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Incidence of C5 nerve root palsy after cervical surgery

A meta-analysis for last decade

Tao Wang, MD[a], Hui Wang, MD[b], Sen Liu, MD[b], Wen-Yuan Ding, MD[b,*]

Abstract

Purpose: We aim to perform a meta-analysis on incidence of C5 nerve root palsy (C5 palsy) for patients after cervical surgery.

Methods: An extensive search of the literature was performed in PubMed/MEDLINE, Embase, the Cochrane library, CNKI, and WANFANG databases on incidence of C5 palsy from January 2007 to January 2017. Prevalence of C5 palsy related to different surgery methods was calculated and data analysis was conducted with STATA 12.0.

Results: A total of 61 studies containing 721 patients with C5 palsy in total 11,481 patients (6.3%) were included in our study. The incidences after anterior cervical discectomy and fusion (ACDF), anterior cervical corpectomy and fusion (ACCF), anterior corpectomy combined with discectomy (ACCDF), laminoplasty (LP) and laminectomy and fusion (LF) were 5.5%, 7.5%, 6%, 4.4%, and 12.2%, respectively. Compared with anterior approaches (5%), female patients (4%) and patients with cervical spondylotic myelopathy (CSM) (4.8%), posterior approaches (6.2%), male patients (5.7%) and patients with ossification of posterior longitudinal ligament (OPLL) (8.1%) have a higher prevalence. In ACDF and LP, patients with OPLL (5.5%, 8.1%, respectively) have a higher incidence than those in patients with CSM (4.7%, 3.1%, respectively); however, in LF, patients with CSM and OPLL have similar incidence of C5 palsy (13% vs 13.1%). In most cases, C5 palsy was unilateral (74.5%).

Conclusions: Based on our meta-analysis, posterior approaches, male patients and patients with OPLL have a higher incidence of C5 palsy. In ACDF and LP, patients with OPLL have a higher incidence of C5 palsy, but in LF, patients with CSM and OPLL have similar result.

Abbreviations: ACCDF = anterior corpectomy combined with discectomy, ACCF = anterior cervical corpectomy and fusion, ACDF = anterior cervical discectomy and fusion, C5 palsy = C5 nerve root palsy, CI = confidence intervals, CSM = cervical spondylotic myelopathy, LF = laminectomy and fusion, LP = laminoplasty, OPLL = ossification of posterior longitudinal ligament.

Keywords: C5 nerve root palsy, incidence, meta-analysis

1. Introduction

C5 nerve root palsy (C5 palsy) is a common complication after cervical surgery including anterior and posterior approaches: anterior cervical discectomy and fusion (ACDF), anterior cervical corpectomy and fusion (ACCF), anterior corpectomy combined with discectomy (ACCDF), laminoplasty (LP), and laminectomy and fusion (LF), which was reported first by Scoville.[1] Shou et al[2] reported that the incidence of C5 palsy was 5.3% (95% CI 4.6%–6.0%). Sakaura et al[3] showed that prevalence of C5 palsy varied from 0% to 30%. Patients with C5 palsy had paresis of the deltoid muscle and/or the biceps brachii muscle after surgery without any deterioration of myelopathic symptoms.[4,5]

Previous studies that reported the posterior decompression were easier to cause C5 palsy compared with the anterior decompression.[6,7,8] But the reason remained controversial. Few hypotheses reported that the spinal cord or nerve root may lead to C5 palsy. Some believed that nerve root traction caused by the cord shifting resulted in C5 nerve root lesion after posterior decompression surgery, which is called "tethering phenomenon."[9–11] Another hypothesis was that spinal cord lesion caused by acute decompression and expansion of the spinal cord lead to C5 plasy.[12–14] Hence, it is necessary to review studies related to C5 palsy for concluding the incidence of C5 palsy after all kinds of surgeries and it can give some valuable comments for spinal surgeons.

Previous reviews[2,8,15] on the prevalence and risk factors of C5 palsy have few included studies or some included studies in the 1990s and 2000s, which was far from now. So, we performed a meta-analysis on incidence of C5 palsy for the last decade.

2. Materials and methods

2.1. Ethics statement

There is no need to seek informed consent from patients, since this is a meta-analysis based on the published data, without any

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Authors' contributions—conceived and designed the study: W-YD; collected data: TW, HW; analyzed the data: SL; wrote the paper: TW and HW.

The authors have no conflicts of interest to disclose.

[a] Department of Orthopedics, Wuxi NO. 9 People's Hospital Affiliated to Soochow University, Wuxi, [b] Department of Spinal Surgery, The Third Hospital of Hebei Medical University, Shijiazhuang, China.

[*] Correspondence: Wen-Yuan Ding, Department of Spinal Surgery, The Third Hospital of Hebei Medical University, Hebei Provincial Key Laboratory of Orthopedic Biomechanics, NO. 139 Ziqiang Road, Shijiazhuang 050051, China (e-mail: docwangspine@163.com).

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potential harm to the patients; this is approved by Ethics Committee of The Third Hospital of HeBei Medical University.

2.2. Search strategy

An extensive search of literature was performed in PubMed, Embase, the Cochrane library, CNKI, and WANFANG databases. The following key words were used for search: "C5 never root palsy," "cervical," "anterior cervical discectomy and fusion," "anterior cervical corpectomy and fusion," "corpectomy combined with discectomy," "laminoplasty," "laminectomy and fusion," "cervical spondylotic myelopathy," and "ossification of posterior longitudinal ligament" from January 2007 to January 2017, with various combinations of the operators "AND" and "OR." Language was restricted to Chinese and English.

2.3. Inclusion criteria

Studies were included if they met the following criteria: randomized or nonrandomized controlled study; age greater than or equal to 18 years old; studies on C5 palsy after cervical surgery.

2.4. Exclusion criteria

Studies were excluded if they met the following criteria: had repeated data; did not report outcomes of interest; in vitro human cadaveric biomechanical studies; earlier trial, reviews, and case-reports.

2.5. Selection of studies

All subjects, abstracts, and the full text of articles were reviewed independently by 2 reviewers. According to the inclusion criteria, we selected the eligible trials. If disagreement occurred, we consulted the third reviewer to resolve the disagreement.

2.6. Data extraction and management

Two reviewers extracted independently data. The data extracted including the following categories: study ID, study design, study location, total patients, follow-up, mean age, gender, incidence of C5 palsy after anterior or posterior approaches including ACDF, ACCF, ACCDF, LP, and LF, sex of patients with C5 palsy.

2.7. Statistical analysis

We used STATA 12.0 to analyze data (Stata Corporation, College Station, TX). Both were reported with 95% confidence intervals (CI) and a P value of.05 was applied as the level of statistical significance. We used I^2 tests to assess statistical heterogeneity, which was from 0% to 100% in meta-analysis assessments. When I^2 >50% among the included studies, we chose random effects model; if not, we chose fixed-effects model.[17,18]

2.8. Test for risk of publication bias

We used a visual inspection of the funnel plot to assess publication bias. If there is publication bias, the funnel plot should be asymmetric, if not, the funnel plot is symmetric. We also performed the Egger and Begg tests to measure the funnel plot asymmetry by using a significance level of P<.05. Additionally, we applied trim and fill computation to estimate the effect of publication bias.

3. Results

3.1. Search results

We had searched 321 English studies in MEDLINE, EMBASE, 63 Chinese studies in WANFANG and CNKI. Of these, 136 English articles and 30 Chinese after duplicates removed, 80 English articles and 13 Chinese articles were excluded due to unrelated studies. Fifty-four English articles and 10 Chinese article were excluded due to eligibility criteria. As a result, a total of 61 studies were identified for this meta-analysis. The literature search procedure was shown in Fig. 1.

3.2. Baseline characteristics and quality assessment

A total of 61 studies including 721 patients with C5 palsy in total 11,481 patients (6.3%) were included in our study. Baseline characteristics of included articles are shown in Table 1.

All included studies were retrospective studies, we used the Newcastle Ottawa Quality Assessment Scale to assess the quality of each study. This scale for nonrandomized case controlled studies and cohort studies were used to allocate a maximum of 9 points for the quality of selection, comparability, exposure, and outcomes for study participants. Of these studies, 53 studies scored 8 points and 8 studies scored 7 points. Hence, the quality of each study was relatively high (Table 2).

3.3. Overall prevalence of C5 palsy

Sixty-one studies[18–78] containing total 11,481 patients 721 patients with C5 palsy after cervical surgery were included for meta-analysis. Figure 2 shows that the incidence of C5 palsy was 6.3% (95% CI 5.7%–7.9%), with substantial heterogeneity of incidence observed. The incidence of C5 palsy among the studies varied between 1% and 29%.

