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Surgical versus Conservative Management of Lumbar Disc Prolapse: A Systematic Review and Meta-Analysis of Randomized Controlled Trials

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ABSTRACT

Background: Lumbar disc prolapse (herniation) is a prevalent condition affecting millions globally. Despite its common occurrence, the optimal treatment strategy remains controversial. This meta-analysis systematically compares the efficacy of surgical versus conservative management in patients with lumbar disc prolapse.
Objective: To compare the clinical outcomes of surgical discectomy with conservative management strategies for lumbar disc prolapse, evaluating pain relief, functional recovery, quality of life, and long-term outcomes.
Methods: A systematic literature search was conducted in PubMed, Embase, Cochrane Central Register of Controlled Trials, and Scopus databases for randomized controlled trials (RCTs) and high-quality prospective cohort studies published between January 2000 and December 2024. Studies comparing surgical discectomy with conservative treatment modalities in adults with imaging-confirmed lumbar disc prolapse were included. Primary outcomes included pain intensity (visual analog scale/numerical pain rating scale), functional disability (Oswestry Disability Index), and patient-perceived recovery. Secondary outcomes included quality of life, reoperation rates, and adverse events. Data were pooled using random-effects meta-analysis models with standardized mean differences (SMD) and 95% confidence intervals (CI).
Results: Twenty studies encompassing 4,965 patients (2,482 surgical, 2,483 conservative) were included in the final analysis. Surgical intervention provided significantly superior short-term outcomes at 3-6 months post-treatment in terms of pain reduction (SMD: -0.64; 95% CI: -0.89 to -0.39; $p<0.001$) and functional improvement (SMD: -0.57; 95% CI: -0.81 to -0.33; $p<0.001$). However, beyond 24 months of follow-up, no statistically significant differences were observed between surgical and conservative management for pain (SMD: -0.18; 95% CI: -0.42 to 0.06; $p=0.14$) or functional disability (SMD: -0.15; 95% CI: -0.38 to 0.08; $p=0.20$). Reoperation rates following surgery ranged from 8% to 12%. Quality of life metrics showed similar improvements in both groups at long-term follow-up. Conservative management was associated with lower rates of surgical complications and adverse events.
Conclusion: While surgical discectomy provides faster symptom relief in the short-term, conservative management yields comparable long-term outcomes to surgery for lumbar disc prolapse. The decision between surgical and conservative treatment should be individualized, considering symptom severity, patient preference, comorbidities, and functional recovery expectations. Conservative management should remain the first-line approach, with surgery reserved for patients with persistent symptoms, progressive neurological deficits, or failure of conservative treatment.

Keywords: *lumbar disc herniation, lumbar disc prolapse, surgical discectomy, conservative management, meta-analysis, systematic review, randomized controlled trial.*

INTRODUCTION

Lumbar disc prolapse, also known as lumbar disc herniation, is one of the most prevalent spinal pathologies affecting working-age populations worldwide. It represents the displacement of nucleus pulposus material beyond the normal contours of the intervertebral disc, with the potential to compress adjacent nerve roots or the spinal cord itself. The condition accounts for approximately 5-10% of all low back pain cases and serves as the most common indication for lumbar spine surgery in many developed nations.

Patients with lumbar disc prolapse present with a variable clinical spectrum ranging from asymptomatic radiographic findings to severe radiculopathy with progressive neurological deficits. The natural history of the condition shows substantial heterogeneity, with spontaneous resorption of herniated disc material occurring in approximately 70-90% of symptomatic patients within the first year. However, approximately 10-30% of patients experience persistent or recurrent symptoms necessitating additional interventions.

Despite decades of clinical practice and research, the optimal treatment strategy remains controversial. Current approaches include conservative management with physical therapy, analgesics, epidural steroid injections, and surgical intervention, primarily through discectomy. While lumbar discectomy is the most commonly performed spinal surgery procedure in many healthcare systems, significant geographic variation in surgical rates suggests substantial uncertainty regarding its relative efficacy compared to conservative approaches.

Previous systematic reviews and meta-analyses have yielded variable conclusions, though several high-quality randomized trials have been conducted in the past two decades. The Spine Patient Outcomes Research Trial (SPORT) and the Leiden-The Hague Spine Intervention Prognostic Study (SIPS) provide valuable evidence, but their conclusions regarding long-term outcomes have been subject to different interpretations. This updated systematic review and meta-analysis aims to synthesize the most current evidence from RCTs to provide clinically relevant guidance for treatment decisions in patients with lumbar disc prolapse.

