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Prevalence of complications after surgery in treatment for cervical compressive myelopathy

A meta-analysis for last decade

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Abstract

Purpose: We aim to perform a meta-analysis on prevalence of all kinds of operation-related complications following surgery treating cervical compressive myelopathy (CCM) and to provide reference for surgeons making surgical plan.

Methods: An extensive search of literature was performed in PubMed/MEDLINE, Embase, the Cochrane library, CNKI, and WANFANG databases on incidence of operation-related complications from January 2007 to November 2016. Data was calculated and data analysis was conducted with STATA 12.0 and Revman 5.3.

Results: A total of 107 studies included 1705 of 8612 patients (20.1%, 95% CI 17.3%–22.8%) on overall complications. The incidence of C5 plasy, cerebrospinal fluid (CSF), infection, axial pain, dysphagia, hoarseness, fusion failure, graft subsidence, graft dislodgment, and epidural hematoma is 5.3% (95% CI 4.3%–6.2%), 1.9% (95% CI 1.3%–2.4%), 2.8% (95% CI 1.7%–4.0%), 15.6% (95% CI 11.7%–19.5%), 16.8% (95% CI 13.6%–19.9%), 4.0% (95% CI 2.3%–5.7%), 2.6% (95% CI 0.2%–4.9%), 3.7% (95% CI 2.0%–5.5%), 3.4% (95% CI 2.0%–4.8%), 1.1% (95% CI 0.7%–1.5%), respectively. Patients with ossification of posterior longitudinal ligament (OPLL) (6.3%) had a higher prevalence of C5 plasy than those with cervical spondylotic myelopathy (CSM) (4.1%), and a similar trend in CSF (12.2% vs 0.9%). Individuals after laminectomy and fusion (LF) had highest rate of C5 plasy (15.2%), while those who underwent anterior cervical discectomy and fusion (ACDF) had the lowest prevalence (2.0%). Compared with patients after other surgical options, individuals after anterior cervical corpectomy and fusion (ACCF) have the highest rate of CSF (4.2%), infection (14.2%), and epidural hematoma (3.1%). Patients after ACDF (4.8%) had a higher prevalence of hoarseness than those with ACCF (3.0%), and a similar trend for dysphagia between anterior corpectomy combined with discectomy (ACCDF) and ACCF (16.8% vs 9.9%).

Conclusions: Based on our meta-analysis, patients with OPLL have a higher incidence of C5 palsy and CSF. Patients after LF have a higher incidence of C5 palsy, ACCDF have a higher incidence of dysphagia, ACCF have a higher incidence of CSF and infection and ACDF have a higher incidence of hoarseness. These figures may be useful in the estimation of the probability of complications following cervical surgery.

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, CSF = cerebrospinal fluid, CSM = cervical spondylotic myelopathy, LF = laminectomy and fusion, LP = laminoplasty, OPLL = ossification of posterior longitudinal ligament.

Keywords: cervical, complications, incidence, meta-analysis

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The authors have no conflicts of interest to disclose.

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1. Introduction

Cervical compressive myelopathy (CCM), caused by cervical spondylotic myelopathy (CSM) or ossification of posterior longitudinal ligament (OPLL), is a common cervical degenerative disease with increasing elder population, seriously impacting quality of life and even leading to disability.[1–3] The aim of surgery is to decompress spinal cord and preserve the stability of the spinal column.[3–7] However, the selection of optimal surgical treatment for CCM remains controversial.[4,5,8–11] Surgeries, widely used in clinic mainly involved anterior and posterior approaches, including anterior cervical discectomy and fusion (ACDF), anterior cervical corpectomy and fusion (ACCF), anterior corpectomy combined with discectomy (ACCDF), laminoplasty (LP), and laminectomy with fusion (LF).[10–16] Each approach has its own advantages and disadvantages. Anterior approaches are propitious to solve pathogenic structures from anterior, but it has a high risk of complications, like dysphagia, hoarseness, or artery injury, as reported by previous studies.[3–5,7,9] Posterior approaches could adequately decompress spinal cord, but it was reported that posterior approaches were more likely to cause C5 plasy and cervical kyphosis.

Even though, many studies reported on surgical selection for CCM. But there is no meta-analysis on prevalence of complications following cervical surgery treating for CCM. The purpose of our study is to explore incidence of operation-related complications after cervical surgery and we hope that it is helpful in the estimation of the probability of complications following cervical surgery.

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 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/MEDLINE, Embase, the Cochrane library, CNKI, and WANFANG databases. The following key words were used for search: "complications," "cervical," "C5 plasy," "CSF," "infection," "axial pain," "dysphagia," "hoarseness," "fusion failure," "graft subsidence," "graft dislodgment," "epidural hematoma," "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 November 2016, 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 complications 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; sample size >1000 or <30; CCM caused by trauma or tumour; have a history of cervical surgery.

2.5. Selection of studies

Two reviewers independently reviewed all subjects, abstracts, and the full text of articles. Then the eligible trials were selected according to the inclusion criteria. When consensus could not be reached, a third reviewer was consulted to resolve the disagreement.

2.6. Data extraction and management

Two reviewers extracted data independently. The data extracted including the following categories: study ID, study design, study location, number of total patients and patients with complications, diagnose, complications category, incidence of complications after anterior or posterior approaches including ACDF, ACCF, ACCDF, LP, and LF.

2.7. Statistical analysis

Data analysis was performed with STATA 12.0 (Stata Corporation, College Station, TX). Both were reported with 95% confidence intervals (CI), and a P value of 0.05 was used as the level of statistical significance. Assessment for statistical heterogeneity was calculated using the I^2 tests, which described the proportion of the total variation in meta-analysis assessments from 0% to 100%. The random effects model was used for the analysis when an obvious heterogeneity was observed among the included studies (I^2 >50%). The fixed-effects model was used when there was no significant heterogeneity between the included studies ($I^2 \leq 50\%$).[17,18] Flow diagram was performed with Revman 5.3

2.8. Test for risk of publication bias

We performed a visual inspection of the funnel plot for publication bias. The funnel plot should be asymmetric when there is publication bias and symmetric in the case of no publication bias. We performed Egger and Begg tests to measure the funnel plot asymmetry by using a significance level of $P<0.05$. The trim and fill computation was used to estimate the effect of publication bias.

3. RESULTS

3.1. Search results

We had searched 631 English studies in MEDLINE, EMBASE, 93 Chinese studies in WANFANG and CNKI. Of these, 103 English articles and 30 Chinese articles after duplicates removed, 368 English articles and 36 Chinese articles were excluded due to unrelated studies. Seventy-three English articles and 7 Chinese articles were excluded due to eligibility criteria. As a result, a total of 107 studies were identified for this meta-analysis. The literature search procedure is shown in Fig. 1.

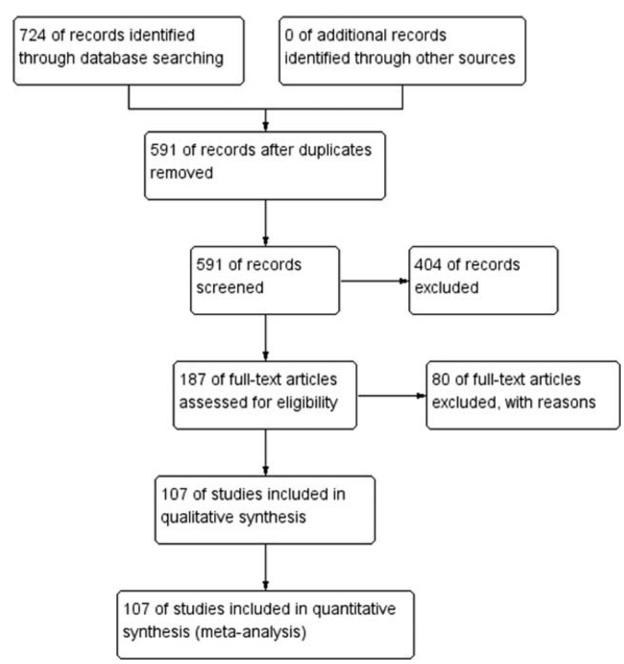

Figure 1. Flow diagram of study selection.

3.2. Baseline characteristics and quality assessment

A total of 8612 patients from 75 studies on total complications, 6349 patients from 57 studies on C5 plasy, 5007 patients from 36 studies on CSF, 591 patients from 6 studies on graft subsidence, 1102 patients from 10 studies on graft dislodgment, 2234 patients from 19 studies on hoarseness, 3489 patients from 25 studies on infection, 5841 patients from 38 studies on dysphagia, 689 patients from 5 studies on fusion failure, 2185 patients from 14 studies on epidural hematoma, 2650 patients from 23 studies on axial pain were included in our study. Table 1 shows the baseline characteristics of included articles.

All included studies were retrospective studies, Newcastle Ottawa Quality Assessment Scale (NOQAS) was applied to estimate the quality of each study. We used NOQAS, the maximum of 9 points, to assess quality of selection for nonrandomized case controlled studies and cohort studies in terms of comparability, exposure, and outcomes. Among these studies, 95 studies scored 8 points and 3 studies scored 12 points. Therefore, each study has relatively high quality (Table 2).

3.3. Prevalence of overall complications

Seventy-five studies[19–92] containing 1705 patients with overall complications of 8612 patients after cervical surgery were included. Figure 2 shows that the incidence was 20.1% (95% CI 17.3%–22.8%), with substantial heterogeneity of incidence observed. The incidence varied between 2.6% and 58.1%.

3.4. C5 plasy

Fifty-seven studies[20–28,30,33–35,37–39,42–43,45,47–48,50,52–56,59,61–71,73–75,77–79, 82–85,88,89,91–96] containing 355 patients with C5 plasy of 6349 patients after cervical surgery were included. Figure 3 shows that the incidence was 5.3% (95% CI 4.3%–6.2%), with substantial heterogeneity of incidence observed. The incidence varied between 0.6% and 28.6%. Compared with patients with CSM (4.1%, 95% CI 2.9%–5.2%), patients with OPLL (6.3%, 95% CI 2.4%–5.2%) has a higher incidence (Figs. 4, 5). In terms of surgical methods, patients who underwent LP had the highest rate (15.2%, 95% CI 10.9%–19.1%), while those who received ACDF had the lowest rate (2.0%, 95% CI 0.8%–2.4%) (Fig 6, Fig 7, Fig 8, Fig 9, Fig 10).

3.5. Dysphagia

Thirty-eight studies[25,32–36,38,40–41,59–60,62,69–70,78,81,85,86,97–115] containing 835 patients with dysphagia of 5841 patients after cervical surgery were included. Figure 11 shows that the incidence was 16.8% (95% CI 13.6%–19.9%), with substantial heterogeneity of incidence observed. The incidence varied between 1.4% and 58.1%. Incidence for patients who underwent ACCDF and ACDF was 16.8% (95% CI 6.9%–27.2%) and 16.2% (95% CI 11.7%–19.8%), which is higher than those who received ACCF 9.9% (95% CI 4.8%–15.9%) (Fig 12, Fig 13, Fig 14).

3.6. Cerebrospinal fluid

Thirty-six studies[20,22–24,27,28,34,35,38,39,42,45,47,48,56,57,60–62,65,66,69–71,73,74,79,81,82,84–86,88,90,91,116] containing 129 patients with CSF of 5007 patients after cervical surgery were included. Figure 15 shows that the incidence was 1.9% (95% CI 1.3%–2.4%), with substantial heterogeneity of incidence observed. The incidence varied between 0.4% and 21.1%. Compared with patients with CSM (0.9%, 95% CI 0.6%–1.7%), patients with OPLL (12.2%, 95% CI 6.2%–17.8%) have a higher incidence (Figs. 16, 17). As for surgical methods, patients who underwent ACCF had the highest rate (4.2%, 95% CI 0.3%–8.2%), while those who received ACDF had the lowest rate (1.9%, 95% CI 0.9%–4.0%) (Figs. 18–20 Fig 18, Fig 19, Fig 20).

3.7. Infection

Twenty-five studies[20,23–25,33,35,36,40,47,51,59,61,62,68,69,73–76,78,85,86,91,117,118] containing 142 patients with infection of 3489 patients after cervical surgery were included. Figure 21 shows that the incidence was 2.8% (95% CI 1.7%–4.0%), with substantial heterogeneity of incidence observed. The incidence varied between 0.4% and 54.6%. Incidence for the patients who underwent ACCF was 14.2% (95% CI −1.1%–30.3%), which higher than those who received ACDF (0.9%, 95% CI 0.2%–2.8%) and LP (2.1%, 95% CI 0.9%–3.2%) (Fig 22, Fig 23, Fig 24).

3.8. Axial pain

Twenty-three studies[20–22,26,30,34,44,46,48,49,56,60,61,66,73,81,83,84,88,89,92,118,119] containing 372 patients with axial pain of 2650 patients after cervical surgery were included for meta-analysis. Figure 25 shows that the incidence was 15.6% (95% CI 11.7%–19.5%), without substantial heterogeneity of incidence observed. The incidence varied between 1.7% and 53.2%. Incidence of axial pain for those following LP and LF was 22.2% (95% CI 14.1%–29.3%) and 23.2% (95% CI 15.8%–31.3%) (Figs. 26, 27).

3.9. Hoarseness

Nineteen studies[25,26,31,35,36,38,40,45,56,62,70,79,81,84–86,90,100,116] containing 99 patients with hoarseness of 2234 patients after cervical surgery were included. Figure 28 shows that the incidence of hoarseness was 4.0% (95% CI 2.3%–5.7%), with substantial heterogeneity of incidence observed. The incidence varied between 0.6% and 60.9%. Patients after ACDF (4.8%, 95% CI 1.9%–7.8%) had a slight higher prevalence of hoarseness than those with ACCF (3.0%, 95% CI 0.9%–4.2%) (Figs. 29, 30).

3.10. Epidural hematoma

Fourteen studies[22,23,33–35,38,39,56,61,65,74,79,81,120] containing 33 patients with epidural hematoma of 2185 patients after cervical surgery were included. Figure 31 shows that the incidence was 1.1% (95% CI 0.7%–1.5%), without substantial heterogeneity of incidence observed. The incidence varied between 0.5% and 5.3%. Incidence of axial pain for those following ACCF and ACDF was 3.1% (95% CI 1.0%–6.2%) and 2.0% (95% CI 0.9%–3.2%) (Figs. 32, 33).

3.11. Graft dislodgment

Ten studies[35,38,40,45,62,64,69,81,82,121] containing 45 patients with graft dislodgment of 1102 patients after cervical surgery were included. Figure 34 shows that the incidence was 3.4% (95% CI 2.0%–4.8%), without substantial heterogeneity of incidence observed. The incidence among the studies varied between 1.4% and 8.2%.

Table 1

Characteristics of included studies.

First author	Year	Country	Diagnosis CSM	Diagnosis OPLL	Study Type	Complications C5 plasy	CSF	Infection	Axial pain	Hematoma	Dysphagia	Fusion failure	Graft subsidence	Graft dislodgment	Hoarseness	Total	Surgical approach
Kuang-Ting Yeh[19]	2016	China	65	0	Retrospective study	—	—	—	—	—	—	—	—	—	—	65	LP
Lili Yang[20]	2013	China	—	—	Retrospective study	14	4	1	32	—	—	—	—	—	—	141	LP, LF
Satoshi[21]	2011	Japan	—	—	Retrospective study	1	—	—	2	—	—	—	—	—	—	22	LP
Yu Chen[22]	2009	China	—	—	Retrospective study	4	4	—	3	1	—	—	—	—	—	50	ACCF, LF
Dong-Geun Lee[23]	2013	Korea	—	—	Retrospective study	3	1	2	—	1	—	—	—	—	—	51	LP
Hua Chen[24]	2016	China	—	—	Retrospective study	13	4	4	—	—	—	—	—	—	—	129	LP
Rafael De la garza-ramos[25]	2016	USA	97	—	Retrospective study	1	—	2	—	—	17	—	—	—	1	97	ACDF
Lie Qian[26]	2014	China	—	—	Retrospective study	2	—	—	20	—	—	1	—	—	2	336	ACCF
Lei Wang[27]	2012	China	—	—	Retrospective study	4	4	—	—	—	—	—	—	—	—	49	LP
Lin-nan Wang[28]	2016	China	—	—	Retrospective study	3	1	—	—	—	—	—	—	—	—	56	LP
Kanishka E Williams[29]	2009	Indian	—	—	Retrospective study	—	—	—	—	—	—	—	—	—	—	24	
Kuang-Ting Yeh[30]	2014	China	—	—	Retrospective study	3	—	—	50	—	—	—	—	—	—	126	LP
Mayur M KaManini[31]	2016	Indian	—	—	Retrospective study	—	—	—	—	—	—	—	—	—	1	20	ACDF
Gregory D[32]	2015	USA	—	—	Retrospective study	—	—	—	—	—	10	—	—	—	—	231	ACDF
M Skeppholm[33]	2015	Sweden	—	—	Retrospective study	1	—	1	—	1	21	—	—	—	—	139	ACDF
Zhonghai Li[34]	2016	China	—	—	Retrospective study	3	1	—	2	1	8	—	2	—	—	70	ACCF, ACDF
Yang Liu[35]	2012	China	—	—	Retrospective study	8	1	2	—	2	19	—	4	4	7	180	ACCF, ACDF, ACCDF
Kyung-Jin Song[36]	2012	Korea	—	—	Retrospective study	—	—	1	—	—	4	—	—	—	1	43	ACDF
Sungjin Kim[37]	2014	Korea	—	—	Retrospective study	6	—	—	—	—	—	—	—	—	—	134	
Qiushui Lin[38]	2012	China	—	—	Retrospective study	5	3	—	—	3	9	—	4	2	5	120	ACCF, ACDF
Qunfeng Guo [39]	2011	China	—	—	Retrospective study	1	2	—	—	2	—	1	8	—	—	120	ACCF, ACDF, ACCDF
Najib Ramzi [40]	2008	Belgium	—	—	Retrospective study	—	—	2	—	—	2	—	—	2	2	40	ACDF
Mariano Ferna'ndez-Fairen [41]	2007	Spain	—	—	Retrospective study	—	—	—	—	—	2	—	—	—	—	61	ACDF
Atsushi Kimura1 [42]	2014	Japan	—	—	Retrospective study	3	6	—	—	—	—	—	—	—	—	116	LP
Victor Chang [43]	2014	USA	58	—	Retrospective study	4	—	—	—	—	—	—	—	—	—	58	LF
H Zhang [44]	2012	China	79	—	Retrospective study	—	—	—	42	—	—	—	—	—	—	79	LP
Atsushi Kimura [45]	2012	Japan	—	106	Retrospective study	14	22	—	—	—	—	—	—	8	7	106	ACDF, LP
Ji-Le Jiang [46]	2011	China	—	—	Retrospective study	—	—	—	6	—	—	—	—	—	—	26	LP
Masaaki Machino [47]	2011	Japan	520	—	Retrospective study	3	9	2	—	—	—	—	—	—	—	520	LP
Atsushi Kimura [48]	2011	Japan	—	—	Retrospective study	4	3	—	17	—	—	—	—	—	—	67	LP
Hironobu Sakaura [49]	2011	Japan	31	—	Retrospective study	—	—	—	3	—	—	—	—	—	—	31	LP
Yong Liu [50]	2009	China	28	—	Retrospective study	1	—	—	—	—	—	—	—	—	—	28	ACCF
Rudolf Andreas Kristof [51]	2009	German	103	—	Retrospective study	—	—	5	—	—	—	—	—	—	—	103	
Deniz Konya [52]	2008	Turkey	40	—	Retrospective study	3	—	—	—	—	—	—	—	—	—	40	
M Ishii [53]	2008	Japan	—	—	Retrospective study	1	—	—	—	—	—	—	—	—	—	47	LP
Yu Chen [54]	2008	China	—	83	Retrospective study	5	—	—	—	—	—	—	—	—	—	83	LF
Chang-Hyun Lee [55]	2016	Korea	—	57	Retrospective study	2	—	—	—	—	—	—	—	—	—	57	
Zhonghai Li [56]	2016	China	97	—	Retrospective study	4	1		3	1					5	97	ACDF
Stefan Koehler [57]	2015	German	—	—	Retrospective study	—	1	—	—	—	—	—	—	—	—	46	ACCF

(*continued*)

Table 1
(continued).

