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LITERATURE REVIEW

A SYSTEMATIC LITERATURE REVIEW AND META-ANALYSIS OF BIPORTAL ENDOSCOPY VERSUS MICROSCOPIC DISCECTOMY IN LUMBAR DISC HERNIATION SURGERY: A COMPARATIVE ASSESSMENT OF OUTCOMES

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ABSTRACT

Background: Biportal Endoscopic Spine Surgery (BESS) is an emerging minimally invasive alternative to Microscopic Discectomy (MD) for lumbar disc herniation (LDH). However, the comparative effectiveness of BESS versus MD remains uncertain. Methods: Following PRISMA guidelines, we searched PubMed, EBSCOhost, and Scopus (2000-2024). We included studies comparing BESS and MD for LDH. Outcomes analyzed were operative time, blood loss, postoperative pain (VAS), functional recovery (ODI), hospital stay, and complication rates. A random-effects meta-analysis was performed.
Methods: Following PRISMA guidelines, we searched PubMed, EBSCOhost, and Scopus (2000-2024). We included studies comparing BESS and MD for LDH. Outcomes analyzed were operative time, blood loss, postoperative pain (VAS), functional recovery (ODI), hospital stay, and complication rates. A random-effects meta-analysis was performed.
Results: Four studies (n = 252 patients) were included. BESS was associated with a significantly shorter hospital stay but a longer operative time. Differences in pain reduction (VAS) and functional recovery (ODI) favored BESS but were not statistically significant. Bleeding and mJOA scores showed high heterogeneity and non-significant differences.
Conclusion: BESS offers potential benefits in hospital stay and recovery but lacks definitive superiority over MD. Larger, high-quality RCTs are needed to draw firmer conclusions.

Keywords: lumbar disc herniation, biportal endoscopy, microscopic discectomy, minimally invasive spine surgery, meta-analysis

INTRODUCTION

Lumbar disc herniation (LDH) is a common spinal disorder that can result in radicular pain, motor-sensory dysfunction, and reduced quality of life. It is a significant contributor to lower back and leg pain in individuals worldwide.[1–3] When conservative therapies are ineffective in relieving symptoms, surgical intervention, specifically discectomy, is frequently required.[2,13,15] Discectomy involves excision of the disc's herniated segment that is extruded onto the spinal nerves, alleviating discomfort and decreasing neurologic function. Historically, open discectomy has been the conventional intervention for lumbar disc herniation. Advancements in surgical techniques have resulted in the emergence of minimally invasive treatments, such as microscopic discectomy and

biportal endoscopic spine surgery (BESS).

Microscopic discectomy has become a recommended minimally invasive technique, using a retractor and a microscope to access the herniated disc.[11] It offers numerous benefits compared to open discectomy, including fewer incisions, reduced muscle dissection, and expedited recuperation. Clinical investigations indicate that microscopic discectomy results are comparable to conventional open surgery, featuring reduced postoperative pain and shorter hospital stays. This treatment has specific constraints, including a restricted field of view and a steep learning curve, which can complicate the procedure of a full discectomy and achieve the goal of optimal results.

To address these limitations, biportal endoscopic spine surgery (BESS) was developed as a recommended minimally invasive alternative.[6] BESS utilizes two small incisions (portals) to facilitate the insertion of surgical instruments and an endoscope, providing an expanded field of visibility and enhanced precision throughout the surgery.[8,11,16] This method is designed to reduce postoperative complications such as muscle atrophy and pain, minimize soft tissue injury, and facilitate the use of conventional spinal instruments, thereby increasing the accessibility of the procedure for spine surgeons.[14,18] Preliminary retrospective investigations indicate that BESS may be as effective as or potentially superior to conventional microscopic discectomy, particularly with enhanced visualization and less risk of complications.

