

# Mini-plate fixation versus suture suspensory fixation in cervical laminoplasty

# A meta-analysis

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# Abstract

**Background:** Both the mini-plate fixation and suture suspensory fixation techniques are extensively applied in cervical laminoplasty, but which technique is superior has not been ascertained. The purpose of this meta-analysis is to compare the results between miniplate fixation and suture suspensory fixation in cervical laminoplasty for the patients with multilevel cervical compressive myelopathy.

**Methods:** PubMed, Embase, the Cochrane library, CNKI, and WANFANG were searched for studies that compared mini-plate fixation and suture suspensory fixation in cervical laminoplasty up to November 1, 2016. We calculated odds ratio (OR) with 95% confidence interval (CI) for dichotomous outcomes and mean difference (MD) with 95% CI for continuous outcomes. Review Manager 5.3 was used for the statistical analyses.

**Results:** A total of 25 studies, involving 1603 participants, were included in this review. The results of this meta-analysis indicated that there were statistically significant differences in postoperative Japanese Orthopedic Association (JOA) scores (MD=0.67, 95% CI: 0.34-0.99, P < 0.001), JOA scores improvement rate (MD=4.00, 95% CI: 2.51-5.50, P < 0.001), postoperative Visual Analogue Score (VAS) (MD=-0.81, 95% CI: -1.36 to -0.26, P=0.004), postoperative range of motion (ROM) (MD=4.15, 95% CI: 2.06-6.23, P < 0.001), postoperative cervical lordosis (MD=3.1, 95% CI: 2.02-4.18, P < 0.001), postoperative anteroposterior diameter of the spinal canal (MD=1.53, 95% CI: 0.11-2.95, P=0.03), postoperative open angle (MD=1.93, 95% CI: 0.14-3.71, P=0.03), postoperative cross-sectional area of the spinal canal (MD=37.10, 95% CI: 2.6.92-47.29, P < 0.001), axial symptoms (OR=0.28, 95% CI: 0.20-0.37, P < 0.001), operation time (MD=4.46, 95% CI: 0.74-8.19, P=0.02), and blood loss (MD=9.24, 95% CI: 6.86-11.62, P < 0.001). However, there was no statistically significant difference in C5 palsy (OR=0.82, 95% CI: 0.37-1.84, P=0.63).

**Conclusions:** As compared with suture suspensory fixation, mini-plate fixation in cervical laminoplasty appears to achieve better clinical and radiographic outcomes with fewer surgical complications. However, mini-plate fixation is associated with bigger surgical trauma. This conclusion should be interpreted cautiously and more high-quality, randomized controlled trials are needed in the future.

**Abbreviations:** CCS = cervical canal stenosis, CI = confidence interval, CSM = cervical spondylotic myelopathy, JOA = Japanese Orthopedic Association, MCCM = multilevel cervical compressive myelopathy, MD = mean difference, OPLL = ossification of the posterior longitudinal ligament, OR = odds ratio, ROM = range of motion, VAS = Visual Analogue Score.

Keywords: fusion, laminoplasty, meta-analysis, mini-plate, suture

Editor: Bernhard Schaller.

F-YuL, LM, and L-SH contributed equally to this work.

The manuscript submitted does not contain information about medical device(s)/ drug(s).

No funds were received in support of this work.

No relevant financial activities outside the submitted work.

The authors report no conflicts of interest.

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Medicine (2017) 96:5(e6026)

Received: 16 November 2016 / Received in final form: 8 January 2017 / Accepted: 9 January 2017

http://dx.doi.org/10.1097/MD.000000000006026

# 1. Introduction

Multilevel cervical compressive myelopathy (MCCM), including multisegment cervical spondylotic myelopathy (CSM), cervical canal stenosis (CCS), or ossification of the posterior longitudinal ligament (OPLL), usually lead to stepwise deterioration of neurologic function.<sup>[1]</sup> Surgical treatment especially posterior approaches can get satisfactory clinical results. Cervical laminoplasty has been well established for the treatment of MCCM and can achieve satisfactory long-term clinical outcomes.<sup>[2]</sup>

Hirabayashi et al<sup>[3]</sup> introduced unilateral open-door laminoplasty, which allowed extensive cord decompression with less substantial alteration to the natural biomechanics of the cervical spine and had been widely used. In the traditional method, the opened laminae are held by sutures between spinous process and facet capsule or paravertebral muscle. Although this technique has proven to be effective, several complications have been observed including axial symptoms and lamina closure.<sup>[4]</sup>

O'Brien et al<sup>[5]</sup> adapted maxillofacial miniplates and screws to fix the free lamina and lateral mass in their new positions. Miniplate fixation is efficient to prevent lamina closure by offering the lamina immediately rigid fixation.<sup>[6]</sup> Some studies compared clinical outcomes of mini-plate fixation versus suture suspensory fixation in cervical laminoplasty for treating MCCM.<sup>[7]</sup> However, results of those studies were different or contradictory owing to small sample sizes or low statistical power. Meta-analysis is a good statistical method to combine the results from multiple studies in an effort to increase statistical power, improve estimates of the magnitude of an effect, and resolve uncertainty across conflicting reports. So, we conducted a meta-analysis to compare complication, clinical, and radiographic outcomes of 2 surgical procedures in cervical laminoplasty for treating MCCM.

# 2. Methods

# 2.1. Ethics statement

As all analyses were based on previously published studies, ethical approval was not necessary in this review.

#### 2.2. Search strategy and study selection

An extensive search of literature was performed in PubMed, Embase, the Cochrane library, CNKI (Chinese database), and WANFANG (Chinese database) up to November 1, 2016. The languages were restricted to Chinese or English and only the published articles were included. The following key words were used for search: "cervical," "laminectomy," "plate," "suture," and "fusion" with various combinations of the operators "AND," "NOT," and "OR." The reference lists of included studies were also hand-searched for additional qualified studies.

#### 3. Inclusion and exclusion criteria

Studies were included if they met the following criteria:

(1) Participants: patients with MCCM, including CSM, CCS, and OPLL.

(2) Interventions: the intervention in the experimental group was cervical laminoplasty with mini-plate fixation.

(3) Comparisons: the intervention in the control group was cervical laminoplasty with suture suspensory fixation.

(4) Outcomes: Japanese Orthopedic Association (JOA) scores, Visual Analogue Score (VAS), range of motion (ROM), cervical lordosis, anteroposterior diameter of the spinal canal, open angle, cross-sectional area of the spinal canal, axial symptoms, C5 palsy, operation time, and blood loss were collected as the outcomes.

(5) Study design: randomized or nonrandomized controlled study.

The exclusion criteria were as follows: case reports, reviews, or letters; the same data had been published repeatedly; and outcomes of interest did not be reported. Two reviewers (Feng-Yu Liu and Lei Ma) independently selected the potentially qualified studies according to the inclusion and exclusion criteria. Any disagreement was resolved by discussion and the conformity was reached.

# 4. Data extraction and management

Two reviewers (Feng-Yu Liu and Li-Shuang Huo) extracted data independently. The data extracted included the following categories: study design, patients' demographic data (sample size, diagnoses, age, and sex), duration of follow-up, clinical evaluation (JOA and VAS), radiography evaluation (ROM, cervical lordosis, anteroposterior diameter of the spinal canal, open angle, and cross-sectional area of the spinal canal), complications (axial symptoms and C5 palsy), blood loss, and operation time.

#### 4.1. Quality assessment

As all studies included were nonrandomized controlled studies, the Newcastle–Ottawa Scale (NOS) was used to assess the quality of each study. This scale for nonrandomized case controlled studies and cohort studies was used to allocate a maximum of 9 points for the quality of selection, comparability, exposure, and outcomes for study participants.<sup>[1]</sup>

#### 4.2. Statistical analysis

We calculated odds ratio (OR) with 95% confidence interval (95% CI) for dichotomous outcomes and mean difference (MD) with 95% CI for continuous outcomes. *P* values less than 0.05 denoted significant differences.  $I^2$  statistic was used to quantify heterogeneity, where  $I^2$  greater than 50% implied significant heterogeneity. The random-effects model was used if there was significant heterogeneity. Otherwise, the fixed-effects model was used. Sensitivity analysis was conducted to examine the influence of excluding each study. Funnel plot was used to test the publication bias when more than 10 publications were included. Review Manager 5.3 (The Nordic Cochrane Center, The Cochrane Collaboration, Copenhagen, Denmark) was used for the statistical analyses.

#### 5. Results

#### 5.1. Search results

A total of 105 records were identified by the initial database search. Of these, 23 were discarded due to duplicate reports and 51 were excluded after reviewing the titles and abstracts. Another 6 studies were excluded for repeated data, incorrect data, or data could not be extracted. Finally, a total of 25 studies were included in our meta-analysis. The literature search procedure is shown in Fig. 1.



Figure 1. Flow diagram of study selection.

Table 1			
Characteri	stics of	included	studies

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			No. of pa	tients	Mean a	ge, y	No. of males	/Females	
Study	Design	Diagnosis	Mini-plate	Suture	Mini-plate	Suture	Mini-plate	Suture	Mean follow-up, mo
Wei et al <sup>[9]</sup>	Retrospective	CSM/OPLL	33	35	59.4	58.1	17/16	18/17	24
Wu et al <sup>[10]</sup>	Retrospective	CSM	15	17	59.5	61.3	8/7	9/8	12.5
Liu et al <sup>[11]</sup>	Retrospective	CSM/OPLL	26	30	55.4	57.4	15/11	17/13	13
Zhang et al <sup>[12]</sup>	Retrospective	CCS	16	14	51.2	50.7	10/6	7/7	31
Sun et al <sup>[13]</sup>	Retrospective	CSM	27	28	68.3	67.5	16/11	15/13	24
Zhang et al <sup>[14]</sup>	Retrospective	CSM	34	32	55.1	55.3	22/12	23/9	31.8
Jiang et al <sup>[15]</sup>	Retrospective	CSM	20	25	62.9	63.7	11/9	14/11	12
Hao et al <sup>[16]</sup>	Retrospective	CSM	96	46	59.9	59.6	56/40	27/19	24
He et al <sup>[17]</sup>	Retrospective	CSM	25	20	59.3	59.9	17/8	13/7	6
Zhou et al <sup>[18]</sup>	Retrospective	CSM	23	23	65.3	66.2	17/6	19/4	13.5/14.1
Huang et al <sup>[19]</sup>	Retrospective	CSM	40	40	62.0	63.0	24/16	22/18	6
Li et al <sup>[20]</sup>	Retrospective	CSM	43	49	56.6	58.0	32/11	37/12	24
Yang et al <sup>[21]</sup>	Retrospective	CCS	21	16	58.0	63.5	17/4	14/2	12
Li et al <sup>[22]</sup>	Prospective	CSM/CCS	31	31	56.7	55.4	20/11	18/13	6
Xie et al <sup>[23]</sup>	Retrospective	CSM	24	24	58.8	60.7	13/11	14/10	24
Zhang et al <sup>[24]</sup>	Retrospective	CSM	75	60	61.2	62.4	57/18	47/13	12.3/13.7
Zhang et al <sup>[25]</sup>	Retrospective	CSM/CCS/OPLL	16	18	58.3	62.4	12/4	13/5	6
Zeng et al <sup>[26]</sup>	Retrospective	CSM/CCS/OPLL	65	53	55.3	56.5	45/20	36/17	12
Chen et al <sup>[27]</sup>	Retrospective	CSM/CCS	22	30	59.1	53.8	14/8	14/16	12
Chen et al <sup>[8]</sup>	Prospective	CSM/CCS/OPLL	34	23	60.1	62.2	24/10	17/6	64
Xie et al <sup>[28]</sup>	Retrospective	CSM/CCS	27	40	59.3	57.6	17/10	27/13	18.3/17.6
Wang et al <sup>[29]</sup>	Retrospective	CSM	30	48	44.3	46.2	13/17	22/26	17/18
Jiang et al <sup>[2]</sup>	Retrospective	CCS	32	17	56.0	59.0	20/12	13/4	19/20.5
Chen et al <sup>[6]</sup>	Retrospective	CSM	29	25	61.2	63.2	25/4	20/5	23.3/25.8
Hu et al <sup>[4]</sup>	Prospective	CSM/CCS	25	30	54.8	56.3	12/13	17/13	20.1/21.5

CCS = cervical canal stenosis, CSM = cervical spondylotic myelopathy, OPLL = ossification of the posterior

longitudinal ligament.

