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Efficacy and Safety of Full-Endoscopic Decompression Surgery for Degenerative Lumbar Spinal Stenosis in Elderly Patients: A Systematic Review and Meta-Analysis

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ABSTRACT

Background and Objective: Degenerative lumbar spinal stenosis is one of the most common causes of pain and functional disability in the elderly. In recent years, total endoscopic decompression surgery has been introduced as a minimally invasive approach that can provide more favorable clinical outcomes than classical methods. The aim of this study was to evaluate the effectiveness and safety of complete endoscopic surgery compared with other surgical methods in elderly patients with degenerative lumbar spinal stenosis.

Method: A comprehensive search of PubMed, Scopus, Embase, and the Cochrane Library was conducted up to 2025. Four randomized trials and four cohort studies that compared the clinical outcomes of total endoscopic surgery with other surgical procedures were included in the meta-analysis. Data were pooled using a random-effects model, and the index of heterogeneity (I^2) was calculated to assess differences between studies.

Result: The results showed that endoscopic surgery resulted in a significant reduction in VAS score for leg pain (MD=-0.82, 95% CI:-1.21 to -0.43, p< 0.001). A subgroup meta-analysis of low back pain severity after full-endoscopic decompression surgery compared with the control group in the elderly showed that the overall effect was -0.033 and non-significant.

Conclusion: full-endoscopic decompression surgery in elderly patients with degenerative lumbar stenosis has similar effectiveness to Microscopic Spinal Decompression, posterior transforaminal lumbar interbody fusion, and open decompression and fusion surgery.

Introduction

With the aging process taking over the global population, one of the most important causes of decreased quality of life, limitation in walking, and nerve pain due to spinal canal stenosis has been reported (1). Degenerative lumbar spinal stenosis (DLSS) has been reported to be one of the most common causes of spinal stenosis. The prevalence of DLSS in the general population is about 11% (2). Imaging findings have shown that the prevalence of DLSS is evident in healthy individuals, suggesting that DLSS is very common not only in symptomatic patients but also in asymptomatic individuals (3). As the prevalence of DLSS has increased, so has the rate of lumbar spine surgery; statistics show that the surgery rate increased from 54.2 per 100,000 people in 2016 to 64.7 per 100,000 people in 2019 (4,5).

Consideration of elderly patients is essential; evidence has shown that patients 80 years of age and older who have surgery for DLSS have had significant improvement compared to nonsurgical treatment, and the rate of complications or mortality has been similar between the elderly and younger groups (6,7). Studies have shown that in 474,651 patients, preoperative frailty was significantly associated with increased mortality, major complications, need for readmission, return to the intensive care unit, and increased length of hospital stay (8).

The use of minimally invasive technologies is particularly important in the elderly, as reduced surgical invasiveness can be associated with shorter recovery times, less bleeding, and faster functional recovery.

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Therefore, Full-Endoscopic Decompression Surgery is receiving more and more attention (9). Since comprehensive data and up-to-date methods to evaluate the efficacy and safety of this procedure in the elderly population with DLSS are limited, the present study aimed to evaluate the Efficacy and Safety of Full-Endoscopic Decompression Surgery for Degenerative Lumbar Spinal Stenosis in Elderly Patients to fill the existing gaps with more comprehensive results and, with a focus on the elderly, to provide high-quality evidence to guide clinical decision-making in this important group of patients.

Method

Study design, Information sources and search strategy

The present study is a systematic review and meta-analysis conducted in accordance with the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guideline (10). A comprehensive search was conducted in PubMed, Scopus, Web of Science, Embase, and Cochrane Library databases up to October 2025. The search terms included combinations of keywords reported in Table 1. References of selected articles and relevant reviews were also manually checked to ensure that no studies were missed. Two independent, blinded researchers performed the search and screening process.

