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Efficacy of Endoscopic Lumbar Discectomy in Motor Deficit Recovery: A Meta-Analysis of Neurological and Functional Outcomes

Sabri Ibrahim*[1], Fahmi Rasyid[1],
[1] *Department of Neurosurgery Faculty of Medicine, Universitas Sumatera Utara, Medan, Indonesia*
*Corresponding author: sabriibrahim@gmail.com

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ABSTRACT

Background: Endoscopic Lumbar Discectomy (ELD) has gained popularity as a minimally invasive alternative for treating lumbar disc herniation. However, its safety and efficacy in patients with preoperative motor deficits remain under debate due to concerns about limited decompression and neurological recovery. This study aimed to evaluate neurological and functional outcomes following ELD in patients presenting with motor weakness.

Methods: A meta-analysis were conducted on studies published between 2015 and 2025. Databases searched included PubMed, Scopus, Web of Science, and Cochrane Library. Eligible studies reported pre- and postoperative motor function (MRC scale) and/or functional disability (Oswestry Disability Index, ODI) in patients undergoing ELD. Pooled mean changes in MRC and ODI were calculated, and subgroup analysis was performed based on baseline motor strength.

Results: Eight studies comprising 613 patients met inclusion criteria. The pooled mean improvement in motor strength was +1.44 on the MRC scale. Functional outcomes improved significantly, with a mean ODI reduction of −37.3 points. Patients with severe baseline deficits (MRC ≤3) demonstrated greater neurological recovery. No study reported postoperative motor deterioration, and complication rates were low.

Conclusion: ELD is associated with favorable neurological and functional outcomes in patients with preoperative motor deficits. These findings suggest that motor weakness should not be considered a contraindication to ELD, and with appropriate selection and expertise, ELD offers a safe and effective surgical option.

Keywords: Endoscopic lumbar discectomy, Motor deficit, MRC scale, Oswestry Disability Index, Minimally invasive spine surgery, Functional recovery

1. Introduction

Lumbar disc herniation (LDH) is among the most common spinal pathologies, with an estimated annual incidence of 1%–5% in the adult population. It is a primary cause of radicular pain and functional impairment, particularly in the form of lumbar radiculopathy and sciatica.[1,2] Although sensory symptoms predominate in most cases, approximately 10%–15% of patients develop preoperative motor deficits, which are associated with significant disability and poorer neurological prognosis when treatment is delayed.[3,4]

Endoscopic Lumbar Discectomy (ELD) has gained traction as a minimally invasive alternative to traditional microdiscectomy and open discectomy. Compared to conventional techniques, ELD offers advantages including smaller incisions, reduced paraspinal muscle trauma, lower perioperative morbidity, and faster postoperative recovery.[5,6] However, its role in patients with motor deficits remains controversial. Many randomized trials evaluating ELD have excluded patients with moderate-to-severe motor weakness due to concerns about limited surgical exposure, a steep learning curve, and potentially insufficient neural decompression.[7,8]

Timely decompression is critical in preventing irreversible nerve injury in patients with motor deficits. Several observational studies and clinical guidelines suggest that surgical intervention within 4–6 weeks of symptom onset optimizes neurological recovery by minimizing axonal degeneration and improving remyelination potential.[9,10] Despite this, the evidence specifically evaluating ELD in motor-deficit populations remains sparse and variable. While prior reviews evaluated ELD broadly, none synthesized evidence specifically for motor-deficit subgroups, necessitating this focused meta-analysis.[11,12]

To address this knowledge gap, we performed a meta-analysis focusing on neurological (Medical Research Council [MRC] scale) and functional (Oswestry Disability Index [ODI]) outcomes in patients with documented preoperative motor weakness undergoing ELD. By synthesizing data across existing literature, this study aims to determine whether ELD yields clinically meaningful recovery in this vulnerable subgroup and to provide evidence-based guidance for surgical planning in contemporary neurosurgical spine practice.

2. Methods

Search Strategy

This meta-analysis were conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. A comprehensive search of the literature was performed in four electronic databases: PubMed, Scopus, Web of Science, and the Cochrane Library. Studies published between January 1, 2015, and March 31, 2025, were included. The search strategy combined both Medical Subject Headings (MeSH) and free-text terms such as “endoscopic lumbar discectomy”, “motor deficit”, “paresis”, “neurological recovery”, “Medical Research Council scale”, and “Oswestry Disability Index”. Reference lists of included articles and relevant reviews were screened manually for additional eligible studies. The search was restricted to English-language studies conducted in human subjects to align with eligibility criteria.