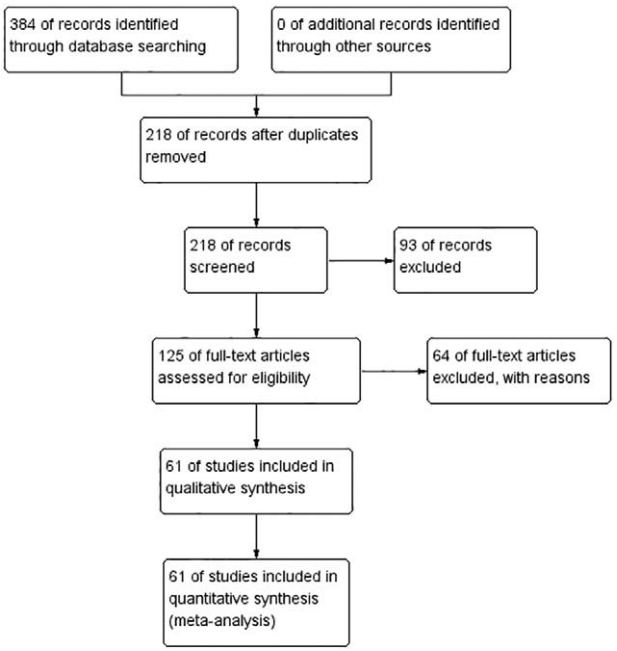

Figure 1. Flow diagram of study selection.

Table 1

Characteristics of included studies.

First author	Year	Country	Diagnosis		Study type	C5 palsy (yes/total)			Surgical approach	Gender (M/F)
			CSM	OPLL		CSM	OPLL	Yes/total		
Yu Chen[18]	2012	China	–	164	Retrospective study	–	9/164	9/164	LP/LF/ACCF	–
Lili Yang[19]	2013	China	141	–	Retrospective study	14/141	–	14/141	LP/LF	–
Shuichi Kaneyama[20]	2010	China	108	31	Retrospective study	5/108	3/31	8/146	LP	108/38
Keiichi Katsumi[21]	2012	Japan	109	42	Retrospective study	4/109	1/42	9/141	LP	–
Seiichi Odate[22]	2013	Japan	–	–	Retrospective study	–	–	32/459	–	–
Sang-Hun Lee[23]	2016	Korea	139	51	Retrospective study	–	–	30/190	LP	105/85
Yu Chen[24]	2011	China	–	75	Retrospective study	–	8/75	8/75	ACCF/LF/LP	–
Masakazu Takemitsu[25]	2008	Japan	–	–	Retrospective study	–	–	10/73	LP	49/24
Keiichi Katsumi[26]	2013	Japan	122	19	Retrospective study	8/122	1/19	9/141	–	100/41
Yu Chen[27]	2014	China	–	15	Retrospective study	–	1/15	1/15	–	–
Jin H. Park[28]	2012	Korea	–	–	Retrospective study	–	–	7/100	–	–
Sungjin Kim[29]	2012	Korea	–	–	Retrospective study	–	–	6/134	ACDF	95/39
Seiichi odate[30]	2012	Japan	–	–	Retrospective study	–	–	9/81	ACCDF/ACCF	
Toshio Nakamae[31]	2012	Japan	124	31	Retrospective study	4/124	2/31	6/184	LP	130/54
Hang Zhang[32]	2015	China	–	–	Retrospective study			10/198	–	–
Jacob Cherian[33]	2015	USA	67	33	Retrospective study	6/67	3/33	18/148	–	78/70
MENG Hailiang[34]	2015	China	–	–	Retrospective study	–	–	19/315	ACCF/LP/LF	169/146
Xuzhou Liu[35]	2014	China	–	–	Retrospective study	–	–	30/653	–	–
Cheng-Rui Bai[36]	2015	China	–	130	Retrospective study	–	9/130	9/130	–	–
Daniel J. Blizzard[37]	2015	USA	–	–	Retrospective study	–	–	13/54	LF	35/19
Mohamad Bydon[38]	2014	USA	–	–	Retrospective study	–	–	9/41	–	24/17
Peter G[39]	2010	USA	–	–	Retrospective study	–	–	2/119	–	–
Po-Yao Chang[40]	2013	Taipei	213	38	Retrospective study	11/213	1/38	12/364	–	233/131
Mark S. Eskander[41]	2012	UK	–	–	Retrospective study	–	–	12/176	–	–
Qunfeng Guo[42]	2011	China	–	–	Retrospective study	–	–	1/53	–	–
Mitsuhiro Hashimoto[43]	2010	Japan	113	62	Retrospective study	9/113	6/62	17/199	–	–
Haiying Wang[44]	2015	China	69	36	Retrospective study	3/69	3/36	8/161	ACDF	108/53
Imagama[45]	2010	Japan	1570	288	Retrospective study	33/1570	10/288	43/1858	LP	1096/762
Tsukasa Kanchiku[46]	2014	Japan	–	–	Retrospective study	–	–	3/43	ACDF/LP	–
Takuto Kurakawa[47]	2016	Japan	–	–	Retrospective study	–	–	17/88	–	47/41
Chae-Hong Lim[48]	2016	Korea	–	–	Retrospective study	–	–	36/710	LP/LF	477/233
Qiushui Lin[49]	2012	China	–	–	Retrospective study	–	–	5/120	ACCF/ACDF	–
Yang Liu[50]	2012	China	–	–	Retrospective study	–	–	22/286	ACCDF/ACCF/ACDF	–
Daniel Lubelski[51]	2014	USA	98	–	Retrospective study	12/98	–	12/98	–	–
Jacob A. Miller[52]	2015	USA	–	–	Retrospective study	–	–	17/245	–	–
Akihito Minamide[53]	2010	Japan	–	–	Retrospective study	–	–	2/51	–	–
Hiroaki Nakashima[54]	2012	Japan	43	6	Retrospective study	6/43	2/6	10/84	LF	45/39
Yu Chen[55]	2007	China	–	46	Retrospective study	–	9/46	9/49	LF	–
SUN Tianwei1[56]	2011	China	–	–	Retrospective study	–	–	9/198		–
Ahmad Nassr[57]	2012	UK	–	–	Retrospective study	–	–	42/630	ACCF/ACDF/LP/LF	–
A. Jessey Chugh[58]	2015	USA	–	–	Retrospective study	–	–	11/149	–	–
Mohamed Macki[69]	2016	USA	–	–	Retrospective study	–	–	44/511	LF	–
Kadir Kotll[60]	2011	Turkey	–	–	Retrospective study	–	–	3/25	ACCF	–
Feng L[61]	2014	China	–	–	Retrospective study	–	–	16/102	LP/LF	76/26
Kazuhiro Yamanaka[62]	2014	Japan	–	–	Retrospective study	–	–	7/58	LP/LF	–
Wang MengYuan[63]	2015	China	–	–	Retrospective study	–	–	7/96	LP	71/24
ZHANG Bin[64]	2011	China	–	–	Retrospective study	–	–	3/46	–	–
Wang Lei[65]	2014	China	42	–	Retrospective study	12/42	–	12/42	LF	–
DUAN Gang[66]	2015	China	–	–	Retrospective study	–	–	7/78	–	–
Li QiYi[67]	2012	China	–	–	Retrospective study	–	–	4/106	LP	–
JIABin[68]	2016	China	–	–	Retrospective study	–	–	20/245	LF/LP	–
XU Hai-ning[69]	2015	China	–	–	Retrospective study	–	–	5/166	LF/LP	–
WANG Xian[70]	2013	China	–	38	Retrospective study	–	2/38	2/38	–	–
Yang Liu[71]	2012	China	108	–	Retrospective study	8/108	–	8/180	ACDF/ACCF/ACCDF	–
Qunfeng Guo[72]	2011	China	–	–	Retrospective study	–	–	1/120	ACCDF	–
Xiao-Feng Lian[73]	2010	China	–	–	Retrospective study	–	–	2/105	–	–
Jiaming Liu[74]	2015	China	–	–	Retrospective study	–	–	1/46	ACDF	–
Qi Min[75]	2012	China	–	–	Retrospective study	–	–	12/69	ACCDF/ACDF/ACCF	–
GuanGdonG Chen[76]	2012	China	–	–	Retrospective study	–	–	4/54	–	–
Zhonghai Li[][77]	2014	China	–	–	Retrospective study	–	–	3/70	ACDF/ACCF	–
Hu Yong[78]	2014	China	–	–	Retrospective study	–	–	4/60	LF/LP	–
Total								721/11481		

ACCDF = anterior corpectomy combined with discectomy, ACCF = anterior cervical corpectomy and fusion, ACDF = anterior cervical discectomy and fusion, C5 palsy = C5 nerve root palsy, CSM = cervical spondylotic myelopathy, LF = laminectomy and fusion, LP = laminoplasty, OPLL = ossification of posterior longitudinal ligament.

