Efficacy and safety of unilateral biportal endoscopy compared with microscopic decompression in the treatment of lumbar spinal stenosis: A systematic review and updated meta-analysis

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Abstract. The incidence of lumbar spinal stenosis is increasing annually, and with an ever-aging population and longer life expectancies, this trend will further continue. It is hoped that a more effective treatment can be found so that the patients can be relieved of their pain. The aim of this systematic review and meta-analysis was to evaluate the effectiveness and safety of unilateral biportal endoscopic surgery (UBE) and microscopic decompression surgery (MD) for the treatment of lumbar spinal stenosis. A literature search of related studies published until April 2022 was performed using PubMed, EMBASE, Cochrane Library, Web of Science, ClinicalTrials.gov, Google Scholar, China National Knowledge Infrastructure (CNKI), and other databases. After filtering of references, 12 eligible studies were identified that compared UBE with MD as a treatment for lumbar spinal stenosis. Data were extracted and analysed using R. A total of 12 articles (four randomized controlled and eight cohort studies) were included, with a total of 1,067 patients: 250 men and 249 women in the UBE group and 290 men and 278 women in the MD group. The meta-analysis showed that the mean intraoperative blood loss in the UBE group [standardized mean difference (SMD)=-2.10, 95% confidence interval (CI) (-3.97, -0.23), P=0.03] was lower than that in the MD group. The postoperative Visual analogue scale (VAS) score for back pain [SMD=-0.52, 95% CI (-0.76, -0.27), P<0.01], leg pain [SMD=-0.30, 95% CI (-0.51, -0.08), P<0.01], postoperative Oswestry disability index [(ODI); SMD=-0.25, 95% CI (-0.48, -0.03), P=0.03], and postoperative C-reactive protein [(CRP); odds ratio (OR)=-0.92, 95% CI (-1.80, 0.03), P=0.04] were lower than those in the MD group. Complications (OR=0.60, 95% CI (0.37, 0.98), P=0.04) and hospital stay (SMD=-1.84, 95% CI (-2.85, 0.83), P <0.01] were also lesser in the UBE group than in the MD group. UBE was preferable to that in the MD group according to the modified MacNab score [OR=2.28, 95% CI (1.28, 4.06), P<0.01]. No significant differences were observed in the operation times between the groups. UBE surgery was found to be a better option for the treatment of lumbar spinal stenosis than MD surgery.

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Abbreviations: UBE, unilateral biportal endoscopic; MD, microscopic decompression; VAS, visual analogue scale; ODI, Oswestry disability index; CRP, C-reactive protein; RCT, randomized controlled trial; CS, cohort study; NOS, Newcastle-Ottawa scale; SMD, standardized mean difference

Key words: unilateral biportal endoscopic, microscopic decompression, lumbar spinal stenosis, surgery

Introduction

The incidence of lumbar degenerative diseases is increasing annually, and with an ever-aging population and longer life expectancies, this trend will further continue (1). Lumbar spinal stenosis is the most common cause of lumbar spinal disease in patients aged >65 years who require surgical treatment (1). The symptoms of lumbar spinal stenosis include compression of the nerve roots and dural sac as well as pathological stenosis of the spinal canal (2). Surgical treatment is usually recommended for patients in whom conservative treatment fails as it results in better clinical outcomes (3). In contrast, traditional open surgery requires extensive dissection of the paravertebral muscles, resulting in muscle ischemia, denervation, and atrophy, leaving patients with residual back pain (4,5). Various minimally invasive techniques have been developed in recent years to overcome these shortcomings. Through small incisions, arthroscopes, endoscopes, and microscopes are used to provide a clear working field and reduce tissue damage (4,6,7). The compression of the nerve caused by lumbar spinal canal

stenosis typically results in lower back pain, leg pain, and other symptoms, thus affecting the quality of life of patients. Microscopic decompression (MD) surgery has been widely used in the clinic for patients with lumbar spinal stenosis and has good outcomes. However, the operation space is narrow, and the cost of training surgeons is high. In addition, when performing lumbar spinal canal decompression using MD, the instrument must first pass through the working cannula, so the choice of available instruments is greatly limited (8).

Recently, clinicians in China and other countries have paid increasing attention to unilateral biportal endoscopic (UBE) surgery given the improvements introduced in this surgical method by Korean researchers (9). In this method, one channel is implanted into the endoscope for visual field coverage and the other serves as a working channel. In several cases, the two channels are located 1.0 cm from the midline and 1.0-1.5 cm from the upper and lower midlines of the lesion gap. This biportal approach prevents damage to the erector spinae caused by conventional debridement procedures that crush the important muscles. Otherwise, variable access angles provide a wider, more detailed view of the surgeon's contralateral side. It allows a wider view of the intervertebral foramen, and possible injuries to the exiting nerve and the radicular artery can be avoided by using a paraspinal extraforaminal approach (10). As a relatively novel surgical technique, it has gained popularity in China and other countries for the treatment of lumbar spinal stenosis (11).

Although the efficacy of these two surgical procedures has been compared, there are no sufficient literature or medical records available to reach accurate conclusions. In this paper, a comprehensive literature search on UBE and MD surgeries for the treatment of lumbar spinal stenosis was performed. The aim was to objectively evaluate the two methods' effectiveness and safety.

Materials and methods

Literature search. The present study was conducted following the PRISMA guidelines (12). The databases searched included PubMed, EMBASE, Cochrane Library, Web of Science, ClinicalTrials.gov, Google Scholar, China National Knowledge Infrastructure (CNKI), Chinese Biomedical databases, Cochrane Library and ProQuest Dissertations and Theses to analyse the efficacy and safety of UBE vs. MD for treating lumbar spinal stenosis. The literature retrieval strategy was as follows: ['UBE'(All Fields) OR 'BESS' (All Fields) OR ('biportal' (All Fields) AND ('endoscoped'(All Fields) OR 'endoscopes' (MeSH Terms) OR 'endoscopes' (All Fields) OR 'endoscope' (All Fields) OR 'endoscopical' (All Fields) OR 'endoscopically' (All Fields) OR 'endoscopy' (MeSH Terms) OR 'endoscopy' (All Fields) OR 'endoscopic' (All Fields))] AND ['MD' (All Fields) OR "MD" (Journal) OR 'monde dent' (Journal) OR 'md chic' (Journal) OR (("microscop" (All Fields) OR 'microscopal' (All Fields) OR 'microscope' (All Fields) OR 'microscopes' (All Fields) OR 'microscopic' (All Fields) OR 'microscopical' (All Fields) OR 'microscopically' (All Fields) OR 'microscopics' (All Fields)] AND ['decompress' (All Fields) OR 'decompressed' (All Fields) OR 'decompresses' (All Fields) OR 'decompressing' (All Fields) OR 'decompression' (MeSH Terms) OR 'decompression' (All Fields) OR 'decompressions' (All Fields) OR 'decompressive'(All Fields))]. The period for retrieval was the establishment of the database to April 2022, and the retrieval languages were limited to English and Chinese.

Eligibility criteria. The inclusion criteria for studies were: i) Patients with clear clinical symptoms and diagnosis of lumbar spinal stenosis by physical and auxiliary examinations; ii) the research design was a randomized controlled trial (RCT) or cohort study (CS); iii) no significant difference in baseline data between the two groups (UBE and MD); iv) at least 6 months of follow-up time; and v) availability of full-text. Studies were excluded based on the following criteria: i) Literature in a language other than Chinese and English; ii) when there were multiple reports from a single centre, the study with the largest sample size without duplication was selected after reading the full text; iii) multiple similar studies in the same unit; duplicate cases were excluded after reading the full text; and iv) studies with a sample size <20.

Data extraction. Following the selection criteria, two authors read the full text of the literature. They independently searched the aforementioned databases and the information was extracted from the literature. Finally, they thoroughly searched and extracted all relevant information from all the studies by repeatedly checking them. The two authors discussed the extracted information and any disagreements were resolved by a third researcher.