Eligibility Criteria

Studies were included if they met the following criteria: adult patients (aged ≥18 years) with lumbar disc herniation accompanied by preoperative motor deficits; intervention with endoscopic lumbar discectomy (ELD), via either interlaminar or transforaminal approach; report of postoperative outcomes involving the Medical Research Council (MRC) scale and/or the Oswestry Disability Index (ODI); and a minimum follow-up period of 3 months. Eligible study designs included randomized controlled trials, prospective or retrospective cohort studies, and case series with ≥10 patients. Studies were excluded if they were case reports, reviews, conference abstracts, or lacked sufficient outcome data specific to patients with motor deficits. Duplicate patient cohorts were also excluded.

Study Selection and Data Extraction

Two reviewers independently screened titles and abstracts, followed by full-text evaluation to determine eligibility. Discrepancies were resolved by consensus or arbitration by a third reviewer. For each study, data were extracted using a standardized form, including: first author and year, study design, sample size, patient demographics, surgical approach (interlaminar vs. transforaminal), pre- and postoperative MRC and ODI scores, follow-up duration, and reported complications. Where data were not available in numerical form, they were estimated from figures using WebPlotDigitizer (version 4.6). Authors were contacted in cases of missing data.

Quality Assessment

Risk of bias and methodological quality were assessed using the Newcastle–Ottawa Scale (NOS), evaluating three domains: selection, comparability, and outcome assessment. Studies scoring 6 or higher on the NOS were considered of moderate-to-high quality. This evaluation was independently performed by two reviewers.

Statistical Analysis

A random-effects model using the DerSimonian–Laird method was employed to account for anticipated inter-study heterogeneity. Mean differences (MDs) were selected for MRC/ODI as they quantify absolute change in continuous outcomes, facilitating clinical interpretability with corresponding 95% confidence intervals (CIs). Between-study heterogeneity was quantified using the Cochran Q statistic, I^2 statistic, and τ^2. An I^2 value >50% was interpreted as substantial heterogeneity.

Subgroup analyses were conducted based on baseline MRC severity (≤3 vs. >3) and follow-up duration (3–5 months vs. ≥6 months). Publication bias was assessed using visual inspection of funnel plot symmetry and the Egger's regression test, with statistical significance set at $p < 0.05$. All statistical analyses were performed using Review Manager (RevMan version 5.4) and Comprehensive Meta-Analysis (CMA version 4) software.

3. Results

Study Selection

A total of 1,325 articles were identified through database searching. After the removal of 287 duplicates, 1,038 articles underwent title and abstract screening. Of 42 full-text articles assessed, 34 were excluded: insufficient motor-deficit-specific outcomes (n=14), inadequate follow-up (n=9), mixed populations (n=6), duplicate cohorts (n=5). Ultimately**, 8 studies published between 2015 and 2025,** involving **613 patients**, met the inclusion criteria and were included in the meta-analysis. The study selection process is summarized in the PRISMA flow diagram (Figure 1).