Table 2

The quality assessment according to the Newcastle Ottawa Quality Assessment Scale (NOQAS) of each study.

Study	Selection	Comparability	Exposure	Total score
Kuang-Ting Yeh 2016	3	2	3	8
Lili Yang 2013	3	3	2	8
satoshi 2011	2	3	2	7
Wei Lin 2016	3	2	3	8
Yu Chen 2009	3	2	3	8
Dong-Geun Lee 2013	2	2	3	7
Hua Chen 2016	2	3	3	8
Rafael De la garza-ramos 2016	3	2	3	8
Lie Qian 2014	3	2	3	8
Lei Wang 2012	2	2	3	7
Lin-nan Wang 2016	2	3	3	8
Kanishka E Williams 2009	2	3	3	8
Kuang-Ting Yeh 2014	3	2	3	8
Mayur M KaManini 2016	3	2	3	8
Gregory D 2015	2	3	3	8
M. Skeppholm 2015	3	2	3	8
Zhonghai Li 2016	3	2	3	8
Yang Liu 2012	2	3	3	8
Kyung-Jin Song 2012	3	2	3	8
Qiushui Lin 2012	3	2	3	8
Qunfeng Guo 2011	2	2	3	7
Gao Hua 2014	2	3	3	8
Li Wenfeng 2015	3	2	3	8
QI Min 2012	3	2	3	8
HOU Shu-bing 2014	2	2	3	7
Cui Guopeng 2016	2	3	3	8
JIA Bin 2016	2	3	3	8
HU Yong 2014	3	2	3	8
LIU Chang-an 2015	3	2	3	8
ZHANG Bin 2011	2	3	3	8
Wang Lei 2014	3	2	3	8
Erik C. 2014	3	2	3	8
SANG-HO LEE 2008	2	3	3	8
Zhonghai Li 2016	2	3	3	8
Kevin A. 2016	3	2	3	8
Bing Wu 2016	3	2	3	8
Ji–Huan Zeng 2013	2	2	3	7
Daniel C. 2013	2	3	3	8
Christopher K. 2012	2	3	3	8
Samuel Kalb1 2012	3	2	3	8
Hiroaki Nakashima 2012	3	2	3	8
Si Hyun Kang 2011	2	3	3	8
Paul C. 2010	3	2	3	8
Christina L. 2013	3	2	3	8
Takafumi Maeno 2015	2	3	3	8
Kuang-Ting Yeh 2015	2	2	3	7
Daniel J. Blizzard1 2015	2	2	3	7
Yasushi Oshima 2015	3	2	3	8
Masaaki Machino 2016	3	2	3	8
Sang-Hun Lee 2016	2	3	3	8
Jacob Cherian 2015	3	2	3	8
Hiroaki Nakashima 2016	3	2	3	8
Lai-Qing Sun 2015	2	3	3	8
Byeongwoo Kim 2014	3	2	3	8
Daniel J. Blizzard 2016	3	2	3	8
Hua Zhou 2016	2	3	3	8
Yu Chen 2008	3	2	3	8
Atsushi Okawa 2011	3	2	3	8
Gurpreet Gandhoke 2011	2	3	3	8
Yang Liu 2012	2	2	3	7
Zhonghai Li 2014	3	2	3	8
Xuzhou Liu 2014	3	2	3	8
Jiaming Liu 2014	2	3	3	8
Darryl Lau 2015	3	2	3	8
Stefan Koehler 2015	2	3	3	8
Zhonghai Li 2016	3	2	3	8
Chang-Hyun Lee 2016	3	2	3	8
Yu Chen 2008	2	3	3	8
M Ishii 2008	3	2	3	8
Deniz Konya 2008	3	2	3	8
Rudolf Andreas Kristof 2009	2	3	3	8
Yong Liu 2009	3	2	3	8
Hironobu Sakaura 2011	3	2	3	8
Atsushi Kimura 2011	2	3	3	8
Masaaki Machino 2011	2	2	3	7
Ji-Le Jiang 2011	3	2	3	8
Atsushi Kimura 2012	3	2	3	8
H Zhang 2012	2	3	3	8
Victor Chang 2014	3	2	3	8
Atsushi Kimura1 2014	3	2	3	8
Mariano Ferna'ndez-Fairen 2007	2	3	3	8
Najib Ramzi 2008	2	2	3	7
Sungjin Kim 2014	3	2	3	8
SANG-HO LEE 2008	3	2	3	8
Li Qiyi 2012	2	3	3	8
Daniel J. 2016	3	2	3	8
Toshitaka Yoshii 2016	2	3	3	8
Hua Chen 2016	3	2	3	8
Hua Chen 2016	3	2	3	8
Jia Xufeng 2014	2	3	3	8
Qunfeng Guo 2011	3	2	3	8
Ahmad Nassr 2009	2	3	3	8
Brad Segebarth 2010	3	2	3	8
SANG Pei-ming 2016	3	2	3	8
Ma Jun-xiong 2014	2	2	3	7
Yu Jie 2016	2	3	3	8
Tao Xiao-hui 2013	2	3	3	8
Wu Bing 2015	3	2	3	8
Chen Bo 2015	3	2	3	8
GU Yifei 2013	2	3	3	8
CHEN Zhi 2012	3	2	3	8
Rahul Vaidya 2007	3	2	3	8
Fujibayashi 2010	2	3	3	8
Hironobu Sakaura 2014	3	2	3	8
Gurpreet Gandhoke 2011	2	3	3	8
Erik C 2014	3	2	3	8
Paul M Arnold 2011	3	2	3	8

3.4. Surgical approaches-related C5 palsy

The results revealed that anterior approaches (5%) have a lower incidence of C5 palsy than these in posterior approaches (6.2%). As for all kinds of surgical methods, patients with ACDF (5.5%) have the lowest incidence of C5 palsy and LF (13%) have the highest incidence of C5 palsy. The incidences of C5 palsy for ACCF, ACCDF, and LP were 7.5%, 6%, 4.4%, respectively (Figs. 3–9).

3.5. Diseases type-related C5 palsy

We only computed the incidence of C5 palsy for CSM and OPLL, because other cervical diseases lack enough data. The