Nevertheless, despite these positive findings, the evidence supporting BESS is still inadequate since no extensive randomized controlled trials (RCTs) directly contrast its outcomes with those of microscopic discectomy. This systematic literature review and meta-analysis aim to evaluate and compare the clinical outcomes of BESS and microscopic discectomy independently in managing lumbar disc herniation. This study seeks to thoroughly assess the efficacy, safety, and benefits of both surgical procedures by examining available research data, contributing to the ongoing discourse regarding the ideal surgical method for LDH.

The primary goal of this study is to evaluate the clinical outcomes, including functional recovery, complication rates, and patient satisfaction, between BESS and microscopic discectomy. We predict that both procedures will exhibit comparable efficacy in alleviating symptoms and enhancing quality of life. We also seek to discover significant differences in surgical performance, intraoperative bleeding, length of hospital stay, and postoperative healing that may impact clinical decision-making for patients with lumbar disc herniation.

MATERIALS AND METHODS

A comprehensive search was conducted in the PubMed, Ebscohost, and Scopus databases from 2000 to 2024, employing the PICO framework (Population, Intervention, Comparison, Outcome). The target population consisted of LDH patients, the intervention analyzed was BESS, and the comparisons were made using clinical scales and radiological parameters. The outcomes examined included functional, clinical, and radiological. Keywords for literature searching use Boolean operators with (Herniated Disc lumbar OR Lumbar disc herniation OR Spinal surgery) AND (Biportal endoscopy OR Minimally invasive spine surgery) AND (Functional outcome OR Clinical outcome OR Visual Analog Scale OR Oswestry Disability Index OR Clinical Global Impression OR Radiological Outcome OR).

The data collection process followed the PRISMA 2020 Flowchart (Figure 1), beginning with a keyword-based literature search. This was followed by the removal of duplicate records, screening based on inclusion and exclusion criteria, filtering relevant titles and abstracts, selecting studies for inclusion, and assessing the quality of the chosen literature.

This study included randomized controlled trials (RCTs), cohort studies, and comparative studies that directly compared BESS and MD in patients diagnosed with lumbar disc herniation. Studies were excluded if they provided insufficient data, were published in languages other than English, or involved other types of surgical techniques or mixed patient populations. This ensured a focused analysis on the targeted interventions. These inclusion and exclusion criteria were carefully defined to maintain the relevance and quality of the evidence base.

The outcomes of interest were operative time, blood loss, postoperative pain as measured by the Visual Analogue Scale (VAS), functional recovery assessed via the Oswestry Disability Index (ODI), Modified Japanese Orthopaedic Association Scoring System (mJOA), and the length of hospital stay. Secondary outcomes focused on complication rates, including infections, nerve injuries, and recurrence of herniation, as well as the recurrence of disc herniation itself. These outcomes were selected to provide a comprehensive evaluation of the comparative effectiveness and safety of BESS and MD in managing lumbar disc herniation. This structured approach ensures that the findings are both clinically meaningful and aligned with the priorities of patients and healthcare providers.

Two independent reviewers extracted data on study characteristics, patient demographics, surgical details, and outcomes. Statistical analysis was performed using SPSS 29 software. A random-effects model was applied, and results were presented as Standardized mean differences (SMD) with 95% confidence intervals (CIs). Heterogeneity was assessed using the I^2 statistic.

