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Endoscopic Spinal Surgery (BESS and UESS) Versus Microscopic Surgery in Lumbar Spinal Stenosis: Systematic Review and Meta-Analysis

Kyu-Bok Kang, MD[1], Young-Soo Shin, MD[2], and Eun-Min Seo, MD[2]

Abstract

Study Design: Systematic Review and Meta-Analysis

Objectives: Various minimally invasive surgical techniques have been developed as alternatives to conventional surgery. According to recent studies, endoscopic spinal surgery (ESS) (biportal ESS [BESS] or uniportal ESS [UESS]) is more favorable compared with microscopic spinal surgery (MSS). This systematic review and meta-analysis aimed to assess the latest evidence on the use of ESS compared with MSS in lumbar spinal stenosis.

Methods: A systematic electronic search using PubMed, Embase, Cochrane Central Database, and Korea Med was performed until December 2019 to identify studies that compared ESS and MSS in patients with lumbar spinal stenosis.

Results: Overall, 1167 patients were included from three randomized controlled trials, six retrospective cohorts, and two prospective case–control studies. This review only presented 3 direct comparative studies. The study had inherent limitations specifically in terms of the study design. Meta-analysis of hospital stay (days) showed significant difference between BESS and MSS, UESS and MSS, BESS +UESS, and MSS at the final follow-up (95% confidence interval [CI]: −3.66 to −.77; P = .003; I^2 = 97%, 95% CI: −2.95 to −1.22; P <.00001; I^2 = 90%, and 95% CI: −2.89 to −1.48; P <.00001; I^2 = 96%, respectively). However, meta-analysis showed no significant difference in other results.

Conclusions: Although a shorter duration of hospital stay was observed in ESS, there were no significant differences in efficacy and safety between ESS and MSS. Further studies are required to validate these results.

Keywords

endoscopic spinal surgery, biportal endoscopic spinal surgery, uniportal endoscopic spinal surgery, microscopic spinal surgery, lumbar spinal stenosis

Introduction

Lumbar spinal stenosis is characterized by narrowing of the spinal canal due to degenerative hypertrophic changes of surrounding soft and bony tissues.[1] These hypertrophic degenerative changes compress the nerve roots, resulting in neurologic symptoms, including back and leg pain, sciatica, claudication, and walking difficulty.[2] This condition often causes a significant deterioration in the quality of life.[3,4]

Surgical treatment is indicated for patients with intractable pain, deteriorating quality of life, progressive neurologic deficit, and failed conservative treatment.[5-7] The primary goal

[1]Department of Orthopaedic Surgery, Veterans Health Service Medical Center, Seoul, South Korea
[2]Department of Orthopedic Surgery, Chunchon Sacred Heart Hospital, Hallym University College of Medicine, Chuncheon, South Korea

Corresponding Author:
Eun-Min Seo, MD, Department of Orthopedic surgery, Chuncheon Sacred Heart Hospital, Hallym University College of Medicine, #153, Kyo-dong, Chuncheon 24252, South Korea.
Email: seoem@hallym.or.kr

of surgical treatment is to decompress the compressed neural structures, thus relieving symptoms and improving function.[6-10] Laminectomy, often combined with medial facetectomy and foraminotomy, is the standard surgical treatment for lumbar spinal stenosis.[6-8] This decompression surgery is performed by making large incisions with dissection of the paraspinal muscles from the spinous processes and prolonged retraction of the paraspinal muscles to expose the lamina.[6-10] Several studies have reported concerns about the extensive invasiveness of such conventional surgery; hence, various minimally invasive spinal surgeries have been developed as alternatives.[10,11,12-26]

Some studies introduced microscopic spinal surgery (MSS) (unilateral laminotomy with bilateral decompression [ULBD] using microscope and tubular retractor system), which minimized muscle and soft tissue damage.[11,25,26] Recently, with the development of surgical instruments, ULBD has been commonly performed via endoscopic spinal surgery (ESS) (biportal ESS [BESS] or uniportal ESS [UESS]).[12-22] The principles of ESS are the same as the concepts of MSS. ESS allows high magnification of the surgical field through continuous irrigation and light source and direct decompression in the lateral recess and foraminal area of the contralateral side without the tilting of patients.[11,12-22] Specially, BESS has a second working port, which allows easy handling of spinal instruments compared with UESS.[11,27] Such minimally invasive spinal surgeries using microscopy or endoscopy have shown effective and comparable clinical results when compared with conventional surgery for lumbar spinal stenosis.[28-31] However, the most superior procedure among the minimally invasive spinal surgeries remains unknown. Recent studies have reported more favorable clinical results in patients treated with ESS than with MSS.[12-22] Thus, we assessed and compared clinical outcomes between ESS and MSS in this systematic review and meta-analysis.

Methods

This meta-analysis was performed according to the guidelines of the preferred reporting items for systematic reviews and meta-analysis (PRISMA) statement. Although the current study involved human participants, ethical approval and informed consent from participants were not required because all data were acquired from previously published studies and analyzed anonymously without any potential harm to participants.

Data and Literature Sources

A systematic electronic search using PubMed, Embase, Cochrane Central Database, and Korea Med was performed until December 2019 to identify studies that compared ESS and MSS in patients with lumbar spinal stenosis. The following search terms were used: "endoscopic spinal surgery," "biportal or uniportal endoscopic spinal surgery," "microscopic spinal surgery," "spinal stenosis," and their synonyms.

