

Anterior decompression and fusion versus laminoplasty for cervical myelopathy due to ossification of posterior longitudinal ligament

A meta-analysis

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Abstract

Background: Both anterior decompression and fusion (ADF) and laminoplasty (LAMP) are frequently used for the treatment of cervical myelopathy due to ossification of the posterior longitudinal ligament (OPLL). However, some controversies still remained in surgical options. We investigated whether ADF had better neurological outcome than LAMP in the treatment of cervical myelopathy due to OPLL. Secondary outcomes included operation time, blood loss, rate of complication and reoperation.

Methods: PubMed, EMBASE and the Cochrane Register of Controlled Trials database were searched to identify potential clinical studies compared ADF with LAMP for treatment of cervical myelopathy owing to OPLL. We also manually searched the reference lists of articles and reviews for possible relevant studies. Quality assessment was performed according to Cochrane Handbook and meta-analysis was conducted using Stata 12.0 software.

Results: Nine studies involving 712 patients were finally included in this analysis. Compared with LAMP, ADF was associated with an increase of the Japanese Orthopaedic Association (JOA) score (WMD = 1.86, 95% CI 0.43 to 3.29, $P = .011$) and recovery JOA score at final follow-up (WMD = 30.94, 95% CI 20.56 to 41.33, $P = .000$). And, ADF was associated with a decrease of the late neurologic deterioration than LAMP group (RR = 0.34, 95% CI 0.12 to 0.92, $P = .003$). However, ADF was associated with an increase of the postoperative cervical lordosis (WMD = 4.47, 95% CI 1.58 to 7.36, $P = .002$) than LAMP. There was no significant difference between the complication, reoperation rate ($P > .05$). What's more, ADF was associated with an increase of the operation time than LAMP ($P < .05$).

Conclusions: ADF yields better neurological improvement, but higher cervical lordosis and longer operation time compared with LAMP for cervical myelopathy caused by OPLL. No significant difference was found in the complication and re-operation rate.

Abbreviations: ADF = anterior decompression and fusion, CI = confidence interval, JOA = Japanese orthopaedic association, LAMP = laminoplasty, NOS = Newcastle-Ottawa quality assessment scale, OPLL = ossification of the posterior longitudinal ligament, RCTs = randomized controlled trials, RR = risk ratio, WMD = weighted mean difference.

Keywords: anterior decompression and fusion, laminoplasty, meta-analysis, ossification of the posterior longitudinal ligament

1. Introduction

Ossification of posterior longitudinal ligament (OPLL) is characterized by ectopic bone formation in spinal ligaments.^[1,2]

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The authors report no conflicts of interest.

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the prevalence of OPLL ranges from 1.9 to 4.3% in East Asian region, while the prevalence ranges from 0.1 to 1.7% among Caucasians.^[3,4] There were several methods to treat OPLL, including conservative treatment, anterior cervical corpectomy and fusion, anterior decompression and fusion (ADF) and posterior laminoplasty (LAMP).^[5,6] When patients were in moderate or severe symptomatic myelopathy due to cervical OPLL, ADF or LAMP can be selected to reduce spinal cord compression.^[7,8]

ADF allows definitive resection or mobilization of the ossified lesion, enables direct decompression of the spinal cord and maintains suitable alignment of the cervical spine.^[9] LAMP increases the available space of the spinal canal and achieves indirect decompression by shifting the spinal cord posteriorly.^[10]

Recent studies have compared the surgical outcomes between ADF and LAMP for cervical myelopathy owing to OPLL. Some studies have reported that neurological improvement after ADF was superior to that after LAMP.^[11] However, other studies have shown that ADF was similar or inferior to LAMP in the surgical outcomes.^[12]

There is therefore considerable controversy over which surgical technique, ADF or LAMP, is better for cervical myelopathy due to OPLL. The purpose of the study was to perform a systematic review and meta-analysis to investigate

whether ADF yielded better neurological outcome than LAMP in the treatment of cervical myelopathy due to OPLL. Other clinical parameters, such as operation time, blood loss, rates of complications and reoperation, were also compared between the 2 groups.

2. Materials and methods

2.1. Search strategy

We systematically searched PubMed, EMBASE and the Cochrane Register of Controlled Trials database up to 12 March 2018. The search strategy was as follows: (((ADF) OR (anterior decompression and fusion))) AND (((Laminoplasties) OR Laminoplasty) OR Laminoplasties) OR "Laminoplasty"[Mesh]) AND (((Calcification of Posterior Longitudinal Ligament) OR Posterior Longitudinal Ligament Calcification) OR Posterior Longitudinal Ligament Ossification) OR Ossification of posterior longitudinal ligament) OR "Ossification of Posterior Longitudinal Ligament"[Mesh]). Reference lists of all relevant retrieved articles and meta-analyses were manually searched to identify additional omitted studies. Ethical approval for meta-analysis is not required because meta-analysis did not involve any subject directly.

2.2. Eligibility criteria and exclusion criteria

Studies were eligible for inclusion if they met the following criteria:

- 1) Patients were diagnosed with cervical myelopathy due to OPLL and prepared for surgery;
- 2) Intervention was ADF for cervical spondylotic myelopathy caused by OPLL;
- 3) Comparison was used LAMP for cervical spondylotic myelopathy caused by OPLL,
- 4) Outcomes including preoperative, postoperative and recovery Japanese orthopaedic association (JOA) score, preoperative and postoperative cervical lordosis, late neurologic deterioration, complication and reoperation rate, blood loss and operation time.
- 5) randomized controlled trials (RCTs) or non-RCTs.

Studies were excluded if they met the following criteria: animal studies, biomechanical studies, duplicate publications of one trial, case report, letter, revision, technology note, thoracic OPLL, commentaries, reviews and meta-analysis.

2.3. Data extraction

Study characteristics and outcomes in the included studies were extracted independently by 2 reviewers, with discrepancies being solved through consensus with a third reviewer. Microsoft Excel (Microsoft Corporation, Redmond, Washington, USA) The primary outcomes of interest were neurological functional outcomes including the preoperative and postoperative JOA scores and recovery rate. Secondary outcomes included operation time, blood loss, rate of complications and rate of reoperation.

2.4. Quality assessment

Two reviewers assessed the quality of the studies according to the Newcastle-Ottawa Quality Assessment Scale (NOS), as

recommended by the Cochrane Non-Randomized Studies.^[13] This scale included 2 items:

- (1) selection of study groups (4 points);
- (2) comparability of groups (2 points); and
- (3) ascertainment of exposure and outcomes (2 points) for case control and cohort studies, respectively.

Study that scored 6 or more was eligible for data-pooling and study that scored 7 or more was considered high quality. Any disagreement was solved by discussion or consulted from a senior reviewer.