Study inclusion and exclusion criteria

- ✓ Inclusion criteria: Based on the PICOS strategy.
- ✓ Population (P): Patients ≥ 60 years of age with DLSS.
- ✓ Intervention (I): Full-Endoscopic Decompression surgery
- ✓ Comparison group (C): Open surgery, microsurgery, or other minimally invasive procedures.
- ✓ Outcomes (O): Effectiveness (Clinical efficacy: OCD, Visual Analogue Scale (VAS), Japanese Orthopaedic Association (JOA) score), and Safety (duration of surgery, bleeding, length of hospital stay, complications (cerebrospinal fluid leak, infection, nerve damage), and recovery rate).
- ✓ Study type (S): Randomized controlled trial (RCT), prospective and retrospective cohort studies.
- ✓ Exclusion criteria: Case reports, reviews, non-English articles, animal studies, and studies lacking quantitative data.

Table 1. Search Strategy for the Systematic Review

Concept	Keywords / Search Terms	Databases Used
Population	"Lumbar spinal stenosis" OR "Degenerative lumbar spinal stenosis" OR "Lumbar canal stenosis" OR "Spinal canal narrowing" OR "Elderly" OR "Older adults" OR "Aged" OR "Geriatric patients"	PubMed, Scopus, Embase, Web of Science, Cochrane Library
Intervention	"Full endoscopic decompression" OR "Full-endoscopic spinal surgery" OR "Percutaneous endoscopic lumbar decompression" OR "Endoscopic interlinear decompression" OR "Endoscopic transformational decompression"	PubMed, Scopus, Embase, Web of Science, Cochrane Library
Comparison	"Open decompression" OR "Microscopic decompression" OR "Laminectomy" OR "Micro endoscopic decompression" OR "Minimally invasive spine surgery"	PubMed, Scopus, Embase, Web of Science, Cochrane Library
Outcomes	"Efficacy" OR "Clinical outcome" OR "Functional recovery" OR "Oswestry Disability Index" OR "VAS score" OR "Complication rate" OR "Reoperation rate" OR "Hospital stay"	PubMed, Scopus, Embase, Web of Science, Cochrane Library
Boolean Combination	("Lumbar spinal stenosis" OR "Degenerative lumbar spinal stenosis") AND ("Full endoscopic decompression" OR "Endoscopic spinal surgery") AND ("Elderly" OR "Older adults") AND ("Efficacy" OR "Safety")	Applied across all databases

Data extraction

Data were extracted independently and blindly by two investigators using a pre-prepared standard form. Information included the following: author name, year of publication, study design, sample size and population characteristics (mean age, sex, comorbidities), type of surgical approach (interlinear/transformational), and follow-up period. Outcome indicators ODI, VAS, JOA, complications, reoperation, hospitalization time, and bleeding were also extracted in another form to enter data into STATA software.

Assessing the quality and risk of bias of studies

To ensure the validity of the results, the methodological quality of each study was assessed as follows:

Randomized trials (RCTs): Using the Cochrane Risk of Bias 2.0 tool, including 5 main areas: randomization and allocation concealment, intervention bias, incomplete data, outcome measurement, selective reporting. Each area was scored at three levels of "low risk", "some concerns" or "high risk".

Cohort studies: Using the Newcastle Ottawa Scale (NOS) in three areas: participant selection (maximum 4 points), group comparability (2 points), outcome or exposure measurement (3 points), the total score ranged from 0 to 9, and studies with a score ≥ 7 were considered high quality.

Quality assessment was performed by two independent and blinded evaluators, and finally the final average score was recorded. At all stages, a third researcher resolved differences of opinion.

Statistical analysis

Data were analyzed with Stata 17 software. For continuous variables (ODI, VAS, JOA), mean difference (MD) with 95% confidence interval was used. For dichotomous variables (adverse events, recurrence), risk ratio (RR) was used. Heterogeneity between studies was assessed with I^2 statistic, where $I^2 < 25\%$ was considered low heterogeneity, 25-50% was considered moderate, and I^2 above 50% was considered high. In case of high heterogeneity between studies, the random effects model (DerSimonian Laird) was used, and otherwise, fixed effects were used. Publication bias was assessed using Egger's test and funnel plot.

Quality Assessment using GRADE

The overall quality of the evidence for each outcome was assessed using the GRADE (Grading of Recommendations Assessment, Development and Evaluation) framework. This approach includes five main areas: 1. Risk of Bias; 2. Inconsistency; 3. Indirectness; 4. Imprecision; 5. Publication Bias. Each outcome was classified into one of four confidence levels based on these criteria: high, moderate, low, and very low.

