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Review Article

Comparative effectiveness of microsurgery and endoscopic surgery in lumbar disc herniation: A systematic review and meta-analysis

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Abstract

Lumbar disc herniation, a common degenerative disc disease, adversely affects quality of life and often necessitates surgical intervention. Microsurgery and endoscopic surgery have emerged as alternatives to traditional open surgery, offering reduced pain and shorter recovery times. The aim of this study was to compare the outcomes of microsurgery and endoscopic surgery for lumbar disc herniation, evaluating effectiveness, safety, and patient-reported outcomes. A systematic search was conducted across six databases (EBSCOhost, OVID, ScienceDirect, Scopus, PubMed, and Cochrane) using terms related to lumbar disc herniation, spine injury, minimally invasive biportal endoscopic spine surgery, and conventional microscopic discectomy. The risk of bias was assessed using the Newcastle-Ottawa Scale (NOS), and a random-effects meta-analysis calculated mean differences (MD) and 95% confidence intervals (CI). Among the 267 studies screened, two studies met the inclusion criteria for a meta-analysis assessing the functional outcomes and safety of microsurgery and endoscopic surgery in patients with spinal disorders. The meta-analysis indicated that patients who received microscopic surgery had no significant difference in terms of operation time (MD: 3.48; 95% confidence interval (CI): -14.74–21.70; p=0.71; I^2=90%), postoperative drainage (MD: 16.28; 95%CI: -2.33–34.89; p=0.09; I^2=47%), postoperative length of stay (MD: -1.26; 95%CI: -2.52–0.00; p=0.05; I^2=77%), and postoperative C-reactive protein (CRP) levels (MD: -13.49; 95%CI: -36.85–9.87; p=0.26; I^2=97%) compared to those treated with endoscopic surgery. In conclusion, microscopic surgery and endoscopic surgery yield similar outcomes in terms of operation time, postoperative drainage, postoperative length of stay, and postoperative CRP levels. Therefore, the choice of techniques should be guided by patient-specific factors, surgeon expertise, and the facilities available at the healthcare center.

Keywords: Lumbar disc herniation, microsurgery, biportal endoscopic surgery, neuropathic pain, compression

Introduction

Spinal disorders, such as lumbar disc herniations, spinal stenosis, and degenerative disc disease, significantly impact patients' quality of life and often require surgery [1,2]. In recent decades, surgical techniques have advanced from traditional open procedures to minimally invasive methods, such as microsurgery and endoscopy, with the goal of minimizing pain, improving function, and speeding up recovery [1,3]. However, the effectiveness and safety of these treatments are still under active investigation [1].

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Microscopic lumbar discectomy (MLD) has been a fundamental technique in spinal surgery for many years [1,4]. MLD utilizes an operating microscope to enhance visualization, allowing precise removal of herniated disc material with minimal disruption to surrounding tissues [4,5]. This reduces postoperative pain, promotes quicker recovery, and lowers the risk of complications, making it an effective minimally invasive approach for spinal decompression [1,4,5]. However, complications such as dural tears, nerve root injury, bleeding, recurrence, and infection may still occur [1,4,6]. Endoscopic surgery, including biportal and uniportal techniques, is a newer, less invasive option for spinal decompression [7,8]. A tubular device and high-definition camera are utilized to visualize and remove abnormal structures through minimally invasive incisions [7,8]. In comparison to traditional microsurgery, it provides advantages including decreased muscle trauma, minimized blood loss, quicker recovery times, better cosmetic results, and a lower risk of infection [8,9]. Nevertheless, the complexity and steep learning curve of endoscopic techniques limits their widespread adoption [8-10]. Studies comparing surgical techniques reveal mixed results, highlighting the complexity of spinal conditions and individual patient factors [9-11]. Emerging findings suggest that endoscopic surgery may achieve similar or better pain relief and functional recovery, with potentially fewer complications, compared to microsurgery [4,6]. However, to definitively determine the advantages and limitations of these methods, additional high-quality randomized controlled trials are essential [1].

