e-ISSN : 2597-6052

MPPKI MEDIA PUBLIKASI PROMOSI KESEHATAN INDONESIA

Review Articles Open Access

Endoscopic Discectomy Versus Open Microdiscectomy: Systematic Review for Lumbar Disc Herniation Treatment

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ARTICLE INFO

Manuscript Received: 27 Jan, 2025
Revised: 17 Mar, 2025
Accepted: 21 Mar, 2025
Date of Publication: 09 Apr, 2025
Volume: 8
Issue: 4
DOI: 10.56338/mppki.v8i4.7139

KEYWORDS

Lumbar Disc Herniation;
Open Microdiscectomy;
Percutaneous Endoscopic Lumbar Discectomy;
Low Back Pain

ABSTRACT

Introduction: Lower back pain (LBP) is a widespread global issue, with nearly 80% of the population expected to experience at least one episode in their lifetime. Disc herniation is closely linked to disc degeneration, a process accelerated by aging. As individuals age, fibro chondrocytes in the disc undergo senescence, leading to reduced proteoglycan production. This reduction results in disc dehydration and collapse, increasing stress on the annulus fibrosus. Consequently, tears and fissures develop, facilitating the herniation of the nucleus pulposus. Chronic symptoms often emerge gradually due to the repetitive mechanical stress applied to the disc. Percutaneous endoscopic lumbar discectomy (PELD) has been shown to yield better outcomes compared to traditional methods, particularly in terms of reduced blood loss, smaller incisions, and shorter bed rest duration. However, conclusive guidelines comparing endoscopic to open approaches remain limited, underscoring the need for rigorous systematic reviews and risk-of-bias assessments to clarify the relative efficacy and safety profiles of these techniques.
Method: We developed the methodology for this systematic review following criteria outlined in the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020 checklist. Additionally, we conducted a preliminary risk-of-bias assessment for the included studies to ensure more rigorous evaluation of their quality.
Result: Both PELD and conventional surgery significantly decrease ODI and VAS scores postoperatively. However, the control group shows a more substantial reduction in scores than the PELD group. Despite this, PELD is effective in treating herniated lumbar discs, offering advantages such as minimal postoperative pain, faster recovery, and reduced blood loss. Due to heterogeneity in outcome measures and follow-up durations across the included studies, a formal meta-analysis was not performed.
Conclusion: While PELD appears to improve surgical outcomes and reduce oxidative stress, further high-quality randomized trials are needed to confirm these benefits and establish standardized selection criteria.

Publisher: Fakultas Kesehatan Masyarakat Universitas Muhammadiyah Palu

INTRODUCTION

Lower back pain (LBP) is a widespread and debilitating condition, with approximately 80% of the global population expected to experience at least one episode in their lifetime. This common health issue imposes a significant burden, costing the United States over $100 billion annually (1). Degenerative disc disease and lumbar disc herniation (LDH) are among the most frequent diagnoses linked to LBP. Approximately 95% of lumbar disc herniations occur at the L4-L5 or L5-S1 levels. The lordotic curvature of the spine is created by the alignment of the five vertebrae and intervertebral discs comprising the lumbar spine (1,2). Despite ongoing research, a comprehensive synthesis comparing different surgical approaches, along with a transparent assessment of their methodological quality, remains crucial to guide clinical practice.

Spinal nerve openings are formed by the intervertebral discs, adjacent vertebral laminae, pedicles, and articular processes. The intervertebral discs consist of the inner nucleus pulposus (NP), the outer annulus fibrosus (AF), and the cartilaginous endplates that connect the discs to the adjacent vertebrae. The space containing these components is known as the foramen magnum. The nucleus pulposus (NP) has a gel-like structure, consisting of approximately 80% water and 20% type 2 collagen and proteoglycans (2–4).

Aggrecan, a large proteoglycan, plays a crucial role in retaining water within the nucleus pulposus, along with versican, which binds to hyaluronic acid. The height of the intervertebral disc is largely determined by the hydrophilic matrix it contains. Surrounding the nucleus pulposus is the annulus fibrosus, a ring-shaped structure made up of 15 to 25 layers of collagen lamellae. These layers are interspersed with proteoglycans, glycoproteins, elastic fibers, and connective tissue cells that secrete extracellular matrix components. The inner annulus fibrosus primarily consists of type 2 collagen, while the outer annulus fibrosus is predominantly composed of type 1 collagen (5,6).

