Systematic Review and Meta-Analysis

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Comparison of single versus double door posterior cervical laminoplasty for patients with cervical spondylotic myelopathy

A systematic review and meta-analysis

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Abstract

Objective: We undertook a meta-analysis to compare the efficacy and safety of single versus double door posterior cervical laminoplasty for cervical spondylotic myelopathy.

Methods: PubMed, Embase, and Cochrane Central Register of controlled trials were searched for randomized controlled trials investigating single and double door posterior cervical laminoplasty for cervical spondylotic myelopathy. The Mantel–Haenszel method with the fixed-effects or random-effects model was used to calculate relative risks and 95% confidence intervals (CIs).

Results: Seven studies with 224 patients met the eligibility criteria and were included. There was a significant difference in Japanese Orthopedic Association score (MD=0.79, 95%CI [0.09, 1.49], $P=.03$; P for heterogeneity=.09, $I^2=45\%$), and adverse events (OR=0.32, 95%CI [0.11, 0.95], $P=.04$; P for heterogeneity=1.00, $I^2=0\%$) between the double door posterior cervical laminoplasty group and the single door posterior cervical laminoplasty group. There was no significance in operative time (MD=0.56, 95%CI [–11.86, 12.98], $P=.93$; P for heterogeneity=0.001, $I^2=73\%$) and length of hospital stay (OR=–0.75, 95%CI [–1.78, 0.27], $P=.15$; P for heterogeneity=1.00, $I^2=0\%$) between the 2 groups.

Conclusion: Double door posterior cervical laminoplasty is more effective and safer than single door laminoplasty in the treatment of cervical spondylotic myelopathy.

Abbreviations: CI = confidence intervals, CMS = cervical spondylotic myelopathy, PRISMA = Preferred Reporting Items for Systematic Review and Meta-Analysis.

Keywords: cervical canal stenosis, cervical spondylotic myelopathy, double door laminoplasty, posterior cervical laminoplasty, single door laminoplasty

1. Introduction

Cervical spondylotic myelopathy (CSM) is a severe disease endangering human health. The disease has an occult onset leading to delayed treatment and is characterized by progressive aggravation. As it progresses over time, a variety of complications will ensue. Irreversible neurological damage and spinal cord damage may occur if intervention is not provided in a timely and effective manner.[1–3]

Posterior cervical spinal canal enlargement includes 2 main methods: posterior cervical single-door laminoplasty and posterior cervical double-door laminoplasty.[4–6] The former constructs the structure of the portal axis at the side of the patient's arch and its lamina; the contralateral lamina was incised, and lifted. The narrow spinal canal can be enlarged. In the course of surgical treatment, the spinous process can be suspended by silk thread, which can avoid lamina re-closure.

Posterior cervical double-door enlarged plasty is the construction of the portal axis at the junction between the cervical lamina and its double lateral mass.[7–10] Relapsing stenosis caused by re-closure can be effectively prevented by maintaining the opening state, using the open door technique in the lamina to lead and fixing the insertion of bone blocks at the opening site.

There are several articles reporting single and double posterior cervical laminoplasty for cervical spondylotic myelopathy patients, but they are varied in study designs, recruitment and exclusion criteria and measurements. Since the clinical efficacy of posterior cervical spinal canal enlargement for CSM still needs to be investigated, we carried out a meta-analysis to evaluate the clinical efficacy and complications of single and double posterior cervical laminoplasty.

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J-XM and X-ZH contributed equally to this work.

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The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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2. Materials and methods

All data of this study were collected from published trials, so an additional ethical approval is not necessary.

2.1. Search strategy

This meta-analysis was performed in accordance with Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) statement and Cochrane Handbook for Systematic Reviews of Intervention. Quality of the study was critically assessed according to the PRISMA 2009 checklists. Literatures were searched in PubMed, Springer, EMBASE, Wiley-Blackwell, and Chinese Journal Full-text Database of all articles published between January 2000 and January 2018. Two members of our team independently searched for articles using the following keywords

(1) cervical spondylotic myelopathy OR CSM;
(2) posterior cervical laminoplasty;
(3) single or double.

All of these terms were assembled with the connection symbol "and" to search the database for related articles. In order to obtain more relevant research and higher accuracy, we also retrieved and reviewed the reference list of each article.

