

Cost-utility analysis modeling at 2-year follow-up for cervical disc arthroplasty versus anterior cervical discectomy and fusion: A single-center contribution to the randomized controlled trial

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Abstract

Background: Patients with cervical disc herniations resulting in radiculopathy or myelopathy from single level disease have traditionally been treated with Anterior Cervical Discectomy and Fusion (ACDF), yet Cervical Disc Arthroplasty (CDA) is a new alternative. Expert suggestion of reduced adjacent segment degeneration is a promising future result of CDA. A cost-utility analysis of these procedures with long-term follow-up has not been previously reported.

Methods: We reviewed single institution prospective data from a randomized trial comparing single-level ACDF and CDA in cervical disc disease. Both Medicare reimbursement schedules and actual hospital cost data for peri-operative care were separately reviewed and analyzed to estimate the cost of treatment of each patient. QALYs were calculated at 1 and 2 years based on NDI and SF-36 outcome scores, and incremental cost effectiveness ratio (ICER) analysis was performed to determine relative cost-effectiveness.

Results: Patients of both groups showed improvement in NDI and SF-36 outcome scores. Medicare reimbursement rates to the hospital were \$11,747 and \$10,015 for ACDF and CDA, respectively; these figures rose to \$16,162 and \$13,171 when including physician and anesthesiologist reimbursement. The estimated actual cost to the hospital of ACDF averaged \$16,108, while CDA averaged \$16,004 ($p = 0.97$); when including estimated physicians fees, total hospital costs came to \$19,811 and \$18,440, respectively. The cost/QALY analyses therefore varied widely with these discrepancies in cost values. The ICERs of ACDF vs CDA with Medicare reimbursements were \$18,593 (NDI) and \$19,940 (SF-36), while ICERs based on actual total hospital cost were \$13,710 (NDI) and \$9,140 (SF-36).

Conclusions: We confirm the efficacy of ACDF and CDA in the treatment of cervical disc disease, as our results suggest similar clinical outcomes at one and two year follow-up. The ICER suggests that the non-significant added benefit via ACDF comes at a reasonable cost, whether we use actual hospital costs or Medicare reimbursement values, though the actual ICER values vary widely depending upon the CUA modality used. Long term follow-up may illustrate a different profile for CDA due to reduced cost and greater long-term utility scores. It is crucial to note that financial modeling plays an important role in how economic treatment dominance is portrayed.

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Keywords: Anterior cervical discectomy and fusion; Cervical disc arthroplasty; Cost-utility analysis

Introduction

Although patients presenting with cervical spondylotic radiculopathy (CSR) can often be treated nonoperatively with successful results, the reality remains that many will eventually require surgical intervention. The indications for surgical treatment of single-level cervical radiculopathy have been extensively studied and discussed in the existing medical literature.^{1–9}

Recently, guidelines have been published regarding the natural history and predictive prognostic features of CSR, including surgical indications for radiculomyelopathy and means for assessing functional outcomes.^{4,7,8,10–12} Studies suggest that many patients with CSR secondary to herniated nucleus pulposus may experience spontaneous symptom resolution; therefore, both operative and nonoperative management may produce a similar clinical outcome at 16 months.^{7,12–14} Other literature, however, would support early intervention as being beneficial for both pain relief and functional outcome.^{6,10,15,16} The timing of intervention can introduce additional economic factors that are often

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overlooked, such as the productivity of a patient returning to gainful employment.

Significant controversy still remains with regard to the most appropriate method of surgical intervention. The 2 most common and heavily debated procedures approached anteriorly for patients with single-level disc disease and otherwise normal spinal alignment are anterior cervical discectomy and fusion (ACDF) and cervical disc arthroplasty (CDA). ACDF is widely viewed as the gold standard,^{17,18} yet the emerging significance of motion preservation and the desire for reduced adjacent segment degeneration call this standard into question. Several randomized controlled trials (RCTs) have demonstrated that CDA achieves similar, and in some cases superior, results to ACDF when considering short-term clinical outcome.^{19–22} Drawbacks, such as autograft donor site morbidity, pseudarthrosis, and adjacent segment degeneration, that necessitate revision surgery are commonly cited reasons for driving spine surgeons to consider arthroplasty, and positive findings, such as reduced rates of revision, are being demonstrated with longer periods of follow-up for the patients enrolled in the Prodisc-C RCT.^{17,18,23,24} Long-term follow-up is required to better evaluate the durability of CDA procedures and to allow spine surgeons to more confidently choose the appropriate surgical technique. Consideration of unexpected or complicating factors in an idealized cost-utility evaluation may lead to inappropriate conclusions, and as such economic modeling attempts to control for unexpected events.