2.5. Statistical analysis

All statistical analyses were conducted using Stata 12.0. Treatment effects were calculated as risk ratio (RR) for dichotomous outcomes and weighted mean difference (WMD) for continuous outcomes with a 95% confidence interval (CI). The heterogeneity among studies was examined by the I² statistic and considered significant if P value $< .05$ or $I^2 > 50\%$. If no evident heterogeneity existed, the fixed effects model was selected to pool results. If present, a random effects model was utilized, and a Galbraith plot was performed to look for outliers in effect sizes. The expectation is that 95% of the studies are within the area defined by 2 CI lines. Then, a sensitivity analysis was performed by eliminating one or more study which was not within or far away from the area defined by 2 CI lines, until there was no heterogeneity and results were compared. Publication bias was formally assessed by funnel plot and Egger test ($P > .05$ suggest no significant bias).^[14]

3. Results

3.1. Search result

In the initial search, 505 potentially relevant publications were identified. After removing 257 duplications, the titles and abstracts of 258 publications were screened. Then, 247 papers were excluded according to the title of abstracts. Two of the 11 studies were excluded according to the following reason:

- (1) with no comparison group;^[15]
- (2) without outcomes.^[16]

Finally, 9 studies were identified to be included in this meta-analysis.^[1,12,17–23] The process is shown in Figure 1.

3.2. General characteristics

Of the 9 included studies, only 1 study was prospective non-RCTs.^[17] The rest of the included studies were all retrospective non-RCTs. The sample of the ADF group was ranged from 12 to 150 and LAMP group was ranged from 12 to 102. The age of the patients ranged from 47.8 to 66 years. Detailed information can be seen in Table 1.

3.3. Quality assessment

Of the nine included studies, 2 obtained 7 points of NOS,^[17,21] the rest 7 studies obtained 8 points of NOS.^[1,12,18–20,22,23] All summary of the quality assessment of included studies was shown in Figure 2. Kappa value between 2 reviewers was 0.877.

3.4. Preoperative and postoperative JOA scores

Preoperative JOA score was available in 8 studies.^[1,12,15,17–22] There was a significant difference in mean preoperative JOA

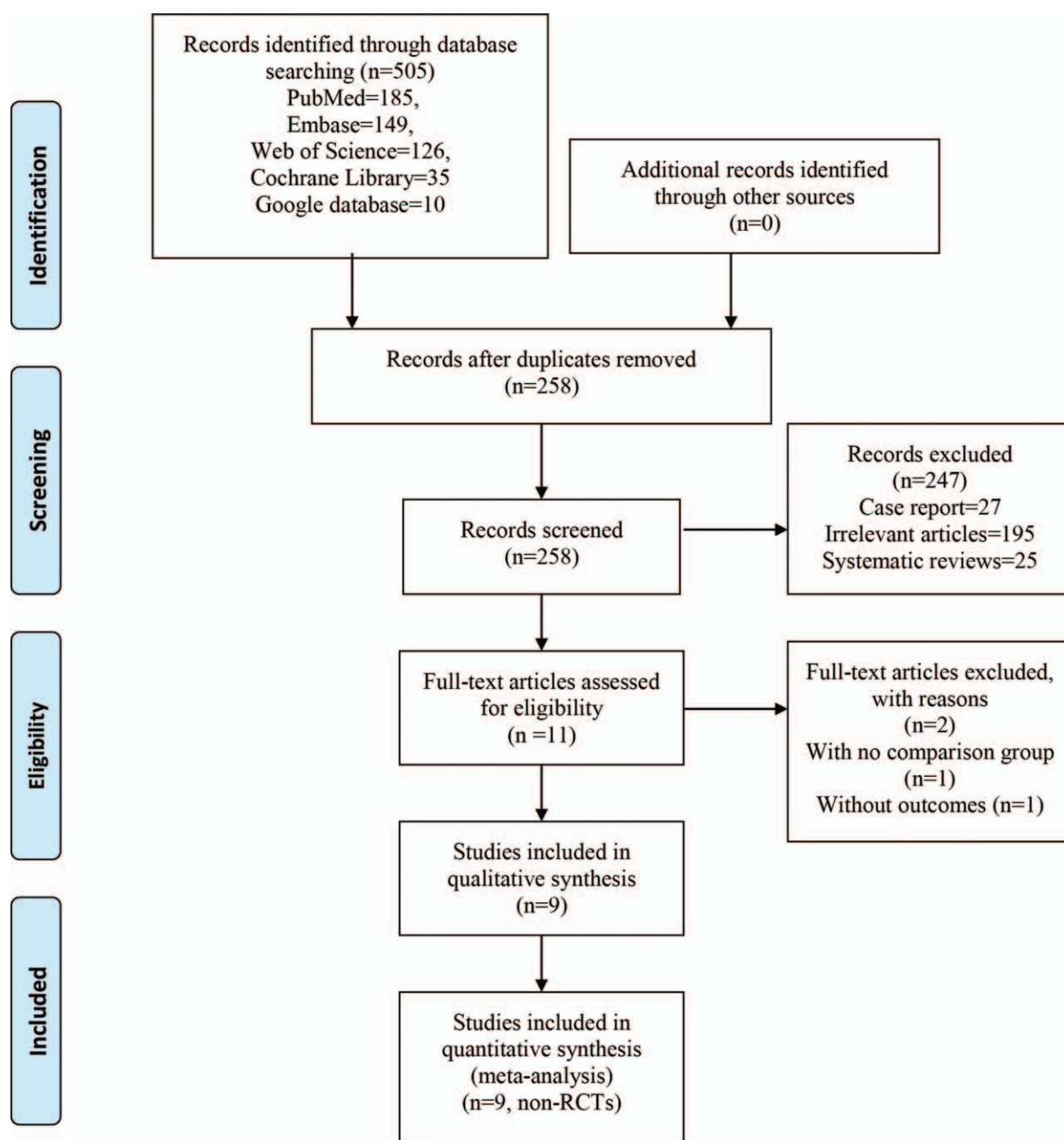


Figure 1. Flow of trials through the meta-analysis.

Table 1
The general characteristic of the included studies.

Author	Country	No. of the patients		Age of patients		Surgical segments		Preoperative JOAs		Study
		ADF	LAMP	ADF	LAMP	ADF	LAMP	ADF	LAMP	
Tani, 2002	Japan	14	12	62	66	3.5	4	9.4	8.8	non-RCTs
Hou, 2017	China	150	102	47.8	45.9	≤3	>3	9.5	9.8	non-RCTs
Koda, 2016	Japan	15	16	57.7	60.3	NA	4–5	9.8	9.5	non-RCTs
Chen, 2011	China	22	25	57.2	54.2	≥3	≥3	9.3	8.5	non-RCTs
Iwasaki, 2007	Japan	27	66	58	57	2–5	NA	9.5	9.2	non-RCTs
Fujimori, 2014	Japan	12	15	55.6	58.7	3.3	5.4	9.5	9.1	non-RCTs
Kim, 2015	Korea	71	64	57.3	56.4	NA	NA	12	12	non-RCTs
Masaki, 2007	Japan	19	40	51.8	62.6	2.9	4.6	8.3	8.6	non-RCTs
Sakai, 2012	Japan	20	22	59.5	57.9	3.1	4.5	11.4	10.9	non-RCTs

ADF = anterior decompression and fusion, JOA = Japanese orthopaedic association, LAMP = laminoplasty.