Based on the studies reviewed, the following information was extracted: i) Last name of the first author; ii) year of publication; iii) country in which the study was conducted; iv) study design (CS or RCT); and v) patient characteristics (treatment level, follow-up time, age, and sex).

Quality assessment. The Newcastle-Ottawa Quality Assessment Scale (NOS) was used to evaluate the quality of the articles included in the CS. The maximum score was 9, and studies with a NOS score ≥7 were considered high-quality studies (13). For RCTs, the risk of bias was assessed using the Cochrane Collaboration Risk of Bias Assessment Tool (14).

Credibility analysis. Data analysis was implemented using the R version 4.1.3 R Core Team (http://www.R-project.org/). Binomial variables were analysed by calculating the odds ratios (OR) and 95% confidence intervals (CI). For continuous variables, the standardized mean difference (SMD) and 95% CI for analysis were used. Heterogeneity was assessed using I^2 statistics, and a random effects model was chosen when heterogeneity was significant (I^2>50%); otherwise, a fixed-effects model was selected. Publication bias was assessed for outcomes in >10 included studies using funnel plots.

Results

Description of included studies. The initial search yielded 268 data points. After removing duplicates, 228 records were screened, after which 156 were excluded due to irrelevance. Subsequently, 72 full-text articles or abstracts were assessed for eligibility, and 60 articles were excluded. The

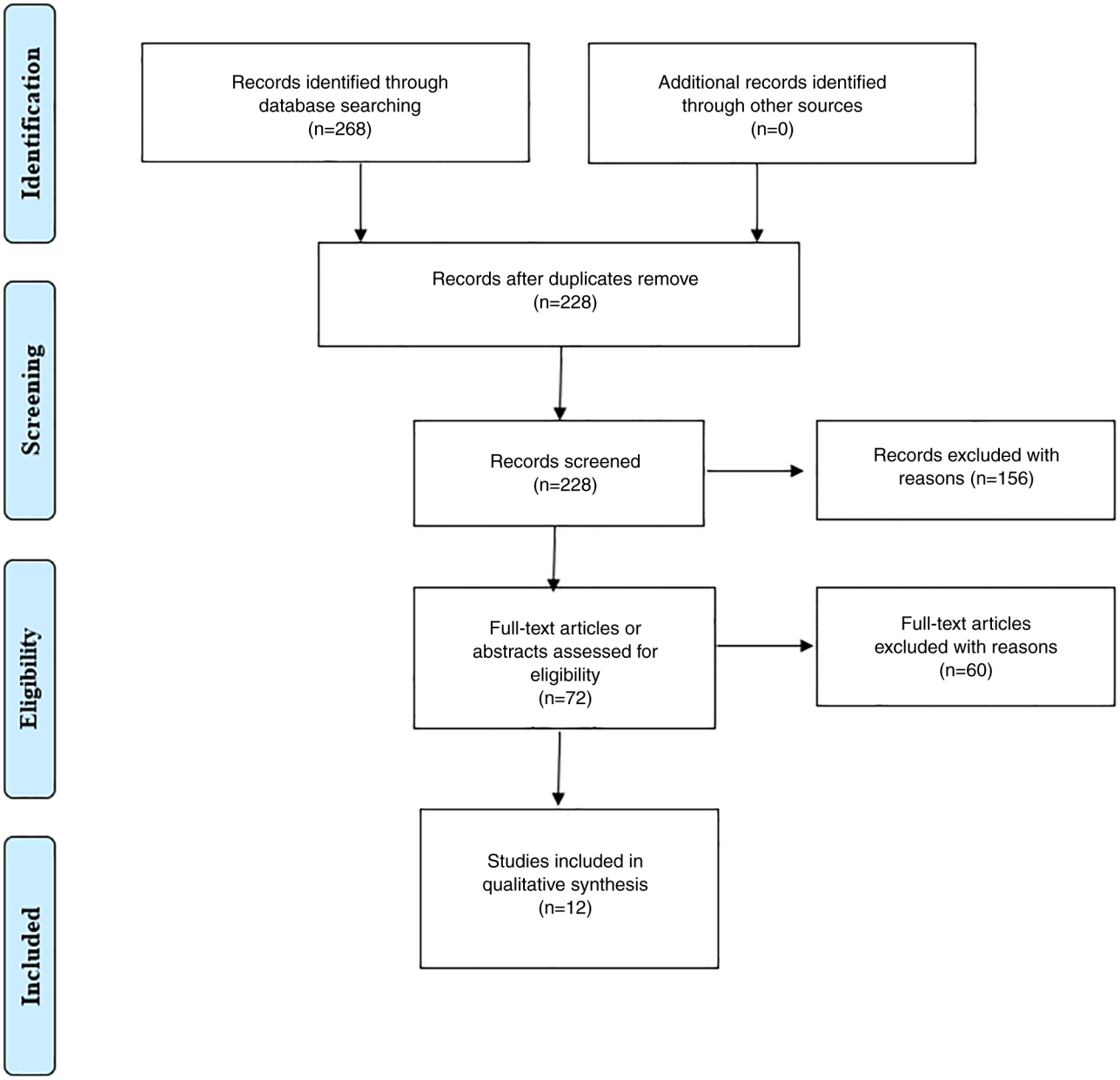


Figure 1. Flow diagram of the literature search.

remaining 12 studies were included in the data synthesis. A total of three Chinese articles (15-17) and nine foreign articles (18-26), including four RCTs and eight CSs, with a total of 1,067 patients, including 250 men and 249 women in the UBE group and 290 men and 278 women in the MD group. The screening process and results are presented in Fig. 1, and the basic characteristics of the study participants are summarized in Table I.

Quality evaluation of the included literature. This was a high-quality study, in that all included studies were RCTs or CSs, and all included studies met the inclusion and exclusion criteria (Fig. 2 and Table I).

Curative effect after operation. The curative effects of surgery from four aspects (VAS score for back pain, VAS score for leg pain, ODI, and the modified MacNab score) were evaluated.

A total of nine studies (15-17,19,21-24,26) presented postoperative VAS scores for back pain. The total meta-analysis showed that the postoperative VAS scores of the UBE group were lower than those of the MD group [SMD=-0.52, 95% CI (-0.76, -0.27), P<0.01]. Subgroup analysis was performed by follow-up time. The postoperative VAS score for back pain in the UBE group was lower than that in the MD group as follows: 1-3 days [SMD=-1.33, 95% CI (-1.84, -0.81], P<0.01], 1-3 months [SMD=-0.56, 95% CI (-1.03, 0.09), P=0.02], and 6 months [SMD=-0.26, 95% CI (-0.47, -0.05), P=0.01] after operation. No significant differences were observed between the UBE and MD groups after 12 months [SMD=-0.10, 95% CI (-0.27, 0.07), P=0.26] (Fig. 3A). In terms of overall data, the postoperative back pain of UBE was lighter than that of MD within 6 months of operation, but both techniques had similar VAS scores for back pain after 12 months. A total of nine studies (15-17,19,21-24,26) presented postoperative

Table I. Information on the included studies.