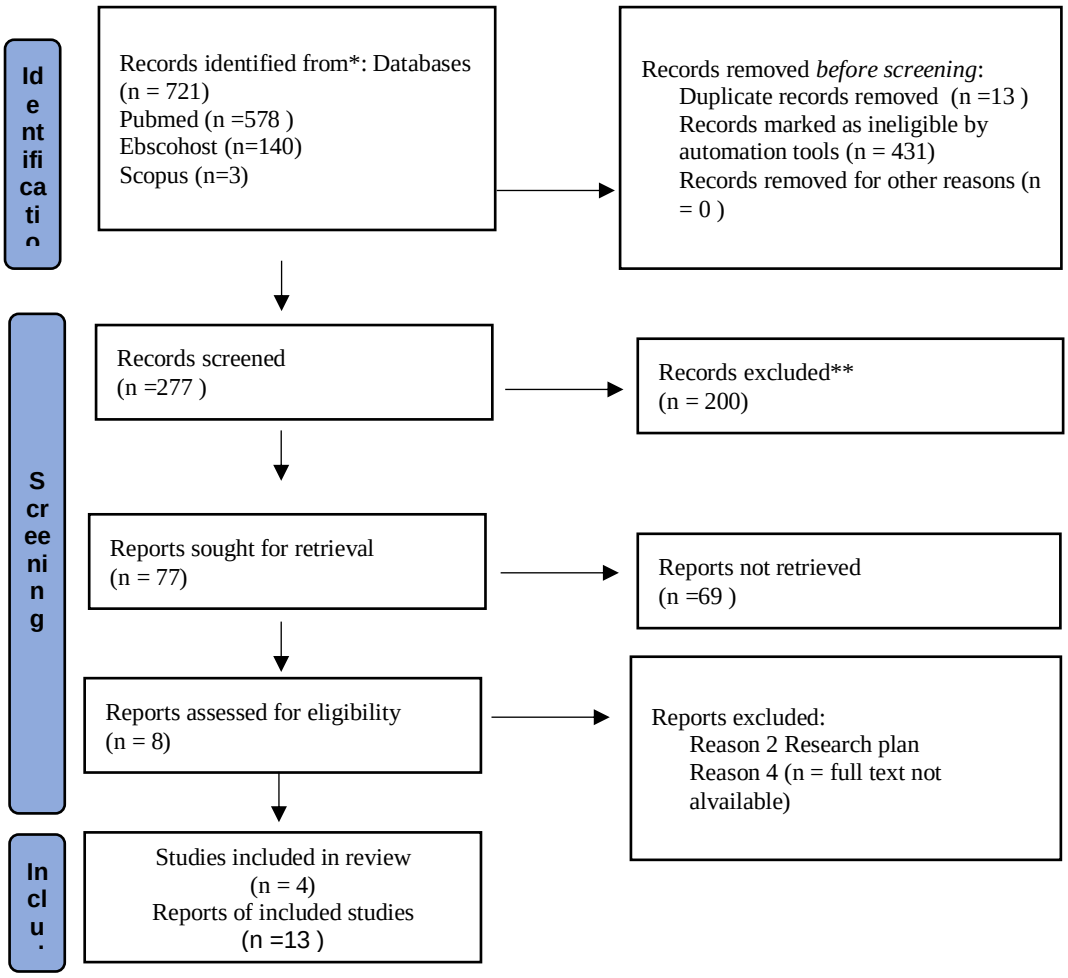

Figure 1. Prisma Flowchart of the Literature Review

RESULTS

A total of 4 studies were included, involving 252 patients (126 in each group). Of these, one was a randomized controlled trial (RCT), and three were retrospective studies. The sample sizes in the included studies ranged from 37 to 109 participants [1,7,10,19].

Table 1 compares patient characteristics and pathology distribution between BESS and MD. The average age was similar for both groups (BESS: 52.56±13.76; MD: 52.39±12.89; P = 0.92). There were no significant differences in pathology distribution (P = 0.36), with most cases occurring at the L4/5 level (BESS: 77%, MD: 68%), followed by L5/S1 (BESS: 15%, MD: 26%) and L3/4 (BESS: 8%, MD: 6%). This suggests that both techniques had comparable patient profiles and pathology distributions. The VAS analysis (Figure 2) showed a slight trend toward better pain reduction with BESS compared to MD, with an overall effect size of -0.46. However, this difference was not statistically significant (α = 0.05), and there was considerable heterogeneity, reducing the reliability of the result.

Table 1. Patient Characteristic Comparison of BESS Group and MD Group

	BESS	MD	P
Age	52.56±13.76	52.39±12.89	0.92
Location			0.36
L3/4	8%	6%	
L4/5	77%	68%	
L5 S1	15%	26%	

Forest Plot of Visual Analogue Scale (VAS) Comparison between BESS and MD

In the Oswestry Disability Index (ODI) analysis (Figure 3), BESS showed minor improvements in functional disability compared to MD, with an overall effect size of 0.17 and a standard error of 0.13, indicating slight improvement for BESS over MD. The heterogeneity value (I^2) was 0%.