Patient preferences play a key role in surgical decision-making, prioritizing factors such as recovery time, postoperative pain, and the likelihood of returning to work when choosing between surgical options [4,5]. Understanding these preferences is essential for tailoring surgical recommendations and optimizing patient satisfaction and outcomes. Two previous systematic reviews have compared the outcomes between microsurgical and endoscopic methods for lumbar disc herniation [10,11]; however, none of these studies included the effects on postoperative drainage and C-reactive protein (CRP) levels, limiting their scope [10,11]. In this present systematic review, we compared the outcomes of microsurgery and endoscopic surgery using biportal endoscopic spine surgery (BESS) for lumbar disc herniation, using existing literature to evaluate effectiveness, safety, and patient-reported outcomes, including postoperative drainage and CRP levels. This will provide a more comprehensive evaluation since it includes assessments of postoperative inflammatory responses and fluid management.

Methods

Search strategy and search strategy

The present systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines [12]. A literature search was conducted on May 12, 2024, across six databases: EBSCOhost, OVID, ScienceDirect, Scopus, PubMed, and Cochrane. The search employed targeted keywords: lumbar disc herniation OR spine injury, AND minimally invasive biportal endoscopic spine surgery (BESS) AND conventional microscopic discectomy AND functional outcome.

Inclusion and exclusion criteria

The inclusion criteria were established using the PICOS framework (Population, Intervention, Comparison, Outcome, and Study Design). Eligible studies should meet the following criteria: (1) population: patients with spinal disorders or injuries; (2) intervention: microscopic or endoscopic surgery; (3) comparison: direct comparison between microscopic and endoscopic surgical techniques; (4) outcomes: operative time, postoperative drainage (mL), length of hospital stay (days), and postoperative CRP levels; and (5) study design: interventional or observational studies with clear methodology and statistical analysis. All review articles, conference proceedings, and grey literature were excluded. The languages were restricted to English and Indonesian.

Screening and selection of the studies

The PRISMA guideline was utilized to guide the screening and selection process [12], conducted by two independent investigators (DK and KSG). The duplicates of the initial identified studies were promptly removed using the Mendeley and manual methods. The titles and abstracts of the remaining studies were screened. After this initial assessment of the title and abstract, a more detailed evaluation through full-text screening according to predetermined inclusion and exclusion criteria was conducted.

Data extraction

Data extraction was performed independently by two investigators (DK and KSG). Any discrepancies in the selection of studies were resolved through consensus among the authors (JA, DK, and KSG). The extracted data included: (1) first author and publication year; (2) study characteristics, including design, location (country), sample size, mean age, and follow-up duration; (3) population characteristics, such as mean age and type of surgery performed; (4) interventions, either microscopic surgery or BESS; (5) clinical outcomes, including operative time, postoperative drainage, length of hospital stay (days), and postoperative CRP levels; and (6) reported complications.

Risk of bias assessment

The quality assessment was carried out by two independent investigators (DK and KSG), with any disagreements resolved through consensus, involving a third author (JA) as needed for discussion and final decision. The risk of bias was assessed using the Newcastle-Ottawa Quality Assessment Scale (NOS) for cohort and case-control studies, focusing on critical factors such as the selection of cases and controls, comparability of study design and analysis, and exposure levels among groups [11]. Studies that scored 7 points or higher on the NOS were deemed high-quality with a low risk of bias, while those scoring below 7 points were classified as low-quality with a high risk of bias.

Statistical analysis

Statistical analyses were performed using Review Manager (RevMan) version 5.4 software (The Cochrane Collaboration, Copenhagen, Denmark). A random-effects meta-analysis was conducted to estimate mean differences and 95% confidence intervals (95%CIs). Heterogeneity was assessed using the Chi-squared test and the I^2 statistic, with a Chi-squared p-value greater than 0.1 and an I^2 value exceeding 50% indicating substantial heterogeneity. For studies demonstrating high heterogeneity, a random-effects model (Mantel-Haenszel method) was utilized. A p-value of less than 0.05 was deemed statistically significant. Sensitivity analyses were conducted to identify the studies contributing to heterogeneity.

Results

Study selection

A total of 572 studies were initially identified from six databases, and after removing 305 duplicates, an additional 249 studies were excluded following title and abstract screening. An additional 16 studies were excluded after full-text review for not meeting the inclusion and exclusion criteria. Finally, only two studies [14,15] were retained for detailed analysis in this review. The study selection process is presented in **Figure 1**, following the PRISMA flowchart guideline.