Result

Literature Search

In the initial search using keywords, 548 articles were identified. After reviewing the titles, duplicate articles (n=95) were removed and 189 articles were excluded from the review due to the type of study. In the next step, the abstracts of 264 articles were evaluated according to the inclusion and exclusion criteria and another 224 articles were excluded. Finally, the full text of 40 articles was reviewed independently by two authors without knowledge of each other's opinions. In cases of disagreement, the opinion of the third author was applied. after this process, 8 articles that were consistent with the study objectives were selected for analysis (Figure 1).

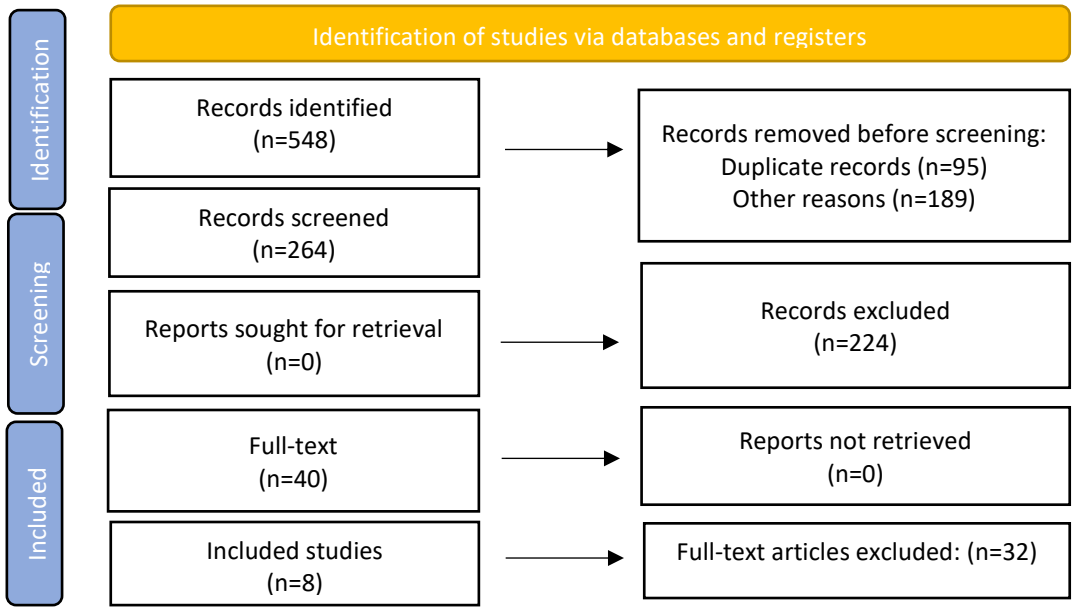

Figure 1. PRISMA 2020 Flow Diagram

Table 2. The study table

Author (Year)	Study Design	Sample Size (n)	Control group/ n	Mean Age (years)	Full-endoscopic type	Follow-up Duration (month)
Gao et al., 2025 (11)	Retrospective study	45	PTLIF/37	75.6	NR	6
Xiong et al., 2024 (12)	Retrospective study	31	MSD/27	62	portal technique	12
Kotheeranurak et al., 2023 (13)	RCT	30	MSD/30	63	portal technique	24
Jiang, et al., 2023 (14)	Retrospective study	58	MSD/38	65	NR	6
Song et al., 2021 (15)	Retrospective study	177	ODFS/181	65.47	NR	38.63
Park et al., 2020 (16)	RCT	32	MSD/32	66.2	portal technique	12
Kang et al., 2019 (17)	RCT	32	MSD/30	65.1	portal technique	6
Komp et al., 2015 (18)	RCT	71	MSD/64	62	Uniportal technique	6

- ✓ MSD: Microscopic Spinal Decompression.
- ✓ PTLIF: posterior transformational lumbar interbody fusion.
- ✓ ODFS: open decompression and fusion surgery.