Study Selection

Two authors independently chose relevant studies for full review by searching through titles and abstracts. The full text of each article was reviewed if the abstract did not provide enough data to make a decision. Studies were included in the meta-analysis if they: (1)assessed patients who underwent ESS or MSS for treatment of lumbar spinal stenosis; (2)reported retrospective or prospective comparisons of surgical outcomes between each group (ESS and MSS); (3) included basic data on at least one of the following parameters: postoperative pain and function scores, complications, operation duration, and duration of hospital stay; (4) reported the number of participants in each group and the means and standard deviations for the parameters; and (5) used adequate statistical methods to compare parameters between groups.

Studies were excluded if they (1) had missing or inadequate outcome data, such as standard deviations or ranges of values; (2) were case reports, expert opinions, reviews, commentaries, or non-English language articles; (3) were abstracts only; and (4) focused on animal in vivo or human in vitro research.

Data Extraction and Assessment of Methodological Quality

Data extraction was performed by two independent authors. The data extracted included authors, year of publication, study design, subject characteristics, sample size, ESS, MSS, age, sex ratio, postoperative pain scores (visual analog scale [VAS] for back pain and leg pain), postoperative function scores (Oswestry Disability Index [ODI]), mean operation duration, duration of hospital stay (days), complications, and follow-up duration.

Two independent authors assessed the methodological quality of the studies. Prospective randomized controlled trials (RCTs) were assessed with the modified Jadad scale and consisted of randomization, blinding, withdrawals and dropouts, inclusion and exclusion criteria, adverse reactions, and statistical analysis.[32] High-quality studies have scores of 4–8, whereas low-quality studies have scores of 0–3.

Non-randomized studies were assessed with the Newcastle-Ottawa Scale. This scale contains eight items, categorized into three dimensions including selection, comparability, and—depending on the study type—outcome (cohort studies) or exposure (case–control studies).[33] Studies of high quality were defined as those with scores higher than 6 points, and total scores lower than 4 points were considered low in quality. Two independent authors resolved all differences by discussion, and their decisions were subsequently reviewed by a third investigator.

Data Synthesis and Analysis

The main outcomes of the meta-analysis were postoperative pain scores (VAS for back pain and leg pain), postoperative

function scores (ODI), mean operation duration, and duration of hospital stay (days) between ESS and MSS.

For all comparisons, odds ratios (ORs) and 95% confidence intervals (CIs) were calculated for binary outcomes, while standardized mean differences (SMDs) and 95% CIs were calculated for continuous outcomes. When standard deviations (SDs) were not included in the original studies, they were calculated from the CIs or P values.

Heterogeneity was determined by estimating the proportion of between-study inconsistencies due to actual differences between studies rather than differences due to random error or chance. We assumed the presence of heterogeneity a priori and used the random-effects model in all pooled analyses. I^2 statistics with a value less than 40% represent low heterogeneity, and a value of 75% or more indicates high heterogeneity. When statistical heterogeneity was substantial, we conducted meta-regression to identify potential sources of bias such as the number of patients, sex ratio, age, and follow-up duration. Publication bias was assessed using funnel plots. Subgroup analyses based on surgical techniques (ESS vs MSS) were performed to explore a potential source of heterogeneity. All statistical analyses were performed with RevMan version 5.3 software (The Cochrane Collaboration, Copenhagen, Denmark) and Stata version 14.2 static software (StataCorp., College Station, TX, USA). Sensitivity analysis was performed to detect the effect of individual studies on the pooled effect. Pooling of data was feasible for five outcomes of interest: postoperative pain scores (VAS for back pain and leg pain), postoperative function scores (ODI), mean operation duration, and duration of hospital stay (days).

Results

Study Identification, Study Characteristics, Patient Populations, Quality Assessment, and Publication Bias of Included Studies

Details on study identification, inclusion, and exclusion are summarized in Figure 1. A total of 111 studies in the databases were found. After the duplicates were excluded, 21 out of 75 screened abstracts were relevant to our selection criteria. We assessed the full text of these articles. Ten studies were excluded because of unusable information, analysis on learning curve, cost-effectiveness analysis, and single-arm studies/case-series. This process eventually resulted in 11 studies in the final meta-analysis.[12-22] A total of 1167 patients were included from three RCTs, six retrospective cohorts, and two prospective case–control studies.[12-22] The RCTs (modified Jadad scale score of >4) and non-RCTs (case–control study and retrospective cohort) (Newcastle-Ottawa Scale score of >6) were of high quality. All the studies compared ESS with MSS on lumbar spinal stenosis; overall, 281 patients underwent BESS, 387 patients underwent UESS, and 537 patients underwent MSS. The quality of the 11 studies included in the meta-analysis is summarized in Table 1.