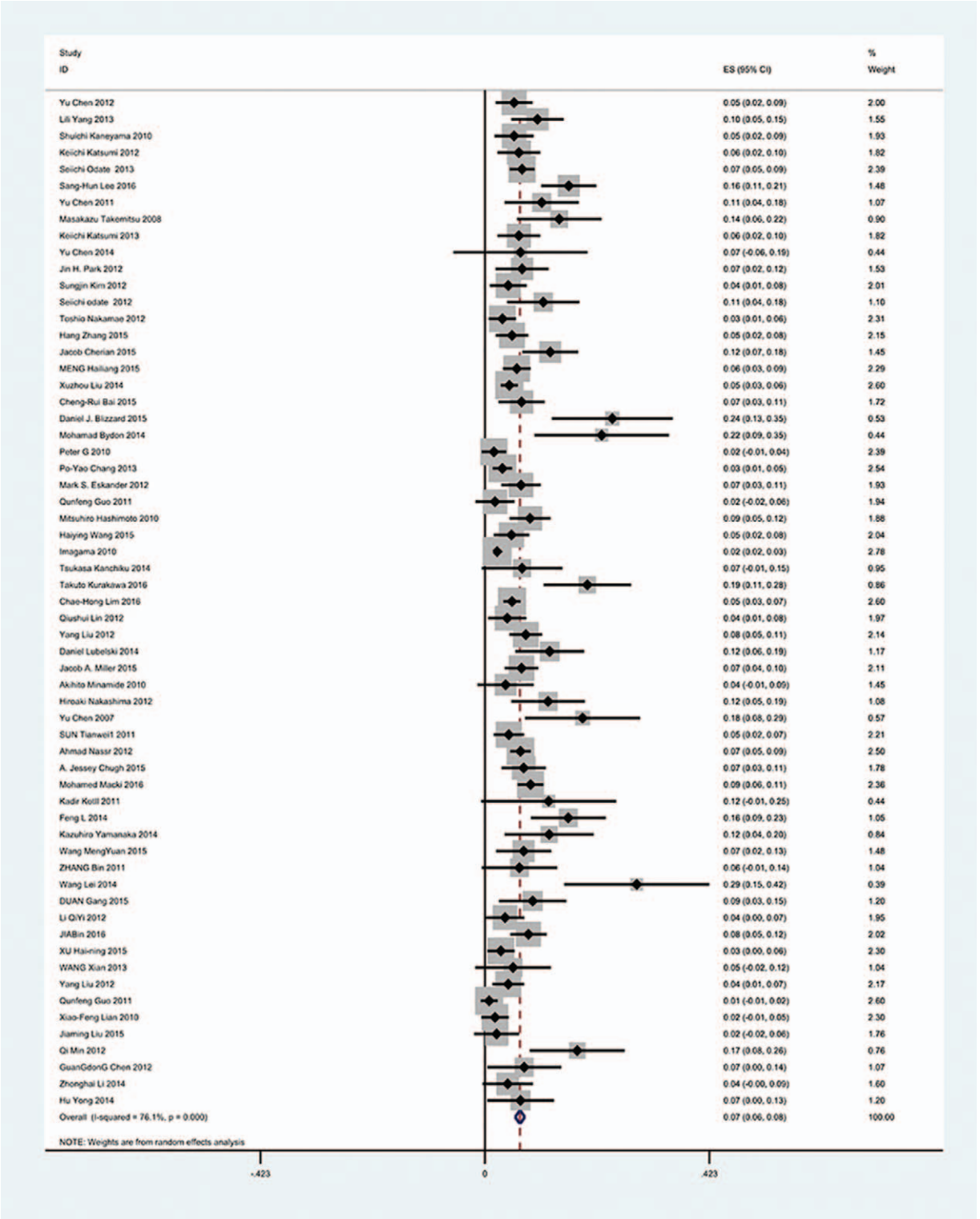

Figure 2. Forest plot showing incidence of C5 after cervical surgery. CI = confidence interval, df = degrees of freedom, M–H = Mantel–Haenszel.

results presented that patients with OPLL (8.1%) have a higher incidence of C5 palsy than patients with CSM (4.8%). We found that, in ACDF and LP, patients with OPLL (5.5%, 8.1%, respectively) have a higher incidence than those in patients with CSM (4.7%, 3.1%, respectively); however, in LF, patients with CSM and with OPLL have similar incidence of C5 palsy (13% vs 13.1%) (Figs. 10–17).

3.6. Gender-related C5 palsy

Figures 18 and 19 reveal that the prevalence of C5 palsy in males has higher incidence than that in females (5.9% vs. 4.1%).

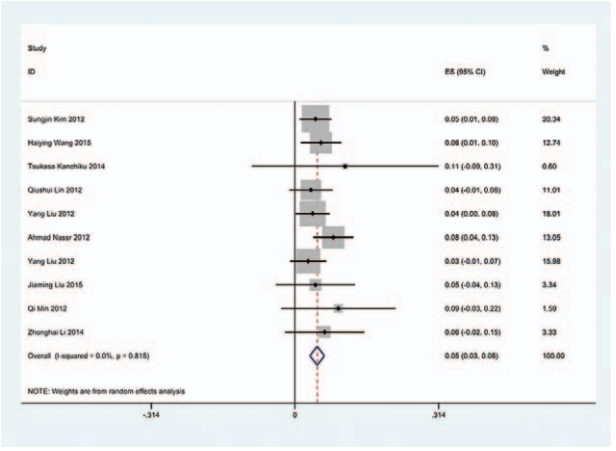

Figure 3. Forest plot showing incidence of C5 after ACDF. ACDF = anterior cervical discectomy and fusion, CI = confidence interval, df = degrees of freedom, M–H = Mantel–Haenszel.

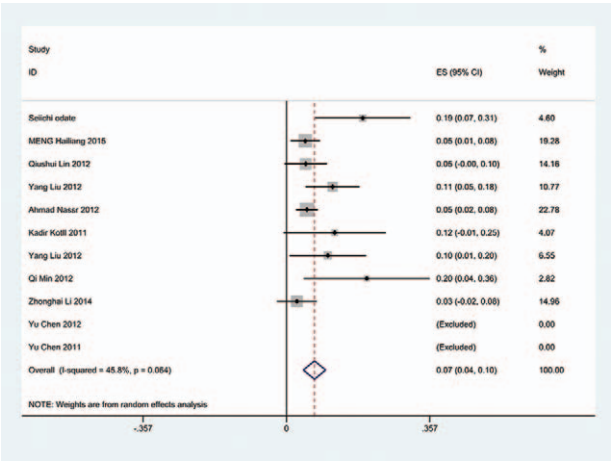

Figure 4. Forest plot showing incidence of C5 after ACCF. ACCF = anterior cervical corpectomy and fusion, CI = confidence interval, df = degrees of freedom, M–H = Mantel–Haenszel.

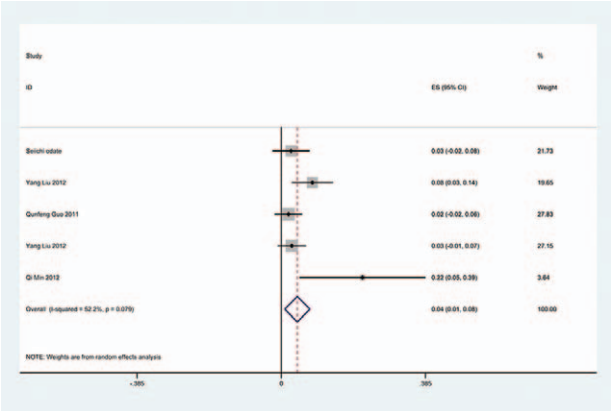

Figure 5. Forest plot showing incidence of C5 after ACCDF. ACCDF = anterior corpectomy combined with discectomy, CI = confidence interval, df = degrees of freedom, M–H = Mantel–Haenszel.

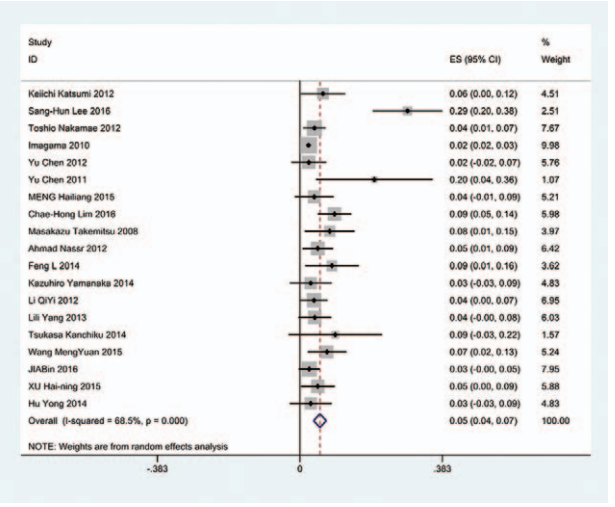

Figure 6. Forest plot showing incidence of C5 after LP. CI = confidence interval, df = degrees of freedom, LP = laminoplasty, M–H = Mantel–Haenszel.

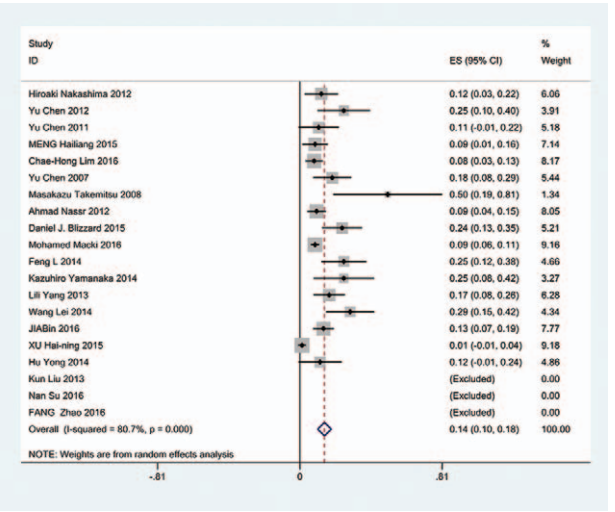

Figure 7. Forest plot showing incidence of C5 after LF. CI = confidence interval, df = degrees of freedom, LF = laminectomy and fusion, M–H = Mantel–Haenszel.