			Diagnosis			Complications											
First author	Year	Country	CSM	OPLL	Study Type	C5 plasy	CSF	Infection	Axial pain	Hematoma	Dysphagia	Fusion failure	Graft subsidence	Graft dislodgment	Hoarseness	Total	Surgical approach
Darryl Lau [58]	2015	USA	—	—	Retrospective study	—	—	—	—	—	—	—	—	—	—	37	
Jiaming Liu [59]	2014	China	46	—	Retrospective study	1	—	5	—	—	3	—	—	—	—	46	ACCF, ACDF
Xuzhou Liu [60]	2014	China	653	—	Retrospective study	—	7	—	19	—	—	—	—	—	—	653	ACDF, LP
Zhonghai Li [61]	2014	China	—	—	Retrospective study	3	1	1	9	2	—	—	—	—	—	67	ACCF, LF
Yang Liu [62]	2012	China	—	—	Retrospective study	22	3	2	—	—	13	—	—	11	10	286	ACCF, ACDF, ACCDF
Gurpreet Gandhoke [63]	2011	USA	—	—	Retrospective study	—	4	—	—	—	—	—	—	—	—	62	ACCF, LP
Atsushi Okawa [64]	2011	Japan	—	—	Retrospective study	—	—	—	—	—	—	—	—	2	—	30	ACCF
Yu Chen [65]	2008	China	19	—	Retrospective study	2	4	—	—	1	—	—	—	—	—	19	ACCF
Hua Chen [66]	2016	China	—	—	Retrospective study	1	7	—	32	—	—	—	—	—	—	105	
Hua Zhou [67]	2016	China	—	—	Retrospective study	2	—	—	—	—	—	—	—	—	—	22	LP
Daniel J Blizzard [68]	2016	USA	—	—	Retrospective study	—	—	—	—	—	—	—	—	—	—	72	LP, LF
Toshitaka Yoshii [69]	2016	Japan	—	61	Retrospective study	4	9	1	—	—	4	—	—	5	—	61	ACDF, LF
Byeongwoo Kim [70]	2014	Korea	—	71	Retrospective study	3	3	—	—	—	1	—	—	—	2	71	ACDF
Lai-Qing Sun [71]	2015	China	—	—	Retrospective study	2	1	—	—	—	—	—	—	—	—	83	LP
Hiroaki Nakashima [72]	2016	Japan	—	—	Retrospective study	—	—	—	—	—	—	—	—	—	—	479	
Hua Chen [73]	2016	China	—	—	Retrospective study	13	4	4	39	—	—	—	—	—	—	129	LP
Masaaki Machino [74]	2016	Japan	—	—	Retrospective study	7	6	3	—	3	—	—	—	—	—	505	LP
Yasushi Oshima [75]	2015	Japan	505	—	Retrospective study	2	—	1	—	—	—	—	—	—	—	37	
Kuang-Ting Yeh [76]	2015	China	—	—	Retrospective study	—	—	1	—	—	—	—	—	—	—	20	LP
Takafumi Maeno [77]	2015	Japan	90	—	Retrospective study	8	—	—	—	—	—	—	—	—	—	90	LP
Hiroaki Nakashima [78]	2012	Japan	—	—	Retrospective study	10	—	1	—	—	—	—	—	—	—	84	
Daniel C[79]	2013	USA	—	—	Retrospective study	2	1	—	—	4	—	—	—	—	3	150	ACDF
Bing Wu[80]	2016	China	—	—	Retrospective study	—	—	—	—	—	—	—	—	—	—	358	
Zhonghai Li [81]	2016	China	—	—	Retrospective study	—	1	—	2	3	18	—	—	2	6	138	ACDF
Daniel J[68]	2016	USA	72	—	Retrospective study	13	—	5	—	—	—	—	—	—	—	72	LP, LF
Sang-Ho Lee[82]	2008	Korea	—	27	Retrospective study	—	2	—	—	—	—	—	—	1	—	48	ACCF, LP
Gao Hua[83]	2014	China	—	—	Retrospective study	—	—	—	24	—	—	—	—	—	—	91	LP, LF
Li Wenfeng[84]	2015	China	—	—	Retrospective study	—	—	—	3	—	—	—	4	—	1	36	LP
QI Min[85]	2012	China	—	—	Retrospective study	—	—	3	—	—	26	—	—	—	12	327	ACCF, ACDF, ACCDF
Hou Shubing[86]	2014	China	—	—	Retrospective study	—	—	1	—	—	2	2	—	—	1	65	ACCF, ACDF
Cui Guopeng[87]	2016	China	—	—	Retrospective study	—	—	—	—	—	—	16	—	—	—	130	ACCF, ACCDF
Jia Bin[88]	2016	China	—	—	Retrospective study	—	—	—	49	—	—	—	—	—	—	245	LP, LF
Hu Yong[89]	2014	China	—	—	Retrospective study	—	—	—	1	—	—	—	—	—	—	60	LP, LF
Liu Chang-an[90]	2015	China	—	—	Retrospective study	—	—	—	—	—	—	1	—	—	2	38	ACCF
Zhang Bin[91]	2011	China	—	—	Retrospective study	—	3	1	—	—	—	—	—	—	—	46	ACCF
Wang Lei[92]	2014	China	—	—	Retrospective study	—	—	—	8	—	—	—	—	—	—	42	LF
Total			—	—												8612	
Gurpreet Gandhoke [63]	2011	USA	62	—	Retrospective study	C5 plasy									4	62	ACCF
Sang-Ho Lee[82]	2008	Korea	—	47	Retrospective study	C5 plasy									2	47	
Jacob Cherian[93]	2015	USA	—	—	Retrospective study	C5 plasy									18	148	LF
Sang-Hun Lee[94]	2016	Korea	—	—	Retrospective study	C5 plasy									30	190	LP, LF

(*continued*)

Table 1
(continued).

First author	Year	Country	Diagnosis		Study Type	Complications											Surgical approach
			CSM	OPLL		C5 plasy	CSF	Infection	Axial pain	Hematoma	Dysphagia	Fusion failure	Graft subsidence	Graft dislodgment	Hoarseness	Total	
Daniel J Blizzard[95]	2015	USA	—	—	Retrospective study	C5 plasy									13	54	LF
Li Qiyi[96]	2012	China	—	—	Retrospective study	C5 plasy									6	106	
Erik C[97]	2014	USA	—	—	Retrospective study	Dysphagia									26	100	ACDF
Paul M Arnold[98]	2011	USA	—	—	Retrospective study	Dysphagia									2	103	ACDF
Brad Segebarth[99]	2010	USA	—	—	Retrospective study	Dysphagia									22	76	ACDF
Rahul Vaidya[100]	2007	USA	—	—	Retrospective study	Dysphagia									38	46	ACDF
Paul C[101]	2010	USA	—	—	Retrospective study	Dysphagia									44	251	ACDF
Si Hyun Kang[102]	2011	Korea	—	—	Retrospective study	Dysphagia									7	45	ACDF
Samuel Kalb[103]	2012	USA	—	—	Retrospective study	Dysphagia									27	249	
Christopher K[104]	2012	USA	—	—	Retrospective study	Dysphagia									25	43	ACDF
Ji-Huan Zeng[105]	2013	China	—	—	Retrospective study	Dysphagia									49	186	ACDF, ACCDF
Kevin A[106]	2016	USA	—	—	Retrospective study	Dysphagia									29	77	
Erik C[97]	2014	USA	—	—	Retrospective study	Dysphagia									26	100	ACDF
Chen Zhi[107]	2012	China	—	—	Retrospective study	Dysphagia									36	135	
Sang Pei-ming[108]	2016	China	—	—	Retrospective study	Dysphagia									63	328	
Ma Jun-xiong[109]	2014	China	—	—	Retrospective study	Dysphagia									67	123	
Yu Jie[110]	2016	China	—	—	Retrospective study	Dysphagia									17	182	LP
Tao Xiao-hui [111]	2013	China	—	—	Retrospective study	Dysphagia									39	354	
Wu Bing[112]	2015	China	—	—	Retrospective study	Dysphagia									36	355	ACDF
Chen Bo[113]	2015	China	—	—	Retrospective study	Dysphagia									44	213	ACDF
Gu Yifei [114]	2013	China	—	—	Retrospective study	Dysphagia									39	98	ACDF
Jia Xufeng[115]	2014	China	—	—	Retrospective study	Dysphagia									25	65	ACDF, ACCF
Wei Lin[116]	2016	China	—	—	Retrospective study	CSF									6	88	ACDF
Ahmad Nassr[117]	2009	USA	—	—	Retrospective study	Infection									89	163	ACCF
Fujibayashi[118]	2010	Japan	—	—	Retrospective study	Axial pain									6	19	LP
Hironobu Sakaura[119]	2014	Japan	—	—	Retrospective study	Axial pain									1	20	
Christina L[120]	2013	Canada	—	—	Retrospective study	Hematoma									8	529	
Qunfeng Guo[39]	2011	China	—	—	Retrospective study	Graft dislodgment									8	120	ACDF

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 [19]	3	2	3	8
Lili Yang [20]	3	3	2	8
Satoshi[21]	2	3	2	7
Yu Chen[22]	3	2	3	8
Dong-Geun Lee [23]	3	2	3	8
Hua Chen[24]	2	2	3	7
Rafael De la garza-ramos [25]	2	3	3	8
Lie Qian[26]	3	2	3	8
Lei Wang[27]	3	2	3	8
Lin-nan Wang [28]	2	2	3	7
Kanishka E Williams[29]	2	3	3	8
Kuang-Ting Yeh [30]	2	3	3	8
Mayur M KaManini [31]	3	2	3	8
Gregory D[32]	3	2	3	8
M. Skeppholm [33]	2	3	3	8
Zhonghai Li [34]	3	2	3	8
Yang Liu [35]	3	2	3	8
Kyung-Jin Song [36]	2	3	3	8
Sungjin Kim [37]	3	2	3	8
Qiushui Lin [38]	3	2	3	8
Qunfeng Guo [39]	2	2	3	7
Najib Ramzi [40]	2	3	3	8
Mariano Ferna'ndez-Fairen [41]	3	2	3	8
Atsushi Kimura1 [42]	3	2	3	8
Victor Chang [43]	2	2	3	7
H Zhang [44]	2	3	3	8
Atsushi Kimura [45]	2	3	3	8
Ji-Le Jiang [46]	3	2	3	8
Masaaki Machino [47]	3	2	3	8
Atsushi Kimura [48]	2	3	3	8
Hironobu Sakaura [49]	3	2	3	8
Yong Liu [50]	3	2	3	8
Rudolf Andreas Kristof [51]	2	3	3	8
Deniz Konya [52]	2	3	3	8
M Ishii [53]	3	2	3	8
Yu Chen [54]	3	2	3	8
Chang-Hyun Lee [55]	2	2	3	7
Zhonghai Li [56]	2	3	3	8
Stefan Koehler [57]	2	3	3	8
Darryl Lau [58]	3	2	3	8
Jiaming Liu [59]	3	2	3	8
Xuzhou Liu [60]	2	3	3	8
Zhonghai Li [61]	3	2	3	8
Yang Liu [62]	3	2	3	8
Gurpreet Gandhoke [63]	2	3	3	8
Atsushi Okawa [64]	2	2	3	7
Yu Chen [65]	2	2	3	7
Hua Chen [66]	3	2	3	8
Hua Zhou [67]	3	2	3	8
Daniel J Blizzard [68]	2	3	3	8
Toshitaka Yoshii [69]	3	2	3	8
Byeongwoo Kim [70]	3	2	3	8
Lai-Qing Sun [71]	2	3	3	8
Hiroaki Nakashima [72]	3	2	3	8
Hua Chen [73]	3	2	3	8
Masaaki Machino [74]	2	3	3	8
Yasushi Oshima [75]	3	2	3	8
Kuang-Ting Yeh [76]	3	2	3	8
Takafumi Maeno [77]	2	3	3	8
Hiroaki Nakashima [78]	2	2	3	7
Daniel C[79]	3	2	3	8

(*continued*)

Table 2

(continued).

Study	Selection	Comparability	Exposure	Total score
Bing Wu [80]	3	2	3	8
Zhonghai Li [81]	2	3	3	8
Daniel J[68]	3	2	3	8
Sang-Ho Lee[82]	2	3	3	8
Gao Hua [83]	3	2	3	8
Li Wenfeng[84]	3	2	3	8
QI Min [85]	2	3	3	8
Hou Shubing [86]	3	2	3	8
Cui Guopeng [87]	3	2	3	8
Jia Bin[88]	2	3	3	8
Hu Yong[89]	3	2	3	8
Liu Chang-an[90]	3	2	3	8
Zhang Bin [91]	2	3	3	8
Wang Lei [92]	2	2	3	7
Gurpreet Gandhoke [63]	3	2	3	8
Sang-Ho Lee[82]	3	2	3	8
Jacob Cherian [93]	2	3	3	8
Sang-Hun Lee [94]	3	2	3	8
Daniel J. Blizzard[95]	3	2	3	8
Li Qiyi [96]	2	3	3	8
Erik C [97]	2	2	3	7
Paul M Arnold [98]	3	2	3	8
Brad Segebarth [99]	3	2	3	8
Rahul Vaidya [100]	2	3	3	8
Paul C[101]	3	2	3	8
Si Hyun Kang [102]	2	3	3	8
Samuel Kalb [103]	3	2	3	8
Christopher K[104]	3	2	3	8
Ji-Huan Zeng[105]	2	3	3	8
Kevin A[106]	3	2	3	8
Erik C[97]	2	3	3	8
Chen Zhi [107]	2	3	3	8
Sang Pei-ming[108]	3	2	3	8
Ma Jun-xiong [109]	3	2	3	8
Yu Jie [110]	2	2	3	7
Tao Xiao-hui [111]	2	3	3	8
Wu Bing [112]	2	3	3	8
Chen Bo [113]	3	2	3	8
Gu Yifei [114]	3	2	3	8
Jia Xufeng [115]	2	3	3	8
Wei Lin [116]	3	2	3	8
Ahmad Nassr [117]	3	2	3	8
Fujibayashi [118]	2	3	3	8
Hironobu Sakaura [119]	3	2	3	8
Christina L[120]	2	3	3	8
Qunfeng Guo[39]	3	2	3	8

3.12. Graft subsidence

Six studies[34,35,38,39,84,115] containing 26 patients with graft subsidence of 591 patients after cervical surgery were included. Figure 35 shows that the incidence of graft subsidence was 3.7% (95% CI 2.0%–5.5%), with substantial heterogeneity of incidence observed. The incidence varied between 2.2% and 11.1%.

3.13. Fusion failure

Five studies[26,39,86,87,90] containing 21 patients with fusion failure of 689 patients after cervical surgery was included.

