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Anterior versus posterior approach for the therapy of multilevel cervical spondylotic myelopathy: a meta-analysis and systematic review

Long Zhang[1] · **Jia Chen**[1] · **Can Cao**[1] · **Ya-Zhou Zhang**[1] · **Li-Fang Shi**[1] · **Jin-Shuai Zhai**[1] · **Teng Huang**[1] · **Xi-Cheng Li**[1]

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Abstract

Background The goal of this meta-analysis is to explore the overall efficacy as well as the safety of anterior versus posterior approach for the therapy of patients with multilevel cervical spondylotic myelopathy based on qualified studies.

Methods Three electronic databases, PubMed, Cochrane, Embase were searched updated to January 2018 to identify all relevant and qualified studies using the index words. The qualified studies were including prospective or retrospective comparative studies. Relative risk (RR) and mean difference (MD) along with 95% confidence interval (95% CI) were used to analyze the main outcomes.

Results In this meta-analysis, there were a total of 24 studies with 959 patients in the anterior approach group and 1072 patients in the posterior approach group. The final results showed, in comparison of the posterior approach group, the anterior approach group significantly increased the JOA score (SMD: 0.36, 95% CI 0.10–0.62), the operation time (WMD: 49.87, 95% CI 17.67–82.08), and the neurological recovery rate (WMD: 10.55, 95% CI 3.99–17.11) with higher complication rate (RR: 1.53, 95% CI 1.24–1.89). Besides, there was no significant difference of the blood loss (SMD: − 0.40, 95% CI − 1.12 to 0.32) and ROM (SMD: − 0.28, 95% CI − 0.78 to − 0.22) between posterior approach group and anterior approach group.

Conclusions Studies found a significant increase of JOA score as well as neurological recovery rate by the anterior approach treatment when compared with posterior approach treatment. However, increased operation time and complications could also occur through the anterior approach treatment. More high-quality randomized controlled trials with larger sample size, multi-centric and longer follow-ups are needed to support our current conclusions.

Keywords Multilevel cervical spondylotic myelopathy · Meta-analysis · Anterior approach · Posterior approach

Introduction

Cervical spondylotic myelopathy (CSM) is a neck condition that occurs when the spinal cord was compressed, which ultimately leads to progressive spinal cord dysfunction [1]. Spinal cord compression and cervical myelopathy can be caused by the degeneration of several parts, such as ligamentum flavum, posterior longitudinal ligament, uncovertebral joint, intervertebral disc, and facet joint [2]. Direct damage or alteration of neurologic pathways could occur when the above injuries and compression happen, which can also lead to traumatic spinal injury due to changes of pathophysiology to a larger extent [3]. Ossification of posterior longitudinal ligament (OPLL) as well as spinal stenosis is widely regarded as the two major conditions that cause CSM.

Multilevel CSM is often accompanied by a wide range of serious symptoms and higher operative risk with older age. It's still the main challenge for a spine surgeon to choose proper operative methods to improve the efficacy and safety of surgical treatment [4]. The overall aim of surgery is to expand the spinal canal, reduce nerve compression, and maintain the stability of cervical vertebrae. CSM could be treated with the following surgical treatments: the anterior approach, the posterior approach, and combined approach with both anterior and posterior side. Anterior cervical corpectomy with fusion (ACCF) and anterior cervical discectomy with fusion (ACDF) are included in the anterior

Long Zhang and Jia Chen Co-first authors.

✉ Xi-Cheng Li
lixicheng9999@163.com

1 Department of Orthopedics, Hebei General Hospital, No. 348 Heping East Road, Shijiazhuang 050051, Hebei, China

approaches. However, in typical posterior approaches, it includes laminoplasty and laminectomy. To relieve the spinal cord that is compressed, a solid cervical stability is set through ACCF/ACDF. Nevertheless, the surgeon's fluency in technology and bone grafts are required to reconstruct the cervical spine, which leads to higher incidence of complications [5, 6]. Posterior approaches, on the other hand, could protect the spinal cord from ventral compression through canal decompression in an indirect way. Nevertheless, if it is not sufficient for the cord for posterior shift, possibility is that cord still suffers from ventral constriction, and the recovery rate of myelopathy could be decreased. The complications include C5 root palsy and axial pain by applying the approach, which are also found by several studiers [7–9].

