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REVIEW

Comparison of clinical outcomes and complications of biportal and uniportal endoscopic decompression for the treatment of cervical spondylotic radiculopathy: A systematic review and meta-analysis

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Cervical spondylotic radiculopathy (CSR) is the most prevalent form of cervical spondylosis, accounting for approximately 60 to 70% of all cases. Symptoms include neck pain, arm pain, finger numbness, or arm weakness. The majority of CSR patients can achieve relief through conservative treatments, such as medication, cervical traction, acupuncture, or wearing a cervical collar.[1,2] Patients who do not respond to three months of conservative treatments should be promptly considered for surgical intervention. Anterior cervical discectomy and fusion (ACDF) has long been regarded as the gold standard for treating CSR. However, ACDF

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ABSTRACT

Objectives: This study aimed to compare the clinical efficacy and complication rates of decompression with unilateral biportal endoscopy (UBE) and percutaneous endoscopy (PE) in cervical spondylotic radiculopathy (CSR).

Materials and methods: A comprehensive literature review was conducted up to April 2024 across multiple databases, including EMBASE, PubMed, Cochrane Library, China National Knowledge Infrastructure, and Wanfang Data, focusing on clinical studies that compare UBE with PE for posterior foraminotomy and discectomy decompression in CSR. The meta-analysis was performed with an emphasis on evaluating clinical outcomes such as operation time, blood loss, incision length, Neck Disability Index (NDI), Visual Analog Scale (VAS) for neck pain and arm pain, and complications.

Results: Out of an initial 1,041 studies identified from electronic databases, eight were deemed eligible based on title, abstract, and full-text screening. These studies involved 552 patients (269 males, 283 females; mean age: 53.9±11.4 years; range, 30 to 79 years), with 287 in the UBE group and 265 in the PE group. Meta-analysis indicated no significant difference in operation time between UBE and PE (mean difference [MD]=–3.68; 95% confidence interval [CI]:–19.38, 12.02; p=0.65). However, both blood loss (MD=17.01; 95% CI: 2.61, 31.41; p=0.02) and incision length (MD=11.62; 95% CI: 9.23, 14.01; p<0.00001) were significantly lower in the PE group compared to the UBE group. Regarding clinical outcomes, no significant differences were observed between the two groups in terms of NDI (MD=0.12; 95% CI:–0.10, 0.34; 0.28), VAS for neck pain (MD=–0.06; 95% CI:–0.19, 0.06; p=0.32), VAS for arm pain (MD=–0.14; 95% CI:–0.26, –0.01; p=0.84), or complications (OR=1.07; 95% CI: 0.54, 2.10; p=0.85).

Conclusion: Our findings suggest that there are no significant disparities in clinical outcomes between UBE and PE, encompassing NDI, VAS for arm pain, and VAS for neck pain, as well as complication rates. Notably, compared to PE, UBE results in increased bleeding and longer incision lengths when treating CSR, without substantially reducing operation time.

Keywords: Cervical spondylotic radiculopathy, decompression, meta-analysis, unilateral biportal endoscopic, uniportal percutaneous endoscopic.

is not without drawbacks, including dysphagia, hematoma, symptomatic recurrent laryngeal nerve palsy, reduced cervical range of motion, and adjacent segment disease.[3-7] To mitigate these disadvantages and potential complications associated with ACDF surgery, an increasing number of minimally invasive technique have been adopted for the treatment of CSR. In 2007, Ruetten et al.[8] introduced a novel minimally invasive surgical technique utilizing single-channel percutaneous endoscopy for cervical foraminotomy and discectomy, achieving high patient satisfaction rates. Percutaneous endoscopic surgery, which employs an endoscopic instrument with rod-lens optics and a separate operating channel, has become a popular minimally invasive technique for managing CSR due to its ability to reduce paravertebral muscle injury, avoid cervical anterior associated complications, achieve adequate decompression, and facilitate rapid recovery (Figure 1a).[9-13] Another innovative minimally invasive technology for spinal disorders is unilateral biportal endoscopy (UBE), also known as biportal endoscopic spinal surgery (BESS). Concurrently, UBE has rapidly advanced and is now widely employed in endoscopic treatments for complex cases, such as thoracic disc herniation, thoracic spinal stenosis, lumbar spinal stenosis, and lumbar instability requiring intervertebral fusion.[14,15] Compared to PE, UBE offers improved visualization and broader decompression, making it more suitable for addressing conditions such as giant disc herniation, severe lumbar spinal stenosis, and even ossification of ligamentum flavum (Figure 1b).[16,17] In recent years, UBE has increasingly been applied to the treatment of CSR.[18-20] Nevertheless, it remains unclear whether UBE surpasses PE in the management of CSR. Consequently, we conducted this systematic review and meta-analysis to evaluate the clinical outcomes and complications associated with UBE and PE in the treatment of CSR, aiming to provide evidence to guide clinical decision-making.

MATERIALS AND METHODS

The current systematic review and meta-analysis was performed in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.