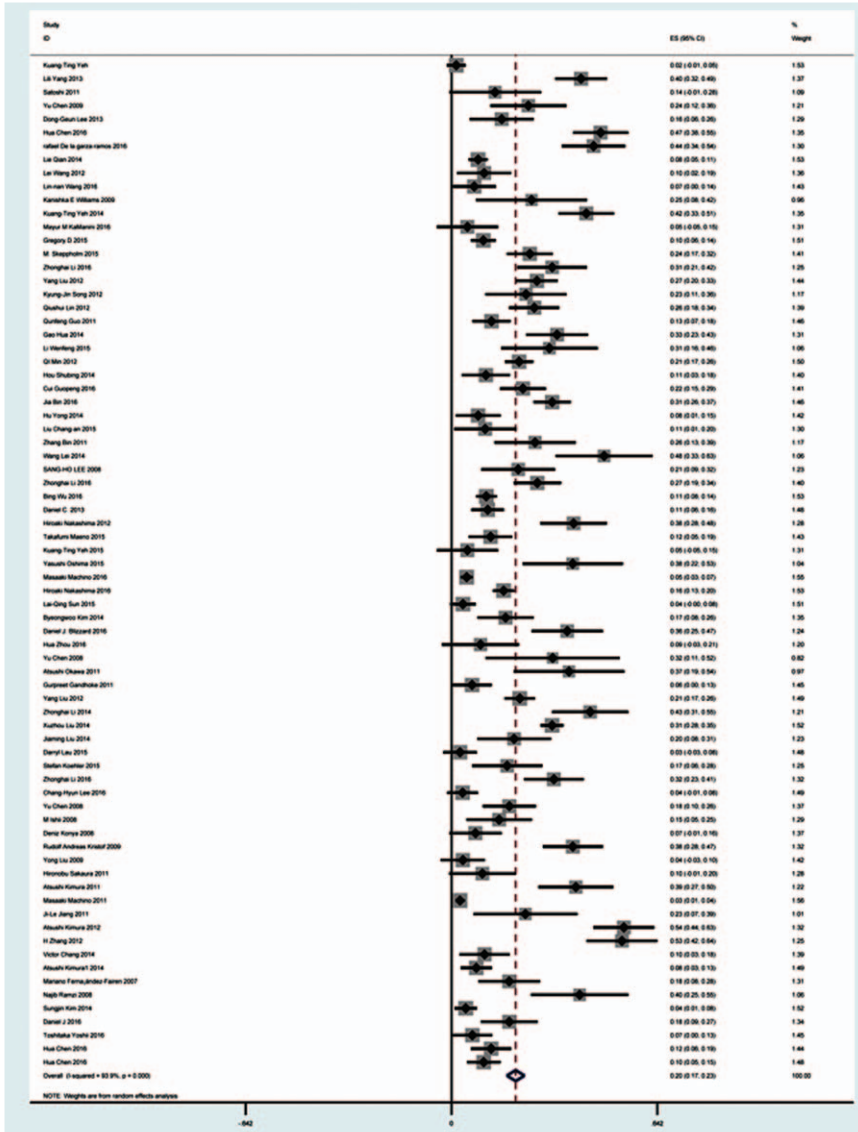

Figure 2. Forest plot showing incidence of overall complications after cervical surgery. CI = confidence interval, df = degrees of freedom, M–H = Mantel–Haenszel.

Figure 36 shows that the incidence was 2.6% (95% CI 0.2%–4.9%), with substantial heterogeneity of incidence observed. The incidence varied between 0.2% and 12%.

3.14. Publication bias

We performed funnel plot for publication bias, as shown in Fig. 37, after a detection of publication bias by Egger and Begg tests using STATA 12.0, there was no publication bias found for all included studies (all $P > 0.05$).

4. Discussion

Increasing studies focused on surgical selection for cervical compressive myelopathy (CCM), which usually caused by CSM or OPLL.[3–5,33] Nearly half a century, surgical procedures were widely applied from posterior approaches including LF and LP to anterior approaches containing ACDF, ACCF, and ACCDF.[47,78] Nevertheless, the option of surgical approach remains debated. Especially, the inevitable complications of anterior and posterior approaches cause our attention.[22,36,48] Anterior approaches had a higher rate of postoperative hoarseness, dysphagia.[55,81] Similarly, C5 palsy and cervical kyphosis may limit the use of posterior surgery.[26] The complications in our study included overall complications, C5 plasy, cerebrospinal fluid (CSF), infection, axial pain, dysphagia, hoarseness, fusion failure, graft subsidence, graft dislodgment, and epidural hematoma. As we know, this is the first meta-analysis on prevalence of various complications after cervical surgery. The aim of the study is to compute prevalence of each complication according to previous studies. We hope that our work can give some suggestions to assess incidence of complications before surgery.

Our results showed that the rates for total complications, C5 plasy, CSF, infection, axial pain, dysphagia, hoarseness, fusion failure, graft subsidence, graft dislodgment and epidural hematoma were 20.1%, 5.3%, 1.9%, 2.8%, 15.6%, 16.8%, 4.0%, 2.6%, 3.7%, 3.4%, 1.1%, respectively. Compared with

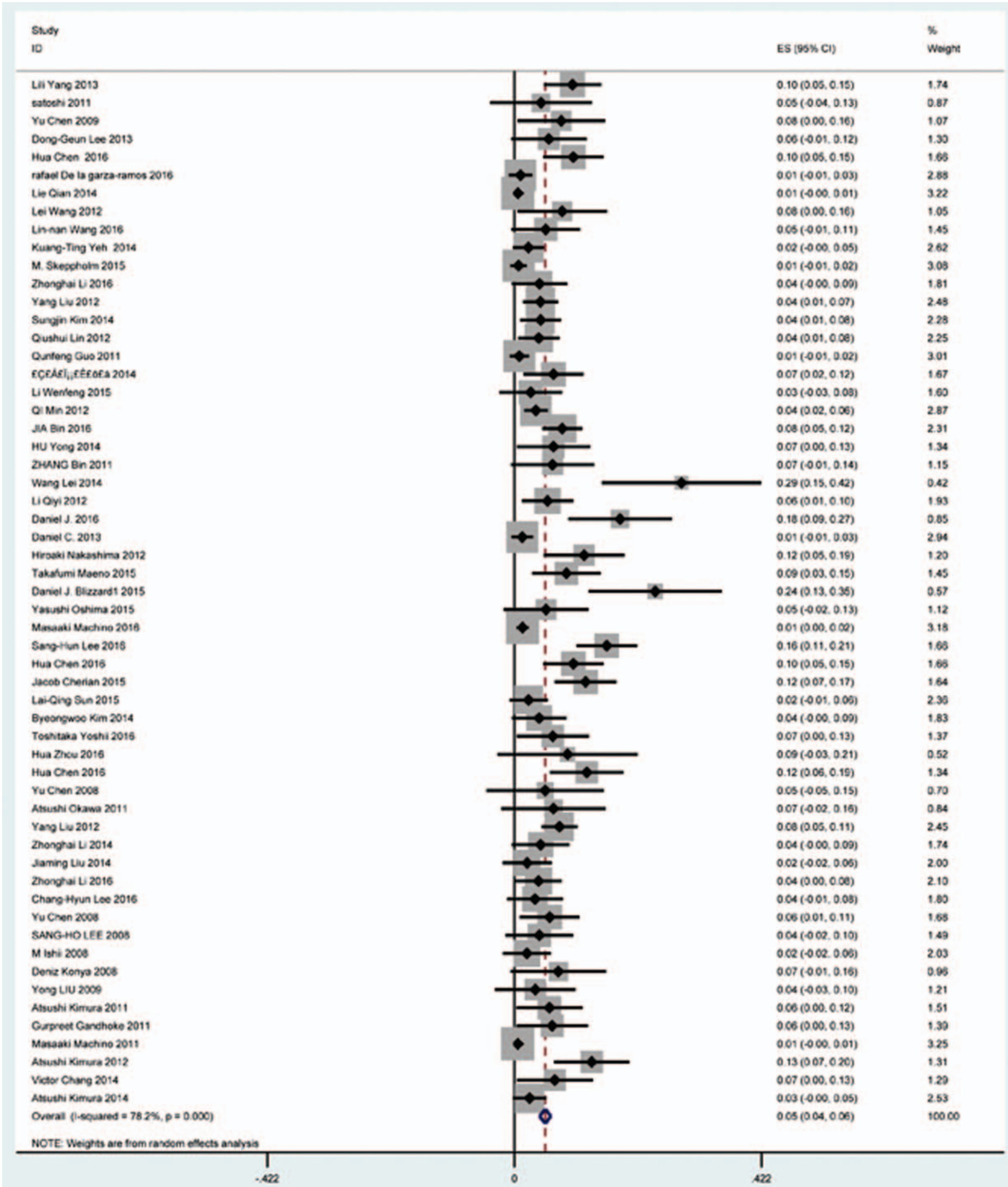

Figure 3. Forest plot showing incidence of C5. CI = confidence interval, df = degrees of freedom, M–H = Mantel–Haenszel.

patients with CSM, patients with OPLL have a higher incidence of C5 plasy (4.1% vs 6.3%) and CSF (0.9% vs 12.2%). In terms of C5 plasy, patients after LP had the highest rate (15.2%), while those after ACDF had the lowest rate (2.0%). As for dysphagia, patients who underwent ACCDF and ACDF were 16.8% and 16.2%, which are higher than those who received ACCF (9.9%). For CSF, patients who underwent ACCF had the highest rate (4.2%), while those who received ACDF had the lowest rate (1.9%), and the same trend for infection between ACCF group (14.2%) and ACDF group (0.9%). While it was opposite for hoarseness between ACDF (4.8%) and ACCF (3.0%).

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 remained a controversial issue. C5 palsy after cervical surgery is considered to be a result of nerve root injury or segmental spinal cord disorder.[36–41,51–55] We reviewed 57 studies and the rate of C5 plasy was 5.3%. We also found that patients with CSM

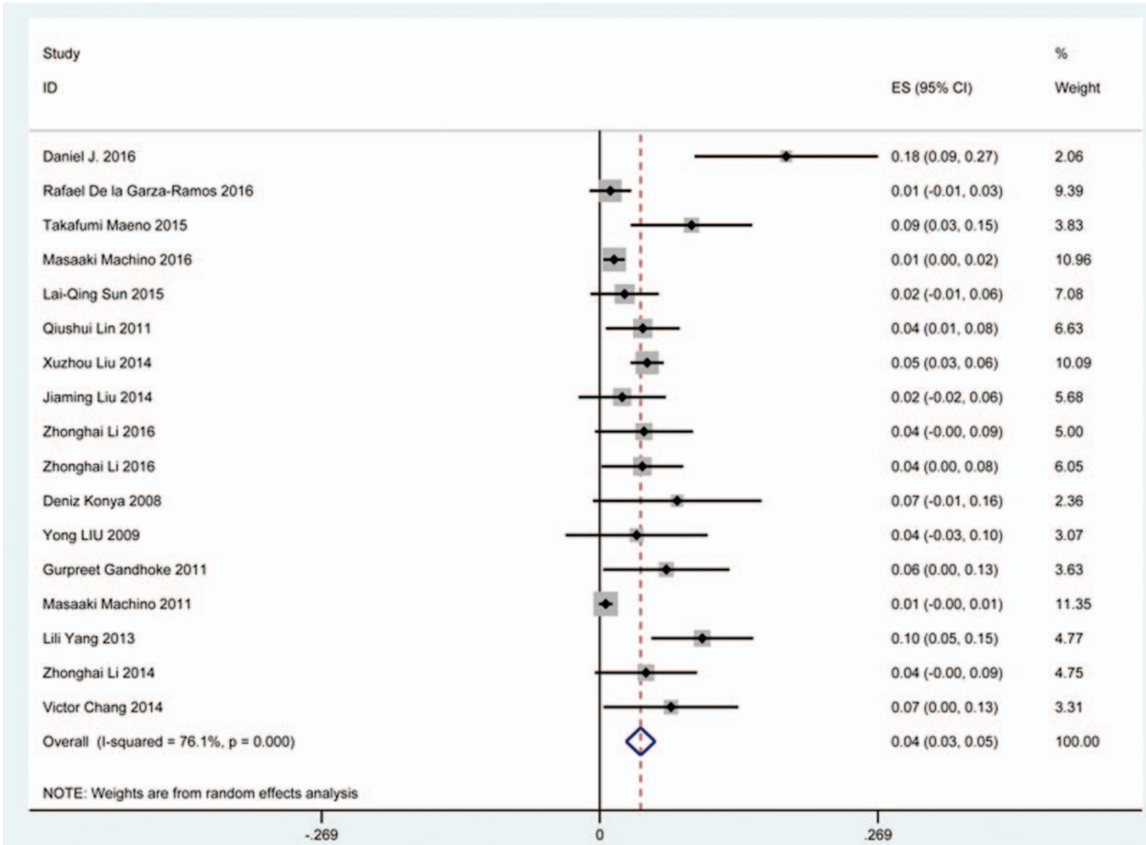

Figure 4. Forest plot showing incidence of C5 for patients with CSM. CI = confidence interval, CSM = cervical spondylotic myelopathy, df = degrees of freedom, M–H = Mantel–Haenszel.

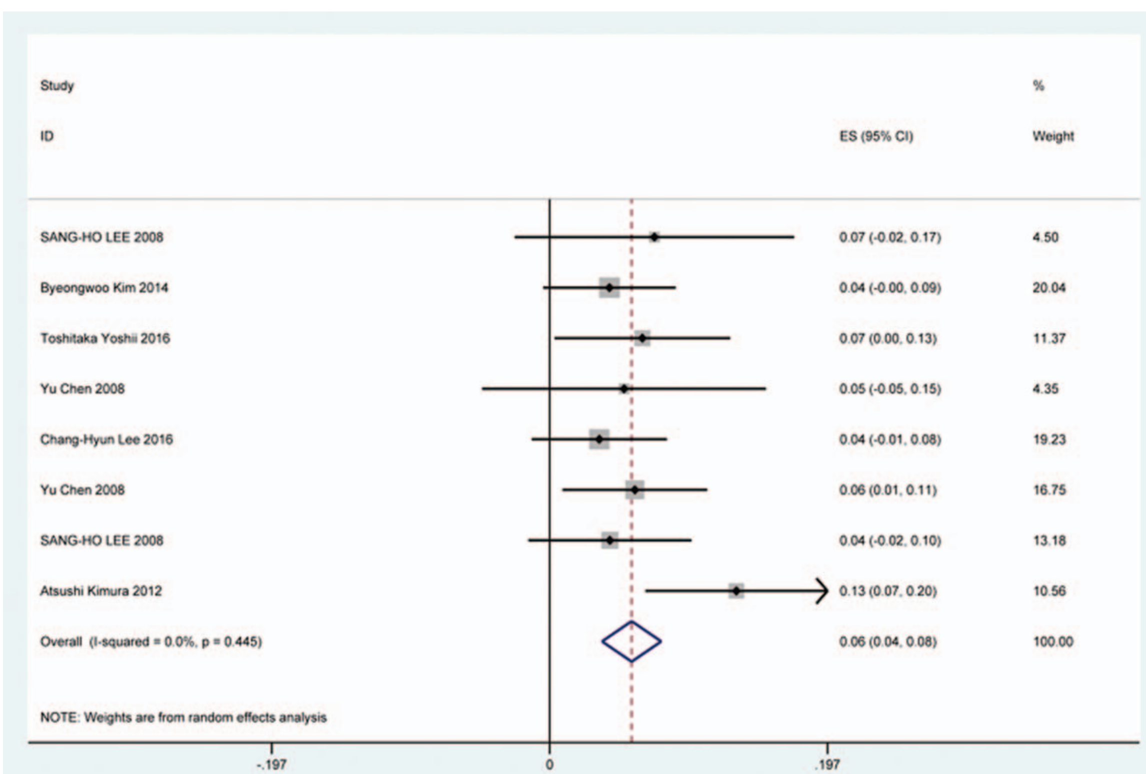

Figure 5. Forest plot showing incidence of C5 for patients with OPLL. CI = confidence interval, df = degrees of freedom, M–H = Mantel–Haenszel, OPLL = ossification of posterior longitudinal ligamen.

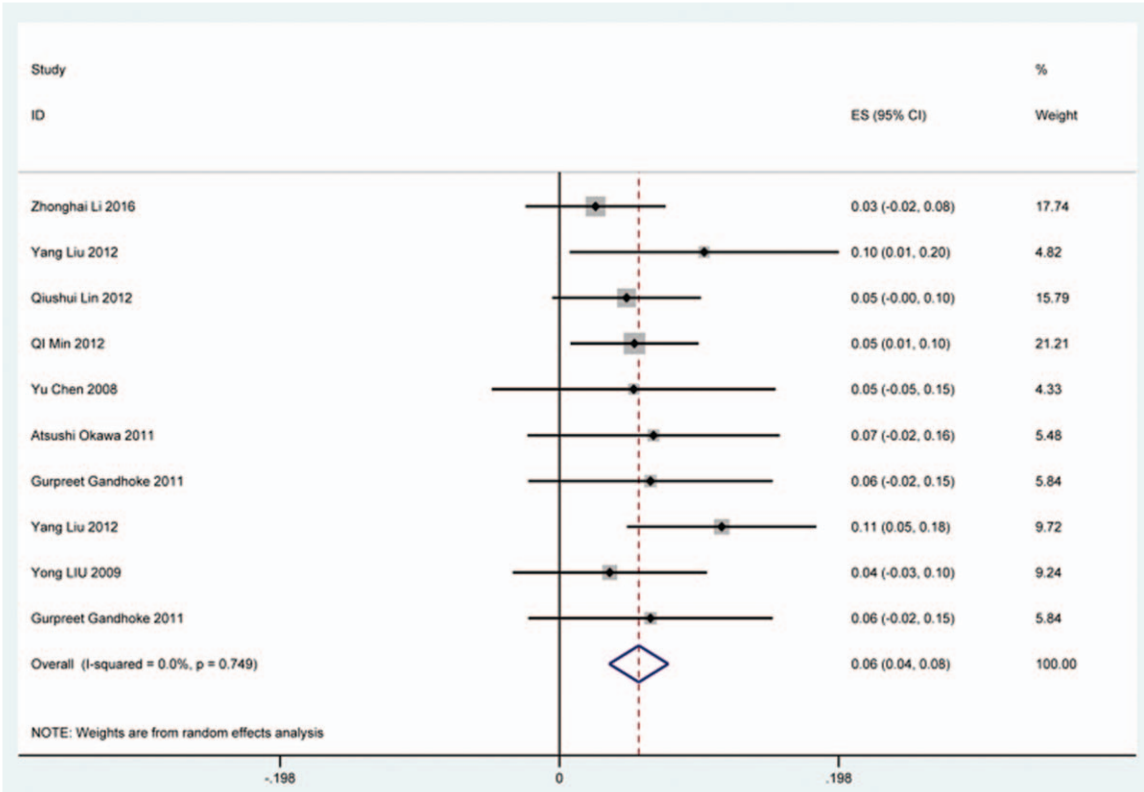

Figure 6. Forest plot showing incidence of C5 after ACCF. ACCF=anterior cervical corpectomy and fusion, CI=confidence interval, df=degrees of freedom, M–H=Mantel–Haenszel.