Publication bias was evaluated using the differences of VAS for back pain among the included studies. The funnel plot showed that the mean differences in VAS for back pain were

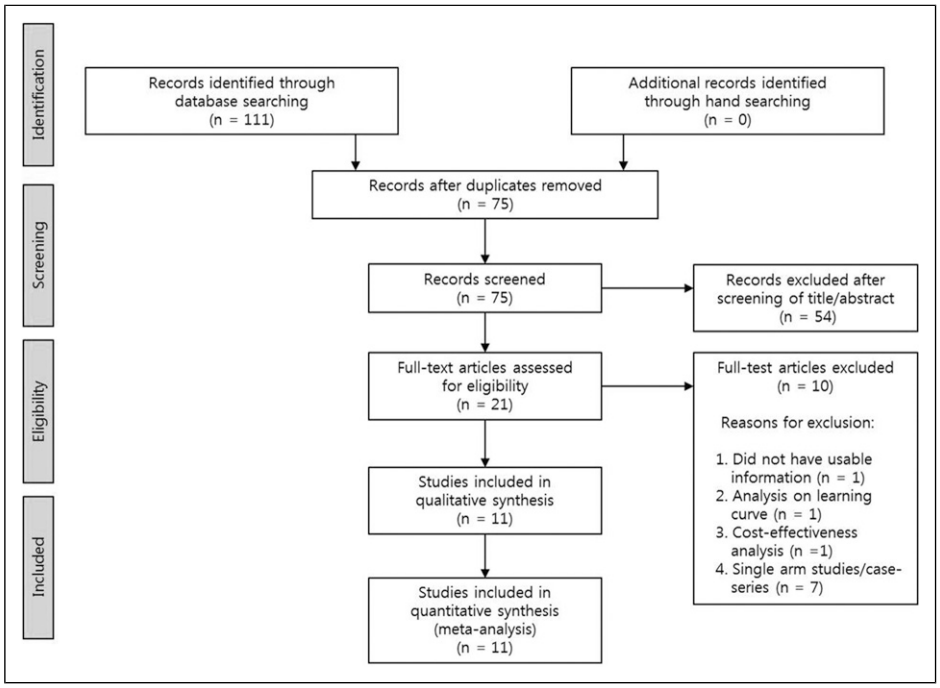

Figure 1. A flow diagram of preferred reporting items for systemic reviews and meta-analyses (PRISMA).

Table 1. Summary of patient characteristics of the included studies.

Study	Study Type	Sample Size (n)	Mean Age (years)	Sex Ratio (M/F)	Endoscopic Spinal Surgery Protocol	Microsurgery Protocol	Complications	Measured Parameters	Final Follow-Up (months)	Quality Score
Choi et al, 2018	Case–control prospective Study	80 (BESS 20, UESS 40 MSS 20)	BESS 47.43 ± 12.21 UESS 45.2 ± 10.0 MSS 44.08 ± 11.38	38 : 42 (BESS 10: 10 UESS 20 : 20 MSS 8: 12)	BESS and UESS	MSS	Not checked	VAS for back and leg, ODI, Operation time, Hospital stay, CPK, and CRP(C-reactive protein)	1	NOS 8
Heo et al, 2018	Case–control prospective study	88 (BESS 46, MSS 42)	BESS 65.8 ± 8.9 MSS 63.6 ± 10.5	34 : 54 (BESS 18 : 28 MSS 16 : 26)	BESS	MSS	BESS: Durotomy (1); postoperative hematoma (1) Microsurgery: Durotomy (1); postoperative hematoma (2)	VAS for back and leg, ODI, Operation time, and dura expansion	14.5 ± 2.3	NOS 8
Kim et al, 2018	Multicenter Retrospective Cohort	141 (BESS 60, MSS 81)	BESS 46.60 ± 14.18 MSS 54.22 ± 20.21	61 : 80 (BESS 37 : 23 MSS 24 : 57)	BESS	MSS	Microsurgery: Durotomy (2); postoperative infection (1)	VAS for back and leg, ODI, Operation time, and Hospital stay	BESS 12.60 ± 1.03 MSS 12.84 ± 1.30	NOS 9
Heo et al, 2019	Retrospective cohort	97 (BESS 37, UESS 27 MSS 81)	BESS 66.7 ± 9.4 UESS 67.3 ± 9.9 MSS	38 : 59 (BESS 15 : 22 UESS 11 : 16	BESS UESS	MSS	BESS: Durotomy (1); postoperative hematoma (1) UESS: Durotomy (1); transient weakness (1);	VAS for back and leg, ODI, Operation time, and dura expansion	12.5 ± 3.3	NOS 8

(continued)

Table 1. (continued)

Study	Study Type	Sample Size (n)	Mean Age (years)	Sex Ratio (M/F)	Endoscopic Spinal Surgery Protocol	Microsurgery Protocol	Complications	Measured Parameters	Final Follow-Up (months)	Quality Score
			3.4 ± 11.1	MSS			Postoperative hematoma (1)			
				12 : 21)			Microsurgery: Durotomy (2); transient weakness (1); Postoperative hematoma (2)			
Min et	Multicenter	89	BESS	46 : 43	BESS	MSS	BESS: Durotomy (2)	VAS for back and leg, ODI,	BESS	NOS 9
al, 2019	Retrospective	(BESS 54,	65.74 ±	(BESS			Postoperative hematoma (1)	Operation time, and Hospital stay	27.2 ± 5.4	
	Cohort	MSS 35)	10.52	27 : 27			Microsurgery: Durotomy (1);	Dynamic intervertebral angle	MSS	
			MSS	MSS			postoperative hematoma (1)	Dynamic intervertebral slip	31.5 ± 7.3	
			66.74 ± 7.96	19 : 16)				percentage		
Park et	Randomized	64	BESS	31 : 33	BESS	MSS	BESS: Durotomy (2)	VAS for back and leg, ODI,	0.5	MJS 6
al, 2019	controlled	(BESS 32,	65.74 ±	(BESS			Postoperative hematoma (1)	European Quality of Life-5		
	trial	MSS 32)	10.52	18 : 14			Microsurgery: Durotomy (2);	dimensions, and operation time,		
			MSS	MSS			postoperative hematoma (1)	Hospital stay, CPK		
			66.74 ± 7.96	13 : 19)				Central stenosis grade		
Hasan et	Retrospective	45	UESS	24 : 21	UESS	MSS	UESS: Durotomy (0)	VAS for back and leg, ODI,	12	NOS 7
al, 2019	Cohort	(UESS 26,	69.9 ±	(UESS			Microsurgery: Durotomy (2	Operation time, and hospital stay		
		MSS 19)	11.6	12 : 14				Imaging measurements		
			MSS	MSS				(disc height, Cobb angle, static		
								spondylolisthesis slip distance		
								and grades, axial facet angle,		

