to provide high-quality yet cost-effective surgical care. In this regard, decompression alone may represent a more sustainable strategy because it requires shorter operative time, fewer surgical resources, reduced hospitalization, and lower overall treatment costs while maintaining comparable clinical effectiveness in selected patient populations. For healthcare policymakers and insurance managers, evidence supporting simpler but equally effective procedures is essential to optimize resource allocation and ensure long-term financial sustainability. Therefore, comparative evaluations between decompression alone and decompression with fusion are not only clinically relevant but also critically important from the perspective of healthcare financing and policy formulation.

Although the evidence overall is mixed, randomized controlled trials have found that, in the short to intermediate term, decompression alone and decompression with fusion lead to similar functional outcomes and pain relief (Inose et al., 2018). Other studies also suggest that over two to five years of follow-up, decompression alone is not inferior to decompression with fusion (Kgomotso et al., 2024). Nevertheless, certain studies continue to report limited advantages of fusion in specific domains, including physical quality of life and radiographic stability, thereby sustaining ongoing clinical debate regarding the optimal surgical approach.

The persistent lack of consensus on the optimal surgical management of degenerative lumbar spondylolisthesis underscores a substantial knowledge gap, particularly regarding long-term functional outcomes and the precise indications for supplemental fusion across varying degrees of spinal instability (Pranata et al., 2022; Kaiser et al., 2023). Prior investigations comparing decompression alone versus decompression with fusion have frequently been constrained by methodological limitations, including small sample sizes, marked population heterogeneity, and variability in surgical techniques (Wei et al., 2022; Gadjradj et al., 2023). These shortcomings have hindered the development of definitive, evidence-based guidelines for clinical practice. Consequently, a comprehensive evidence synthesis through meta-analysis is imperative to systematically evaluate the effectiveness and safety of decompression alone compared to decompression with fusion in patients with degenerative lumbar spondylolisthesis (Pranata et al., 2022; Kaiser et al., 2023). Moreover, limited integration of economic evaluation within prior clinical studies has restricted the applicability of findings for healthcare policymakers and insurance systems seeking to minimize unnecessary high-cost interventions. Consequently, a comprehensive meta-analysis is required to systematically evaluate the effectiveness and safety of decompression alone compared with decompression plus fusion in patients with degenerative lumbar spondylolisthesis.

Based on this background, the present study aims to analyze long-term outcome differences between decompression alone and decompression with fusion using a meta-analytic approach based on randomized controlled trials. The primary focus includes functional outcomes, pain intensity, and procedural safety, with the broader objective of generating stronger evidence to support evidence-based clinical decision-making and economically sustainable healthcare policies. The findings are expected to contribute not only to surgical practice optimization but also to healthcare financing strategies aimed at reducing overtreatment and improving the efficiency of spinal care delivery in aging populations.

METODE

This meta-analysis followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. It aimed to compare the effectiveness and safety of decompression alone with decompression plus fusion in patients with degenerative lumbar spondylolisthesis. Beyond evaluating the surgical outcomes themselves, the analysis also considered the wider public health implications of postoperative functional recovery, particularly its effects on mobility, independence, and quality of life among older adults living in community settings.

Study Design and Eligibility Criteria

The research question and eligibility criteria were formulated using the PICOS framework. We defined the population of interest as adult patients aged 18 years or older who presented with symptomatic degenerative lumbar spondylolisthesis. These individuals typically reported neurogenic claudication or radicular pain and were considered suitable candidates for operative treatment. The intervention under study consisted of decompression performed in isolation, such as laminectomy or other midline-preserving techniques that did not involve fusion. The comparator arm received decompression combined with instrumented spinal fusion, employing pedicle screw fixation with or without interbody cages.

Functional improvement at long-term follow-up of 24 months or longer served as the primary outcome, measured with the Oswestry Disability Index (ODI). The scale employed for assessing disability ranged from 0 to 100, with higher scores reflecting greater levels of impairment. Secondary outcomes of interest included the intensity of back and leg pain, evaluated through the Visual Analogue Scale (VAS), together with reoperation rates, operative duration, length of hospital stay, and complication rates. Only randomized controlled trials published in English and available in full text were considered eligible for inclusion.