2.2. Citation selection

All articles after initial screening were further collected by 2 other researchers. The titles and abstracts of these articles were independently and carefully screened. Then, if the study was relevant, the full-text article was obtained.

The articles were then screened using the following inclusion criteria:

(1) a randomized control trial or a controlled clinical trial;
(2) comparison of single versus double door posterior cervical laminoplasty;
(3) patients with CSM;
(4) availability of full text articles.

The studies were excluded if:

(1) they were non-randomized study;
(2) studies were not related to posterior cervical laminoplasty;
(3) studies lacked outcome measures or comparative results.

There were no language restrictions in the selection. The bibliography of all selected articles was manually searched to identify additional articles that met our inclusion criteria. In cases where multiple publications were available with increasing number of patients or longer follow-up for the same group, only data from the most recent article were used for statistical analysis.

2.3. Data extraction

Two authors independently reviewed the formally published versions of all eligible studies for content and screened them according to the specified inclusion criteria using a data extraction form based on the Cochrane Consumers and Communication Review Group's data extraction template. Disagreements were resolved by discussion between the 2 review authors; if no agreement was reached, a third author was consulted to reach a consensus. The characteristics extracted in this study included the first author's name, publication year, years of onset, sample size, age range of patients, and outcome parameters.

2.4. Statistical analysis

Meta-analysis was performed by Review Manager 5.0 (Cochrane Collaboration, 2011) to assess differences in clinical efficacy between single and double door laminoplasty to assess publication bias. A X^2 based Q-test was also performed to check between-study heterogeneity. An I^2 value higher than 50 indicated moderate heterogeneity between the studies and the effect size for each study was calculated by the random effects model using Der Simonian–Laird approach. Alternatively a fixed-effects model was run.

Quality evaluation was assessed by the risk of bias table in the software. Seven criteria were used in the evaluation: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting and other bias. Besides, funnel plot was conducted to estimate possible publication bias.

3. Results

3.1. Search results

The initial search yielded 1030 studies; 985 were selected for eligibility assessment after exclusion of duplicated publications. After detailed evaluation including reading the abstract, checking study design and examining the data in the papers, 6 papers were excluded because of the study design, 55 papers were excluded due to insufficient data and 5 review articles were also excluded. Finally, 7 studies fulfilled the eligibility criteria and were included in the current meta-analysis. The literature search and screening process is shown in Figure 1.

3.2. Characteristics of the included studies

All these articles were published between 2001 and 2018. The sample size ranged between 17 and 53. The study had 99 patients in the double door group and 125 in the single door group. Table 1 lists the name of the first author, year of publication, gender, sample size, age range of patients, years of onset, and outcome parameters for each study.

3.3. Quality assessment

We used The Cochrane Collaboration's "Risk of Bias Tool."[11] Each study was graded for risk of bias in each of the following domains: adequate sequence generation, allocation concealment, blinding, incomplete outcome data addressed, free of selective outcome reporting, and free of other bias. Due to the nature of the interventions, assessor blinding was also evaluated. The risk of bias in this study is listed in Figure 2. Participants and respondents had low risk between the single door group and the double door group. The details of bias among each included article are shown in Figure 3.

3.4. Results of meta-analysis

3.4.1. JOA scores. All the included studies contained data on Japanese Orthopedic Association (JOA) scores.[12] Figure 4 shows the forest plot of the JOA score of the double door group and the single door group. All 7 studies showed statistically significant differences in JOA scores between the 2 groups. The meta-analysis suggested that the double door group had better JOA score than the single door group (MD = 0.79, 95%CI [0.09, 1.49], $P=.03$; P for heterogeneity = .09, $I^2=45\%$).