(continued)

Table 1. (continued)

Study	Study Type	Sample Size (n)	Mean Age (years)	Sex Ratio (M/F)	Endoscopic Spinal Surgery Protocol	Microsurgery Protocol	Complications	Measured Parameters	Final Follow-Up (months)	Quality Score
			66.6 ± 8.0	12 : 7)				pelvic incidence, and lumbar lordosis)		
Kang et al, 2019	Randomized controlled trial	62 (BESS 32, MSS 30)	BESS 65.1 ± 8.6 MSS 67.2 ± 9.5	32 : 30 (BESS 18 : 14 MSS 14 : 16)	BESS	MSS	BESS Postoperative hematoma (1) Microsurgery: Postoperative hematoma (1)	VAS for back and leg, ODI, Operation time, and hospital stay	6	MJS 6
Komp et al, 2015	Randomized controlled trial	160 (UESS 80, MSS 80)	62 (41 ~ 84)	69 : 91	UESS	MSS	UESS: Durotomy (2) Postoperative hematoma (0) Transient dysesthesia (4) Transient weakness (1) Microsurgery: Durotomy (3) Postoperative hematoma (1) Transient dysesthesia (7) Transient weakness (2) Postoperative infection (2)	VAS for back and leg, ODI Operation time North American Spine Society Instrument (NASS)	24	MJS 6
Lee et al, 2019	Retrospective Cohort	246 (UESS 164, MSS 72)	UESS 53.22 ± 3.5 MSS 59.32 ±	73 : 163 (UESS 52 : 112 MSS 21 : 51)	UESS	MSS	UESS: Durotomy (4) Transient dysesthesia (7) Transient weakness (1) Microsurgery: Durotomy (1) Transient dysesthesia (4)	VAS for back and leg, ODI, Operation time, CPK Spinal canal dimension	BESS 6.42 ± 2.68 MSS 6.32 ±	NOS 7

(continued)

Table 1. (continued)

Study	Study Type	Sample Size (n)	Mean Age (years)	Sex Ratio (M/F)	Endoscopic Spinal Surgery Protocol	Microsurgery Protocol	Complications	Measured Parameters	Final Follow-Up (months)	Quality Score
			8.28				Transient weakness (0)		4.82	
Mcgrath et al, 2019	Retrospective Cohort	95 (UESS 50, MSS 45)	62 ± 1.3	54 : 41 (UESS 27 : 23 MSS 27 : 18)	UESS	MSS	UESS: Durotomy (0) Postoperative hematoma (0) Transient dysesthesia (3) Microsurgery: Durotomy (3) Postoperative hematoma (2) Transient dysesthesia (1)	VAS for back and leg, ODI, Operation time, and Hospital stay	12	NOS 7

BESS, biportal endoscopic spinal surgery; UESS, uniportal endoscopic spinal surgery; MSS, microscopic spinal surgery; VAS, visual analog scale; ODI, Oswestry Disability Index; CPK, creatine phosphokinase; MJS, modified Jadad scale; NOS, Newcastle-Ottawa Scale

asymmetrically skewed right, indicating some publication bias among included studies (Figure 2).

The sensitivity analysis found no significant differences compared to the original analysis, indicating that the findings were robust to decisions made in the data collection process (Table 2).

Clinical Outcomes

Of the 11 studies, nine compared postoperative back pain between patients with ESS and MSS. Meta-analysis showed no significant difference between BESS and MSS, UESS and MSS, BESS plus UESS, and MSS (95% CI: −.23 to .03; P = .43; I^2 = 0%, 95% CI: −1.33 to .09; P = .09; I^2 = 95%, and 95% CI: −.73 to .05; P = .09; I^2 = 94%, respectively) (Figure 3).

Of the 11 studies, eight compared postoperative leg pain between patients with ESS and MSS. Meta-analysis showed no significant difference between BESS and MSS, UESS and MSS, BESS plus UESS, and MSS (95% CI: −.17 to .18; P = .95; I^2 = 0%, 95% CI: −1.38 to .06; P = .07; I^2 = 95%, and 95% CI: −.83 to .20; P = .23; I^2 = 95%, respectively) (Figure 4).

Of the 11 studies, eight compared postoperative ODI between patients with ESS and MSS. Meta-analysis showed no significant difference in ODI between BESS and MSS, UESS and MSS, BESS plus UESS, and MSS at the final follow-up (95% CI: −1.46 to .55; P = .37; I^2 = 7%, 95% CI: −11.25 to 3.95; P = .35; I^2 = 99%, and 95% CI: −6.19 to 1.68; P = .26; I^2 = 97%, respectively) (Figure 5).