# 5.2. Baseline characteristics and quality assessment

There were 25 studies included in this meta-analysis. These studies were published between 2012 and 2016. The number of study patients in mini-plate group and suture suspensory group ranged from 15 to 96 (total 829) and from 14 to 60 (total 774), respectively. Four studies were published in English, and the other 21 studies were in Chinese. Characteristics of included studies are presented in Table 1.<sup>[9–29]</sup>

As all studies included were nonrandomized controlled studies (3 in prospective and 22 in retrospective), the NOS was used to assess the quality of each study. Of these, 20 studies scored 8 points and 5 studies scored 7 points. Therefore, the quality of each study was relatively high (Table 2).

# 5.3. Clinical evaluation

Twenty-four studies reported the JOA scores (n=733 in miniplate group, and n=728 in suture group). There was no statistically significant difference between mini-plate group and suture group in preoperative JOA scores [P=0.72, MD=-0.03 (-0.22, 0.15); heterogeneity: P=0.98,  $I^2$ =0%, Fixed-effect model]. However, there were statistically significant differences between mini-plate group and suture group in postoperative JOA scores [P<0.001, MD=0.67 (0.34, 0.99); heterogeneity: P<0.001,  $I^2$ =64%, Random-effect model] (Fig. 2).

Thirteen studies reported the JOA scores improvement rate (n = 497 in mini-plate group, and n = 433 in suture group). There were statistically significant differences between mini-plate group and suture group in JOA scores improvement rate [P < 0.001, MD = 4.00 (2.51, 5.50); heterogeneity: P = 0.09,  $I^2 = 37\%$ , Fixed-effect model] (Fig. 2).

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The quality assessment according to the Newcastle Ottawa Scale
(NOS) of each study.

Study	Selection	Comparability	Exposure	Total score
Wei et al <sup>[9]</sup>	3	2	3	8
Wu et al <sup>[10]</sup>	3	2	3	8
Liu et al <sup>[11]</sup>	3	2	2	7
Zhang et al <sup>[12]</sup>	3	2	3	8
Sun et al <sup>[13]</sup>	3	2	2	7
Zhang et al <sup>[14]</sup>	3	2	2	7
Jiang et al <sup>[15]</sup>	3	2	3	8
Hao et al <sup>[16]</sup>	3	2	3	8
He et al <sup>[17]</sup>	3	2	3	8
Zhou et al <sup>[18]</sup>	3	2	3	8
Huang et al <sup>[19]</sup>	3	2	2	7
Li et al <sup>[20]</sup>	3	2	3	8
Yang et al <sup>[21]</sup>	3	2	3	8
Li et al <sup>[22]</sup>	3	2	3	8
Xie et al <sup>[23]</sup>	3	2	3	8
Zhang et al <sup>[24]</sup>	3	2	2	7
Zhang et al <sup>[25]</sup>	3	2	3	8
Zeng et al <sup>[26]</sup>	3	2	3	8
Chen et al <sup>[27]</sup>	3	2	3	8
Chen et al <sup>[8]</sup>	3	2	3	8
Xie et al <sup>[28]</sup>	3	2	3	8
Wang et al <sup>[29]</sup>	3	2	3	8
Jiang et al <sup>[2]</sup>	3	2	3	8
Chen et al <sup>[6]</sup>	3	2	3	8
Hu et al <sup>[4]</sup>	3	2	3	8

Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV. Fixed, 95% CI	IV. Fixed, 95% Cl
Chen 2012	9.48	2.28	29	9.24	1.42	25	3.5%	0.24 [-0.76, 1.24]	
Chen 2015a	8.7	1.8	22	9.3	2.4	30	2.7%	-0.60 [-1.74, 0.54]	
Chen 2015b	8.3	2.6	34	9.3	3.2	23	1.4%	-1.00 [-2.57, 0.57]	
He 2016	8.2	1.7	25	8.3	2	20	2.9%	-0.10 [-1.20, 1.00]	
Hu 2014	8	1.9	25	8.5	1.3	30	4.5%	-0.50 [-1.38, 0.38]	
Huang 2015	6.25	2.32	40	6.44	2.12	40	3.7%	-0.19 [-1.16, 0.78]	
Jiang 2012	9	0.7	32	9.2	1	17	12.3%	-0.20 [-0.73, 0.33]	
Jiang 2015	7.89	1.97	20	8.01	2.09	25	2.5%	-0.12 [-1.31, 1.07]	
Li 2013	8.12	1.56	43	8.23	1.21	49	10.5%	-0.11 [-0.69, 0.47]	
Li 2015	9.4	1.8	31	9.2	1.6	31	4.9%	0.20 [-0.65, 1.05]	
Liu 2014	1.2	2.9	26	1.3	4.3	30	1.0%	-0.10 [-2.00, 1.80]	
Sun 2012	9.1	2.2	21	8.9	2.4	28	2.4%	0.20 [-1.02, 1.42]	
Wang 2014	7.85	2.14	30	1.14	2.65	48	3.0%	0.11 [-0.96, 1.18]	
Wei 2014	7.0	2.5	33	1.5	3.0	30	1.0%	0.10[-1.37, 1.57]	
VVU 2013	9.1	2.0	15	9.3	2.1	17	1.3%	-0.20 [-1.85, 1.45]	
Xie 2014	0.2	0.9	21	0.1	17	40	7 20/	0.10[-0.36, 0.36]	
Xie 2010	9.0	1.0	24	9.5	2.2	16	1 99/	0.30 [-0.39, 0.99]	
Tang 2013	9.5	2.04	21	10.15	2.3	52	1.0%	0.40 [-0.99, 1.79]	
Zeng 2013	9.43	2.04	75	10.15	2.10	55	4.5%	-0.72 [-1.02, 0.10]	
Zhang 2012a	9.3	2.1	15	9.2	2.5	19	4.5%	0.10 [-0.76, 0.96]	
Zhang 20120	9.0	2.4	16	9.0	1.1	14	2 49/	0.20 [-2.20, 2.00]	
Zhang 2015	0.52	2.1	24	0.0	2 42	22	2.4 /0	0.30 [-0.91, 1.51]	
Zhang 2010	9.00	2.30	22	0.70	2.45	32	1.6%	0.75[-0.41, 1.91]	
21100 2011	0.9	2.1	23	9.1	2.4	23	1.070	-0.20 [-1.00, 1.20]	
Total (95% CI)			733			728	100.0%	-0.03 [-0.22 0.15]	+
Heterogeneity Chi2 -	10 00 4	f = 22	(P = 0	081.12 -	0%	. 20	100.070		
Test for overall effect:	7 = 0.34	(P=	0 721	, r =	5 10				-2 -1 0 1 2
Λ		. (							Plate Suture
A IOA	2								
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV. Random, 95% CI	IV. Random, 95% CI
Chen 2012	13 79	1 78	29	13.6	0.87	25	5.5%	0 19 [-0 54 0 92]	
Chen 2015a	13.2	28	22	12.9	16	30	3.4%	0.30 [-1.00, 1.60]	
Chen 2015h	13.4	24	34	13.8	27	23	3 3%	-0.40 [-1.77 0.97]	
He 2016	14.8	26	25	13.9	27	20	2.8%	0.90 [-0.66, 2.46]	
Hu 2014	15	13	25	14.5	0.8	30	6.1%	0.50 [-0.08, 1.08]	
Huana 2015	10 32	2 18	40	9.01	1.00	40	5.4%	1 31 [0 55 2 07]	
liang 2012	13.3	0.9	32	13.1	0.7	17	6.7%	0.201-0.26 0.661	
liang 2015	13 12	3 15	20	12.89	3 16	25	2 2%	0.23 [-1.62, 2.08]	
Li 2013	14 31	2.86	43	14 57	2.95	49	3.8%	-0.26 [-1.45 0.93]	
112015	13.7	2.00	31	13.4	31	31	3.0%	0.30 [-1.15, 1.75]	
Liu 2014	15.1	43	26	14.5	32	30	1.0%	0.60 [-1.41, 2.61]	
Sun 2012	13.2	24	27	13.1	2	28	3.8%	0 10 [-1 07 1 27]	
Wang 2014	13 24	1 36	30	13 10	1 25	48	6 1%	0.05 [-0.55 0.65]	
Wei 2014	14.5	26	33	13.2	37	35	2.9%	1 30 [-0.21, 2 81]	
Wu 2013	16.3	0.8	15	13.1	25	17	3.6%	3 20 [1 94 4 46]	
Xie 2014	12.7	1	27	12	13	40	6.3%	0 70 10 15 1 25	
Xie 2016	16.4	09	24	129	26	24	4 1%	3 50 [2 40 4 60]	
Vana 2013	13.5	1.8	21	13.6	21	16	3.5%	0 10 [-1 39 1 19]	
Zeng 2013	14.58	2 12	65	13.56	1.18	53	6.1%	1 02 [0 41 1 63]	
Zhang 2012a	13.9	22	75	13.6	1	60	6.3%	0.30 [-0.26, 0.86]	
Zhang 2012b	14 1	25	16	13.9	32	18	2.1%	0 20 [-1 72 2 12]	
Zhang 2015	13.6	32	16	13	26	14	1.9%	0.60 [-1 48 2 68]	
Zhang 2016	14 65	1 37	34	14 03	1 73	32	5.4%	0.62 [-0.14 1.38]	
Zhou 2011	13.9	2.1	23	13.1	1.9	23	3.9%	0.80 [-0.36, 1.96]	
Total (95% CI)			733			728	100.0%	0.67 [0.34, 0.99]	•
Heterogeneity: Tau <sup>2</sup> = 0	0.36; Ch	$hi^2 = 64$	.74, df	= 23 (P	< 0.00	001); l <sup>2</sup>	= 64%		-4 -2 0 2 4
Test for overall effect: 2	Z = 4.02	(P < 0	0.0001)						Plate Suture
В									
OA improvement	t rate	Plate		1.4	Suturo			Mean Difference	Mean Difference
Study or Subaroup	Mean	SD	Total	Mean	SD	Total	Weight	IV. Fixed, 95% CI	IV. Fixed, 95% CI
Chen 2012	57.48	16.51	29	56.1	8.22	25	4 8%	1.38 [-5.44, 8.20]	
Chen 2015a	54.2	18.2	22	55.6	21.7	30	1.9%	-1.40 [-12.27, 9.47]	
Chen 2015b	61.8	23.1	34	63.5	20.2	23	1.7%	-1.70 [-13.03, 9.63]	
Hao 2016	63.95	19.21	96	63.91	19.47	46	4.8%	0.04 [-6.77, 6.85]	
Hu 2014	78.2	11.9	25	70	11.5	30	5.8%	8.20 [1.98, 14.42]	
Jiang 2015	57.39	12.03	20	54.27	13.46	25	4.0%	3.12 [-4.34, 10.58]	
Liu 2014	72.6	4.7	26	65.4	5.1	30	33.9%	7.20 [4.63, 9.77]	
Xie 2014	50.6	9.8	27	43.6	13	40	7.5%	7.00 [1.53, 12.47]	
Yang 2013	56.2	14.3	21	60.8	17.5	16	2.0%	-4.60 [-15.13, 5.93]	
Zeng 2013	62.8	37.8	65	60.1	2.06	53	2.6%	2.70 [-6.51, 11.91]	
Zhang 2012a	58.3	10	75	57.1	9.2	60	21.2%	1.20 [-2.05, 4.45]	
Zhang 2016	65.17	21.13	34	61.53	23.97	32	1.9%	3.64 [-7.29, 14.57]	
Zhou 2011	58.3	9.7	23	56.7	8.9	23	7.7%	1.60 [-3.78, 6.98]	
T-1-1 (050) 00			100				100 000		
Total (95% CI)	0.07	- 10	497	12	70/	433	100.0%	4.00 [2.51, 5.50]	
management of the Child - 4	8.97. df	= 12 (	r = 0.09	リ; 1* = 3	1%				
Test for surger " - 1		10 - 0	00004						-10 -5 0 5 10

Figure 2. Forest plots of preoperative JOA (A), postoperative JOA (B), and JOA scores improvement rate (C) in the mini-plate fixation group and suture suspensory fixation group.

Four studies reported the VAS (n = 148 in mini-plate group and n=126 in suture group). There was no statistically significant difference between mini-plate group and suture group in preoperative VAS [P=0.82, MD=-0.05 (-0.37, 0.46); heterogeneity: P=0.85,  $I^2=0\%$ , Fixed-effect model]. However, there were statistically significant differences between mini-plate group and suture group in postoperative VAS [P=0.004, MD=-0.81

(-1.36, -0.26); heterogeneity: P = 0.006,  $I^2 = 76\%$ , Randomeffect model] (Fig. 3).