Search Strategy

To find eligible studies, we carried out a systematic search of PubMed, the Cochrane Library, and Google Scholar, covering articles published up to January 2024. We used a combination of Medical Subject Headings (MeSH) and free-text keywords, such as “degenerative spondylolisthesis,” “lumbar spondylolisthesis,” “decompression,” “laminectomy,” “spinal fusion,” “instrumented fusion,” “lumbar spinal stenosis,” “randomized controlled trial,” and “long-term outcomes.” We then used Boolean operators (AND, OR, NOT) to create targeted search strings. For example: ("degenerative spondylolisthesis" OR "lumbar spondylolisthesis") AND ("decompression" OR "laminectomy") AND ("fusion" OR "instrumented fusion") AND ("randomized controlled trial" OR "RCT").

Study Selection and Data Extraction

After completing the database searches, all records were imported into Rayyan.ai to support duplicate removal and the initial screening process. We first reviewed titles and abstracts to exclude studies that were clearly unrelated to the topic. Full-text copies of the remaining articles were then obtained and assessed using the predefined inclusion criteria: studies had to fit the PICOS framework, be published in English, and provide complete full-text data. In total, 9,524 articles were identified across the databases. After removing duplicates and completing the preliminary screening, six articles moved forward to full-text eligibility assessment. Of these, three randomized controlled trials met all inclusion criteria and were included in the quantitative synthesis and meta-analysis.

Risk of Bias Assessment

The methodological quality and risk of bias of the included studies were assessed using the Cochrane Risk of Bias 2 (ROB 2) tool. Specifically, we reviewed five key domains in a structured way: the randomization process, deviations from the intended interventions, missing outcome data, outcome measurement, and the selection of reported results.

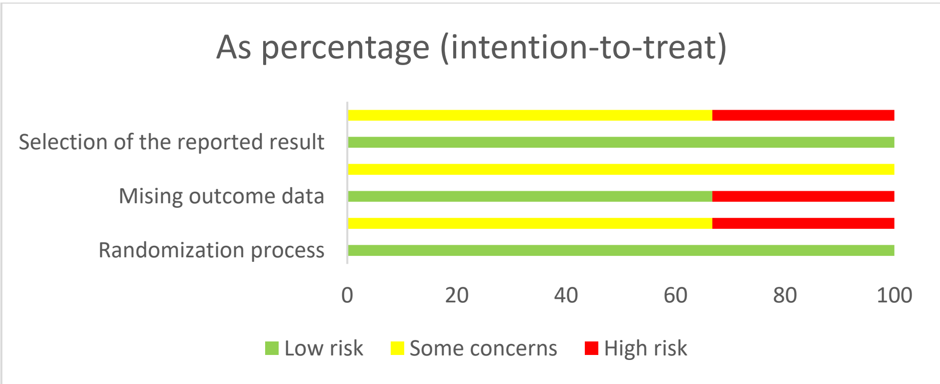

Figure 1. Risk of Bias assessment based on RoB 2 tools

Risk of bias in the included studies was evaluated with the Cochrane Risk of Bias 2 (RoB 2) tool. This tool covers multiple domains, including random sequence generation, allocation concealment, performance bias, detection bias, attrition bias, reporting bias, and other possible sources of bias. For each domain, studies were rated as low, unclear, or high risk. Two reviewers assessed the methodological quality of each study independently, and any differences were resolved through discussion with the other authors until a consensus was reached.

Statistical Analysis

Quantitative analyses were performed in Review Manager (RevMan) version 5.4. For continuous outcomes, we calculated mean differences (MD) with 95% confidence intervals (CI). We assessed statistical heterogeneity among the included studies and, based on the level observed, used either a fixed-effects or random-effects model. The pooled estimates were then used to directly compare clinical outcomes between decompression alone and decompression combined with fusion.