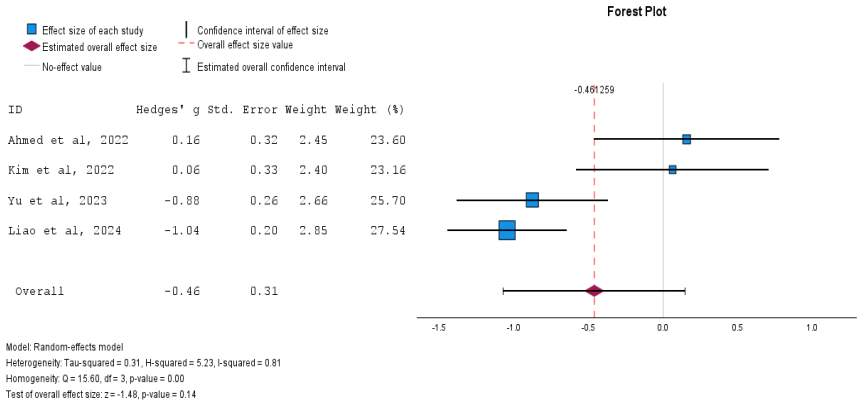

Figure 2. Forest Plot of Visual Analogue Scale (VAS) Comparison between BESS and MD

Oswestry Disability Index (ODI)

The effect size for operative time (Figure 4) was 1.32 (95% CI: 0.10 to 2.54, p = 0.03), indicating a statistically significant effect. The heterogeneity statistics showed a high degree of variability among studies (Tau^2 = 1.44, H^2 = 16.30, I^2 = 94%), suggesting substantial heterogeneity. The overall effect size test (Z = 2.13, p = 0.03) confirmed a significant combined effect. However, the high I^2 value (94%) indicates considerable variability among the studies.

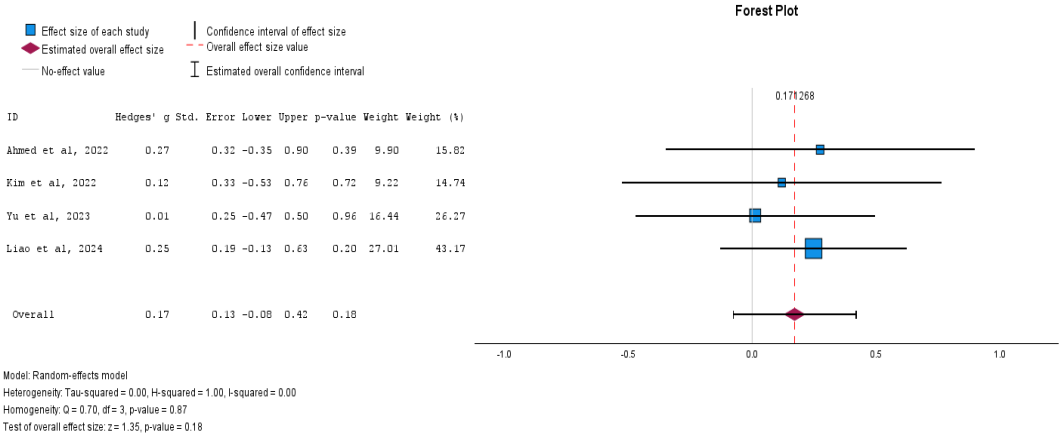

Figure 3. Forest Plot of Oswestry Disability Index (ODI) Comparison between BESS and MD

Operative time

The effect size for surgical bleeding (Figure 5) was -0.86 (95% CI: -3.10 to 1.37, p = 0.45), indicating no statistically significant overall effect. The heterogeneity statistics revealed extremely high variability among the studies (Tau^2 = 5.08, H^2 = 48.92, I^2 = 98%), confirming substantial heterogeneity. The overall effect size test (Z = -0.76, p = 0.45) confirmed that the combined effect was not statistically significant. The high I^2 value (98%) indicates substantial heterogeneity.

