Anterior cervical disectomy and fusion versus hybrid surgery in multilevel cervical spondylotic myelopathy
A meta-analysis

Chun-Ming Zhao, MD*a,b, Qian Chen, MDab, Yu Zhang, MDa, Ai-Bing Huang, MDa, Wen-Yuan Ding, MDab,∗, Wei Zhang, MDa

Abstract

Objective: A meta-analysis was performed to compare the radiographic and surgical outcomes between anterior cervical disectomy and fusion (ACDF) and hybrid surgery (HS), corpectomy combined with disectomy) in the treatment for multilevel cervical spondylotic myelopathy (mCSM).

Summary of background data: Both ACDF and HS are used to treat mCSM, however, which one is better treatment for mCSM remains considerable controversy.

Methods: An extensive search of literature was searched in PubMed/Medline, Embase, the Cochrane library, CNKI, and WANFANG databases on ACDF versus HS treating mCSM from January 2011 to December 2017. The following variables were extracted: blood loss, operation time, fusion rate, Cobb angles of C2–C7, total complications, dysphagia, hoarseness, C5 palsy, infection, cerebral fluid leakage, epidural hematoma, and graft subsidence. Data analysis was conducted with RevMan 5.3 and STATA 12.0.

Results: A total of 4 studies including 669 patients were included in our study. The pooled analysis showed that there were no significant difference in the operation time, fusion rate, Cobb angles of C2–C7, dysphagia, hoarseness, C5 palsy, infection, cerebral fluid leakage, epidural hematoma, and graft subsidence. However, there were significant difference between 2 groups in blood loss [P < .00001, SMD = −30.29 (−45.06, −15.52); heterogeneity: P = .38, I2 = 0%] and total complications [P = .04, OR = 0.66 95%CI (0.44, 0.98); heterogeneity: P = .37, I2 = 4%].

Conclusions: Based on our meta-analysis, except for blood loss and total complications, both ACDF and hybrid surgery are effective options for the treatment of multilevel cervical spondylotic myelopathy.

Abbreviations: ACCF = anterior cervical corpectomy and fusion, ACDF = anterior cervical disectomy and fusion, CSM = cervical spondylotic myelopathy, HS = hybrid surgery, corpectomy combined with disectomy, SMD = standardized mean difference.

Keywords: anterior cervical disectomy and fusion, hybrid surgery, multilevel cervical spondylotic myelopathy

1. Introduction

Cervical spondylotic myelopathy (CSM) is a common clinical degenerative disease, seriously impacting quality of life and even causing disability for the elderly population.[1,2] CSM is usually caused by narrowing of the cervical spinal canal due to degenerative and congenital changes.[3–5] The selection of optimal surgical treatment for CSM, especially for multilevel cervical spondylotic myelopathy (mCSM), remains debated.[1–6,8] Surgeries mainly involved anterior and posterior approaches, including ACDF,[9] anterior cervical corpectomy and fusion (ACCF),[10–12] hybrid surgery,[13,14] laminoplasty,[15] laminectomy,[16] and laminectomy with fusion.[17,18] ACDF was firstly introduced to treat CSM by Smith and Robinson[19] and Cloward,[20] then the anterior procedure has become the most widely used surgical choice.[21] Among the anterior approaches, ACDF can decompress the anterior spinal cord and preserve the stability of the spinal column,[22–24] however, ACDF may have a high risk of incomplete decompression, limited visual exposure and injury to the cord.[23–27] In recent years, hybrid surgery (HS), corpectomy combined with disectomy, provides a good option for nerve tissue decompression and spinal reconstruction while reducing complications.[28–32]
Previous meta-analysis mainly focused on the comparison between ACCF and ACDF or between ACCF and combining cervical disc arthroplasty with fusion in treatment for mCSM. However, no meta-analysis focused on the comparison of outcomes between ACDF and HS, corpectomy combined with discectomy, treating mCSM. The purpose of this meta-analysis is to compare radiographic and surgical outcomes of ACDF compared with HS in treatment for mCSM.

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 Affiliated Taizhou People’s Hospital of Nantong University.