Study	Country	Study design	Group	Treated level					Follow-up	Age, year, mean ± SD	Sex		NOS score	(Refs.)
				L1/2	L2/3	L3/4	L4/5	L5/S1	Time, month		Male	Female		
Guo *et al*, 2022	China	Retrospective-CS	UBE			9	17	16	12	37.5±12.25	22	20	8	(15)
			MD			7	20	18	12	41.5±1.73	23	22		
Wang *et al*, 2022	China	Retrospective -CS	UBE				27	23	NA	44.7±14.6	26	24	8	(16)
			MD				28	22	NA	45.2±11.0	27	23		
Aygun *et al*, 2021	Saudi Arabia	RCT	UBE			NA			24	64.64±10.09	44	33	Fig.2	(18)
			MD			NA			24	65.05±9.24	50	27		
Ito *et al*, 2021	Japan	Retrospective -CS	UBE			13	24	5	6.7±0.6	66.3±12.3	28	14	7	(19)
			MD			38	86	15	6.9±0.8	65.0±11.1	71	68		
Yu *et al*, 2021	China	Retrospective -CS	UBE			5	10	7	12	59.1±11.7	12	10	8	(17)
			MD			6	11	8	12	58.3±8.7	11	14		
Kim *et al*, 2020	Korea	Retrospective -CS	UBE		2	8	18	2	12	64.23±5.26	13	17	8	(20)
			MD		4	8	16	2	12	66.20±6.01	12	18		
Min *et al*, 2020	Korea	RCT	UBE		1	7	43	2	27.2±5.4	65.74±10.52	27	27	Fig.2	(21)
			MD		1	7	24	3	31.5±7.3	66.74±7.96	19	16		
Park *et al*, 2020	Korea	RCT	UBE	0	2	5	25	0	12	66.2 (41-80)	13	19	Fig.2	(22)
			MD	3	3	7	17	2	12	67.1 (45-79)	18	14		
Choi, *et al*, 2019	Korea	Retrospective -CS	UBE			NA			6	65.4±11.8	14	21	7	(23)
			MD			NA			6	65.2±12.0	17	13		
Heo *et al*, 2019	Korea	Retrospective -CS	UBE				37		12	66.7±9.4	15	22	8	(24)
			MD				33		12	63.4±11.1	12	21		
Kang *et al*, 2019	Korea	RCT	UBE			4	16	12	6	65.1±8.6	18	14	Fig.2	(25)
			MD			5	15	10	6	67.2±9.5	14	16		
Heo *et al*, 2018	Korea	Prospective-CS	UBE		1	8	33	4	14.5±2.3	65.4±11.8	18	28	7	(26)
			MD		2	7	30	3	14.5±2.3	65.2±12.0	16	26		

UBE, unilateral biportal endoscopic; MD, microscopic decompression; CS, cohort study; RCT, randomized controlled trial; NA, not available.

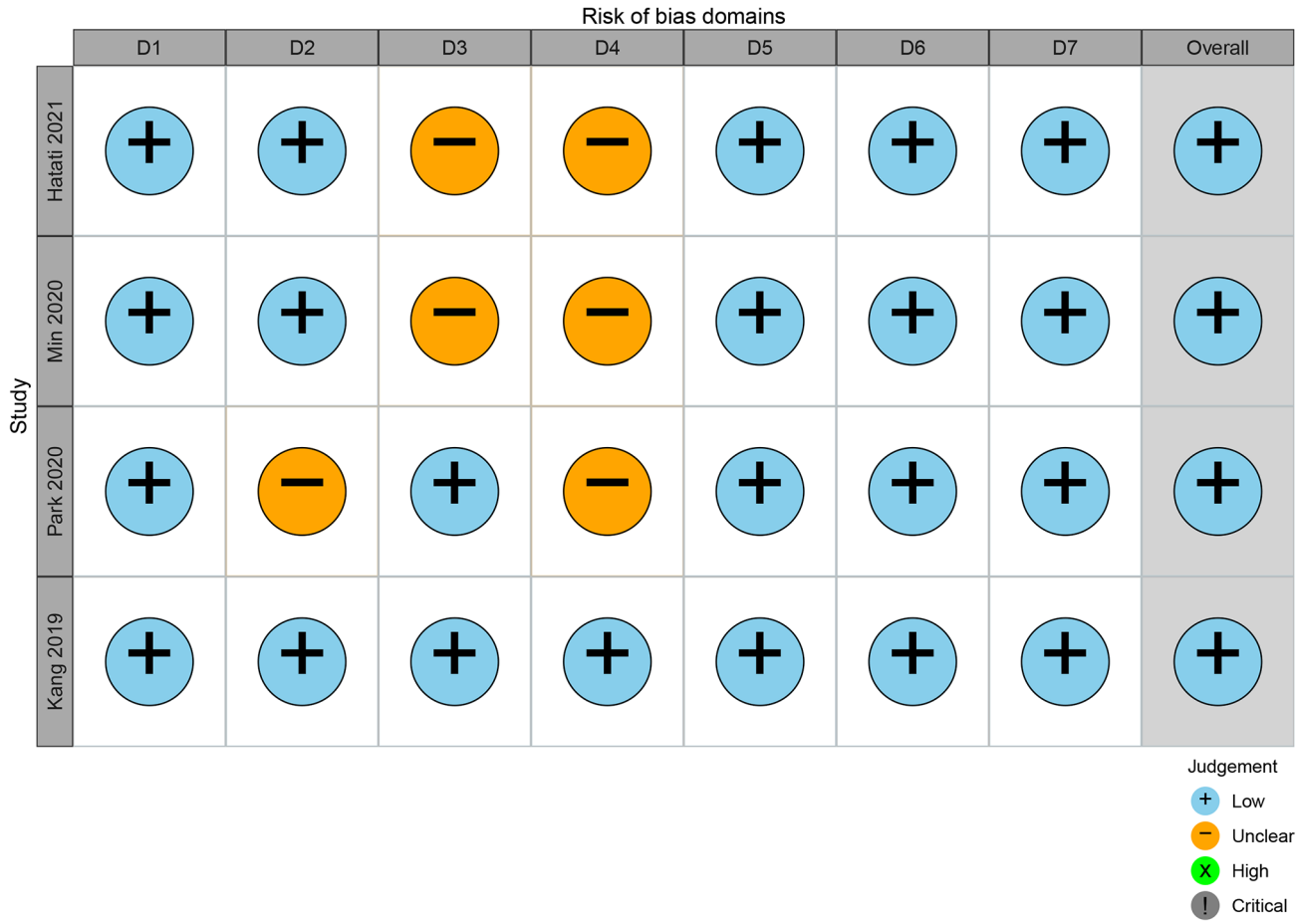


Figure 2. Risk of bias assessment of randomized controlled trials. D1, random sequence generation (selection bias); D2, allocation concealment (selection bias); D3, blinding of participants and personnel (performance bias); D4, blinding of outcome assessment (detection bias); D5, incomplete outcome data (attrition bias); D6, selective reporting (reporting bias); D7, other bias.

VAS scores for leg pain. The total meta-analysis showed that the postoperative VAS score for leg pain was lower in the UBE group than that in the MD group [SMD=-0.30, 95% CI (-0.51, -0.08), P<0.01]. Subgroup analysis performed by the follow-up time showed that the postoperative VAS score for leg pain in the UBE group was lower than that in the MD group; 1-3 days [SMD=-0.49, 95% CI (-0.88, -0.11), P=0.01] and 6 months [SMD=-0.41, 95% CI (-0.62, -0.20), P<0.01]. However, no significant difference was observed in the VAS score for leg pain between the two groups at 1-3 months [SMD=-0.08, 95% CI (-0.36, 0.19), P=0.54] and 12 months [SMD=-0.24, 95% CI (-0.82, 0.34), P=0.42] after the operation (Fig. 3B). In terms of overall data, the postoperative leg pain of UBE was lighter than that of MD in the first 3 days and half a year. The patients treated with UBE achieved satisfactory curative effects in the early stage.

A total of nine studies (15-17,19-22,24,26) included the postoperative ODI data. The total meta-analysis showed that the postoperative ODI was lower in the UBE group than that in the MD group [SMD=-0.25, 95% CI (-0.48, -0.03), P=0.03]. Follow-up time-based subgroup analysis did not reveal significant differences in ODI between the UBE and MD groups during the ≤1 week, 1-3 months, 6 months, and 12 months periods (Fig. 3C). In terms of overall data, the postoperative ODI of UBE was lower than that of MD, but based on the subgroup analysis, the two techniques had a similar postoperative ODI. A total of five studies (15-18,20) presented the modified MacNab score data. The total meta-analysis showed that the modified MacNab score was better in the UBE group than that in the MD group [SMD=2.28, 95% CI (1.28, 4.06), P<0.01]. Subgroup analysis showed no significant difference in the 12 months postoperative modified MacNab score between the UBE and MD groups [SMD=1.38, 95% CI (0.65, 2.93), P=0.40] (Fig. 3D). In terms of overall data, the modified MacNab score of the UBE group was better than that of the MD group.

