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Review

Anterior cervical discectomy with arthroplasty *versus* anterior cervical discectomy and fusion for cervical spondylosis

Gao-Ling Li [a,1], Jian-Zhong Hu [a,1], Hong-Bin Lu [b,*], Jin Qu [b], Li-Yun Guo [b], Feng-Lei Zai [b]

[a] Department of Spinal Surgery, Xiangya Hospital, Central South University, Changsha, People's Republic of China
[b] Department of Sports Medicine, Research Center of Sports Medicine, Xiangya Hospital, Central South University, Changsha 410008, People's Republic of China

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ABSTRACT

This meta-analysis aims to estimate the benefits and drawbacks associated with anterior cervical discectomy with arthroplasty (ACDA) *versus* anterior cervical discectomy and fusion (ACDF) for cervical spondylosis. Of 3651 identified citations, 10 randomised controlled studies involving 2380 participants were included. Moderate quality evidence supports that patients in the ACDA group had: (1) a higher Neck Disability Index (NDI) success rate at 3 month (relative risk [RR] = 0.85, 95% confidence interval [CI] 0.78 to 0.93, $p = 0.0002$) and 2 year follow-up (RR = 0.95, 95%CI 0.91 to 1.00, $p = 0.04$); (2) greater neurological success at 2 year follow-up (RR = 0.95, 95%CI 0.92 to 0.98); and (3) were more likely to be employed within 6 weeks after surgery (RR = 0.80 95%CI 0.66 to 0.96). In summary, the current evidence indicates that ACDA is associated with a higher NDI success rate in the short and long-term as well as a higher neurological success rate. Patients who undergo ACDA may also have a greater likelihood of being employed in the short-term. However, all of the evidence reviewed is of moderate or low quality and the clinical significance often marginal or unclear. Additional data are needed to compare the benefits and limitations of ACDA and ACDF.

1. Introduction

Cervical spondylosis is an age-related condition of the cervical spine resulting from progressive intervertebral disc degeneration. Disc degeneration can potentially cause compression, stretching or angulation of the nerve roots resulting in radiculopathy, myelopathy and repeated trauma to the spinal cord [1–3]. This can manifest as a range of symptoms, including localised axial pain, radiating radicular pain, headache, motor weakness and sensory loss. Conservative treatment options such as nerve blocks, steroids or radiofrequency denervation are offered when symptoms persist. When the patients have not responded to conservative treatments, surgical interventions are considered.

Traditionally, anterior cervical discectomy and fusion (ACDF) has been the standard intervention. In this procedure, neurological decompression is achieved by discectomy and spinal stability is achieved by fusing two or more vertebrae with either bone autografts, allografts or synthetic materials such as polyetheretherketone (PEEK). ACDF has shown good spinal fusion rates and high clinical success [4–6], however, various limitations have led to a search for improvements in the procedure. Disadvantages of ACDF include limitation or loss of spinal mobility, higher intradiscal pressures as well as increased segmental motion in adjacent segments, graft pseudoarthrosis, and autograft harvest site pain [7–12]. Adjacent segment degeneration (ASD) develops following single level ACDF in nearly 25% of patients [13]. Altered biomechanics rather than natural degeneration are implicated in ASD following ACDF. Further, secondary surgical procedures are required in nearly two-thirds of ASD patients [14–16].

Artificial cervical disc arthroplasty (ACDA) offers the same degree of neural decompression as ACDF. Furthermore, it provides spinal stability along with segmental motility [17]. This is achieved by performing anterior cervical discectomy followed by the implantation of a mobile prosthesis that imitates an intervertebral disc. With its putative motion sparing characteristic [19] at the operated segment, the prosthesis is thought to reduce the alteration in biomechanics in the adjacent segment [18], which in turn may reduce the incidence of ASD. Two prostheses, the Bryan Cervical Disc System (Medtronic; Memphis, TN, USA) and the Pres-

* Corresponding author. Tel./fax: +86 158 7488 9777.
E-mail address: hongbinlu@hotmail.com (H.-B. Lu).
[1] These authors have contributed equally to the manuscript.

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tige-ST Cervical Disc (Medtronic) have received U.S. Food and Drug Administration approval for clinical use [20,21]. Another prosthesis, the Pro-Disc-C (Synthes Spine USA Products; LLC, West Chester, PA, USA), is undergoing clinical trials [22].