2.2. Search strategy

An extensive search of literature was performed in PubMed, Embase, the Cochrane library, CNKI, and WANFANG databases. The following keywords were used for search: “anterior cervical discectomy and fusion,” “hybrid surgery,” “corpectomy combined with discectomy,” “multilevel cervical spondylotic myelopathy” from January 2011 to December 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 compared ACDF with HS in treatment of CSM; HS was defined as corpectomy combined with discectomy; 3 or 4 levels cervical spondylotic myelopathy; follow-up more than 2 years

2.4. Exclusion criteria

Studies were excluded if they met the following criteria: dealt only with ACDF or HS alone for treatment of CSM; had an average follow-up time of less than 2 years; had repeated data; did not report outcomes of interest; in vitro human cadaveric biomechanical studies; earlier trial, reviews, and case-reports have ossification of posterior longitudinal ligament

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, total patients, follow-up, mean age, gender, radiographic outcomes: preoperation and at the final follow-up Cobb angles of C2–C7, fusion rate, graft subsidence, and surgical outcomes: blood loss, operation time, total complications, dysphagia, hoarseness, C5 palsy, infection, cerebral fluid leakage, and epidural hematoma.

2.7. Statistical analysis

Data analysis was performed with RevMan 5.3 (The Nordic Cochrane Center, The Cochrane Collaboration, Copenhagen, Denmark) and STATA 12.0 (Stata Corporation, College Station, TX). Odds ratio (OR) was used as a summary statistic to analyze dichotomous variables, and the standardized mean difference (SMD) was used to analyze continuous variables. Both were reported with 95% confidence intervals (CI), and a P value of .05 was used as the level of statistical significance. Assessment for statistical heterogeneity was calculated using the I² 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 (I² > 50%). The fixed-effects model was used when there was no significant heterogeneity between the included studies (I² ≤ 50%).

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 < .05. The trim and fill computation was used to estimate the effect of publication bias.

3. Results

3.1. Search results

We had searched 96 English studies in MEDLINE, Embase, 51 Chinese studies in WANFANG, and CNKI. Of these, 49 English articles and 44 Chinese after duplicates removed, 31 English articles and 5 Chinese articles were excluded due to unrelated studies. Around 13 English articles and 1 Chinese article were excluded due to eligibility criteria. As a result, a total of 4 studies were identified for this meta-analysis. The literature search procedure was shown in Figure 1.

3.2. Baseline characteristics and quality assessment

In total, 669 patients who suffered from mCSM from 4 studies were included in our study. Table 1 showed the baseline feature of included articles in our study.

All included studies were retrospective studies, Newcastle Ottawa Quality Assessment Scale (NOQAS) with a maximum of 9 points was applied for evaluating the quality of each study. There were 3 aspects for the quality: selection, comparability, exposure, and outcomes. Three studies scored 8 points and 1 studies scored 7 points, hence, the quality of each study was relatively high (Table 2).

3.3. Radiographic outcomes

3.3.1. The angle of C2-C7. Two studies[17,39] reported preoperative and at the final follow-up angle of C2–C7 between ACDF and HS. The meta-analysis showed that there were no difference between ACDF and HS in preoperative and the final
follow-up angle of C2-C7 \( P = .15, \text{SMD} = -.5.75 (-13.51, 2.01); \) heterogeneity: \( P = .007, I^2 = 86\% \), random-effect model, Fig. 2; \( P = .62, \text{SMD} = -.098 (-4.85, 2.90); \) heterogeneity: \( P = .08, I^2 = 68\% \), random-effect model, Fig. 3).

**3.3.2. Fusion rate.** Two studies\(^{37,39}\) reported fusion rate between ACDF and HS. The meta-analysis showed that there was no significant difference between ACDF and HS in fusion rate \( P = .78, \text{OR} = 1.66 95\% CI (0.05, 54.51); \) heterogeneity: \( P = .11, I^2 = 61\% \), random-effect model, Fig. 4).

**3.3.3. Graft subsidence.** Two studies\(^{37,39}\) reported graft subsidence between ACDF and HS. The meta-analysis showed that there was no significant difference between ACDF and HS in graft subsidence \( P = .09, \text{OR} = 0.16 95\% CI (0.02, 1.30); \) heterogeneity: \( P = .58, I^2 = 0\% \), fixed-effect model, Fig. 5).

### 3.4. Surgical outcomes

**3.4.1. Blood loss.** Two studies\(^{37,39}\) reported blood loss between ACDF and HS. The meta-analysis showed that there
was significant difference between ACDF and HS in blood loss \( [P < .00001, \text{SMD} = -30.29 \, (−45.06, −15.52); \text{heterogeneity: } P = .38, I^2 = 0\%] \), fixed-effect model, Fig. 6).