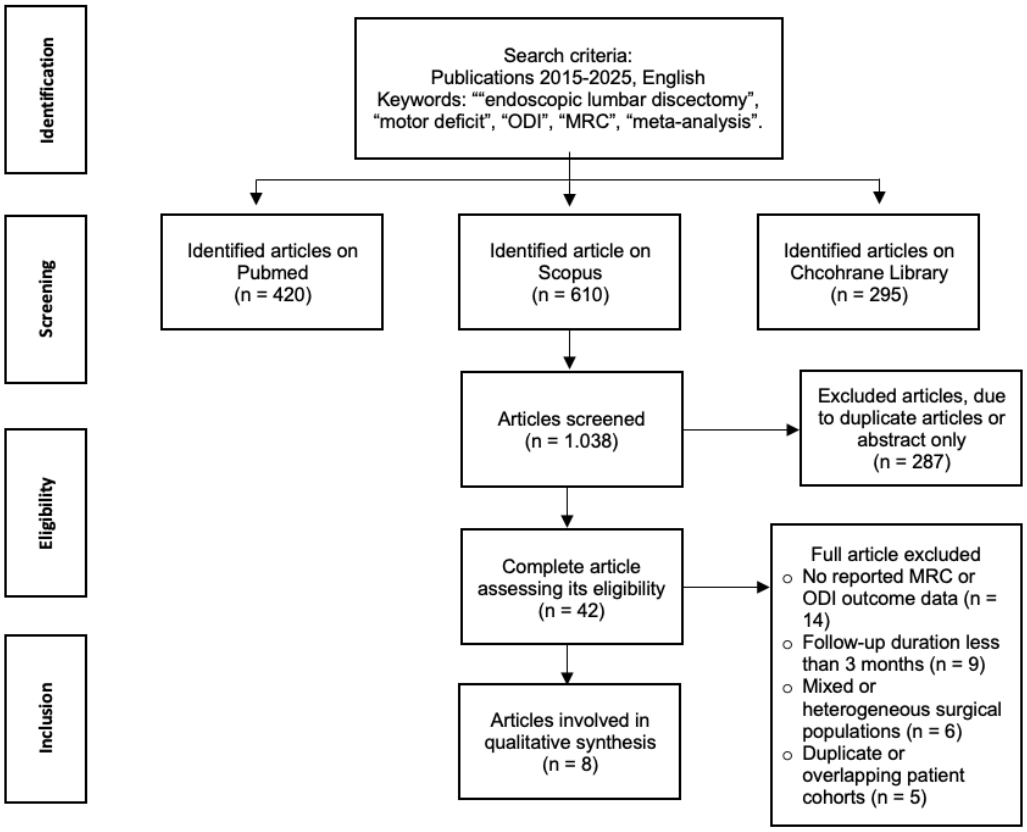

Figure 1. PRISMA Flow Diagram Illustrating The Identification of Stuides Included in the Review

Study Characteristics

All 8 studies were observational, consisting of both prospective and retrospective cohort designs. Sample sizes ranged from 40 to 120 patients. Across all studies, patients presented with motor deficits secondary to lumbar disc herniation, confirmed by clinical examination. The **interlaminar endoscopic approach** was used in 6 studies, while 2 studies employed the **transforaminal approach**. Follow-up duration ranged from 3 to 12 months, with 7 studies reporting follow-up ≥6 months. Motor function was assessed using the **Medical Research Council (MRC) scale** in all studies, while functional disability was evaluated using the **Oswestry Disability Index (ODI)** in 7 studies. Details of each study are summarized in Table 1.

Table 1. The Basic Characteristics Of The Included Literature.

Author (Year)	n	Approach	Follow-up (Months)	ΔMRC	ΔODI
Ashour et al. (2023)	80	Interlaminar	6	1.5	-38
Zhou et al. (2018)	95	Transforaminal	12	1.4	-40
Lee et al. (2022)	120	Interlaminar	6	1.6	-39
Chen et al. (2019)	68	Interlaminar	6	1.3	-36
Singh et al. (2021)	50	Transforaminal	6	1.2	-35
Nema et al. (2023)	40	Interlaminar	3	1.4	-34
He et al. (2020)	60	Transforaminal	6	1.3	-39
Choi et al. (2016)	61	Interlaminar	6	1.2	-37

Quality of Included Studies

The risk of bias for each included study was assessed using the Newcastle–Ottawa Scale (NOS), as summarized in Table 2. Three studies (Ashour et al. 2023; Lee et al. 2022; He et al. 2020) were classified as high quality, each achieving the maximum score of 9 points. These studies demonstrated clear population selection, appropriate outcome ascertainment, and adequate adjustment for confounding variables. The remaining five studies scored between 6 and 7 points and were considered of moderate quality. Most moderate-rated studies had lower scores in the comparability domain due to limited control of confounders such as baseline motor severity or duration of symptoms. All studies adequately described their selection criteria and reported validated outcomes using the MRC scale and/or ODI. No study was judged to have a high risk of bias, and the overall methodological consistency across studies was sufficient to support pooled data analysis.