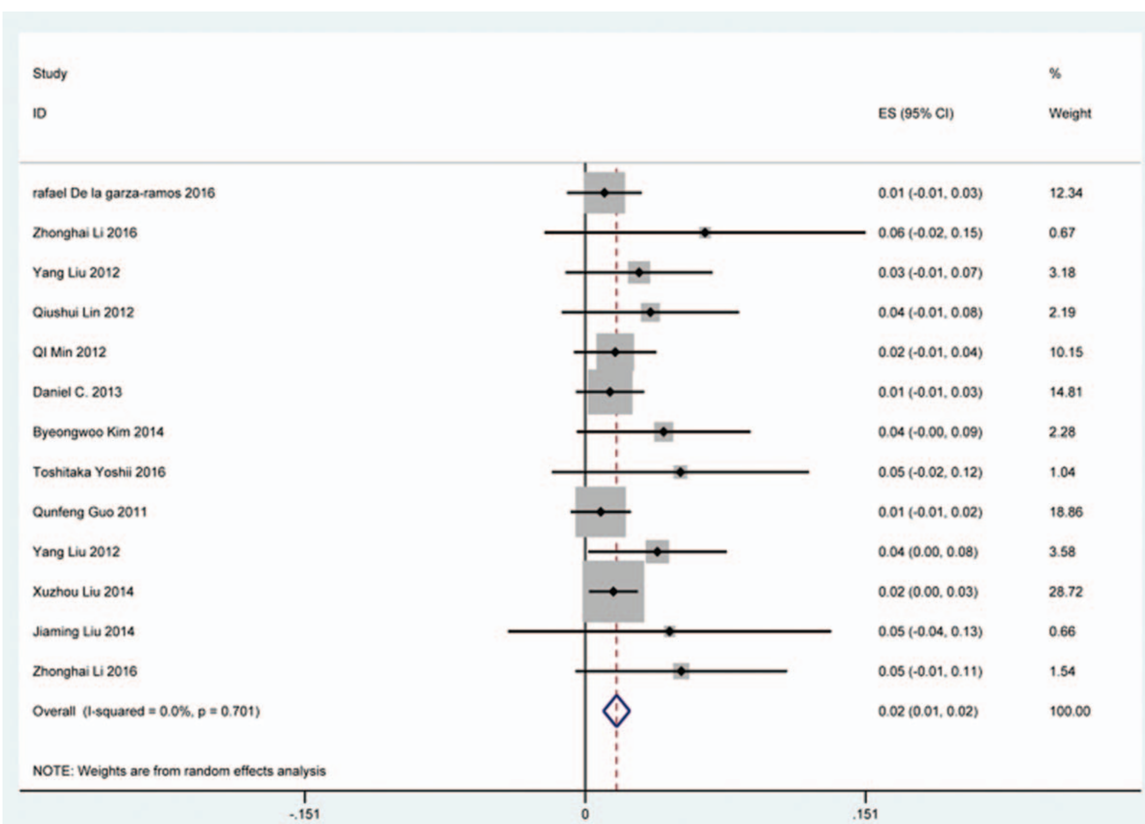

Figure 7. Forest plot showing incidence of C5 after ACDF. ACDF=anterior cervical discectomy and fusion, CI=confidence interval, df=degrees of freedom, M–H=Mantel–Haenszel.

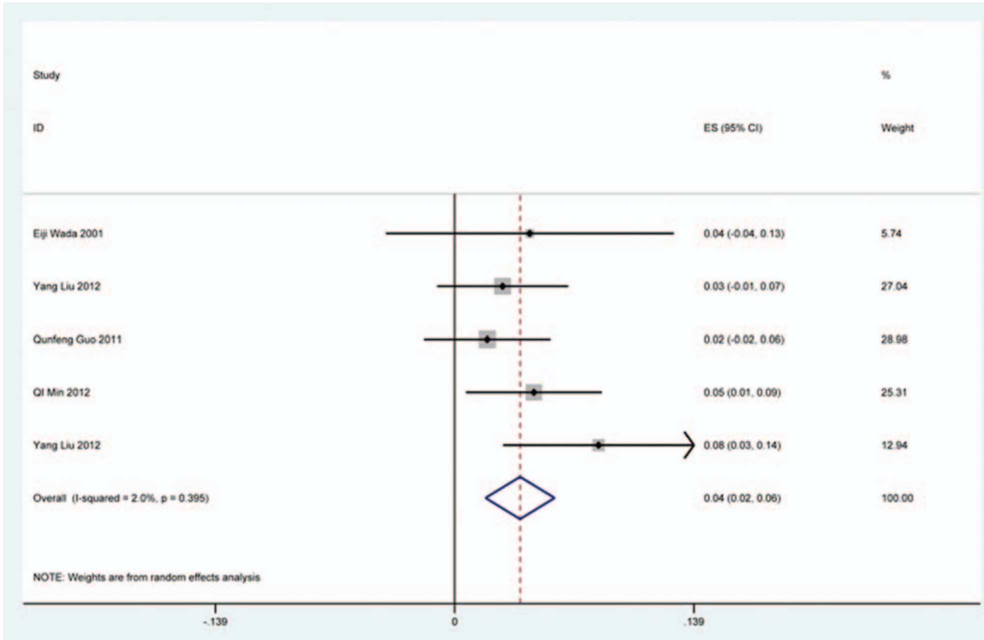

Figure 8. Forest plot showing incidence of C5 after ACCDF. ACCDF = anterior corpectomy combined with discectomy, CI = confidence interval, df = degrees of freedom, M–H = Mantel–Haenszel.

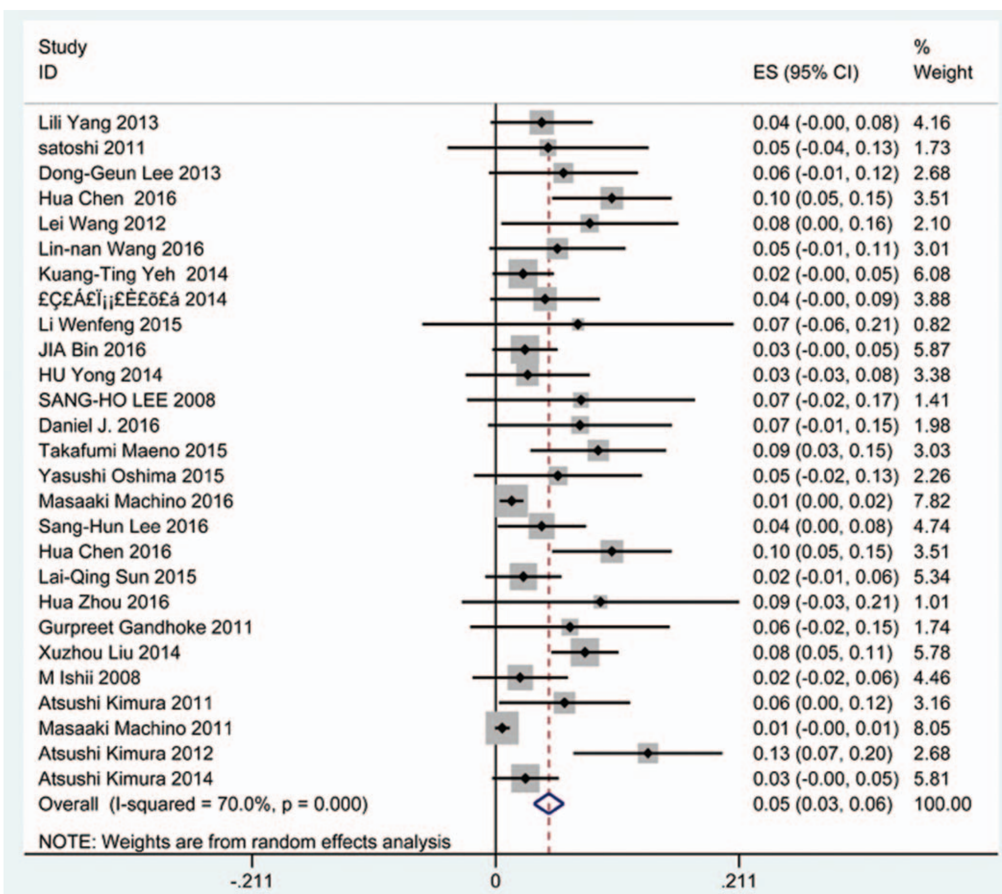

Figure 9. Forest plot showing incidence of C5 after LP. CI = confidence interval, df = degrees of freedom, LP = laminoplasty, M–H = Mantel–Haenszel.

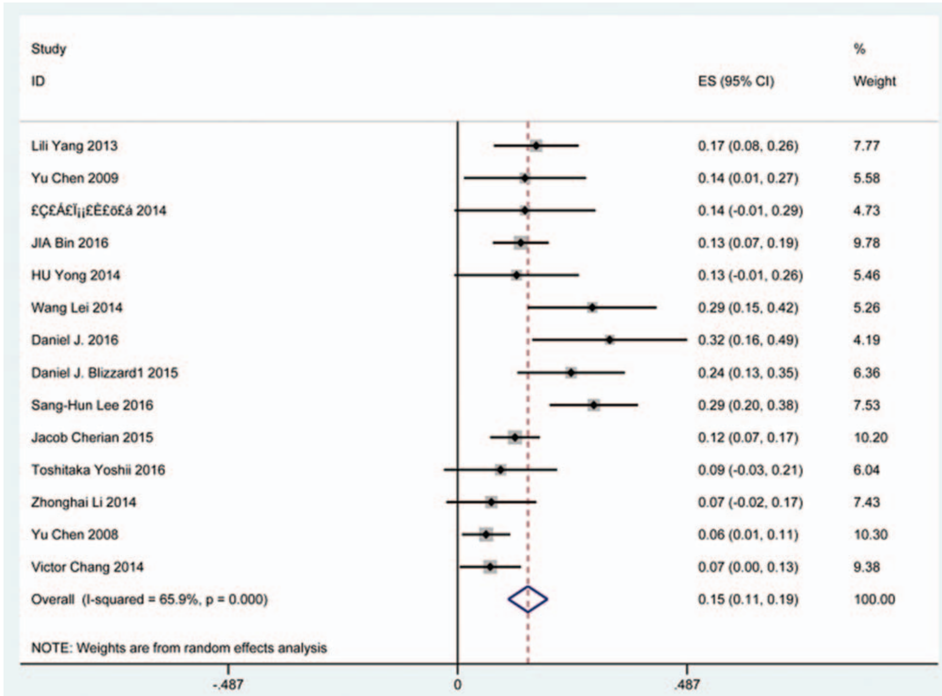

Figure 10. Forest plot showing incidence of C5 after LF. CI=confidence interval, df=degrees of freedom, LF=laminectomy and fusion, M–H=Mantel–Haenszel.

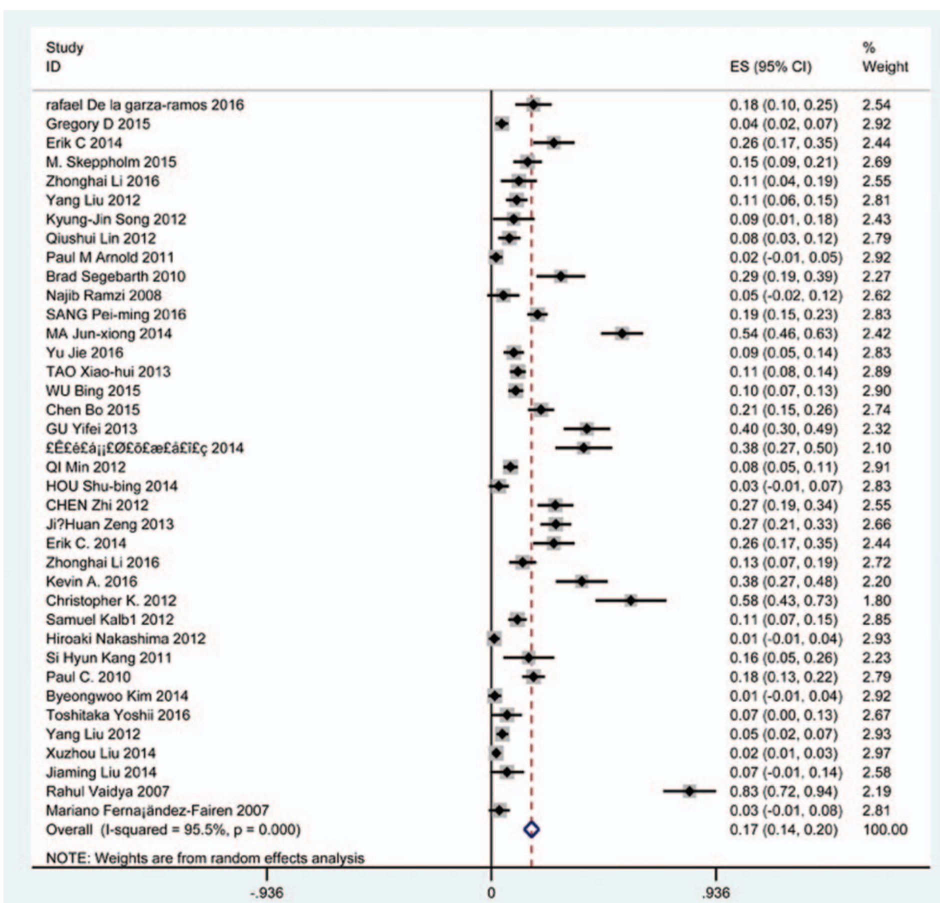

Figure 11. Forest plot showing incidence of dysphagia. CI=confidence interval, df=degrees of freedom, M–H=Mantel–Haenszel.

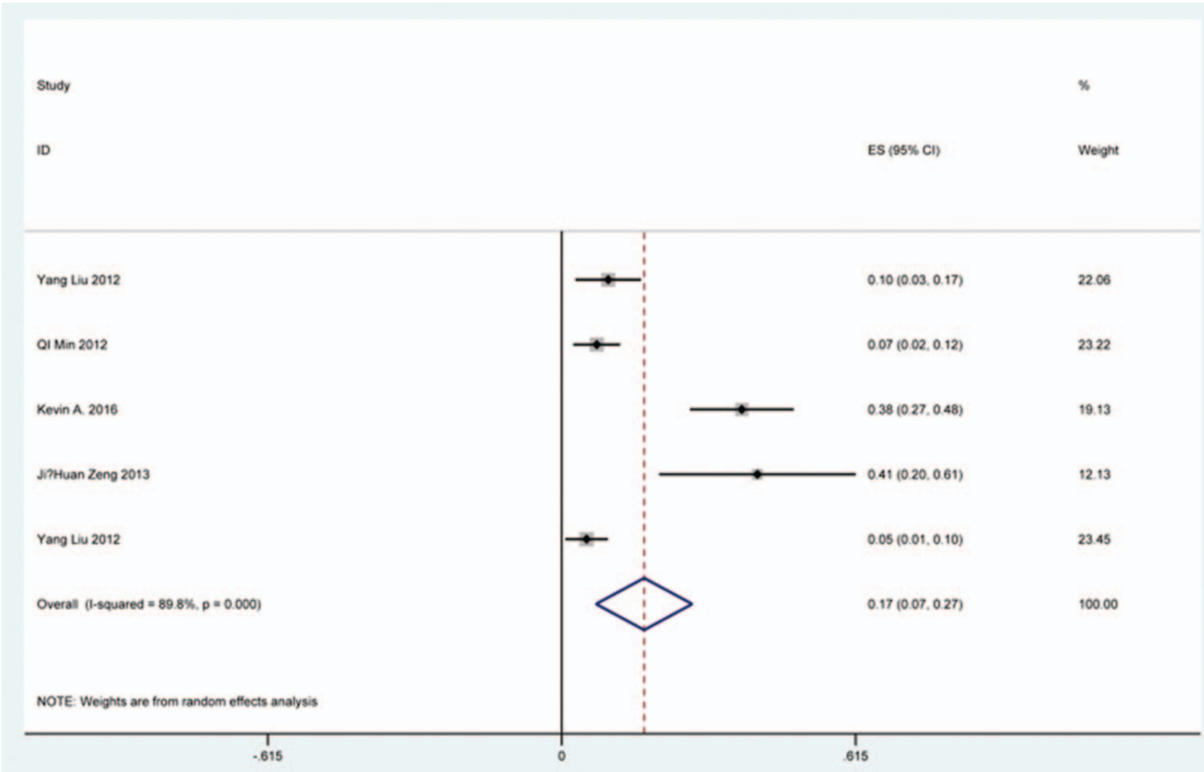

Figure 12. Forest plot showing incidence of dysphagia after ACCDF. ACCDF = anterior corpectomy combined with discectomy, CI = confidence interval, df = degrees of freedom, M–H = Mantel–Haenszel.