An extensive literature search was performed in EMBASE, PubMed, Cochrane Library, China National Knowledge Internet, and Wanfang Data up to April 2024. The search strategy was as follows: ((((unilateral biportal endoscopic[Title/Abstract]) OR (UBE[Title/Abstract])) OR (biportal endoscopic spinal surgery[Title/Abstract])) OR (BESS[Title/Abstract])) AND ((((cervical[Title/Abstract]) OR (decompression[Title/Abstract])) OR (keyhole[Title/Abstract])) OR (discectomy[Title/Abstract])). The inclusion criteria were as follows: *(i)* patients diagnosed with CSR, *(ii)* clinical studies comparing UBE with PE, and *(iii)* description of outcome parameters, such as operation time, blood loss, incision length, Visual Analog Scale (VAS), Neck Disability Index (NDI), and complications. The exclusion criteria were as follows: *(i)* reviews, meta-analysis, animal research, biomechanical research, *(ii)* patients diagnosed with cervical spondylotic myelopathy or cervical spinal stenosis,

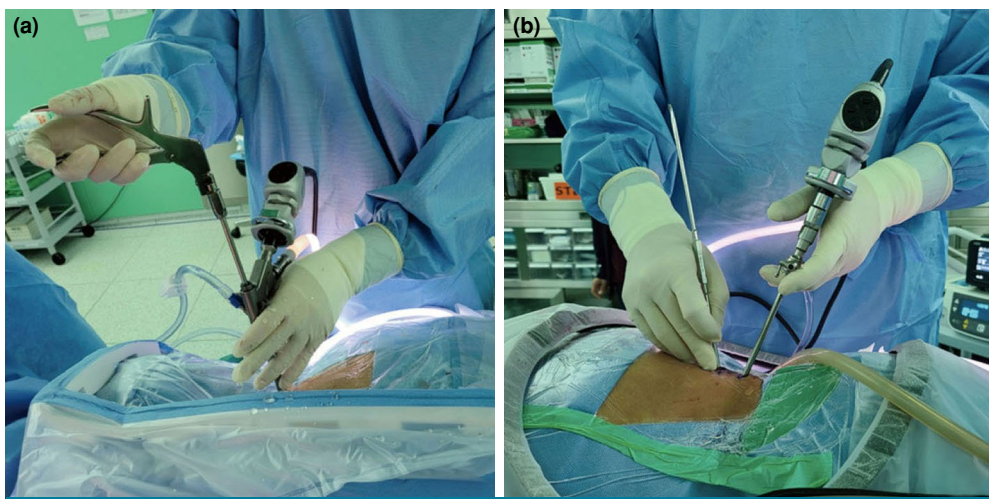

FIGURE 1. Intraoperative view of **(a)** uniportal PE and **(b)** UBE.[20]
PE: Percutaneous endoscopic; UBE: Unilateral biportal endoscopic.

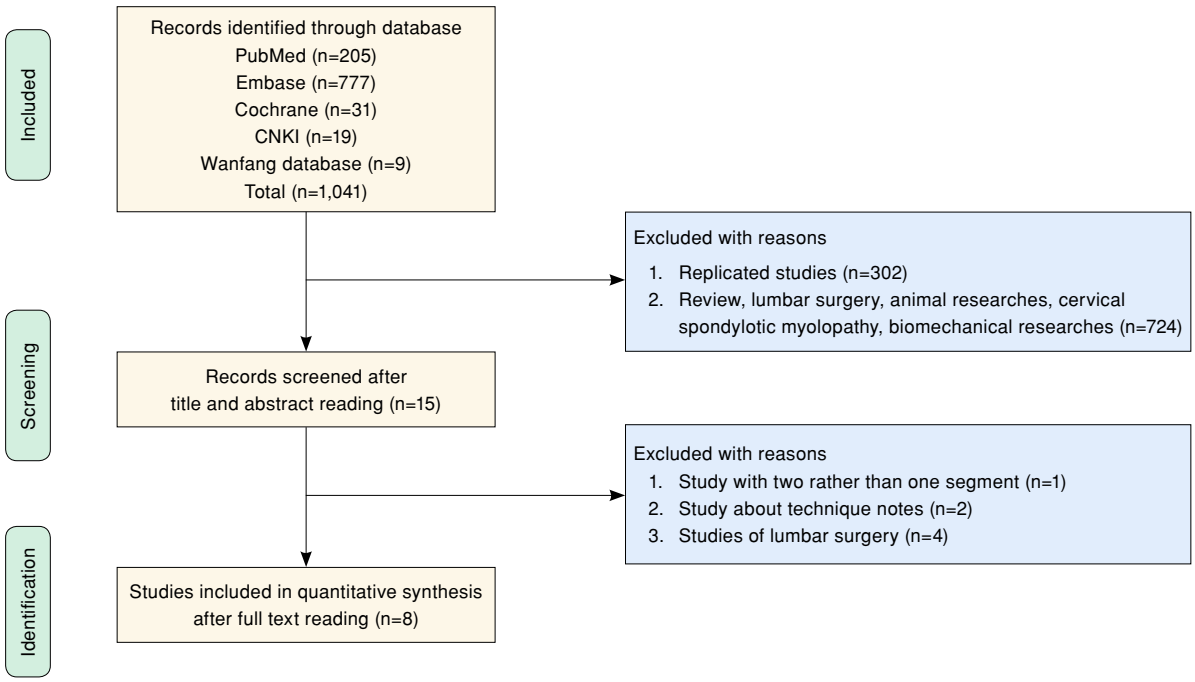

FIGURE 2. The flowchart depicting the process of literature search and screening in this meta-analysis.
CNKI: China National Knowledge Infrastructure.