In this meta-analysis, the aim of the present study was to explore the overall effects and safety of anterior approach treatment versus posterior approach treatment for patients with multilevel cervical spondylotic myelopathy based on qualified studies.

Methods

Data sources and searches

Three electronic databases including The Cochrane, PubMed and Embase and all evidence-based studies were searched updated to January 2018 to identify all the qualified studies that involved multilevel CSM with anterior approach versus posterior approach. Additionally, publications and reference materials with correlation were also identified. The literature was independently searched and assessed by two reviewers. Any arising differences were settled by discussion with a third reviewer.

Study selection

Studies were eligible for inclusion if they met the following criteria: (1) retrospective or prospective comparative studies; (2) the included patients had no other serious combined disease; (3) anterior cervical canal decompression was performed in the anterior approach group; (4) posterior cervical canal decompression was performed in the posterior approach group; (5) the outcomes are including one of the Japanese Orthopedic Association (JOA) score, operation time, neurological recovery rate, blood loss, complications, range of motion (ROM).

The studies were excluded due to following criteria: (1) shared publications, or same results and content; (2) systematic review, meta-analysis, conference report, expert comment, theoretical research, economic analysis, case report; (3) irrelevant outcomes.

The full text of each study was independently searched by two reviewers for inclusion based on the predefined criteria. Any arising differences were settled by discussion with the aim of a third party.

Extraction process of data and quality assessment

We assessed and extracted eligible studies with two parts, which were basic information and main outcomes. The basic information was considered as the first part, including the authors' name, the publication year, the study design, the country, the sample size, the gender, the age. And the clinical outcomes were set as the second part, with JOA score, operation time, neurological recovery rate, blood loss, complications and range of motion (ROM). The relevant studies were independently assessed and performed by two studies and differences were then settled by discussion.

Data synthesis and analysis

We assessed the included studies using STATA 10.0 (TX, USA). Heterogeneity was identified to assess the results of the clinical trial using I^2 tests as well as Chi-squared and to determine the model for analysis (random-effect model or fixed-effect model). High heterogeneity was defined with the assessment of random effects model when I^2tests-value was larger than 50% and Chi-squared test *P* value was less than 0.05. Acceptable heterogeneity was defined with the assessment of fixed effects model when I^2 tests-value was less than 50% and Chi-squared test *P* value was larger than 0.05. The continuous variables are expressed as the mean ± standard deviation and analyzed by mean difference (MD). The categorical data were presented as percentages and analyzed by relative risk (RR) or odds ratio (OR). The complication was analyzed by RR and 95%CI. The operation time, JOA score, neurological recovery rate, blood loss, range of motion (ROM) were analyzed by MD and 95%CI.

Results

Study features

Totally, 1476 publications were identified using the index words. During the screening of abstract and title, 1382 publications were then excluded, leaving 95 publications for evaluation further. During full-text screening, 71 publications were excluded due to the following predefined criteria: no eligible grouping [17], has non clinical outcomes [31], theoretical research or review [14], risk factor analysis [9]. In the meta-analysis, at last 24 studies [10–33] were included with 959 patients in anterior approach group and 1072 patients in posterior approach group. The selection and evaluation details are shown in Fig. 1.

We summarized the included studies in term of main features in Table 1. 17 studies were retrospective studies; 6 studies were prospective studies. The countries of studies were including USA, Japan, Germany, South Korea, China. The main age of all the included studies was above 50 years.

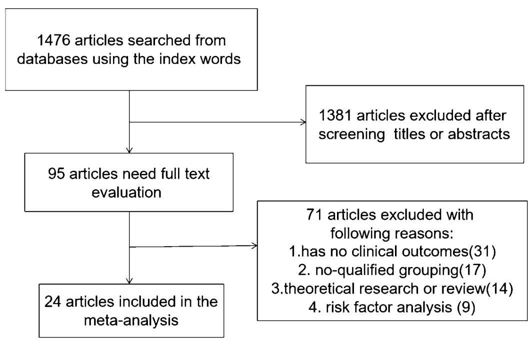


Fig. 1 Flow diagram of process of data searches and evaluation

JOA score

Nineteen studies with 829 patients in the posterior approach group and 807 patients in anterior approach group offered the data about JOA score. Based on I^2 tests-value ($I^2 = 83.3\%$) and Chi-squared test P value ($P = 0.000$), we chose a random effect model to analyze the JOA score. The pooled results showed the anterior approach group could significantly increase the JOA score (SMD: 0.36, 95% CI 0.10–0.62, Fig. 2) in comparison of the posterior approach group.

