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Comparison of laminectomy and fusion vs laminoplasty in the treatment of multilevel cervical spondylotic myelopathy

A meta-analysis

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Abstract

Purpose: The purpose of this study is to evaluate the clinical safety and efficacy between laminectomy and fusion (LF) versus laminoplasty (LP) for the treatment of multi-level cervical spondylotic myelopathy (CSM).

Methods: The authors searched electronic databases using PubMed, MEDLINE, Embase, Cochrane Controlled Trial Register, and Google Scholar for relevant studies that compared the clinical effectiveness of LF and LP for the treatment of patients with multilevel CSM. The following outcome measures were extracted: the Japanese Orthopaedic Association (JOA) scores, cervical curvature index (CCI), visual analog scale (VAS), Nurich grade, reoperation rate, complications, rate of nerve palsies. Newcastle Ottawa Quality Assessment Scale (NOQAS) was used to evaluate the quality of each study. Data analysis was conducted with RevMan 5.3.

Results: A total of 14 studies were included in our meta-analysis. No significant difference was observed in terms of postoperative Japanese Orthopaedic Association score ($P = .29$), visual analog scale neck pain ($P = .64$), cervical curvature index ($P = .24$), Nurich grade ($P = .16$) and reoperation rate ($P = .21$) between LF and LP groups. Compared with LP group, the total complication rate (OR 2.60, 95% CI 1.85, 3.64, $I^2 = 26\%$, $P < .00001$) and rate of nerve palsies (OR 3.18, 95% CI 1.66, 6.11, $I^2 = 47\%$, $P = .0005$) was higher in the LF group.

Conclusions: Our meta-analysis reveals that surgical treatments of multilevel CSM are similar in terms of most clinical outcomes using LF and LP. However, LP was found to be superior than LF in terms of nerve palsy complications. This requires further validation and investigation in larger sample-size prospective and randomized studies.

Abbreviations: ACDF = anterior cervical decompression and fusion, CCI = cervical curvature index, CI = confidence intervals, CSM = cervical spondylotic myelopathy, JOA = Japanese Orthopaedic Association, LF = laminectomy and fusion, LP = laminoplasty, NOQAS = Newcastle Ottawa Quality Assessment Scale, RCT = randomized controlled trial, RR = risk ratio, VAS = visual analog scale, WMD = standardized mean difference.

Keywords: cervical spondylotic myelopathy, laminectomy and fusion, laminoplasty

1. Introduction

Cervical spondylotic myelopathy (CSM) is a clinically symptomatic condition associated with degeneration of intervertebral discs and adjacent vertebral structures. The degeneration of the intervertebral disc, uncovertebral joint, facet joint, posterior longitudinal ligament, and ligamentum flavum cause spinal cord compression and cervical myelopathy.[1] At present, patients diagnosed with single-level symptomatic CSM were often recommended to receive anterior cervical decompression and fusion (ACDF).[2–5] However, ACDF for multilevel CSM means a more complex procedure and may be associated with longer operative times as well as complications such as hoarseness, dysphagia, graft dislodgement, and trigeminal nerve palsy.[6,7]

Currently, 2 representative posterior surgical approaches are usually performed for multilevel CSM: laminectomy and fusion (LF) vs laminoplasty(LP).[8–12] Laminectomy was regarded as the gold standard surgical procedure for multilevel CSM.[13] But postoperative segmental instability and kyphosis is the main drawbacks of the technique. More recently, laminectomy followed by lateral mass fixation or fusion may reduce the incidence of post-operative segmental instability and kyphosis.[14,15] However, due to the alteration of normal cervical spine biomechanics, there is increasing concern that fusion may cause adjacent segment disease and the need for additional surgery.[16,17] Laminoplasty was developed as an alternative to laminectomy, permitting extensive cord decompression while

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XY and CW equally contributed to this work.

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preserving motion and mechanical stability in the cervical spine.[8]

There is currently no consensus in the literature concerning the superiority of laminoplasty or laminectomy with fusion in the treatment of multilevel CSM.[12,13,18–22] To address limitations in the current literature, we performed the present meta-analysis to systematically evaluate the safety and efficacy of the 2 posterior approaches for multi-level CSM.