In the present study, there were 445 patients in the experimental group and 399 in the control group; four studies compared the MSD (Microscopic Spinal Decompression) technique, one study compared PTLIF (posterior transformational lumbar interbody fusion), and one study compared ODFS (open decompression and fusion surgery). This diversity of the control group prompted the subgroup meta-analysis. The mean age of patients ranged from 62 to 75.6 years, age differences may affect pain and function outcomes. The follow-up period ranged from 6 to 38.63 months (Table 2).

leg pain

According to figure 2:

Overall (Overall MD = -0.26, 95% CI -0.65 to 0.13), the overall effect of reducing leg pain in elderly patients after Full-Endoscopic Decompression Surgery compared to the control group was not statistically significant (p>0.05). However, the direction of the negative effect (towards pain reduction) indicates that clinically observed pain reduction is occurring.

The test of group differences showed a significant difference was observed between the control groups in terms of leg pain reduction results (p<0.001).

A significant reduction in leg pain was observed in the comparison of Full-endoscopic decompression surgery with Microscopic Spinal Decompression (MD= -0.52, CI -0.91 to -0.14, p < 0.05). While in the other two comparisons, only one study was included in the meta-analysis and no significant difference was observed between the two groups.

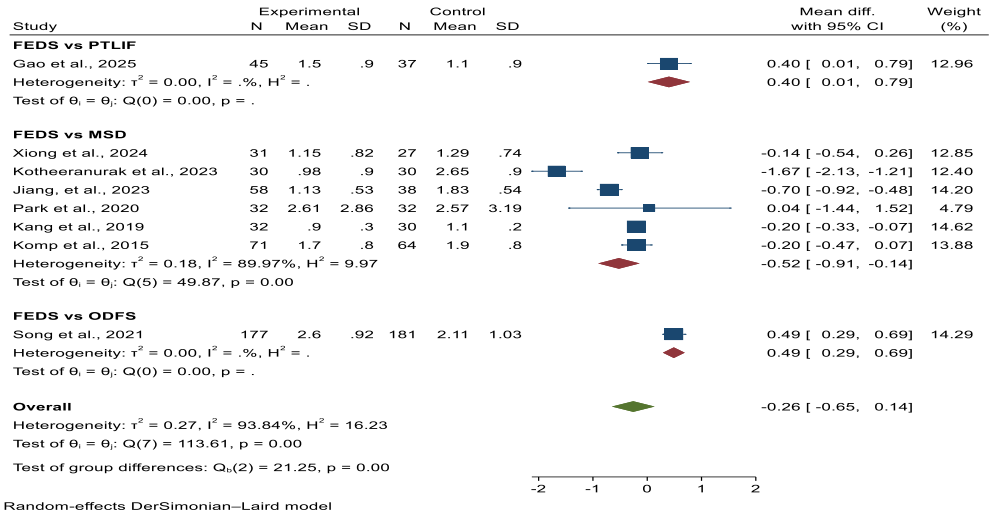

Figure 2. Forest plot of Visual analogue scale (VAS) for leg pain

Back pain

According to figure 3:

A subgroup meta-analysis of low back pain severity after full-endoscopic decompression surgery compared with the control group in the elderly showed that the overall effect was very small and non-significant. The cumulative mean difference (Overall MD) was -0.033 with a 95% confidence interval of -0.229 to 0.164.

In the comparison of Full-endoscopic decompression surgery with Microscopic Spinal Decompression, the mean difference was 0.30 (95% CI: -0.091 to 0.691), indicating a slight increase in back pain, but the confidence interval included zero and therefore the effect was no significant. Overall, there was no statistically significant difference between Full-Endoscopic Decompression surgery and the control group in elderly patients with degenerative lumbar canal stenosis. There was no significant effect on low back pain.