### 3.4.2. Operation time

Two studies\(^{[37,39]}\) reported operation time between ACDF and HS. The meta-analysis showed that there was no significant difference between ACDF and HS in operation time \( [P = .82, \text{SMD} = 2.63 \, (−19.62, 24.87); \text{heterogeneity: } P = .0002, I^2 = 93\%] \), random-effect model, Fig. 7).

### 3.4.3. Total complications

Four studies\(^{[37–40]}\) reported number of total complications between ACDF and HS. The meta-analysis showed that there was significant difference between ACDF and HS in number of total complications \( [P = .04, \text{OR} = 0.66 \, 95\% \text{CI} \, (0.44, 0.98); \text{heterogeneity: } P = .37, I^2 = 4\%] \), fixed-effect model, Fig. 8).

### 3.4.4. C5 palsy

Four studies\(^{[37–40]}\) reported C5 palsy between ACDF and HS. The meta-analysis showed that there was no
significant difference between ACDF and HS in C5 plasty \[P = 0.09, \ OR = 0.48 \ 95\% CI (0.21, 1.11); \text{heterogeneity: } P = .85, \ I^2 = 0\%\], fixed-effect model, Fig. 9).

3.4.5. Infection. Three studies\[37,38,40\] reported infection between ACDF and HS. The meta-analysis showed that there was no significant difference between ACDF and HS in infection \[P = .14, \ OR = 0.25 \ 95\% CI (0.04, 1.55); \text{heterogeneity: } P = .95, \ I^2 = 0\%\], fixed-effect model, Fig. 10).

3.4.6. Cerebral fluid leakage. Four studies\[37-40\] reported cerebral fluid leakage between ACDF and HS. The meta-analysis
showed that there was no significant difference between ACDF and HS in cerebral fluid leakage \[P = .24, \text{OR} = 2.16 \text{ 95\%CI (0.59, 7.89)}; \text{heterogeneity: } P = .66, I^2 = 0\%, \text{fixed-effect model, Fig. 11}].

3.4.7. Hoarseness. Three studies\cite{37,38,40} reported hoarseness between ACDF and HS. The meta-analysis showed that there was no significant difference between ACDF and HS in hoarseness \[P = .45, \text{OR} = 1.42 \text{ 95\%CI (0.57, 3.53); heterogeneity: } P = .98, I^2 = 0\%, \text{fixed-effect model, Fig. 12}].

3.4.8. Dysphagia. Three studies\cite{37,38,40} reported dysphagia between ACDF and HS. The meta-analysis showed that there was no significant difference between ACDF and HS in dysphagia \[P = .45, \text{OR} = 1.27 \text{ 95\%CI (0.68, 2.37); heterogeneity: } P = .96, I^2 = 0\%, \text{fixed-effect model, Fig. 13}].

3.4.9. Epidural hematoma. Two studies\cite{37,39} reported epidural hematoma between ACDF and HS. The meta-analysis showed that there was no significant difference between ACDF and HS in epidural hematoma \[P = .90, \text{OR} = 1.14 \text{ 95\%CI (0.15, 8.34); heterogeneity: } P = .37, I^2 = 0\%, \text{fixed-effect model, Fig. 14}].

3.4.10. Publication bias. After a detection of publication bias by STATA 12.0, but there was no publication bias found for all included studies (all \(P > .05\)).

4. Discussion
Up to now, surgical methods treated CSM for more than half a century. Regarding single-level CSM, the surgical option tends to agreement; however, as for multilevel, it remains debated.\cite{41} In the 1960s, posterior approaches included laminectomy and laminoplasty as popular surgical option for mCSM.\cite{24-26,42} But, the anterior approaches were widely used in recent years, which can provide directly decompression.\cite{13-7,43} Nevertheless, it is difficult to avoid complications like graft migration, dysphagia, and so on.\cite{44,45}
Recently, Liu et al.\(^{[37]}\) reported the comparison of 3 reconstructive techniques in the treatment for mCSM. In terms of clinical outcomes, radiological parameters, and complication incidence, Liu believed that the hybrid surgery (1-level corpectomy plus 1-level discectomy) was the best alternative compared with ACDF and ACCF. Shamji et al.\(^{[46]}\) reviewed studies on the same topic, but concluded that all 3 operative approaches are effective strategies for the anterior surgical option of multilevel CSM. However, which surgery is the best option in the treatment of multilevel CSM remains unclear. Wen et al.\(^{[33]}\) and Han et al.\(^{[34]}\) performed a meta-analysis on comparison of surgical treatment for mCSM between ACDF and ACCF. They had the same conclusion that both ACDF and ACCF are effective option in treatment for mCSM. Nevertheless, no meta-analysis focused on the comparison between ACDF and HS for mCSM. The purpose of this meta-analysis is to compare radiographic outcomes and surgical outcomes of ACDF compared with HS in treatment for mCSM.