2. Materials and methods

2.1. Search strategy and study selection

Electronic searches were performed using PubMed, MEDLINE, Embase, Cochrane Controlled Trial Register and Google Scholar from their dates of inception to Oct. 2018. We restricted the language to English. The following search terms were used: "cervical", "laminectomy" and "laminoplasty" as either keywords or MeSH terms. Reference lists of all included studies were scanned to identify additional potentially relevant studies. Two reviewers (Xiaojun Yuan and Chunmei Wei) independently screened the titles and abstracts of identified papers, and full text copies of all potentially relevant studies were obtained. When consensus could not be reached, a third reviewer (Jiaquan Luo) was consulted to resolve the disagreement.

2.2. Inclusion criteria

Studies were included if they met the following criteria:

1. randomized or nonrandomized controlled study;
2. those including patients with CSM caused by multisegmental spinal stenosis (≥3 segments); and
3. those comprising patients who underwent LF and LP. We also searched the bibliographies of relevant articles to identify additional studies. All publications were limited to those involving human subjects and in the English language. Abstracts, case reports, conference presentations, editorials and expert opinions were excluded.

2.3. Quality assessment of included studies

The checklist reported by Furlan et al[23] was utilized to assess methodological quality of randomized controlled studies. Risk of bias assessment was performed using the checklist proposed by Cowley et al[24] for non-randomized studies. The items were scored with "yes", "no", or "unclear".A Furlan score of 6 or more out of a possible 12, or a Cowley score of 9 or more out of a possible 17, was considered to reflect "high methodological quality". These studies were independently evaluated by 2 reviewers, and any discrepancies were resolved by discussion and consensus.

2.4. Data extraction

Two reviewers independently extracted the data using a standardized form, which covered the following items:

1. basic characteristics, including country, study design, age, enrolled number, and length of follow-up;
2. Nurich grade and reoperation rate,
3. postoperative mean Japanese Orthopaedic Association (JOA) score,
4. postoperative mean visual analogue scale(VAS) score,
5. postoperative mean cervical curvature index (CCI), and
6. complications including reoperations and nerve palsies.

2.5. Data analysis

We performed all meta-analyses with the Review Manager software (RevMan Version 5.2; (Cochrane Collaboration, Oxford, UK)). Heterogeneity was tested using Chi square test and quantified by calculating I^2 statistic, for which $P < .1$ and $I^2 > 50\%$ was considered to be statistically significant. For the pooled effects, weighted mean difference (WMD) or standard mean difference (SMD) was calculated for continuous variables according to the consistency of measurement units, and odds ratio (OR) was calculated for dichotomous variables. Continuous variables are presented as mean differences and 95% confidence intervals (CI), whereas dichotomous variables are presented as odds ratios and 95% CI. Random-effects or fixed-effects models were used depending on the heterogeneity of the studies included.

3. Results

The process of identifying relevant studies is summarized in Figure 1. From the selected databases, 1236 references were obtained. By screening the titles and abstracts, 1174 references were excluded due to duplicates, irrelevant studies, case reports, not comparative studies, and review articles. The remaining potentially relevant 62 studies underwent a detailed and comprehensive evaluation. Finally, 14 studies[13,20,25–36] were included in our meta-analysis. The characteristics of these studies are summarized in Table 1.

3.1. Quality assessment

Newcastle Ottawa Quality Assessment Scale (NOQAS) was used to evaluate the quality of each study. This scale for nonrandomized case controlled studies and cohort studies had a maximum of 9 points, which included the quality of selection, comparability, exposure, and outcomes for study participants. Of these studies, 12 scored 8 points and 2 scored 7 points. Therefore, the quality of each study was relatively high (Table 2).

3.2. Clinical outcome

3.2.1. Postperative JOA and VAS score. Postoperative JOA scores were reported in 9 studies.[20,25,26,28–32,34] No significant difference in postoperative VAS score was found between LF and LP groups. (WMD −0.41, 95% CI −1.18, 0.36, $I^2 = 95\%$, $P = .29$) (Fig. 2a). Postoperative neck VAS scores were reported in 7 studies. There was no significant difference between LF and LP groups (WMD 0.20, 95% CI −0.63, 1.02, $I^2 = 80\%$, $P = .64$) (Fig. 2b).

3.2.2. Postperative CCI and Nurich grade. Postoperative mean cervical curvature index (CCI) were reported in 3 studies.[20,29,31] There was no significant difference between LF and LP groups (WMD 0.01, 95% CI −0.01, 0.03, $I^2 = 0\%$, $P = .24$) (Fig. 3a). Postoperative Nurich grade were reported in 5 studies.[28,29,33,35,36] No significant difference was found between LF and LP groups (WMD −0.36, 95% CI −0.87, 0.14, $I^2 = 82\%$, $P = .16$) (Fig. 3b).