Characteristics of the included studies

The characteristics of the included studies are summarized in **Table 1**. Both studies utilized a retrospective cohort design and were conducted in South Korea, involving a total of 236 patients with spinal disorders undergoing single-level lumbar decompression. The average age of the patients ranged from 48.80±9.98 [14] to 60.9±15.9 years [15]. Participants underwent either microscopic surgery or BESS, with a minimum follow-up duration of six months.

Clinical outcomes: Descriptive analysis

The clinical outcomes in the included studies are summarized in **Table 2**. The analyzed outcomes include operation time, postoperative drainage (mL), postoperative length of stay (days), and postoperative CRP levels. Both studies reported contrasting results regarding the operation time

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for microscopic surgery and BESS [14,15]. Lee *et al.* [15] found that microscopic surgery was faster than BESS, while Kang *et al.* [14] reported that BESS had a shorter operation time compared to microscopic surgery (both studies had $p<0.005$) [14,15]. Additionally, Lee *et al.* [15] examined the impact of both surgeries on disability reduction and pain, measured by the Oswestry Disability Index (ODI) and numerical rating scale (NRS). Both surgical approaches resulted in decreased disability and pain at the six-month follow-up; however, the difference was significant only for the ODI scale ($p<0.006$) [15].

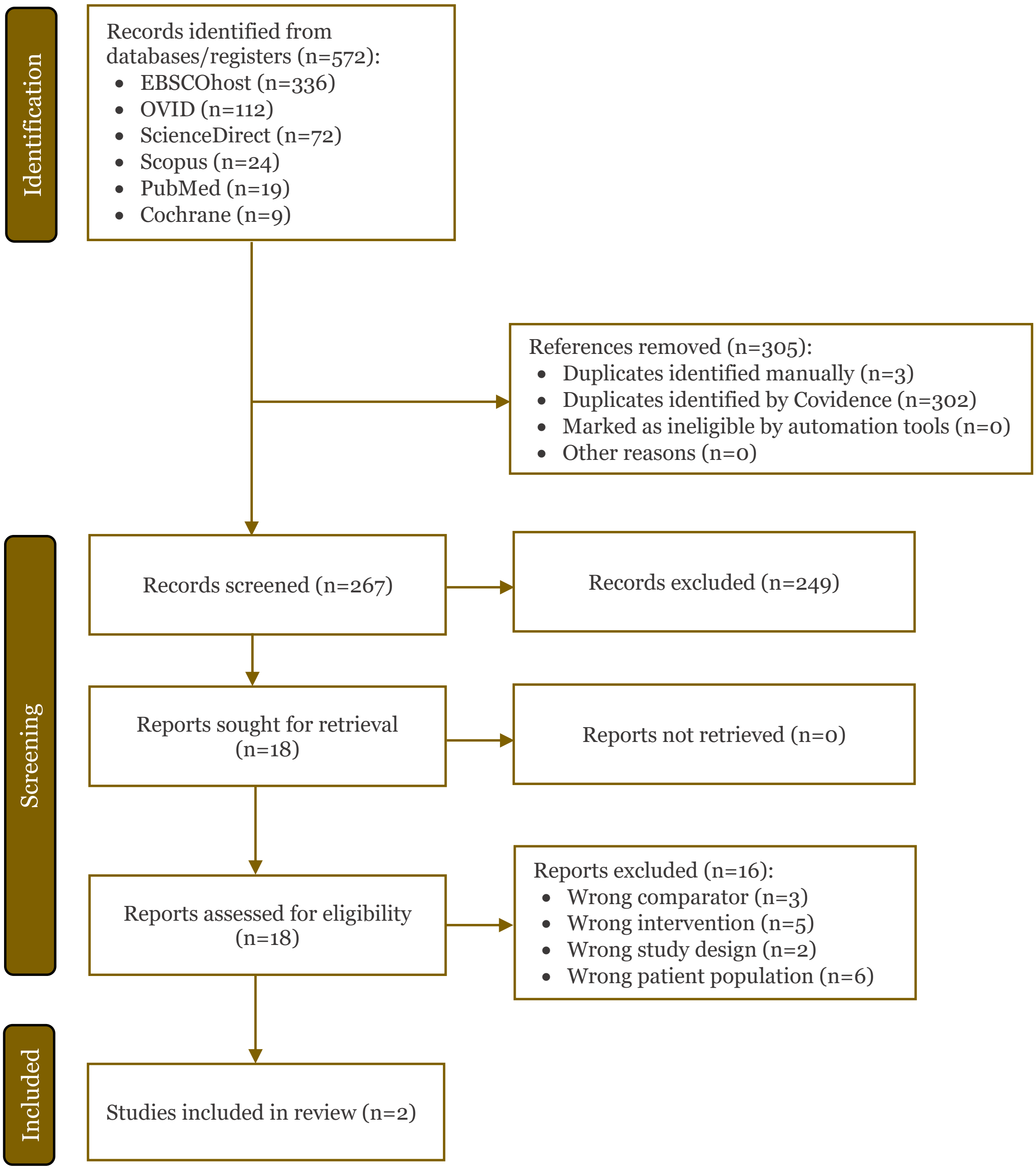

Figure 1. Literature search and selection flowchart.

Table 1. Characteristics of the included studies

Author, year	Study design	Country	Sample size, n		Age (years), mean±SD		Follow-up duration
			Microscopic surgery	BESS	Microscopic surgery	BESS	