(iii) inability to obtain the full article or related data, and *(iv)* lumbar surgery.

Data extraction and quality assessment

Two independent researchers screened the articles by reading the titles, abstracts, and full texts according to the inclusion and exclusion criteria. Any disagreements were resolved through discussion. The quality of the included studies (observational studies) was assessed using the Newcastle-Ottawa Scale, based on study population selection, comparability of parameters, and outcomes evaluation by two independent researchers. Studies with more than seven stars were defined as high-quality studies and were included in the analysis. Disagreements were reached consensus through discussion by all authors.

Data synthesis and statistical analysis

The extracted data were analyzed using Review Manager software version 5.4.1 (Cochrane Collaboration). The size of heterogeneity was assessed using the I^2 statistic. A I^2<50% indicated no significant heterogeneity among studies, and a fixed-effects model was used for analysis. A I^2>50% indicated significant heterogeneity among studies, and a random-effect model was used for analysis. A p-value <0.05 was considered statistically significant. For the subgroup analysis, different follow-up times were examined. Funnel plots were used to assess publication bias.

RESULTS

A PRISMA flowchart detailing the database search and literature screening process for the studies is presented in Figure 2. A total of 1,041 studies were identified in the databases. After removing duplicates, 739 titles and abstracts were screened, resulting in 15 titles and abstracts that met our selection criteria. Full texts of these 15 articles were assessed. Seven studies were excluded for the following reasons: *(i)* one study with two segments instead of one, *(ii)* two studies concerning technique notes, and *(iii)* four studies on lumbar surgery. Consequently, eight studies were included in this meta-analysis. All of the included literature was retrospective cohort studies, comparing UBE with PE for single-level CSR. A total of 552 patients (269 males, 283 females; mean age: 53.9±11.4 years; range, 30 to 79 years) were included, with 287 undergoing UBE and 265 undergoing PE surgery. The details and quality of the eight included studies are summarized in Table I.

TABLE I
The demographic characteristics of the included studies

Study	Year	Location	Study period	Study design	Diagnosis	Sample size		Mean age (year)		Follow-up (month)	NOS
						UBE	PE	UBE	PE		
						n	n	Mean±SD	Mean±SD		
Kim et al.[20]	2022	Korea	2019.1-2020.1	Retrospective	CSR	30	38	52.3±12.0	55.3±9.1	UBE (11.7±6.4) PE (10.0±3.9)	9
Kang et al.[21]	2022	Korea	2018.9-202.1	Retrospective	CSR	33	32	52.68±9.56	53.74±8.50	12	9
Zhao[22]	2023	China	2020.10-2022.3	Retrospective	CSR	25	25	55.60±9.66	57.28±9.54	12	9
Yu et al.[23]	2023	China	2020.9-2021.8	Retrospective	CSR	32	30	53.37±7.16	53.70±6.35	17.30±2.73	9
Yan et al.[24]	2023	China	2019.9-2021.8	Retrospective	CSR	19	21	45.05±10.73	43.19±9.83	6	8
Wang et al.[19]	2023	China	2917.5-2020.4	Retrospective	CSR	89	65	58.28±11.94	60.10±9.69	UBE (26.48±2.22), PE (26.58±1.72)	9
Zhong et al.[25]	2023	China	2019.7-2021.12	Retrospective	CSR	36	33	Average 53.5		ND	7
Xie et al.[26]	2024	China	2018.12-2021.12	Retrospective	CSR	23	21	44.4±12.2	41.9±13.8	3-12, average 6.9	8

UBE: Unilateral biportal endoscopic; PE: Uniportal percutaneous endoscopic; SD: Standard deviation; CSR: Cervical spondylotic radiculopathy; ND: No described.

Operation time

Seven studies included in the meta-analysis compared the operation time of UBE and PE in the meta-analysis, with 251 patients in the UBE group and 232 patients in the PE group. The results showed no significant difference in operation time between UBE and PE (MD=–3.68; 95% CI:–19.38, 12.02; p=0.65; heterogeneity: Tau^2=438.67, Chi^2=383.57, degrees of freedom [df]=6, p<0.01, I^2=98%; Figure 3).

Blood loss

Three studies compared the blood loss between UBE and PE in the meta-analysis, involving 137 patients in the UBE group and 111 patients in the PE group. The results indicated a significant difference in blood loss between UBE and PE (MD=17.01; 95% CI: 2.61, 31.41; p=0.02; heterogeneity: Tau^2=150.00, Chi^2=45.53, degrees of freedom [df]=2, p<0.01, I^2=96%; Figure 4). The findings indicated that UBE resulted in a greater volume of blood loss compared to PE.

Incision length

Two studies compared the incision length between UBE and PE in the meta-analysis, which included 121 patients in the UBE group and 95 patients in the PE group. The results indicated a significant difference in incision length between UBE and PE (MD=11.62; 95% CI: 9.23, 14.01; p<0.00001; heterogeneity: Tau^2=2.88, Chi^2=31.28, degrees of freedom [df]=1, p<0.01, I^2=97%; Figure 5). Compared to PE, UBE caused more trauma.