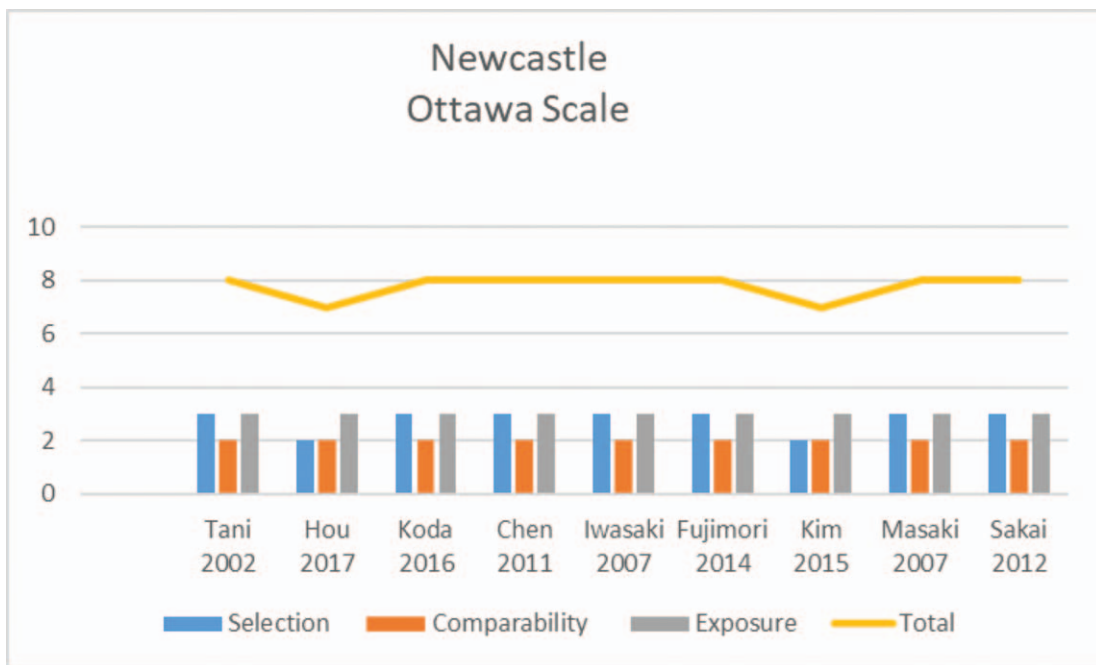


Figure 2. Risk of bias according to the Newcastle-Ottawa Quality Assessment Scale.

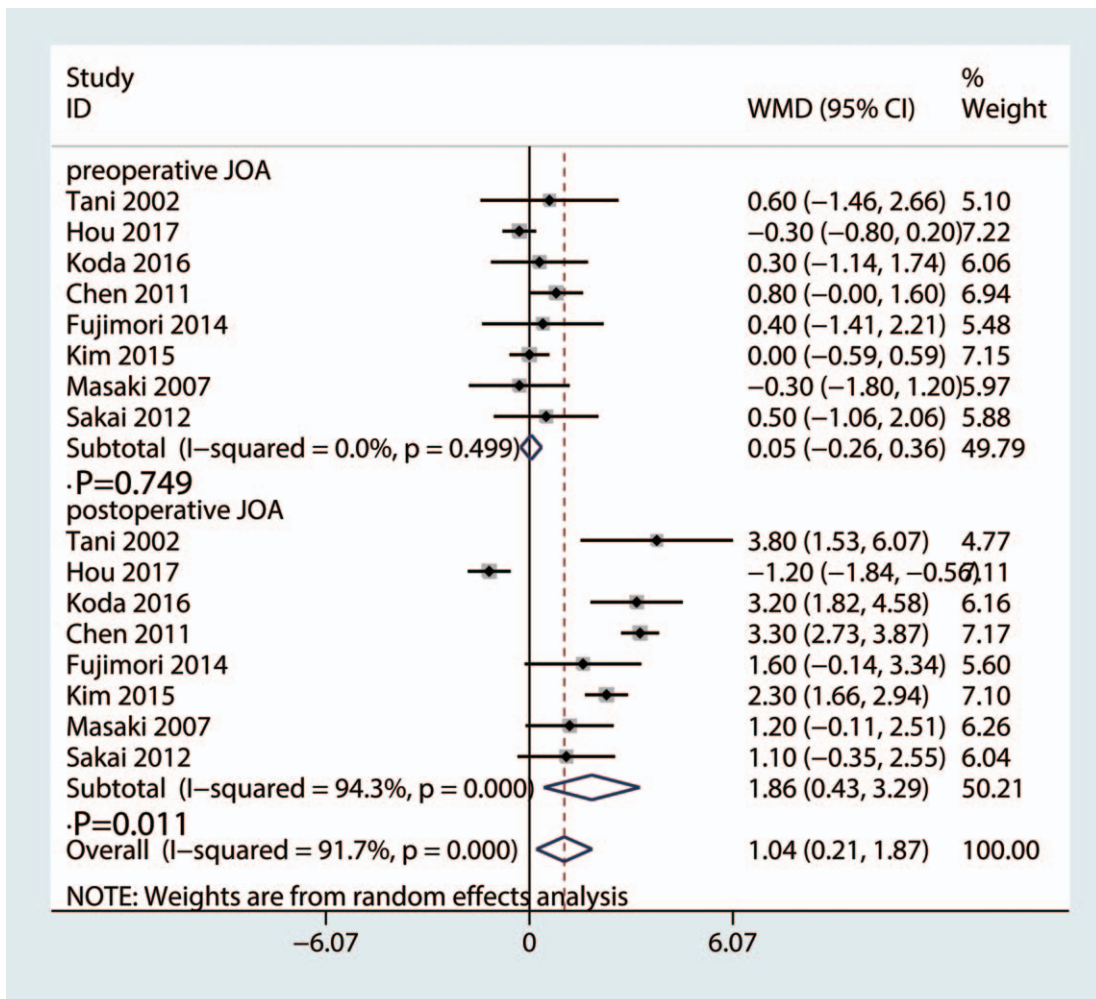


Figure 3. Forest plots of the included studies comparing preoperative and postoperative JOA scores. JOA = Japanese orthopaedic association.