Complications. All 12 studies (15-26) presented the complication data. The total meta-analysis revealed that the UBE group had fewer complications than those in the MD group [SMD=-0.60, 95% CI (0.37, 0.68), P=0.04]. Country-based subgroup analysis showed no significant differences between the UBE and MD groups in China [SMD=-0.83, 95% CI (0.35, 1.94), P=0.66], Korea [SMD=0.64, 95% CI (0.32, 1.29), P=0.21], and the other two countries [SMD=0.29,95% CI (0.08, 1.10), P=0.07] (Fig. 4). In terms of overall data, the complications of UBE were lower than that of the MD group. This reduces the patient's pain and greatly reduced the financial burden of dealing with complications.

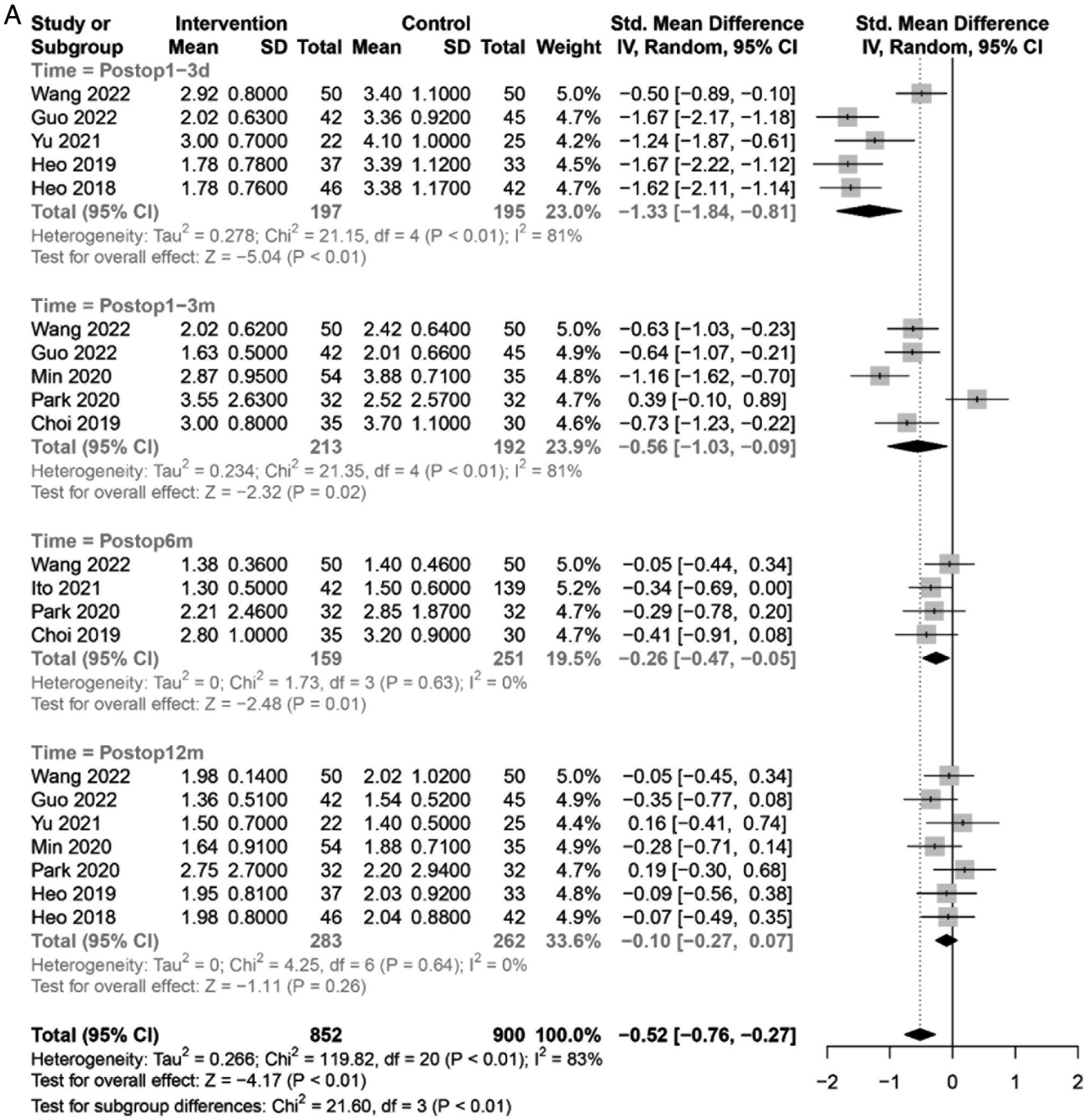
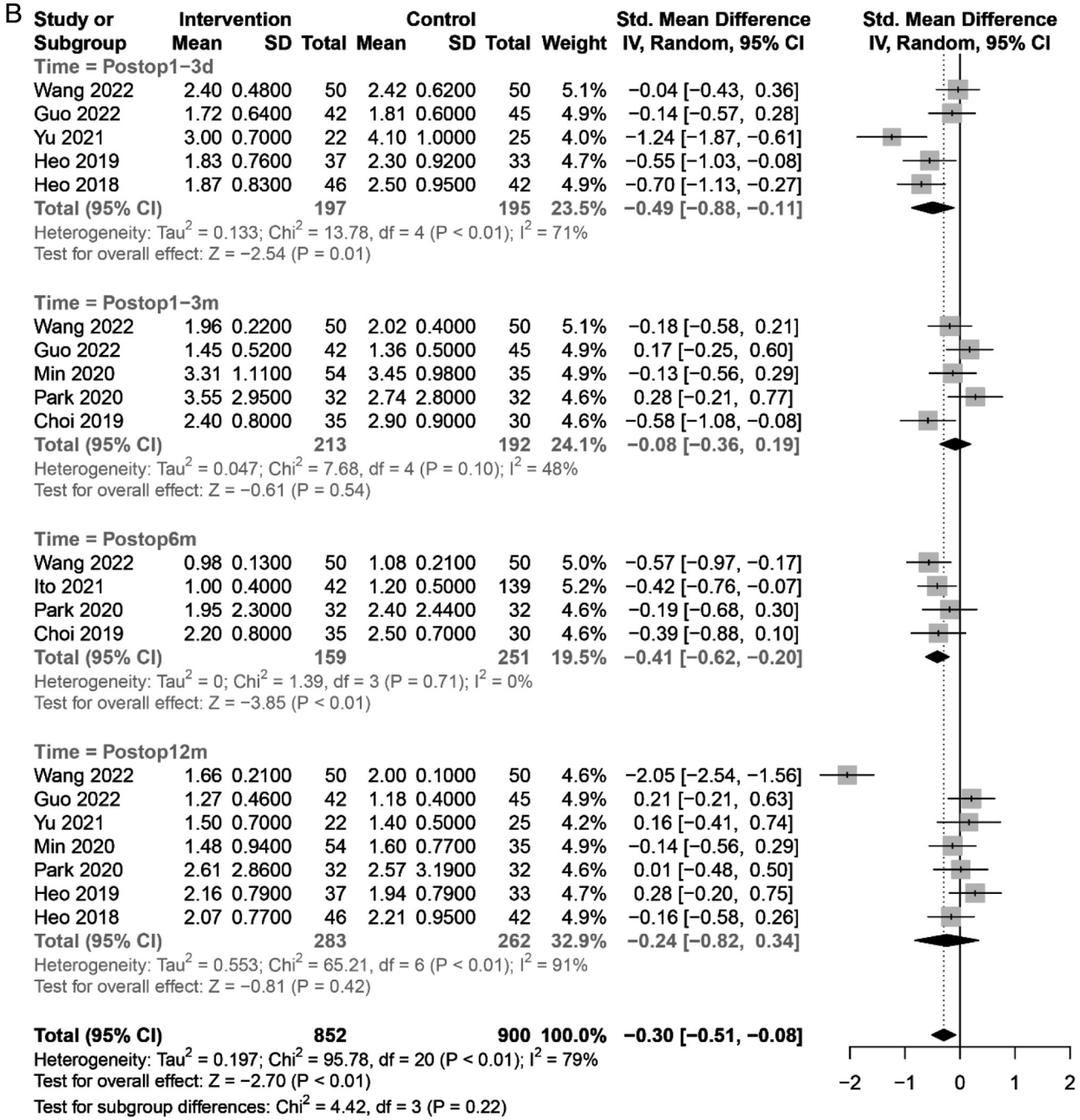


Figure 3. Continued.