Neck Disability Index

The NDI was reported in seven studies. Among the seven studies that reported preoperative NDI, no significant differences were observed (MD=0.46; 95% CI:–0.87, 1.79; p=0.50; heterogeneity: Tau^2=2.30, Chi^2=26.08, df=6, p<0.01, I^2=77%). The NDI was reported in six studies right after the operation, in four studies one month after the operation, in five studies three months after the operation, in five studies six months after the operation, and in five studies at the final follow-up. The meta-analysis revealed no significant difference at any of these time points (MD=0.12; 95% CI:–0.10, 0.34; p=0.28; heterogeneity: Tau^2=0.14, Chi^2=64.02, df=31, p<0.05, I^2=52%; Figure 6).

Visual Analog Scale for neck pain

Visual Analog Scale scores for neck pain was reported in six studies. Among the six studies reporting preoperative VAS for neck pain, no significant difference was observed (MD=–0.47; 95% CI:–0.95, 0.01; p=0.05; heterogeneity: Tau^2=0.30,

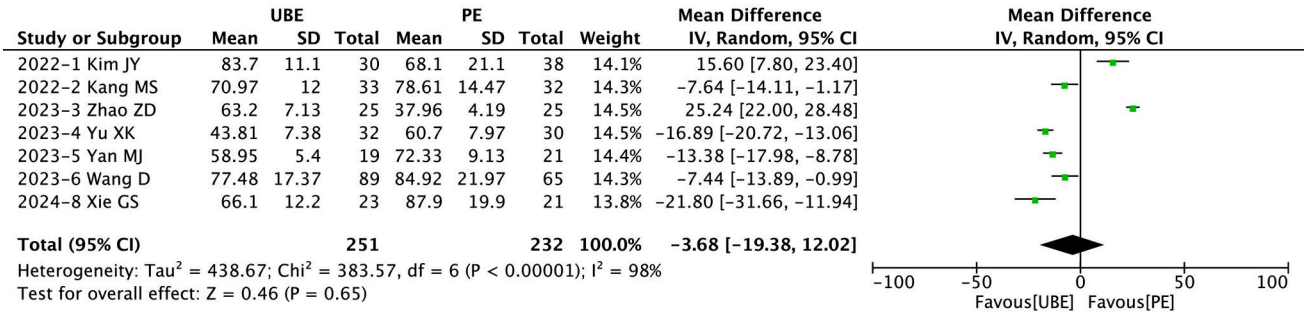

FIGURE 3. Forest plot comparing the operation time between UBE and PE.
UBE: Unilateral biportal endoscopic; PE: Percutaneous endoscopic; SD: Standard deviation; CI: Confidence interval.

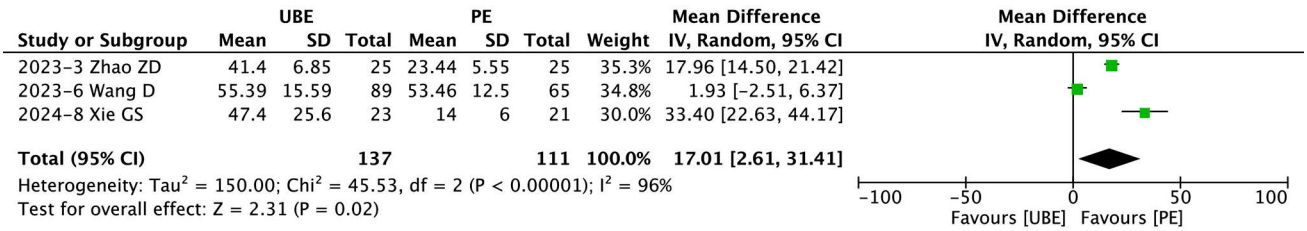

FIGURE 4. Forest plot comparing the blood loss between UBE and PE.
UBE: Unilateral biportal endoscopic; PE: Percutaneous endoscopic; SD: Standard deviation; CI: Confidence interval.

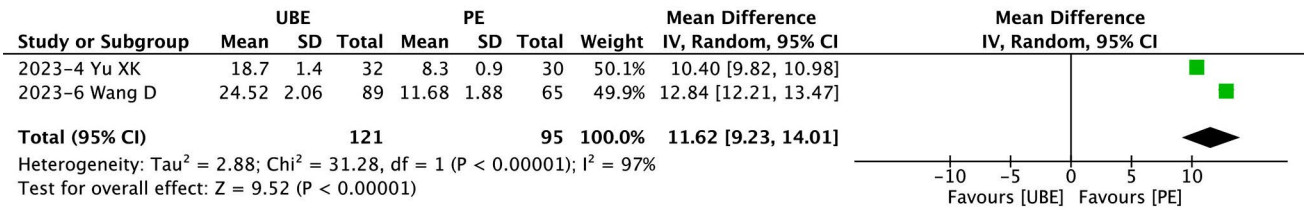

FIGURE 5. Forest plot comparing the incision length between UBE and PE.
UBE: Unilateral biportal endoscopic; PE: Percutaneous endoscopic; SD: Standard deviation; CI: Confidence interval.