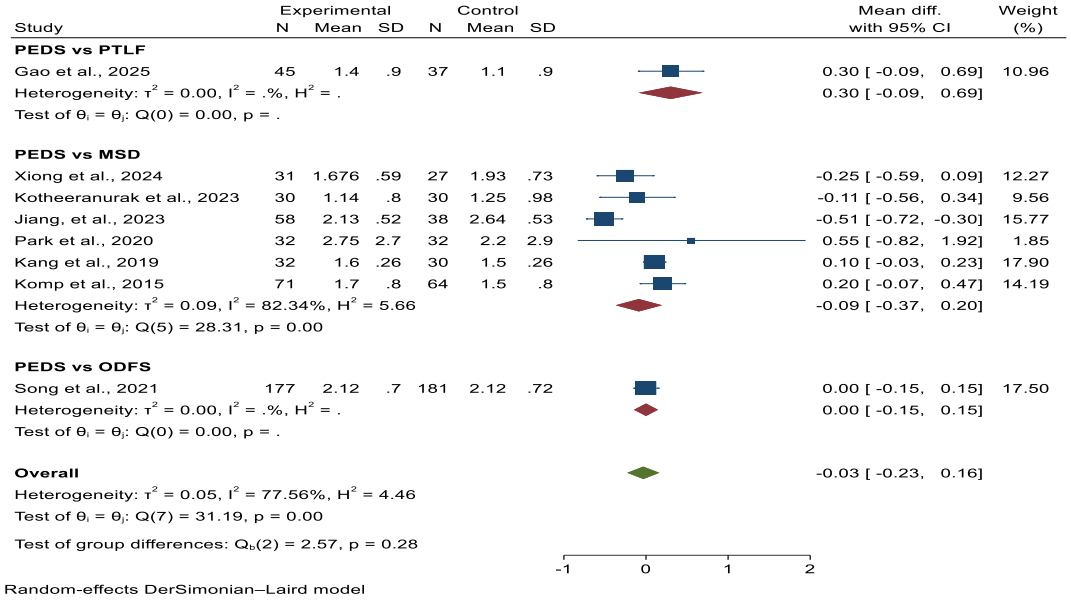

Figure 3. Forest plot of Visual analogue scale (VAS) for beck pain

Oswestry disability Index (ODI)

Full-Endoscopic Decompression surgery does not have a significant difference in reducing ODI compared to the control group in elderly patients with degenerative lumbar stenosis.

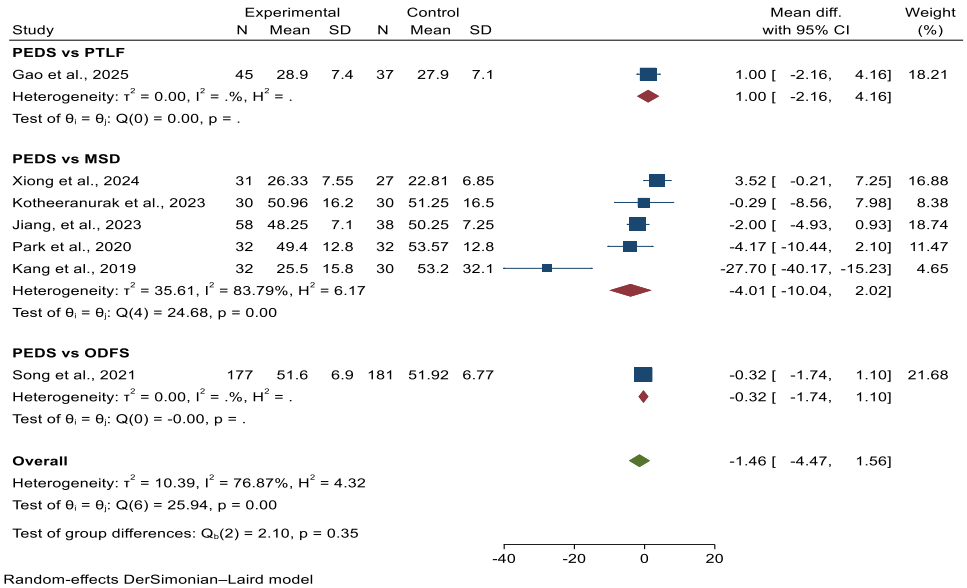

Figure 4. Forest plot of Oswestry disability Index (ODI) between groups.