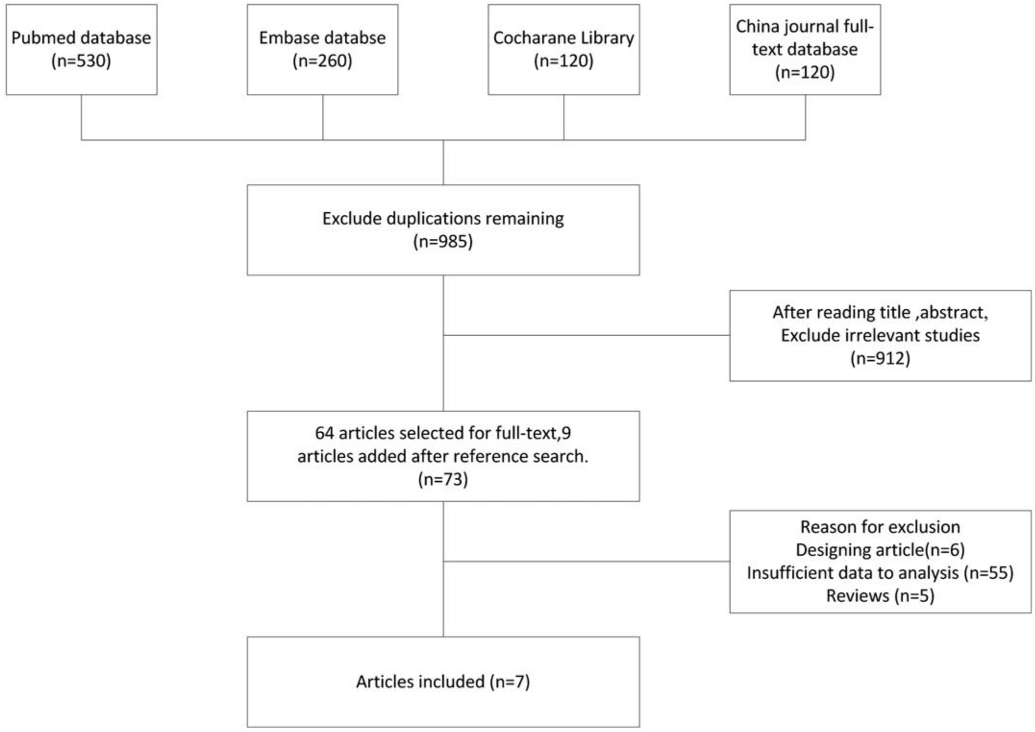

Figure 1. The flow diagram of the study identification, inclusion and exclusion process.

3.4.2. Operative time. The forest plot for meta-analysis of operative time (minute) is presented in Figure 5. The results demonstrated no difference in operative time between the 2 groups (MD = 0.56, 95%CI [–11.86, 12.98], P = .93; P for heterogeneity = .001, I^2 = 73%).

3.4.3. Length of hospital stay. The forest plot for length of hospital stay (day) for all the included studies is shown in Figure 6. The overall results indicated that the length of hospital stay in the single door group was higher than that of the double door group (OR = –0.75, 95%CI [–1.78, 0.27], P = .15; P for heterogeneity = 1.00, I^2 = 0%).

3.4.4. Adverse events. The forest plot for adverse events of all the included studies is shown in Figure 7. The overall results indicated that the single door group had significantly higher rates of adverse events than the double door group (OR = 0.32, 95%CI [0.11, 0.95], P = .04; P for heterogeneity = 1.00, I^2 = 0%).

3.5. Sensitivity analysis

The heterogeneity of JOA score was moderate (I^2 = 45%). As shown in Figure 8, the high heterogeneity of the JOA score may be attributed to the different results of each study. When the study by Yamada et al was excluded, I^2 changed from 45% to 54%.

Table 1

Characteristics of the included studies.

Study	Year of publication	Language	Country	Age range (mean), yr	Gender (female/male)	Groups	n	Yr of onset
Fan et al[13]	2017	Chinese	China	56.52 ± 10.2	9/21	Double door	15	January 2012 to January 2017
						Single door	15	
Gu et al[14]	2014	English	China	58.6 ± 8.3	8/12	Double door	10	September 2010 to January 2013
						Single door	10	
Hirabayashi et al[15]	2010	English	Japan	62.7 ± 9.1	14/39	Double door	20	March 2002 to February 2008
						Single door	33	
Mandal[et al[16]	2016	English	India	60.3 ± 8.7	2/15	Double door	8	April2010 to April 2015
						Single door	9	
Rowe et al[17]	2018	English	USA	54.1 ± 10.1	13/17	Double door	15	January 2010 to January 2016
						Single door	15	
Tsutsumimoto et al[18]	2011	English	Japan	66.9 ± 9.3	9/31	Double door	20	January 2007 to May 2008
						Single door	20	
Wang et al[19]	2006	English	China	55.8 ± 9.4	14/20	Double door	11	January 2000 to May 2004
						Single door	23	