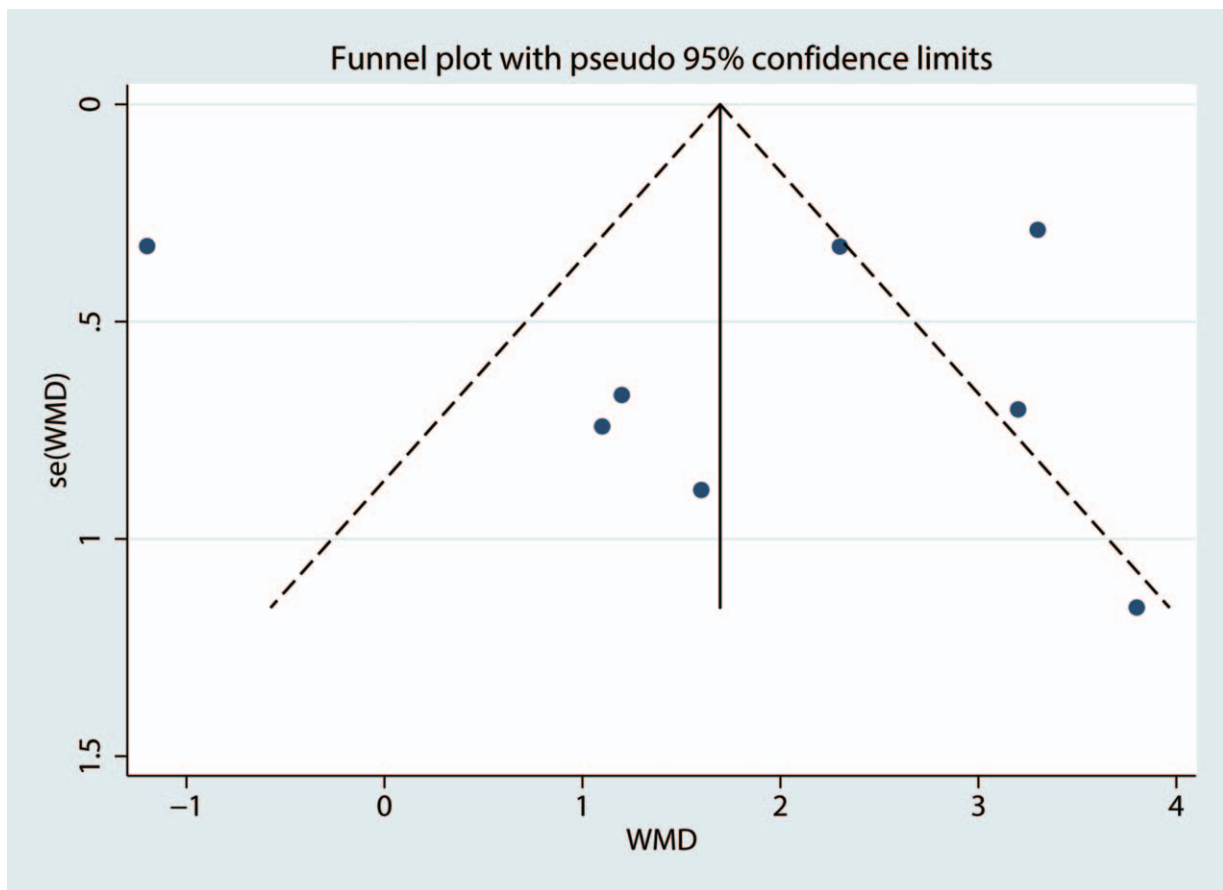


Figure 4. Funnel plot of the postoperative JOA scores. JOA = Japanese orthopaedic association.

score between ADF and LAMP groups (WMD=0.05, 95% CI -0.26 to 0.36, $P=.749$, Fig. 3). There was significant heterogeneity across studies between the included studies ($I^2=0.0\%$, $P=.499$).

Postoperative JOA score was available in 8 studies.^[1,12,17–22] Compared with LAMP, ADF was associated with an increase of the JOA score at final follow-up (WMD=1.86, 95% CI 0.43 to 3.29, $P=.011$, Fig. 3). Funnel plot showed that effect size was symmetrical and thus there was no publication bias (Fig. 4). P value obtained from Begg test was .215 and thus there was no publication bias between the studies (Fig. 5). To further increase the stability of the outcome, we performed sensitivity analysis by omitting study in turn and results were within the area defined by 2 CI lines (Fig. 6).

3.5. Recovery JOA score

Recovery JOA score was available in 6 studies.^[1,12,18–20,22] There was a high heterogeneity between the included studies ($I^2=72.3\%$, $P=.003$). Compared with LAMP, ADF was associated with an increase of the recovery JOA score at final follow-up by 30.94% (WMD=30.94, 95% CI 20.56 to 41.33, $P=.000$, Fig. 7).

3.6. Preoperative and postoperative cervical lordosis

Preoperative and postoperative cervical lordosis were analyzed in 4 studies and 6 studies respectively. There was no heterogeneity between the included studies for preoperative cervical lordosis

($I^2=0.0\%$, $P=.957$). There was no significant difference between the ADF and LAMP group in terms of the preoperative cervical lordosis (WMD=-2.65, 95% CI -5.83 to 0.54, $P=.104$, Fig. 8). There was a high heterogeneity across the included studies ($I^2=0.0\%$, $P=.603$). Compared with LAMP, ADF was associated with an increase of the postoperative cervical lordosis (WMD=4.47, 95% CI 1.58 to 7.36, $P=.002$, Fig. 8).

3.7. Late neurologic deterioration, complication and reoperation rate

Late neurologic deterioration was available in 7 studies.^[1,12,18–20,22] There was a high heterogeneity between the included studies ($I^2=0.0\%$, $P=.753$). Compared with LAMP, ADF was associated with a decrease of the late neurologic deterioration at final follow-up (RR=0.34, 95% CI 0.12 to 0.92, $P=.003$, Fig. 9).

There was no significant difference between the ADF and LAMP groups in terms of the complication rate (RR=1.58, 95% CI 0.62 to 4.03, $P=.343$, Figure 3) and reoperation rate (RR=1.61, 95% CI 0.66 to 3.93, $P=.297$, Fig. 9).

3.8. Operation time

Data of operation time was available in five studies.^[12,15,17,18,20] Compared with LAMP group, ADF was associated with an increase of the operation time by 120.78 min (WMD=120.78, 95% CI 79.66 to 161.90, $P=.000$, Fig. 10), with significant heterogeneity across studies ($I^2=85.7\%$, $P=.000$).