Recent studies have shown that conservative and surgical treatments produce similar outcomes in the medium and long term. However, other research suggests that surgical intervention may provide better outcomes by promoting faster symptom relief and improving patients' overall quality of life. Although no published guidelines currently exist for selecting between non-operative and operative approaches, certain relative indications may necessitate immediate surgical intervention, particularly for patients presenting with red flags (7). To address this gap, the present review critically evaluates the available evidence, including the methodological strengths and limitations of each study, aiming to inform clinical decision-making.

This article critically compares the outcomes of endoscopic discectomy and open microdiscectomy for the treatment of lumbar disc herniation, highlighting the need to assess risk of bias and other quality indicators in the existing literature.

METHOD

We developed the methodology for this systematic review following criteria outlined in the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020 checklist. This systematic review assessed studies comparing endoscopic discectomy versus open microdiscectomy for lumbar disc herniation. This topic is addressed in the studies under evaluation. To be included in the review, studies must meet the following criteria: 1) Articles must be fully accessible online; 2) articles must be written in English; and 3) articles must have been published between 2015 and the time of compiling this systematic review. We also applied a structured risk-of-bias evaluation (e.g., Cochrane RoB 2 for randomized trials and ROBINS-I for non-randomized studies), resolving any discrepancies through discussion among reviewers.

The search for studies to be included in the systematic review was conducted starting on May 4th, 2023, using the PubMed and SagePub databases with the following keywords "percutaneous transforaminal endoscopic discectomy," "open microdiscectomy," and "lumbar disc herniation." Given resource constraints, we focused on these two databases but also examined reference lists of eligible articles to mitigate potential selection bias. Where ("percutaneous"[All Fields] OR "percutaneously"[All Fields] OR "percutanous"[All Fields]) ... ("disc herniation [All Fields]).

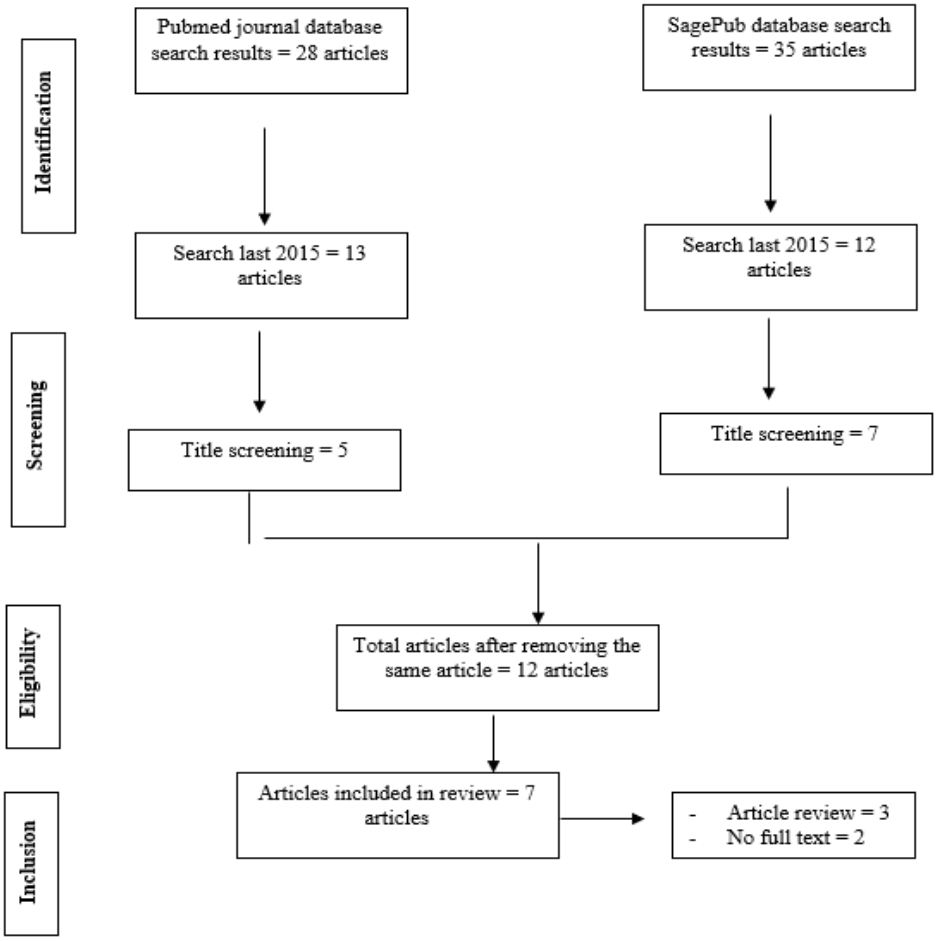

Figure 1. Article search flowchart

The inclusion and exclusion criteria for the study were revised after a thorough review of the literature, including an examination of titles and abstracts of previously published studies. Only research projects that met all the criteria were included in the systematic review. Key elements for distinguishing studies included the title, author, publication date, country of origin, research design, and the variables studied.