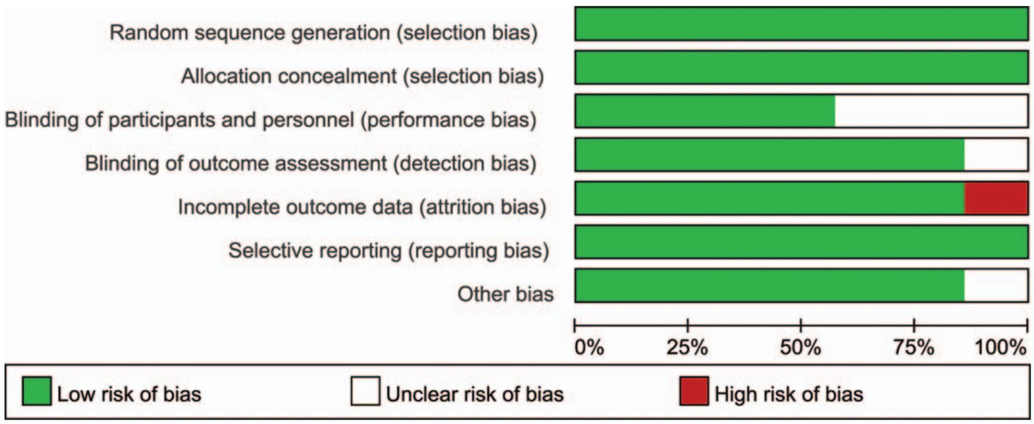

Figure 2. Assessment of the quality of the included studies: low risk of bias (green hexagons), unclear risk of bias (white hexagons), and high risk of bias (red hexagons).

3.6. Bias analysis

The funnel plot of JOA scores in the double door group and the single door group was drawn. All the studies were included in the plot. The results showed that the funnel plot had limited symmetry and some publication bias (Fig. 9).

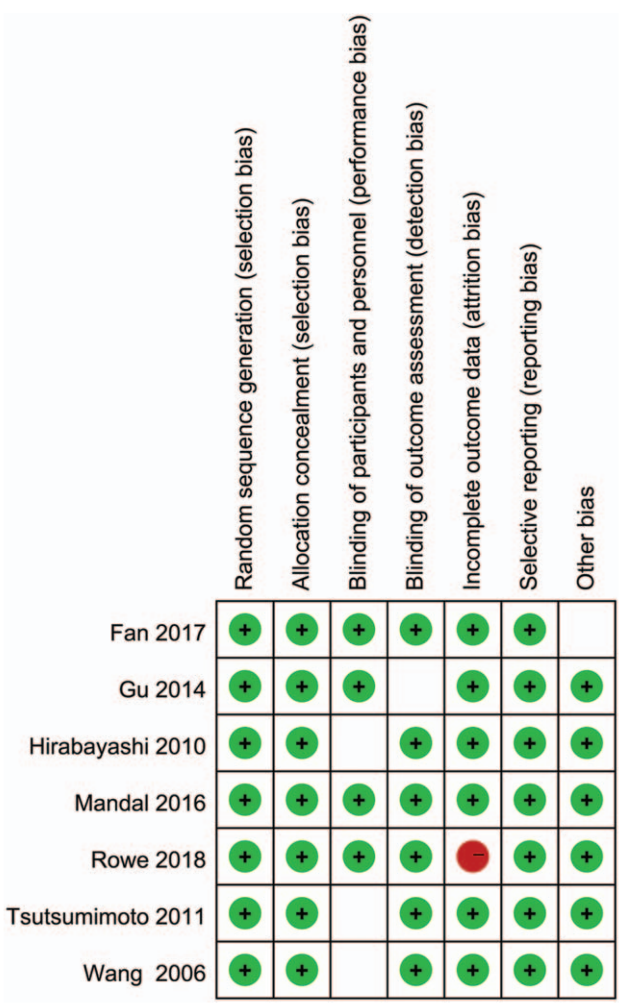

Figure 3. Quality assessment of the included studies.