Lee *et al*, 2023 [15]	Retrospective cohort	South Korea	150	50	60.9±15.9	62.6±12.5	Six months
Kang *et al*, 2023 [14]	Retrospective cohort	South Korea	20	16	48.80±9.98	48.19±8.87	Minimum of 1 year

BESS: biportal endoscopic spinal surgery

Table 2. The results of key outcomes from the included studies

Author, year	Study outcomes	Group		*p*-value
		Microscopic surgery	Biportal endoscopic spinal surgery (BESS)	
Lee *et al*, 2023 [15]	Oswestry Disability Index (ODI), mean±SD			
	Preoperative	49.46±17.22	49.60±17.41	0.969
	Postoperative (six months)	11.54±9.70	6.90±5.98	0.006
	Numerical rating scale (NRS) (back), mean±SD			
	Preoperative	4.96±2.90	4.23±2.81	0.223
	Postoperative (six months)	2.04±1.92	1.50±1.11	0.100
	C-reactive protein (CRP) (mg/L), mean±SD			
	Preoperative	1.68±1.40	1.93±2.89	0.602
	Peak	42.40±37.73	16.63±19.41	<0.001
	Hemoglobin (g/dL), mean±SD			
	Preoperative	13.99±1.87	14.21±1.39	0.533
	Lowest	11.89±1.89	12.16±1.46	0.454
	Operative time (min), mean±SD	70.27±23.24	83.72±35.71	0.047
	Postoperative drain (mL), mean±SD	35.56±42.65	61.30±64.66	0.095
	Postoperative length of stay (day), mean±SD	4.43±2.04	3.79±2.53	0.181
Kang *et al*, 2023 [14]	Operative time (min), mean±SD	58.00±7.33	52.81±5.76	0.023
	Amount of surgical drain (mL), mean±SD	59.50±37.52	66.25±20.62	0.498
	Postoperative length of stay (day), mean±SD	4.55±1.96	2.62±0.72	<0.001
	C-reactive protein (CRP), (mg/L), mean±SD			
	Preoperative	0.11±0.20	0.12±0.27	0.963
	Postoperative day 1	2.45±0.42	0.53±0.39	0.001
	Postoperative day 2	1.09±0.72	0.23±0.44	0.030
	Creatine phosphokinase, (mg/L), mean±SD			
	Preoperative	102.35±57.20	106.00±50.75	0.927
	Postoperative day 1	178.34±77.23	128.52±49.56	0.014
	Complication, n (%)			
	Incidental durotomy	2 (10)	1 (6.3)	
	Epidural hematoma	1 (5)	0 (0)	
	Local recurrence	3 (15)	2 (12.5)	