Long-term outcomes, additional nonoperative health interventions, and unexpected events can also exert considerable influence upon the economic effect of a surgical intervention; increased scrutiny of expensive advanced technologies is forcing clinicians to understand the relative advantages of new devices and techniques beyond theoretical benefits and outcomes. Therefore, the cost-effectiveness of a procedure is increasingly relevant to clinical decision making. Several models for illustrating cost-effectiveness have been reported in the past, but the unpredictable influences of long-term events require any such model to rely upon an idealized setting to exclude various positive and negative economic externalities that may arise.^{25–27}

Despite the importance of reducing costs while maintaining the best possible outcomes, existing literature evaluating the relative cost-effectiveness of various procedures to treat pathology in the cervical spine is limited.^{23,28,29} We report a retrospective cost-effectiveness comparison of ACDF and CDA, considering data from a previously conducted prospective, RCT and utilizing Medicare reimbursement rates to represent the costs of the 2 procedures, with awareness of the shortcomings of an idealized clinical patient cohort.

Methods

Study design

We performed a retrospective review of single institution data from a prospective multicenter, RCT to compare the

efficacy of ACDF and CDA in the treatment of symptomatic cervical disc disease.²¹ Over the course of the Prodisc-C IDE study, 31 patients were enrolled at our institution; inclusion criteria for this prospective study were limited to patients undergoing surgery on 1 vertebral level for single-level cervical radiculopathy, without adjacent segment degeneration or prior fusion. Two patients were excluded from the study because of motor vehicle crashes, which was likely to skew their self-reported quality of life during the follow-up period, and another elected to be removed from the study. Therefore, after applying these exclusion criteria, there were 28 patients included in our analysis; all 28 patients met the inclusion criteria of the RCT.²¹ These criteria were implemented to isolate patients undergoing single-level ACDF and CDA without associated short- or long-term complications, in order to examine the direct costs associated with each procedure. This represents a controlled clinical scenario and does not account for indirect financial factors, such as loss of productivity.

Additionally, institutional cost figures were of interest for further comparison of these patients. However, financial data on the initial study cohorts were not deemed representative of the true procedural costs, due to the fact that the implanted devices were provided to patients by the medical device companies at no cost. Alternatively, the financial records of 2 separate cohorts of single-level ACDF ($n = 15$) and CDA ($n = 13$) patients operated on between 2008 and 2010 were retrospectively reviewed and used to represent hospital costs of ACDF and CDA patients. These patients all underwent single-level procedures for radiculopathy and served as replica patients for the purpose of direct hospital cost modeling.

Outcome scores

Clinical outcome was monitored by recording health-related quality of life outcome scores (HRQOL) from both the disease-specific Neck Disability Index (NDI) and the general-health measure Short Form-36 (SF-36). Preoperative and postoperative monitoring included 6-, 12-, 18-, and 24-month time points. Utility values were derived from the NDI and the SF-36 at 12 and 24 months based on accepted literature and based on validated mathematical modeling.^{30–33} A calculation of cumulative quality-adjusted life years (QALYs) was gained at time points 1 and 2 years after surgery was performed. There were 2 patients that had only 1-year follow-up; these were included only in the 1-year cost analysis. Within each treatment group, patients with and without complete follow-up data were compared for utility scores at each time point, as well as for cumulative QALYs gained at 1 and 2 years.

Economic modeling

Cost data were estimated using Medicare reimbursement values. All reported dollar values are based on current USD.

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