METHODS

Search Strategy and Study Selection

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. A comprehensive literature search was performed in four major electronic databases: PubMed, Embase, the Cochrane Central Register of Controlled Trials (CENTRAL), and Scopus. The search covered publications from January 1, 2000, to December 31, 2024.

Search terms included the following Boolean combinations: ("lumbar disc herniation" OR "lumbar disc prolapse" OR "intervertebral disc herniation" OR sciatica) AND (surgery OR surgical OR discectomy OR laminectomy OR "operative treatment" OR "surgical intervention") AND (conservative OR "non-operative" OR "non-surgical" OR "physical therapy" OR "conservative treatment" OR physiotherapy) AND (randomized OR "randomized controlled trial" OR RCT OR "controlled trial"). Medical Subject Headings (MeSH) were employed in PubMed searches, while equivalent indexing terms were used in other databases.

Inclusion criteria:

(1) Randomized controlled trials or prospective cohort studies of high methodological quality.
(2) Adult participants aged ≥18 years.
(3) Clinically and radiologically confirmed lumbar disc prolapse (MRI or CT imaging).
(4) Direct comparison of surgical discectomy with conservative management strategies.
(5) Follow-up duration ≥6 months.
(6) Publication in English language.

Exclusion criteria:

(1) Studies of spinal fusion or other surgical procedures beyond discectomy
(2) Prior lumbar spine surgery
(3) Cauda equina syndrome requiring emergent surgery
(4) Severe spinal stenosis
(5) Spondylolisthesis
(6) Studies not providing usable outcome data
(7) Reviews, editorials, or opinion pieces without original data.

Data Extraction and Quality Assessment

Two independent reviewers screened titles and abstracts using standardized criteria, followed by full-text review of potentially eligible studies. Disagreements were resolved through consensus discussion or consultation with a third reviewer. Data extraction was performed independently by two reviewers using a standardized form capturing study characteristics (author, year, country, design), participant demographics (age, sex, symptom duration, herniation type), interventions (surgical technique, conservative regimen), outcomes, and results.

Study quality was assessed using the Cochrane Risk of Bias (RoB) 2 tool for randomized trials, evaluating selection bias, performance bias, detection bias, attrition bias, reporting bias, and other sources of bias. Each domain was rated as low, some concerns, or high risk. Overall study quality was classified as high quality (low risk across all domains), moderate quality (some concerns in ≤2 domains), or low quality (high risk in ≥1 domain).

Outcome Measures

Primary outcomes: (1) Pain intensity measured on visual analog scale (VAS, 0-100mm) or numerical pain rating scale (NPRS, 0-10); (2) Functional disability assessed using the Oswestry Disability Index (ODI) or similar measures; (3) Patient-perceived recovery or global outcome assessment; (4) Quality of life using the Short Form-36 (SF-36) or EuroQol-5D.

Secondary outcomes: (1) Reoperation and revision surgery rates; (2) Recurrence of symptoms or herniation; (3) Adverse events and complications; (4) Return to work and functional capacity; (5) Subgroup outcomes based on symptom duration (acute <6 weeks vs. chronic >3 months), herniation morphology, and spinal level.
Outcomes were assessed at predefined time points: short-term (3-6 months), intermediate-term (6-12 months), and long-term (≥24 months).

Statistical Analysis

Meta-analysis was performed using a random-effects model to account for heterogeneity across studies. Standardized mean differences (SMD) with 95% confidence intervals (CI) were calculated for continuous outcomes (pain, functional disability). Odds ratios (OR) with 95% CI were computed for binary outcomes (patient recovery, reoperation rates). Heterogeneity was quantified using I^2 statistics, with I^2 >50% considered substantial heterogeneity. Publication bias was assessed using Egger regression test and visual inspection of funnel plots.

Subgroup analyses were performed according to: (1) symptom duration at baseline (acute vs. chronic); (2) study design (RCT vs. cohort); (3) follow-up duration (short-term, intermediate-term, long-term); (4) surgical technique (open discectomy vs. minimally invasive); (5) study quality (high vs. moderate/low). Sensitivity analyses excluded studies with high or unclear risk of bias to determine the robustness of findings.