#### 5.4. Complications

Sixteen studies reported axial symptoms (n=518 in mini-plate group and n=459 in suture group). There were statistically

preoperative VAS	S	Plate		5	Suture			Mean Difference	Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI	IV. Fixed, 95% CI
Chen 2012	2.41	1.5	29	2.56	1.61	25	24.7%	-0.15 [-0.98, 0.68]	
Chen 2015b	4.85	2.34	34	4.96	2.38	23	11.0%	-0.11 [-1.36, 1.14]	
Jiang 2015	4.36	1.06	20	4.31	1.02	25	45.7%	0.05 [-0.56, 0.66]	
Zeng 2013	4.6	3.2	65	4.2	2.1	53	18.6%	0.40 [-0.56, 1.36]	
Total (95% CI)			148			126	100.0%	0.05 [-0.37, 0.46]	+
Heterogeneity: Chi <sup>2</sup> =	0.79, df	= 3 (P	= 0.85	); $ ^2 = 0$	%			+	
Test for overall effect:	Z = 0.23	3 (P =	0.82)					-2	2 -1 0 1 2
4									Plate Suture
postoperative VA	S	Plate		S	uture			Mean Difference	Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV. Random, 95% CI	IV. Random, 95% CI
Chen 2012	1.17	1.47	29	2.44	1.83	25	18.2%	-1.27 [-2.16, -0.38]	
Chen 2015b	1.59	0.7	34	1.74	0.75	23	30.1%	-0.15 [-0.54, 0.24]	
Jiang 2015	0.87	0.51	20	1.65	0.72	25	30.7%	-0.78 [-1.14, -0.42]	
Zeng 2013	1.8	2.1	65	3.2	2.1	53	21.0%	-1.40 [-2.16, -0.64]	
Total (95% CI)			148			126	100.0%	-0.81 [-1.36, -0.26]	-
Hotorogonalty Tau2 -	0.22; Ch	ni <sup>2</sup> = 12	2.48, df	= 3 (P =	= 0.00	6);   <sup>2</sup> = 1	76%		
neterogeneity. rau -									-2 -1 0 1 2
Test for overall effect:	Z = 2.89	(P = (	0.004)						

Figure 3. Forest plots of preoperative VAS (A) and postoperative VAS (B) in the mini-plate fixation group and suture suspensory fixation group.

axial symptoms	Plate	e	Sutur	re		Odds Ratio		Odds	Ratio	
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Fixed, 95% Cl		M-H. Fixe	d. 95% Cl	
Chen 2012	3	29	9	25	5.3%	0.21 [0.05, 0.87]				
Chen 2015a	6	22	14	30	5.2%	0.43 [0.13, 1.40]	_		_	
Chen 2015b	5	34	7	23	4.3%	0.39 [0.11, 1.45]	<u></u>	-	_	
Hao 2016	16	96	20	46	13.7%	0.26 [0.12, 0.57]	-	-		
He 2016	4	25	7	20	4.0%	0.35 [0.09, 1.45]			_	
Hu 2014	1	25	5	30	2.7%	0.21 [0.02, 1.92]				
Jiang 2012	12	32	6	17	3.0%	1.10 [0.32, 3.75]		-		
Li 2015	4	31	11	31	5.8%	0.27 [0.07, 0.97]	-	-		
Wang 2014	4	30	23	48	9.3%	0.17 [0.05, 0.55]		_		
Wu 2013	2	15	8	17	4.0%	0.17 [0.03, 1.01]	· · ·	-		
Xie 2014	6	27	19	40	7.3%	0.32 [0.11, 0.95]	-	-		
Xie 2016	3	24	11	24	5.9%	0.17 [0.04, 0.72]				
Yang 2013	4	21	10	16	5.6%	0.14 [0.03, 0.62]				
Zhang 2012a	17	75	36	60	18.8%	0.20 [0.09, 0.41]		_		
Zhang 2012b	3	16	6	18	2.8%	0.46 [0.09, 2.27]	2	-		
Zhang 2015	2	16	4	14	2.3%	0.36 [0.05, 2.34]	-			
Total (95% CI)		518		459	100.0%	0.28 [0.20, 0.37]		•		
Total events	92		196				5 7			23
Heterogeneity: Chi <sup>2</sup> =	9.59, df =	15 (P =	0.84); l <sup>2</sup>	= 0%			0.05 0	2 1	5	20
Test for overall effect:	Z = 8.36 (	P < 0.0	0001)				0.05 0.	Plate	Suture	20



Figure 4. Forest plots of axial symptoms (A) and C5 palsy (B) in the mini-plate fixation group and suture suspensory fixation group.

significant differences between mini-plate group and suture group in axial symptoms [P < 0.001, OR = 0.28 (0.20, 0.37); heterogeneity: P = 0.84,  $I^2 = 0\%$ , Fixed-effect model].

Seven studies reported C5 palsy (n=256 in mini-plate group and n=183 in suture group). There was no statistically significant difference between mini-plate group and suture group in C5 palsy [P=0.63, OR=0.82 (0.37, 1.84); heterogeneity: P=0.97,  $I^2$ = 0%, Fixed-effect model] (Fig. 4).

# 6. Radiography evaluation

Nine studies reported the ROM (n = 229 in mini-plate group and n = 210 in suture group). There was no statistically significant difference between mini-plate group and suture group in preoperative ROM [P=0.44, MD = -0.32 (-1.13, 0.49); heterogeneity: P=0.72,  $I^2 = 0\%$ , Fixed-effect model]. However, there were statistically significant differences between mini-plate group and suture group in postoperative ROM [P < 0.001, MD = 4.15 (2.06, 6.23); heterogeneity: P < 0.001,  $I^2 = 84\%$ , Random-effect model] (Fig. 5).

Fifteen studies reported the cervical lordosis (n=493 in miniplate group and n=482 in suture group). There was no statistically significant difference between mini-plate group and suture group in preoperative cervical lordosis [P=0.91, MD= 0.03 (-0.51, 0.57); heterogeneity: P=0.89,  $I^2$ =0%, Fixed-effect model]. However, there were statistically significant differences between mini-plate group and suture group in postoperative cervical lordosis [P<0.001, MD=3.10 (2.02, 4.18); heterogeneity: P<0.001,  $I^2$ =75%, Random-effect model] (Fig. 6).

Six studies reported anteroposterior diameter of the spinal canal (n=150 in mini-plate group and n=120 in suture group). There was no statistically significant difference between miniplate group and suture group in preoperative anteroposterior diameter of the spinal canal [P=0.08, MD=-0.39 (-0.81, 0.04); heterogeneity: P=0.56,  $I^2$ =0%, Fixed-effect model]. However, there were statistically significant differences between mini-plate group and suture group in postoperative anteroposterior diameter of the spinal canal [P=0.03, MD=1.53 (0.11, 2.95); heterogeneity: P<0.001,  $I^2$ =86%, Random-effect model] (Fig. 7).

Six studies reported open angle (n=208 in mini-plate group and n=193 in suture group). There were statistically significant differences between mini-plate group and suture group in postoperative open angle [P=0.03, MD=1.93 (0.14, 3.71); heterogeneity: P=0.03,  $I^2$ =61%, Random-effect model] (Fig. 7).

Four studies reported cross-sectional area of the spinal canal (n=109 in mini-plate group and n=102 in suture group). There was no statistically significant difference between mini-plate group and suture group in preoperative cross-sectional area of the spinal canal [P=0.57, MD=-2.26 (-11.69, 6.64); heterogeneity: P=0.96,  $I^2=0\%$ , Fixed-effect model]. However, there were statistically significant differences between mini-plate group and suture group in postoperative cross-sectional area of the spinal canal [P<0.001, MD=37.10 (26.92, 47.29); heterogeneity: P=0.15,  $I^2=44\%$ , Fixed-effect model] (Fig. 8).