3.7. Sides-related C5 palsy

Figures 20 and 21 suggest that most cases of C5 palsy were unilaterally involved.

3.8. Publication bias

According to the shape of the funnel plot (Fig. 22) and *P* value (*P* = .557,.117) of the Begg and Egger regression tests, no visually asymmetrical and statistical evidence of publication bias of included studies is revealed. Likewise, for subgroup analysis, publication bias was also not found in included studies.

4. Discussion

A number of studies focused on the occurrence of C5 palsy after cervical surgery. Even though some mechanisms trying to explain this common complication have been proposed, it remains a

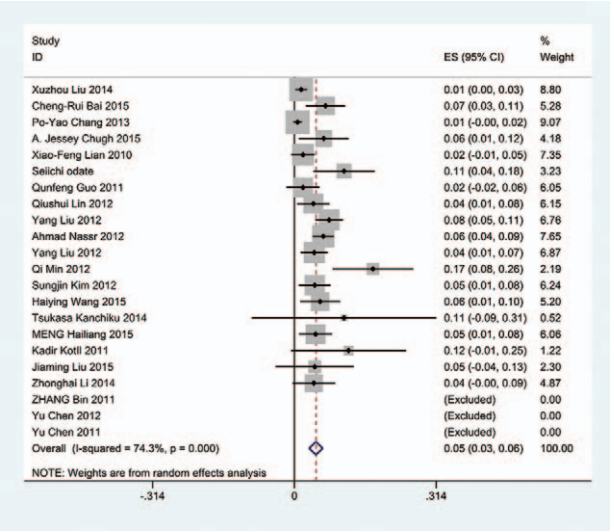

Figure 8. Forest plot showing incidence of C5 after anterior surgery. CI = confidence interval, df = degrees of freedom, M–H = Mantel–Haenszel.

controversial issue. C5 palsy after cervical surgery is considered to be a result of nerve root injury or segmental spinal cord disorder.[64] As some conditions may contribute to C5 palsy, we reviewed 5 pathologic mechanisms as follows: inadvertent injury to the nerve root during surgery;[79] shifting of the cord caused nerve root traction after surgery;[80] spinal cord ischemia caused by decreased blood supply;[81] segmental spinal cord disorder;[82] and reperfusion injury of the spinal cord.[83]

Several meta-analyses reported on the incidence of C5 palsy. Shou et al[2] performed a meta-analysis focused on the epidemiological prevalence estimates of C5 palsy following cervical surgery and it was based on 13,621 patients from 79 articles. He concluded that cervical surgery is associated with C5 palsy, particularly in patients who received LF and male patients are risk factors of C5 palsy. Gu[16] explored the incidence and risk factors of C5 palsy after posterior cervical surgery by a meta-analysis and found that patients with excessive spinal cord drift, preexisting intervertebral foramenal stenosis, OPLL, laminectomy, and male patients were risk factors for C5 palsy. Gu just assessed the C5 palsy after posterior approaches. We conducted a meta-analysis on C5 palsy for the last decade.

The results showed that 721 with C5 palsy from total 11,481 patients (6.3%) after cervical surgery in 61 included articles. Posterior approaches have a higher incidence of C5 palsy than that in anterior approached. Among all the procedures, occurrences of C5 palsy after ACDF, ACCF, ACCDF, LP, LF were 5.5%, 7.5%, 6%, 4.4%, and 12.2%. In ACDF and LP, patients with OPLL (5.5%, 8.1%, respectively) have a higher incidence than in patients with CSM (4.7%, 3.1%, respectively); however, in LF, patients with CSM and with OPLL have similar incidence of C5 palsy (13% vs 13.1%). In most cases, C5 palsy was unilateral (74.5%).

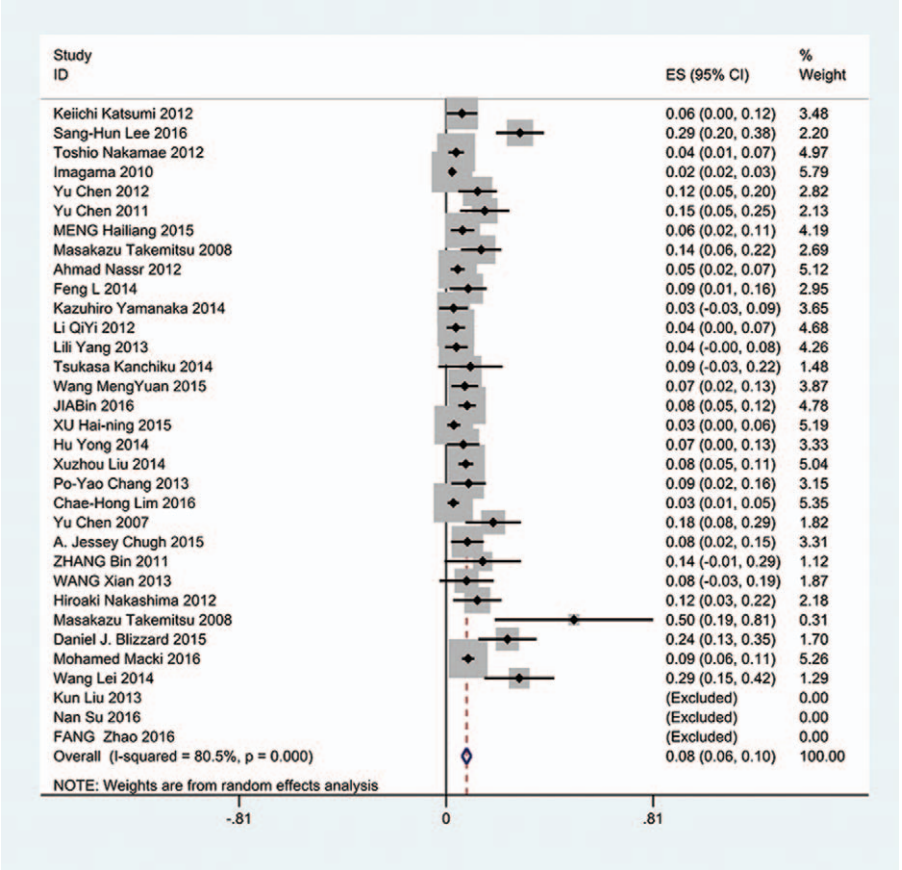

Figure 9. Forest plot showing incidence of C5 after posterior surgery. CI = confidence interval, df = degrees of freedom, M–H = Mantel–Haenszel.

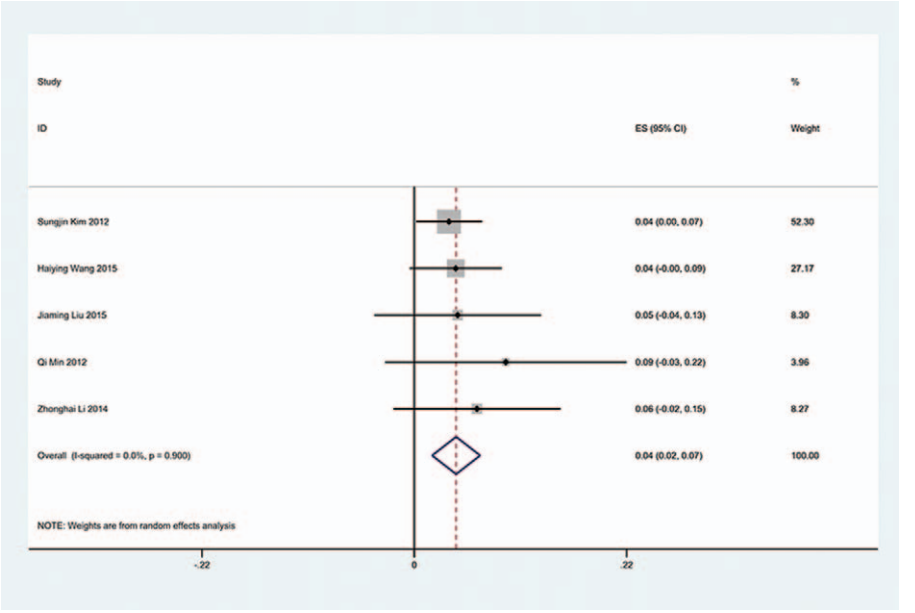

Figure 10. Forest plot showing incidence of C5 for patients with CSM after ACDF. ACDF = anterior cervical discectomy and fusion, CI = confidence interval, CSM = cervical spondylotic myelopathy, df = degrees of freedom, M–H = Mantel–Haenszel.