The material has been organized in a specific format for your review and critical assessment. To determine the suitability of studies for inclusion, the authors performed independent evaluations of selected research based on the titles and abstracts. The full texts of studies meeting the inclusion criteria were then assessed for final inclusion. Any disagreements among reviewers regarding study selection or data extraction were resolved through consensus discussions, thereby reinforcing the reliability of the review process.

RESULTS

Chang et al. found that operation times were comparable between the groups. However, the observation group (percutaneous endoscopic lumbar discectomy) experienced less blood loss, smaller incision sizes, and shorter bed rest compared to the control group (traditional open surgery) ($P<0.05$) (8). Three months after surgery, both groups showed significant reductions in Oswestry Disability Index (ODI) and Visual Analog Scale (VAS) scores compared to preoperative levels. However, the values in the observation group were significantly higher than those in the control

group (P <0.05). Before surgery, levels of tumor necrosis factor-α (TNF-α), C-reactive protein (CRP), malondialdehyde (MDA), myeloperoxidase (MPO), superoxide dismutase (SOD), and total antioxidant capacity (TAC) were similar in both groups. (P > 0.05). levels of TNF-α, CRP, MDA, MPO, SOD, and TAC were significantly lower in the observation group compared to the control group (P<0.05). Thus, percutaneous endoscopic lumbar discectomy can enhance functional outcomes, reduce pain, lower inflammatory factor levels, and mitigate oxidative stress indicators, leading to improved surgical results. This approach should be widely adopted.

In the percutaneous transforaminal endoscopic spine system (TESSYS) group, Pan et al. (9) reported shorter incision length, reduced blood loss, shorter hospital stays, lower hospitalization costs, raped recovery time, and fewer complications (P <0.001). additionally, VAS scores of lumbago and skelalgia were significantly lower at three days, one, three, and six months postoperatively (P<0.05). At 24 and 48 hours postoperatively, the CRP levels in the traditional fenestration discectomy (FD) group were significantly higher compared to those in the TESSYS group (P <0.001). Furthermore, a comparison of IL-6 levels at 6, 12, 24, and 48 hours postoperatively showed that the FD group had significantly higher levels than the TESSYS group (P <0.001).

Choi et al. (10) found that the microdiscectomy (MD) group exhibited the highest levels and ratios of creatine phosphokinase (CPK) on postoperative days 1 and 3 (P <0.01, P = 0.02, P = 0.04). The MD group exhibited the highest levels of C-reactive protein over time (P <0.01). On postoperative day 1, the percutaneous endoscopic lumbar discectomy (PELD) and percutaneous endoscopic interlaminar discectomy (PEID) groups had lower C-reactive protein levels compared to the unilateral bi-portal endoscopic discectomy (UBED) group (P <0.01). The MD group had the largest cross-sectional area. Additionally, the UBED group had a greater cross-sectional area compared to the PELD and PEID groups (P <0.01). The PELD group had the shortest operative time and hospital stay (P <0.01 for both). On postoperative days 1 and 3, the MD group had significantly higher visual analog scale scores for back pain compared to the other groups (P < 0.01, P = 0.02).

Table 1. The literature included in this study

Author	Origin	Method	Sample Size	Result
Chang, 2018(8)	China	Cross-sectional study	110 patients with lumbar disc herniation	Percutaneous endoscopic lumbar discectomy is a good way to treat a herniated lumbar disc because it causes less damage, less blood loss, and a faster recovery. It can also improve dysfunction, reduce pain and serum levels of inflammatory factors, and improve oxidative stress indicators, improving surgical results. So, this method could be used by a lot of people.
Pan, 2016(9)	Korea, China	Prospective cohort study	106 lumbar disc herniation (LDH) patients	TESSYS has clinical advantages over FD, and it involves less trauma and speedier postoperative recovery, all of which suggest that patients tolerate TESSYS and is a superior method to FD in the surgical treatment of lumbar disc herniation (LDH).
Choi, 2018(10)	Korea, China	Cross-sectional study	4 lumbar disc herniation (LDH) patients	The least intrusive method of spinal surgery is called the percutaneous endoscopic lumbar discectomy (PELD) procedure.