3.2.3. Complications, reoperation rate, and nerve palsies. Postoperative complications were reported in 11 studies.[13,20,27–33,32–36] LF groups had higher complications compared to LP

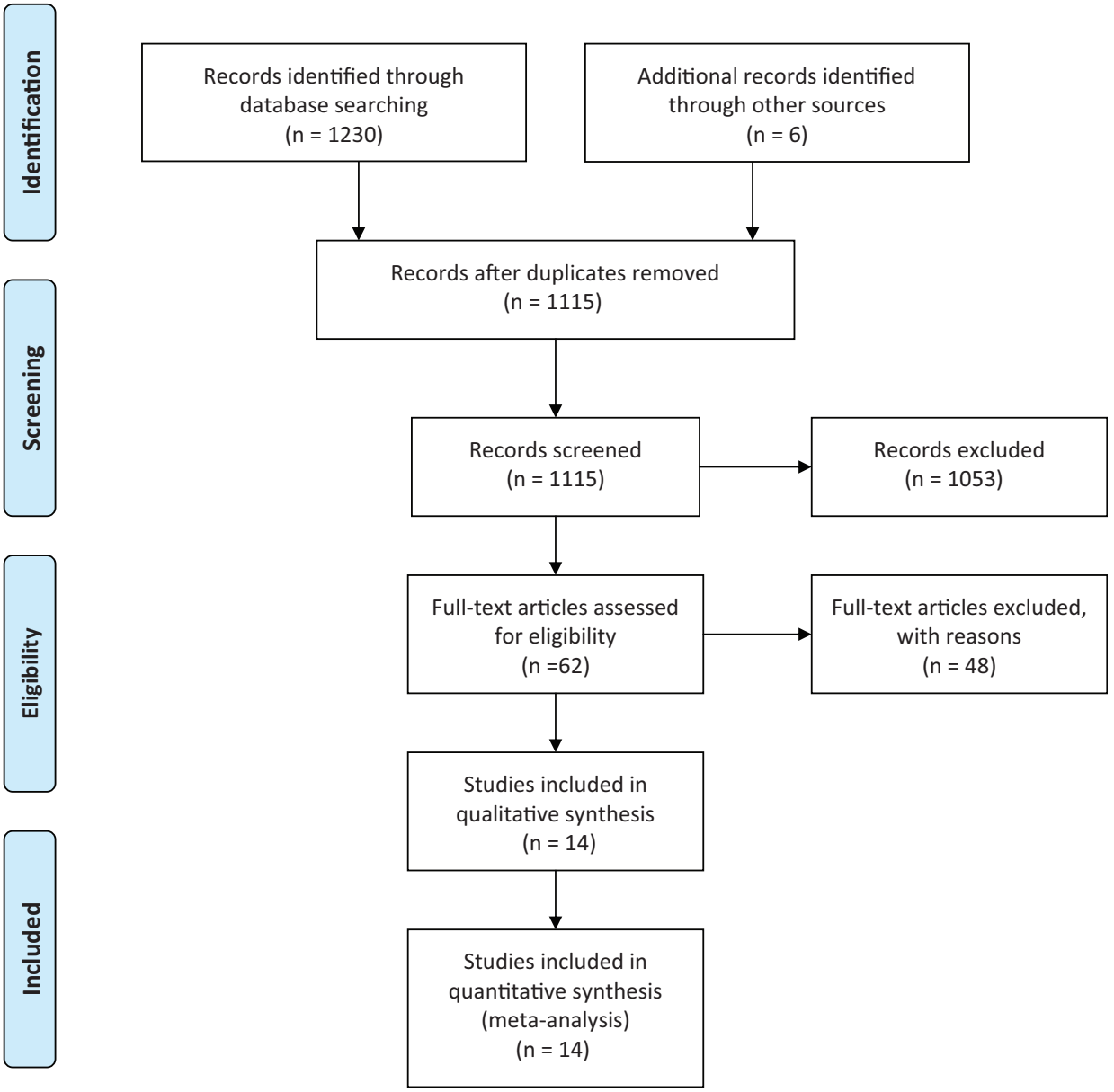

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Figure 1. The flow diagram showing the article selection process we performed.

groups (OR 2.60, 95% CI 1.85, 3.64, $I^2=26\%$, $P < .00001$) (Fig. 4a). Reoperation rate was reported in 5 studies.[13,28,29,34,36] No significant difference was found in reoperation rate between LF and LP groups(OR 1.60, 95% CI 0.77, 3.33, $I^2=0\%$, $P=.21$) (Fig. 4b). Nerve palsies was reported in 6 studies.[13,28,29,32,34,35] A significantly higher rate was found in the LF group compared to LP (OR 3.18, 95% CI 1.66, 6.11, $I^2=47\%$, $P=.0005$) (Fig. 4c).