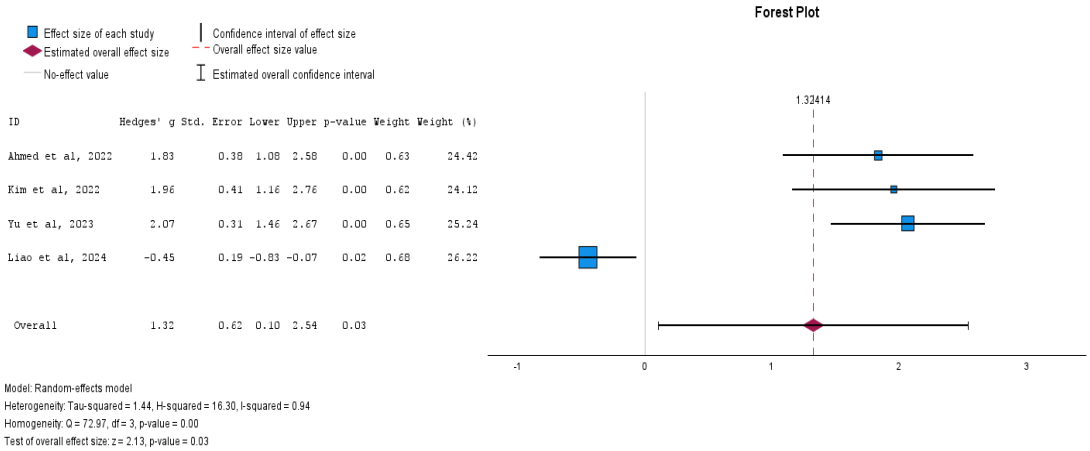

Figure 4. Forest Plof Operative Time Comparison BESS and MD

Surgery Bleeding

For hospital stay (Figure 6), the effect size was -1.83 (95% CI: -2.35 to -1.30, p = 0.00), indicating a statistically significant reduction in hospital stay. The heterogeneity statistics showed moderate variability (Tau^2 = 0.18, H^2 = 2.83, I^2 = 65%), suggesting a moderate level of heterogeneity. The overall effect size test (Z = -6.80, p = 0.00) confirmed a highly significant combined effect. Despite some heterogeneity (I^2 = 65%), the consistency of negative effect sizes across studies strengthens the reliability of the findings.