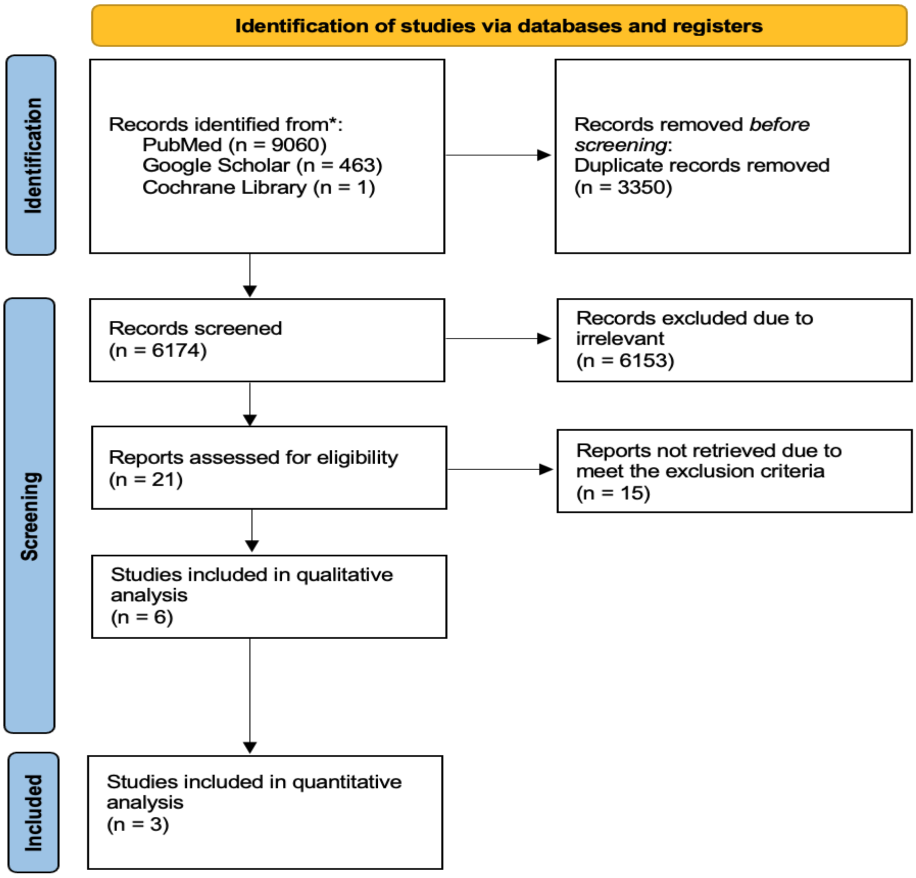

Figure 2. PRISMA Flow Diagram

The study selection process is outlined in the PRISMA flowchart in Figure 2. Searches of PubMed, the Cochrane Library, and Google Scholar initially identified 9,524 articles. After removing duplicates in Rayyan.ai, we screened titles and abstracts and excluded studies that were clearly not relevant. This resulted in six articles being reviewed in full text for eligibility. In the end, three randomized controlled trials met all inclusion criteria and were included in the quantitative synthesis and meta-analysis.

RESULT

Study Characteristics

This meta-analysis drew upon data from three randomized controlled trials conducted in Norway and the United States, which together included 690 participants diagnosed with degenerative lumbar spondylolisthesis and accompanying lumbar spinal stenosis. The patient groups across these studies showed considerable similarity, with a mean age of around 66 years and a clear majority of female participants (68–84%). The degree of vertebral slippage varied from 3 mm to 14 mm, and dynamic instability was noted in several cases, especially within the Norwegian cohorts. Surgical approaches differed as expected between arms. Patients receiving decompression alone most often underwent laminectomy or a midline-preserving decompression procedure. Those in the fusion arms, however, additionally underwent instrumented stabilization with pedicle screws and rods, with or without the placement of interbody cages. The primary outcome in each trial centered on functional improvement, quantified using the Oswestry Disability Index (ODI). Additional outcomes of interest encompassed back pain, leg pain, hospital length of stay, and reoperation rates. Follow-up durations ranged between 24 and