Of the 11 studies, ten compared mean operation duration between patients with ESS and MSS. Meta-analysis showed no significant difference in mean operation duration between BESS and MSS, UESS and MSS, BESS plus UESS, and MSS at the final follow-up (95% CI: −5.89 to 6.82; P = .89;

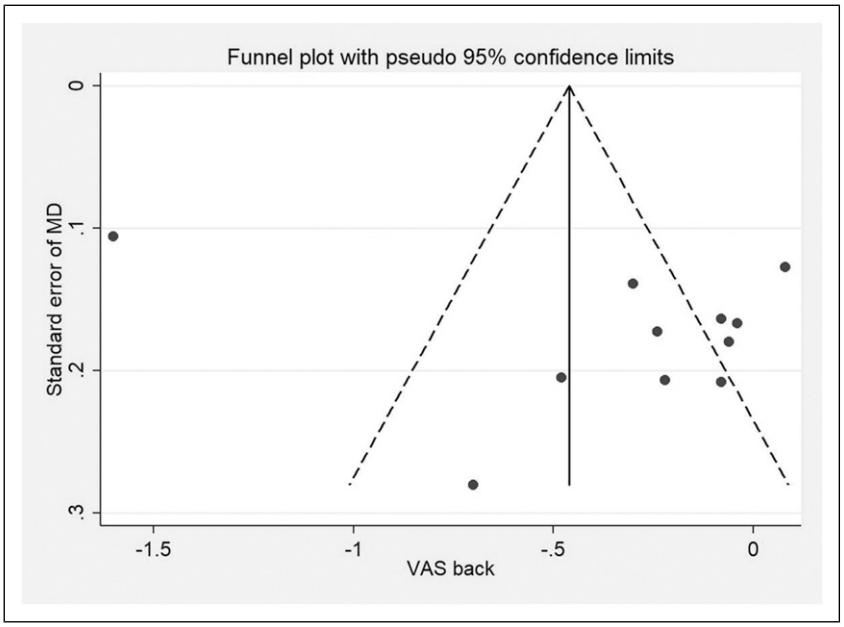

Figure 2. Funnel plot showing asymmetricity on VAS for back pain.

Table 2. Sensitivity analysis.

Study Type	Parameter	Before Exclusion	After Exclusion	Statistical Significance<
RCS	VAS(back)	MD = −.34, 95% CI = −.73, .05, Z=1.71, P=.09	MD = −.14, 95% CI = −.30, .02, Z=1.75, P=.08	No difference
	VAS(leg)	MD = −.31, 95% CI = −.83, .20, Z=1.19, P=.23	MD = −.02, 95% CI = −.31, .26, Z=.16, P=.87	No difference
	ODI	MD = −2.25, 95% CI = −6.19, 1.68, Z=1.12, P=.26	MD = −1.75, 95% CI = −3.75, .25, Z=1.71, P=.09	No difference
	Operation time	MD = 5.58, 95% CI = −9.94, 21.11, Z=.70, P=.48	MD = −7.25, 95% CI = −18.88, 4.38, Z=1.22, P=.22	No difference
	Hospital stay	MD = −2.19, 95% CI = −2.89 −1.48, Z=6.05, P<.01	MD = −2.14, 95% CI = −4.06 −.23, Z=2.19, P=.03	No difference

RCS, retrospective comparative study; VAS, visual analog scale; ODI, Oswestry Disability Index; CI, confidence interval; MD, mean difference.

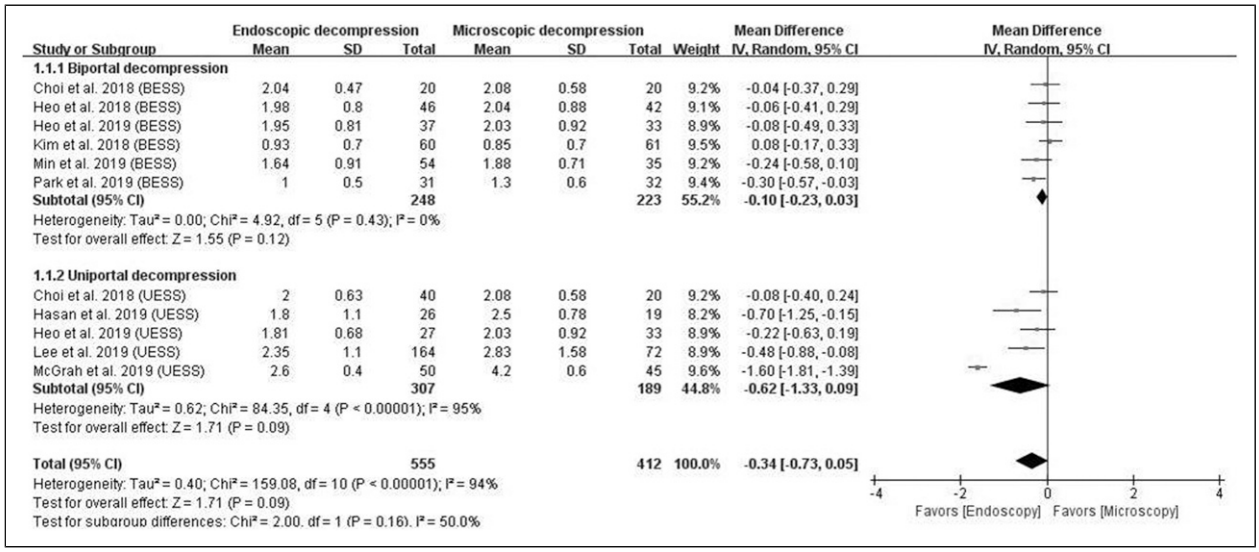

Figure 3. Clinical outcome (VAS for back pain).