The two studies also assessed postoperative drainage volume, defined as the use of a surgical drain to remove excess fluids from the surgical site [14,15]. Both studies reported less surgical drainage in patients treated with microscopic surgery, although this difference was not statistically significant [14,15]. Postoperative length of stay was found to be shorter for BESS in both studies [14,15], with only one study achieving statistical significance [14]. Lee *et al.* [15] measured both preoperative and peak CRP levels, while Kang *et al.* [14] assessed CRP levels preoperatively and up to two days postoperatively. Both studies reported significantly lower postoperative CRP levels in patients undergoing BESS compared to microscopic surgery ($p<0.05$) [14,15]. Additionally, Kang *et al.* [14] noted several surgical complications, including incidental durotomy, epidural hematoma, and local recurrences, with BESS demonstrating lower complication rates compared to microscopic surgery [14].

Clinical outcomes: Meta-analysis

Operation time

A meta-analysis of two studies was conducted to compare operation times between BESS and microscopic surgery. The mean difference in operation time was 3.48 (95%CI: -14.74–21.70). The tau² value of 156.79 indicated substantial variability among studies, while the Chi-squared value was 10.26, showing a slight, non-significant favor towards microscopic surgery (p=0.71). The analysis demonstrated high heterogeneity (I^2=90%) (**Figure 2**).

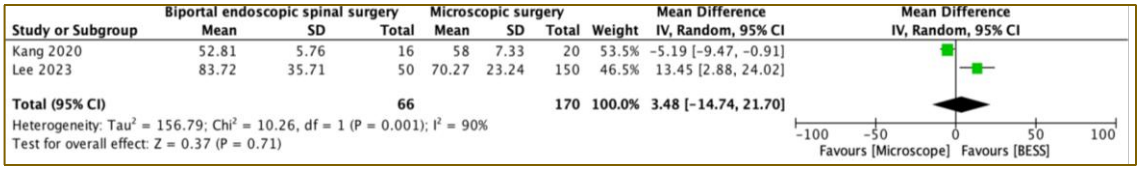

Figure 2. Forest plot presenting the meta-analysis of the comparison of biportal endoscopic spinal surgery (BESS) and microscopic surgery on operation time (minutes).

Postoperative drainage

A meta-analysis of two studies was conducted to compare the postoperative drainage between BESS and microscopic surgery. The mean difference in drainage was 16.28 mL (95%CI: -2.33–34.89), favoring microscopic surgery. The Tau² value of 83.96 indicated moderate between-study variation, and the Chi-squared value was 1.87, showing no statistical significance (p=0.09). Moderate heterogeneity was observed (I^2=47%) (**Figure 3**).

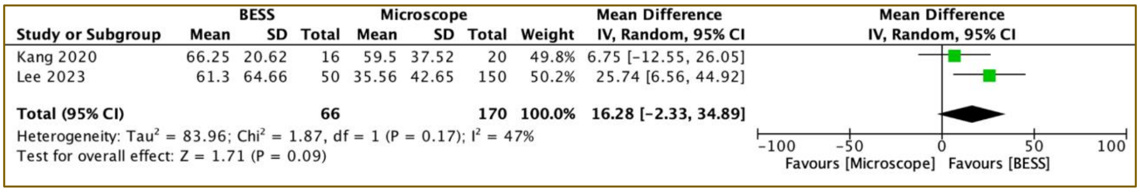

Figure 3. Forest plot presenting the meta-analysis of the comparison of biportal endoscopic spinal surgery (BESS) and microscopic surgery on postoperative drainage (mL).

Postoperative length of stay

A meta-analysis of two studies was conducted to compare the postoperative length of stay between BESS and microscopic surgery. The meta-analysis indicated a significantly longer length of stay for microscopic surgery (p=0.05), with a mean difference of -1.26 days (95%CI: -2.52–0.00). Tau² value of 0.64 suggested moderate to high between-study variation, while Chi-squared value was 4.38, indicating high heterogeneity (I^2=77%) (**Figure 4**).