60 months. Pooled findings indicated that the addition of fusion to decompression did not result in a meaningful long-term decrease in reoperation rates when compared with decompression alone. Nevertheless, the combined procedure was associated with prolonged hospitalization, higher overall healthcare resource use, and a potentially increased long-term economic burden on providers. These patterns highlight the value of monitoring hospital length of stay (LOS) and broader service efficiency metrics within public health frameworks.

Table 1. Characteristics of Included Studies

Author, year country	Participants	Definition of DS	Surgical Approach	Outcomes	FU (months)	Interventions (Sample Size)	Age (years), mean (SD)	Gender (female), n (%)	Degree of vertebral slip (mm), mean (SD)	Dynamic instability, n (%)	VAS-back, mean (SD)	VAS-leg, mean (SD)
Kgomotso et al 2024 Norway	Symptomatic DS (≥3 mm slip) with spinal stenosis	≥3 mm slip on standing radiographs; no exclusion for dynamic instability	Decompression: Midline-preserving laminectomy Fusion: Decompression + pedicle screws/rods ± interbody fusion	Primary: ≥30% improvement in ODI at 2/5 years Secondary: VAS leg/back pain, ZCQ, EQ-5D, reoperations	60	Decompression-alone (n=133)	66.0± 7.4	92 (69%)	7.6 (3.2)	22% had ≥3 mm translation	6.7±2.0	6.7±2.1
						Decompression + fusion (n=129)	66.5± 7.9	88 (68%)	7.2 (2.8)	17% had ≥3 mm translation	6.6±2.0	6.7±1.8
Austevoll, et al 2021 Norway	18–80 years; neurogenic claudication or radicular radiating pain in the lower limbs that had not responded to at least 3 months of conservative care; LSS; DS ≥ 3 mm Mix of stable and instable	Dynamic instability -> slippage of at least 3 mm, or at least 10 degrees of angulation, as assessed by dynamic standing radiographs	Decompression-alone group: Posterior decompression preserving midline structures (supraspinous–interspinous ligament complex). Fusion group: Decompression (optional midline preservation) + instrumented fusion (pedicle screws with rods and bone grafting, ± intervertebral cage).	Primary: Reduction ≥30% in Oswestry Disability Index (ODI) at 2 years. Secondary: ODI mean change, Zurich Claudication Questionnaire (ZCQ), leg/back pain (NRS), EQ-5D-3L, complications, reoperations.	24 months (2 years)	Decompression-alone (n=133)	66.0± 7.4	92 (69.2)	7.6 (3.2)	35 (26)	6.7±2.0	6.6±2.0
						Decompression + fusion (n=129)	66.5± 7.9	88 (68.2)	7.2 (2.8)	27 (21)	6.7±2.1	6.7±2.1
Ghogawala, et al 2016 USA	**Symptomatic grade I DS with spinal stenosis**	**Grade I (3–14 mm slip), stable (≤3 mm dynamic motion)**	Decompression: Laminectomy Fusion: Laminectomy + posterolateral instrumented fusion	Primary: SF-36 PCS at 2 years Secondary: ODI, reoperation rates	48 months	Decompression-alone (n=35)	66.5 (8.0)	27 (77)	6.5 (2.3)	-	-	-
						Decompression + fusion (n=31)	66.7 (7.2)	26 (84)	5.6 (2.2)	-	-	-