4. Discussion

Cervical spondylosis is caused by degeneration of cervical intervertebral discs and associated secondary changes, congenital bone dysplasia, or other causes of cervical structural imbalance, stimulation, or compression of adjacent normal tissues, compromising spinal cord blood supply, and neurological function, leading to various clinical symptoms.[20–22] There are many types of cervical spondylosis, of which CSM is one of the most common CSMs. The main clinical manifestations are due to compression of the spinal cord, nerve and blood vessel, which results in severe neurological symptoms such as numbness and paresthesia of limbs as a result of cervical spinal stenosis.

Expanded cervical spinal canal plasty is the main method for the treatment of cervical spinal stenosis.[23–25] It can maintain the physiological position of patients and ensure the stability of the spine. It has little influence on cervical vertebral mobility of the patients.

The JOA scores of the double door group were higher than those of the single door group. This showed that double posterior cervical laminoplasty could improve the health status and quality of life of CSM patients. Zhang et al stated that compared with the single door laminoplasty, double door laminoplasty shortens the operation time and postoperative hospital stay, reduces the amount of bleeding during the operation, significantly reduces the loss rate of axial symptoms and cervical activity, and improves the quality of life of patients, which is consistent with our results.[26] The double door group had lower rates of complications than the single door group. This is consistent with Tao et al's report that after the single door operation, patients are more likely to have dural adhesion, scar formation and other postoperative complications such as reclosing and spinal instability. In double door posterior cervical laminoplasty, it can preserve the posterior structure of cervical vertebrae, maintain the stability of cervical vertebrae, reduce the situation of dural adhesion, and avoid the situation of lamina reclosing.[27] On the other hand, we found no statistical difference in operative time and length of hospital stay between the double door group and the single door group.

Some researchers reported that for the treatment of cervical spondylotic myelopathy, clinical surgeons can use different methods to open the door according to different indications. Because cervical surgery is a high-risk operation, at the same time, we should choose different surgical methods according to the

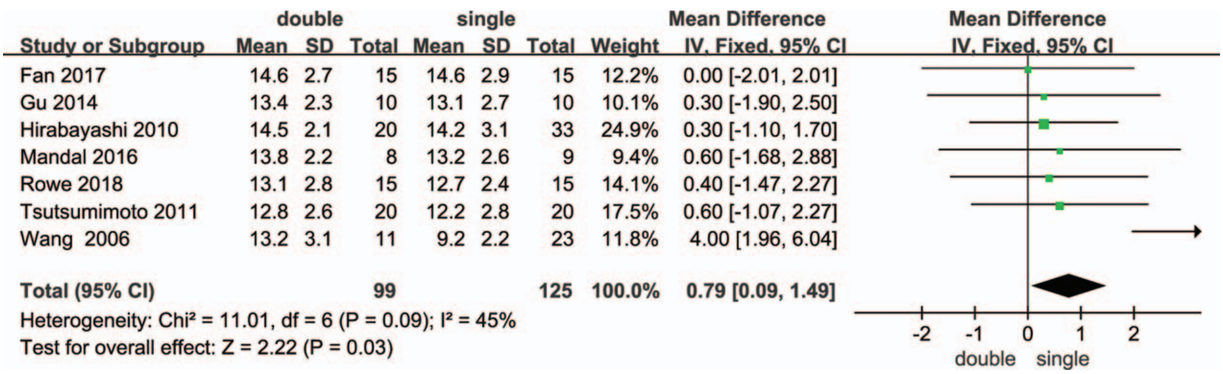

Figure 4. The forest plot for Japanese Orthopedic Association scores in the double door group versus the single door group.