Chi²=35.91, df=5, p<0.05, I^2=86%). Five, four, five, four, and four studies reported VAS for neck pain right after the operation, one month after the operation, three months after the operation, six months after the operation, and at the final follow-up, respectively. Meta-analysis showed no significant difference at any of these time points (MD=–0.06; 95% CI:–0.19, 0.06; p=0.32; heterogeneity: Tau²=0.09, Chi²=125.47, df=27, p<0.05, I^2=78%; Figure 7).

Visual Analog Scale for arm pain

Visual Analog Scale scores for arm pain was reported in seven articles. Among the six studies reporting preoperative VAS for neck pain, no significant differences were observed (MD=0.09; 95% CI:–0.07, 0.25; p=0.27; heterogeneity: Chi²=7.81, df=6, p>0.05, I^2=23%). Right after the operation, one month after the operation, three months after the operation, six months after the operation, and at the final follow-up, six, four, five, five, and five studies reported VAS for arm pain, respectively. Only at the three-month postoperative mark did a significant difference emerge between UBE and PE, with findings indicating superior alleviation of arm pain in UBE as opposed to PE. (MD=–0.14; 95% CI:–0.26, –0.01; p=0.84; heterogeneity: Chi²=0.45, df=4, p>0.05, I^2=0%). No substantial differences were observed at any other follow-up intervals (Figure 8).

Complications

Six articles reported the complications in UBE and PE, involving 245 patients in the UBE group and 223 patients in the PE group. The results showed no significant difference in complications rate between UBE and PE (OR=1.07; 95% CI: 0.54, 2.10; p=0.85;

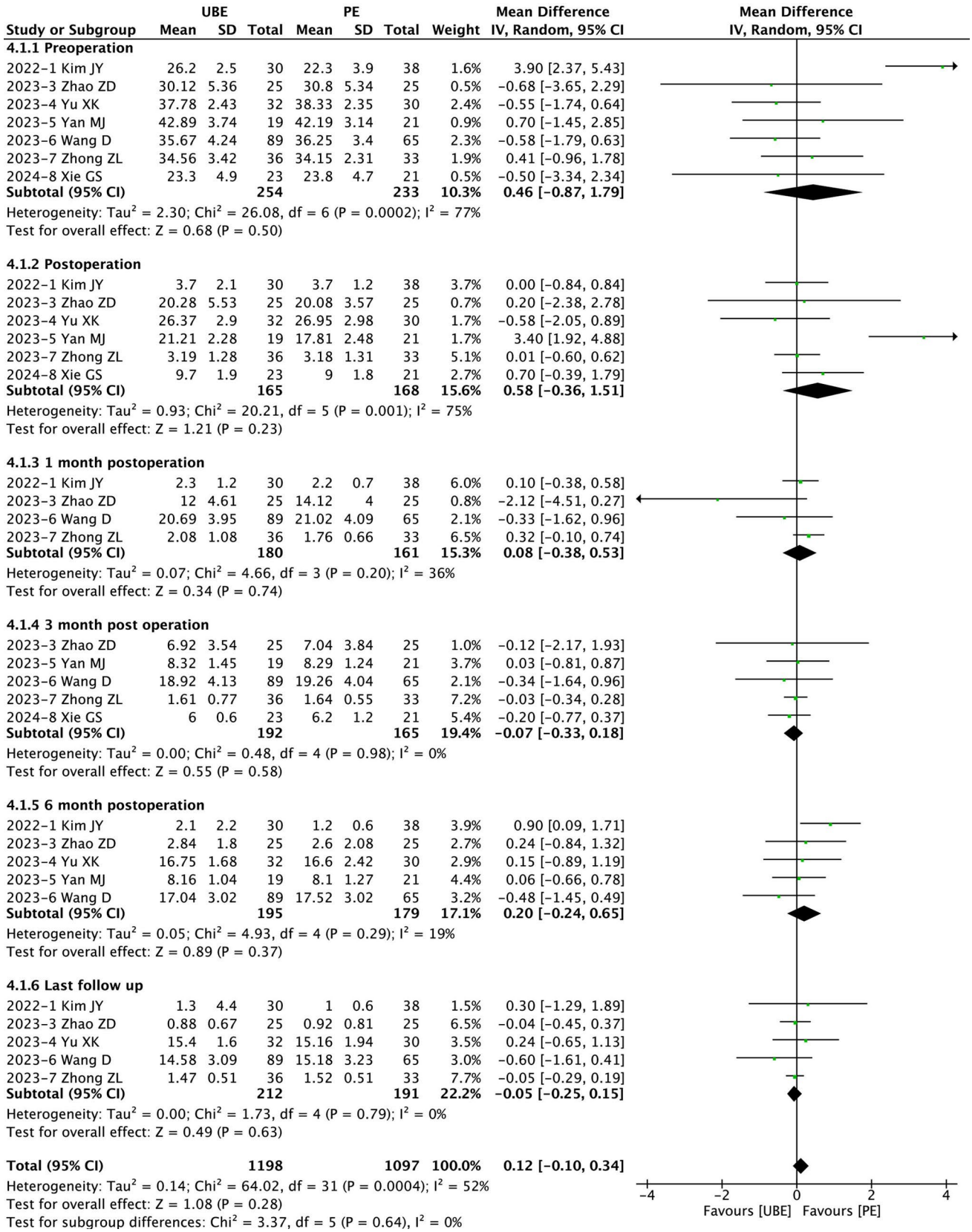

FIGURE 6. Forest plot comparing the NDI right after the operation and different time points after the operation between UBE and PE.
NDI: Neck Disability Index; UBE: Unilateral biportal endoscopic; PE: Percutaneous endoscopic; SD: Standard deviation; CI: Confidence interval.