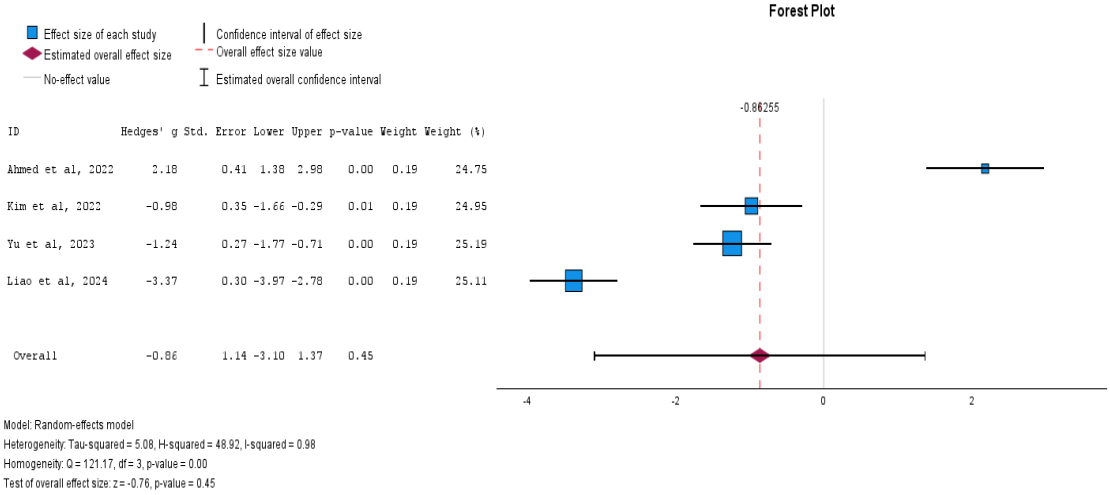

Figure 5. Forest Plot Surgery Bleeding Comparison of BESS and MD Hospital Stay

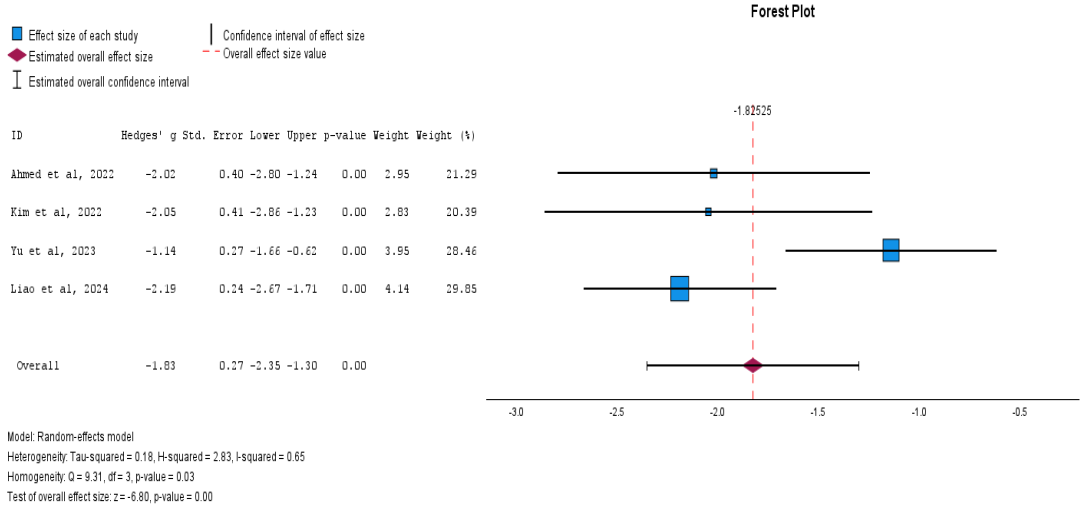

Figure 6. Forest Plot Hospital Stay BESS and MD

The effect size for mJOA (Figure 7) was 13.06 (95% CI: -18.45 to 44.57, p = 0.42). The wide confidence interval indicates substantial uncertainty in the overall effect estimate, and the p-value (0.42) suggests no statistically significant combined effect. The heterogeneity statistics showed extreme variability (Tau^2 = 514.64, H^2 = 239.57, I^2 = 100%), confirming substantial heterogeneity. The overall effect size test (Z = 0.81, p = 0.42) further supports the lack of statistical significance.