4.1. Anterior approaches versus posterior approaches

Bydon et al[84] reported on comparison between anterior and posterior approaches, the incidence of C5 palsy was significantly higher in the posterior method than the anterior method (8.6% vs 1.6%) ($P<.001$). Chang et al[40] performed another study to compare anterior and posterior approaches. In their study, the incidence of C5 palsy has been reported as 0.7% and 8.8% for anterior and posterior, respectively. Chen et al[24] reported the incidence of C5 palsy following posterior surgical routes as 24.3% and 0% following anterior surgical routes. In the same study, the highest incidence of C5 palsy of all published studies has been reported (25% for posterior laminectomy and fusion). These studies revealed that anterior surgical routes for patients had lower risk of developing postoperative C5 palsy. Shou et al[2] suggested that patients who received posterior cervical surgery (5.8%) had a slightly higher prevalence than patients who underwent anterior surgery (5.2%). Our results showed that posterior approaches (6.2%) had a higher incidence of C5 palsy, compared with anterior approaches (5%). We had a similar trend with Shou's, but we had difference of the incidence of C5 palsy

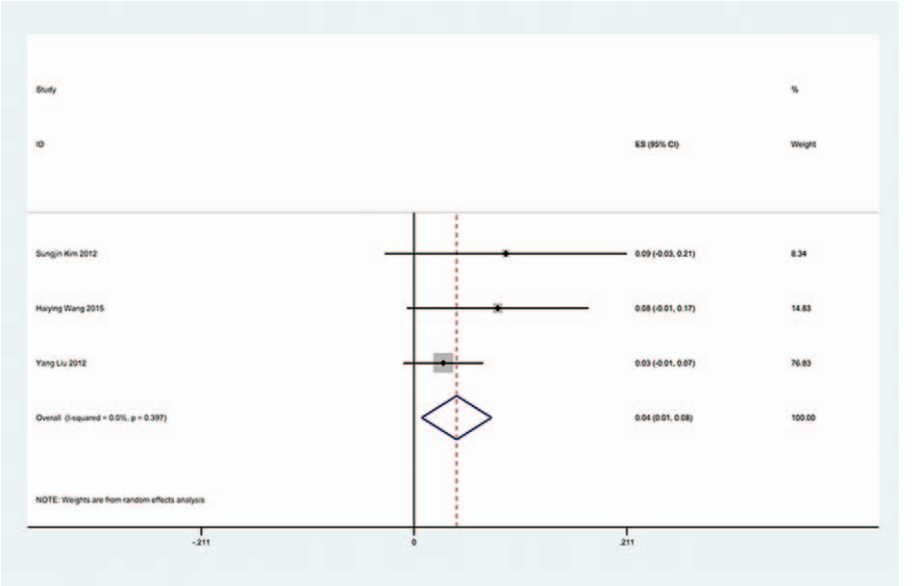

Figure 11. Forest plot showing incidence of C5 for patients with OPLL after ACDF. ACDF = anterior cervical discectomy and fusion, CI = confidence interval, CSM = cervical spondylotic myelopathy, df = degrees of freedom, M–H = Mantel–Haenszel, OPLL = ossification of posterior longitudinal ligament.

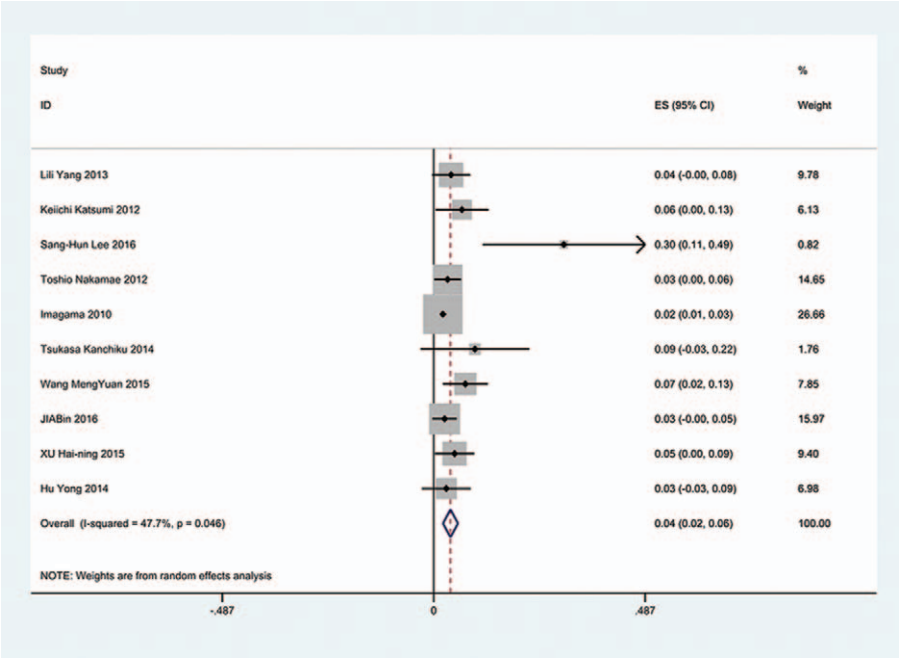

Figure 12. Forest plot showing incidence of C5 for patients with CSM after LP. CI = confidence interval, df = degrees of freedom, LP = laminoplasty, M–H = Mantel–Haenszel.

after anterior and posterior approaches, this may be relation with difference of year for included studies. Our included studies were derived from last decade, but Shou's were from 1989 to 2014, which might lead to the difference. As we know, posterior shift of the spinal cord at C4–5 in posterior group has been significantly greater than that in anterior group. Nakashima et al[54] reported that C5 palsy was caused by posterior shift of the spinal cord and additional iatrogenic foraminal stenosis due to cervical alignment correction after posterior instrumentation with fusion.

4.2. Different anterior procedures

Liu et al[50] accessed complications of different techniques anterior decompression and found that patients who underwent

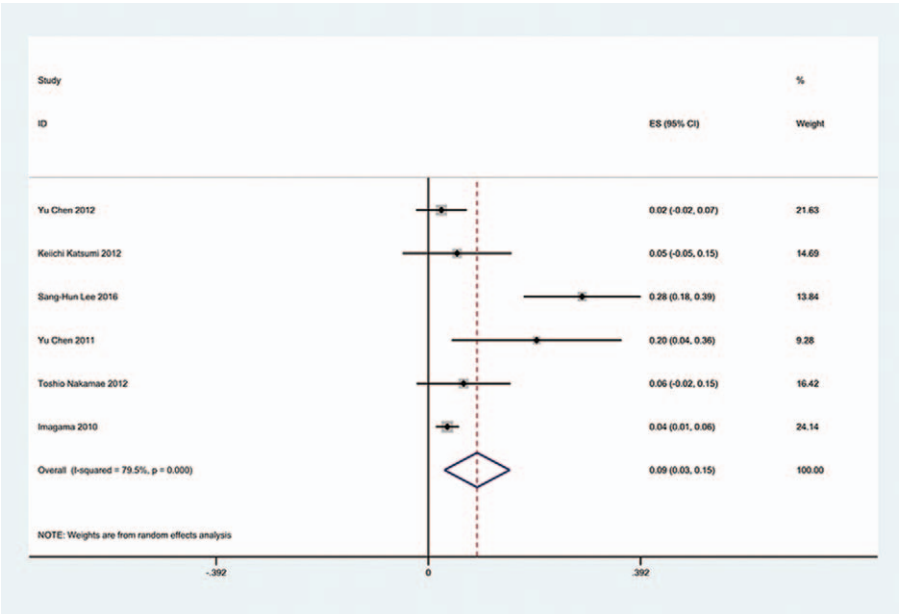

Figure 13. Forest plot showing incidence of C5 for patients with OPLL after LP. CI = confidence interval, df = degrees of freedom, LP = laminoplasty, M–H = Mantel–Haenszel, OPLL = ossification of posterior longitudinal ligament.

