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Clinical Study

Comparison of cervical kinematics between patients with cervical artificial disc replacement and anterior cervical discectomy and fusion for cervical disc herniation

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Abstract

BACKGROUND CONTEXT: Although anterior cervical discectomy and fusion (ACDF) is an effective treatment option for patients with cervical disc herniation, it limits cervical range of motion, which sometimes causes discomfort and leads to biomechanical stress at neighboring segments. In contrast, cervical artificial disc replacement (ADR) is supposed to preserve normal cervical range of motion than ACDF. A biomechanical measurement is necessary to identify the advantages and clinical implications of ADR. However, literature is scarce about this topic and in those available studies, authors used the static radiological method, which cannot identify three-dimensional motion and coupled movement during motion of one axis.

PURPOSE: The purpose of this study was to compare the clinical parameters and cervical motion by three-dimensional motion analysis between ACDF and ADR and to investigate the ability of ADR to maintain cervical kinematics.

STUDY DESIGN: This was a prospective case control study.

PATIENT SAMPLE: Patients who underwent ADR or ACDF for the treatment of single-level cervical disc herniation.

OUTCOME MEASURES: Visual analog scale (VAS), Korean version of Neck Disability Index (NDI, %), and three-dimensional motion analysis were used.

METHODS: The patients were evaluated by VAS and the Korean version of the NDI (%) to assess pain degree and functional status. Cervical motions were assessed by three-dimensional motion analysis in terms of sagittal, coronal, and horizontal planes. Markers of 2.5 cm in diameter were attached at frontal polar (Fpz), center (Cz), and occipital (Oz) of 10–20 system of electroencephalography, C7 spinous process, and both acromions. These evaluations were performed preoperatively and 1 month and 6 months after surgery.

RESULTS: The ACDF and ADR groups revealed no significant difference in VAS, NDI (%), and cervical range of motion preoperatively. After surgery, both groups showed no significant difference in VAS and NDI (%). In motion analysis, significantly more range of motion was retained in flexion and extension in the ADR group than the ACDF group at 1 month and 6 months. There was no significant difference in lateral tilt and rotation angle. In terms of coupled motion, ADR group exhibited significantly more preserved sagittal plane motion during right and left rotation and also showed significantly more preserved right lateral bending angle during right rotation than ACDF group at 1 month and 6 months. There was no significant difference in other coupled motions.

FDA device/drug status: Approved (Prodisc-C).

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CONCLUSION: Three-dimensional motion analysis could provide useful information in an objective and quantitative way about cervical motion after surgery. In addition, it allowed us to measure not only main motion but also coupled motion in three planes. ADR demonstrated better retained cervical motion mainly in sagittal plane (flexion and extension) and better preserved coupled sagittal and coronal motion during transverse plane motion than ACDF. ADR had the advantage in that it had the ability to preserve more cervical motions after surgery than ACDF.

Keywords: Cervical kinematics; Artificial disc replacement; Anterior cervical discectomy and fusion; Visual analogue scale; Neck disability index

Introduction

Anterior cervical discectomy and fusion (ACDF) is an effective and safe intervention for treating patients with cervical radiculopathy [1]. However, ACDF may limit the segmental motion at the fusion level and consequently result in the subjective discomfort of patients and increased biomechanical stresses and accelerated degeneration of the neighboring spinal motion segments [2–4]. The flexion and extension angle is decreased at the fusion level but increased at the adjacent level, which increases the risk of adjacent segmental disorders [5–9]. The lateral bending and rotation angle of the patients with ACDF are decreased compared with healthy subjects [10]. Other limitations include morbidities related to pseudarthrosis, bone grafting, allograft, or plate and adverse muscular effects induced by immobilization.

In contrast, artificial disc replacement (ADR) is designed to avoid the limitations at the operative level and allow patients to quickly return to routine activities. It avoids the morbidity of bone graft harvest and anterior cervical plating [11]. In addition, it prevents pseudarthrosis and adverse side effects caused by cervical immobilization [5]. ADR also is supposed to preserve coupled motions at levels above and below the device, which was demonstrated in a study in cadavers [12].

The biomechanical measurement is necessary to identify the advantage and clinical implication of ADR. However, literature is scarce on this topic, and in those available studies, authors used radiologic methods such as flexion extension X-ray, which cannot identify three-dimensional motion and coupled movement during main motion [3,6,13]. The purpose of this study was to compare the clinical parameters and cervical motion by three-dimensional motion analysis between ACDF and ADR and to investigate the ability of ADR to maintain cervical kinematics.

Patients and methods

This study was approved by institutional review board of our hospital. Patients were included who (1) were 19 between 60 years of age; (2) had neck or radiating pain over the upper extremities for least 3 months that did not respond to conservative management, including oral medication and physical therapy; and (3) were diagnosed as having a single-level cervical disc herniation. Diagnosis was made based on the clinical manifestations and the magnetic resonance imaging (MRI) findings. The MRI findings were evaluated by a spinal radiologist. We excluded those patients with history of shoulder and cervical trauma, neurologic deficit of upper limb, additional musculoskeletal problems of an upper limb, previous surgery of cervical area, suspicious sign of infectious spondylitis or discitis in MRI and laboratory findings, or radiologic or clinical evidence of cervical myelopathy. After we informed all patients about the procedures, objectives of the study, and the possible complications, patients who gave written informed consent were selected. The patients were allocated by simple randomization method using randomization table and underwent either ACDF or ADR via the ProDisc-C Total Disc Replacement System (DePuy Sythes, West Chester, PA). Finally, nine patients and ten patients were included in ADR and ACDF groups, respectively. As to lesions level, the ADR group included six patients with C5–C6 level and three with C6–C7 level. ACDF group included 1 patient of with C3–C4 level, six with C5–C6 level, and three with C6–C7 level.

Patients were evaluated by a visual analogue scale (VAS) and the Korean version of Neck Disability Index (NDI, %) to assess pain degree and functional status respectively before surgery [14,15]. VAS ranged from 0 (no pain) to 10 (worst possible pain). The NDI consisted of 10 sections, each with a total score of 5. The first statement was scored as 0 and the last statement was scored as 5. If all 10 sections were completed by each patient, the score was calculated as a percentage. For example, if the total score from 10 sections for one patient was 16, the score of that patient would be 32% (16/50 (maximal possible score)$\times$100). All patients were asked to give their answers considering the average severity of their symptoms over a recent period. Evaluations were conducted by a nurse who was blinded to the method of treatment. The Korean version of the NDI has been found to be a reliable and valid instrument for measuring disability in Korean patients with cervical disorders [16].

Three-dimensional motion analysis was conducted to evaluate the cervical range of motion preoperatively using