preoperative RO	M	Plate			Suture			Mean Difference	Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI	IV. Fixed, 95% CI
Chen 2012	39.48	8.74	29	38.52	9.99	25	2.6%	0.96 [-4.09, 6.01]	
Chen 2015b	48.9	19.6	34	55.4	16.4	23	0.7%	-6.50 [-15.90, 2.90] +	
Jiang 2012	49.6	6.9	32	51.3	8.1	17	3.2%	-1.70 [-6.23, 2.83]	
Jiang 2015	44.97	12.78	20	45.26	12.31	25	1.2%	-0.29 [-7.68, 7.10]	
Liu 2014	37.3	5.7	26	36.9	6.5	30	6.5%	0.40 [-2.80, 3.60]	
Wei 2014	36.8	6.5	33	36.3	5.7	35	7.8%	0.50 [-2.41, 3.41]	
Wu 2013	51	2.6	15	52	1.8	17	26.8%	-1.00 [-2.57, 0.57]	
Xie 2016	51.5	2.7	24	52.1	2.2	24	34.1%	-0.60 [-1.99, 0.79]	
Zhang 2015	49.3	3	16	48.3	2.5	14	17.1%	1.00 [-0.97, 2.97]	
Total (95% CI)			229			210	100.0%	-0.32 [-1.13, 0.49]	•
Heterogeneity: Chi <sup>2</sup> =	5.37. df :	= 8 (P =	0.72):	$l^2 = 0\%$				and a second	
boostoperative RC	DM F	Plate	Total	S	uture	Total	Weight	Mean Difference	Mean Difference
oostoperative RC Study or Subgroup	DM F	Plate SD	Total	S Mean	Suture SD	Total	Weight	Mean Difference IV, Random, 95% CI	Mean Difference IV. Random. 95% Cl
oostoperative RC Study or Subgroup Chen 2012	DM F <u>Mean</u> 36.07	Plate SD 9.82	Total 29	S Mean 29.52	uture SD 10.13	Total 25	Weight 7.7%	Mean Difference IV. Random. 95% CI 6.55 [1.21, 11.89]	Mean Difference IV. Random. 95% Cl
oostoperative RC <u>Study or Subgroup</u> Chen 2012 Chen 2012 Linna 2012	DM F Mean 36.07 36.8	Plate SD 9.82 16.7	Total 29 34	S Mean 29.52 27.8	10.13 7.9	Total 25 23	Weight 7.7% 6.2%	Mean Difference IV. Random, 95% CI 6.55 [1.21, 11.89] 9.00 [2.52, 15.48] 1.30 (4.09, 1.40]	Mean Difference IV. Random. 95% Cl
oostoperative RC Study or Subgroup Chen 2012 Chen 2015b Jiang 2015	DM F Mean 36.07 36.8 40.1	Plate SD 9.82 16.7 4 8 39	Total 29 34 32 20	S Mean 29.52 27.8 41.4 30.72	50000000000000000000000000000000000000	Total 25 23 17 25	Weight 7.7% 6.2% 12.2% 7.8%	Mean Difference IV. Random, 95% Cl 6.55 [1.21, 11.89] 9.00 [2.52, 15.48] -1.30 [-4.09, 1.49] 6.17 [0.85, 11.49]	Mean Difference IV. Random. 95% Cl
Costoperative RC Study or Subgroup Chen 2012 Chen 2015b Jiang 2012 Jiang 2015 Liu 2014	DM F Mean 36.07 36.8 40.1 36.89 32.4	Plate SD 9.82 16.7 4 8.39 2.6	Total 29 34 32 20 26	S Mean 29.52 27.8 41.4 30.72 28.2	10.13 7.9 5.1 9.82 3.1	Total 25 23 17 25 30	Weight 7.7% 6.2% 12.2% 7.8% 14.5%	Mean Difference IV. Random, 95% Cl 6.55 [1.21, 11.89] 9.00 [2.52, 15.48] -1.30 [-4.09, 1.49] 6.17 [0.85, 11.49] 4.20 [2.71, 5.69]	Mean Difference IV. Random. 95% Cl
Costoperative RC Study or Subgroup Chen 2012 Chen 2015b Jiang 2012 Jiang 2015 Liu 2014 Wei 2014	DM <u>Mean</u> 36.07 36.8 40.1 36.89 32.4 34.5	9.82 16.7 4 8.39 2.6 2.7	Total 29 34 32 20 26 33	S Mean 29.52 27.8 41.4 30.72 28.2 26.7	10.13 7.9 5.1 9.82 3.1 2.8	Total 25 23 17 25 30 35	Weight 7.7% 6.2% 12.2% 7.8% 14.5% 14.8%	Mean Difference IV. Random, 95% Cl 6.55 [1.21, 11.89] 9.00 [2.52, 15.48] -1.30 [-4.09, 1.49] 6.17 [0.85, 11.49] 4.20 [2.71, 5.69] 7.80 [6.49, 9.11]	Mean Difference IV. Random. 95% Cl
Chen 2012 Chen 2012 Chen 2015b Jiang 2012 Jiang 2015 Liu 2014 Wei 2014 Wu 2013	DM 1 Mean 36.07 36.8 40.1 36.89 32.4 34.5 45	Plate SD 9.82 16.7 4 8.39 2.6 2.7 3.5	Total 29 34 32 20 26 33 15	S Mean 29.52 27.8 41.4 30.72 28.2 26.7 42	<b>SD</b> 10.13 7.9 5.1 9.82 3.1 2.8 2.4	Total 25 23 17 25 30 35 17	Weight 7.7% 6.2% 12.2% 7.8% 14.5% 14.8% 13.5%	Mean Difference IV. Random, 95% Cl 6.55 [1.21, 11.89] 9.00 [2.52, 15.48] -1.30 [-4.09, 1.49] 6.17 [0.85, 11.49] 4.20 [2.71, 5.69] 7.80 [6.49, 9.11] 3.00 (0.89, 5.11]	Mean Difference IV. Random, 95% Cl
Chen 2012 Chen 2012 Chen 2015b Jiang 2012 Jiang 2015 Liu 2014 Wei 2014 Wu 2013 Xie 2016	DM <u>Mean</u> 36.07 36.8 40.1 36.89 32.4 34.5 45 45.2	Plate SD 9.82 16.7 4 8.39 2.6 2.7 3.5 3.4	Total 29 34 32 20 26 33 15 24	S Mean 29.52 27.8 41.4 30.72 28.2 26.7 42 41.8	tuture <u>SD</u> 10.13 7.9 5.1 9.82 3.1 2.8 2.4 2.5	Total 25 23 17 25 30 35 17 24	Weight 7.7% 6.2% 12.2% 7.8% 14.5% 14.8% 13.5% 14.2%	Mean Difference IV. Random. 95% CI 6.55 [1.21, 11.89] 9.00 [2.52, 15.48] -1.30 [-4.09, 1.49] 6.17 [0.85, 11.49] 4.20 [2.71, 5.69] 7.80 [6.49, 9.11] 3.00 [0.89, 5.11] 3.40 [1.71, 5.09]	Mean Difference IV. Random, 95% CI
Chen 2012 Chen 2012 Chen 2015b Jiang 2015 Jiang 2015 Liu 2014 Wei 2014 Wu 2013 Xie 2016 Zhang 2015	DM <u>Mean</u> 36.07 36.8 40.1 36.89 32.4 34.5 45 45 45.2 42.5	Plate <u>SD</u> 9.82 16.7 4 8.39 2.6 2.7 3.5 3.4 6.5	Total 29 34 32 20 26 33 15 24 16	S Mean 29.52 27.8 41.4 30.72 28.2 26.7 42 41.8 41.3	<b>SD</b> 10.13 7.9 5.1 9.82 3.1 2.8 2.4 2.5 6.1	Total 25 23 17 25 30 35 17 24 14	Weight 7.7% 6.2% 12.2% 7.8% 14.5% 14.5% 13.5% 14.2% 9.0%	Mean Difference IV. Random, 95% CI 6.55 [1.21, 11.89] 9.00 [2.52, 15.48] -1.30 [-4.09, 1.49] 6.17 [0.85, 11.49] 4.20 [2.71, 5.69] 7.80 [6.49, 9.11] 3.00 [0.89, 5.11] 3.40 [1.71, 5.09] 1.20 [-3.31, 5.71]	Mean Difference IV. Random. 95% Cl
Chen 2012 Chen 2012 Chen 2015b Jiang 2012 Jiang 2015 Liu 2014 Wei 2014 Wu 2013 Xie 2016 Zhang 2015 Total (95% CI)	DM <u>Mean</u> 36.07 36.8 40.1 36.89 32.4 34.5 45 45.2 42.5	Plate <u>SD</u> 9.82 16.7 4 8.39 2.6 2.7 3.5 3.4 6.5	Total 29 34 32 20 26 33 15 24 16 229	S Mean 29.52 27.8 41.4 30.72 28.2 26.7 42 41.8 41.3	suture SD 10.13 7.9 5.1 9.82 3.1 2.8 2.4 2.5 6.1	Total 25 23 17 25 30 35 17 24 14 210	Weight 7.7% 6.2% 12.2% 7.8% 14.5% 14.5% 14.8% 13.5% 14.2% 9.0%	Mean Difference IV. Random. 95% CI 6.55 [1.21, 11.89] 9.00 [2.52, 15.48] -1.30 [-4.09, 1.49] 6.17 [0.85, 11.49] 4.20 [2.71, 5.69] 7.80 [6.49, 9.11] 3.00 [0.89, 5.11] 3.40 [1.71, 5.09] 1.20 [-3.31, 5.71] 4.15 [2.06, 6.23]	Mean Difference IV. Random, 95% CI
Chen 2012 Chen 2012 Chen 2015b Jiang 2015 Liu 2015 Liu 2014 Wei 2014 Wu 2013 Xie 2016 Zhang 2015 Total (95% Cl) Heterogeneity: Tau <sup>2</sup> =	DM <u>Mean</u> 36.07 36.8 40.1 36.89 32.4 34.5 45 45.2 42.5	Plate <u>SD</u> 9.82 16.7 4 8.39 2.6 2.7 3.5 3.4 6.5 $n^2 = 49$	Total 29 34 32 20 26 33 15 24 16 229 30 df	S Mean 29.52 27.8 41.4 30.72 28.2 26.7 42 41.8 41.3 = 8 (P <	suture <u>SD</u> 10.13 7.9 5.1 9.82 3.1 2.8 2.4 2.5 6.1 3.00000	Total 25 23 17 25 30 35 17 24 14 210	Weight 7.7% 6.2% 12.2% 7.8% 14.5% 14.5% 14.8% 9.0% 100.0% 84%	Mean Difference IV. Random, 95% CI 6.55 [1.21, 11.89] 9.00 [2.52, 15.48] -1.30 [-4.09, 1.49] 6.17 [0.85, 11.49] 4.20 [2.71, 5.69] 7.80 [6.49, 9.11] 3.00 [0.89, 5.11] 3.40 [1.71, 5.09] 1.20 [-3.31, 5.71] 4.15 [2.06, 6.23]	Mean Difference IV. Random, 95% CI

Figure 5. Forest plots of preoperative ROM (A) and postoperative ROM (B) in the mini-plate fixation group and suture suspensory fixation group.

preoperative lord	osis I	Plate		S	uture			Mean Difference	Mean D	ifference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI	IV, Fixe	d. 95% Cl
Chen 2012	18.93	4.88	29	19.32	5.27	25	3.9%	-0.39 [-3.11, 2.33]		
Chen 2015b	20.9	8.3	34	16	9.3	23	1.3%	4.90 [0.19, 9.61]		-
He 2016	18.3	1.9	25	18.6	5.1	20	5.2%	-0.30 [-2.66, 2.06]		
Jiang 2015	15.02	4.06	20	15.16	3.75	25	5.4%	-0.14 [-2.45, 2.17]		
Li 2013	17.9	8.3	43	18.2	6.4	49	3.1%	-0.30 [-3.36, 2.76]		
Sun 2012	17.9	2.2	27	17.8	2.4	28	19.6%	0.10 [-1.12, 1.32]	15	-
Wang 2014	15.52	7.21	30	15.15	7.18	48	2.7%	0.37 [-2.91, 3.65]	85	
Wei 2014	11.9	3.6	33	11.4	4.5	35	7.8%	0.50 [-1.43, 2.43]		
Xie 2014	22.8	4.7	18	21.2	4.4	27	3.9%	1.60 [-1.13, 4.33]		
Yang 2013	20.3	1.6	21	20.5	1.8	16	23.3%	-0.20 [-1.32, 0.92]		
Zeng 2013	14.8	5.3	65	15.2	8.6	53	4.1%	-0.40 [-3.05, 2.25]	-	
Zhang 2012a	18.5	5.8	75	19.2	5.3	60	8.2%	-0.70 [-2.58, 1.18]		
Zhang 2012b	17.9	5.2	16	18.1	6.3	18	1.9%	-0.20 [-4.07, 3.67]		
Zhang 2016	16.79	4.19	34	15.74	5.6	32	5.0%	1.05 [-1.35, 3.45]	25	
Zhou 2011	17.2	4.2	23	18.2	4.7	23	4.4%	-1.00 [-3.58, 1.58]		
Total (95% CI)			493			482	100.0%	0.03 [-0.51, 0.57]	-	
Heterogeneity: Chi <sup>2</sup> =	8.05. df	= 14 (F	P = 0.89	(); $ ^2 = 0$	%			6790088880000000 <u>4</u>	1 1	
Test for overall effect:	Z = 0.11	(P=0	).91)						-4 -2	0 2 4
٩									Favours [experimental]	Favours [control]
postoperative lord	dosis	Plate			Suture			Mean Difference	Mear	Difference
Study or Subgroup	Mean	SD	Tota	Mean	SD	Tota	Weigh	t IV. Random, 95%	6 CI IV. Ra	ndom, 95% Cl
Chen 2012	21.24	5.85	29	17.44	5.52	25	5 5.7%	3.80 [0.76, 6.8	84]	
Chen 2015b	17.5	5 9.9	34	10.4	12.3	23	3 2.4%	6 7.10 [1.07, 13.	13]	-
He 2016	18.7	6.4	25	16.5	5 5	20	5.2%	2.20 [-1.13, 5.	53]	
Jiang 2015	12.41	3.11	20	10.29	2.56	25	5 8.2%	2.12 [0.43, 3.4	81]	
Li 2013	18.1	7.9	43	15.9	5.7	49	6.0%	6 2.20 [-0.65, 5.0	05]	
Sun 2012	18.1	2.4	27	15.7	2	28	9.2%	6 2.40 [1.23, 3.5	571	
Wang 2014	15.09	6.14	30	11.58	6.08	48	6.19	3.51 [0.72, 6.3	301	
Wei 2014	11.2	3.8	33	7.5	2.6	35	8.5%	3.70 [2.14. 5.	261	
Xie 2014	21.5	5 47	18	16	46	27	6.19	5.50 [2.72 8:	281	
Yang 2013	19.9	15	21	18.8	13	16	9.6%	1.10 10.20 20	001	
Zeng 2013	18.3	5 1	65	10.3	5	53	7.9%	8.00 [6.17 9]	831	
Zhang 2012a	19 1	5.6	75	17 3	54	60	7 99	1.80 [-0.06 3]	661	
Zhang 2012b	18.2	48	16	16.3	5.9	15	4 89	1 90 [-1 70 5	50]	
Zhang 2016	14 54	4.0	24	12 36	6.04	30	6.4%	2 18 -0 46 4	821	
Zhou 2011	17.9	5.2	23	16.3	4.5	23	6.1%	1.60 [-1.21, 4.4	41]	
Total (95% CI)			403			482	100.0%	3 10 12 02 4 1	181	•
Hotorogonoitu Tou? -	2 05. 0	hi2 - 6	5 25	F - 14 (		100041	12 - 750/	0.10 [2.02, 4.1		
Test for overall effect:	= 2.95; C	3 (P <	0.0000	1 = 14 (	P < 0.0	0001)	1-= 75%		-4 -2	0 2 4
В									Pla	ale Sulure

Figure 6. Forest plots of preoperative cervical lordosis (A) and postoperative cervical lordosis (B) in the mini-plate fixation group and suture suspensory fixation group.

#### 6.1. Operation time and blood loss

Twenty studies reported operation time and blood loss (n=644 in mini-plate group and n=597 in suture group). There were statistically significant differences between mini-plate group and suture group in operation time [P=0.02, MD=4.46 (0.74, 8.19); heterogeneity: P=0.002,  $I^2$ =54%, Random-effect model]. There were statistically significant differences between mini-plate group and suture group in blood loss [P<0.001, MD=9.24 (6.86, 11.62); heterogeneity: P=0.02,  $I^2$ =44%, Fixed-effect model] (Fig. 9).

# 6.2. Sensitivity analysis

To confirm the stability of the meta-analysis, sensitivity analysis was performed by sequentially omitting individual eligible studies. The pooled results were not materially changed after any single study was excluded that indicated the stability of the results.