Three investigations have examined the relative merits of decompression surgery alone compared with decompression augmented by fusion in patients who have degenerative spondylolisthesis (DS) accompanied by spinal stenosis. The Norwegian cohorts described by Kgomotso et al. (2024) and Austevoll et al. (2021) included individuals with at least 3 mm of vertebral slip; dynamic instability was present in roughly 22 % and 17 % of participants, respectively. In these studies decompression was performed while preserving midline structures, whereas fusion involved pedicle screw–rod constructs together with interbody cages. Improvement of at least 30 % on the Oswestry Disability Index (ODI) served as the primary endpoint, and secondary outcomes comprised pain intensity measured by the visual analogue scale (VAS) or numeric rating scale (NRS) as well as reoperation rates. By contrast, Ghogawala et al. (2016) in the United States restricted enrolment to patients with stable Grade I DS whose slips ranged from 3 to 14 mm and whose segmental motion remained below 3 mm, indicating an absence of meaningful instability. The decompression-only arm consisted of laminectomy without any fusion procedure. Primary outcomes were the SF-36 Physical Component Summary (PCS) score and the ODI, with assessments extending to 48 months. Across the three investigations, patient characteristics were broadly similar: mean age approximately 66 years and a clear majority of female participants. The collective evidence indicates that decompression without fusion can be sufficient for individuals whose degenerative spondylolisthesis is stable, whereas those who exhibit instability may benefit from the addition of fusion. Direct comparison remains difficult, however, because the studies employed differing definitions of stability and employed distinct surgical techniques. Longer-term follow-up from the Kgomotso et al. (2024) cohort would help clarify the durability of outcomes and support more individualised decision-making according to each patient's specific profile and degree of instability.

Functional Outcome (Oswestry Disability Index)

The pooled analysis found no statistically significant difference in functional outcomes at the 2-year follow-up between decompression alone and decompression plus fusion. The mean difference in ODI scores was 1.51 (95% CI −1.38 to 4.41; P = 0.31), suggesting both groups experienced similar improvements in disability. Heterogeneity was low (I^2 = 20%), indicating the included studies were reasonably consistent.

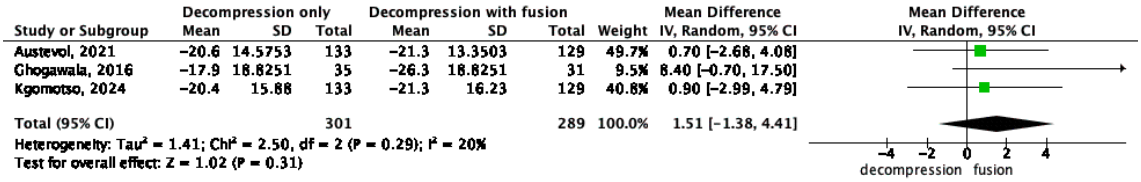

Figure 3. Forest Plot of Oswestry Disability Index (ODI) at 2-Year Follow-Up

The forest plot shows the pooled effect estimate based on three studies. Since all the confidence intervals cross the line of no effect, there doesn't appear to be a statistically significant difference between the two interventions.

Back Pain Outcome

An analysis of back pain outcomes likewise found no meaningful difference between the two treatment approaches. The pooled mean difference was −1.00 (95% CI: −4.31 to 2.32; P = 0.56), and heterogeneity was moderate (I^2 = 36%). Overall, the results indicate that both interventions are similarly effective at reducing back pain intensity over time.

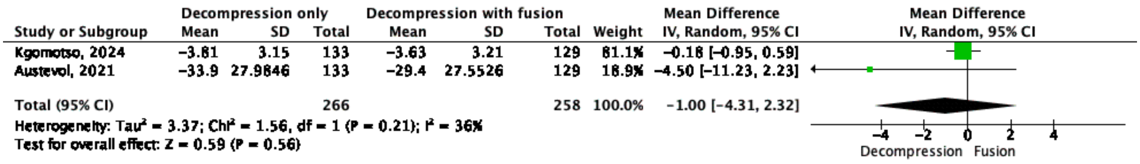

Figure 4. Forest Plot of Back Pain at ≥2-Year Follow-Up

The distribution of effects across studies is relatively consistent, with most estimates centered around zero, indicating the absence of a meaningful clinical advantage.