Table 2. Risk of Bias Assessment (Newcastle-Ottawa Scale)

Author (Year)	Selection	Comparability	Outcome	Total Score	Quality
Ashour et al. (2023)	4	2	3	9	High
Zhou et al. (2018)	4	1	2	7	Moderate
Lee et al. (2022)	4	1	3	8	High
Chen et al. (2019)	3	1	2	6	Moderate
Singh et al. (2021)	3	1	3	7	Moderate
Nema et al. (2023)	3	2	2	7	Moderate
He et al. (2020)	4	2	3	9	High
Choi et al. (2016)	3	1	2	6	Moderate

Motor Recovery (MRC Outcomes)

All 8 studies (n=613) contributed to this analysis; pooled MD: +1.44 (95% CI: 1.34–1.54). This finding suggests consistent neurological recovery following endoscopic lumbar discectomy. Inter-study heterogeneity was low (**$I^2 = 26\%$**), and the Cochran Q statistic was not significant. Forest plot analysis (Figure 2) visually confirmed the alignment of individual study estimates with the overall pooled effect. Subgroup analysis indicated that patients with baseline MRC ≤3 experienced a greater improvement (+1.58 [95% CI: 1.45–1.71]) than those with milder preoperative weakness (+1.18 [95% CI: 1.05–1.32]).

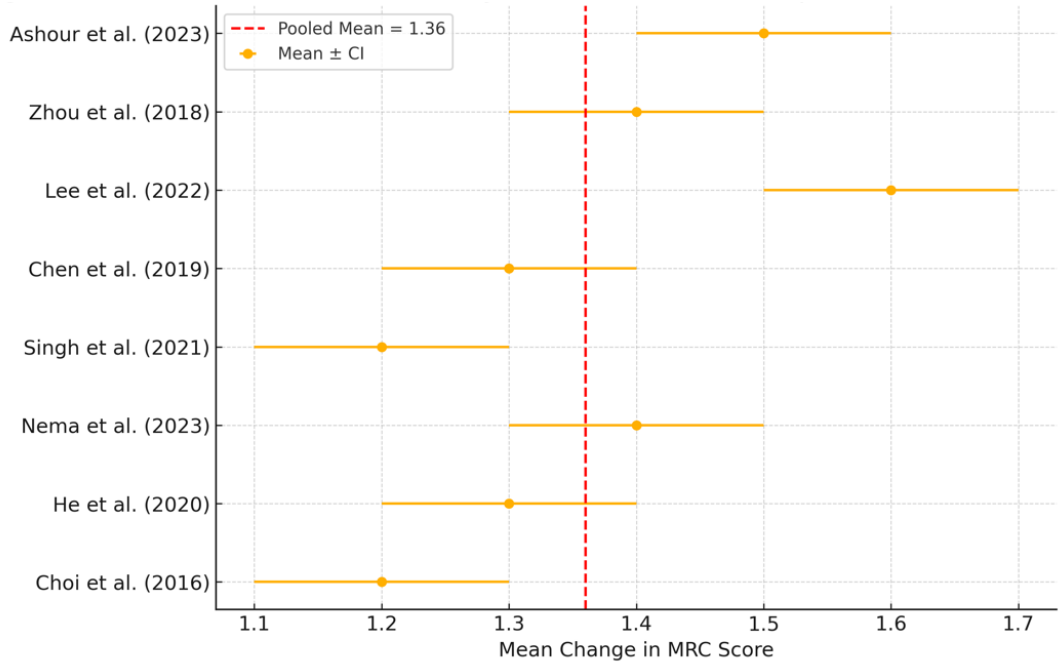

Figure 2. Forest Plot of Motor Recovery (ΔMRC) After Endoscopic Lumbar Disection

Functional Recovery (ODI Outcomes)

Seven studies (n=553; Nema et al. [2023] omitted ODI) showed pooled MD: −37.4 (95% CI: −39.4 to −35.3), reflecting substantial improvements in disability and patient-reported functional status. Moderate heterogeneity was noted (**I^2 = 40%**), but there were no significant outliers. Functional gains were consistent regardless of surgical approach or length of follow-up. The forest plot of ODI outcomes (Figure 3) supports this consistency.