Intraoperative condition. The intraoperative situation of the two operations based on the amount of intraoperative blood loss and the operation time was evaluated. A total of four studies (15-17,20) reported data on mean blood loss. The meta-analysis found that patients with UBE experienced less blood loss than patients with MD [SMD=-2.10, 95% CI (-3.97, -0.23), P=0.03]. When subgroup analysis was conducted on the mean blood loss by country, no significant difference was observed between the UBE and MD groups in China [SMD=-2.67, 95% CI (-5.59, 0.26), P=0.07, (Fig. 5A)]. In terms of overall data, UBE resulted in less blood loss than MD, and that was conducive to the rapid recovery of patients. A total of nine studies (15,16,19,20-22,24-26) presented the mean operative time data. The meta-analysis showed no significant difference in operation time between the UBE and MD groups [SMD=0.07, 95% CI (-0.66, 0.81), P=0.85]. Country-based subgroup analysis showed no significant difference between the UBE and MD groups in China [SMD=0.93, 95% CI (-2.37, 4.23), P=0.58] and Korea [SMD=-0.28, 95% CI (-1.02, 0.45), P=0.45, (Fig. 5B)]. In terms of overall data, the operation time of the UBE and MD were basically the same.

Hospital stays and CRP. A total of five studies (16,17,21,22,25) presented hospital stay data. Hospital stays were shorter in the UBE group than those in the MD group [SMD=-1.84, 95% CI (-2.85, -0.83), P<0.01]. Country-based subgroup analysis revealed shorter hospital stays in the UBE group than that in the MD group in China [SMD=-1.84, 95% CI (-2.97, -0.71),



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P<0.01) and Korea [SMD=-1.85, 95% CI (-3.62, -0.07), P=0.04, (Fig. 6)]. In terms of overall data, the patients staying in the hospital in the UBE group was shorter than that of MD, so UBE could relieve the patient's pain that would otherwise require long-term hospitalization. A total of three studies (16,20,23) presented CRP data. The meta-analysis showed that the postoperative CRP levels were lower in the UBE group than those in the MD group [SMD=-0.92, 95% CI (-1.80, -0.03), P=0.04]. Follow-up time-based subgroup analysis showed that the postoperative CRP levels in the UBE group were lower than those in the MD group in the 1-2-week time point [SMD=-0.55, 95% CI (-1.06, -0.05), P=0.03], with no significant difference at 1-2 days after the operation [SMD=-1.31, 95% CI (-3.34, 0.73), P=0.21, (Fig. 7). In terms of overall data, the postoperative CRP levels in the UBE were lower than that in the MD group.

Heterogeneity and sensitivity analyses. High heterogeneity was observed in the mean blood loss (I^2=97%), postoperative VAS score for back pain (I^2=83%), postoperative VAS score for leg pain (I^2=79%), ODI (I^2=79%), postoperative CRP (I^2=94%), hospital stay (I^2=94%), and operation time (I^2=96%). When literature was excluded individually for these parameters followed by merging of the remaining literature, the heterogeneity remained high, indicating that the results of this meta-analysis were stable. Surgeons' surgical techniques or perioperative care in the hospital may have contributed to the heterogeneity of the results.

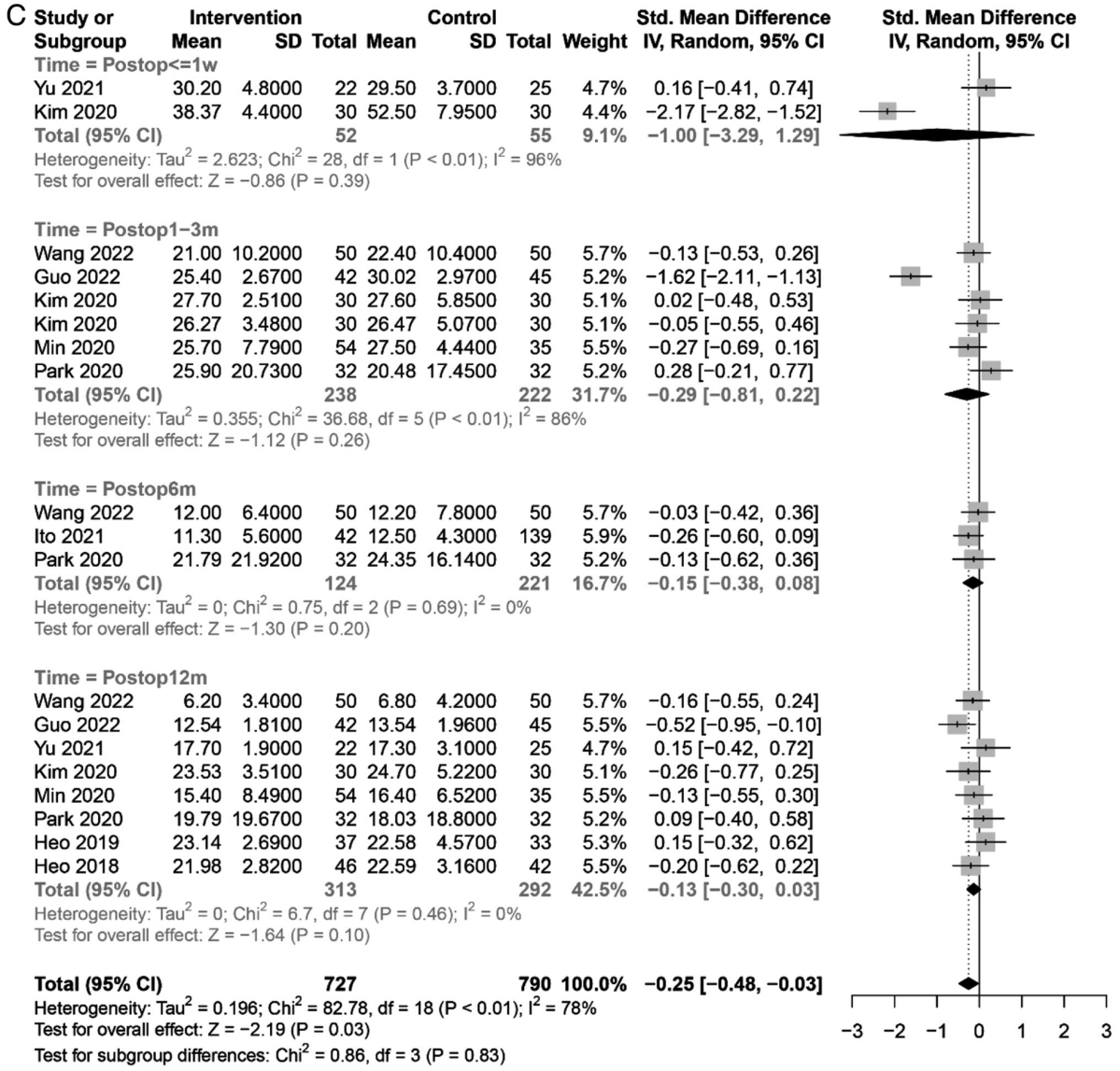

Figure 3. Forest plot of the curative effect after operation. (A) Analysis of the postoperative VAS score for back pain between UBE and MD in the treatment of lumbar spinal stenosis. (B) Analysis of the postoperative VAS score for leg pain between UBE and MD in the treatment of lumbar spinal stenosis. (C) Analysis of the postoperative ODI between UBE and MD in the treatment of lumbar spinal stenosis. (D) Analysis of the modified MacNab score between UBE and MD in the treatment of lumbar spinal stenosis. Intervention=UBE group, Control=MD group. UBE, unilateral biportal endoscopic; MD, microscopic decompression; VAS, visual analogue scale; CI, confidence interval; IV, inverse-variance weighting; MH, Mantel-Haenszel; d, days; m, months; w, weeks; postop, postoperative time; df, degrees of freedom.