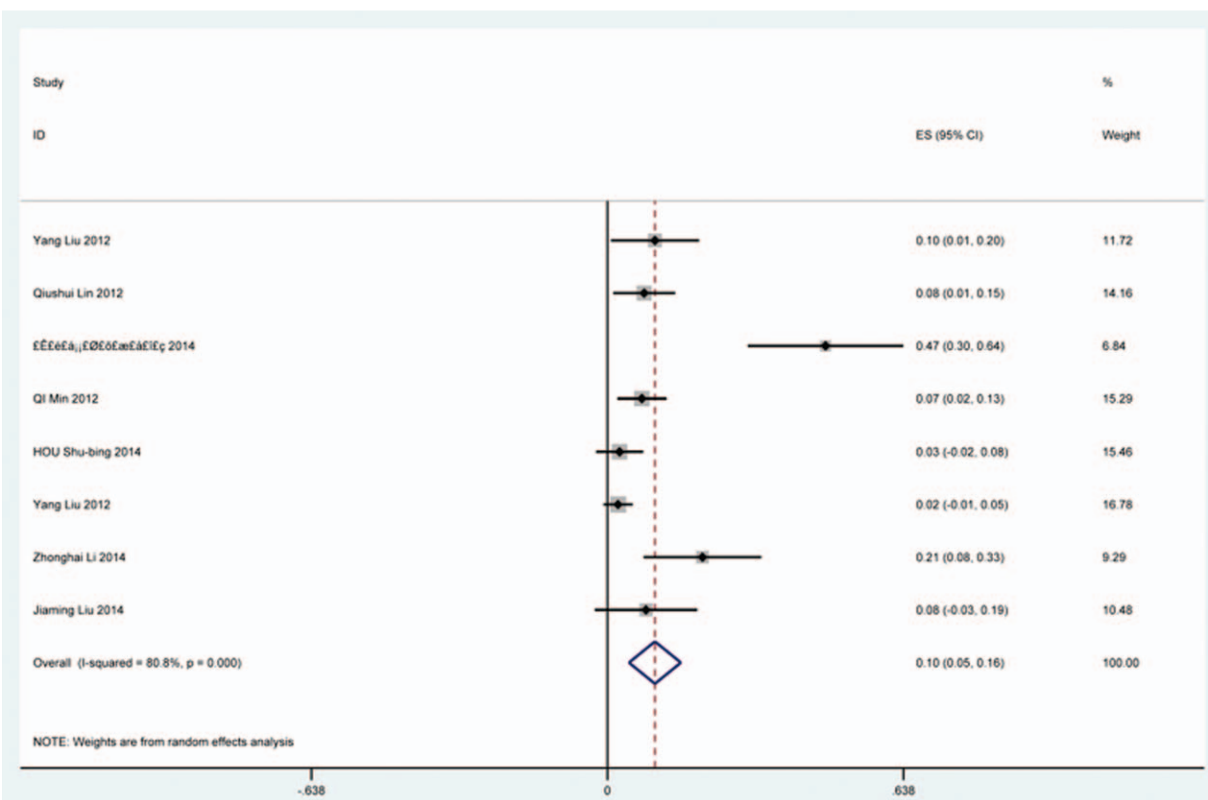

Figure 13. Forest plot showing incidence of dysphagia after ACCF. ACCF = anterior cervical corpectomy and fusion, CI = confidence interval, df = degrees of freedom, M–H = Mantel–Haenszel.

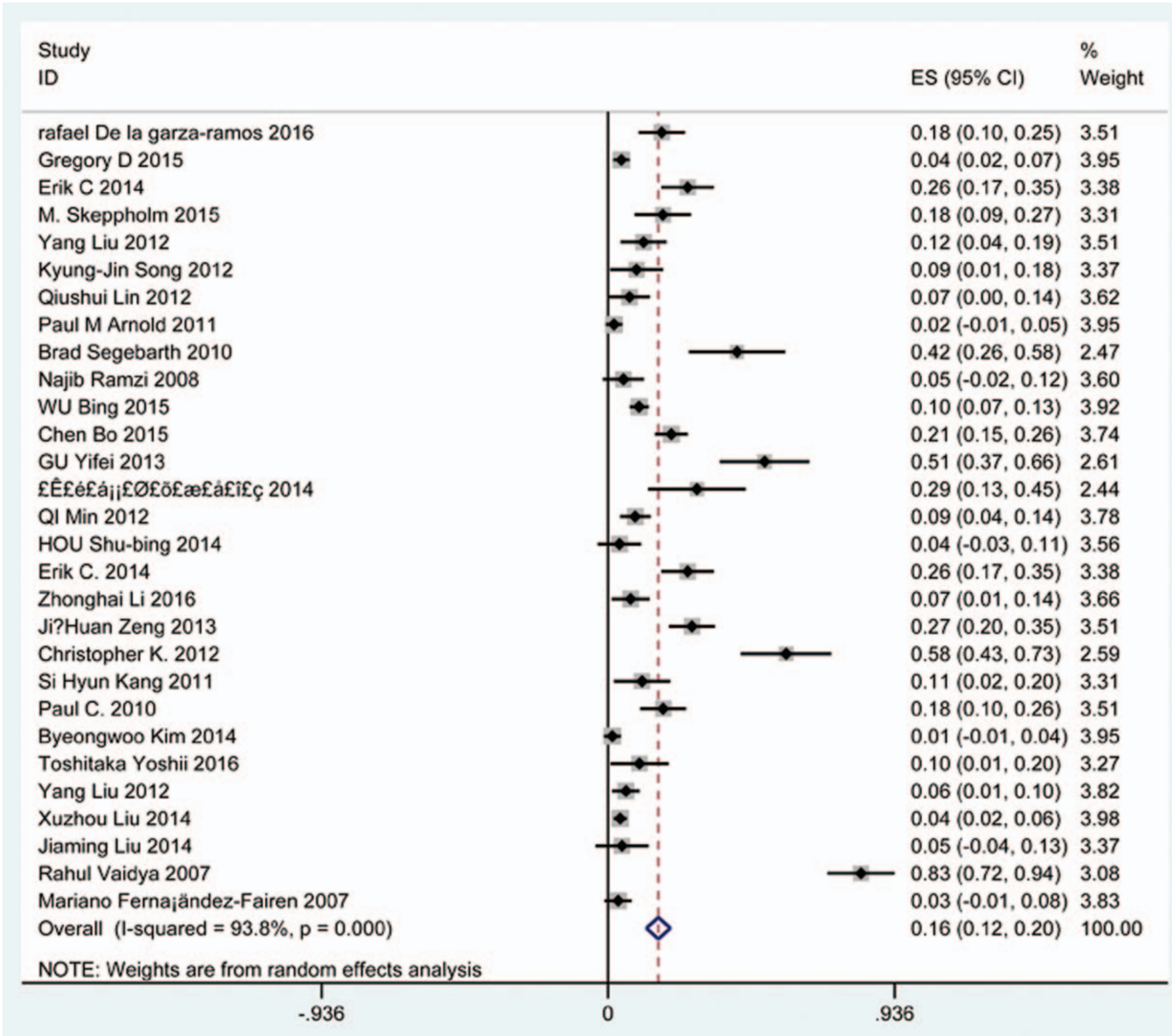

Figure 14. Forest plot showing incidence of dysphagia after ACDF. ACDF=anterior cervical discectomy and fusion, CI=confidence interval, df=degrees of freedom, M–H=Mantel–Haenszel.

(4.1%) have a lower incidence of C5 palsy than patients with OPLL (6.3%). The reason is still unclear. In all surgical options, LF had the highest rate, ACDF had the lowest incidence. Nakashima[72] 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. It was obvious that posterior shift of the spinal cord in LF was largest, which was similar to our results.

Dysphagia is a relatively common complication after cervical surgery. Smith-Hammond et al[121] found that the prevalence of dysphagia on the first postoperative day was approximately 50% in the anterior cervical group. As Fig. 11 has shown, the rate was 16.8% (95% CI 13.6%–19.9%). According to included articles in our series, the rate for this complication ranged from 1.4% to 58.1%. Patients after ACCDF (16.8%, 95% CI 6.9%–27.2%) and ACDF (16.2%, 95% CI 11.7%–19.8%) had higher incidence than those who received ACCF (9.9%, 95% CI 4.8%–15.9%). Multifactors as reported by recent studies,[63,68–71,75–80] hematoma, pharyngeal plexus denervation, vocal cord paralysis, adhesion formation, plate profile, and swelling due to biologic agents, may be related to dysphagia. Brad[99] indicated that a no-profile cervical disc arthroplasty had a significantly lower rate of dysphagia compared with ACDF. Due to few included articles on disc arthroplasty, we did not assess rate of dysphagia in arthroplasty group.

CSF is a serious complication of cervical surgery,[87,88] which may cause wound infection, purulent meningitis, or even high risk of death. Rate of CSF after cervical operation ranged from 0.4% and 21.1%[122]. As the same with previous reports, our results implied that patients with OPLL had a higher rate compared with those with CSM. We surprisingly found that patients after ACCF (4.2%) had a higher rate than those who received ACDF (1.9%), which was possibly different with our thinking. Compared with ACCF, operative field of ACDF was smaller, which was more likely to cause CSF. Large sample studies are needed to further investigate this issue. Figure 21 shows that the rate of infection was 2.8%. The same trend as CSF, individual who underwent ACCF (14.2%) had higher than those who received ACDF (0.9%) and LP (2.1%).

As for axial pain, which is terrible complication after posterior approaches, the results show that LP (22.2%) and LF (23.2%) are similar. Muscles were widely dissected and ligamentous

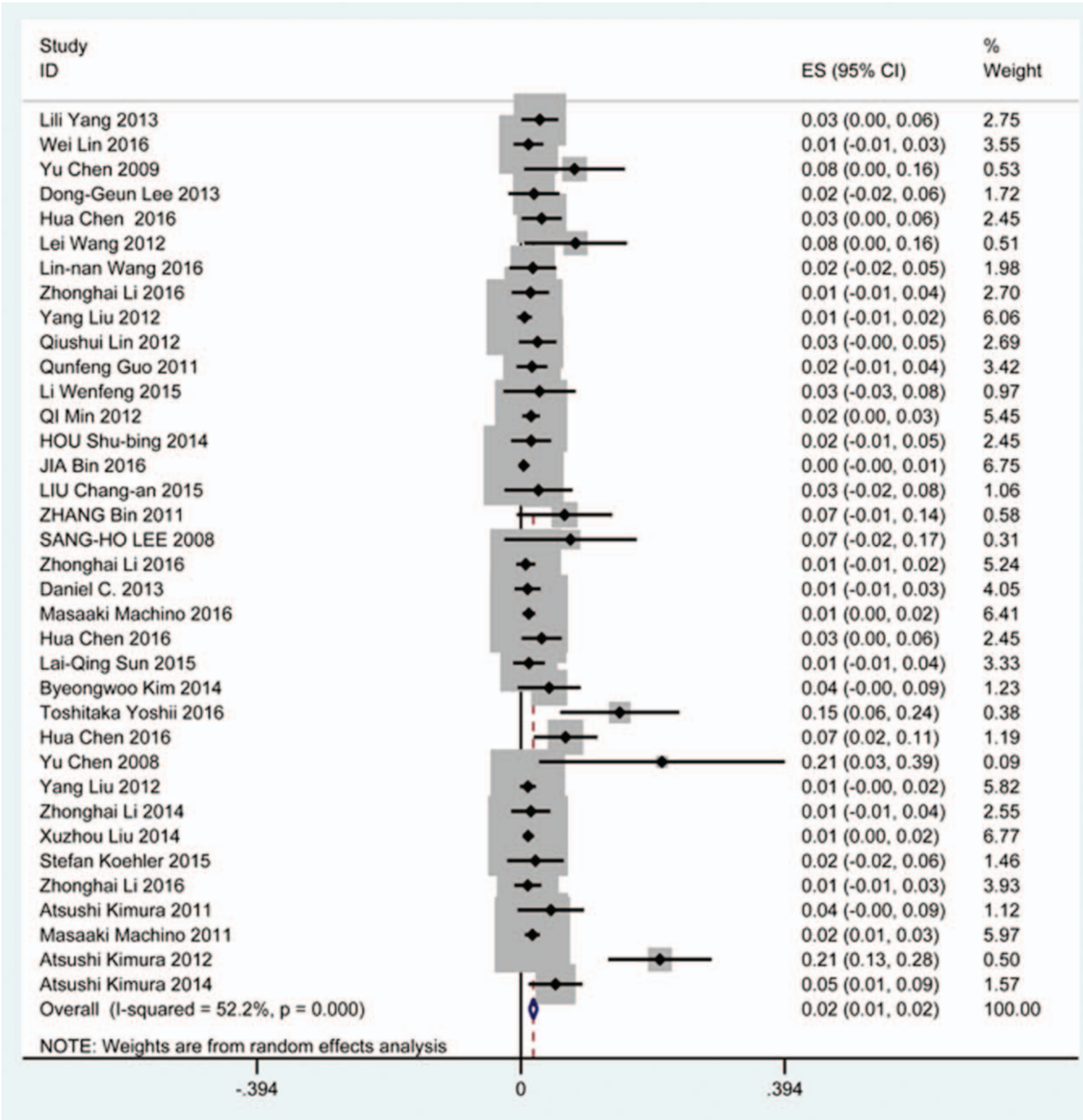

Figure 15. Forest plot showing incidence of CSF. CI = confidence interval, df = degrees of freedom, M–H = Mantel–Haenszel.

structures transected in both techniques resulting in axial pain to some extent. Hoarseness and epidural hematoma had relatively low rate. Overstretch or improper handing may lead to these complications. We also estimated implant-related complications, but the rate on these complications in various surgical options were not assessed due to lack relevant data. The rates of graft dislodgment, graft subsidence, and fusion failure were 3.7%, 3.4%, and 1.1%.

There are several limitations of this study. First, there was no RCT on all complications, we need RCT to further study; second, the statistical power could be improved in the future by including more studies. Some parameters, like one-level, two-level, or multilevel CSM for C5 palsy, due to 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 published in other languages were not included because of anticipated difficulties in obtaining accurate medical translations. Fourth, it is difficult to avoid that many figures presented high heterogeneity due to relative large sample.

In summary, the rate of overall complications was 21%, patients with OPLL have a higher incidence of C5 palsy and CSF. Patients after LF have a higher incidence of C5 palsy, ACCDF have a higher incidence of dysphagia, ACCF have a higher incidence of CSF and infection, and ACDF have a higher incidence of hoarseness. Considering the limitations noted above, a further well-designed, large population-based study on the topic of the prevalence of complications after cervical surgery should be conducted.

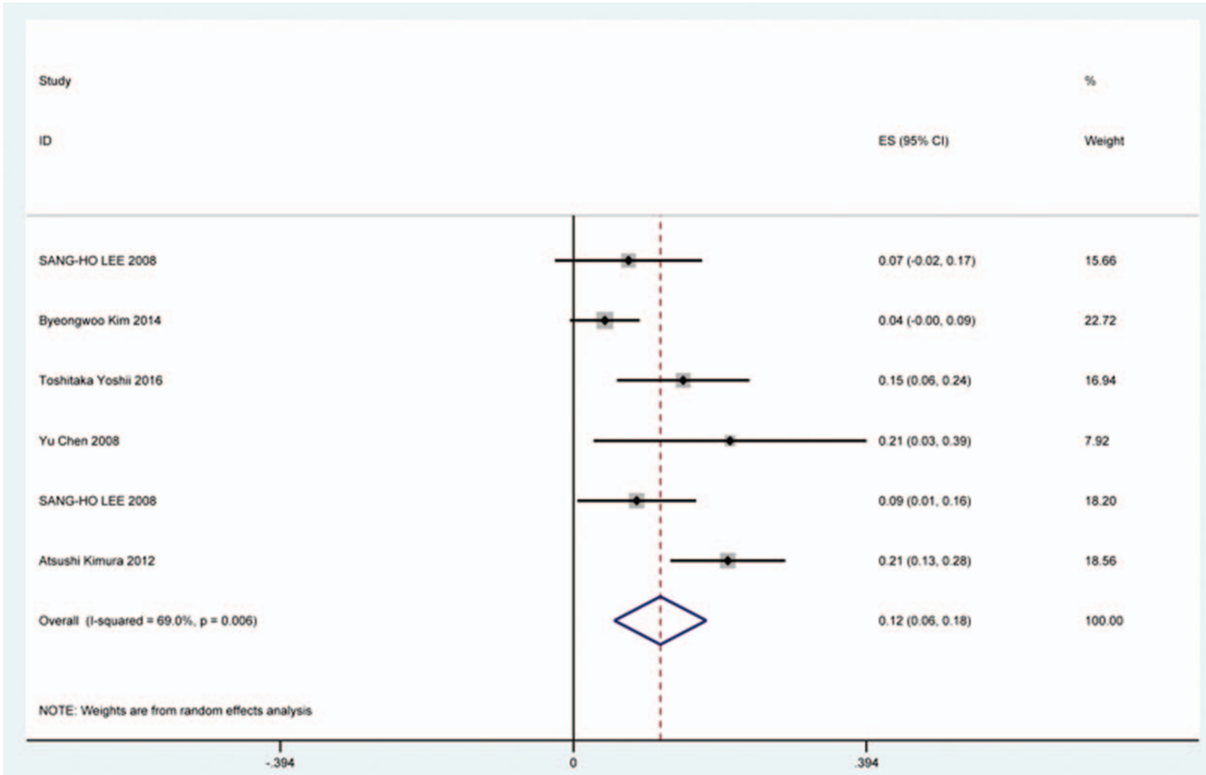

Figure 16. Forest plot showing incidence of CSF for patients with OPLL. CI = confidence interval, df = degrees of freedom, M–H = Mantel–Haenszel, OPLL = ossification of posterior longitudinal ligamen.