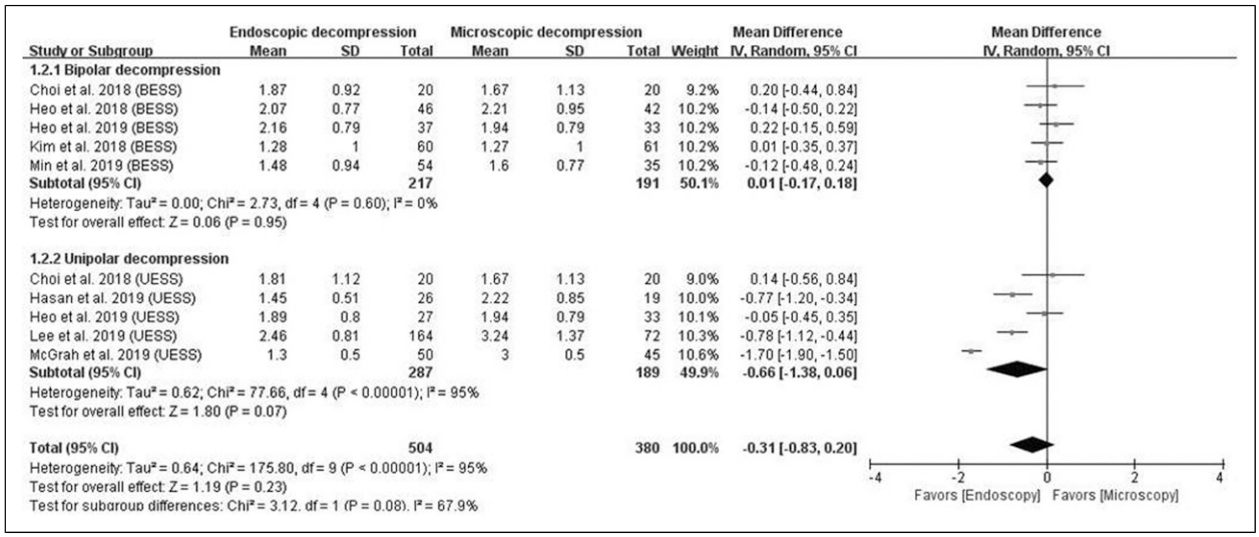

Figure 4. Clinical outcome (VAS for leg pain).

I^2 = 94%, and 95% CI: −22.47 to 45.75; P = .50; I^2 = 100%, 95% CI: −9.94 to 21.11; P = .48; I^2 = 100%, respectively) (Figure 6). The mean operation duration was similar in ESS and MSS.

Of the 11 studies, eight compared hospital stay (days) between patients with ESS and MSS. Meta-analysis showed significant difference in hospital stay between BESS and MSS, UESS and MSS, BESS plus UESS, and MSS at the final follow-up (95% CI: −3.66 to −.77; P = .003; I^2 = 97%, and 95% CI: −2.95 to −1.22; P <.00001; I^2 = 90%, 95% CI: −2.89 to −1.48; P <.00001; I^2 = 96%, respectively) (Figure 7). Shorter duration of hospital stay was found in ESS. Complications were similar in ESS and MSS. Details of reported complications are shown in Table 1.

Meta-Regression Analysis

The results of the meta-regression analysis are summarized in Table 3.

Number of patients (P = .311), age (P = .089), and follow-up duration (P = .637) were not significant sources of heterogeneity for VAS (back pain) in the included studies. Only sex ratio was a significant source of heterogeneity for VAS (back pain) in the included studies (P = .037).

Discussion

The surgical treatment goal of lumbar spinal stenosis is to relieve pain by neural decompression (laminectomy, medial facetectomy, and foraminotomy).[3] The success rate of decompression surgery ranges from 62% to 70%.[23] However,