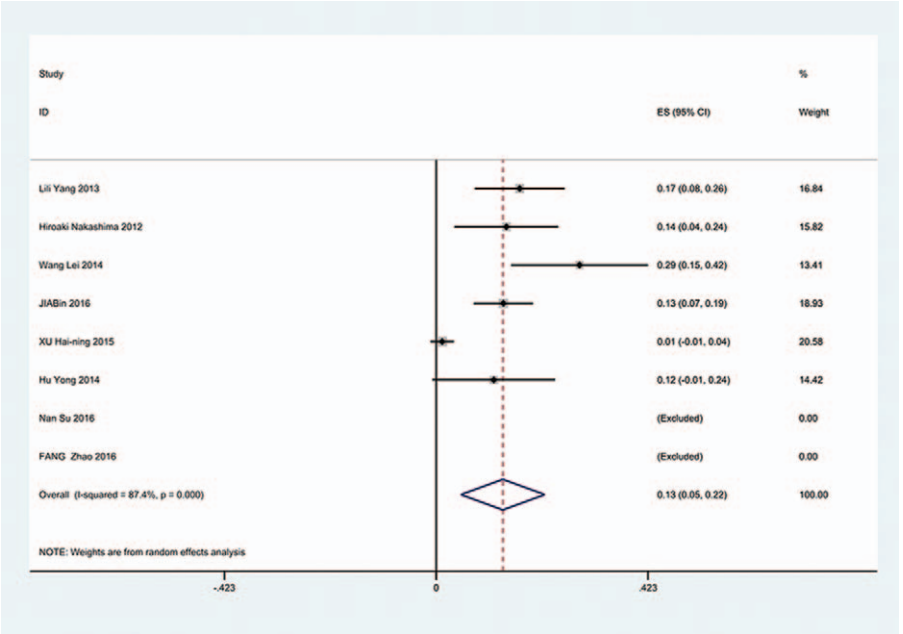

Figure 14. Forest plot showing incidence of C5 for patients with CSM after LF. CI = confidence interval, CSM = cervical spondylotic myelopathy, df = degrees of freedom, LF = laminectomy and fusion, M–H = Mantel–Haenszel.

multilevel corpectomy group had the highest incidence of C5 palsy (11.9%). Lin et al[49] explored the same topic on comparison of ACDF and ACCF in patients with multilevel CSM. Their conclusions revealed that the incidence of C5 palsy was 3.5% in ACDF and 4.8% in ACCF. ACCF had higher incidence of C5 palsy. In our meta-analysis, patients who received ACDF had the lowest incidence of C5 palsy (5.5%) and ACCF was reported as the highest prevalence (7.5%) in anterior group. ACDF could preserve more vertebral body and provide more points of distraction and fixation except for the graft and interbody space shaping than these of ACCF. ACCF may lead to significant drift of spinal cord away from ventral side.

4.3. Different posterior procedures

Posterior cervical decompression, LP and LF, is a well-recognized surgical approach for multilevel CSM or OPLL. Yang et al[19] believed that the C5 palsy rate in the LP group is significantly higher than that in the LF group. However, Xia et al[85] had diverse point that there was no significant difference between LP

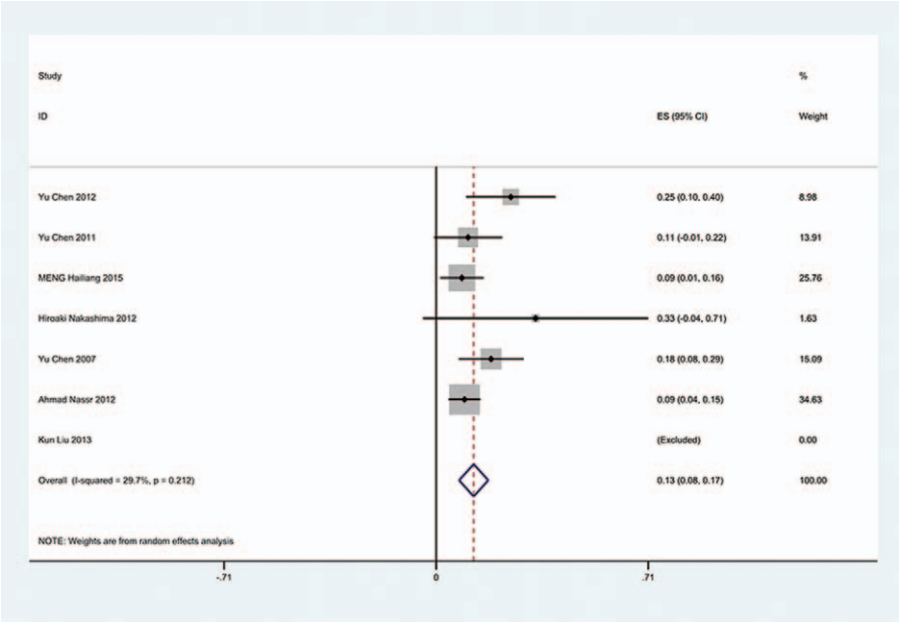

Figure 15. Forest plot showing incidence of C5 for patients with OPLL after LF. CI = confidence interval, df = degrees of freedom, M-H = Mantel-Haenszel.

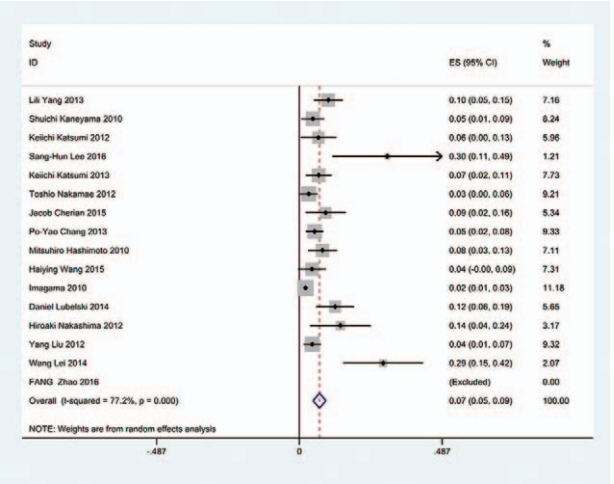

Figure 16. Forest plot showing incidence of C5 for patients with CSM after cervical surgery. CI = confidence interval, CSM = cervical spondylotic myelopathy, df = degrees of freedom, M–H = Mantel–Haenszel.

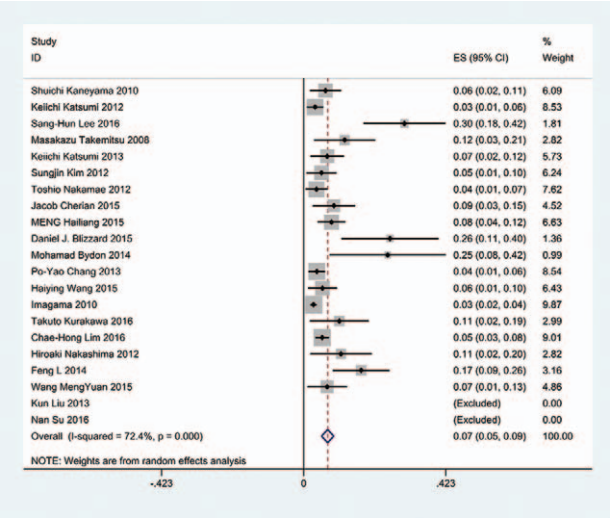

Figure 18. Forest plot showing incidence of C5 for male patients after cervical surgery. CI = confidence interval, df = degrees of freedom, M–H = Mantel–Haenszel.

and LF. Although many studies reported on the occurrence of C5 palsy after posterior cervical decompression, its detailed mechanism remained poorly understood. Our results showed that the incidence of C5 palsy was significant higher in LF, which was similar to results of previous meta-analysis, and suggested LF as a significant risk factor. That may be because the LF removes the intact posterior arch of the vertebra, thus providing an excessive space for the spinal cord to shift posteriorly and showing greater change in dural sac area. For this reason, we considered LP as a more viable posterior option for patients with CSM or OPLL.

4.4. CSM and OPLL

We evaluated incidence of C5 palsy for patients with CSM and OPLL. We found that patients with CSM (4.8%) had a lower incidence of C5 palsy than patients with OPLL (8.1%). We also assessed the incidence of C5 palsy for CSM or OPLL in ACDF, LP, or LF. The consequences showed that incidences of C5 palsy for CSM in ACDF, LP, and LF were 4.7%, 3.1%, 13%, respectively and for OPLL were 5.5%, 8.1%, 13.1%, respectively. The incidence of C5 palsy for CSM group by ACDF and LP was lower than these in the OPLL group; nevertheless, the prevalence for both CSM group and OPLL group in LF was similar. Above all suggested that patients with OPLL, compared with patients with CSM, were more susceptible to this complication.

4.5. Sex and sides for C5 palsy

Our results revealed that male patients (5.9%), compared with female patients (4.1%), were more likely to have C5 palsy, which were similar to Shou's. In most cases, C5 palsy was unilateral.