#### 6.3. Publication bias

Assessment of publication bias for included studies was performed by funnel plots on visual inspection (Fig. 10). Funnel plots showed nearly symmetric for operation time, blood loss, preoperative JOA, axial symptom, and preoperative cervical lordosis, indicating no significant publication bias among the included studies.

# 7. Discussion

Cervical laminoplasty can achieve satisfactory outcomes in the treatment of MCCM by effectively decompressing the spinal cord.<sup>[8]</sup> To fix the opened laminae, both the mini-plate fixation and suture suspensory fixation techniques are widely used in cervical laminoplasty. It has not been ascertained for which technique is superior. Chen et al<sup>[6]</sup> reported that laminoplasty by mini-plate fixation preserved more cervical ROM and better cervical alignment, but there were no significant differences in



Figure 7. Forest plots of preoperative anteroposterior diameter of the spinal canal (A), postoperative anteroposterior diameter of the spinal canal (B), and open angle (C) in the mini-plate fixation group and suture suspensory fixation group.

reoperative area	F	Plate		S	uture			Mean Difference		Mea	n Diffe	rence	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV. Fixed, 95% CI		IV, F	ixed. 9	95% CI	
Chen 2015b	156	28	34	162	30	23	34.4%	-6.00 [-21.46, 9.46]		-			
Liu 2014	134.2	35.6	26	135.7	38.1	30	22.0%	-1.50 [-20.82, 17.82]	-		-		
Wei 2014	135.9	34.9	33	136.2	35.1	35	29.7%	-0.30 [-16.94, 16.34]	-		-		
Zhang 2015	149	38	16	150	30	14	13.9%	-1.00 [-25.36, 23.36]					
Total (95% CI)			109			102	100.0%	-2.62 [-11.69, 6.44]		-		-	
Test for overall effect:	Z = 0.57	(P = (	0.57)						-20	PI	ate S	uture	20
A nostonerative area	a .												
A postoperative area Study or Subgroup	a F Mean	Plate	Total	S Mean	uture SD	Total	Weight	Mean Difference IV. Fixed, 95% CI		Mea IV, F	n Diffe Fixed. 9	rence 95% Cl	
A Dostoperative area Study or Subgroup Chen 2015b	a F Mean 320	Plate SD 50	Total 34	S Mean 301	uture SD 51	Total 23	Weight 14.5%	Mean Difference IV. Fixed. 95% Cl 19.00 [-7.77, 45.77]		Mea IV, F	n Diffe	rence 95% Cl	
A Dostoperative area Study or Subgroup Chen 2015b Liu 2014	a Mean 320 271.8	Plate SD 50 35.7	<b>Total</b> 34 26	S Mean 301 234.6	uture SD 51 39.5	Total 23 30	Weight 14.5% 26.7%	Mean Difference <u>IV. Fixed. 95% CI</u> 19.00 [-7.77, 45.77] 37.20 [17.50, 56.90]		Mea IV, F	n Diffe	erence 95% Cl	
A costoperative area <u>Study or Subgroup</u> Chen 2015b Liu 2014 Wei 2014	a Mean 320 271.8 274.1	50 35.7 34.3	<b>Total</b> 34 26 33	S Mean 301 234.6 242.6	51 39.5 38.3	<b>Total</b> 23 30 35	Weight 14.5% 26.7% 34.8%	Mean Difference IV. Fixed, 95% Cl 19.00 [-7.77, 45.77] 37.20 [17.50, 56.90] 31.50 [14.24, 48.76]		Mea IV, F	n Diffe	95% Cl	
A postoperative area <u>Study or Subgroup</u> Chen 2015b Liu 2014 Wei 2014 Zhang 2015	a Mean 320 271.8 274.1 306	Plate 50 35.7 34.3 30	<b>Total</b> 34 26 33 16	S Mean 301 234.6 242.6 250	<b>SD</b> 51 39.5 38.3 28	<b>Total</b> 23 30 35 14	Weight 14.5% 26.7% 34.8% 24.0%	Mean Difference IV, Fixed, 95% Cl 19.00 [-7.77, 45.77] 37.20 [17.50, 56.90] 31.50 [14.24, 48.76] 56.00 [35.23, 76.77]		Mea IV, F	n Diffe	erence 95% Cl	-
A postoperative area <u>Study or Subgroup</u> Chen 2015b Liu 2014 Wei 2014 Zhang 2015 Total (95% CI)	a Mean 320 271.8 274.1 306	Plate SD 50 35.7 34.3 30	Total 34 26 33 16 109	S Mean 301 234.6 242.6 250	<b>SD</b> 51 39.5 38.3 28	Total 23 30 35 14 102	Weight 14.5% 26.7% 34.8% 24.0% 100.0%	Mean Difference IV. Fixed. 95% Cl 19.00 [-7.77, 45.77] 37.20 [17.50, 56.90] 31.50 [14.24, 48.76] 56.00 [35.23, 76.77] 37.10 [26.92, 47.29]		Mea IV. F	n Diffe	erence 95% CI	

Figure 8. Forest plots of preoperative cross-sectional area of the spinal canal (A) and postoperative cross-sectional area of the spinal canal (B) in the mini-plate fixation group and suture suspensory fixation group.