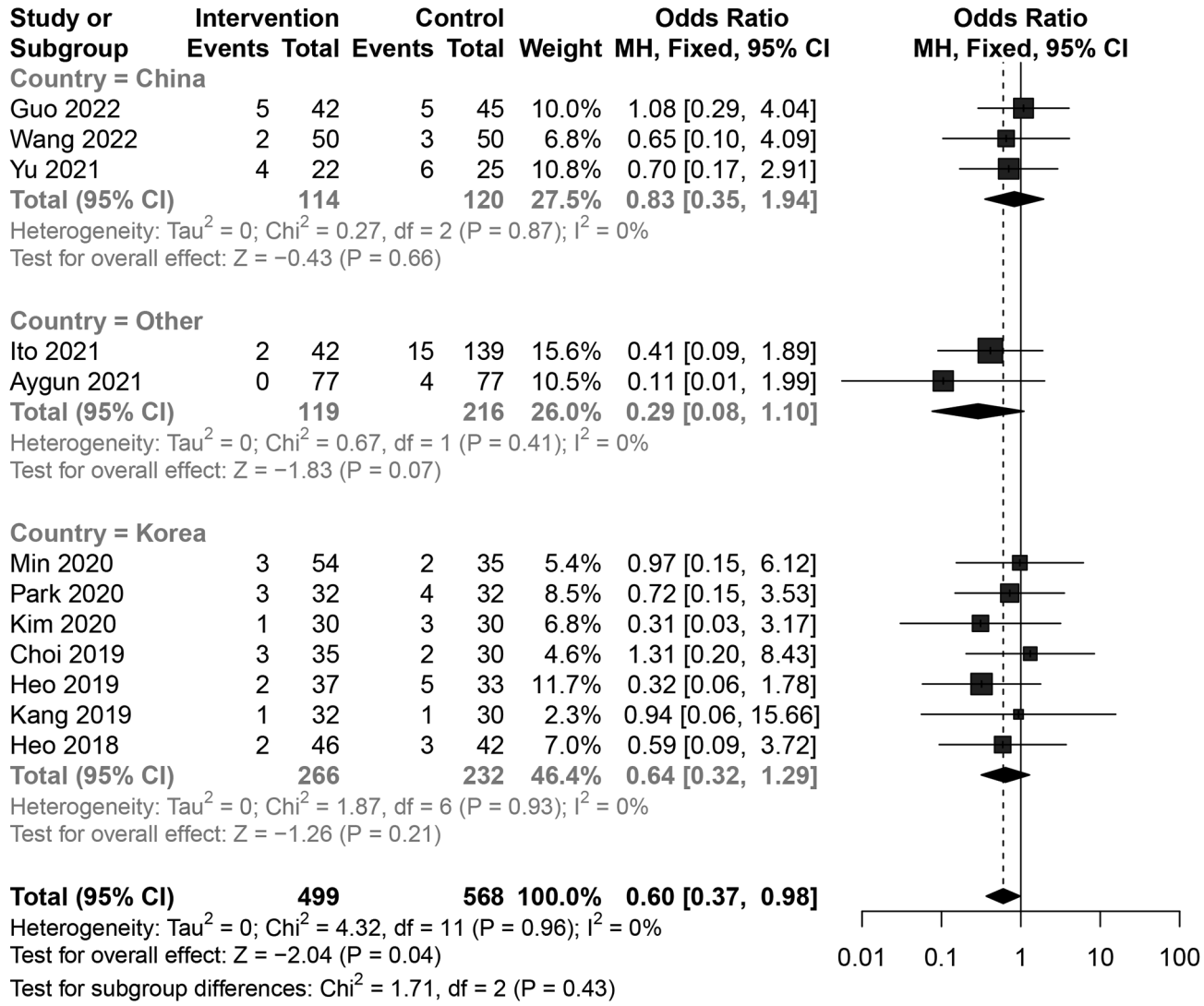

Figure 4. Analysis of the complications between UBE and MD in the treatment of lumbar spinal stenosis; Intervention=UBE group, Control=MD group. UBE, unilateral biportal endoscopic; MD, microscopic decompression; CI, confidence interval; MH, Mantel-Haenszel; df, degrees of freedom.

Publication bias. All comparisons were included, and publication bias was estimated using a funnel plot test (Fig. 8). Although funnel plots are symmetrical, publication bias may still have been present given the inclusion of more studies by Korean researchers.

Discussion

The development of UBE. Minimally invasive spine surgery has been widely used in the treatment of degenerative diseases of the lumbar spine. It can preserve the structural integrity of the spine to the greatest extent possible and allows for a faster recovery (27,28). Since its conception, MD surgery has been widely promoted and applied owing to its better vision and lesser surgical trauma than those associated with open surgery. However, the procedure is associated with several shortcomings that hamper its clinical application, such as limited scope regarding indications and incomplete decompression. More recently, less invasive UBE surgery has increasingly been used for the treatment of lumbar spinal stenosis, which has been shown to provide better clinical results (29). Using an endoscope to look into the channel and flush it continuously with normal saline, a clear field of view can be achieved. Conventional spinal surgical instruments are used for the operation through the working channel, similar to traditional posterior fenestrations (30,31). Regardless of the minimally invasive approach used to relieve lumbar spinal stenosis, the goal was to provide extensive decompression of the spinal canal while minimizing damage to the posterior ligament muscle structure (32).

Lower intraoperative blood loss, ODI, CRP changes, and shorter hospital stays were associated with UBE than with MD, indicating a less traumatic and rapid recovery process. This may be due to the flexibility of UBE. In addition, UBE offers a wider operating space, and the surgical procedure is similar to traditional open surgery, which allows for easier identification of the anatomical structures, thus preventing damage to adjacent tissues. UBE has a larger field of vision under a normal saline medium of 25-30 mmHg, and it is easier to find the bleeding point and stop the bleeding as soon as possible in this medium (33-35).