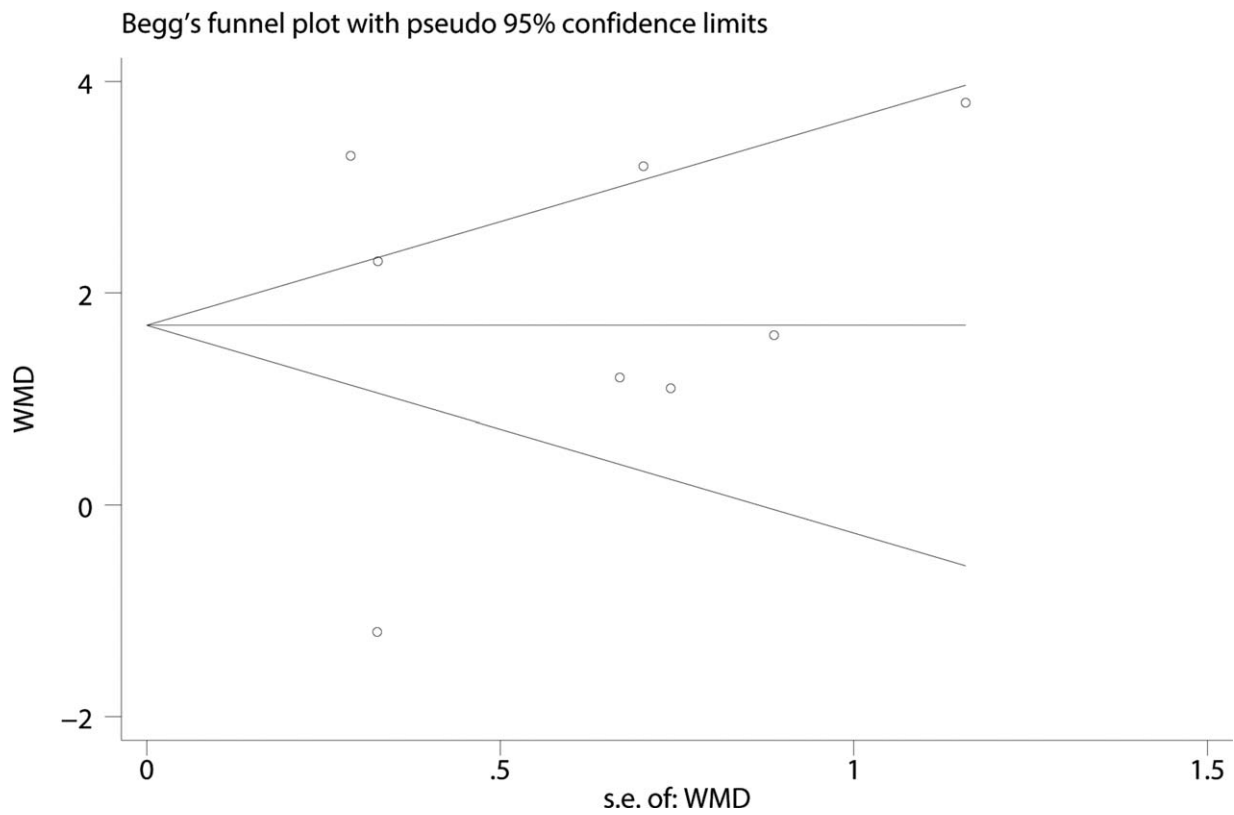


Figure 5. Begg test for postoperative JOA scores. JOA = Japanese orthopaedic association.

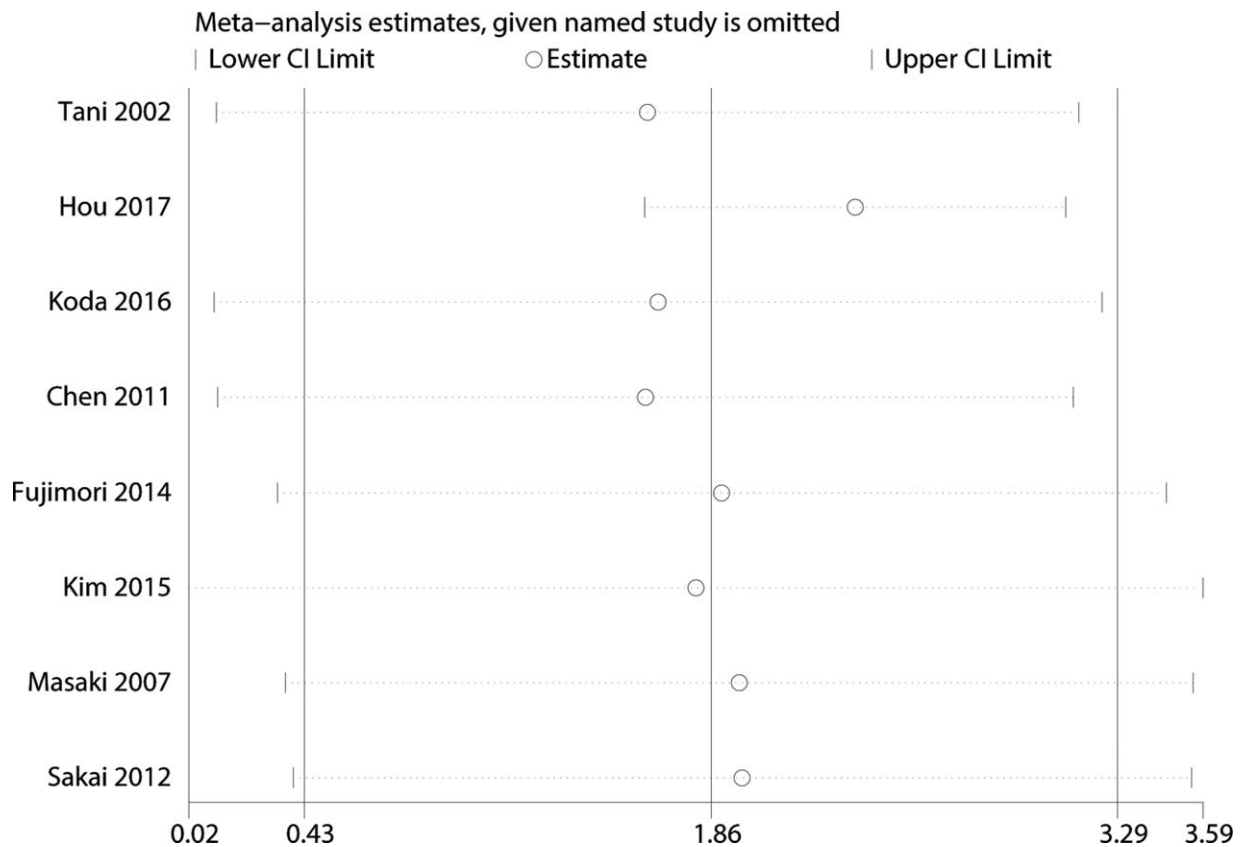


Figure 6. Sensitivity analysis for postoperative JOA scores. JOA = Japanese orthopaedic association.