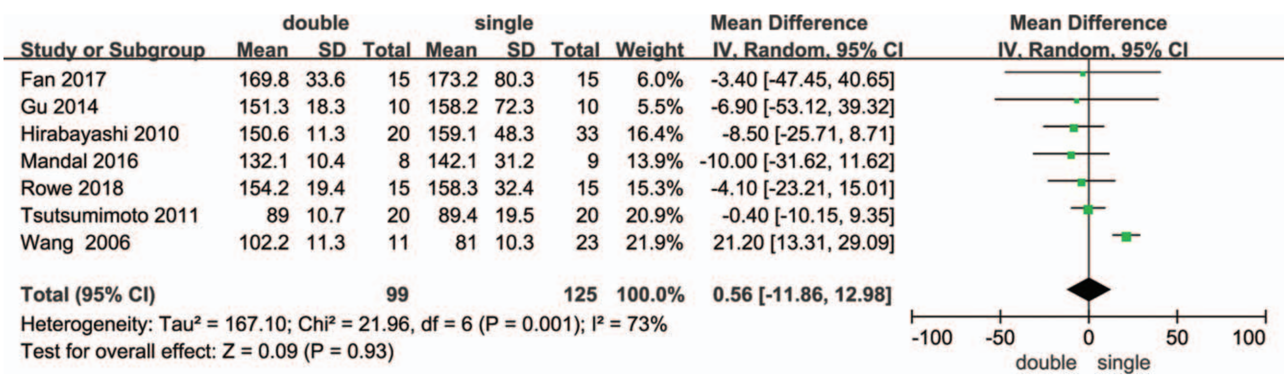

Figure 5. The forest plot for operative time in the double door group versus the single door group.

proficiency of the operator.[28] It is considered that the single open door operation is more suitable for patients with cervical spondylotic myelopathy, patients with severe ossification of the posterior longitudinal ligament or patients who cannot accept the double open door operation due to the small spinous process. The double door operation is more suitable for the vast majority of patients with cervical spondylotic myelopathy, patients with mild ossification of the posterior longitudinal ligament or patients with bilateral neuropathy.

The current meta-analysis has several limitations. First, the follow up data for CSM patients was not collected, which is little while only end point of follow up was gathered, and it could be evaluated in the future. Second, adverse events need to be analyzed in greater details, which could be conducted in future studies.

In this study, low heterogeneities of meta-analyses were observed, and according to the funnel plots, limited publication bias was present, which would support our results better. All the

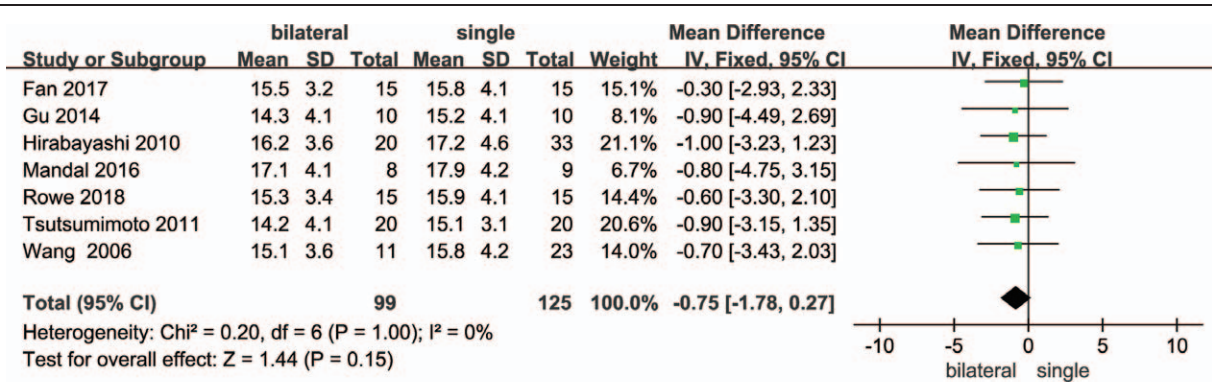

Figure 6. The forest plot for length of hospital stay in the double door group versus the single door group.