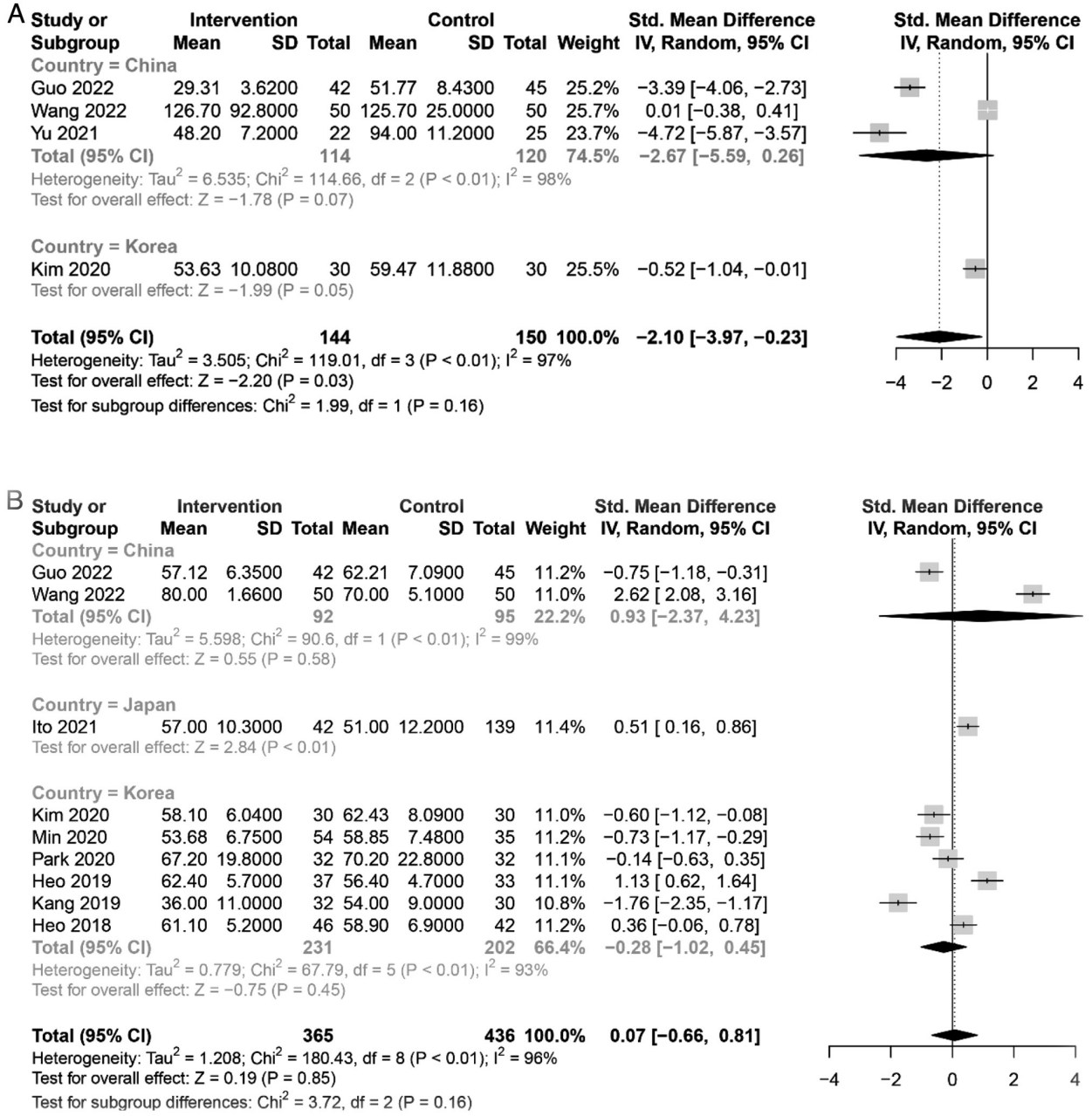

Figure 5. Forest plot of the intraoperative condition. (A) Analysis of the mean blood loss (ml) between UBE and MD in the treatment of lumbar spinal stenosis. (B) Analysis of the operation time between UBE and MD in the treatment of lumbar spinal stenosis. Intervention=UBE group, Control=MD group. UBE, unilateral biportal endoscopic; MD, microscopic decompression. CI, confidence interval; IV, inverse-variance weighting; df, degrees of freedom.

Within 1-3 days after surgery, the UBE group had a lower VAS score for leg pain. The UBE operation channel is smaller than the MD channel (1.0 cm vs. 1.8 cm). This allows for reduced damage to the tissues, a clearer operation field to avoid nerve contact during operation, and effective reduction of early postoperative pain. However, within 1-3 months after surgery, the VAS score for leg pain in the UBE group was similar to that in the MD group. However, as a result of soft tissue injury healing, the pain gradually eased and the oppressed nerve root was decompressed, showing that both UBE and MD treatments were very effective. Compared with MD however, UBE resulted in less postoperative back pain, irrespective of whether it manifested early (days) or later (months) after the operation because of the preservation of the back muscle and a smaller incision.

All the included articles mentioned complications such as nerve root injury, dural tear, epidural hematoma, and wound infection (15-26). According to the present meta-analysis, UBE had a lower overall incidence of complications than MD. MD may be associated with a higher rate of complications due to limitations in the surgical field of view and mechanical damage caused by constraints of the limited surgical space. UBE solves this problem by providing a clear surgical field of view (11,36). Interestingly, subgroup analyses in China, Korea, and the other two countries did not show any significant differences between the UBE and MD groups, indicating that the data included in the subgroup analysis were limited; that is,

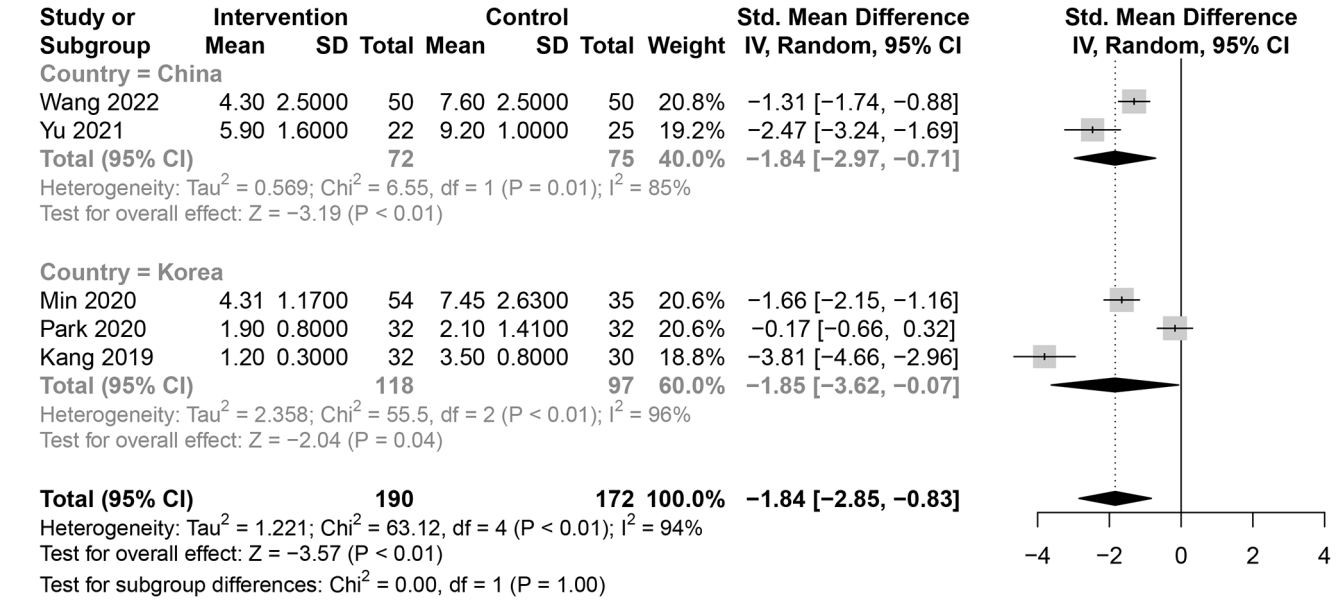

Figure 6. Analysis of the length of hospital stay between UBE and MD in the treatment of lumbar spinal stenosis. Intervention=UBE group, Control=MD group. UBE, unilateral biportal endoscopic; MD, microscopic decompression. CI, confidence interval; IV, inverse-variance weighting; df, degrees of freedom.