3.2.4. Publication bias. Assessment of publication bias for all included studies was performed by the funnel plot. The funnel plots demonstrated a symmetry in postoperative JOA scores and neck VAS score, CCI, Nurich grade, total complication rates, reoperations, and nerve palsy (Fig. 5a–g), which indicated there was no publication bias. Therefore, it suggested this was a reliable analysis.

4. Discussion

Our meta-analysis demonstrate that there was no significant difference in terms of postperative JOA score, neck VAS score, CCI and Nurich grade, and reoperation rate between LF and LP. Compared with LP group, total complication rate and rate of nerve palsies were significant higher in the LF group. Both groups showed similar improvements in myelopathy, according to the JOA score and in neck pain. This study showed no clear

Table 1

Characteristics of included studies.

Study ID	Design	Contry	Number of patient	Mean patient age	Average follow-up (months)
Highsmith et al[13]	Retrospective Comparative	USA	LF: 26, PL: 30	LF: 58 (42–81) LP: 61(44–81)	41.8 (12.5–77)
Cowley et al[24]	Retrospective Comparative	China	LF: 30, PL: 36	LF:56.2 (43–74) LP:55.9 (40–72)	110 (84–144)
Du et al[25]	Prospective Randomized	USA	LF: 7, PL: 9	LF:55 LP:61	12
Manzano et al[19]	Retrospective Comparative	China	LF: 21, PL: 23	LF:68.4±18.1 LP: 66.1±14.8	–
Ren et al[26]	Retrospective Comparative	UK	LF: 25, PL: 25	LF: 69.6 (54–89) LP: 62.4 (51–82)	–
Sivaraman et al[27]	Retrospective Comparative	USA	LF: 82, LP: 39	LF: 64±10.7 LP:60±12.5	23.89
Woods et al[28]	Retrospective Comparative	China	LF: 66, LP: 75	LF:56.98±8.34 LP:57.19±7.33	24
Yang et al[29]	Prospective Randomized	Japan	LF: 20, LP: 21	LF:66.1±10.8 LP:62.3±11.4	28.1
Yukawa et al[30]	Retrospective Comparative	South Korea	LF: 26, LP: 21	LF:62.7±7.1 LP:54.2±10.3	24
Lee et al[31]	Retrospective Comparative	China	LF: 32, LP:41	LF:52.6±1.7 LP:46.3±2.5	48 (48–72)
Chen et al[32]	Matched cohorts Comparative	USA	LF: 44, LP:101	-	17.2
Lau et al[33]	Retrospective Comparative	USA	LF: 31, LP:41	LF:58.97±9.79 LP:57.88±10.73	PF: 18.2 PL:19.2
Blizzard et al[34]	Cohort Prospective	USA	LF: 166, LP:100	LF:61.36±10.59 LP:60.68±11.32	24
Fehlings et al[35]	Matched cohorts Comparative	Portland	LF: 43, LP:91	LF: 60.9±9.0 LP: 63.9±11.9	17.3±11.3

LF = laminectomy and fusion, LP = laminoplasty.

superiority between the LF and LP groups after surgery according to the JOA and neck pain VAS scores.

JOA score and VAS were often used to evaluate the improvement of nerve function. Our study shown that there was no statistically difference in JOA scores as well as VAS scores for neck pain between LF and LP. Hence, these results suggest that both procedures can have sufficient decompression and improve the patients' neurological function. Our findings is in line with previous study confirming that surgical managements of multilevel CSM by LF or LP show no significant differences in terms of achieved nerve improvement.[28,30,34,35] Recent a study reported by Fehlings et al also found that both LP and LF were effective at improving clinical disease severity, functional status, and quality of life in patients with degenerative cervical myelopathy.[35] In both techniques, the muscles are widely dissected, ligamentous structures transected, and the lamina are removed or opened.[37,38] As both surgical approaches effectively removed spinal cord compression, symptoms are improved.

Table 2

Quality assessmentof included studies in the meta-analysis according to NOQAS.