Operation time

Twelve studies provided the data about the operation time, with 548 patients in the posterior approach group and 654 patients in the anterior approach group. Based on the

Table 1 The basic characteristics description of included studies

Study	Study design	Country	No. of patients		Gender		Age	
			Anterior	Posterior	Anterior	Posterior	Anterior	Posterior
Edwards [2]	Non-randomized retrospective matched-cohort	USA	13	13	16M		53	54
Lin [11]	Non-randomized prospective controlled	China	27	24	19M	17M	52.2	54.5
Masaki [12]	Non-randomized retrospective controlled	Japan	19	40	14M	30M	51.8	62.6
Kristof [13]	Non-randomized retrospective controlled	Germany	42	61	31M	46M	62.5	66
Cabraja [14]	Non-randomized retrospective controlled	Germany	24	24	12M	17M	60.4	66.2
Ghogawala [15]	Non-randomized prospective controlled	USA	28	22	16M	16M	60	64
Hirai [16]	Non-randomized prospective comparative	Japan	39	47	27M	36M	59.2	61.2
Liu [17]	Non-randomized retrospective controlled	China	71	45	44M	30M	53.9	57.1
Shunzhi [18]	Non-randomized prospective comparative	China	29	24	–	–	59.6	
Yonenobu [19]	Non-randomized retrospective controlled	Japan	41	42	32M	29M	56	54.3
Lee [20]	Non-randomized retrospective controlled	South Korea	20	27	15M	26M	56.8	54.7
Iwasaki [21]	Non-randomized retrospective comparative	Japan	27	66	15M	51M	58	57
Chen [22]	Non-randomized retrospective comparative	China	22	25	14M	16M	57.2	54.2
Sakai (2012)	Non-randomized prospective comparative	Japan	20	22	–	–	59.5	58.4
Wada [24]	Non-randomized retrospective comparative	Japan	23	24	–	–	52.7	56.5
Liu [17]	Non-randomized retrospective controlled	China	25	27	14M	16M	54.64	57.33
Shibuya [26]	Non-randomized retrospective analysis of case series	Japan	34	49	–	–	60.4	64.8
Hirai [28]	Non-randomized prospective comparative cohort	Japan	24	27	16M	23M	58.3	57.9
Yoshii (2017)	Retrospective observational single-center study	Japan	33	46	22M	27M	64.5	68.5
Ren [29]	Non-randomized retrospective comparative	China	67	65	47M	45M	52.9	54.6
Qingfeng (2016)	Non-randomized retrospective comparative	China	29	25	22M	16M	58.4	57.2
Bo (2016)	Non-randomized retrospective comparative	China	34	22	22M	12M	57.2	56.5
Li [32]	Non-randomized retrospective cohort	China	19	76	8M	52M	53.9	56.3
Kato [33]	Prospective multicenter study	Canada	255	180	147M	120M	52.4	61.1

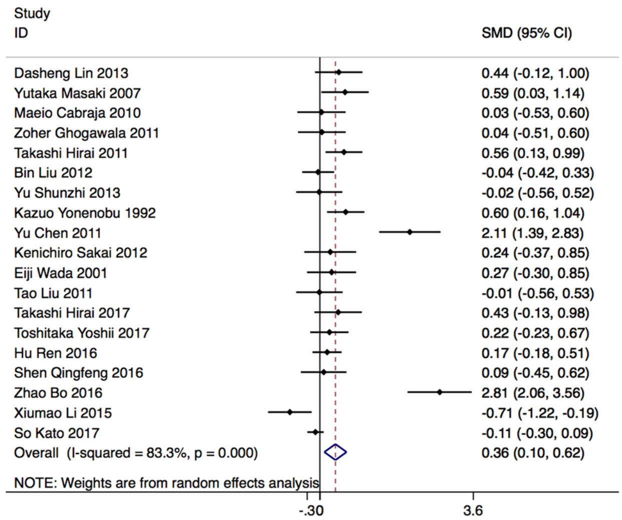


Fig. 2 Forest plot showing the JOA score of anterior approach versus posterior approach

I^2 tests-value ($I^2 = 97.1\%$) and Chi-squared test P value ($P = 0.000$), we chose a random effect model to analyze the operation time. The pooled results showed the anterior approach group could significantly increase the operation time (WMD: 49.87, 95% CI 17.67–82.08, Fig. 3) in comparison of the posterior approach group.