Leg Pain Outcome

Likewise, when leg pain outcomes were pooled, there was no statistically significant difference between decompression alone and decompression plus fusion. The mean difference was −0.44 (95% CI −1.17 to 0.29; P = 0.24), and there was no heterogeneity across studies (I^2 = 0%). Overall, the trials were highly consistent, suggesting that both approaches are similarly effective at relieving radicular symptoms.

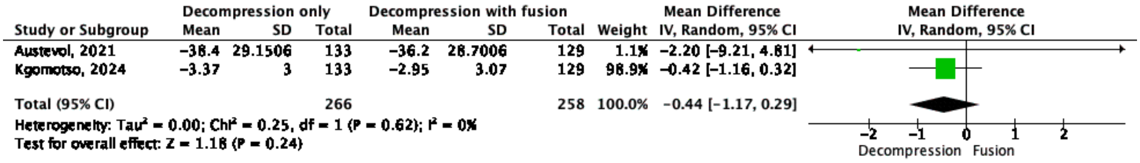

Figure 5. Forest Plot of Leg Pain at ≥2-Year Follow-Up

In patients with degenerative lumbar spondylolisthesis, decompression performed without fusion produced improvements in functional status and pain relief that were broadly equivalent to those obtained when fusion was added. While certain studies noted modest differences in reoperation rates and in selected surgical metrics, none of these reached statistical significance. For individuals with stable disease in particular, the data indicate that decompression alone can deliver adequate clinical benefit, thereby avoiding the greater technical demands, longer operative times, and potential added morbidity of fusion.

DISCUSSION

This meta-analysis suggests that, for degenerative lumbar spondylolisthesis (DS), decompression alone works about as well as decompression combined with fusion. Functional outcomes (Oswestry Disability Index/ODI) and pain measures did not differ significantly between the two approaches, implying that adding fusion provides little extra clinical benefit, especially for patients with stable DS (Gadjradj et al., 2022; Wei et al., 2020). The equivalence of ODI outcomes further suggests that functional impairment in DS is predominantly driven by neural compression rather than biomechanical instability, positioning adequate *neural decompression* as the primary determinant of postoperative recovery (Dea et al., 2020). This interpretation is reinforced by contemporary evidence indicating that decompression alone achieves non-inferior improvements in disability and patient-reported outcomes compared to combined fusion procedures, despite fusion occasionally demonstrating modest advantages in general quality-of-life domains (Chen et al., 2021). Collectively, these findings underscore the importance of prioritizing clinically meaningful, disease-specific endpoints over generalized quality-of-life indicators in surgical decision-making, while supporting a more selective and evidence-based approach to the use of fusion in stable DS cases.

This meta-analysis found that, in patients with degenerative lumbar spondylolisthesis (DS), decompression alone leads to functional outcomes similar to decompression plus fusion, with no statistically significant differences in Oswestry Disability Index (ODI) scores at follow-up of 2 years or longer. These findings are consistent across the included randomized controlled trials conducted by Kgomotso et al. (2024), Austevoll et al. (2021), and Ghogawala et al. (2016), all of which reported equivalent or non-inferior disability improvement between decompression-alone and fusion-based procedures. In the Norwegian multicenter trials by Kgomotso et al. (2024) and Austevoll et al. (2021), decompression alone achieved similar rates of ≥30% ODI improvement despite the inclusion of patients with varying degrees of dynamic instability. Likewise, Ghogawala et al. (2016) observed no substantial long-term advantage of fusion regarding disease-specific disability outcomes, although modest differences were identified in general quality-of-life measures such as the SF-36 Physical Component Summary (PCS). Collectively, these findings reinforce the growing body of evidence suggesting that adequate neural decompression, rather than routine biomechanical stabilization, constitutes the principal determinant of postoperative functional recovery in stable or low-grade DS.