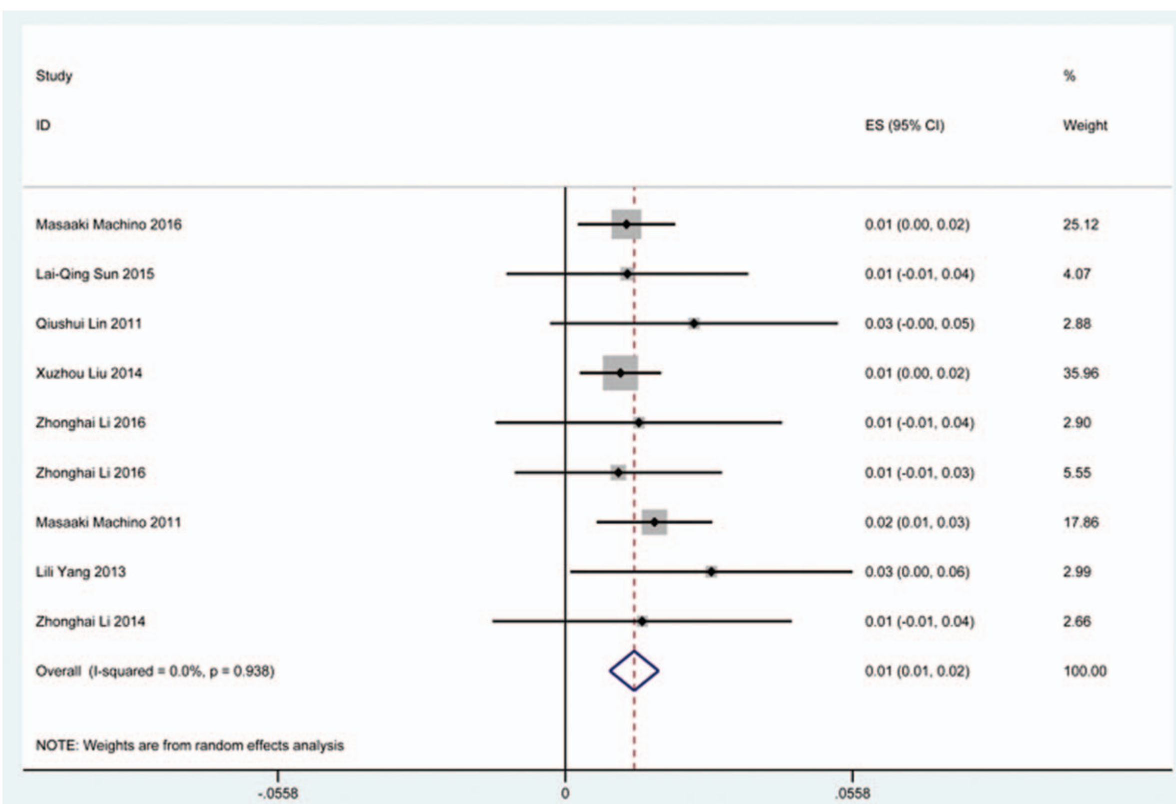

Figure 17. Forest plot showing incidence of CSF for patients with CSM. CI = confidence interval, CSM = cervical spondylotic myelopathy, df = degrees of freedom, M–H = Mantel–Haenszel.

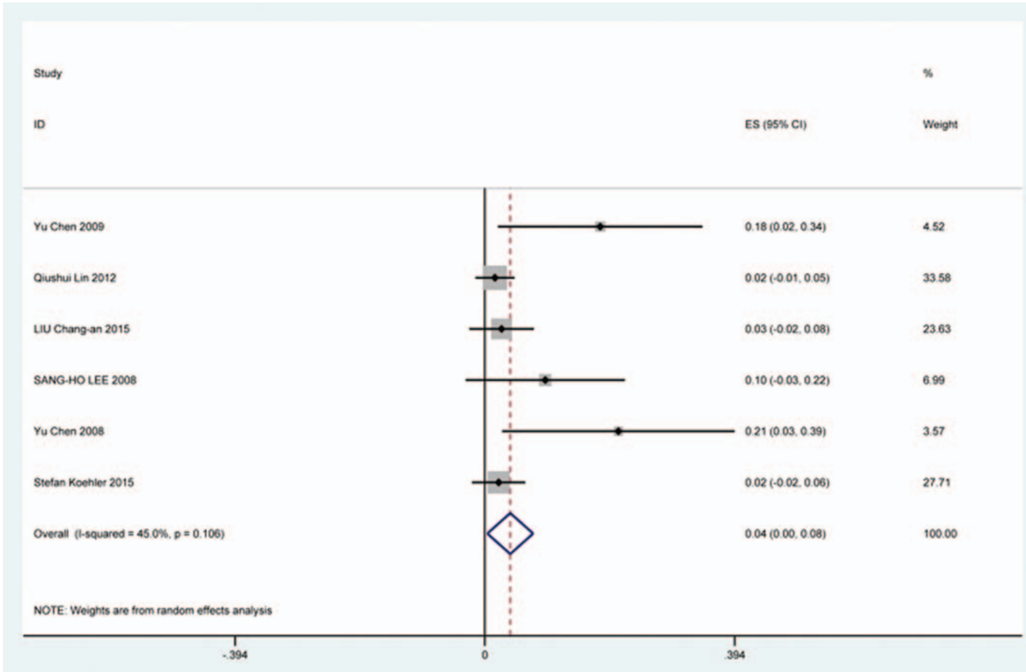

Figure 18. Forest plot showing incidence of CSF after ACCF. ACCF=anterior cervical corpectomy and fusion, CI=confidence interval, df=degrees of freedom, M–H=Mantel–Haenszel.

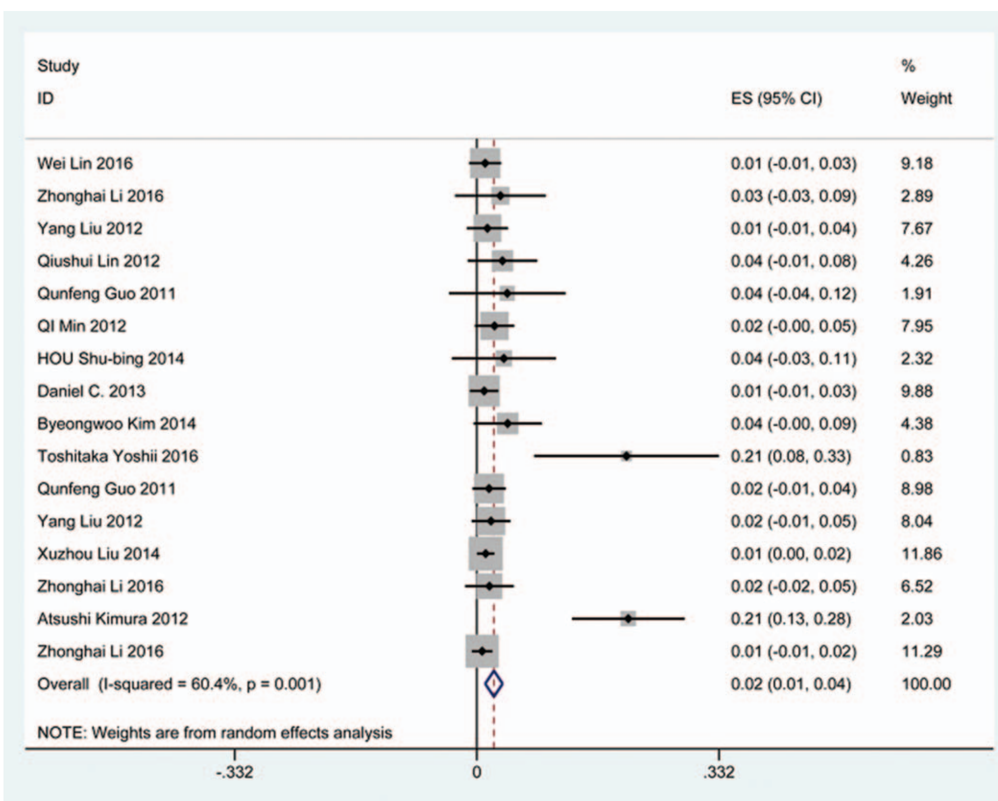

Figure 19. Forest plot showing incidence of CSF after ACDF. ACDF=anterior cervical discectomy and fusion, CI=confidence interval, df=degrees of freedom, M–H=Mantel–Haenszel.

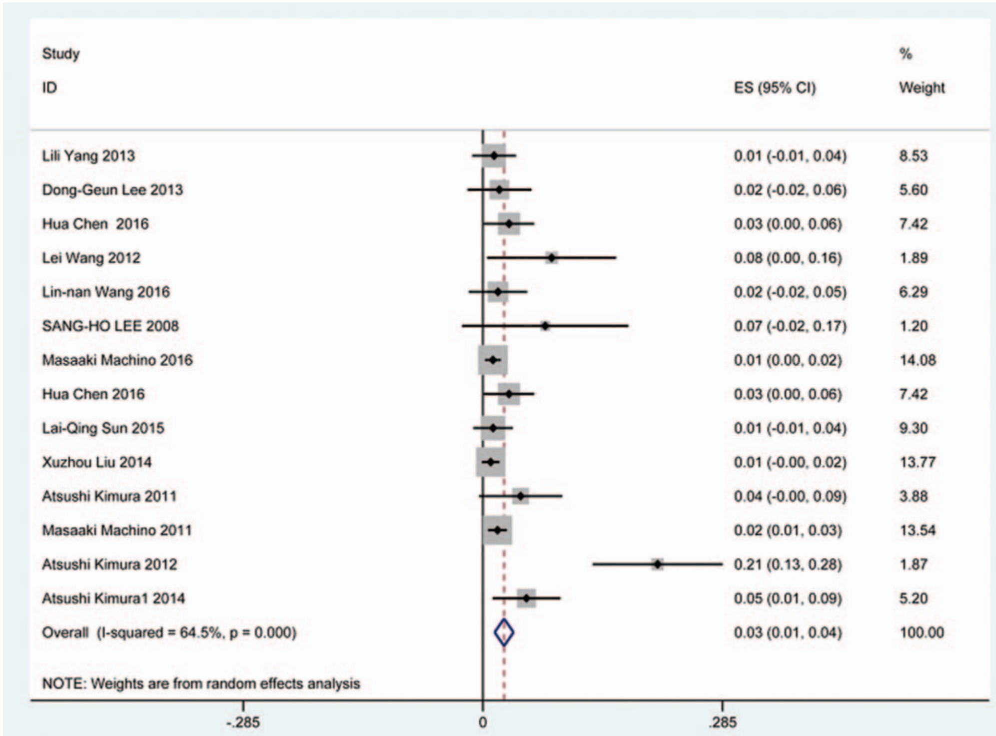

Figure 20. Forest plot showing incidence of CSF after LP. CI = confidence interval, df = degrees of freedom, LP = laminoplasty, M–H = Mantel–Haenszel.

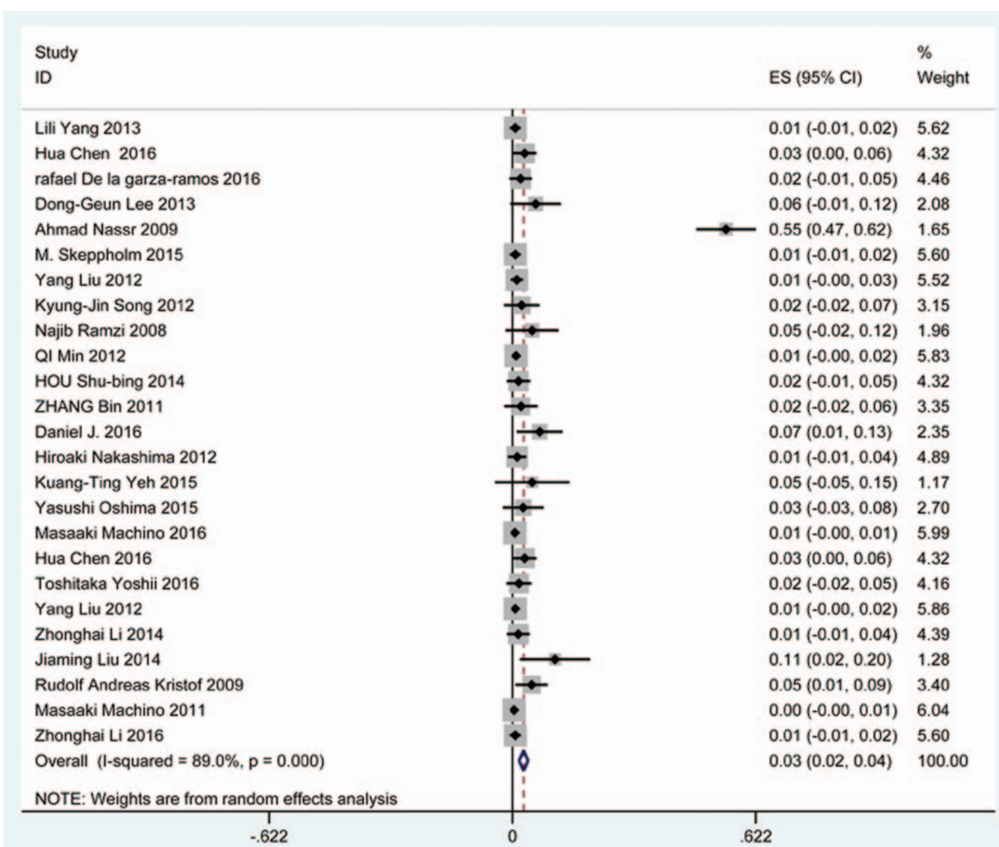

Figure 21. Forest plot showing incidence of infection. CI = confidence interval, df = degrees of freedom, M–H = Mantel–Haenszel.

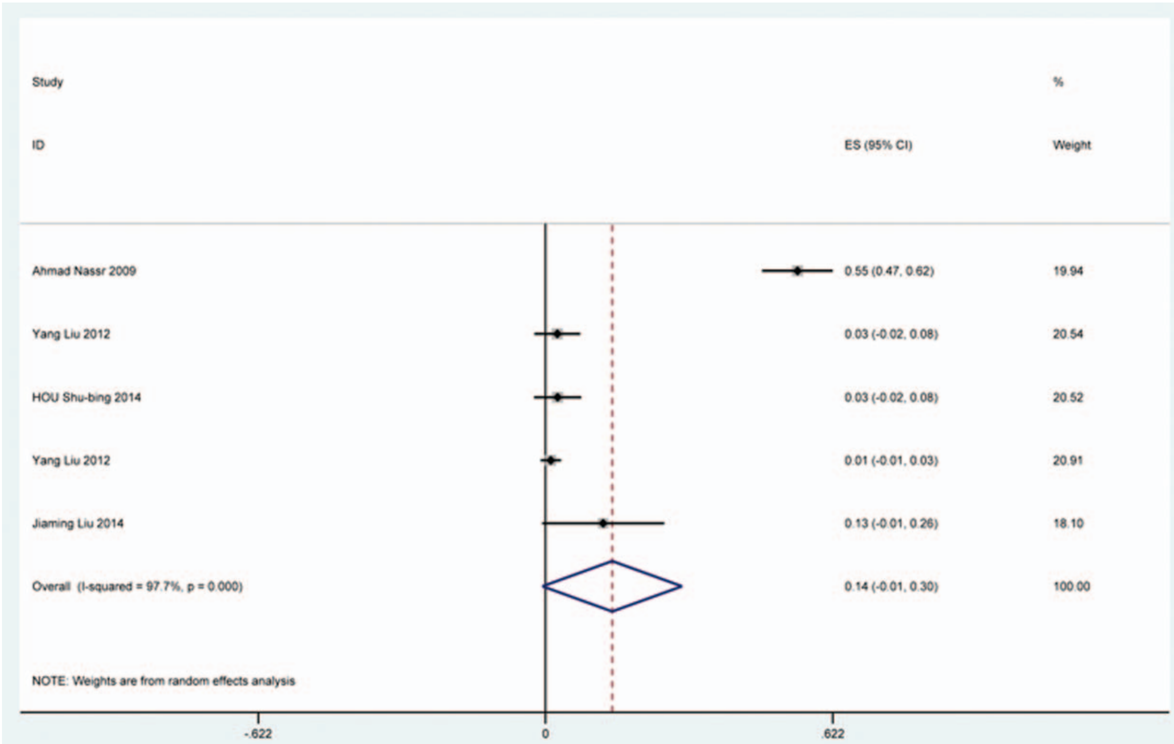

Figure 22. Funnel plot showing incidence of infection after ACCF. ACCF = anterior cervical corpectomy and fusion, CI = confidence interval, df = degrees of freedom, M–H = Mantel–Haenszel.