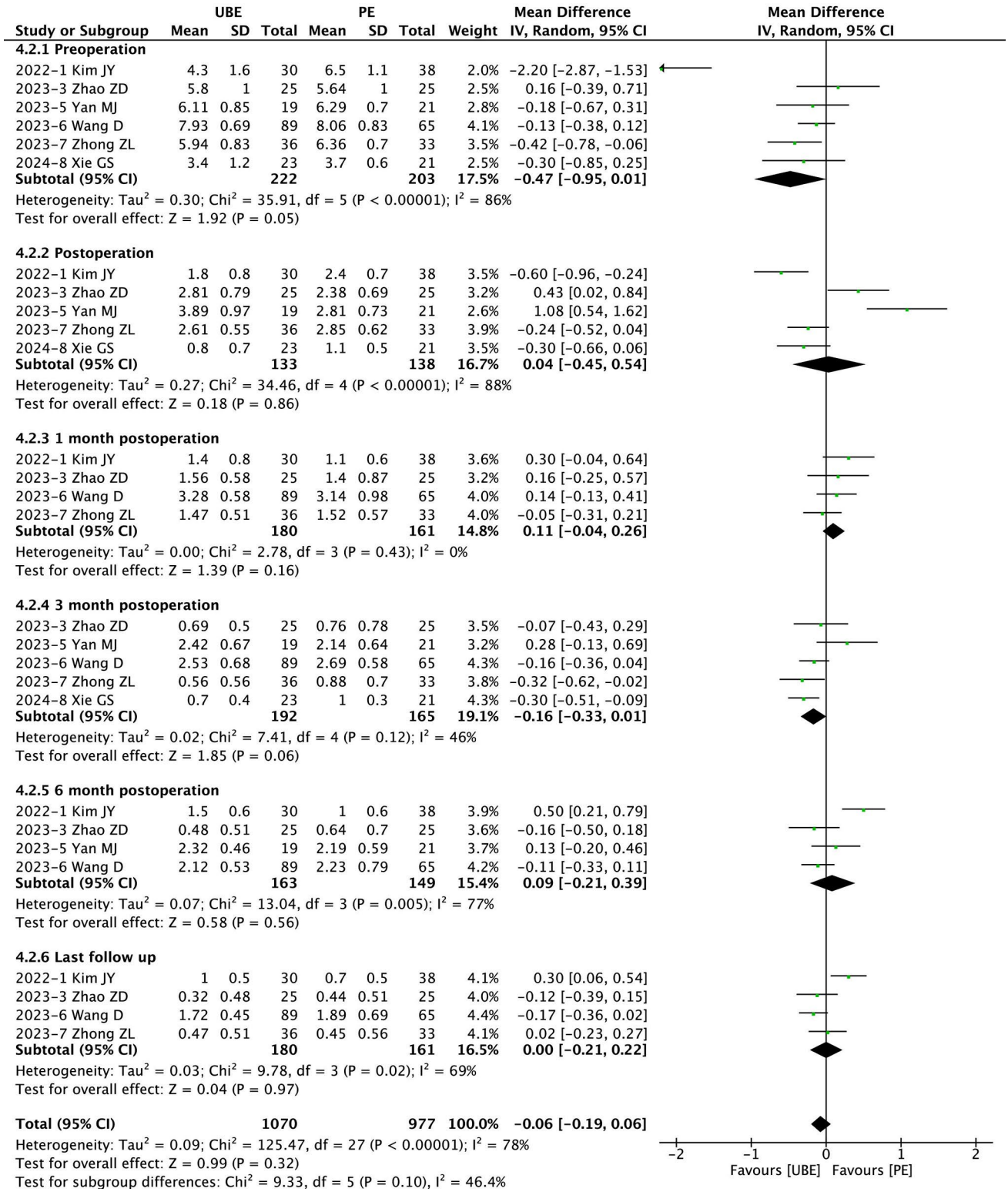

FIGURE 7. Forest plot comparing VAS for neck pain right after the operation and at time points after the operation between UBE and PE.

VAS: Visual Analog Scale; PE: Percutaneous endoscopic; SD: Standard deviation; CI: Confidence interval.