In this meta-analysis, we carried on strict eligibility criteria. Although no RCT studies were included in our study, all included studies had high quality according to the Newcastle Ottawa Quality Assessment Scale (NOQAS) and the baseline variables were similar. Thus, we considered the included reports suitable for meta-analysis. We assessed radiographic outcomes (Cobb angles of C2-C7, fusion rate and graft subsidence) and surgical outcomes (blood loss, operation time, dysphagia, hoarseness, C5 palsy, infection, cerebral fluid leakage, and epidural hematoma) were similar between the 2 groups. C5 palsy is considered as an important complication after cervical decompression surgery. Sakaura et al.\(^{[50]}\) reported the average incidence was 4.6% (range from 0 to 30%). But pathogenesis of C5 palsy remains unclear still now, multilevel corpectomy may lead to significant drift of spinal cord away ventral side. But both ACDF and HS had the same result in C5 palsy. There were similar rates of dysphagia and hoarseness in 2 groups. Dysphagia and hoarseness were common complications after multilevel anterior cervical surgery,\(^{[51]}\) which may be caused by trachea and esophagus traction.\(^{[52]}\)

There are several limitations of this study. First, no RCT study was included in our article; Second, we were unable to analyze some parameters, such as Japanese Orthopedic Association scores, because of small number of included studies, which may cause a high heterogeneity. We need more included articles in further study. Third, the follow-up of all included article is up to 2 years, which is not enough to observe the long-term recovery and complications. Fourth, we just searched English and Chinese articles on this topic. However, other articles could not be included in other languages due to difficulty in language translation.
In summary, although, in term of total complications and blood loss, ACDF have more satisfactory efficacy in our meta-analysis. However, both ACDF and HS for multilevel CSM have effective surgical option. Future more studies with high methodological quality and long-term follow-up periods are needed to evaluate the 2 procedures for multilevel CSM treatment.

Author contributions

Authors’ contributions—conceived and designed the study: ZCM; collected data: CQ, ZY; analyzed the data: HAB, ZW; wrote the paper: CQ and ZY.

Data curation: Wen-Yuan Ding, Qian Chen.

Formal analysis: Wen-Yuan Ding.

Methodology: Yu Zhang.

Visualization: Wen-Yuan Ding.

Writing – original draft: Chun-Ming Zhao, Ai-Bing Huang, Wei Zhang.