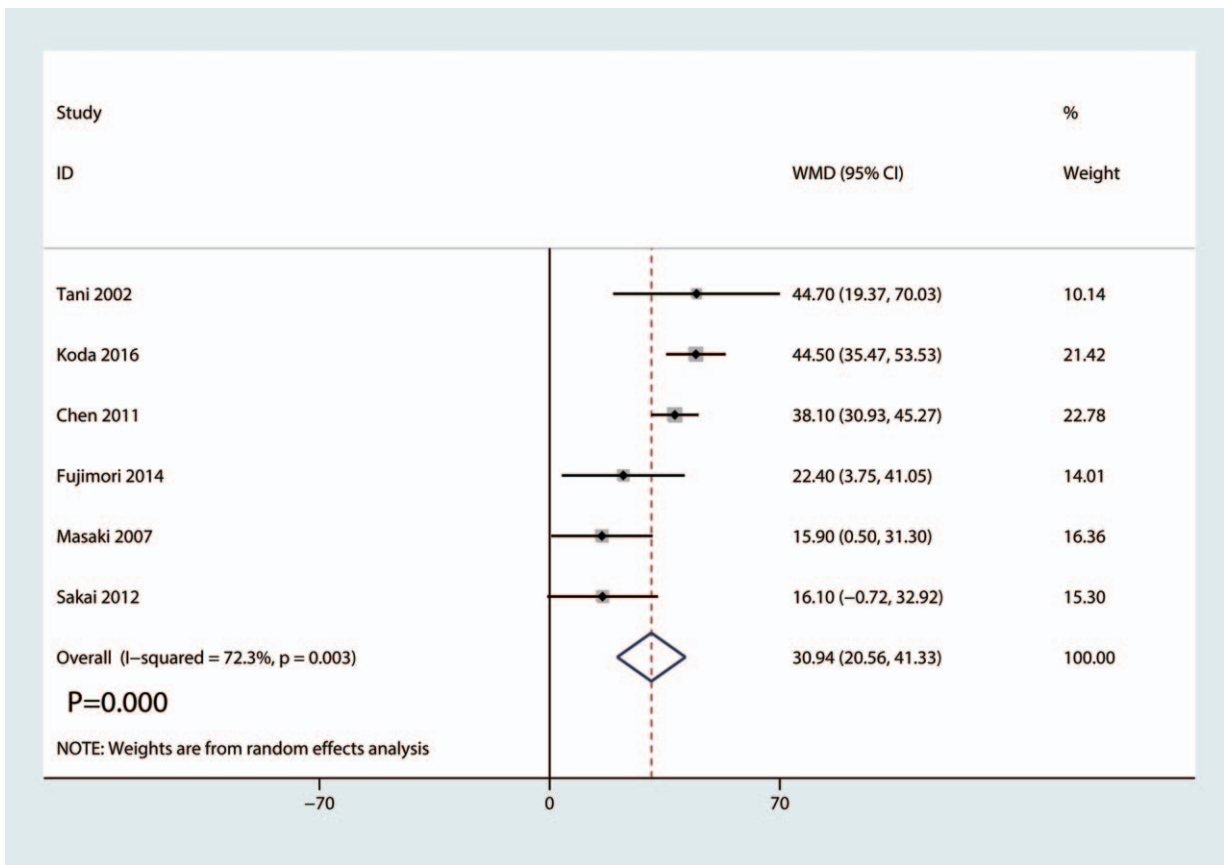


Figure 7. Forest plots of the included studies comparing the recovery JOA score. JOA = Japanese orthopaedic association.

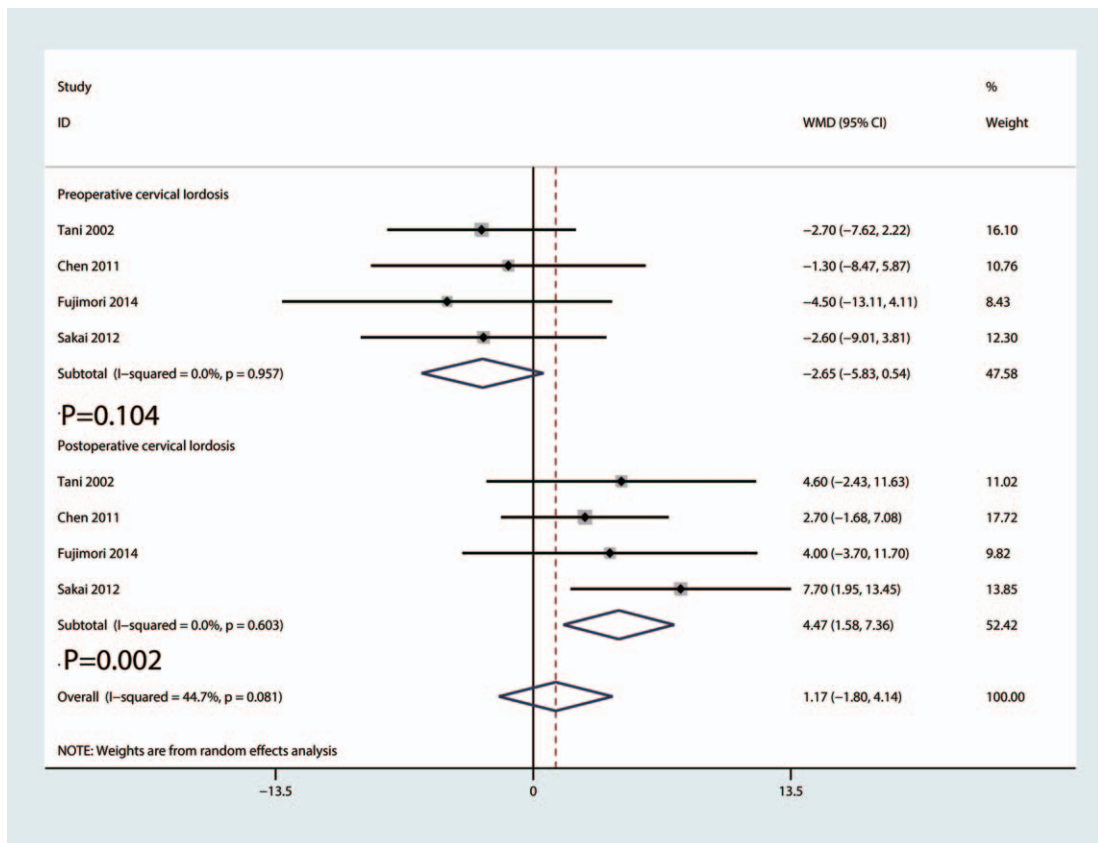


Figure 8. Forest plots of the included studies comparing the preoperative and postoperative cervical lordosis.