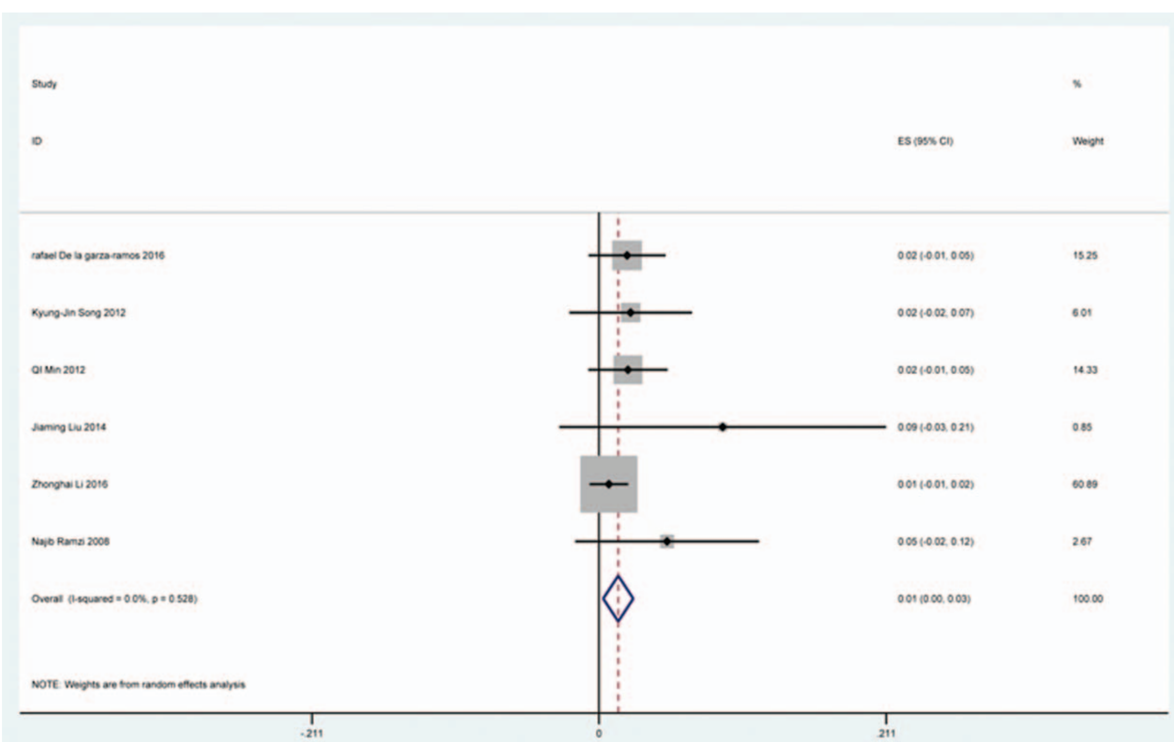

Figure 23. Forest plot showing incidence of Infection after ACDF. ACDF = anterior cervical discectomy and fusion, CI = confidence interval, df = degrees of freedom, M–H = Mantel–Haenszel.

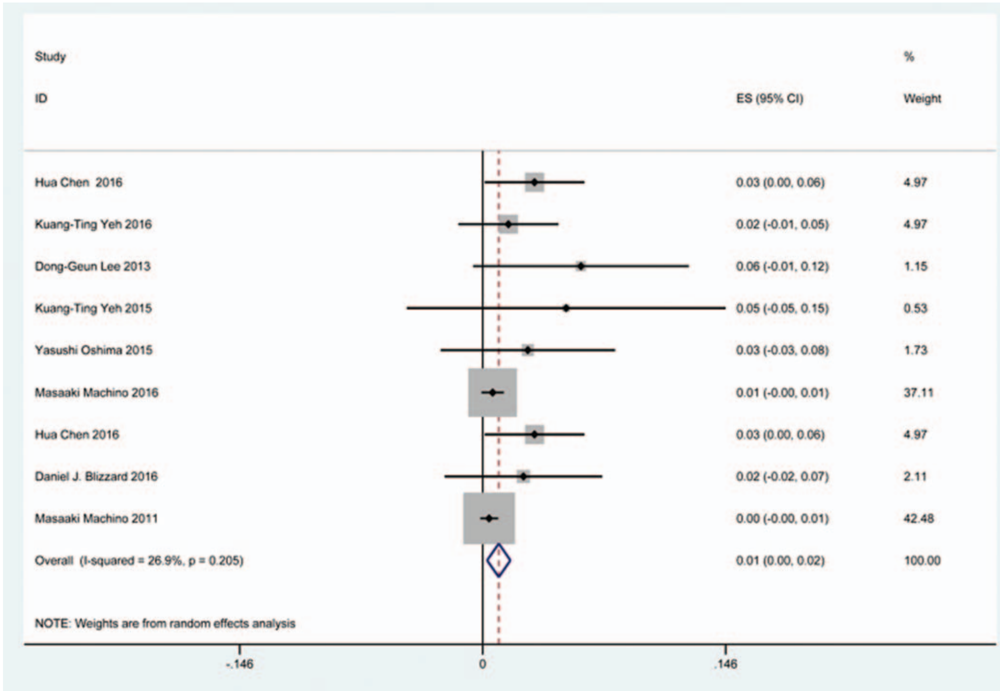

Figure 24. Forest plot showing incidence of infection after LP. CI=confidence interval, df=degrees of freedom, LP=laminoplasty, M–H=Mantel–Haenszel.

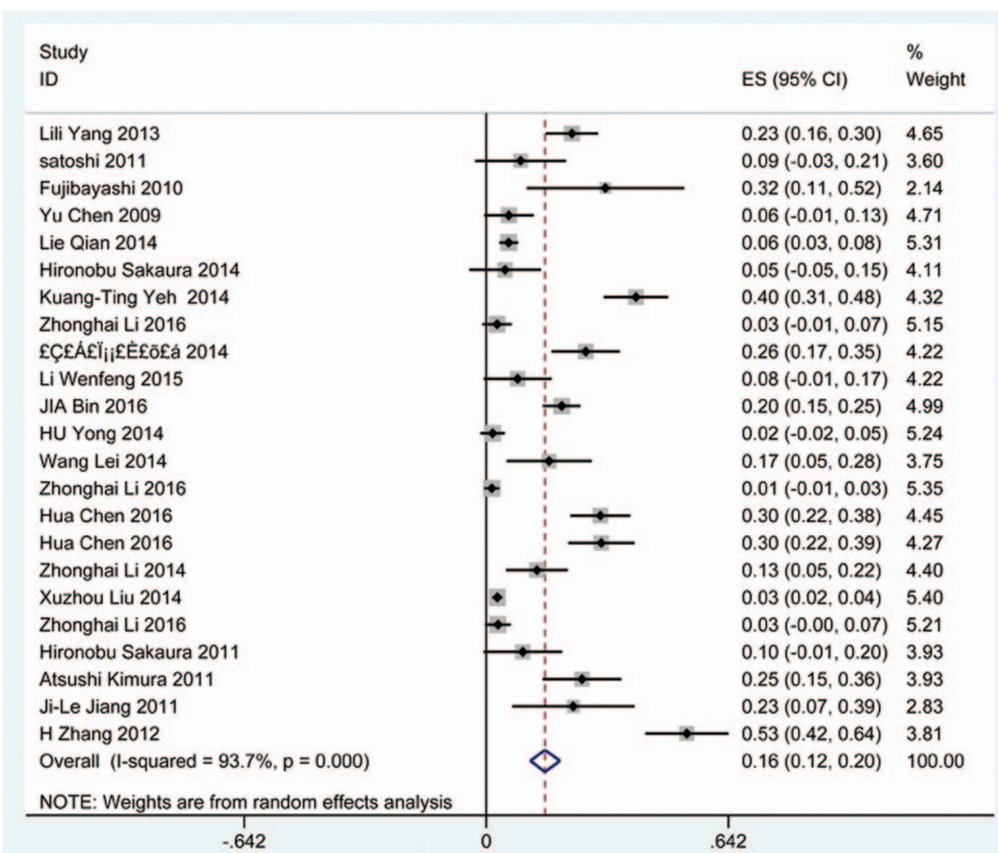

Figure 25. Forest plot showing incidence of axial pain. CI=confidence interval, df=degrees of freedom, M–H=Mantel–Haenszel.

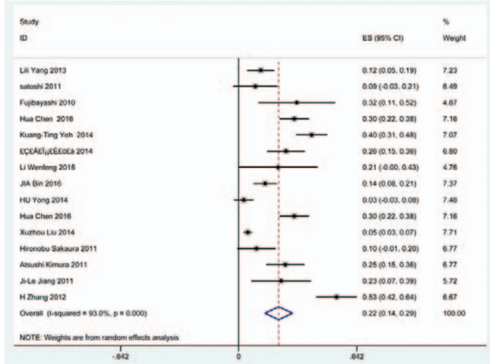

Figure 26. Forest plot showing incidence of axial pain after LP. CI=confidence interval, df=degrees of freedom, LP=laminoplasty, M–H=Mantel–Haenszel.

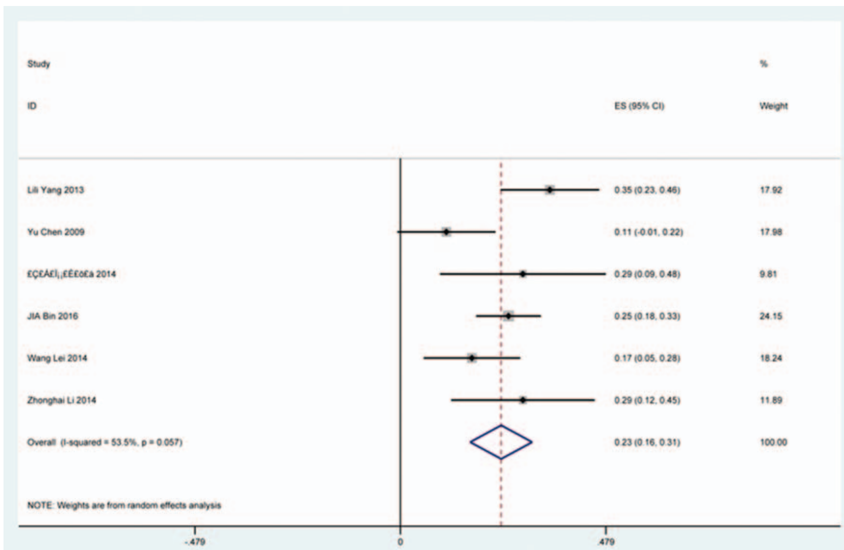

Figure 27. Forest plot showing incidence of axial pain after LF. df=degrees of freedom, I=confidence interval, LF=laminectomy and fusion, M–H=Mantel–Haenszel.

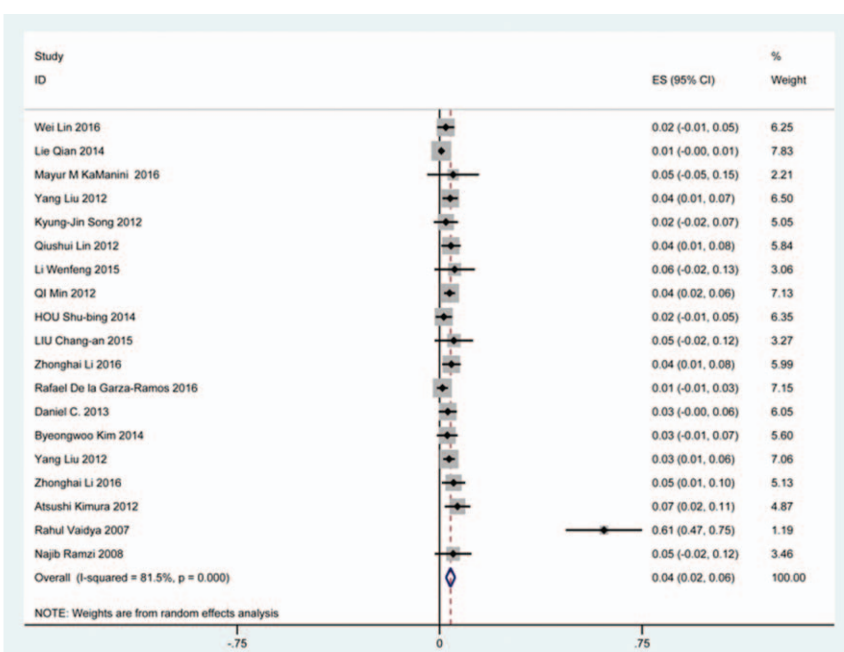

Figure 28. Forest plot showing incidence of hoarseness. CI=confidence interval, df=degrees of freedom, M–H=Mantel–Haenszel.

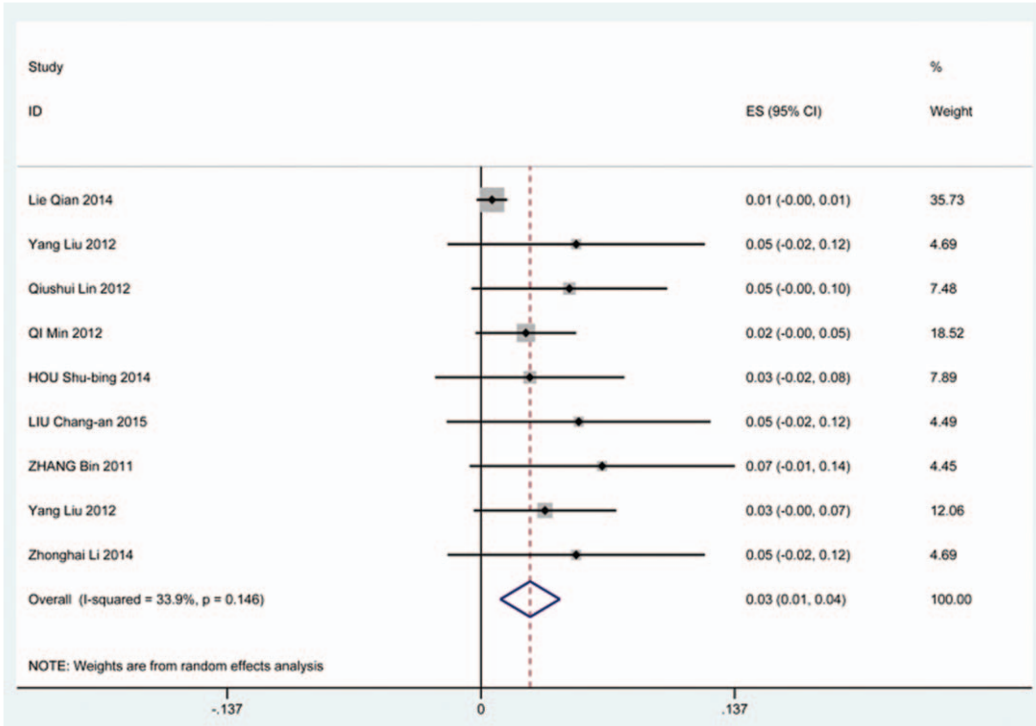

Figure 29. Forest plot showing incidence of hoarseness after ACCF. ACCF = anterior cervical corpectomy and fusion, CI = confidence interval, df = degrees of freedom, M–H = Mantel–Haenszel.

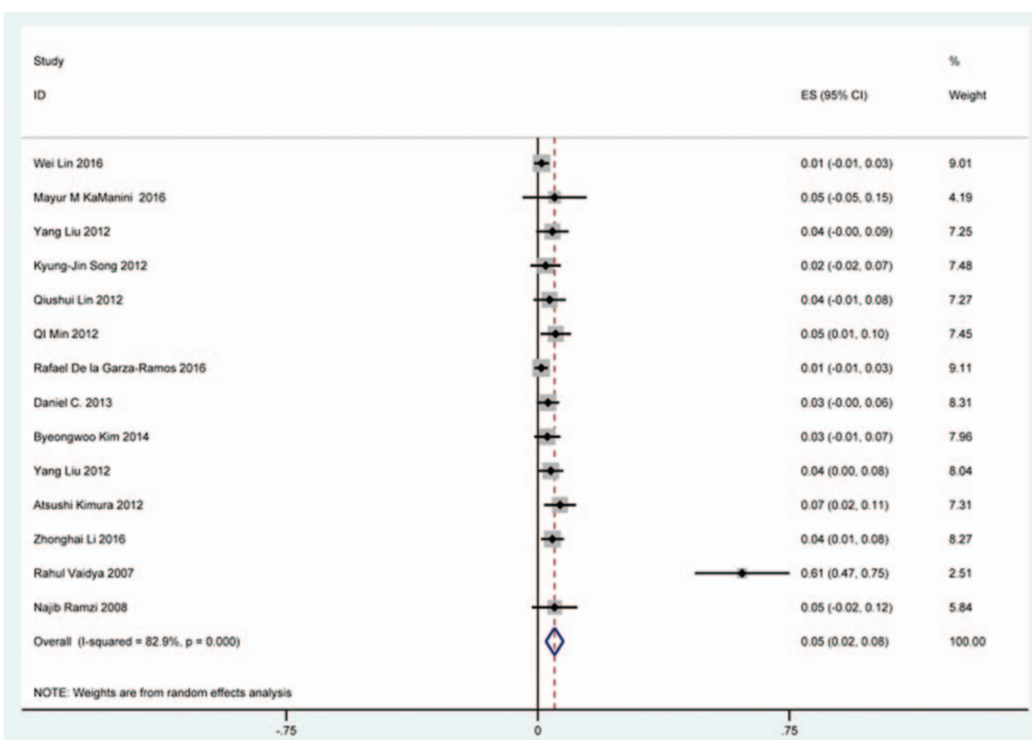

Figure 30. Forest plot showing incidence of hoarseness after ACDF. ACDF = anterior cervical discectomy and fusion, CI = confidence interval, df = degrees of freedom, M–H = Mantel–Haenszel.