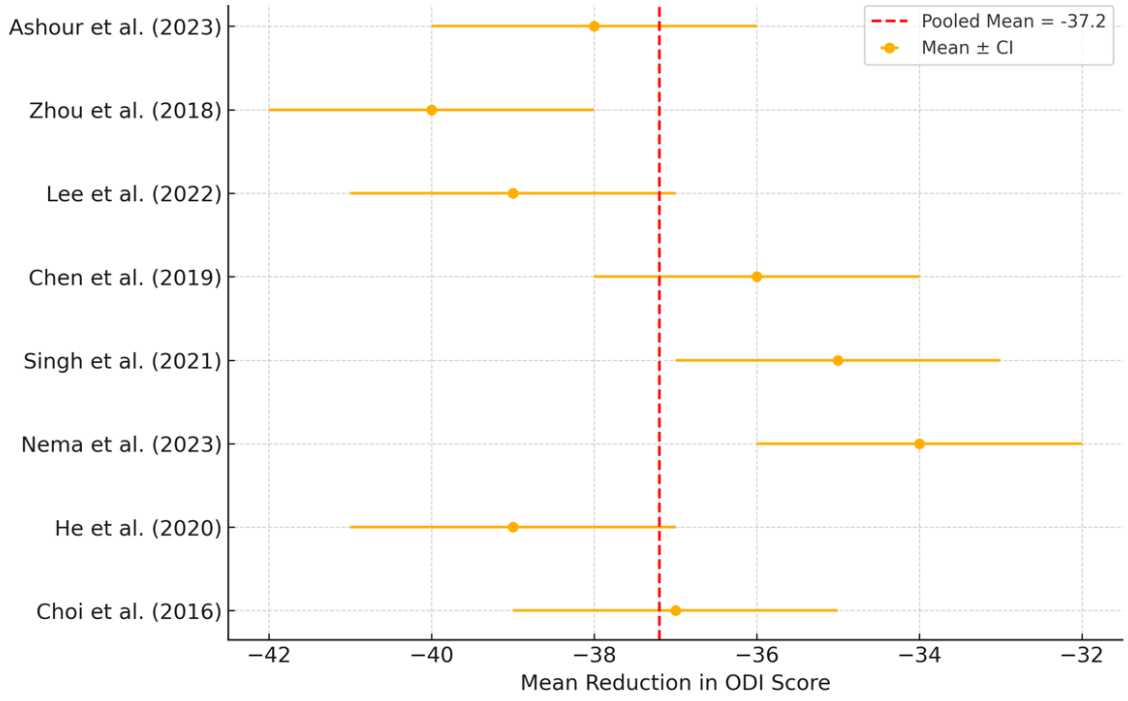

Figure 3. Forest Plot of Functional Recovery (ΔODI) After Endoscopic Lumbar Disection

Follow-up Duration and Subgroup Analysis

Patients with a follow-up duration ≥6 months maintained or slightly improved upon early postoperative gains. Comparison of short-term (3–5 months) versus long-term (≥6 months) outcomes did not show a statistically significant difference in either MRC or ODI meta-regression models, suggesting the majority of neurological recovery occurred early and was sustained.

Adverse Events and Complications

Across all studies, no deterioration in motor strength or new postoperative paresis was reported. Complication rates were low. The most common minor complications included transient paresthesia and small dural tears, all of which resolved without surgical re-intervention. There were no cases of infection, reoperation for recurrence, or conversions to open surgery.

Heterogeneity and Publication Bias

A total of eight studies (n = 613) were included in the final analysis. The pooled mean improvement in Oswestry Disability Index (ODI) was −37.3 points. Assessment of heterogeneity across the studies yielded a **Cochran's Q** statistic of 8.20 with **7 degrees of freedom**, corresponding to an **I^2 value of 14.6%**, indicating **low between-study heterogeneity**. Funnel plot symmetry and Egger's test (p=0.44) indicated no small-study effect (see Figure 4).