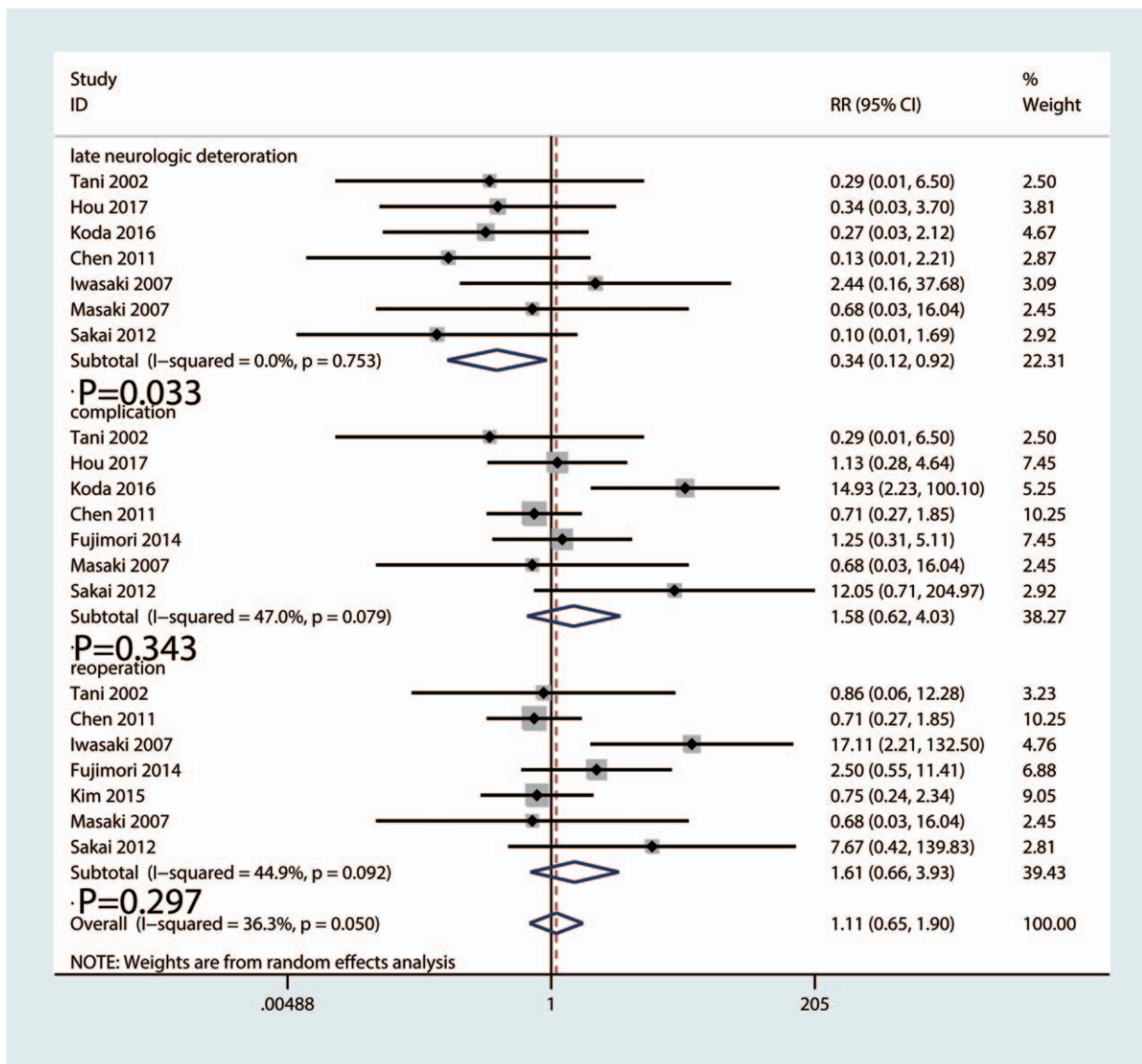


Figure 9. Forest plots of the included studies comparing the late neurologic deterioration, complication and reoperation rate.

3.9. Blood loss

Data of blood loss was available in five studies.^[12,15,17,18,20] There was no significant difference in mean blood loss between 2 groups (WMD=33.46, 95% CI -19.14 to 86.06, $P=.212$, Fig. 11), with little heterogeneity across studies ($I^2=40.7%$, $P=.150$).

4. Discussion

4.1. Main findings

Our meta-analysis comprehensively and systematically reviewed the currently available literature and found that

- (1) ADF group had higher postoperative JOA score and JOA recovery rate than LAMP group;
- (2) ADF has a benefit on decreasing the late neurologic deterioration than LAMP; (3) ADF was associated with an increase of the cervical lordosis than LAMP;
- (3) ADF will also increase the operation time than LAMP.

4.2. Comparison with other meta-analyses

Several relevant meta-analyses on the topic have been published.^[11,24] Differences between current meta-analysis and the previous ones should be noted. Liu et al^[11] conducted a meta-analysis about ADF and LAMP for OPLL. Several shortcomings were as follows:

- (1) sample size may not be large enough to draw a definitive conclusion;
- (2) Grade evidence was not performed for the outcomes.

Wu et al^[24] comprehensively compared different surgical interventions for OPLL. Mixed comparison between ADF and LAMP has a significant selection bias.

4.3. Implications for clinical practice

First, we found that ADF group had higher postoperative JOA score and JOA recovery rate than LAMP group. This outcome indicated that ADF has a better neurological recovery and

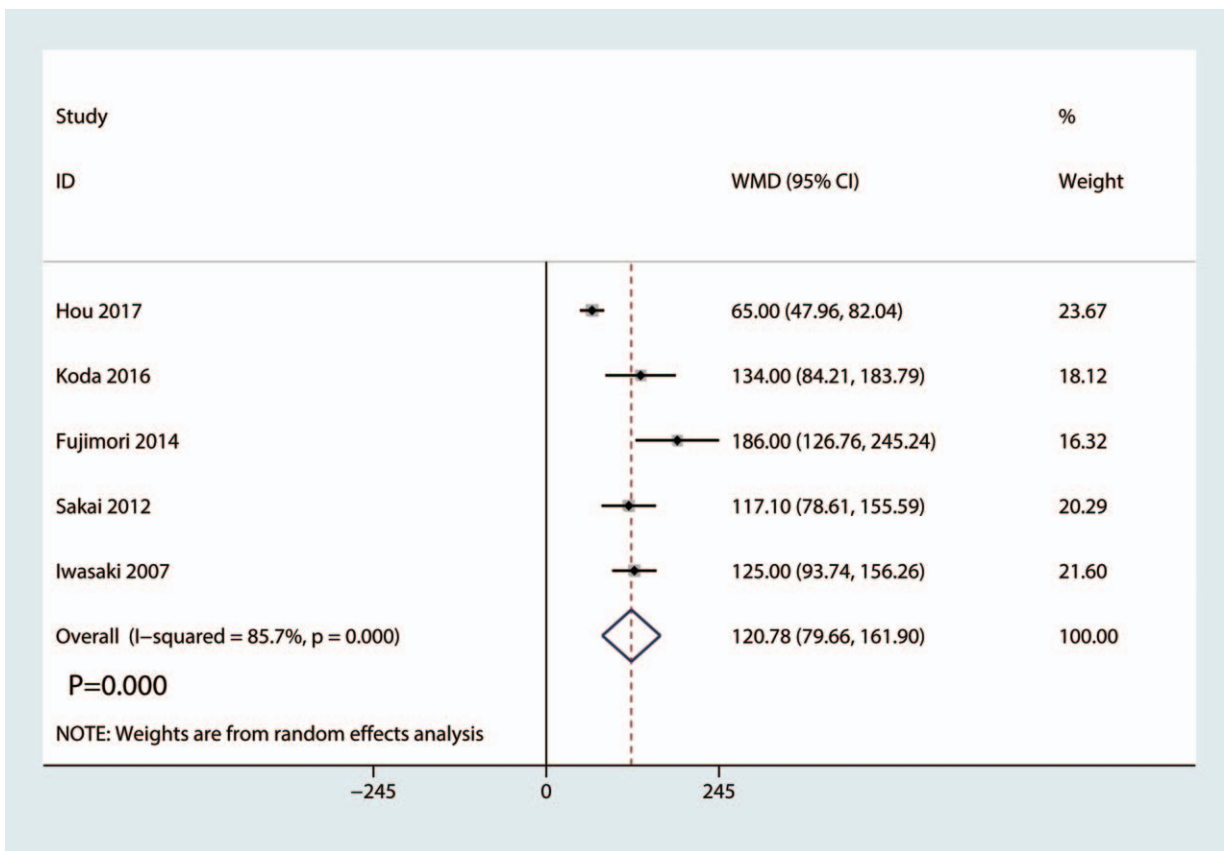


Figure 10. Forest plots of the included studies comparing the operation time.