Neurological recovery rate

Fourteen studies with 677 patients in the posterior approach group and 691 patients in the anterior approach group and provided the data about the neurological recovery rate. Based on the I^2 tests-value ($I^2 = 88.3\%$) and Chi-squared test P value ($P = 0.000$), we chose a random effect model to analyze the neurological recovery rate. The pooled results showed the anterior approach group could significantly increase the neurological recovery rate (WMD: 10.55, 95% CI 3.99–17.11, Fig. 4) in comparison of the posterior approach group.

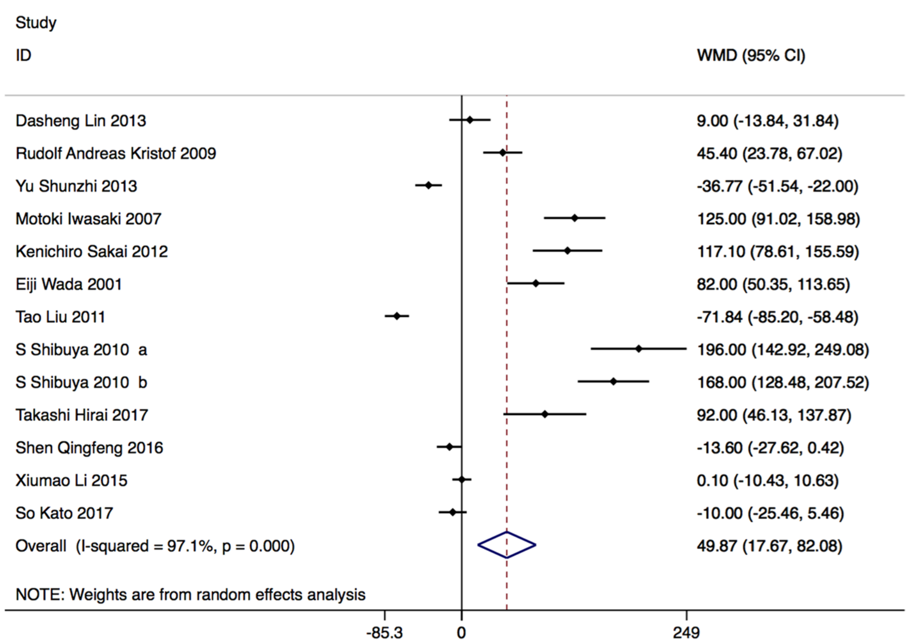
Complications

Fifteen studies with 667 patients in the posterior approach group and 683 patients in the anterior approach group provided the data about the complications. Based on the I^2 tests-value ($I^2 = 28.9\%$) and Chi-squared test P value ($P = 0.140$), we chose fixed-effect model to analyze the complications. The pooled results showed significant higher rate of complications in the anterior approach group in comparison of that in the posterior approach group (RR: 1.53, 95% CI 1.24–1.89, Fig. 5).

Blood loss

Twelve studies with 521 patients in the posterior approach group and 332 patients in the anterior approach group provided the data about the blood loss. Based on I^2 tests-value ($I^2 = 95.2\%$) and Chi-squared test P value ($P = 0.000$), we chose a random effect model to analyze the blood loss. The pooled results showed there was no significant difference of the blood loss between the posterior approach group and anterior approach group (SMD: − 0.40, 95% CI − 1.12 to 0.32, Fig. 6).

Fig. 3 Forest plot showing the operation time of anterior approach versus posterior approach