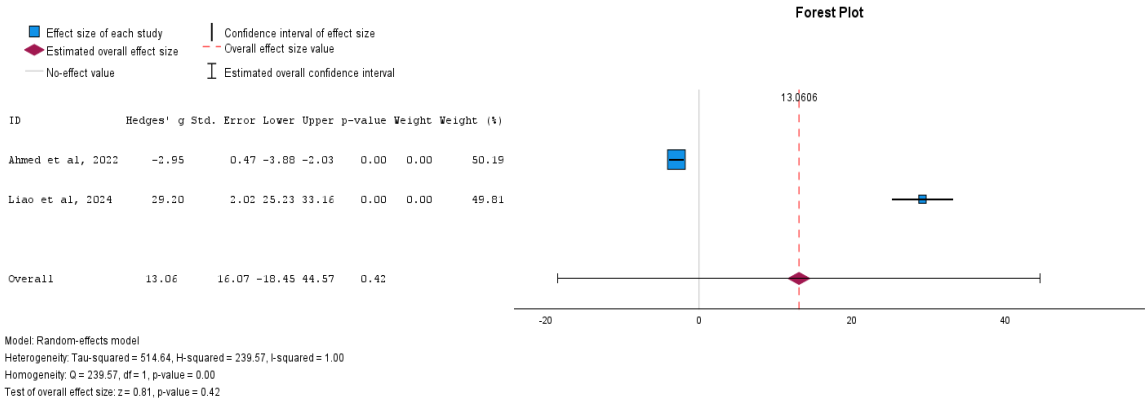

Figure 7. Forest Plot mJOA BESS and MD mJOA

DISCUSSION

The comparative analysis of Biportal Endoscopy Spine Surgery (BESS) and Microscopic Discectomy (MD) revealed several insights into patient demographics, clinical outcomes, and procedural characteristics. The average patient age was nearly identical in both groups (BESS: 52.56±13.76, MD: 52.39±12.89), indicating that age did not play a role in choosing either surgical approach (P = 0.92). Both techniques were predominantly applied at the L4/5 spinal level, with BESS accounting for 77% and MD for 68% of cases. Pathologies at the L3/4 level were less common, representing 8% and 6% in the BESS and MD groups, respectively. At the L5/S1 level, MD showed a higher frequency of use (26%) compared to BESS (15%). The distribution of spinal pathology locations (P = 0.36) showed no statistically significant differences between the two techniques, underscoring their application to similar patient populations and anatomical levels.

The analysis of postoperative pain reduction, as measured by VAS, demonstrated a slight trend favoring BESS over MD. However, the difference was not statistically significant. This suggests that while BESS may provide better pain relief for some patients, the overall impact remains uncertain due to high variability across studies. The minimally invasive nature of BESS, with smaller incisions and reduced tissue disruption, may theoretically reduce pain and accelerate recovery.[3,4] Clinically, patients undergoing BESS might experience less immediate discomfort, enabling earlier mobilization and reduced reliance on pain medications.[3] However, these theoretical benefits remain hypotheses until further validated by high-quality trials.

Functional recovery, assessed using the Oswestry Disability Index (ODI), also indicated a minor improvement with BESS compared to MD. The small effect size (0.17) suggests a limited but potentially beneficial impact on patient-reported disability outcomes. Furthermore, the heterogeneity was relatively low (I^2 = 0%), indicating consistency among the included studies in functional recovery results. This underscores the need for additional studies to explore whether BESS can achieve meaningful functional benefits in practical applications. These findings align with previous studies suggesting that BESS may improve early postoperative mobility and reduce postoperative pain; however, larger and more homogeneous studies are necessary to validate these findings.[12]

One of the most significant findings of this study was the increased operative time associated with BESS compared to MD. The effect size of 1.32 (p = 0.03) indicates that BESS requires a longer duration for completion. This is likely due to the complexity of the biportal technique, which requires precise visualization and instrument manipulation within a confined space. The other causes are the learning curve in BESS, early cases of BESS, triangulation, anatomical view in endoscopy, and maintaining bleeding during surgery, which are challenging steps.[17,18]

Despite this drawback, the potential benefits, including reduced tissue disruption and faster recovery times, may offset this limitation.1[7] The substantial heterogeneity (I^2 = 94%) suggests that variations in surgical expertise, patient selection, and institutional protocols may contribute to differences in operative duration. Standardizing surgical expertise and optimizing protocols could further reduce operative times and improve the adoption of BESS in clinical settings.

In contrast, the analysis of intraoperative blood loss did not reveal a statistically significant difference between the two techniques (effect size = -0.86, p = 0.45). One significant advantage of BESS lies in its ability to reduce surgical bleeding, which is consistent with its minimally invasive design. Lower bleeding rates can minimize perioperative complications, enhancing patient safety. The high heterogeneity (I^2 = 98%) suggests variability in reporting methods and patient factors that influence intraoperative bleeding. While some studies report reduced blood loss with BESS due to minimal tissue disruption, others indicate comparable bleeding volumes between the two procedures.[5,9] Future standardized assessments of intraoperative bleeding are needed to clarify these findings.