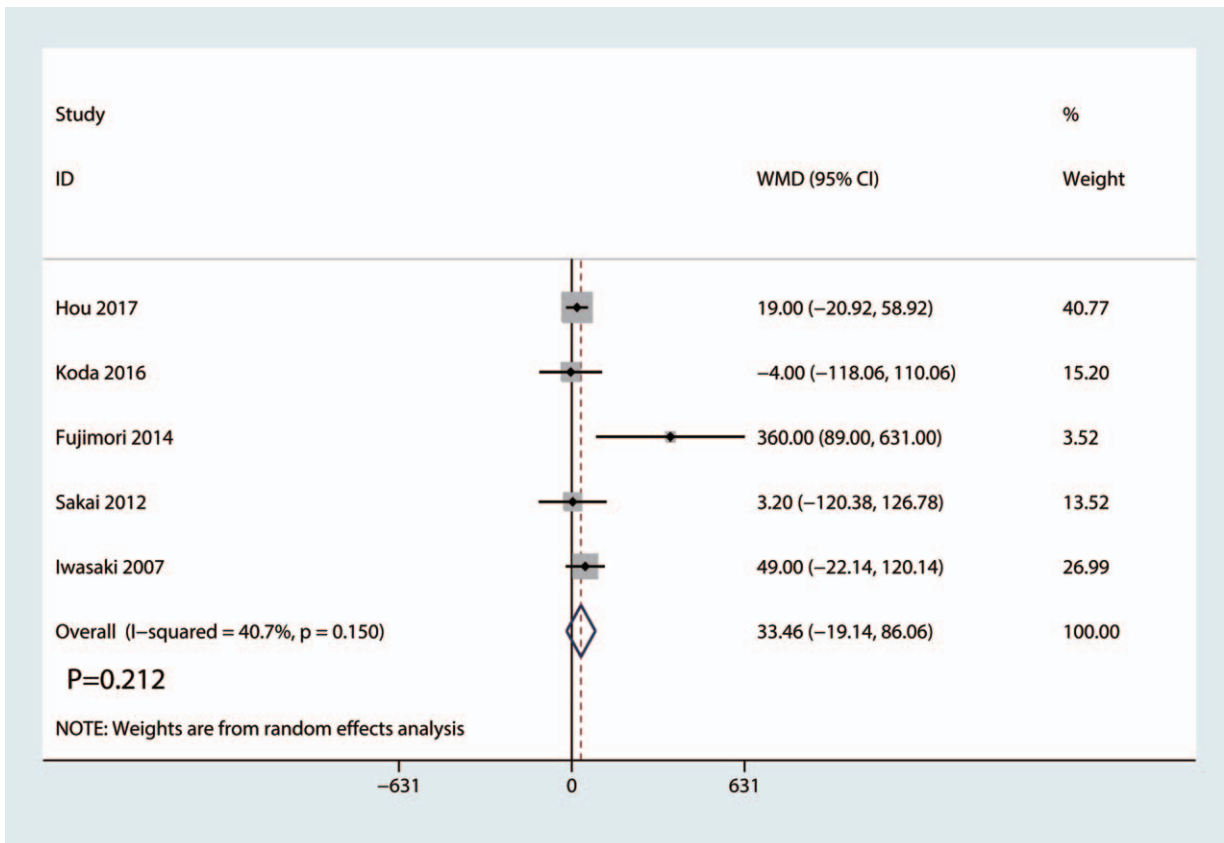


Figure 11. Forest plots of the included studies comparing the blood loss.

function than LAMP. The reason may LAMP relies heavily on the decompression effect for indirect decompression through a posterior shift of the spinal cord. Our result was in accordance with previous clinical study. Koda et al^[18] revealed that LAMP should not be used for K-line (-) cervical OPLL and neurological recovery and function was not recover than pre-operation. We further analyzed preoperative JOA score of the ADF group and LAMP group. No significant difference was found between the 2 group. Thus, general characteristic of the included studies was comparable. Liu et al^[11] also revealed that ADF was associated was an increase of the JOA score than LAMP.

Then, we compared ADF and LAMP in terms of the cervical lordosis and late neurological deterioration. We found that ADF was associated with an increase of the cervical lordosis and decrease of the late neurologic deterioration than LAMP. Dynamic factors can affect clinical outcomes of ADF and LAMP. Thus, more studies should control clinical variable to identify the factors that affect clinical outcomes.

Another important finding in this meta-analysis was that we found ADF was associated with an increase of the operation time. Since ADF was a new surgical technique and thus need for time to learn. Qin et al^[25] compared anterior cervical corpectomy and fusion versus posterior laminoplasty for the treatment of OPLL. Results showed that anterior cervical corpectomy was associated with an increase of the operation time than posterior laminoplasty. Previous meta-analyses did not include this important outcome. Thus, we when prepared administration ADF, operation time should be taken into consideration. There was no significant difference between the ADF and LAMP group in terms of the total blood loss. We then further analyzed the complication and reoperation rate between ADF and LAMP groups.

4.4. Strengths and limitations

A major strength of current meta-analysis was compliance with the PRISMA guidelines and assessed the evidence by Grade evidence. To increase the robustness of this meta-analysis, we applied sensitivity analysis for postoperative JOA score.

Our meta-analysis also had several limitations. First, the included patients have various clinical settings and general characteristic. Second, the operator experience was different and thus may cause potential bias. Third, no RCTs were included in this meta-analysis, and thus selection bias could not be ignored. Future large sample RCTs should be performed to further identify the optimal surgical method for OPLL.

5. Conclusion

Our meta-analysis suggested that ADF was associated with better postoperative neurological function, neurological recovery rate, and less late neurological deterioration than LAMP in the treatment of OPLL. However, ADF was associated with an increase of the operation time than LAMP. No significant difference was found in blood loss, complication, re-operation rate. Future studies should be focused on long-term effects of ADF and LAMP.

Author contributions

Conceptualization: Li-gang Qian, Kang Chen, Yu-min Chen.
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Validation: Jian-bao Jiao.

Writing – original draft: Kang Chen, Yu-min Chen.

Writing – review & editing: Tao-ping Chen, Zhi-xing Liang Liang, Yu-min Chen.

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