ELSEVIER

CrossMark

The Spine Journal 15 (2015) 2016–2027

THE SPINE JOURNAL

Clinical Study

Pseudoarthrosis rates in anterior cervical discectomy and fusion: a meta-analysis

Michael F. Shriver, BS[a,*], Daniel J. Lewis, BA[b], Varun R. Kshettry, MD[c,d], Benjamin P. Rosenbaum, MD[c,d], Edward C. Benzel, MD[c,d], Thomas E. Mroz, MD[d,e]

[a]*Case Western Reserve University School of Medicine, 2109 Adelbert Rd, Cleveland, OH 44106, USA*
[b]*Baylor College of Medicine, 1 Baylor Plaza, Houston, TX 77030, USA*
[c]*Department of Neurosurgery, Neurological Institute, Cleveland Clinic, 9500 Euclid Ave., Cleveland, OH 44195, USA*
[d]*Center for Spine Health, Cleveland Clinic, 9500 Euclid Ave., Cleveland, OH 44195, USA*
[e]*Department of Orthopaedic Surgery, Cleveland Clinic, 9500 Euclid Ave., Cleveland, OH 44195, USA*

Received 31 January 2015; accepted 7 May 2015

Abstract

BACKGROUND CONTEXT: Anterior cervical discectomy and fusion (ACDF) is a commonly performed procedure for patients presenting with cervical radiculopathy, myelopathy, or deformity. A systematic literature review and meta-analysis of pseudoarthrosis rates associated with ACDF with plate fixation have not been previously performed.

PURPOSE: The purpose of this study was to identify all prospective studies reporting pseudoarthrosis rates for ACDF with plate fixation.

STUDY DESIGN/SETTING: This study is based on a systematic review and meta-analysis.

PATIENT SAMPLE: Studies reporting pseudoarthrosis rates in patients who received one-, two-, or three-level ACDF surgeries were included.

OUTCOME MEASURES: Outcomes of interest included reported pseudoarthrosis events after ACDF with plate fixation.

METHODS: We conducted a MEDLINE, SCOPUS, Web of Science, and EMBASE search for studies reporting complications for ACDF with plate fixation. We recorded pseudoarthrosis events from all included studies. A meta-analysis was performed to calculate effect summary mean values, 95% confidence intervals (CIs), Q statistics, and I^2 values. Forest plots were constructed for each analysis group.

RESULTS: Of the 7,130 retrieved articles, 17 met the inclusion criteria. The overall pseudoarthrosis rate was 2.6% (95% CI: 1.3–3.9). Use of autograft fusion (0.9%, 95% CI: –0.4 to 2.1) resulted in a reduced pseudoarthrosis rate compared with allograft fusion procedures (4.8%, 95% CI: 1.7–7.9). Studies were separated based on the length of follow-up: 12 to 24 and greater than 24 months. These groups reported rates of 3.1% (95% CI: 1.2–5.0) and 2.3% (95% CI: 0.1–4.4), respectively. Studies performing single-level ACDF yielded a rate of 3.7% (95% CI: 1.6–5.7). Additionally, there was a large difference in the rate of pseudoarthrosis in randomized controlled trials (4.8%, 95% CI: 2.6–7.0) versus prospective cohort studies (0.2%, 95% CI: –0.1 to 0.5), indicating that the extent of follow-up criteria affects the rate of pseudoarthrosis.

CONCLUSIONS: This review represents a comprehensive estimation of the actual incidence of pseudoarthrosis across a heterogeneous group of surgeons, patients, and ACDF techniques. The definition of pseudoarthrosis varied significantly within the literature. To ensure its diagnosis and

FDA device/drug status: Not applicable.

Author disclosures: ***MFS:*** Nothing to disclose. ***DJL:*** Nothing to disclose. ***VRK:*** Nothing to disclose. ***BPR:*** Nothing to disclose. ***ECB:*** Grant: OREF (F), Rawlings (F); Personal Fees: Axiomed (B, Stock Ownership and Consulting); Other: Axiomed (B, Stock Ownership and Consulting), Depuy (B, Stock Ownership), Orthomens (B, Stock Ownership), Turning Point (B, Stock Ownership); Royalties: Elsevier Pub (B, Royalties <B), Thieme Pub (Comments: Royalties <D). ***TEM:*** Personal Fees: Globus Medical (B), AO Spine (B), CeramTec (B); Other: PearlDiver Inc (Stock ownership - No monies received).

The disclosure key can be found on the Table of Contents and at www.TheSpineJournalOnline.com.

All authors confirm that they have no applicable conflicts to report in relation to this manuscript.

* Corresponding author: Case Western Reserve University School of Medicine, 2109 Adelbert Rd, Cleveland, OH 44106, USA. Tel.: (216) 368-6972.