From a pathophysiological standpoint, these findings suggest that symptomatic DS is driven mainly by nerve compression resulting from degenerative changes in the spine, rather than by clear-cut mechanical instability on its own. Thickening of the ligamentum flavum, facet joint arthrosis, degeneration of the intervertebral discs, and a narrowed spinal canal all play a major role in compressing the nerve roots and producing neurogenic symptoms. In the included studies, decompression procedures directly targeted these pathological mechanisms through laminectomy or midline-preserving decompression techniques, thereby effectively reducing neural compression. Conversely, fusion procedures were designed to address segmental instability using pedicle screw fixation, rods, and, in some cases, interbody cages. However, because most participants in the included studies exhibited low-grade vertebral slippage and relatively stable radiographic profiles, the additional stabilization provided by fusion may not have produced clinically meaningful benefits beyond decompression alone. This interpretation is strengthened by the low-to-moderate heterogeneity across pooled analyses (I^2 = 0–36%), indicating consistent comparative outcomes across different populations and surgical approaches.

The pain findings add further weight to the conclusion that the two approaches are comparably effective. When results were pooled, there were no significant differences in how much either back or leg pain improved after decompression alone compared with decompression plus fusion. What stands out is the complete lack of heterogeneity in leg pain outcomes (I^2 = 0%), which indicates that decompression is generally sufficient to tackle radicular pain by taking the pressure off the involved nerves. This is in line with the observations of Austevoll et al. (2021) and Kgomotso et al. (2024), both of whom found similar drops in pain scores using the Visual Analog Scale (VAS) and Numeric Rating Scale (NRS) over follow-ups lasting up to five years. While it is reasonable to suppose that fusion would help more with mechanical back pain through added stability, the combined evidence did not support a meaningful difference on this point. Therefore, routinely fusing patients just to improve pain control seems hard to justify in patients without marked instability.

Beyond clinical effectiveness, the present findings have important implications for surgical efficiency and healthcare resource utilization. Across the included studies, fusion procedures were consistently associated with greater operative complexity, including longer operative duration, higher intraoperative blood loss, and prolonged hospitalization. These observations were particularly evident in the multicenter Norwegian trials, where fusion required instrumented stabilization in addition to decompression. Increased procedural invasiveness may contribute to higher perioperative morbidity, delayed postoperative mobilization, and greater rehabilitation demands. Furthermore, from a health economics perspective, instrumented fusion substantially increases healthcare expenditures due to implant costs, longer hospital stays, and increased perioperative resource utilization. Given the absence of superior functional outcomes, the routine use of fusion in stable DS populations may therefore represent a less cost-effective strategy when compared with decompression alone. These findings align with contemporary principles of value-based healthcare, which emphasize maximizing patient outcomes while minimizing unnecessary procedural burden and healthcare costs.

The issue of reoperation rates requires careful interpretation. Although several included studies reported numerically higher reoperation rates in the decompression-alone group, pooled analyses did not demonstrate statistically significant differences between treatment strategies. In the study by Ghogawala et al. (2016), for example, some patients undergoing decompression alone subsequently required fusion because of recurrent symptoms or progressive instability; however, the overall clinical outcomes remained comparable between groups. Similarly, Kgomotso et al. (2024) and Austevoll et al. (2021) reported that differences in reoperation frequency did not reach statistical significance despite long-term follow-up. These findings suggest that the theoretical protective effect of fusion against postoperative instability may not necessarily translate into substantial long-term clinical benefit for most patients with stable DS. Moreover, reoperation is a multifactorial outcome influenced by disease progression, aging-related degeneration, patient comorbidities, surgical technique, and postoperative biomechanical adaptation. Consequently, attributing reoperation risk exclusively to the absence of fusion may oversimplify the complexity of postoperative spinal degeneration.