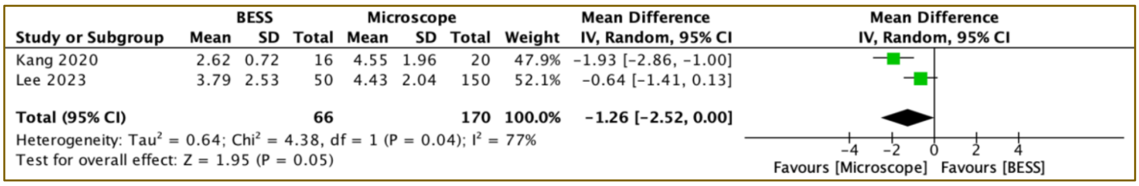

Figure 4. Forest plot presenting the meta-analysis of the comparison of BESS and microscopic surgery on postoperative length of stay durations (days).

Postoperative C-reactive protein markers

A meta-analysis of two studies was conducted to compare the postoperative CRP levels between BESS and microscopic surgery. The analysis indicated lower postoperative CRP levels favoring microscopic surgery, with a mean difference of -13.49 (95%CI: -36.85–9.87). The Tau² value of 275.89 and I^2=97% indicated high between-study variation and heterogeneity. The Chi-squared value was 4.38 (p=0.26), suggesting no statistically significant difference was found (**Figure 5**).

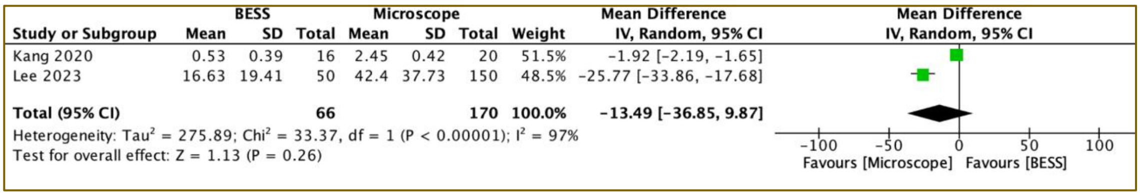

Figure 5. Forest plot presenting the meta-analysis of the comparison of biportal endoscopic spinal surgery (BESS) and microscopic surgery on postoperative C-reactive protein (CRP) marker.

Risk of bias assessment

Both studies [14,15] received 4 stars in the selection domain, 1 star in the comparability domain, and 3 stars in the exposure/outcome domain, yielding a total score of 8 for each study. This indicates that both studies were of good quality (**Table 3**).

Table 3. Risk of bias of included studies

Author, year	Selection	Comparability	Exposure/outcome	Total	Interpretation
Lee *et al.*, 2023	****	*	***	8	Good
Kang *et al.*, 2020	****	*	***	8	Good

Discussion

Early surgery, typically performed within six months to a year after the onset of symptoms, is associated with faster recovery and better long-term outcomes for patients with lumbar disc herniation [16]. Emerging evidence indicates that prolonged operation time is an independent, modifiable risk factor for complications, with studies demonstrating a positive correlation between procedure duration and complications such as bleeding, hematoma, necrosis, and surgical site infections (SSIs) [17]. Two previous systematic review studies [10,11] have been conducted comparing percutaneous endoscopic lumbar discectomy (PELD) and open lumbar microdiscectomy (OLD). Our systematic review is different from those two previous studies because we include additional variables that were not examined in the previous reviews: postoperative drainage and postoperative CRP levels.

In our study, we found a similar result in patients who underwent BESS and microscopic surgery. Although those with BESS experienced longer operative time, higher postoperative drainage, shorter hospital length of stay (LOS), and higher CRP levels compared to those within the microscopic surgery group, the results were not statistically significant. Although not statistically significant, patients undergoing BESS experienced longer operation times compared to those receiving microscopic surgery. This discrepancy may be attributed to the learning curve associated with endoscopic techniques and the greater magnification of the operative field provided by the endoscope (×30), which can present technical challenges, especially during the early stages of a surgeon's endoscopic training [18,19]. Furthermore, the use of unfamiliar endoscopic equipment and the angular vision created by lenses with greater than 0-degree angles may further contribute to these challenges, resulting in extended operative times for the endoscopic group [20].