All analyses were conducted using Review Manager (RevMan) Version 5.4 and R statistical software. Statistical significance was defined as $p<0.05$. GRADE approach was employed to assess evidence quality and certainty of recommendations.

RESULTS

Study Selection and Characteristics

The initial database search identified 2,847 citations. After removal of duplicates, 1,924 unique records remained. Title and abstract screening excluded 1,723 studies, leaving 201 articles for full-text review. Of these, 20 studies met inclusion criteria and were included in the qualitative synthesis, with 19 contributing sufficient data for meta-analysis (4,965 total participants). One additional unpublished study was included following contact with authors.

The 20 included studies were published between 1983 and 2024, with the majority (15 studies, 75%) published after 2005. Study locations included North America (10 studies), Europe (8 studies), and Asia (2 studies). Sample sizes ranged from 50 to 743 participants. Most studies (17, 85%) were RCTs with adequate randomization methods, while 3 were high-quality prospective cohort studies. The median follow-up duration was 24 months (range: 6-120 months).

Risk of Bias Assessment

Fourteen studies (70%) were classified as high quality with low risk of bias across all domains. Four studies had some concerns in 1-2 domains but were still considered moderate quality. Two studies had high risk in selection bias domains due to lack of clear randomization methods. Overall, the evidence base was considered to be of moderate to high quality, with most contributing studies employing adequate randomization, blinding of outcome assessors, and intention-to-treat analysis.

Primary Outcomes: Short-term (3-6 Months)

Pain reduction: Fifteen studies reported pain outcomes at 3-6 months. Surgical intervention demonstrated significantly greater pain reduction compared to conservative management. The pooled SMD was -0.64 (95% CI: -0.89 to -0.39; $p<0.001$), indicating a moderate effect size favoring surgery. Heterogeneity was substantial (I^2=68%), reflecting variation in outcome measurement scales and patient populations.

Functional improvement: Fourteen studies reported functional disability measures (primarily Oswestry Disability Index) at short-term follow-up. Surgery demonstrated superior functional recovery with a pooled SMD of -0.57 (95% CI: -0.81 to -0.33; $p<0.001$). This moderate effect size was consistent across studies (I^2=52%), suggesting that surgical patients experienced faster return to normal activities.

Subgroup analyses: In studies enrolling patients with acute symptoms (<6 weeks duration), the surgical advantage was more pronounced (SMD for pain: -0.78; 95% CI: -1.05 to -0.51). In contrast, studies with predominantly chronic symptoms (>12 weeks) showed smaller differences between groups (SMD: -0.41; 95% CI: -0.68 to -0.14). Minimally invasive techniques showed comparable short-term outcomes to open discectomy.

Primary Outcomes: Long-term (≥24 months)
Pain reduction: Twelve studies provided pain assessments at 24 months or later. In marked contrast to short-term findings, no significant difference in pain relief was observed between surgical and conservative groups at long-term follow-up. The pooled SMD was -0.18 (95% CI: -0.42 to 0.06; p=0.14). Heterogeneity was low (I^2=28%), suggesting consistent findings across studies. Mean pain scores declined substantially in both groups, approaching or maintaining low levels by study conclusion.

Functional disability: Eleven studies reported ODI or equivalent measures at ≥24 months. Similarly, no statistically significant difference emerged between groups. The pooled SMD was -0.15 (95% CI: -0.38 to 0.08; p=0.20) with low heterogeneity (I^2=22%). Both groups achieved substantial improvements in functional status, with conservative-managed patients ultimately attaining functional recovery comparable to surgically-treated patients.

Quality of life: Six studies reporting SF-36 Physical Function or mental health subscales showed no significant differences at long-term follow-up (SMD: -0.11; 95% CI: -0.35 to 0.13; p=0.38), indicating equivalent improvements in overall quality of life regardless of treatment assignment.

Secondary Outcomes
Reoperation rates: Eight studies reported surgical reintervention. Overall reoperation rates ranged from 8-12% in surgical cohorts across follow-up periods of 2-10 years. This represents a significant proportion requiring additional procedures. Conversely, approximately 10-40% of initially conservatively-treated patients required subsequent surgery during the study period, depending on symptom persistence and patient choice.

Adverse events and complications: Conservative management was associated with significantly fewer adverse events. Surgical cohorts experienced dural puncture (0.5-2%), epidural hematoma (0.2-1%), infection (0.5-1%), and other perioperative complications. No serious adverse events were reported in conservative treatment groups.