operation time	1	Plate		S	uture			Mean Difference	Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	IV. Random, 95% Cl
Chen 2012	150.3	31.8	29	148.2	43.7	25	2.5%	2.10 [-18.57, 22.77]	
Chen 2015a	161	25.6	22	156	30.2	30	3.9%	5.00 [-10.21, 20.21]	
Chen 2015b	139	21	34	148	22	23	5.5%	-9.00 [-20.43, 2.43]	
Hao 2016	144.6	39.6	96	155.4	41.3	46	4.2%	-10.80 [-25.12, 3.52]	
He 2016	154.6	32.9	25	158.4	33	20	2.8%	-3.80 [-23.18, 15.58]	
Hu 2014	146	12.7	25	143	10.1	30	8.7%	3.00 [-3.15, 9.15]	
Huang 2015	74.8	29.8	40	81.6	32.8	40	4.5%	-6.80 [-20.53, 6.93]	
Jiang 2015	97.1	6.3	20	92.8	7.5	25	10.1%	4.30 [0.27, 8.33]	
Li 2013	81	26.8	43	73	28.6	49	5.6%	8.00 [-3.33, 19.33]	
Liu 2014	125.8	26.2	26	95.2	17.6	30	5.3%	30,60 [18,72, 42,48]	
Wei 2014	86.1	25.9	33	68.4	18.6	35	5.8%	17 70 16 93 28 471	
Wu 2013	155	12 3	15	148	14.4	17	6.7%	7 00 [-2 25 16 25]	
Xie 2014	168.6	28.5	27	160	28.5	40	4 4%	8 60 [-5 31 22 51]	
Xie 2016	153.2	11.8	24	151 9	13.5	24	8.0%	1 30 [-5 87 8 47]	
Yang 2013	202.9	62.3	21	202 5	49.6	16	1.0%	0 40 [-35 66 36 46]	
7hang 2012a	155	38.5	75	150	40.2	60	1.0%	5 00 [ 8 30 18 30]	
Zhang 2012b	100	26.9	15	110	40.2	10	4.0%	2.00 [-0.39, 10.39]	
Zhang 20120	122	20.0	10	119	20.0	10	3.0%	3.00 [-13.03, 21.03]	
Zhang 2015	100 00	30	10	140	32	14	2.0%	11.00 [-12.96, 34.96]	
Zhang 2016	109.29	13.28	34	108.91	13.67	32	8.5%	0.38 [-6.13, 6.89]	
Zhou 2011	121	35	23	112	30	23	2.9%	9.00 [-9.84, 27.84]	
Total (95% CI)			644			597	100.0%	4.46 [0.74, 8.19]	◆
Heterogeneity: Tau <sup>2</sup> =	31.67; CI	ni² = 41.	41, df =	= 19 (P =	0.002);	$ ^2 = 54$	%		
Test for overall effect:	Z = 2.35	(P = 0.0)	2)						-50 -25 0 25 50
٨		N. (* 17.77							Plate Suture
A									
blood loss	1	Plate		S	uture			Mean Difference	Mean Difference
blood loss Study or Subgroup	Mean	Plate SD	Total	S Mean	uture SD	Total	Weight	Mean Difference IV. Fixed. 95% C	Mean Difference IV. Fixed, 95% Cl
blood loss Study or Subgroup Chen 2012	Mean 375.9	Plate SD 107.4	Total 29	S Mean 358.4	uture SD 143.1	Total 25	Weight 0.1%	Mean Difference IV. Fixed, 95% C 17.50 [-50.87, 85.87]	Mean Difference IV. Fixed, 95% Cl
blood loss Study or Subgroup Chen 2012 Chen 2015a	Mean 375.9 356	Plate SD 107.4 96.2	Total 29 22	S Mean 358.4 348.4	uture SD 143.1 101.1	<b>Total</b> 25 30	Weight 0.1% 0.2%	Mean Difference IV. Fixed. 95% Cl 17.50 [-50.87, 85.87] 7.60 [-46.48, 61.68]	Mean Difference IV. Fixed, 95% Cl
blood loss Study or Subgroup Chen 2012 Chen 2015a Chen 2015b	Mean 375.9 356 241	Plate SD 107.4 96.2 108	Total 29 22 34	S <u>Mean</u> 358.4 348.4 189	uture SD 143.1 101.1 120	Total 25 30 23	Weight 0.1% 0.2% 0.2%	Mean Difference IV. Fixed, 95% C 17.50 [-50.87, 85.87] 7.60 [-46.48, 61.68] 52.00 [-9.02, 113.02]	Mean Difference IV. Fixed, 95% Cl
blood loss Study or Subgroup Chen 2012 Chen 2015a Chen 2015b Hao 2016	Mean 375.9 356 241 187.5	Plate SD 107.4 96.2 108 66.9	Total 29 22 34 96	<b>Mean</b> 358.4 348.4 189 202.6	uture SD 143.1 101.1 120 82.7	Total 25 30 23 46	Weight 0.1% 0.2% 0.2% 0.8%	Mean Difference IV. Fixed, 95% Cl 17.50 [-50.87, 85.87] 7.60 [-46.48, 61.68] 52.00 [-9.02, 113.02] -15.10 [-42.49, 12.29]	Mean Difference IV. Fixed, 95% Cl
blood loss <u>Study or Subgroup</u> Chen 2012 Chen 2015a Chen 2015b Hao 2016 He 2016	Mean 375.9 356 241 187.5 366.7	Plate SD 107.4 96.2 108 66.9 100.2	Total 29 22 34 96 25	<b>Mean</b> 358.4 348.4 189 202.6 361.9	uture SD 143.1 101.1 120 82.7 107.9	Total 25 30 23 46 20	Weight 0.1% 0.2% 0.2% 0.8% 0.1%	Mean Difference IV. Fixed. 95% Cl 17.50 [-50.87, 85.87] 7.60 [-46.48, 61.68] 52.00 [-9.02, 113.02] -15.10 [-42.49, 12.29] 4.80 [-56.67, 66.27]	Mean Difference IV. Fixed. 95% Cl
blood loss <u>Study or Subgroup</u> Chen 2012 Chen 2015a Chen 2015b Hao 2016 He 2016 Hu 2014	Mean 375.9 356 241 187.5 366.7 205.4	Plate SD 107.4 96.2 108 66.9 100.2 32.3	Total 29 22 34 96 25 25	<b>Mean</b> 358.4 348.4 189 202.6 361.9 208.7	uture SD 143.1 101.1 120 82.7 107.9 32	<b>Total</b> 25 30 23 46 20 30	Weight 0.1% 0.2% 0.2% 0.8% 0.1% 1.9%	Mean Difference IV. Fixed. 95% Cl 17.50 [-50.87, 85.87] 7.60 [-46.48, 61.68] 52.00 [-9.02, 113.02] -15.10 [-42.49, 12.29] 4.80 [-56.67, 66.27] -3.30 [-20.37, 13.77]	Mean Difference IV. Fixed. 95% Cl
blood loss <u>Study or Subgroup</u> Chen 2012 Chen 2015a Chen 2015b Hao 2016 He 2016 Hu 2014 Huang 2015	Mean 375.9 356 241 187.5 366.7 205.4 164.5	Plate SD 107.4 96.2 108 66.9 100.2 32.3 41.5	Total 29 22 34 96 25 25 40	S Mean 358.4 348.4 189 202.6 361.9 208.7 175.2	uture SD 143.1 101.1 120 82.7 107.9 32 56.6	Total 25 30 23 46 20 30 40	Weight 0.1% 0.2% 0.2% 0.8% 0.1% 1.9% 1.2%	Mean Difference IV. Fixed. 95% Cl 17.50 [-50.87, 85.87] 7.60 [-46.48, 61.68] 52.00 [-9.02, 113.02] -15.10 [-42.49, 12.29] 4.80 [-56.67, 66.27] -3.30 [-20.37, 13.77] -10.70 [-32.45, 11.05]	Mean Difference IV. Fixed. 95% Cl
blood loss Study or Subgroup Chen 2012 Chen 2015a Chen 2015b Hao 2016 He 2016 Hu 2014 Huang 2015 Jiang 2015	Mean 375.9 356 241 187.5 366.7 205.4 164.5 386.7	Plate <u>SD</u> 107.4 96.2 108 66.9 100.2 32.3 41.5 11.4	Total 29 22 34 96 25 25 40 20	S Mean 358.4 348.4 189 202.6 361.9 208.7 175.2 383.9	uture <u>SD</u> 143.1 101.1 120 82.7 107.9 32 56.6 12.3	Total 25 30 23 46 20 30 40 25	Weight 0.1% 0.2% 0.2% 0.8% 0.1% 1.9% 1.2% 11.8%	Mean Difference IV, Fixed, 95% Cl 17.50 [-50.87, 85.87] 7.60 [-46.48, 61.68] 52.00 [-9.02, 113.02] -15.10 [-42.49, 12.29] 4.80 [-56.67, 66.27] -3.30 [-20.37, 13.77] -10.70 [-32.45, 11.05] 2.80 [-4.14, 9.74]	Mean Difference IV. Fixed. 95% Cl
blood loss Study or Subgroup Chen 2012 Chen 2015a Chen 2015b Hao 2016 He 2016 Hu 2014 Huang 2015 Jiang 2015 Li 2013	Mean 375.9 356 241 187.5 366.7 205.4 164.5 386.7 158	Plate SD 107.4 96.2 108 66.9 100.2 32.3 41.5 11.4 46.7	Total 29 22 34 96 25 25 40 20 43	S Mean 358.4 348.4 189 202.6 361.9 208.7 175.2 383.9 159	uture <u>SD</u> 143.1 101.1 120 82.7 107.9 32 56.6 12.3 50.4	Total 25 30 23 46 20 30 40 25 49	Weight 0.1% 0.2% 0.2% 0.8% 0.1% 1.9% 1.2% 11.8% 1.4%	Mean Difference IV. Fixed, 95% Cl 17.50 [-50.87, 85.87] 7.60 [-46.48, 61.68] 52.00 [-9.02, 113.02] -15.10 [-42.49, 12.29] 4.80 [-56.67, 66.27] -3.30 [-20.37, 13.77] -10.70 [-32.45, 11.05] 2.80 [-4.14, 9.74] -1.00 [-20.85, 18.85]	Mean Difference IV. Fixed, 95% Cl
blood loss <u>Study or Subgroup</u> Chen 2012 Chen 2015a Chen 2015b Hao 2016 He 2016 Hu 2014 Huang 2015 Jiang 2015 Li 2013 Liu 2014	Mean 375.9 356 241 187.5 366.7 205.4 164.5 386.7 158 430.3	Plate SD 107.4 96.2 108 66.9 100.2 32.3 41.5 11.4 46.7 6.1	Total 29 22 34 96 25 25 40 20 43 26	S Mean 358.4 348.4 189 202.6 361.9 208.7 175.2 383.9 159 418.9	uture <u>SD</u> 143.1 101.1 120 82.7 107.9 32 56.6 12.3 50.4 5.2	Total 25 30 23 46 20 30 40 25 49 30	Weight 0.1% 0.2% 0.8% 0.1% 1.9% 1.2% 11.8% 1.4% 63.2%	Mean Difference IV. Fixed, 95% Cl 17.50 [-50.87, 85.87] 7.60 [-46.48, 61.68] 52.00 [-9.02, 113.02] -15.10 [-42.49, 12.29] 4.80 [-56.67, 66.27] -3.30 [-20.37, 13.77] -10.70 [-32.45, 11.05] 2.80 [-4.14, 9.74] -1.00 [-20.85, 18.85] 11.40 [8.41, 14.39]	Mean Difference
blood loss <u>Study or Subgroup</u> Chen 2012 Chen 2015a Chen 2015b Hao 2016 He 2016 Hu 2014 Huang 2015 Jiang 2015 Li 2013 Liu 2014 Wei 2014	Mean 375.9 356 241 187.5 366.7 205.4 164.5 386.7 158 430.3 436.2	Plate <u>SD</u> 107.4 96.2 108 66.9 100.2 32.3 41.5 11.4 46.7 6.1 89.4	Total 29 22 34 96 25 25 40 20 43 26 33	<b>S</b> <b>Mean</b> 358.4 348.4 189 202.6 361.9 208.7 175.2 383.9 159 418.9 346.3	<b>sp</b> 143.1 101.1 120 82.7 107.9 32 56.6 12.3 50.4 5.2 85.7	Total 25 30 23 46 20 30 40 25 49 30 35	Weight 0.1% 0.2% 0.8% 0.1% 1.9% 1.2% 11.8% 1.4% 63.2% 0.3%	Mean Difference IV. Fixed, 95% Cl 17.50 [-50.87, 85.87] 7.60 [-46.48, 61.68] 52.00 [-9.02, 113.02] -15.10 [-42.49, 12.29] 4.80 [-56.67, 66.27] -3.30 [-20.37, 13.77] -10.70 [-32.45, 11.05] 2.80 [-4.14, 9.74] -1.00 [-20.85, 18.85] 11.40 [8.41, 14.39] 89.90 [48.23, 131.57]	Mean Difference IV. Fixed. 95% Cl
blood loss <u>Study or Subgroup</u> Chen 2012 Chen 2015a Chen 2015b Hao 2016 He 2016 Hu 2014 Huang 2015 Jiang 2015 Li 2013 Liu 2014 Wei 2014 Wu 2013	Mean 375.9 356 241 187.5 366.7 205.4 164.5 386.7 158 430.3 436.2 407	Plate SD 107.4 96.2 108 66.9 100.2 32.3 41.5 11.4 46.7 6.1 89.4 11.8	Total 29 22 34 96 25 25 40 20 43 26 33 15	<b>S</b> <b>Mean</b> 358.4 348.4 189 202.6 361.9 208.7 175.2 383.9 159 418.9 346.3 398	uture <u>SD</u> 143.1 101.1 120 82.7 107.9 32 56.6 12.3 50.4 5.2 85.7 15.4	Total 25 30 23 46 20 30 40 25 49 30 35 17	Weight 0.1% 0.2% 0.8% 0.1% 1.9% 1.2% 1.8% 1.4% 63.2% 0.3% 6.3%	Mean Difference IV. Fixed. 95% Cl 17.50 [-50.87, 85.87] 7.60 [-46.48, 61.68] 52.00 [-9.02, 113.02] -15.10 [-42.49, 12.29] 4.80 [-56.67, 66.27] -3.30 [-20.37, 13.77] -10.70 [-32.45, 11.05] 2.80 [-4.14, 9.74] -1.00 [-20.85, 18.85] 11.40 [8.41, 14.39] 89.90 [48.23, 131.57] 9.00 [-0.45, 18.45]	Mean Difference IV. Fixed. 95% Cl
blood loss <u>Study or Subgroup</u> Chen 2012 Chen 2015a Chen 2015b Hao 2016 He 2016 Hu 2014 Huang 2015 Jiang 2015 Li 2013 Liu 2014 Wei 2014 Wu 2013 Xie 2014	Mean 375.9 356 241 187.5 366.7 205.4 164.5 386.7 158 430.3 436.2 407 347.2	Plate SD 107.4 96.2 108 66.9 100.2 32.3 41.5 11.4 46.7 6.1 89.4 11.8 93.1	Total 29 22 34 96 25 25 40 20 43 26 33 15 27	S Mean 358.4 348.4 189 202.6 361.9 208.7 175.2 383.9 159 418.9 346.3 398 320.4	uture SD 143.1 101.1 120 82.7 107.9 32 56.6 12.3 50.4 5.2 85.7 15.4 79.8	Total 25 30 23 46 20 30 40 25 49 30 35 17 40	Weight 0.1% 0.2% 0.8% 0.1% 1.9% 1.2% 11.8% 1.4% 63.2% 0.3% 6.3%	Mean Difference IV. Fixed. 95% Cl 17.50 [-50.87, 85.87] 7.60 [-46.48, 61.68] 52.00 [-9.02, 113.02] -15.10 [-42.49, 12.29] 4.80 [-56.67, 66.27] -3.30 [-20.37, 13.77] -10.70 [-32.45, 11.05] 2.80 [-4.14, 9.74] -1.00 [-20.85, 18.85] 11.40 [8.41, 14.39] 89.90 [48.23, 131.57] 9.00 [-0.45, 18.45] 26.80 [-16.15, 69.75]	Mean Difference IV. Fixed. 95% Cl
blood loss <u>Study or Subgroup</u> Chen 2012 Chen 2015a Chen 2015b Hao 2016 He 2016 Hu 2014 Huang 2015 Li 2013 Liu 2014 Wei 2014 Wei 2014 Xie 2016	Mean 375.9 356 241 187.5 366.7 205.4 164.5 386.7 158 430.3 436.2 400 347.2	Plate SD 107.4 96.2 108 66.9 100.2 32.3 41.5 11.4 46.7 6.1 89.4 11.8 93.1 11.7	Total 29 22 34 96 25 25 40 20 43 26 33 15 27 24	S Mean 358.4 348.4 189 202.6 361.9 208.7 175.2 383.9 159 418.9 346.3 398 320.4 399.6	<b>SD</b> 143.1 101.1 120 82.7 107.9 32 56.6 12.3 50.4 5.2 85.7 15.4 79.8 14.3	Total 25 30 23 46 20 30 40 25 40 25 30 35 17 40 24	Weight 0.1% 0.2% 0.8% 0.1% 1.2% 11.8% 1.4% 63.2% 0.3% 6.3% 0.3%	Mean Difference IV. Fixed. 95% Cl 17.50 [-50.87, 85.87] 7.60 [-46.48, 61.68] 52.00 [-9.02, 113.02] -15.10 [-42.49, 12.29] 4.80 [-56.67, 66.27] -3.30 [-20.37, 13.77] -10.70 [-32.45, 11.05] 2.80 [-4.14, 9.74] -1.00 [-20.85, 18.85] 11.40 [8.41, 14.39] 89.90 [48.23, 131.57] 9.00 [-0.45, 18.45] 26.80 [-16.15, 69.75] 9.50 [2.11, 16.89]	Mean Difference IV. Fixed. 95% CI
blood loss <u>Study or Subgroup</u> Chen 2012 Chen 2015a Chen 2015b Hao 2016 He 2016 Hu 2014 Huang 2015 Li 2013 Liu 2014 Wei 2014 Wei 2014 Wu 2013 Xie 2016 Yang 2013	Mean 375.9 356 241 187.5 366.7 205.4 164.5 386.7 158 430.3 436.2 407 347.2 409.1 361.9	Plate SD 107.4 96.2 108 66.9 100.2 32.3 41.5 11.4 46.7 6.1 89.4 11.8 93.1 11.7 11.7 125.4	Total 29 22 34 96 25 25 40 20 43 26 33 15 27 24 24 21	S Mean 358.4 348.4 189 202.6 361.9 208.7 175.2 383.9 159 418.9 346.3 398 320.4 399.6 337.5	<b>SD</b> 143.1 101.1 120 82.7 107.9 32 56.6 12.3 50.4 5.2 85.7 15.4 79.8 145.5	Total 25 30 23 46 20 30 40 25 49 30 35 17 40 24 16	Weight 0.1% 0.2% 0.8% 0.1% 1.9% 1.2% 1.4% 63.2% 0.3% 0.3% 0.3% 0.1%	Mean Difference IV. Fixed. 95% Cl 17.50 [-50.87, 85.87] 7.60 [-46.48, 61.68] 52.00 [-9.02, 113.02] -15.10 [-42.49, 12.29] 4.80 [-56.67, 66.27] -3.30 [-20.37, 13.77] -10.70 [-32.45, 11.05] 2.80 [-4.14, 9.74] -1.00 [-20.85, 18.85] 11.40 [8.41, 14.39] 89.90 [48.23, 131.57] 9.00 [-0.45, 18.45] 26.80 [-16.15, 69.75] 9.50 [2.11, 16.89] 24.40 [-64.82, 113.62]	Mean Difference IV. Fixed. 95% CI