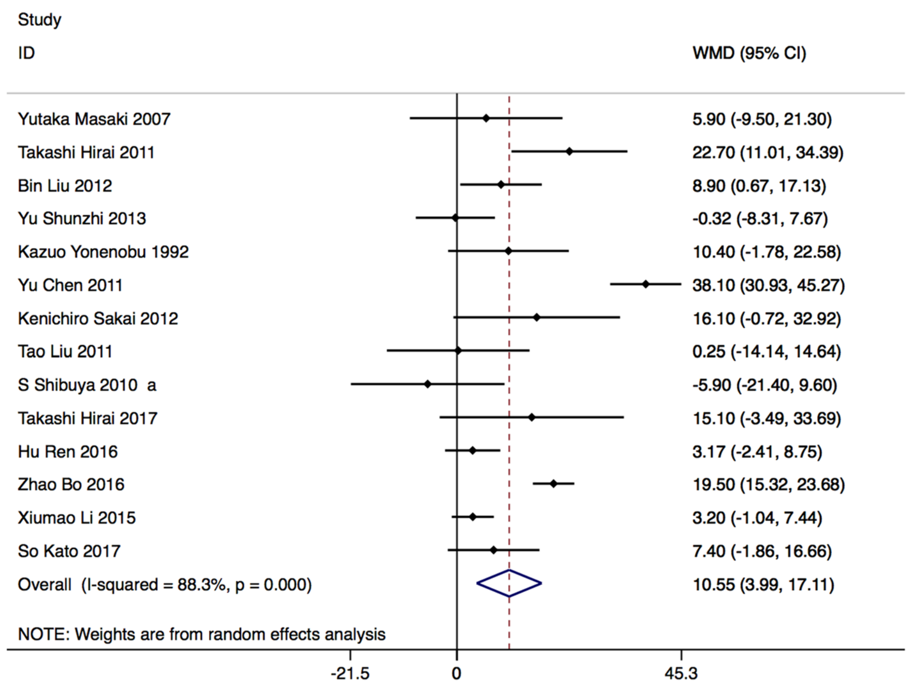


Fig. 4 Forest plot showing the neurological recovery rate of posterior approach versus anterior approach

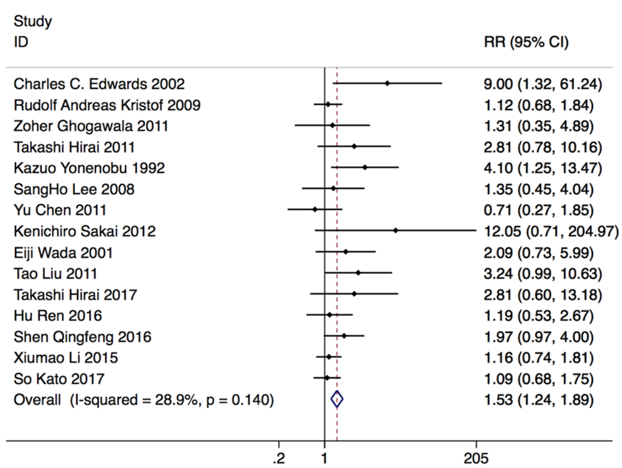


Fig. 5 Forest plot showing the complications of anterior approach versus posterior approach

ROM

Seven studies with 223 patients in the posterior approach group and 197 patients in the anterior approach group provided the data about the ROM. Based on the I^2 tests-value ($I^2=84.0\%$) and Chi-squared test P value ($P=0.000$) and, we chose a random effect model to analyze the ROM. The pooled results indicated no significant difference of the ROM between the posterior approach group and anterior approach group (SMD: − 0.28, 95% CI − 0.78 to − 0.22, Fig. 7).