Study	Selection	Comparability	Exposure	Total score
J.M.Highsmith et al[13]	3	2	3	8
Cowley et al[24]	3	2	3	8
Du et al[25]	3	2	3	8
Manzano et al[19]	3	2	3	8
Ren et al[26]	3	2	3	8
Sivaraman et al.[27]	3	2	3	8
Woods et al[28]	3	2	3	8
Yang et al[29]	3	2	3	8
Yukawa et al[30]	3	2	3	8
Lee et al[31]	2	2	3	7
Chen et al[32]	2	2	3	7
Lau et al[33]	3	2	3	8
Blizzard et al[34]	3	2	3	8
Fehlings et al[35]	3	2	3	8

NOQAS = Newcastle Ottawa quality assessment scale.

In terms of the Nurich grade, the data showed that there was no significant difference between the 2 groups. However, previous study reported that LF had lower mean Nurick score.[33] Fehlings MG et al also found that Nurick grades improved by 1.57 (95% CI:1.23, 1.90) in the LP group and 1.18 (95% CI: 0.92, 1.44) in the LF group.[35]

CCI were often used to evaluate cervical lordosis. Our meta-analysis revealed that no significant differences were found in CCI between LF and LP. It suggested that postoperative cervical lordosis was similar. When choosing surgery technique before the operation, we should evaluate cervical lordosis of patient with multilevel CSM. LF was advisable if the patient with severe cervical kyphotic deformity in preoperation. However, we can choose both techniques if the patient with no cervical kyphotic deformity before operation.

Meta-analysis revealed that total complication rate and rate of nerve palsies were significant higher in the LF group compared to LP group. These results were consistent with those previously reported in the literature[34] Blizzard et al found that LF was associated with a

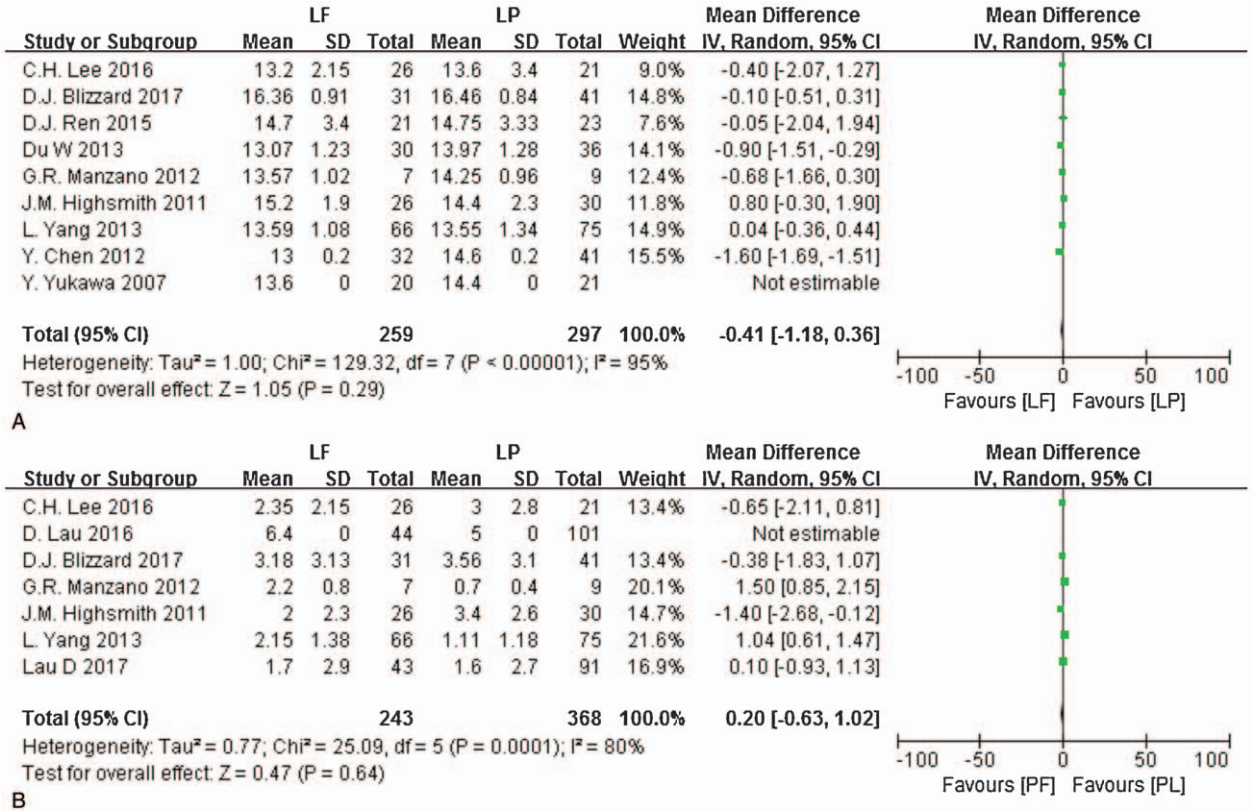

Figure 2. Forest plot of postoperative JOA scores (a) and neck VAS score (b) between LF and LP groups. JOA = Japanese Orthopaedic Association, LF = laminectomy and fusion, LP = laminoplasty, VAS = visual analog scale.