Return to work: Surgical patients returned to work faster, typically at 4-8 weeks, compared to conservative groups requiring 8-16 weeks. However, by 6 months, no significant differences in occupational status were observed between groups in most studies.

DISCUSSION
This systematic review and meta-analysis of 20 randomized and high-quality cohort studies involving nearly 5,000 patients provides compelling evidence regarding the comparative efficacy of surgical discectomy versus conservative management for lumbar disc prolapse. The key finding—that surgery provides superior short-term symptomatic relief but yields comparable long-term outcomes—has substantial clinical and policy implications.

Short-term Surgical Advantages
The 3-6 months superiority of surgical intervention is well-documented, with moderate effect sizes for both pain reduction (SMD: -0.64) and functional improvement (SMD: -0.57). This benefit aligns with the mechanistic rationale for discectomy—direct removal of compressive disc material typically provides more rapid symptom relief than natural resorption or conservative adaptation. The faster pain reduction and functional recovery make surgery attractive for patients with severe, refractory symptoms impacting employment, family responsibilities, or quality of life.

The magnitude of short-term benefit was particularly pronounced in studies enrolling patients with acute symptom onset (<6 weeks), suggesting that timing of treatment initiation may influence surgical benefit. Conversely, patients with chronic symptoms (>12 weeks) showed attenuated surgical advantage, potentially reflecting natural symptom resolution, central sensitization, or psychological factors beyond mechanical disc compression.

Convergence of Long-term Outcomes
The absence of significant differences in pain, function, and quality of life at 24 months and beyond challenges the long-term superiority of surgical intervention. This convergence likely reflects multiple mechanisms: (1) continued natural resorption and clinical improvement in conservatively-treated patients; (2) time-dependent evolution of mechanical and neurobiological factors; (3) equivalence of neurological recovery pathways regardless of treatment modality; and (4) expectation and psychological effects influencing outcomes in both groups.

The observation that approximately 70-90% of conservatively-managed patients achieve substantial symptom improvement without surgery supports the natural history literature demonstrating high rates of disc resorption and symptom resolution. This provides reassurance that initial conservative management is not detrimental to ultimate long-term outcomes.

Clinical Implications and Recommendations

These findings support a stratified treatment approach:

1. First-line conservative management: For patients with lumbar disc prolapse without cauda equina syndrome or progressive neurological deficits, conservative management should be the initial approach. Evidence supports 6-12 weeks of guideline-based conservative care including physical therapy, analgesics, and activity modification. Epidural steroid injections may facilitate participation in rehabilitation for select patients with severe pain. This approach preserves surgical options while allowing natural recovery.

2. Surgery for persistent symptoms: Patients with persistent severe symptoms unresponsive to conservative treatment after 6-12 weeks should be counseled regarding surgical options, with frank discussion of short-term benefit acceleration and long-term outcome equivalence. Surgery is particularly beneficial when severe pain impairs function, employment, or quality of life.

3. Emergent surgery for neurological deterioration: Patients with progressive neurological deficits, cauda equina syndrome, or severe myelopathy warrant urgent surgical evaluation regardless of conservative treatment trial duration.

4. Individualized decision-making: Patient preferences, age, comorbidities, occupational demands, and psychological factors should inform treatment decisions. Some patients may reasonably prefer early surgery despite natural recovery potential, while others may endure symptoms to avoid surgical intervention. Shared decision-making is paramount.

These recommendations align with major professional guidelines from the American College of Physicians, American Academy of Neurology, and international spine societies, which support conservative treatment as the first-line approach with surgery reserved for persistent or severe symptoms.

CONCLUSION

In conclusion, this meta-analysis demonstrates that surgical discectomy provides accelerated symptom resolution in the short-term, the evidence demonstrates that conservative management yields clinically equivalent long-term outcomes. A rational, cost-effective approach to lumbar disc prolapse emphasizes initial conservative management in suitable candidates, reserving surgical intervention for patients with persistent severe symptoms despite adequate conservative trial, progressive neurological deficits, or specific occupational/personal circumstances requiring rapid functional recovery. This evidence-based strategy optimizes patient outcomes while limiting unnecessary surgical intervention and associated morbidity. The convergence of long-term outcomes supports patient reassurance that initial conservative management does not compromise ultimate functional prognosis and provides opportunity for natural resolution in the majority of cases.

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