References

[1] Goiffon J, Van LJ, Van CF, et al. A clinical analysis of 4- and 6-year follow-up results after cervical disc replacement surgery using the Bryan Cervical Disc Prosthesis. J Neurosurg Spine 2010;12:261–9.
[2] Lee SB, Cho KS, Kim JY, et al. Hybrid surgery of multilevel cervical degenerative disc disease: review of literature and clinical results. J Korean Neurosurg Soc 2012;52:452–8.
[3] Kang L, Lin D, Ding Z, et al. Artificial disk replacement combined with midlevel ACDF versus multilevel fusion for cervical disk disease involving 3 levels. Orthopedics 2013;36:e68–94.
[4] Hey HWD, Hong CC, Long AS, et al. Is hybrid surgery of the cervical spine a good balance between fusion and arthroplasty? Pilot results from a single surgeon series. Eur Spine J 2013;22:116–22.
[5] Shen C, Shen Y, Ding W, et al. Contrastive analysis of neck axial symptoms after hybrid surgery or traditional anterior cervical discectomy and fusion for treatment of two-level cervical disease. Zhongguo Xu Fu Chong Jian Wai Ke Za Zhi 2013;27:58–61.
[6] Grasso G. Clinical and radiological features of hybrid surgery in multilevel cervical degenerative disc disease. Eur Spine J 2015;24(suppl 7):S42–8.
[7] Mao N, Wu J, Zhang Y, et al. A comparison of anterior cervical corpectomy and fusion combined with artificial disc replacement and cage fusion in patients with multilevel cervical spondylotic myelopathy. Spine (Phila Pa 1976) 2015;40:1277–83.
[8] Ding F, Jia Z, Wu Y, et al. Fusion-nontfusion hybrid construct versus anterior cervical hybrid decompression and fusion: a comparative study for 3-level cervical degenerative disc diseases. Spine (Phila Pa1976) 2014;39:1914–42.
[9] Cho BY, Lim J, Sim HB, et al. Biomechanical analysis of the range of motion after placement of a two-level cervical ProDisc-C versus hybrid construct. Spine (Phila Pa 1976) 2010;35:1769–76.
[10] Lee MJ, Dumonski M, Phillips FM, et al. Disc replacement adjacent to cervical fusion: a biomechanical comparison of hybrid construct versus two-level fusion. Spine (Phila Pa 1976) 2011;36:1932–9.
[11] Barrey C, Campana S, Persohn S, et al. Cervical disc prosthesis versus arthrodesis using one-level, hybrid and two-level constructs: an in vitro investigation. Eur Spine J 2012;21:432–42.
[12] Burkus JK, Traynelis VC, Had RW, et al. Clinical and radiographic analysis of an artificial cervical disc 7-year follow-up from the Prestige prospective randomized controlled clinical trial. J Neurosurg Spine 2014;21:316–28.
[13] Dan X, Ma XL, Ma JX, et al. A meta-analysis of cervical arthroplasty compared to anterior cervical discectomy and fusion for single-level cervical disc disease. J Clin Neurosci 2013;20:970–8.
[14] Fallah A, Akk EA, Erhram S, et al. Anterior cervical discectomy with arthroplasty versus arthrodesis for single-level cervical spondylolisthesis: a systematic review and meta-analysis. PLoS One 2012;7:e43407.
[15] Stang A. Critical evaluation of the Newcastle–Ottawa scale for the assessment of the quality of nonrandomized studies in meta-analyses. Eur J Epidemiol 2010;25:603–5.
[41] Papadopoulos EC, Huang RC, Girardi FP, et al. Three-level anterior cervical discectomy and fusion with plate fixation: radiographic and clinical results. Spine 2006;31:897–902.

[42] Chang SW, Kakarla UK, Maughan PH, et al. Four-level anterior cervical discectomy and fusion with plate fixation: radiographic and clinical results. Neurosurgery 2010;66:639–46.

[43] Rapat MR, Chaudhary K, Sharma A, et al. Surgical approach to cervical spondylotic myelopathy on the basis of radiological patterns of compression: prospective analysis of 129 cases. Eur Spine J 2008;17:1651–63.

[44] Anakwenze OA, Auerbach JD, Milby AH, et al. Sagittal cervical alignment after cervical disc arthroplasty and anterior cervical discectomy and fusion: results of a prospective, randomized, controlled trial. Spine (Phila Pa 1976) 2009;34:2001–7.

[45] Liu T, Xu W, Cheng T, et al. Anterior versus posterior surgery for multilevel cervical myelopathy, which one is better? A systematic review. Eur Spine J 2011;20:224–35.

[46] Shamji MF, Massicotte EM, Traynelis VC, et al. Comparison of anterior surgical options for the treatment of multilevel cervical spondylotic myelopathy: a systematic review. Spine (Phila Pa 1976) 2013;38(22 suppl 1):S195–209.

[47] Park Y, Maeda T, Cho W, et al. Comparison of anterior cervical fusion after two-level discectomy or single-level corpectomy: sagittal alignment, cervical lordosis, graft collapse, and adjacent-level ossification. Spine J 2010;10:193–9.

[48] Uribe JS, Sangala JR, Duckworth EA, et al. Comparison between anterior cervical disectomy fusion and cervical corpectomy fusion using titanium cages for reconstruction: analysis of outcome and long-term follow-up. Eur Spine J 2009;18:654–62.

[49] Grob D, Luca A. Surgery for cervical stenosis: anterior cervical decompression, corpectomy, and fusion. Eur Spine J 2010;19:1801–2.

[50] Sakaura H, Hosono N, Mukai Y, et al. C5 palsy after decompression surgery for cervical myelopathy: review of the literature. Spine (Phila Pa 1976) 2003;28:2447–51.

[51] Edwards CC, Heller JG, et al. Corpectomy versus laminoplasty for multilevel cervical myelopathy: an independent matched-cohort analysis. Spine 2002;27:1168–75.

[52] Apfelbaum RI, Kriskovich MD, Haller JR. On the incidence, cause, and prevention of recurrent laryngeal nerve palsies during anterior cervical spine surgery. Spine 2000;25:2906–12.