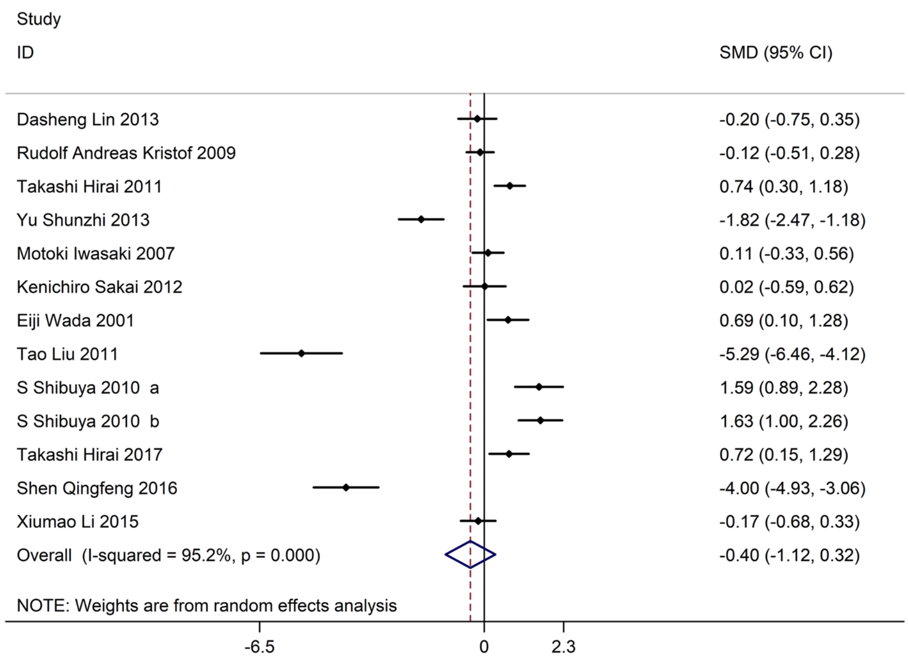
Eligibility and risk of bias assessment

According to the included and excluded criteria, a total of 24 publications were involved in the meta-analysis. The eligibility and risk of bias assessment were performed by funnel plot, Begg's and Mazumdar' s rank test, as well as the Egger's test. The funnel plot for log SMD in JOA score of relevant studies was notably symmetrical, suggesting significant publication bias (Fig. 8). Also, significant non-symmetry was calculated using Begg's and Mazumdar's rank test (Z = 1.96, $P=0.050$). However, the Egger's test result showed there was significant publication bias ($P=0.020$).

Discussion

The previous studies presented several similar meta-analyses about the posterior versus anterior approach for patients with multilevel cervical spondylotic myelopathy. Zihao Chen et al. [34] found no significant statistical difference in the preoperative JOA score ($P=0.08$, 95% CI − 0.02 to 0.40), complication rate ($P=0.17$, 95% CI 0.89–1.95), revision rate ($P=0.21$, 95% CI 0.72–4.61), operation time ($P=0.31$, 95% CI − 20.20–63.30), blood loss ($P=0.88$, 95% CI − 166.86–143.81) between the posterior group and anterior group. The anterior group appeared to be associated with higher postoperative JOA score ($P=0.02$, 95% CI 0.10–1.33) and recovery rate ($P=0.006$, 95% CI 2.33–13.90) compared with the posterior group. Jianquan Luo et al. [35] reported that no significant difference was observed in the JOA score before surgery [$P=0.05$,

Fig. 6 Forest plot showing the blood loss of posterior approach versus anterior approach



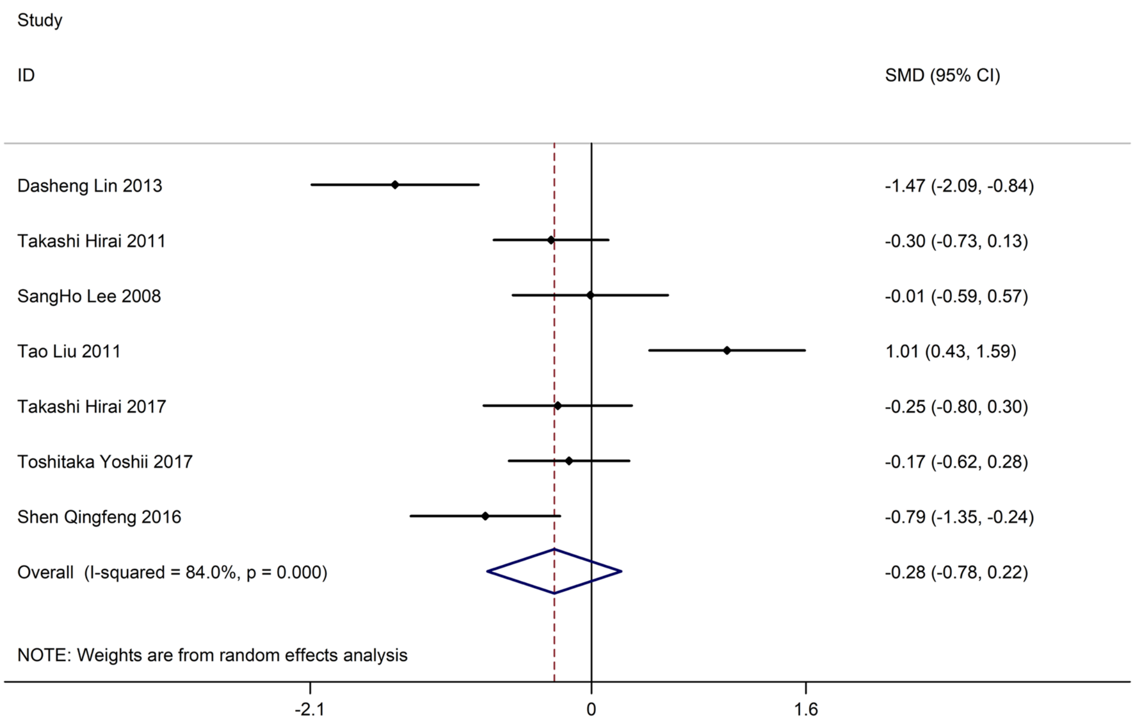


Fig. 7 Forest plot showing the ROM of posterior approach versus anterior approach