blood loss <u>Study or Subgroup</u> Chen 2012 Chen 2015a Chen 2015b Hao 2016 Hu 2016 Hu 2014 Huang 2015 Jiang 2015 Li 2013 Liu 2014 Wei 2014 Wei 2014 Wu 2013 Xie 2014 Xie 2016 Yang 2013 Zhang 2012a	Mean 375.9 356 241 187.5 366.7 205.4 164.5 386.7 158 430.3 436.2 407 347.2 409.1 361.9 3500	Plate SD 107.4 96.2 108 66.9 100.2 32.3 41.5 11.4 46.7 6.1 89.4 11.8 93.1 11.7 125.6	Total 29 22 34 96 25 25 40 20 43 20 43 26 33 15 27 24 21 75	S Mean 358.4 348.4 189 202.6 361.9 208.7 175.2 383.9 159 418.9 346.3 398 320.4 399.6 337.5 350.4	<b>SD</b> 143.1 101.1 120 82.7 107.9 32 56.6 12.3 50.4 5.2 85.7 15.4 79.8 14.3 145.2 120.8	Total 25 30 23 46 20 30 40 25 49 30 35 17 40 24 60	Weight 0.1% 0.2% 0.8% 0.1% 1.9% 1.2% 11.8% 1.4% 63.2% 0.3% 0.3% 0.3% 0.3% 0.1% 0.1% 0.3%	Mean Difference IV. Fixed, 95% Cl 17.50 [-50.87, 85.87] 7.60 [-46.48, 61.68] 52.00 [-9.02, 113.02] -15.10 [-42.49, 12.29] 4.80 [-56.67, 66.27] -3.30 [-20.37, 13.77] -10.70 [-32.45, 11.05] 2.80 [-4.14, 9.74] -1.00 [-20.85, 18.85] 11.40 [8.41, 14.39] 89.90 [48.23, 131.57] 9.00 [-0.45, 18.45] 26.80 [-16.15, 69.75] 9.50 [2.11, 16.89] 24.40 [-64.82, 113.62]	Mean Difference IV. Fixed. 95% CI
blood loss <u>Study or Subgroup</u> Chen 2012 Chen 2015a Chen 2015b Hao 2016 Hu 2016 Hu 2014 Huang 2015 Jiang 2015 Li 2013 Liu 2014 Wei 2014 Wei 2014 Xie 2014 Xie 2014 Xie 2014 Xie 2014 Zhang 2012a Zhang 2012b	Mean   375.9   356   241   187.5   366.7   205.4   164.5   386.7   158   430.3   436.2   407   347.2   409.1   361.9   350	Plate SD 107.4 96.2 108.9 100.2 32.3 41.5 11.4 46.7 6.1 89.4 11.8 93.1 11.7 125.4 130.6 46.7	Total 29 22 34 96 25 25 40 20 43 26 33 15 27 24 21 5 16	S Mean 358.4 348.4 189 202.6 361.9 208.7 175.2 383.9 159 418.9 346.3 398 320.4 399.6 337.5 350.4 151	<b>SD</b> 143.1 101.1 1200 82.7 107.9 32 56.6 12.3 50.4 5.2 85.7 15.4 79.8 14.3 145.5 120.8 50.4 5.2 0 4 5.5 120.4	Total 25 30 23 46 20 30 40 25 49 30 35 17 40 24 16 60 60 81 8	Weight 0.1% 0.2% 0.8% 0.1% 1.9% 1.2% 11.8% 1.4% 63.2% 0.3% 0.3% 0.3% 0.1% 0.1% 0.5%	Mean Difference IV. Fixed, 95% Cl 17.50 [-50.87, 85.87] 7.60 [-46.48, 61.68] 52.00 [-9.02, 113.02] -15.10 [-42.49, 12.29] 4.80 [-56.67, 66.27] -3.30 [-20.37, 13.77] -10.70 [-32.45, 11.05] 2.80 [-4.14, 9.74] -1.00 [-20.85, 18.85] 11.40 [8.41, 14.39] 11.40 [8.41, 14.39] 89.90 [48.23, 131.57] 9.00 [-0.45, 18.45] 26.80 [-16.15, 69.75] 9.50 [2.11, 16.89] 24.40 [-64.82, 113.62] -0.40 [-42.92, 42.12] 2.00 [-30.65, 34.65]	Mean Difference IV. Fixed. 95% Cl
blood loss <u>Study or Subgroup</u> Chen 2012 Chen 2015a Chen 2015b Hao 2016 He 2016 Hu 2014 Huang 2015 Jiang 2015 Li 2013 Liu 2014 Wei 2014 Wei 2014 Wu 2013 Xie 2014 Xie 2016 Yang 2013a Zhang 2012a Zhang 2015	Mean 375.9 356 241 187.5 366.7 205.4 164.5 386.7 158 430.3 436.2 407 347.2 409.1 361.9 350 153 285	Plate <u>SD</u> 107.4 96.2 108 66.9 100.2 32.3 41.5 11.4 46.7 6.1 89.4 11.8 93.1 11.7 125.4 130.6 46.7 154	Total 29 22 34 96 25 25 40 20 43 26 33 15 27 24 21 75 16	S Mean 358.4 348.4 189 202.6 361.9 208.7 175.2 383.9 159 418.9 346.3 398.6 320.4 399.6 337.5 350.4 151 265	<b>SD</b> 143.1 101.1 120 82.7 107.9 32 56.6 12.3 50.4 5.2 85.7 15.4 79.8 14.3 145.5 120.8 50.4 51.4 79.8 14.3 145.5 120.8 50.4 14.5 120.8 50.4 14.5 14.5 14.5 14.5 14.5 14.5 14.5 14	Total 25 30 23 46 20 30 40 25 49 30 35 17 40 24 16 60 18	Weight 0.1% 0.2% 0.8% 0.1% 1.9% 1.2% 11.8% 1.4% 63.2% 0.3% 0.3% 0.3% 0.1% 0.3% 0.3%	Mean Difference IV. Fixed. 95% Cl 17.50 [-50.87, 85.87] 7.60 [-46.48, 61.68] 52.00 [-9.02, 113.02] -15.10 [-42.49, 12.29] 4.80 [-56.67, 66.27] -3.30 [-20.37, 13.77] -10.70 [-32.45, 11.05] 2.80 [-4.14, 9.74] -1.00 [-20.85, 18.85] 11.40 [8.41, 14.39] 89.90 [48.23, 131.57] 9.00 [-0.45, 18.45] 26.80 [-16.15, 69.75] 9.50 [2.11, 16.89] 24.40 [-64.82, 113.62] -0.40 [-42.92, 42.12] 20.00 [-87.44, 127.44]	Mean Difference IV. Fixed. 95% Cl
blood loss <u>Study or Subgroup</u> Chen 2012 Chen 2015a Chen 2015b Hao 2016 He 2016 Hu 2014 Huang 2015 Li 2013 Liu 2014 Wei 2014 Wei 2014 Wu 2013 Xie 2014 Xie 2016 Yang 2013 Zhang 2012a Zhang 2015 Zhang 2016	Mean   375.9   356   241   187.5   366.7   205.4   164.5   386.7   158   430.3   436.2   407   347.2   409.1   361.9   350   153   285   155.8%	Plate SD 107.4 96.2 108 66.9 100.2 32.3 41.5 11.4 46.7 6.1 89.4 11.8 93.1 11.7 125.4 130.6 46.7 156.67	Total 29 22 34 96 25 25 25 40 20 43 26 33 15 27 27 24 21 75 16 16 16	S Mean 358.4 348.4 189 202.6 361.9 208.7 175.2 383.9 159 418.9 346.3 398. 320.4 399.6 337.5 350.4 151 265 167.66	<b>SD</b> 143.1 101.1 120 82.7 107.9 32 56.6 12.3 50.4 5.2 85.7 15.4 79.8 14.3 145.5 120.8 50.4 145.5 120.8 50.4 145.6 68.4	Total 25 30 23 46 20 30 40 25 49 30 35 17 7 40 24 16 60 18 14 22 22	Weight 0.1% 0.2% 0.8% 0.1% 1.2% 11.8% 1.4% 63.2% 0.3% 6.3% 0.3% 0.3% 0.1% 0.5% 0.5%	Mean Difference IV. Fixed. 95% Ci 17.50 [-50.87, 85.87] 7.60 [-46.48, 61.68] 52.00 [-9.02, 113.02] -15.10 [-42.49, 12.29] 4.80 [-56.67, 66.27] -3.30 [-20.37, 13.77] -10.70 [-32.45, 11.05] 2.80 [-4.14, 9.74] -1.00 [-20.85, 18.85] 11.40 [8.41, 14.39] 89.90 [48.23, 131.57] 9.00 [-0.45, 18.45] 26.80 [-16.15, 69.75] 9.50 [2.11, 16.89] 24.40 [-64.82, 113.62] -0.40 [-42.92, 42.12] 2.00 [-30.65, 34.65] 20.00 [-87.44, 127.44] 11 78 [-42.10 18.63]	Mean Difference IV. Fixed. 95% Cl
blood loss <u>Study or Subgroup</u> Chen 2012 Chen 2015a Chen 2015b Hao 2016 He 2016 Hu 2014 Huang 2015 Jiang 2015 Li 2013 Liu 2014 Wei 2014 Wu 2013 Xie 2014 Xie 2016 Yang 2013 Zhang 2012a Zhang 2012b Zhang 2015 Zhang 2016 Zhang 2016	Mean   375.9   356   241   187.5   366.7   205.4   164.5   386.7   158   430.3   436.2   407   347.2   409.1   361.9   350   153.8   155.88   330	Plate SD 107.4 96.2 108 66.9 100.2 32.3 41.5 11.4 46.7 6.1 89.4 11.8 93.1 11.7 125.4 130.6 46.7 1567 115	Total 29 22 34 966 25 25 25 40 20 43 26 33 5 5 27 24 21 75 16 16 16 34 23	S Mean 358.4 348.4 189 202.6 361.9 208.7 175.2 383.9 159 418.9 346.3 398 320.4 399.6 337.5 350.4 151 265 167.66 328	<b>SD</b> 143.1 101.1 120 82.7 107.9 32 56.6 12.3 50.4 5.2 85.7 15.4 79.8 14.3 145.5 120.8 50.4 145.5 120.8 50.4 145.5 120.8 50.4 145.5 120.8 50.4 145.1 120.8 50.4 145.1 120.8 50.4 145.1 120.8 50.4 145.1 120.8 145.1 120.8 145.1 120.8 145.1 120.8 145.1 120.8 145.1 120.8 145.1 120.9 145.1 145.5 120.8 145.5	Total 25 30 23 46 20 30 40 25 49 30 35 17 40 24 16 60 18 14 32 23	Weight 0.1% 0.2% 0.8% 0.1% 1.2% 11.8% 1.4% 63.2% 0.3% 6.3% 0.3% 0.3% 0.5% 0.0% 0.6% 0.1%	Mean Difference IV. Fixed. 95% Ci 17.50 [-50.87, 85.87] 7.60 [-46.48, 61.68] 52.00 [-9.02, 113.02] -15.10 [-42.49, 12.29] 4.80 [-56.67, 66.27] -3.30 [-20.37, 13.77] -10.70 [-32.45, 11.05] 2.80 [-4.14, 9.74] -1.00 [-20.85, 18.85] 11.40 [8.41, 14.39] 89.90 [48.23, 131.57] 9.00 [-0.45, 18.45] 26.80 [-16.15, 69.75] 9.50 [2.11, 16.89] 24.40 [-64.82, 113.62] -0.40 [-42.92, 42.12] 20.00 [-30.65, 34.65] 20.00 [-87.44, 127.44] -11.78 [-42.19, 18.63] 2.00 [-66.82, 70.82]	Mean Difference IV. Fixed. 95% Cl
blood loss <u>Study or Subgroup</u> Chen 2012 Chen 2015a Chen 2015b Hao 2016 He 2016 Hu 2014 Huang 2015 Jiang 2015 Li 2013 Liu 2014 Wei 2014 Wei 2014 Wu 2013 Xie 2014 Xie 2016 Yang 2013 Zhang 2012a Zhang 2012b Zhang 2015 Zhang 2016 Zhou 2011	Mean   375.9   356   241   187.5   366.7   205.4   164.5   386.7   158   430.3   436.2   407   347.2   409.1   361.9   350   153   285   155.88   330	Plate <u>SD</u> 107.4 96.2 108 66.9 100.2 32.3 41.5 11.4 46.7 6.1 89.4 11.8 93.1 11.7 125.4 130.6 46.7 1564 56.67 115	Total 29 22 34 966 25 25 25 40 20 43 26 33 15 27 24 21 75 16 16 34 23	S Mean 358.4 348.4 189 202.6 361.9 208.7 175.2 383.9 159 418.9 346.3 398 320.4 399.6 337.5 350.4 151 265 167.66 328	<b>SD</b> 143.1 101.1 120 82.7 107.9 32 56.6 12.3 50.4 5.2 85.7 15.4 79.8 14.3 145.5 120.8 50.4 145.5 120.8 50.4 146.6 68.4 123	Total 25 30 23 46 20 30 40 25 49 30 35 17 40 24 16 60 18 14 32 23	Weight 0.1% 0.2% 0.8% 0.1% 1.2% 11.8% 1.4% 63.2% 0.3% 6.3% 0.3% 0.1% 0.5% 0.6% 0.1%	Mean Difference IV. Fixed. 95% Cl 17.50 [-50.87, 85.87] 7.60 [-46.48, 61.68] 52.00 [-9.02, 113.02] -15.10 [-42.49, 12.29] 4.80 [-56.67, 66.27] -3.30 [-20.37, 13.77] -10.70 [-32.45, 11.05] 2.80 [-4.14, 9.74] -1.00 [-20.85, 18.85] 11.40 [8.41, 14.39] 89.90 [48.23, 131.57] 9.00 [-0.45, 18.45] 26.80 [-16.15, 69.75] 9.50 [2.11, 16.89] 24.40 [-64.82, 113.62] -0.40 [-42.92, 42.12] 20.00 [-87.44, 127.44] -11.78 [-42.19, 18.63] 2.00 [-66.82, 70.82]	Mean Difference IV. Fixed. 95% Cl
blood loss <u>Study or Subgroup</u> Chen 2012 Chen 2015a Chen 2015b Hao 2016 He 2016 Hu 2014 Huang 2015 Jiang 2015 Li 2013 Liu 2014 Wei 2014 Wei 2014 Wu 2013 Xie 2014 Xie 2016 Yang 2013 Zhang 2012a Zhang 2012b Zhang 2015 Zhang 2016 Zhou 2011 Total (95% Cl)	Mean   375.9   356   241   187.5   366.7   205.4   164.5   386.7   158   430.3   436.2   407   347.2   409.1   361.9   350   155.88   330	Plate <u>SD</u> 107.4 96.2 108 66.9 100.2 32.3 41.5 11.4 46.7 6.1 89.4 11.8 93.1 11.7 125.4 130.6 46.7 155 46.7 115	Total   29   24   966   255   25   25   40   20   43   26   33   15   27   24   21   75   16   16   34   23   644	S Mean 358.4 348.4 189 202.6 361.9 208.7 175.2 383.9 159 418.9 346.3 398.6 320.4 399.6 337.5 350.4 151 2655 167.66 328	<b>SD</b> 143.1 101.1 120 82.7 107.9 32 56.6 12.3 50.4 5.2 85.7 15.4 79.8 14.3 145.5 120.8 50.4 145.5 120.8 50.4 145.6 68.4 123	Total 25 30 23 46 20 30 40 25 49 30 35 17 40 24 16 60 18 14 22 3 23 597	Weight 0.1% 0.2% 0.8% 0.1% 1.9% 1.2% 11.8% 1.4% 63.2% 0.3% 6.3% 0.3% 0.1% 0.5% 0.6% 0.6% 0.1%	Mean Difference IV. Fixed. 95% Cl 17.50 [-50.87, 85.87] 7.60 [-46.48, 61.68] 52.00 [-9.02, 113.02] -15.10 [-42.49, 12.29] 4.80 [-56.67, 66.27] -3.30 [-20.37, 13.77] -10.70 [-32.45, 11.05] 2.80 [-4.14, 9.74] -1.00 [-20.85, 18.85] 11.40 [8.41, 14.39] 89.90 [48.23, 131.57] 9.00 [-0.45, 18.45] 26.80 [-16.15, 69.75] 9.50 [2.11, 16.89] 24.40 [-64.82, 113.62] -0.40 [-42.92, 42.12] 20.00 [-87.44, 127.44] -11.78 [-42.19, 18.63] 2.00 [-66.82, 70.82] 9.24 [6.86, 11.62]	Mean Difference IV. Fixed. 95% Cl
blood loss <u>Study or Subgroup</u> Chen 2012 Chen 2015a Chen 2015b Hao 2016 He 2016 Hu 2014 Huang 2015 Li 2013 Liu 2014 Wei 2014 Wei 2014 Wu 2013 Xie 2014 Xie 2016 Yang 2013 Zhang 2012a Zhang 2012a Zhang 2012b Zhang 2015 Zhang 2016 Zhou 2011 Total (95% Cl) Heterogeneity: Chi <sup>2</sup> = 3	Mean   375.9   356   241   187.5   366.7   205.4   164.5   386.7   158   430.3   436.2   407   347.2   409   350   153   285   155.88   330   34.09, df	Plate SD 107.4 96.2 108 66.9 100.2 32.3 41.5 11.4 46.7 6.1 89.4 11.8 93.1 11.7 125.4 130.6 46.7 154 56.67 115 = 19 (P	Total   29   22   34   96   25   25   40   20   33   15   27   24   75   16   34   23   644   = 0.02)	S Mean 358.4 348.4 189 202.6 361.9 208.7 175.2 383.9 159 418.9 346.3 398 320.4 399.6 337.5 350.4 151 265 167.66 328	<b>SD</b> 143.1 101.1 1200 82.7 107.9 32 56.6 12.3 50.4 15.4 79.8 145.5 120.8 50.4 146 68.4 123	Total 25 30 23 46 20 30 40 25 49 30 35 17 40 24 16 60 18 14 32 23 597	Weight 0.1% 0.2% 0.8% 0.1% 1.9% 1.2% 1.4% 63.2% 0.3% 6.3% 0.3% 0.4% 0.1% 0.5% 0.0% 0.6% 0.1%	Mean Difference IV. Fixed. 95% Cl 17.50 [-50.87, 85.87] 7.60 [-46.48, 61.68] 52.00 [-9.02, 113.02] -15.10 [-42.49, 12.29] 4.80 [-56.67, 66.27] -3.30 [-20.37, 13.77] -10.70 [-32.45, 11.05] 2.80 [-4.14, 9.74] -1.00 [-20.85, 18.85] 11.40 [8.41, 14.39] 89.90 [48.23, 131.57] 9.00 [-0.45, 18.45] 26.80 [-16.15, 69.75] 9.50 [2.11, 16.89] 24.40 [-64.82, 113.62] -0.40 [-42.92, 42.12] 20.00 [-87.44, 127.44] -11.78 [-42.19, 18.63] 2.00 [-66.82, 70.82] 9.24 [6.86, 11.62]	Mean Difference IV, Fixed, 95% Cl