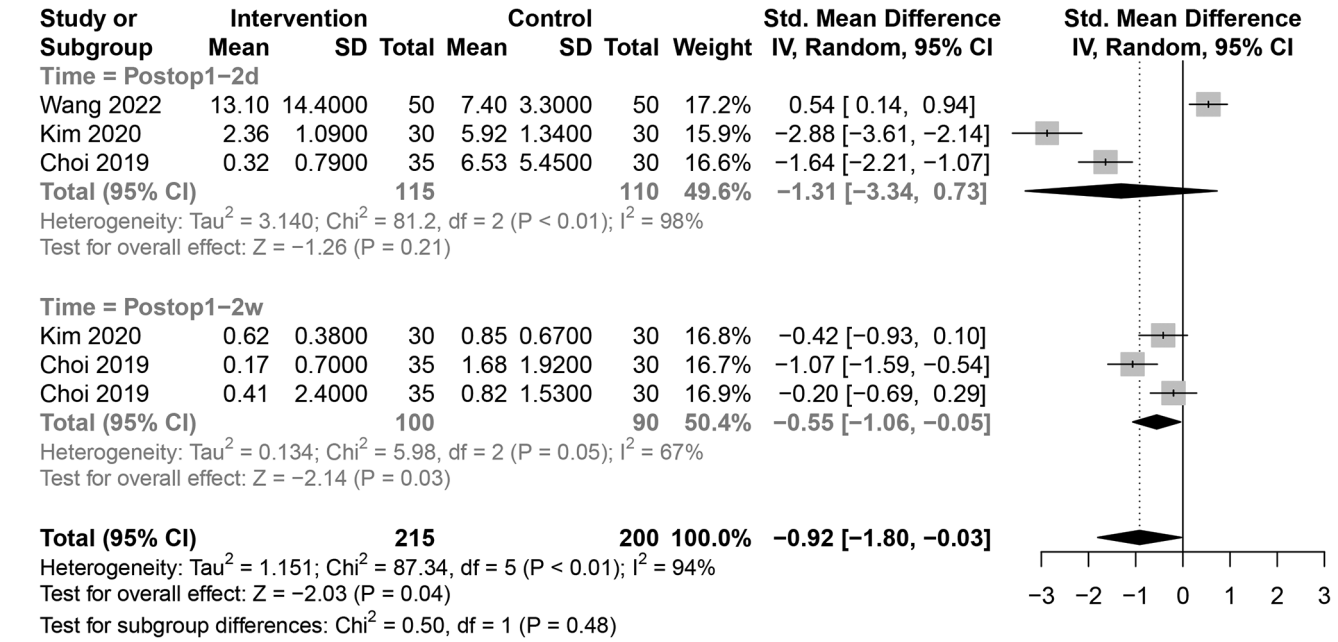

Figure 7. Analysis of the postoperative CRP between UBE and MD in the treatment of lumbar spinal stenosis; Intervention=UBE group, Control=MD group. UBE, unilateral biportal endoscopic; MD, microscopic decompression; CI, confidence interval; IV, inverse-variance weighting. d, days; m, months; w, weeks; postop, postoperative time; df, degrees of freedom.

it was not sufficient to show the overall effect. In the present study, cases from several countries were included, and the results showed that the UBE group had fewer complications than the MD group, as determined by the analyses.

The present study has some limitations. First, it included primarily Korean and Chinese studies, and this is not reflective of surgical procedures in other countries around the world. Each subgroup had a smaller sample size in the subgroup analysis and may not be sufficient in power to reflect the real-world scenario. Second, a publication bias exists since small-scale studies are prone to remain unpublished, which could account for language limitations in the inclusion criteria or selective publication. Third, in this study, four RCTs were included, whereas the rest of the studies were CSs. Since it is difficult to completely apply randomized and blinded controls in practice, observational studies were included, which limited the quality of the literature included. In certain studies, only descriptive analyses were performed, precluding accurate clinical data extraction. The use of different surgical procedures can also lead to bias. Finally, the absence of ethical approvals may have affected data analysis, causing inevitable bias. Therefore, the conclusions of this study need to be further verified using a

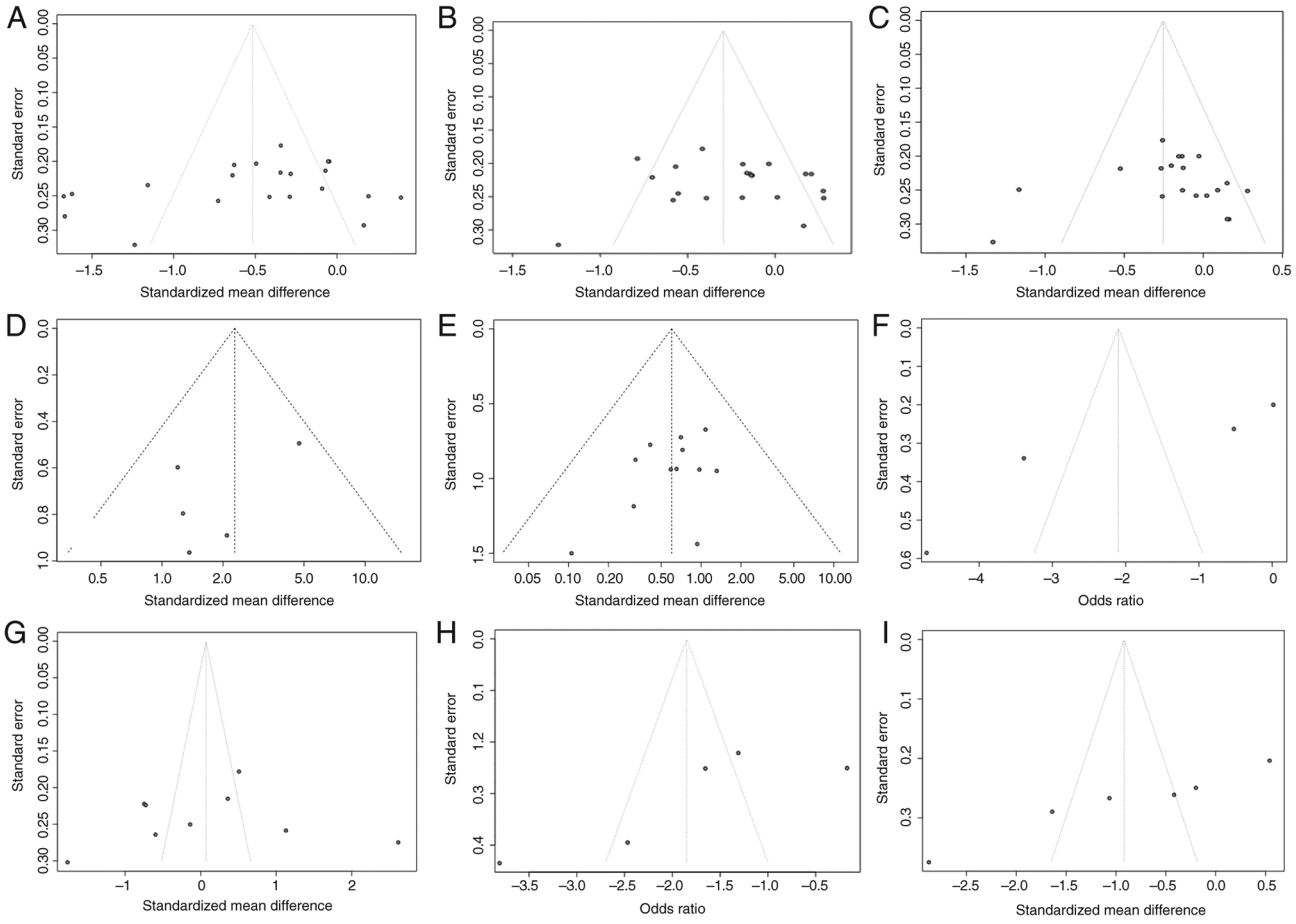

Figure 8. Funnel plots for assessment of publication bias. (A) The postoperative VAS score for back pain. (B) The postoperative VAS score for leg pain. (C) The postoperative ODI. (D) The modified MacNab score. (E) The complications. (F) The mean blood loss (ml). (G) The operation time. (H) The length of hospital stay. (I) The postoperative CRP.

large sample prospective RCT. It is important to note that this evaluation was based on a small number of studies; therefore, caution should be exercised when interpreting and extrapolating the results.

In conclusion, compared with MD surgery, UBE is less prone to intraoperative bleeding and has a shorter postoperative hospital stay, milder short-term pain symptoms, faster recovery, and fewer postoperative complications. UBE surgery may replace MD surgery as a better treatment option for lumbar spinal stenosis. The results confirm that the UBE technique is a viable option for lumbar surgery. This technology is not only applicable to the lumbar spine but can also be used to treat diseases such as the cervical and thoracic spine. However, existing studies are limited to small cohort studies with short-term follow-ups, and further large cohort prospective studies and long-term follow-up studies are required to evaluate the relative benefits and harms of UBE. It is hypothesized that as UBE technology is further developed, it will usher in a new era in spinal endoscopy. However, at present, additional randomized controlled studies are required to compare these two technologies.

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Availability of data and materials

The datasets used and/or analysed during the present study are available from the corresponding author on reasonable request.

Authors' contributions

YPW and SLQ designed the study, performed the research, collected and analysed the data, and wrote the manuscript. SY collected and analysed the data. YPW, SLQ and SY confirm the authenticity of all the raw data. YFX and PFH conceived the study, performed the interpretation of data and reviewed the article. All authors have read and approved the final manuscript.

Ethics approval and consent to participate

Not applicable.

Patient consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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