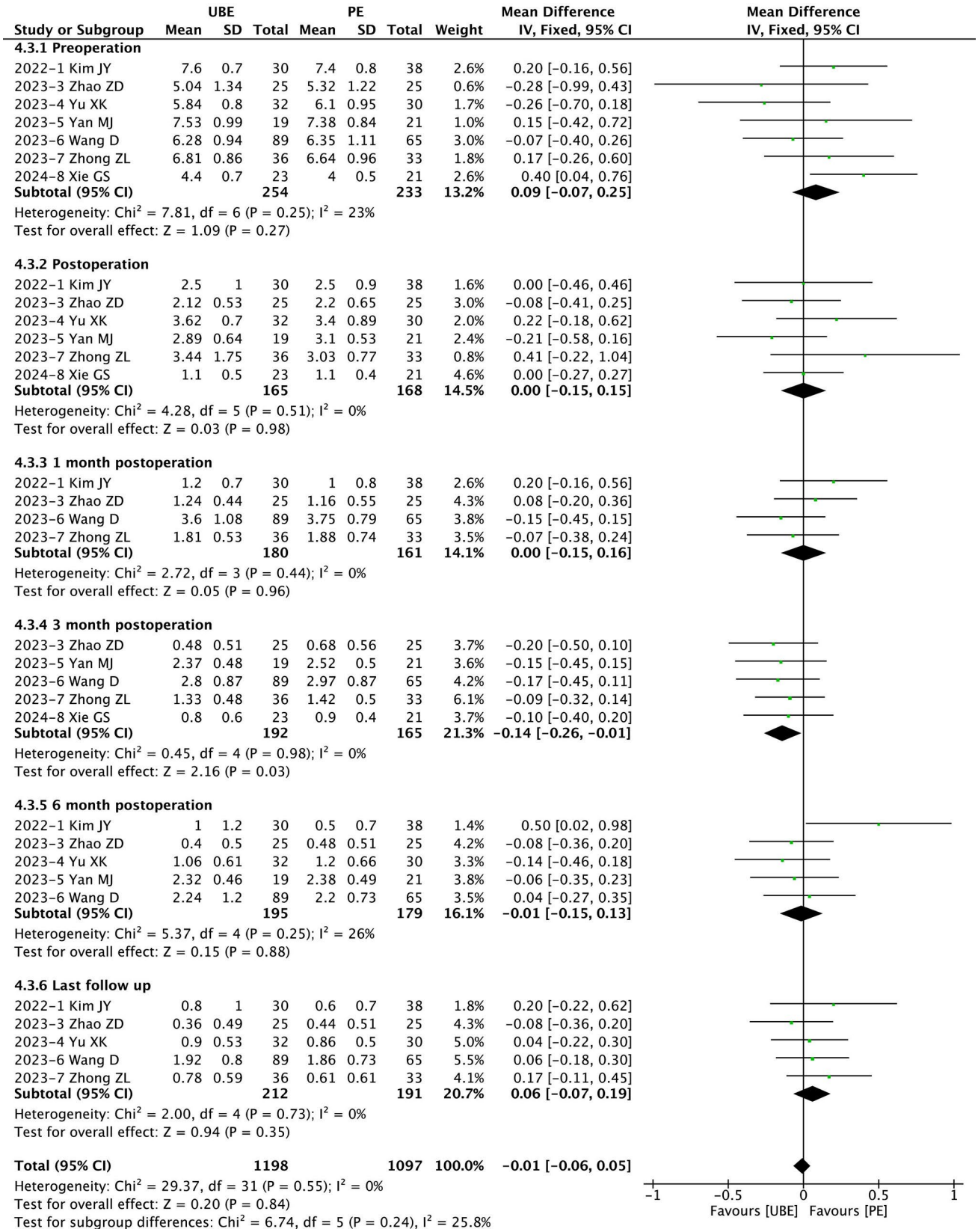

FIGURE 8. Forest plot comparing VAS for arm pain right after the operation and at time points after the operation between UBE and PE.
VAS: Visual Analog Scale; PE: Percutaneous endoscopic; SD: Standard deviation; CI: Confidence interval.

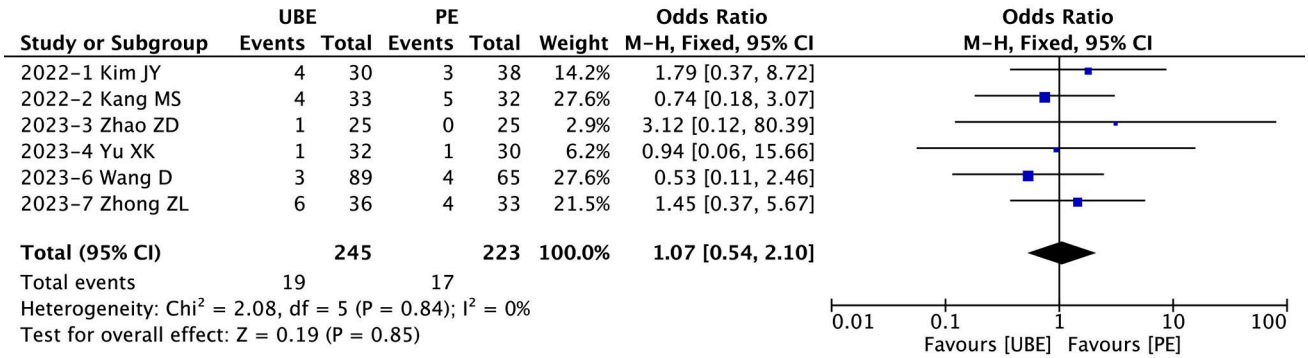

FIGURE 9. Forest plot comparing the complications between UBE and PE.
UBE: Unilateral biportal endoscopic; PE: Percutaneous endoscopic; CI: Confidence interval.