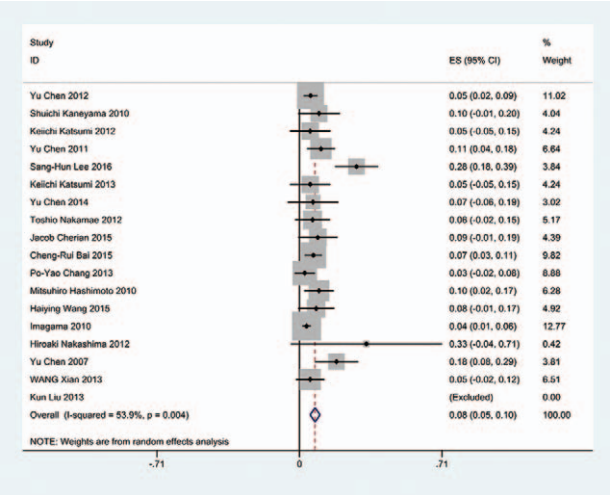

Figure 17. Forest plot showing incidence of C5 for patients with OPLL after cervical surgery. CI = confidence interval, df = degrees of freedom, M–H = Mantel–Haenszel, OPLL = ossification of posterior longitudinal ligament.

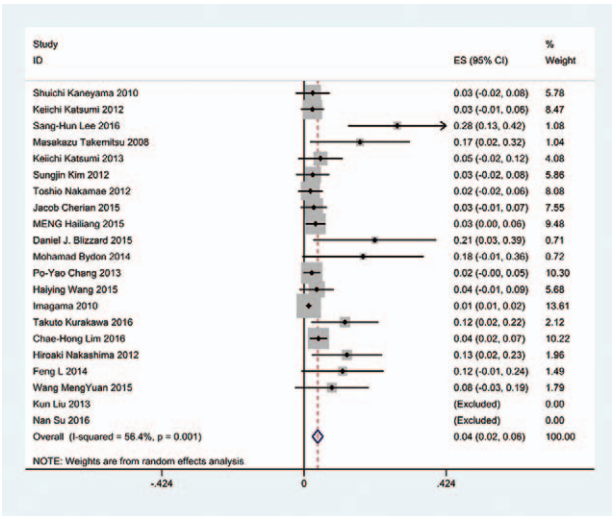

Figure 19. Forest plot showing incidence of C5 for female patients after cervical surgery. CI = confidence interval, df = degrees of freedom, M–H = Mantel–Haenszel.

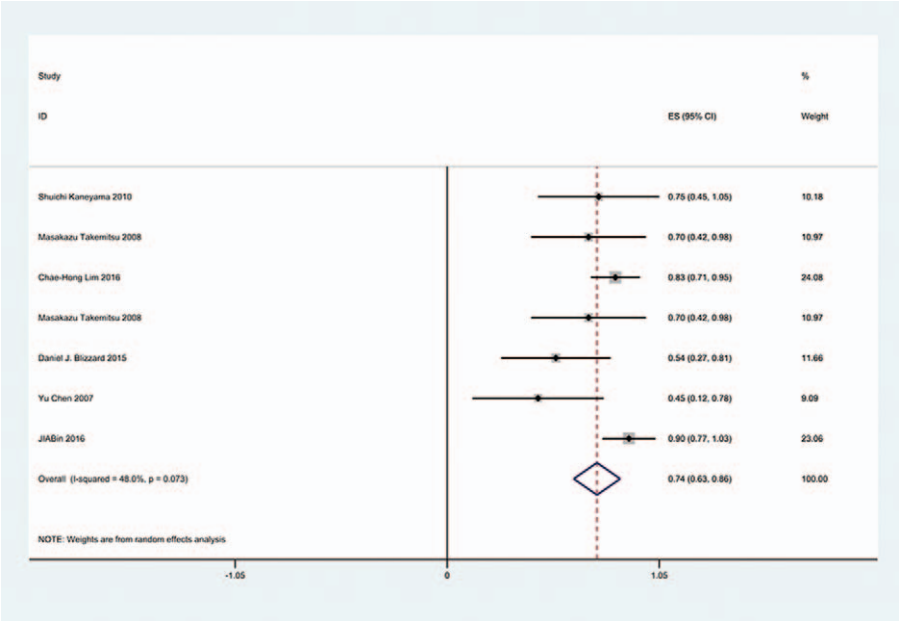

Figure 20. Forest plot showing incidence of unilateral C5 after cervical surgery. CI = confidence interval, df = degrees of freedom, M–H = Mantel–Haenszel.

4.6. Limitations

There were several limitations of this study. First, there was no RCT on C5 palsy, we need RCT to further study; Second, the statistical power could be improved in the future by including more studies. Some parameters, like 1-level CSM for C5 palsy, 2-level CSM for C5 palsy, or multilevel CSM for C5 palsy, due to the lack of data could not be analyzed by subgroups to avoid a high heterogeneity which may exert instability on the consistency of the outcomes; Third, the searching strategy was restricted to articles published in the English and Chinese languages. Articles with potentially high-quality data that were published in other languages were not included because of anticipated difficulties in obtaining accurate medical translations.

In summary, in posterior approaches, male patients and patients with OPLL have a higher incidence of C5 palsy. In ACDF and LP, patients with OPLL had a higher incidence of C5 palsy, but in LF, both patients with CSM and OPLL had similar incidence of C5 palsy. Future more studies with high

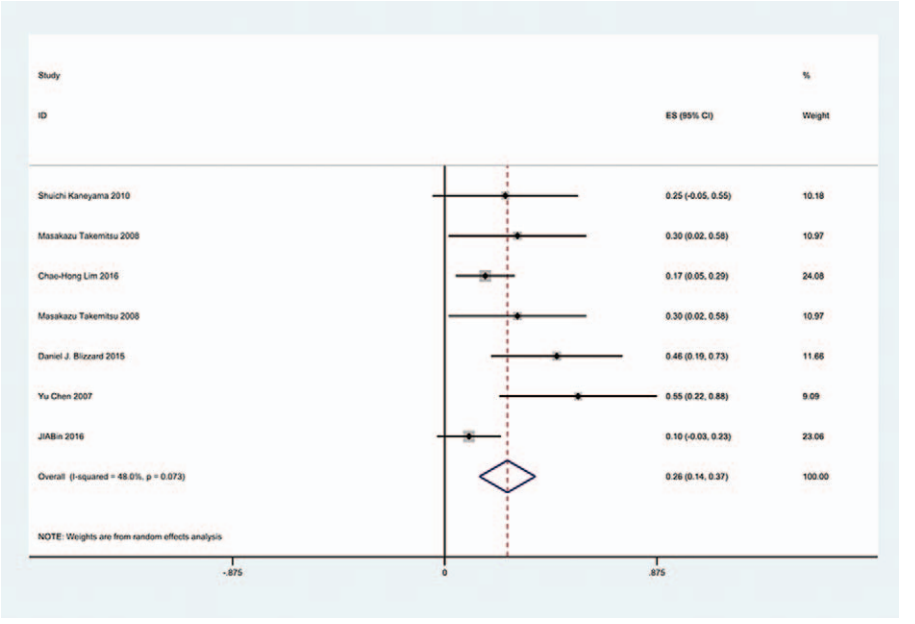

Figure 21. Forest plot showing incidence of bilateral C5 after cervical surgery. CI = confidence interval, df = degrees of freedom, M–H = Mantel–Haenszel.

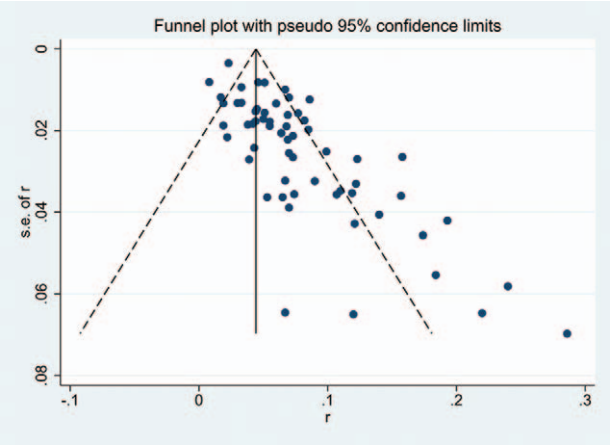

Figure 22. Funnel plot showing incidence of C5 for after cervical surgery. CI = confidence interval, df = degrees of freedom, M–H = Mantel–Haenszel.

methodological quality are needed to evaluate incidence of C5 palsy.

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