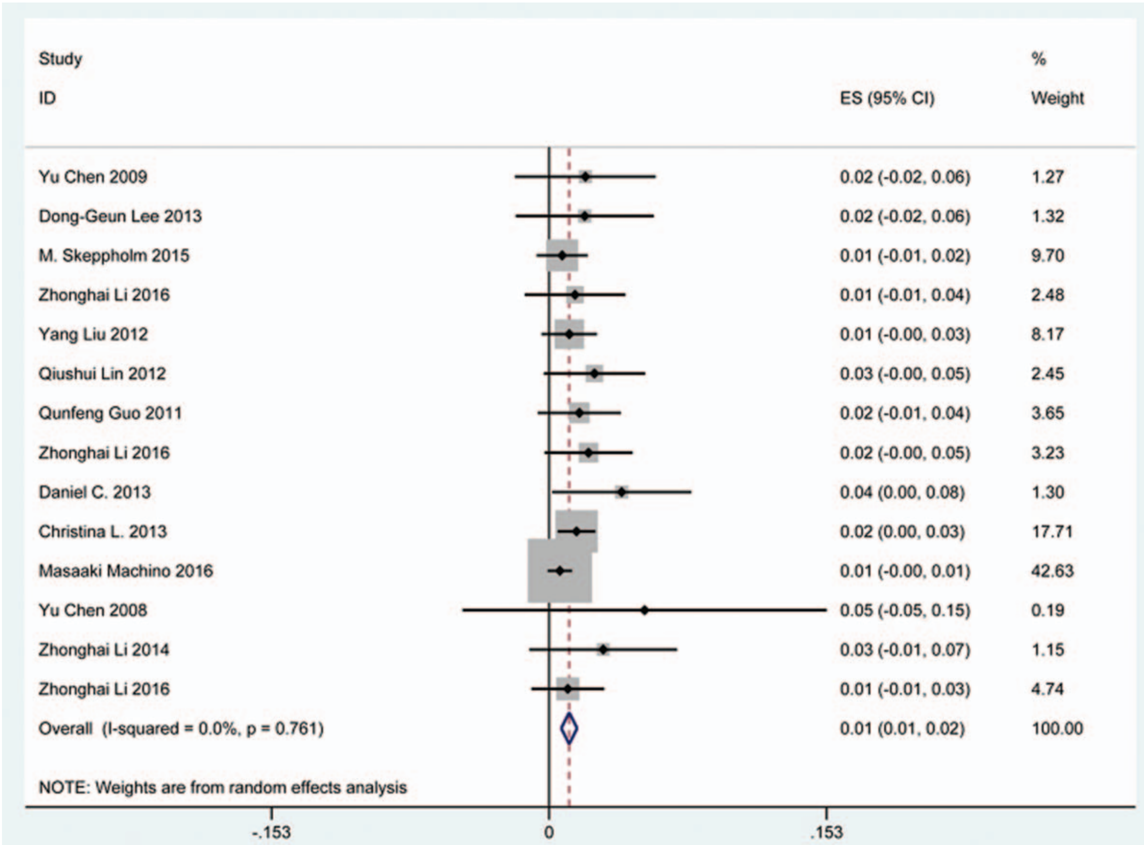

Figure 31. Forest plot showing incidence of epidural hematoma. CI = confidence interval, df = degrees of freedom, M–H = Mantel–Haenszel.

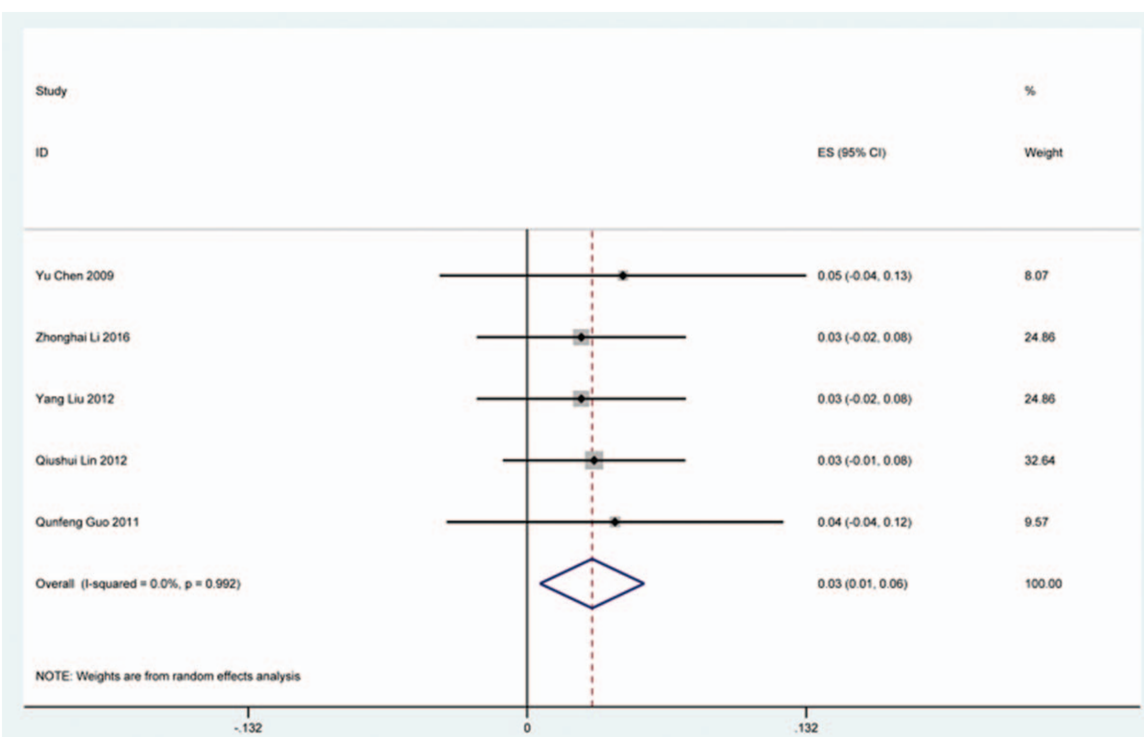

Figure 32. Forest plot showing incidence of epidural hematoma after ACCF. ACCF = anterior cervical corpectomy and fusion, CI = confidence interval, df = degrees of freedom, M–H = Mantel–Haenszel.

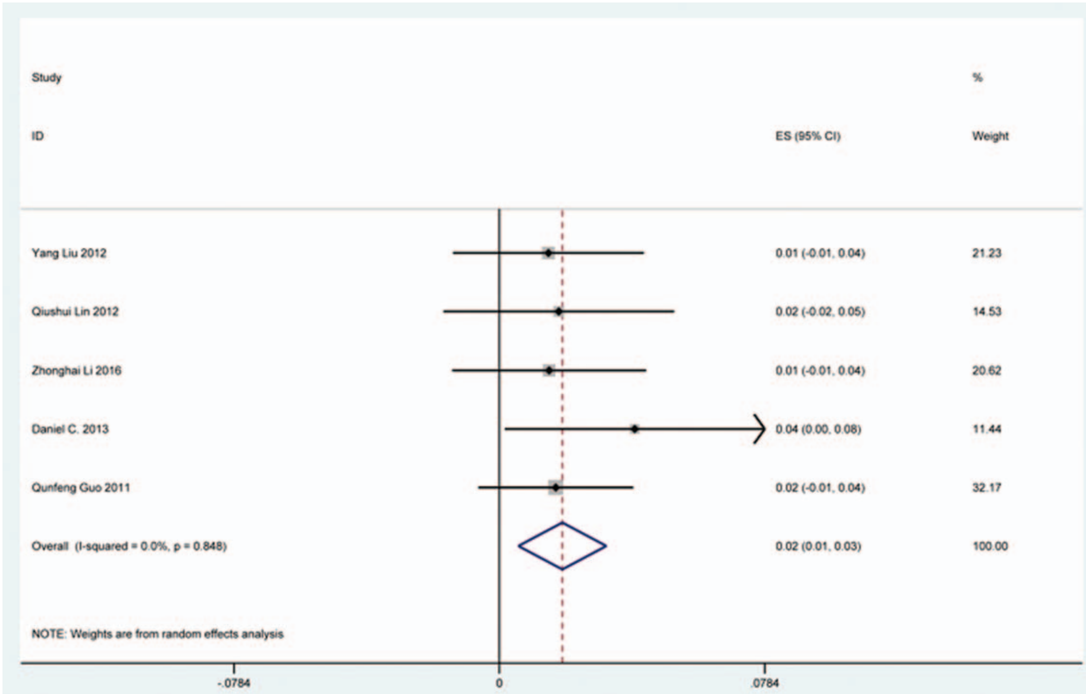

Figure 33. Forest plot showing incidence of epidural hematoma after ACDF. ACDF = anterior cervical discectomy and fusion, CI = confidence interval, df = degrees of freedom, M–H = Mantel–Haenszel.

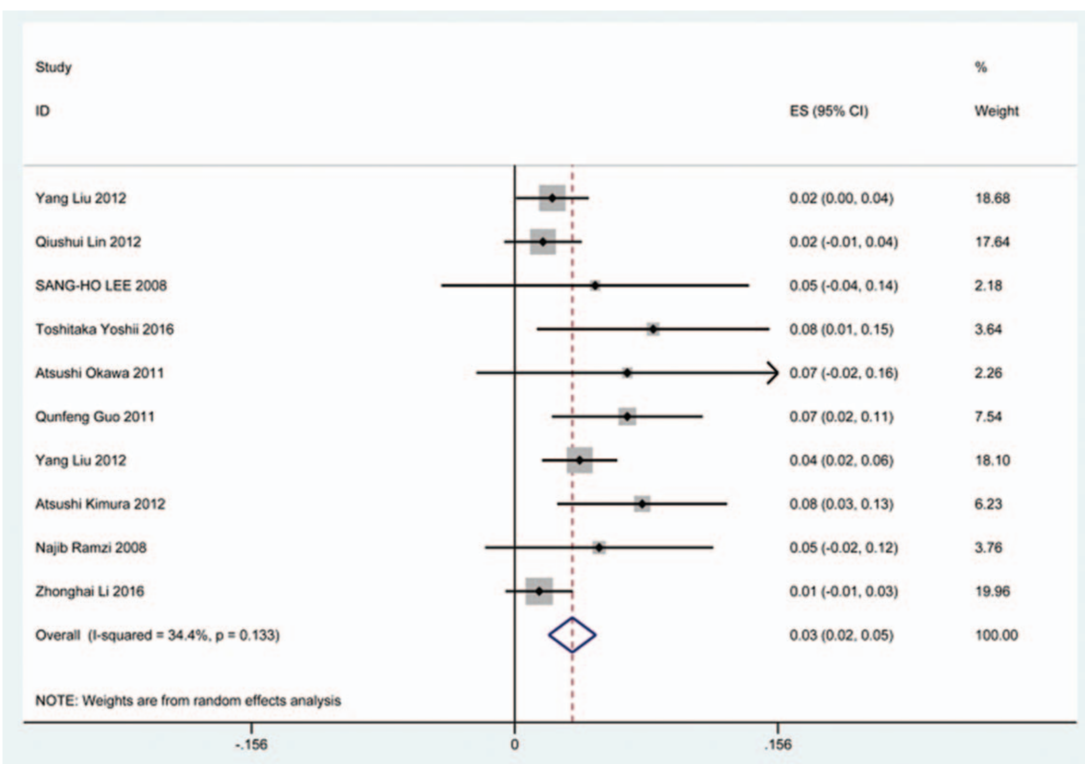

Figure 34. Forest plot showing incidence of graft dislodgment. CI = confidence interval, df = degrees of freedom, M–H = Mantel–Haenszel.

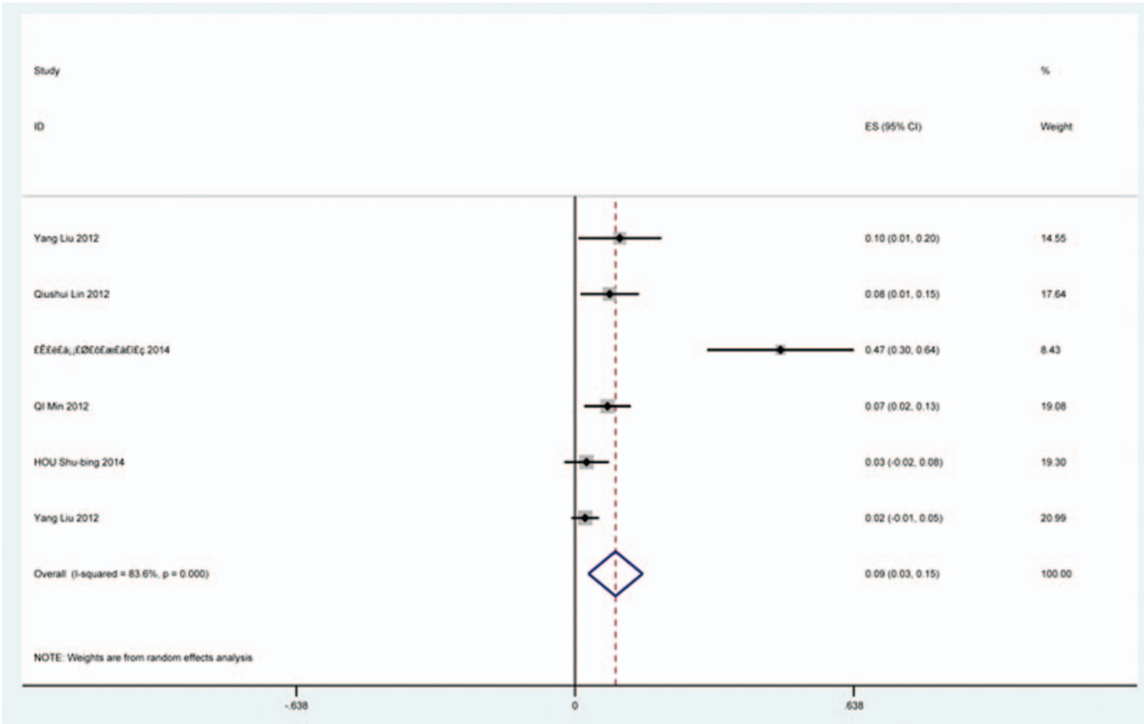

Figure 35. Forest plot showing incidence of graft subsidence. CI=confidence interval, df=degrees of freedom, M–H=Mantel–Haenszel.

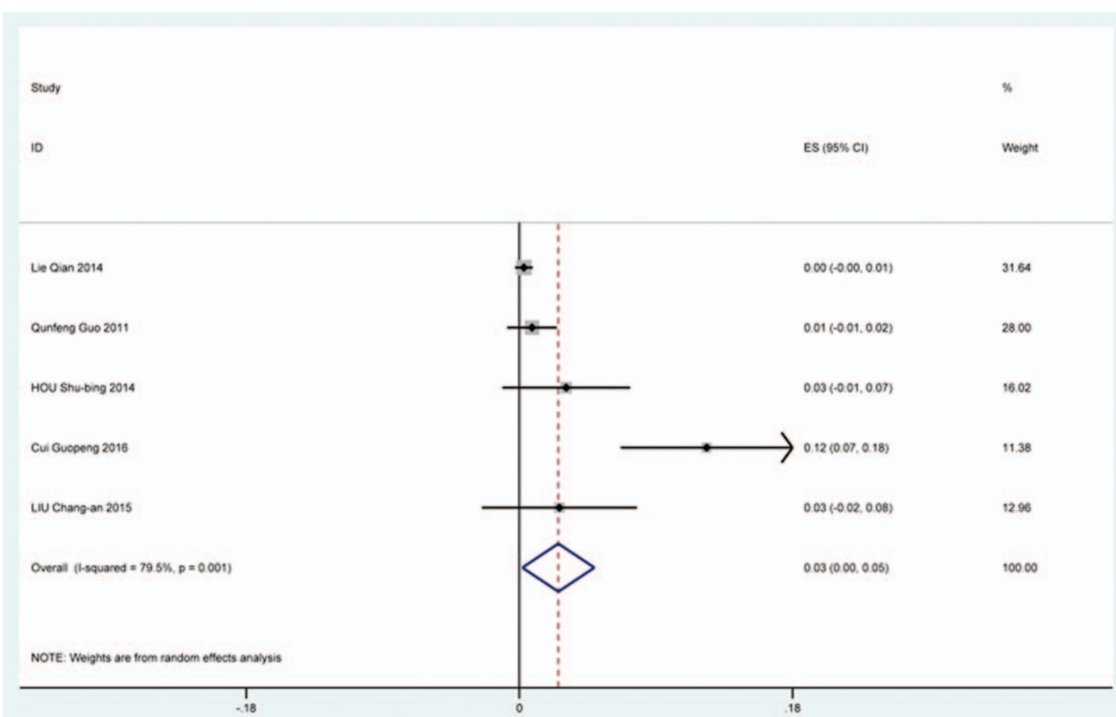

Figure 36. Forest plot showing incidence of fusion failure. CI=confidence interval, df=degrees of freedom, M–H=Mantel–Haenszel.

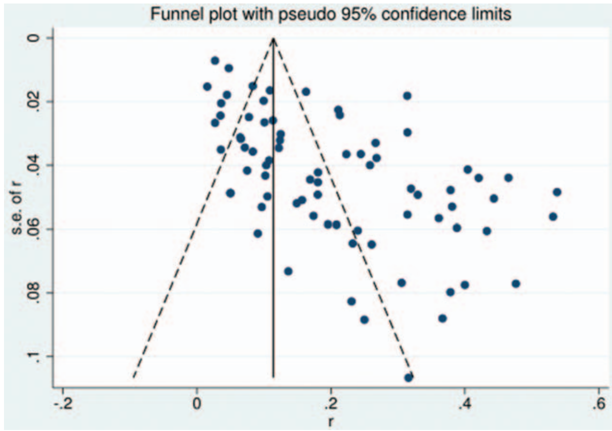

Figure 37. Funnel plot showing incidence of all complications after cervical surgery.

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