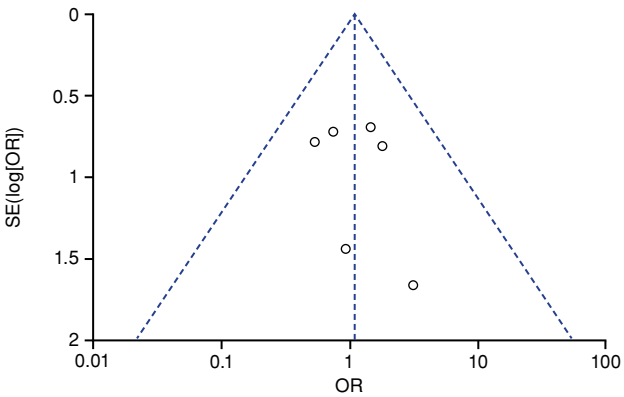

FIGURE 10. Funnel plot of publication bias in complications.
SE: Standard error; OR: Odds ratio.

heterogeneity: Chi²=2.08, degrees of freedom [df]=5, p>0.05, I^2=0%; Figure 9).

Publication bias and sensitivity analysis

To evaluate publication bias for all the parameters, funnel plots were utilized (Figure 10). The findings indicated that all funnels were relatively asymmetrical. Sensitivity analysis was conducted by excluding one study at a time randomly, and the results remained stable after removing any of the included studies.

DISCUSSION

Cervical spondylotic radiculopathy is typically managed through conservative treatments, such as external fixation with cervical collar, cervical traction, or acupuncture.[2,27,28] If standard conservative treatment proves ineffective after more than three months, surgical intervention becomes necessary. Anterior cervical discectomy and fusion is the most common surgical method for treating CSR.[29] Although ACDF has been utilized for CSR over an extended period, it can lead to various complications, including laryngeal edema, neurovascular injury, recurrent laryngeal nerve palsy, and dysphagia. Techniques involving UBE and PE, two minimally invasive approaches, have been reported for treating CSR, but the superiority between them remains controversial. Therefore, this meta-analysis compared the operative parameters, clinical outcomes, and complication rates between UBE and PE, intending to inform clinical decision-making.

In this meta-analysis, the operation time between UBE and PE was found to be comparable, with no significant difference observed. Out of seven articles comparing the two techniques' operation times, only two reported longer operation times for UBE, while the remaining five indicated shorter durations. The UBE procedure involves creating two portals, one for observation and the other for manipulation, allowing surgeons to use tools similar to those in open surgery, thus potentially enhancing efficiency. However, given that PE has been used in cervical surgeries longer than UBE, many surgeons may be more adept at performing PE. It is anticipated that as surgeons gain proficiency in UBE, its operation time will decrease relative to PE, a hypothesis that requires further investigation with additional literature.

Some research suggests that UBE may cause greater soft tissue and bone damage than PE.[30,31] Consistent with previous findings, this meta-analysis revealed that UBE caused more bleeding and required a longer incision length compared to PE, attributed to the dual incisions and channels used in UBE and the lower irrigation fluid pressure compared to PE.

Despite the increased trauma associated with UBE, this meta-analysis indicates that its clinical outcomes are nearly equivalent to those of PE, including NDI, VAS for neck pain, and VAS for arm pain, as well as complication rates.[32] At three months after the operation, UBE demonstrated superior results for arm pain VAS scores, although this singular follow-up time point might lack clinical significance.

Complication rates were also found to be comparable between UBE and PE in our meta-analysis. Dural tears were the most common complication in both groups, affecting 2.9% (n=7) of UBE patients and 2.7% (n=6) of PE patients. Most dural tear cases exhibited no significant symptoms, although some patients experienced headaches and neck stiffness, which were promptly alleviated through conservative treatments, such as mannitol and oxygen therapy. The second most frequent complication was nerve root injury or paralysis, occurring in 2.0% (n=5) of UBE patients and 1.8% (n=4) of PE patients, manifesting as C5 nerve root palsy, hand grasp weakness, or finger numbness. These conditions typically resolved within two weeks to six months through conservative treatment and rehabilitation exercises, with only one persistent dysesthesia case reported in the UBE group.[21]

This systematic review represents the first comprehensive meta-analysis comparing clinical outcomes and complications between UBE and PE surgery for CSR patients. However, certain limitations must be acknowledged. First, the evidence level of the included studies is relatively low, consisting of eight retrospective case-control studies rather than multicenter or randomized controlled trials. Second, several meta-analysis results exhibited high heterogeneity. Nevertheless, all literature with high Newcastle-Ottowa Scale scores consisted of high-quality case-control studies, and the number of included studies was adequate, with most reaching conclusions consistent with this study. We believe that the findings presented herein can support clinical decision-making and that further analysis of additional multicenter and randomized controlled trials is warranted.

In conclusion, there are no significant disparities in the majority of clinical outcomes between UBE and PE. Despite the potential for increased trauma with UBE, the clinical outcomes and complication rates were found to be comparable between the two techniques. To further substantiate our findings, high-quality multicenter and randomized controlled trials are essential in the future.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Contributed to the conceptualization and design of the study, systematic literature search and data analysis, contributing significantly to the interpretation of the data: J.L., T.Z.; Was responsible for drafting the manuscript and performing the statistical review: J.L.; Provided a critical review of the manuscript and took primary responsibility for the final content: T.Z.; All authors reviewed and approved the final version of the manuscript.

Conflict of Interest: The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

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