As more evidence emerges about ACDA outcomes in cervical spondylosis, it is imperative to provide a critical analysis of both the benefits and limitations associated with ACDA compared with ACDF in patients with cervical spondylosis.

2. Materials and methods

We developed a protocol prior to this systematic review that was registered in PROSPERO. The registration number is CRD42013005201.

2.1. Eligibility criteria

We included randomised controlled trials from the literature in this review. Participants in the trials had either single or multilevel cervical spondylosis (defined by the authors). Trials were excluded if the spondylotic change involved any other part of the vertebrae apart from the cervical region. Participants underwent either ACDF or ACDA.

2.2. Outcomes

Primary outcomes were Neck Disability Index Questionnaire (NDI) success (defined as an increase in the NDI score of >20% from baseline or an increase in the score of >15 points) and pain in the arm and neck measured by validated rating scales. Secondary outcomes included neurological success (maintenance or improvement in each of the neurologic evaluations including sensory, motor, and reflex functions), employment, and any adverse effects. Short-term was defined as up to 3 months, medium-term was defined as 3 to 12 months, and long-term longer than 12 months.

2.3. Search strategy

In July 2013, we searched the following electronic databases: MEDLINE, Cumulative Index to Nursing and Allied Health Literature, EMBASE, Cochrane Central Register of Controlled Trials, UK National Health Service Economic Evaluation Database and Chinese Academic Journals. Language or publication year limits were not applied to any search. All references of relevant reviews were also inspected. The search strategy was developed by an information specialist and is presented in the registered protocol.

2.4. Selection of studies

Two of the authors (L.Y.G. and F.L.Z.) inspected all of the results obtained from the search process and independently decided whether these studies could be included. Any disagreement was resolved by discussion and the reasons for the differences of opinion were recorded.

2.5. Data collection

We developed a standard data extraction form on an electronic spreadsheet. Two reviewers (G.L.L. and J.Z.H.) extracted data independently. Any dispute was either resolved by discussion or by involving a third author (H.B.L.) when necessary. The participant characteristics, intervention, comparison and outcomes of interest reported in each study were extracted. Risk of bias information was also extracted from eligible studies, including randomisation, allocation concealment, blindedness of participants and assessors, incomplete data, selective reporting and other biases [23].

2.6. Assessment of risk of bias in included studies

Two authors (G.L.L. and J.Q.) used the Cochrane Collaborations tool for assessing risk of bias [23]. This tool uses six domains: (1) adequate sequence generation; (2) allocation concealment; (3) blinding; (4) incomplete outcome data, (5) selective outcome reporting; and (6) other sources of bias. Two review authors assessed the risk of bias independently. Whether there is a risk of bias or not in each domain depends on measured outcomes.

2.7. Data management and analysis

Two authors (G.L.L. and J.Z.H.) used Review Manager (RevMan version 5.2) for data entry and analysis. For binary data, we calculated the relative risk (RR) with its 95% confidence interval (CI). In order to combine continuous data, we used the mean difference (MD) and its 95% CI if available. Where data were skewed, we did not pool it into the meta-analysis but rather described it in the reporting of results. For missing binary data, we assumed that the patients leaving the study early had the same rate as the completers.

2.8. Heterogeneity

We explored heterogeneity by using the I^2 method alongside the chi-squared p value. We defined an I^2 score of 0% to 40% as "heterogeneity might not be important", 30% to 60% as "may represent moderate heterogeneity", 50% to 90% as "may represent substantial heterogeneity", and 75% to 100% as "considerable heterogeneity" [23]. We explored the source of heterogeneity when an I^2 score of at least 30% was accompanied by a statistically significant chi-squared test ($p < 0.1$). When the heterogeneity could be explained, subgroup analyses were then applied. Where it could not be explained, we simply described the finding of each study in the "Results" section.

2.9. Additional analysis

To determine the robustness of our conclusions, we performed sensitivity analyses for interested outcomes where included studies implied randomisation and wherever the data was assumed.

2.10. Grading of Recommendations Assessment, Development and Evaluation quality of evidence

We used the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach to assess the quality of the findings. GRADE profiler 3.6 was used to import data from RevMan 5.2 and to create a "summary of findings" table. Five factors that can reduce the quality of evidence from randomised controlled trials were assessed as follows: risk of bias; imprecision; inconsistency; indirectness; and publication bias. All judgements were based on information presented in the instructional manual in the GRADE profiler software [24].

3. Results

3.1. Study selection

We eventually included 38 references from 10 studies. Figure 1 presents the study screening flow diagram.