higher rate of C5 nerve root palsy and overall complications.[34] However, previous a meta-analysis reported by Lao et al found that the incidence of complications was not significantly different between the 2 groups.[8] The results of this study is inconsistent with our findings. There are a few potential explanations for the contrasting results, including the different effects of surgery in different patient populations, small or poor-quality studies, or random variation around a small true effect, among others.

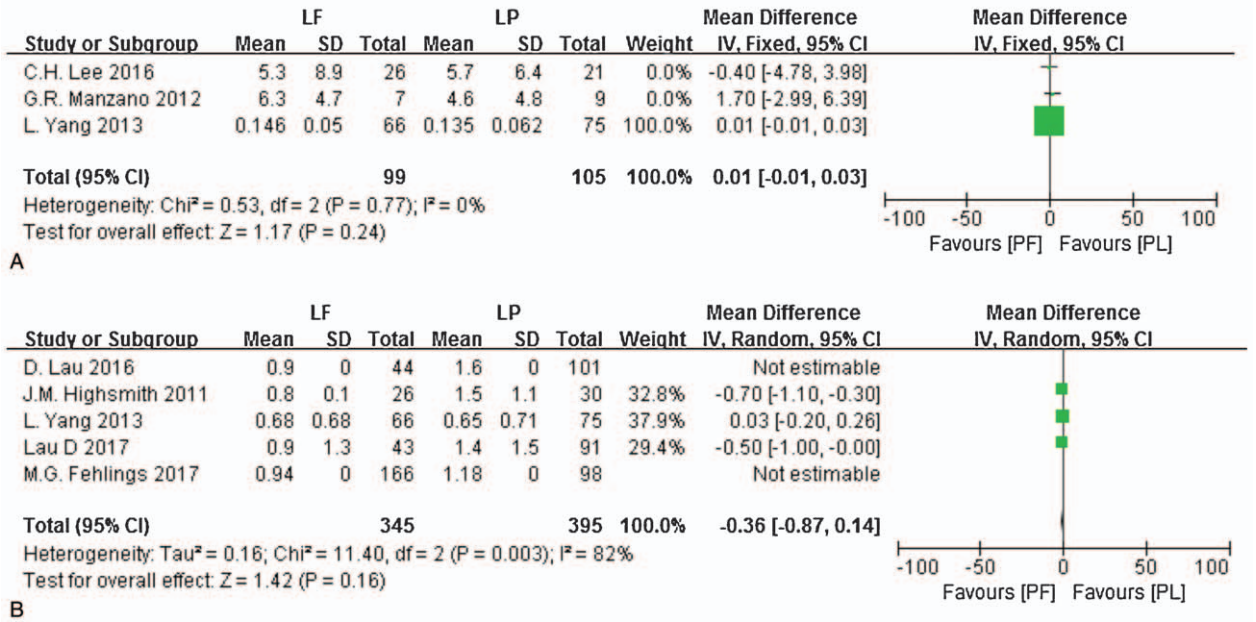

Figure 3. Forest plot of postoperative CCI (a) and Nurich grade (b) between LF and LP groups. CCI = cervical curvature index, LF = laminectomy and fusion, LP = laminoplasty.