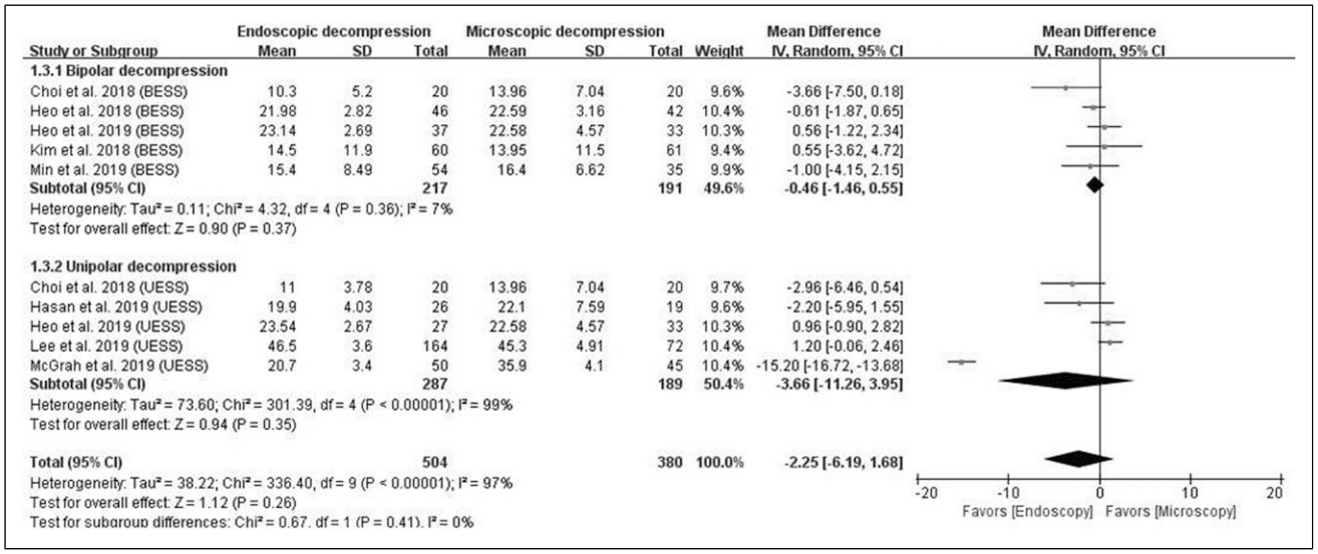

Figure 5. Clinical outcome (ODI).

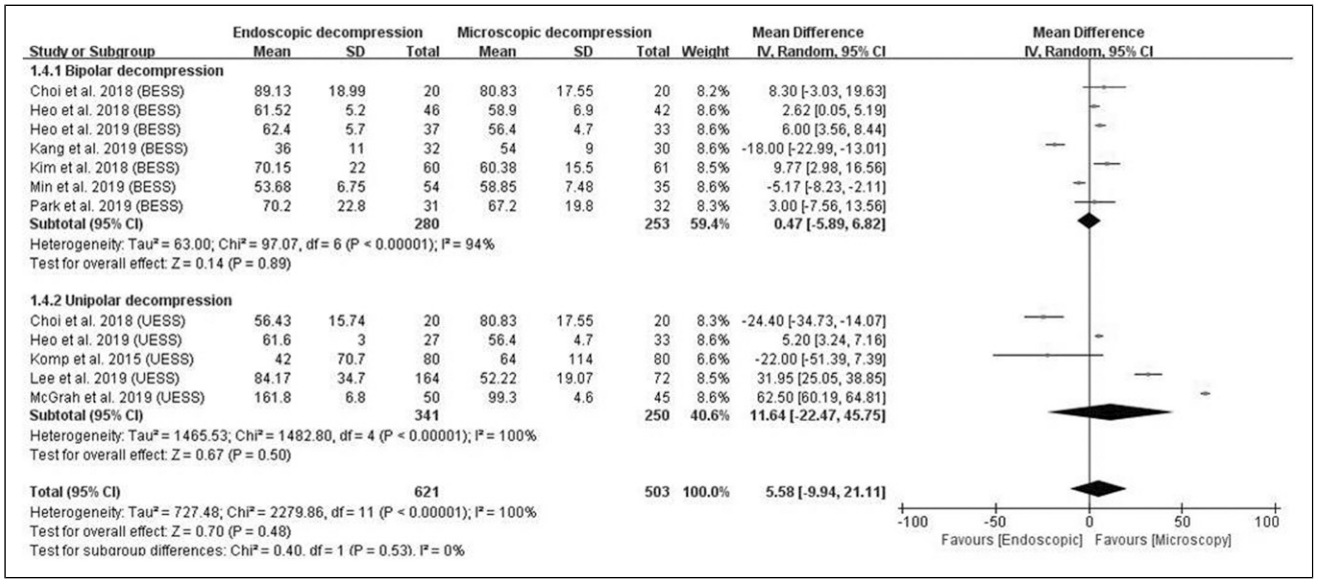

Figure 6. Clinical outcome (mean operation time).

conventional decompression surgeries need massive dissection and retraction of the paraspinal muscles from the spinous processes to expose the lamina.[24] Therefore, iatrogenic tissue injury related to conventional decompression surgery occasionally results in postoperative chronic back pain and secondary spinal instability.[24] This secondary spinal instability can cause additional fusion surgery.

Recently, various kinds of minimally invasive spine surgeries have been developed to minimize iatrogenic tissue injury. In some studies, the role of elevated serum creatine phosphokinase (CPK) levels as a biochemical indicator of muscle injury has been reported.[12,15,21] According to these studies, ESS has been associated with a decrease in CPK enzyme levels compared with MSS. Although it was not significant, ESS has more advantages to reduce paraspinal muscle damage than MSS. One study evaluated dural expansion after decompression was checked using MRI.[13]; however, no significant difference between MSS and ESS was observed. This showed that ESS is a reasonable decompression technique. Thus, the purpose of this systematic review and meta-analysis was to assess the reasonable evidence on the use of ESS compared with MSS.