Hospital stay is an important measure of surgical efficiency and postoperative recovery. Our findings showed that BESS significantly reduced the duration of hospital stay compared to MD, with an effect size of -1.83 (p = 0.00). The moderate level of heterogeneity (I^2 = 65%) suggests some variability but overall consistency in the results. This aligns with existing literature indicating that minimally invasive procedures like BESS promote faster recovery, reduced postoperative complications, and earlier mobilization, leading to shorter hospital stays, which reduce costs and the risk of hospital-acquired infections.[6]

The analysis of the mJOA score, which evaluates neurological function, showed a highly variable and non-significant effect size of 13.06 (p = 0.42). The extreme heterogeneity (I^2 = 100%) suggests that the included studies had substantial differences in patient selection, assessment methods, and follow-up durations. Improvements in mJOA scores suggest better functional recovery with BESS compared to MD. While BESS may offer certain advantages in preserving neurological structures, the current evidence does not support a conclusive benefit over MD in mJOA scores.

Comparative evaluations of BESS and MD reveal nuanced differences in clinical outcomes. While BESS shows promise in reducing postoperative pain and improving functional recovery, the lack of statistical significance and variability in study designs limits the

robustness of these findings. Operative times remain challenging for BESS, but its advantages in shorter hospital stays, reduced bleeding, and potentially faster recovery highlight its potential as a minimally invasive option. The significant reduction in hospital stay suggests that BESS may be preferable in settings where rapid recovery and early discharge are prioritized. However, the longer operative time associated with BESS may be a limiting factor, particularly in high-volume surgical centers.

Additionally, while BESS demonstrated trends toward improved pain reduction and functional recovery, the statistical significance was not consistently achieved, highlighting the need for further large-scale and high-quality randomized controlled trials. Future research should focus on addressing the gaps in surgical techniques and protocol by prioritizing uniform methodologies, including consistent surgical techniques, patient selection criteria, and follow-up protocols. Long-term outcomes, such as sustained functional recovery, pain relief, and quality-of-life improvements, are critical to understanding the durability of BESS benefits. Large-scale, multicenter randomized controlled trials are needed to overcome limitations like small sample sizes and single-center biases, improving the generalizability of findings. Additionally, economic evaluations could highlight the cost-effectiveness of BESS by considering reduced hospital stays and perioperative complications.

The integration of emerging technologies, such as robotics and augmented reality, could further optimize the precision and efficiency of BESS. Exploring these innovations and their impact on clinical outcomes will help advance minimally invasive spine surgery, ensuring evidence-based improvements in patient care. The evolving priorities in spinal surgery emphasize patient-centered outcomes, long-term benefits, and cost-effectiveness, paving the way for BESS to become a viable alternative to MD in specific clinical scenarios.

CONCLUSION

The findings of this study indicate that while BESS shows promise as a minimally invasive alternative to MD, the current evidence does not yet establish its superiority with statistical certainty. The theoretical benefits of BESS, such as reduced postoperative pain, improved functional recovery, and shorter hospital stays, align with clinical goals but remain inconclusive due to significant limitations. These include small sample sizes, methodological inconsistencies, and high heterogeneity across analyses, which challenge the generalizability of the results. From a clinical perspective, the findings underscore the critical role of pain management in minimally invasive surgical techniques. BESS's potential to minimize postoperative pain and accelerate recovery aligns well with the priorities of modern surgical care. However, the lack of definitive statistical significance suggests the need for further robust evidence to confirm these benefits. The variability in results highlights the importance of addressing methodological and procedural challenges to establish a clearer understanding of BESS's efficacy and outcomes.

Future studies should prioritize larger and more diverse patient populations, standardized surgical protocols, and extended follow-up periods to comprehensively evaluate the long-term clinical advantages of BESS. Additionally, strategies to address current limitations, such as prolonged operative time, must be explored to optimize its clinical utility. As advancements in spine surgery continue to evolve, BESS holds the potential to significantly enhance patient outcomes, provided that future research can consistently validate its benefits through rigorous and well-designed studies.

DECLARATIONS

Ethics approval and consent to participate

Not applicable.

Conflict **interests**

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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