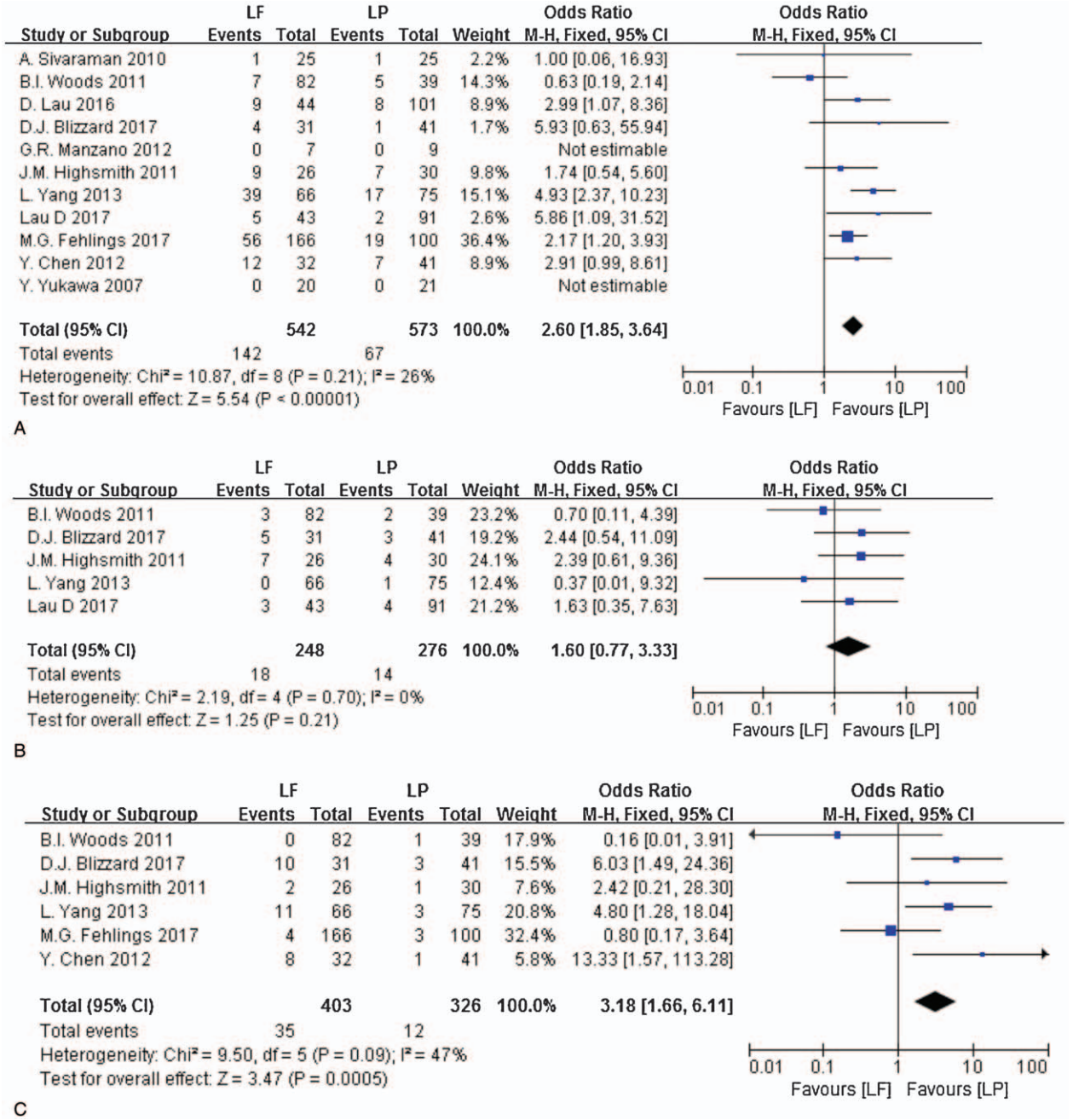

Figure 4. Forest plot of postoperative complications (a), reoperation rate (b) and nerve palsies (c) between LF and LP groups. LF = laminectomy and fusion, LP = laminoplasty.

We believe that our result of meta-analysis is affected by several reasons. Firstly, in this meta-analyses, most the studies selected were not RCT, while it did not influence the credibility of the results. Secondly, laminoplasty had different techniques, such as open door and French door and these differences were not considered. Thirdly, the current research was not been registered and there may be some small bias, but we still follow the steps of system evaluation strictly. Finally, clinical heterogeneity might be caused by the various indications for surgery and the surgical technologies used at the different treatment centers. Due to these limitations, the combined results of this meta-analysis should be cautiously accepted, and high-quality RCTs with long term follow-up and large sample size are needed.

5. Conclusions

In conclusion, our meta-analysis reveals that surgical treatments of multilevel CSM are similar in terms of most clinical outcomes using LF and LP. However, a higher complication rate was found in LF group, including significantly higher nerve palsy complications. This requires further validation and investigation in larger sample-size prospective and randomized studies.