Author	Origin	Method	Sample Size	Result
Xu, 2020(11)	China	Prospective cohort study	145 patients with lumbar intervertebral disc protrusion (LIDP)	Patients with LIDP benefit significantly from the therapeutic benefits of endoscopic excision of the intervertebral disc's nucleus pulposus (NP). It decreases inflammation and lowers immunological function while posing a lower risk, making its usage in clinical settings desirable.
Gibson, 2017(12)	United Kingdom	Randomized controlled trial	143 patients	Both groups continued to experience functional improvements at the 2-year mark, with transforaminal endoscopic discectomy (TED) patients experiencing less continuing sciatica. A higher rate of revision following TED was more than compensated for by a quicker recovery.
Tao, 2018(13)	China	Randomized controlled trial	462 patients with prolapse of lumbar intervertebral disc	Transforaminal endoscopic spine system (TESSYS) has the advantages of reduced bleeding, fewer traumatic reactions, fewer problems, rapid postoperative recovery, and exact short-term effects in the treatment of prolapse of the lumbar intervertebral disc.
Dai, 2020(14)	China	Prospective cohort study	94 patients with lumbar disc herniation	PTED has a better effect on disease control and pain relief in patients with lumbar disc herniation; it has played a greater role in improving patients' quality of life, which is worthy of clinical promotion.

Xu et al. (11) demonstrated that the minimally invasive group had shorter surgical incision lengths, reduced intraoperative blood loss, shorter operation times, less bed rest, and shorter hospital stays compared to the fenestration group ($P < 0.05$). Patients in the minimally invasive group had lower Oswestry and VAS scores at one, three-, and six-months post-surgery compared to those in the fenestration group ($P < 0.05$). Patients in the minimally invasive group experienced a significantly lower incidence of spinal instability and overall complications compared to those in the fenestration group ($P < 0.05$). Patients in the minimally invasive group had lower levels of TNF-α and IL-6 at 24- and 48-hours post-surgery compared to those in the fenestration group (P 0.05). Additionally, cellular levels of IL-4, CD3+, CD4+, and CD8+ were higher in the minimally invasive group ($P < 0.05$).

Gibson et al. (12) conducted a randomized controlled trial (RCT) with 143 patients, finding statistically significant improvements in all outcome measures for both groups ($p < 0.001$). At two years, leg pain on the affected side was lower in the Transforaminal endoscopic discectomy (TED) group compared to the control group (1.9 ± 2.6 vs. 3.5 ± 3.1, $p = 0.002$). Following TED, patients had shorter hospital stays (0.7 ± 0.7 days) compared to those who

did not undergo TED (1.4 ± 1.3 days, p 0.001). A revision was required for two micropatients and five TED patients, resulting in a relative risk of revision for TED of 2.62 (95% confidence interval [CI]: 0.49-14.0).

Other studies indicated that the TESSYS group experienced shorter operation times, reduced intraoperative blood loss, shorter hospital stay, rapid postoperative ambulation, and fewer complications compared to those in the control group ($p < 0.05$). No significant differences were observed in VAS and ODI scores on the first day before surgery or the first, third-, and sixth-months post-surgery. According to the improved MacNab standard, the excellent and good rate was 87.88% in the study group and 84.85% in the control group. However, this difference was not statistically significant. Before surgery, there were no significant differences in CRP, IL-6, CPK, or WBC levels between the two groups. CRP, IL-6, CPK, and WBC levels were significantly higher in the study group compared to the control group ($p < 0.05$) (13).

Dai et al. found that group B (PTED) had shorter surgery duration, less total bleeding, and shorter hospital stays compared to group A (fenestration discectomy) ($P < 0.001$). After treatment, group B had significantly lower levels of TNF-α and IL-6, as well as a lower VAS score, compared to group A ($P<0.001$) (14). The Japanese Orthopaedic Association (JOA) score in group B was higher than in group A ($P<0.001$). Additionally, the incidence of adverse complications, including lumbar deformation, aggravated pain, and postoperative diastasis, was lower in group B compared to group A, although this difference was not statistically significant ($P>0.05$). Quality of life scores were higher in group B compared to group A ($P<0.001$).