In this systematic review and meta-analysis, postoperative back and leg pain and ODI did not differ significantly between ESS and MSS (Figure 3-5). However, the duration of hospital stay was lower in ESS (Figure 7). Generally, the causes of

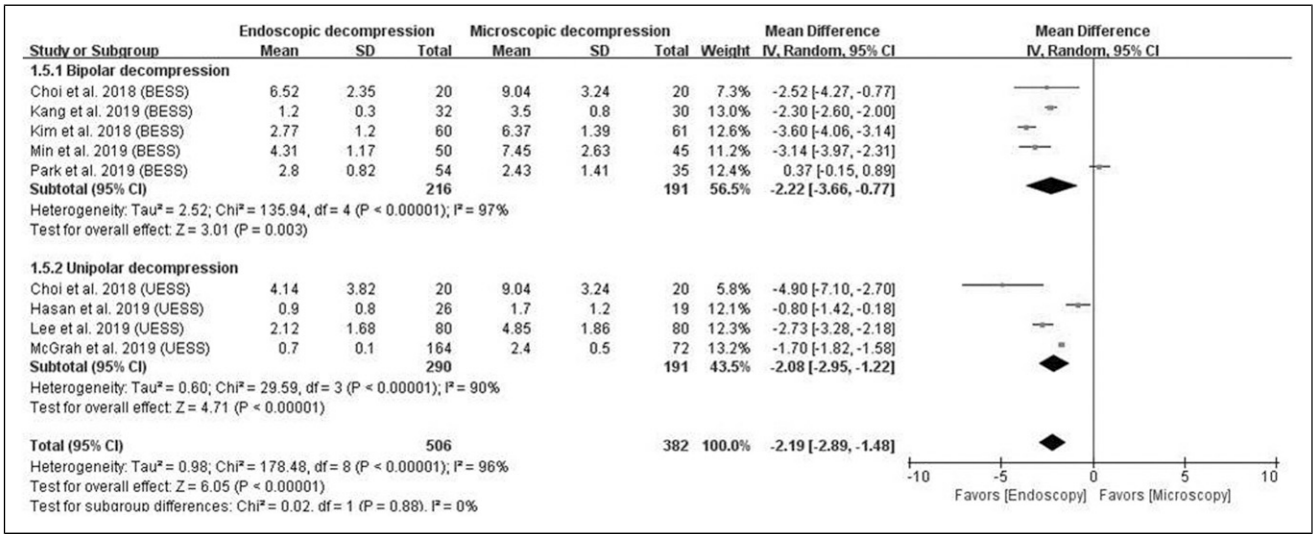

Figure 7. Clinical outcome (length of hospital stay).

Table 3. Meta-regression analyses of potential sources and difference in VAS (back).

Variable	Coefficient	Standard Error	P-Value	95% Confidence Interval
VAS(back)				
Number of patients (≤50 or≥50)	−.200	.187	.311	−.623 to .222
Men, % (≤48 or≥48)	−.467	.190	.037	−.897 to −.036
Age, mean year (≤50 or≥50)	−.434	.228	.089	−.950 to .082
Average follow-up (≤1 year or≥1 year)	−.142	.291	.637	−.799 to .516

Significant result in bold text, VAS, visual analog scale.

shorter duration of hospital stay in ESS were because it was performed under less invasive local or regional anesthesia and less muscle retraction during operation, as the portals were made percutaneously. Thus, lower back VAS may be related with less tissue damage and shorter duration of hospital stay. Although, overall postoperative back VAS did not differ significantly between ESS and MSS in this systematic review and meta-analysis. The early postoperative VAS for back pain in individual studies was lower in ESS.[12-22] We assume that such results lead to shorter duration of hospital stay in ESS.

Some studies have reported that a small working space and the difficulty in managing endoscopic equipment may be related with the higher rates of complications such as dura tear or neural injury.[16,34-36] However, in this systematic review and meta-analysis, the incidence of complications in ESS was not high compared with that of MSS. Continuous saline irrigation during the procedure provided more epidural working space between the neural structures and the surrounding soft tissues, which makes it easy to identify and manipulate the related structures in the narrow operative fields. Therefore, continuous saline irrigation helped to decrease the complication rate. After ESS, some patients complained of headaches and neck pain. The reason is related to the increase in cerebrospinal fluid pressure under continuous water irrigation. Therefore, an excessive increase of irrigative pressure in ESS is not recommended.[16,34-36]

The limitation of this systematic review and meta-analysis is the small number of studies that compared ESS with MSS. Only three of the included studies were RCTs; the remaining eight studies were observational, resulting in some inherent heterogeneity due to uncontrolled bias even though the studies had high quality scores. Thus, multicenter RCTs that compare ESS with MSS are required to validate the results and create a more solid recommendation for practice. Another limitation involved the pooling of heterogeneous data. However, we did use sensitivity analysis and meta-regression analysis to incorporate heterogeneous outcomes. Nonetheless, this heterogeneity should be considered when interpreting our findings.

Conclusion

This systematic review and meta-analysis have inherent limitations in the study design. This review only presented three direct comparative studies. Other studies consisted of heterogeneous case series or retrospective cohorts. Hence, we were unable to combine results from different studies.

Although shorter duration of hospital stay was observed in ESS, there were no significant differences in efficacy and safety

between ESS and MSS. However, these findings have weak evidence because of the heterogeneity (pooling of heterogeneous data) in this study. Thus, multicenter RCTs that compare ESS with MSS are needed to provide a high quality of evidence and a more solid recommendation.

Declaration of Conflicting Interests

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ORCID iD

Eun-Min Seo https://orcid.org/0000-0001-7964-9694

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