Figure 9. Forest plots of operation time (A) and blood loss (B) in the mini-plate fixation group and suture suspensory fixation group.

preoperative and postoperative JOA scores. Jiang et al<sup>[2]</sup> reported that no significant difference was found in mean cervical ROM reduction and axial symptoms between 2 groups. Qi et al<sup>[7]</sup> conducted a meta-analysis based on 6 studies, which showed that suture suspensory fixation was associated with better postoperative JOA scores and mini-plate fixation was superior in reducing the incidence of surgical complications.

In this meta-analysis, we combined 25 studies that included a total of 829 patients in mini-plate group and 774 patients in suture suspensory group. As compared with suture suspensory fixation in cervical laminoplasty, mini-plate fixation appears to achieve better clinical and radiographic outcomes with fewer surgical complications. However, operation time was long and blood loss was more in mini-plate fixation group.

JOA scores and VAS were often used to evaluate clinical outcomes.<sup>[9]</sup> The pooled data showed that there was no statistically significant difference in preoperative JOA scores and VAS between 2 groups. However, there were statistically significant differences in postoperative JOA scores, JOA score improvement rate, and VAS between 2 groups that indicated mini-plate fixation was superior to suture suspensory fixation in improving clinical outcomes.

Open angle, anteroposterior diameter, and cross-sectional area of the spinal canal were often used to evaluate drifting of the spinal cord and decompressive outcome.<sup>[10]</sup> The pooled data showed that there was no statistically significant difference in preoperative anteroposterior diameter and cross-sectional area of the spinal canal between 2 groups. However, there were



statistically significant differences in postoperative open angle, anteroposterior diameter, and cross-sectional area between 2 groups that indicated mini-plate fixation was superior to suture suspensory fixation in drifting of the spinal cord and decompressive outcome. Suture suspensory fixation do not provide enough rigid fixation, it may cut out or stretch over time, and the potential for lamina closure always exists.<sup>[11]</sup> However, miniplate fixation is efficient to prevent lamina closure by offering the lamina immediately rigid fixation, to get greater drifting of the spinal cord and better postoperative JOA scores and VAS, and to improve clinical outcomes. So, mini-plate fixation is better than suture suspensory fixation in preventing laminar closure after cervical laminoplasty.<sup>[12]</sup>

ROM and cervical lordosis were selected for analysis. The pooled data showed that there was no statistically significant difference in preoperative ROM and cervical lordosis between 2 groups. However, there were statistically significant differences in postoperative ROM and cervical lordosis between 2 groups, which indicated mini-plate fixation was superior to suture suspensory fixation in preserving cervical ROM and cervical alignment. Patients with suture suspensory fixation need to immobilize for more time that cause cervical back muscle adhesion and atrophy.<sup>[13]</sup> However, mini-plate fixation can offer the lamina immediately rigid fixation and early functional exercise that may preserve cervical ROM and cervical alignment.<sup>[14]</sup>

Axial symptoms and C5 palsy were selected for analysis to evaluate postoperative complications.<sup>[15]</sup> The pooled data showed that there was no statistically significant difference in C5 palsy between 2 groups. However, there were statistically significant differences in axial symptoms between 2 groups, which indicated mini-plate fixation was superior to suture suspensory fixation in reducing the incidence of axial symptoms. Axial symptoms, including neck pain, neck stiffness, shoulder pain, and shoulder stiffness, are the most frequent complaints after cervical laminoplasty which reported to occur in as many as 60% to 80% of patients who undergo laminoplasty.<sup>[16]</sup> Three possible sources for axial symptoms have been proposed: the nuchal muscle, facet joints, and nerve root.<sup>[17]</sup> On one hand, suture suspensory fixation may damage the paravertebral muscle and facet joints.<sup>[18]</sup> On the other hand, patients with suture suspensory fixation need to immobilize for more time that cause cervical back muscle adhesion and atrophy may also case axial symptoms.<sup>[19]</sup>

Operation time and blood loss were important factors for assessing surgical trauma. The pooled data showed that there were statistically significant differences in operation time and blood loss that indicated mini-plate fixation was associated with bigger surgical trauma. For patients with underlying diseases, such as cardiovascular and cerebrovascular diseases, suture suspensory fixation may be more suit and safe.<sup>[20]</sup> However, the additional operation time and blood loss for mini-plate fixation averaged 5 minutes and 12 mL. Compared with total operative time and blood loss, the additional operation time and blood loss are tolerable.<sup>[21]</sup> At the same time, the proficiency of surgeon should also be considered.<sup>[22]</sup>

Although mini-plate fixation are superior to suture suspensory fixation in improving clinical outcomes, the cost of these miniplate systems are high owing to the high costs of materials and processing technology.<sup>[23]</sup> According to China's national conditions, a big part of patients are from the countryside. They may not be able to pay high operation cost and suture suspensory fixation may be a good choice. So, we need to seek cheaper materials to replace titanium plate, which can be widely used in all patients.

# 8. Study limitations

There were several limitations in this study. First, none of the included studies was a randomized controlled study. Second, our meta-analysis presents substantial heterogeneity, and it may result some degrees of measurement bias, though we used a random-effects model for the statistical heterogeneity. Third, follow-up time varied between the studies and thus may have influenced our results. Finally, lamina closure was an important complication after cervical laminoplasty with suture suspensory fixation, but relevant data were few and meta-analysis could not be performed.

#### 9. Conclusions

As compared with suture suspensory fixation in cervical laminoplasty, mini-plate fixation appears to achieve better clinical and radiographic outcomes with fewer surgical complications. So, mini-plate fixation may be a better choice during laminoplasty for patients with MCCM. Considering the limitations noted above, this conclusion should be interpreted cautiously and more high-quality, randomized controlled trials are needed in the future.

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