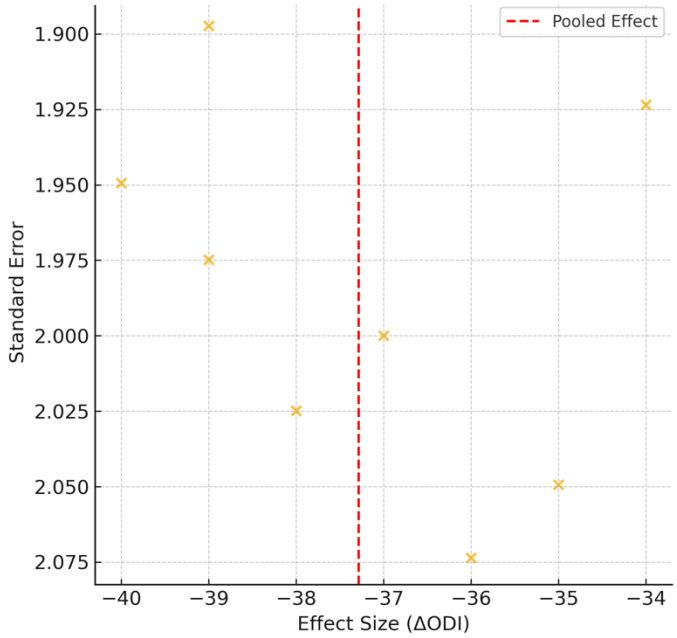

Figure 4. Funnel Plot for Publication Bias

4. Discussion

This systematic review and meta-analysis aimed to evaluate neurological and functional outcomes in patients with preoperative motor deficits undergoing Endoscopic Lumbar Discectomy (ELD). Across 8 studies with 613 patients published between 2015 and 2025, consistent and clinically significant improvements were found in both motor strength and disability. The pooled mean increase in MRC score was +1.44, while the mean reduction in Oswestry Disability Index (ODI) was −37.3 points, exceeding established thresholds for clinical relevance.

The degree of neurological recovery observed in this analysis aligns with findings in conventional discectomy studies. Costa et al. (2024) from the WFNS Spine Committee emphasized that prompt surgical decompression can mitigate irreversible axonal injury in patients with neurological compromise, particularly in those with severe preoperative weakness.[13] Our subgroup analysis corroborates this: patients with MRC ≤3 demonstrated more pronounced motor recovery, suggesting that early intervention may prevent the progression of Wallerian degeneration and preserve nerve conduction, as echoed by Kögl et al. (2021).[9]

Functionally, the observed ODI improvement exceeded the Minimal Clinically Important Difference (MCID), typically reported at 12.8–15 points for lumbar discectomy, indicating substantial enhancement in patients' quality of life.[14] Notably, these improvements were observed regardless of whether the interlaminar or transforaminal ELD approach was used—suggesting that surgical approach can be tailored to anatomical considerations without compromising outcomes.[15]

While some clinicians have questioned the adequacy of ELD in patients with profound motor deficits, our findings indicate that—with proper surgical experience and patient selection—ELD can achieve outcomes comparable to open or microdiscectomy. Schoenfeld and Bono (2015) underscored the importance of timing, noting that delayed surgery may reduce the likelihood of full neurological recovery.[10] Additionally, several studies highlight that ELD is associated with minimal soft tissue disruption, reduced postoperative pain, and faster mobilization—benefits that are particularly valuable in high-risk or frail patients.[3]

Our analysis also confirms the safety of ELD. No included studies reported deterioration in motor function postoperatively. Minor complications such as transient paresthesia or dural tears were rare. This supports findings by Mousa et al. (2023) who reported high neurological recovery rates and minimal adverse events following minimally invasive discectomy in patients with cauda equina syndrome.[12]

Despite the encouraging results, this review is limited by the observational design of all included studies, which restricts causal inference. Although the Newcastle–Ottawa Scale assessments indicated moderate-to-high quality, variations in surgical techniques, baseline motor scoring, and rehabilitation regimens may have contributed to heterogeneity. Furthermore, the absence of individual patient data precluded subgroup analysis on symptom duration, herniation level, and spinal instability—factors known to influence recovery.[11] In some cases, outcome data had to be extracted from graphical representations, introducing potential measurement bias.

Nonetheless, this meta-analysis provides the most up-to-date and comprehensive synthesis of ELD outcomes in patients with preoperative motor deficits. The consistency in findings across diverse study populations reinforces the generalizability of ELD as an effective and safe technique for neural decompression, even in neurologically compromised individuals.

5. Conclusion

This meta-analysis demonstrates that Endoscopic Lumbar Discectomy (ELD) provides substantial neurological and functional recovery in patients presenting with preoperative motor deficits. Across eight studies involving 613 patients, consistent improvements were observed in motor strength and disability scores, with a mean MRC gain of +1.44 and a mean ODI reduction of −37.3. These outcomes exceed established thresholds for clinical significance and support the use of ELD as a safe and effective decompression strategy, even in neurologically compromised patients.

While further high-quality randomized trials are warranted, current evidence suggests that, in experienced hands, ELD can achieve outcomes comparable to conventional techniques with potential advantages in recovery profile and morbidity. Thus, preoperative motor weakness should not be considered a contraindication to endoscopic approaches.

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