DISCUSSION

experiencing at least one episode in their lifetime (1). LDH is a common spine illness. While open discectomy is the primary treatment for this condition, it is associated with significant surgical trauma and a high rate of postoperative complications, including nerve root adhesions and lumbar instability (3).

Disc herniation is often associated with degeneration. As disc fibro chondrocytes age, they undergo senescence and exhibit reduced production of proteoglycans. The reduction in proteoglycans leads to dehydration and collapse of the disc, which increases strain on the annulus fibrosus and causes tears and fissures. This creates conditions conducive to the herniation of the nucleus pulposus. Consequently, repeated mechanical stress on the disc contributes to the gradual development of chronic symptoms (5).

Axial overloading exerts a substantial biomechanical force on a healthy disc, potentially leading to the extrusion of disc material through a compromised annulus fibrosus. Such injuries often result in more severe acute symptoms. Less common causes include connective tissue disorders and congenital conditions, such as short pedicles (15). Most symptomatic presentations of LDH are transient and resolve within six to eight weeks, so conservative management is typically the initial approach. However, if red flag symptoms indicate potential emergent conditions, such as progressive neurologic deficits or cauda equina syndrome, more aggressive treatment may be required (7).

Recent research has demonstrated that conservative and surgical treatments yield comparable outcomes in the medium and long term. However, other studies suggest that surgical treatment may offer better outcomes, potentially leading to rapid symptom remission and enhanced overall quality of life for patients. Although there is no definitive published research on criteria for choosing between non-operative and operative treatments, there are relative indications for immediate surgical intervention in patients presenting with red flags (7).

The final decision regarding the treatment modality for non-emergent LDH should be based on a discussion between the treating physician and the patient. This discussion should consider the evaluation results, the duration of symptoms, and the patient's preferences. Choi et al. compared paraspinal muscle injury across four surgical techniques: MD, PELD, PEID, and UBED. Among these, the PELD is considered the least invasive spinal surgery method (10).

The PELD group showed superior outcomes in terms of blood loss, incision size, and bed rest duration compared to the control group. Both groups experienced significant reductions in ODI and VAS scores compared to preoperative levels. However, the reductions in the observation group were less pronounced than those in the control group (8). Other studies have indicated that the minimally invasive group experienced less postoperative pain and less severe immune function inhibition. Our research supports these findings. The minimal invasive group had significantly higher levels of CD3+, CD4+, and CD8+ cells 24 hours after surgery compared to the fenestration group

(11). Nevertheless, it is important to consider potential drawbacks of PELD, such as a steeper learning curve and the possibility of higher recurrence in specific patient populations, when interpreting these advantages.

This finding aligns with the results of Mroz et al. (16), which suggest that PELD for lumbar disc herniation can minimize surgical trauma, decrease blood loss, enhance postoperative recovery, shorten hospital stays, and alleviate the economic burden on patients' families. Possible explanations include the use of the working channel in PELD, which provides direct access to the protruding disc, enabling precise removal of the nucleus pulposus. This approach allows for direct removal of the protruding portion and more accurate targeting, ensuring effective decompression of the nerve root (17–19).

CONCLUSION

Percutaneous transforaminal endoscopic discectomy (PTED) for lumbar disc herniation offers several advantages, including reduced trauma, less blood loss, and rapid postoperative recovery. This method can significantly enhance functionality, reduce discomfort, lower serum levels of inflammatory markers, and minimize oxidative stress, thereby improving surgical outcomes. However, further large-scale, high-quality trials are necessary to confirm these findings, evaluate long-term recurrence rates, and assess cost-effectiveness before broadly recommending PTED in clinical practice.

AUTHOR'S CONTRIBUTION STATEMENT

Eric Wijaya: Conceptualized the research framework, conducted the systematic review, and contributed to data analysis and manuscript writing. Alhoi Hendry Henderson: Assisted in data extraction, quality assessment, and contributed to the methodology and discussion sections. I Nyoman Ehrich Lister: Provided critical revisions, ensured adherence to PRISMA guidelines, and assisted in final manuscript editing and submission.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest related to this study.

SOURCE OF FUNDING STATEMENTS

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

ACKNOWLEDGMENTS

The authors would like to thank our entire team for their support, which made the completion of this manuscript possible.

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