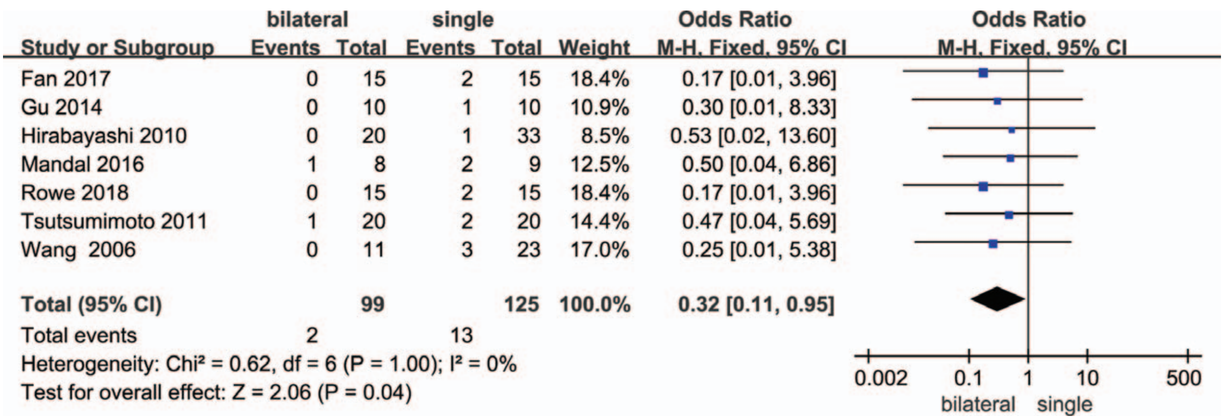

Figure 7. The forest plot for adverse events in the double door group versus the single door group.

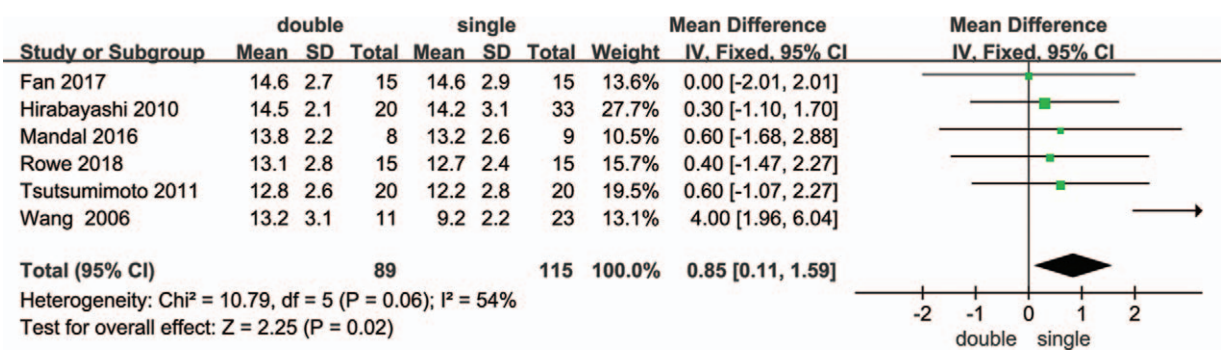

Figure 8. The forest plot for sensitivity analysis of Japanese Orthopedic Association scores in the double door group versus the single door group.

results show that double posterior cervical laminoplasty is an effective and safe therapy for CSM patients. These results are coincident with several published studies. Considering different indications and needs of patients, we can choose a proper one from these 2 therapies.

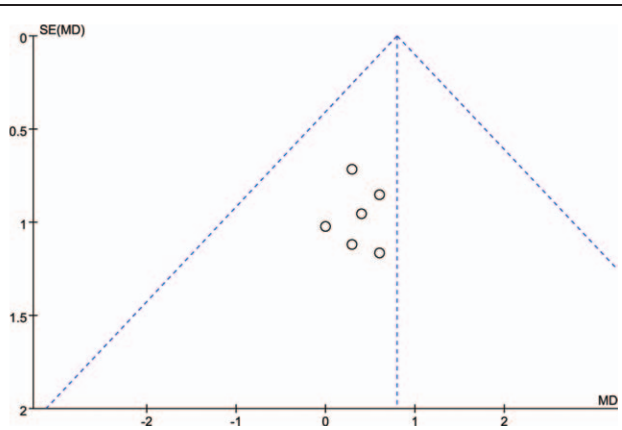

Figure 9. The funnel plot of publication bias.

Author contributions

Conceptualization: Jing-Xin Ma, Xiao-Zhen Han, Xiang-Yan Wang.
Data curation: Jing-Xin Ma, Xiao-Zhen Han.
Methodology: Xiang-Yan Wang.
Project administration: Xiang-Yan Wang.
Writing – original draft: Jing-Xin Ma, Xiao-Zhen Han
Writing – review & editing: Xiang-Yan Wang.

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