The primary function of a suction drain is to prevent the accumulation of fluids, such as blood or contaminated materials, at the surgical site [21]. Surgical drains also play a crucial role in detecting complications, including hemorrhage, pancreatic fistulas, ureteric injury, anastomotic leaks, and intra-abdominal infections [22]. In the present study, BESS exhibited higher postoperative drainage compared to microscopic surgery, likely due to the infiltration of irrigation saline into the surrounding musculature during the procedure, which subsequently drained postoperatively [23]. Additionally, bleeding controlled intraoperatively by water pressure may have contributed to increased drainage after surgery [17]. Consequently, this may explain the greater postoperative drainage volume observed in the BESS group compared to the microscopic surgery group, although the difference was not statistically significant.

Length of hospital stay serves as a key indicator of healthcare quality and is closely associated with medical expenses [24]. Generally, an extended Length of hospital stay indicates poorer medical care and higher costs [24]. One objective of enhanced recovery after surgery is to minimize postoperative length of hospital stay, which is a critical component of total length of hospital stay in surgical patients [24]. For elective open posterior spine surgery, LOS typically ranges from 3 to 7 days [24]. In the present study, patients undergoing microscopic surgery demonstrated a longer overall postoperative LOS. These findings align with those of Heo *et al.* [25] and Choi *et al.* [26] which indicated that microscopic surgery was associated with a higher incidence of intraoperative muscle injury compared to BESS. This was evidenced by elevated serum C-protein kinase levels postoperatively, contributing to increased back pain and prolonged hospitalization [25,26]. However, as the differences were not statistically significant, caution is warranted in interpreting these results.

CRP is a widely used serum inflammatory marker for identifying infections and detecting early surgical complications when levels exceed the normal range [27-29]. It serves as a reliable and sensitive indicator of inflammatory responses in patients undergoing spine surgery and is minimally affected by common comorbidities or prior spine surgeries, except in cases of liver failure [30]. A primary advantage of endoscopic surgery is its capacity to preserve normal spinal anatomy. Additionally, one study reported significantly lower CRP levels one week postoperatively in patients who underwent BESS [30]. In contrast, the present study indicated lower postoperative CRP levels in patients who received microscopic surgery. This discrepancy may be attributed to the fact that while BESS involves smaller incisions and less muscle stripping, it necessitates muscle splitting and shaving to create the working space, potentially leading to higher serum CPK levels in the BESS group [30]. The present study's findings align with previous study [31]; however, the results of the present study were inconclusive, lacking statistical significance.

The clinical implications of our study's findings indicate that microscopic surgery offers advantages over BESS, including shorter intraoperative time, reduced postoperative drainage, and lower CRP levels. These factors contribute to a shorter length of hospital stay. These benefits may serve as important considerations for spine surgeons when selecting an appropriate and efficient intervention that aligns with treatment objectives.

This study has several limitations, primarily the limited number of studies included in this systematic review, with only two studies involving a total of 236 participants. As a result, the comparisons and findings from these studies cannot be generalized to everyday practice. There is significant potential for further research, as additional outcomes such as complications and surgical failure, assessed through reoperation rates, can be evaluated. Expanding the study could provide more comprehensive and representative results. Therefore, additional high-quality studies, particularly randomized controlled trials, are essential to strengthen the evidence. Additionally, our study only compares two surgical approaches in lumbar disc herniation. Future research could involve comparisons of other surgical interventions to determine the most appropriate operative approach for each patient. This would enhance the understanding of the relative efficacy and safety of various surgical options, ultimately guiding personalized treatment strategies in clinical practice.

Conclusion

Our systematic review and meta-analysis data suggested that microscopic surgery and BESS yield similar outcomes, evidenced by reduced operation time, postoperative drainage, postoperative length of stay, and lower postoperative CRP levels. These findings support the consideration of both techniques as effective options for appropriate patient populations. The choice between microscopic surgery and BESS can be tailored based on surgeon expertise, patient-specific factors, and available resources, ensuring optimal outcomes and efficient resource utilization in clinical settings.

Ethics approval

Not required.

Acknowledgments

None declared.

Competing interests

All the authors declare that there are no conflicts of interest.

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Underlying data

Derived data supporting the findings of this study is presented as part of the article.

Declaration of artificial intelligence use

We hereby confirm that no artificial intelligence (AI) tools or methodologies were utilized at any stage of this study, including during data collection, analysis, visualization, or manuscript preparation. All work presented in this study was conducted manually by the authors without the assistance of AI-based tools or systems.

How to cite

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