WMD − 0.00 (− 0.50, 0.50)], and recovery rate [$P = 0.05$, WMD 2.73 (− 8.69, 14.15)] between the posterior group and the anterior surgery group. The postoperative JOA score [$P = 0.05$, WMD 0.79 (0.16, 1.42)] and complication rate [$P = 0.009$, OR 1.65(1.13, 2.39)], the reoperation rate [$P = 0.0001$, OR 8.67(2.85, 26.34)], the intraoperative blood loss [$P = 0.05$, WMD − 40.25(− 76.96, − 3.53)] and operation time [$P = 0.00001$, WMD 61.3 (52.33, 70.28)] were significantly higher in anterior surgery group compared with posterior surgery group. Additionally, in anterior surgery group, there was a significantly lower duration in hospital in comparison of the posterior surgery group [$P = 0.00001$,

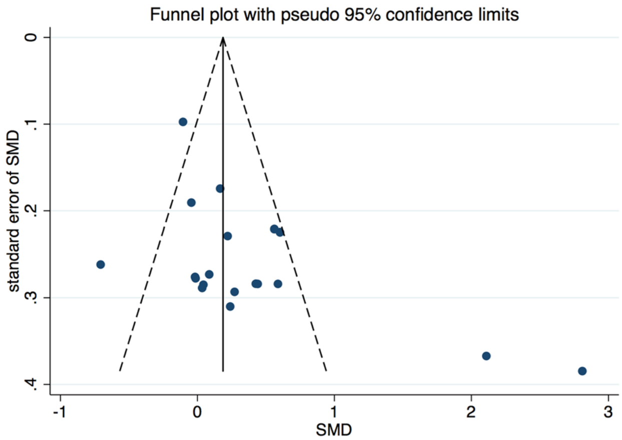


Fig. 8 Funnel plot of included studies in the meta-analysis

WMD − 1.07 (− 2.23, − 1.17)]. Yifu Sun et al. [36] concluded that shorter duration in hospital ($P=0.004$) and higher post-JOA score ($P=0.002$) in anterior approaches group were observed in comparison of posterior approaches; higher neurological recovery rate ($P=0.005$) and shorter operation time ($P<0.000$) were found in patients with ossification of posterior longitudinal ligament compared with posterior approaches; lower complication rate of posterior approaches was observed in spinal stenosis subgroup ($P<0.000$).

In this study, we included 24 studies and found that comparison of the posterior approach group, the anterior approach group significantly increased the JOA score (SMD: 0.36, 95% CI 0.10–0.62), the operation time (WMD: 49.87, 95% CI 17.67–82.08), and the neurological recovery rate (WMD: 10.55, 95% CI 3.99–17.11) with higher complication rate (RR: 1.53, 95% CI 1.24–1.89). The conclusions about JOA score, operation time and neurological recovery rate were consistent with the previous meta-analysis. The included study of So Kato et al. has supported the conclusions with larger sample and higher quality.

Admittedly, limitations exist in several aspects in the meta-analysis: (1) differences remain in the above-predefined criteria for objects; (2) patients with other previous diseases as well as treatments were not available; (3) surgical techniques in different studies are various; (4) the analysis used the pooled data with unavailable single patients' data, which limited more comprehensive analyses.

In conclusion, this meta-analysis and systematic review suggest that anterior approach treatment has several advantages in increasing the neurological recovery rate and JOA score compared with posterior approach treatment. Therefore, anterior approach treatment can be regarded as an alternative therapy for multilevel CSM. However, the posterior approach treatment appears to decrease the operation time as well as complications compared with the anterior approach treatment. Considering several limitations of this meta-analysis, more high-quality randomized controlled trials with larger sample size, multi-centric, and longer follow-ups are warranted to support the conclusions.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

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