Discussion

In the present meta-analysis, it was observed that Full-Endoscopic Decompression surgery had similar results on pain and function compared to other surgeries. For lower extremity pain (VAS leg pain), there was a significant difference in the reduction of leg pain compared to Microscopic Spinal Decompression. In contrast, for low back pain (VAS low back pain), the overall effect was very small and non-significant, and for the ODI index, a small reduction was also observed, which was not statistically significant. The results show that the reduction of lower extremity pain occurs due to direct nerve decompression, but axial pain and functional disability are affected by multiple structural and degenerative factors in the elderly and do not improve significantly with endoscopic surgery alone. Heterogeneity between studies was a prominent feature of this meta-analysis. For the leg pain VAS, I^2=89.97% in the second subgroup and 93.84% in all studies were reported, indicating significant differences between studies. High heterogeneity was also observed for the back VAS and ODI (I^2≈77.56% and 76.87%). This heterogeneity includes differences in study design (retrospective vs RCT), sample sizes, population characteristics (mean age 62 to 75.6 years), type of surgical technique (uniportal vs portal), follow-up duration (6 to 38 months), and differences in control groups (MSD, PTLIF, ODFS).

The present findings are largely consistent with previous studies that reported that the fully endoscopic approach significantly reduced lower extremity pain but had no significant effect on back pain or functional disability (19,20). Elderly patients are less likely to experience functional improvement through nerve decompression alone due to degenerative changes and structural complexity. Minor discrepancies between our results and previous meta-analyses could be due to our specific focus on the elderly population, differences in follow-up duration, surgical technique, and baseline disease severity.

The meta-analysis Full-endoscopic versus microscopic spinal decompression for lumbar spinal stenosis (2024) reported that the endoscopic method significantly reduced bleeding, reduced length of hospital stays, and reduced complications, but no significant effect on pain or function was clearly observed (21). The present finding regarding ODI and low back pain is similar to these reports, where no significant improvement in function or back pain was observed. The study showed that uniporter endoscopic approach did not significantly differ from MIS in clinical pain scores or ODI (22). Another study reported that the endoscopic procedure significantly reduced back pain, but no difference was observed for ODI (23). The results of another meta-analysis showed that endoscopic compared with microscopic treatment improved lower extremity pain (MD ≈ -0.20; 95% CI -0.30 to -0.10; p=0.001) and had no effect on back pain (24). Another study showed no significant difference in VAS of back pain, leg pain, or ODI between endoscopic and microscopic portal (25).

Comparison with previous meta-analyses shows that the present findings are largely consistent with them. This agreement indicates the validity of the present results and emphasizes that the elderly is less likely to experience functional improvement through purely neural discharge due to degenerative changes and structural complexity. Minor discrepancies between the present results and previous meta-analyses could be due to the focus of the present study on the elderly population, differences in follow-up duration, surgical technique, and baseline disease severity.

The present study has several limitations that should be considered when interpreting the results. A significant proportion of the included studies were retrospective in nature, which increases the possibility of patient selection bias. The sample sizes in some studies were relatively small, which may have reduced the statistical power of the meta-analysis results. Considerable heterogeneity (I^2> 50%) was observed in some outcomes, particularly in VAS assessment for leg and back pain, which was likely due to differences in surgeon experience, follow-up duration, and characteristics of the elderly populations. Also, some studies lacked detailed reporting of complications, bleeding rates, and length of hospital stay, which limited the safety analysis. The lack of standardized data on postoperative quality of life (QoL) and ODI performance index in a significant proportion of articles limited the possibility of a more comprehensive meta-analysis.

Conclusion

Full-Endoscopic Decompression Surgery is more effective than microscopic surgical methods in improving leg pain (VAS-Leg) in elderly patients with degenerative lumbar canal stenosis. The present meta-analysis supports the high efficacy of the endoscopic approach in the elderly, but due to methodological limitations, the results should be interpreted with caution. Randomized studies with a more rigorous design and larger sample size are recommended for definitive confirmation. It is recommended that multicenter randomized clinical trials with large sample sizes and longer follow-up be conducted to investigate the stability of functional outcomes and late complications. Also, factors that predict treatment success, such as muscle mass, severity of degeneration, and systemic comorbidities, should be investigated in elderly patients. It is recommended to establish a standard protocol for reporting complications and functional outcomes to allow for more accurate meta-analysis.

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Conflicts of interest
The authors declare that they have no competing interests.

Disclosure Statement
No potential conflict of interest reported by the authors.

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Authors' Contributions
All authors contributed to data analysis, drafting, and revising of the paper and agreed to be responsible for all the aspects of this work.

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