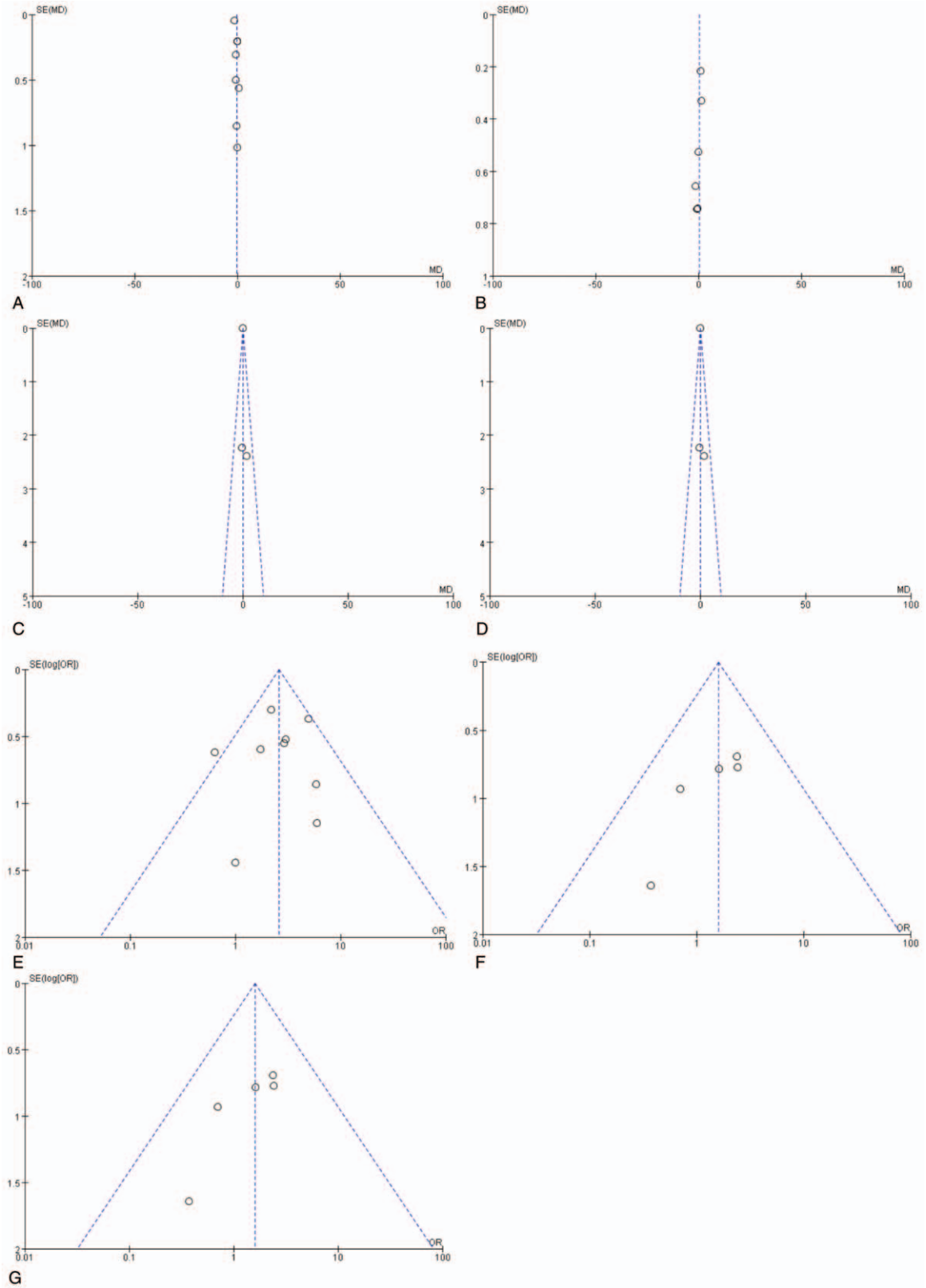

Figure 5. Funnel plots for postoperative JOA (a), VAS (b), CCI (c), Nurich grade (d), total complication rates (e), reoperations (f), and nerve palsy (g). CCI = cervical curvature index, JOA = Japanese Orthopaedic Association, VAS = visual analog scale.

Author contributions

Conceptualization: Jiaquan Luo.
Formal analysis: Wenhua Xu, Xinrong Gan.
Investigation: Wenhua Xu.
Methodology: Chunmei Wei, Shengsheng Cao.
Supervision: Shengsheng Cao, Jiaquan Luo.
Validation: Xinrong Gan.
Writing – original draft: Xiaojun Yuan, Jiaquan Luo.
Writing – review & editing: Chunmei Wei, Jiaquan Luo.

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