An important clinical implication emerging from this meta-analysis concerns the role of segmental instability in determining optimal surgical strategy. Although subgroup analyses did not identify statistically significant interactions between instability status and treatment outcomes, the limited number of available randomized studies may have reduced statistical power to detect clinically meaningful differences. Conceptually, patients with substantial radiographic instability, high-grade vertebral slippage, or sagittal imbalance may still benefit from fusion because biomechanical stabilization could prevent progressive deformity and recurrent symptoms. In contrast, the majority of patients included in the present analysis exhibited stable or low-grade DS, for whom decompression alone appeared sufficient to achieve favorable outcomes. This distinction highlights the importance of individualized surgical decision-making based on radiographic findings, spinal alignment, symptom characteristics, and patient-specific functional demands rather than a uniform operative paradigm. Therefore, selective rather than routine application of fusion may represent a more rational and evidence-based approach in the management of DS.

Several methodological limitations should be acknowledged when interpreting the findings of this study. First, only three randomized controlled trials met the eligibility criteria, limiting the statistical robustness and external validity of pooled estimates. Second, variability in definitions of instability, surgical techniques, decompression approaches, and outcome measurements may have introduced clinical heterogeneity not fully captured by statistical indices. For instance, the Norwegian studies included patients with varying degrees of dynamic instability, whereas Ghogawala et al. (2016) primarily evaluated stable Grade I DS. Third, the predominance of low-grade and stable DS cases restricts the generalizability of findings to patients with severe instability or more advanced deformity. Finally, although follow-up durations ranged from 24 to 60 months, evidence regarding very long-term outcomes, adjacent segment degeneration, and durability beyond five years remains limited. Future large-scale randomized trials with standardized definitions of instability and extended follow-up are therefore needed to refine surgical indications and optimize patient selection criteria.

Overall, the findings from this meta-analysis lend support to the view that decompression alone can serve as an effective and less invasive treatment option for many patients with degenerative lumbar spondylolisthesis, particularly those with stable or low-grade disease. The randomized studies examined here Kgomotso et al. (2024), Austevoll et al. (2021), and Ghogawala et al. (2016) demonstrated that decompression without fusion produced functional and pain-related outcomes broadly comparable to those seen when fusion was added. At the same time, the standalone procedure appeared to lower operative burden, reduce perioperative morbidity, and potentially limit overall healthcare costs. These observations suggest that fusion need not be applied routinely in every case of degenerative spondylolisthesis. Rather, it may be more appropriately reserved for carefully selected patients who show clear evidence of instability or deformity that would benefit from additional biomechanical stabilization. Looking ahead, further progress in this area will depend on well-designed multicenter randomized trials that enroll larger patient groups, adopt consistent criteria for defining instability, and incorporate longer-term follow-up. Work of this kind would help strengthen the evidence base and support more individualized surgical decision-making for degenerative lumbar spondylolisthesis.

CONCLUSION

This study suggests that, over the long term, decompression alone and decompression combined with fusion lead to largely similar clinical outcomes for patients with degenerative lumbar spondylolisthesis. A meta-analysis of three randomized controlled trials including 690 participants found no statistically significant differences in Oswestry Disability Index scores, back pain, or leg pain with at least two years of follow-up. Overall, it appears that most patients' functional improvement and symptom relief are driven mainly by effective nerve decompression, not by adding fusion. For patients with stable or low-grade disease, decompression without fusion can therefore be considered a reasonable and effective standalone approach. At the same time, fusion did not show a clear clinical advantage over decompression alone, but it was consistently associated with longer operative times, longer hospital stays, and greater use of healthcare resources. Reoperation rates were somewhat higher in the decompression-only group, although this difference was not statistically significant. Taken together, these findings support individualized surgical decision-making based on the degree of instability, relevant radiologic features, and the patient's overall clinical situation. Fusion should be used selectively, rather than routinely, in every case of degenerative lumbar spondylolisthesis.

Larger and more diverse patient cohorts would strengthen the external validity of future work. Equally important is the development of clearer, more uniform criteria for defining spinal instability; without such standardization, meaningful comparisons across studies remain difficult. Longer follow-up periods are also needed to better understand the durability of clinical gains, the incidence of adjacent-segment degeneration, and the true long-term risk of reoperation. Finally, incorporating formal health-economic analyses into subsequent trials would allow a more complete assessment of the relative value of each surgical approach.

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