E-mail address: mfs82@case.edu (M.F. Shriver)

http://dx.doi.org/10.1016/j.spinee.2015.05.010

prevent sequelae, standardized criteria need to be established. This investigation sets the framework for surgeons to understand the impact of surgical techniques on the rate of pseudoarthrosis.

Keywords: Anterior cervical discectomy and fusion; ACDF; Pseudoarthrosis; Nonunion; Complication; Meta-analysis

Introduction

Anterior cervical discectomy and fusion (ACDF) has been successful in the surgical treatment of cervical radiculopathy, myelopathy, myeloradiculopathy, and/or deformity because of cervical degenerative disease, tumors, infection, or trauma [1,2]. Whereas ACDF is associated with high rates of osseous fusion, pseudoarthrosis remains an important complication [3]. Although pseudoarthrosis is not always symptomatic, many reports suggest that pseudoarthrosis after ACDF adversely affects clinical outcome [3–5]. Pseudoarthrosis may cause mechanical pain or lead to ongoing mobility, producing strain on hardware and ultimately leading to failure and the need for surgical revision.

Rates of pseudoarthrosis after ACDF vary widely in the literature [4]. Variability arises, in part, from the lack of standard radiographic criteria for determining the presence of bony fusion [4]. Plain radiography, dynamic flexion-extension radiography, and thin-slice computed tomography (CT) scanning may be used to assess the vertebral body-graft interface for pseudoarthrosis. Radiographic criteria indicating pseudoarthrosis include segmental motion on dynamic radiographs in addition to a radiolucent strip, or ''halo sign,'' suggesting the absence of bridging bony trabeculae at the body-graft interface [4].

Rates vary further based on the type of bone graft used, number of levels fused, smoking status, and length of follow-up. For example, Samartzis et al. [6] reported comparable fusion results with iliac crest autograft versus allograft in one-level ACDF with plate fixation. Others, although, report higher rates of pseudoarthrosis with autograft than with allograft, and some others show higher rates with allograft [7,8]. Moreover, Wang et al. [9,10] demonstrated that the risk of pseudoarthrosis is increased in multilevel compared with single-level ACDF. Wang et al. [9,10] reported the rates of fusion for one-, two-, and three-level ACDF as 88% to 90%, 73% to 80%, and 70%, respectively.

An analysis of the overall incidence of pseudoarthrosis after ACDF would prove useful in educating patients and surgeons during the informed consent process. In addition, an estimate of the complication rate over a large study population would enable it to be used in future comparative effectiveness studies. We conducted a systematic literature review and meta-analysis to estimate the incidence of pseudoarthrosis after ACDF and to compare rates associated with the number of fused levels, follow-up time, and various bone-graft types.

Methods

Study search

We conducted MEDLINE, SCOPUS, Web of Science, and EMBASE database searches with the search algorithm: (''Anterior Cervical Discectomy (ACDF) and Fusion Complication(s)'') OR (''Anterior Cervical Discectomy and Fusion Complication(s) and Outcome(s)'') OR ((''Anterior'' and ''Cervical'' and ''Discectomy'') AND (''fusion'' or ''arthrodesis.'')) The search returned 7,130 citations (Fig. 1). The search period ended November 10, 2014.

Inclusion and exclusion criteria

Only prospective cohort studies and randomized controlled trials (RCTs) were included in this meta-analysis because of their superior evidence level compared with that of retrospective cohort studies [11]. Articles published before 1990 were excluded because anterior plate fixation became much more prevalent after 1990 [12]. To create a more homogenous patient cohort, studies involving the following procedures were excluded: anterior cervical discectomy without graft fusion, ACDF without plate fixation, anterior cervical corpectomy and fusion, arthroplasty, combined anterior-posterior surgeries, and ACDF greater than three intervertebral disc levels. We imposed no restrictions on publication status. Animal, in vitro, biomechanical and non-English studies were excluded. Studies using bone morphogenic protein-2 were excluded because bone morphogenic protein-2 has been shown to increase complication rates and is not approved by the Food and Drug Administration for use in anterior cervical surgery. In fact, its use has plummeted since a 2008 Food and Drug Administration warning [13]. We also excluded large administrative data sets because plating and nonplating procedures were not differentiated, and many complications are frequently underreported in coded data [14–20].

Data collection

Two reviewers (MFS and DJL) independently conducted data extraction from the 17 included articles. The extracted data sets were compared to confirm accuracy. Level of evidence for each of the included articles was assessed using the Oxford Centre for Evidence Based Medicine Level of Evidence 2 classification system [11]. From the eligible articles, we obtained the following information: type of