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Clinical Study

Cervical anterior hybrid technique with bi-level Bryan artificial disc replacement and adjacent segment fusion for cervical myelopathy over three consecutive segments

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ABSTRACT

This study aimed to assess the preliminary clinical efficacy and feasibility of the hybrid technique for multilevel cervical myelopathy. Considering the many shortcomings of traditional treatment methods for multilevel cervical degenerative myelopathy, hybrid surgery (bi-level Bryan artificial disc [Medtronic Sofamor Danek, Memphis, TN, USA] replacement and anterior cervical discectomy and fusion) should be considered. Between March 2006 and November 2012, 108 patients (68 men and 40 women, average age 45 years) underwent hybrid surgery. Based on the Japanese Orthopaedic Association (JOA) score, Neck Disability Index (NDI), and Odom's criteria, the clinical symptoms and neurological function before and after surgery were evaluated. Mean surgery duration was 90 minutes, with average blood loss of 30 mL. Mean follow-up duration was 36 months. At the final follow-up, the mean JOA (± standard deviation) scores were significantly higher compared with preoperative values (15.08 ± 1.47 *versus* 9.18 ± 1.22; $P < 0.01$); meanwhile, NDI values were markedly decreased (12.32 ± 1.03 *versus* 42.68 ± 1.83; $P < 0.01$). Using Odom's criteria, the clinical outcomes were rated as excellent (76 patients), good (22 patients), fair (six patients), and poor (four patients). These findings indicate that the hybrid method provides an effective treatment for cervical myelopathy over three consecutive segments, ensuring a good clinical outcome.

1. Introduction

Surgery is generally required in multilevel cervical myelopathy with substantial symptoms due to intervertebral disc protrusion and osteophytosis at the posterior edge of the vertebral body when conservative treatments fail [1]. However, as an indirect method, the effectiveness of posterior decompression is limited, especially in individuals with absence or reversal of the physiological curvature. In anterior approach surgeries, anterior cervical discectomy and fusion (ACDF) and cervical artificial disc replacement (ADR) are the most commonly used methods to reconstruct cervical stability in patients with sufficient decompression. However, long segment bone graft is needed for anterior long segmental decompression, which results in long fusion segments and increased risk of internal fixation collapse and displacement; more importantly, fusion of multiple segments can accelerate the degeneration of adjacent intervertebral discs. Studies in recent years have shown that fusion of two or more cervical segments can significantly increase the range of motion (ROM) of adjacent cervical vertebrae and intradisc pressure, thus increasing the risk of adjacent segment disorders [2].

Multilevel cervical degenerative myelopathy (with involvement of two or more segments) is common in our clinic. Due to the known shortcomings of ACDF or ADR performed as single therapy, hybrid surgery (ADR + ACDF) has been suggested for the treatment of multilevel cervical degenerative myelopathy; this should not only adapt to the disease characteristics in different segments, but should also maximise the advantages of artificial discs and overcome the limitations of cervical fusion [3]. Therefore, hybrid surgery has been recognized as a promising method.

At the time of writing, most hybrid surgeries have been performed on patients with two-level cervical degenerative myelopathy [4]. In a prospective study, Barbagallo et al. [5] carried out hybrid surgery to treat 24 cervical degenerative myelopathy patients with ProDisc-C (DePuy Synthes, West Chester, PA, USA), Prestige LP (Medtronic Sofamor Danek, Memphis, TN, USA), or Bryan (Medtronic Sofamor Danek) cervical disc prosthesis, with 12–40 month follow-up. Short Form 36-item health survey and Neck Disability Index (NDI) data revealed significant improvement

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after surgery, and relative disc replacement and fusion positions did not substantially influence the ROM of the artificial disc. Follow-up data showed that hybrid surgery is safe and effective in these patients. Comparing hybrid surgery (ADR + ACDF) and ACDF monotherapy, Liu et al. [6] found no significant difference in symptom remission at 6 months postoperatively. Of note, the ROM of adjacent upper and lower segments increased in the ACDF group, suggesting an increased risk of adjacent segment degeneration; however, hybrid surgery may reduce the risk of adjacent segment disorders.

Cardoso and Rosner [7] compared the efficacy of ADR + ACDF and ADR + ACDF + ADR in 31 patients with multilevel cervical myelopathy. Short-term effectiveness was found to be good after insertion of an Prestige ST prosthesis, and the 18 month follow-up study showed that cervical lordosis was slightly affected by hybrid surgery; ROM decreased significantly after surgery in patients with bi-level cervical myelopathy (39.5° *versus* 50.5°); however, no significant change in the ROM was found in patients with three-level cervical myelopathy, which could be due to the relatively short postoperative follow-up.

In the present study, clinical and follow-up data of patients operated at three levels for multilevel cervical spondolytic myelopathy were retrospectively analyzed, and the feasibility of hybrid surgery was evaluated.

2. Materials and methods

2.1. General characteristics

In total, 108 patients with cervical spondylosis in three continuous segments were included in the study, comprising 68 men and 40 women with an average age of 45 years (range: 36–64 years). The disease course ranged from 3 to 16 months. Overall, 70, 22, and 16 patients had myelopathy, radiculopathy, and cervical vertigo concomitantly, respectively. The main clinical symptoms included neck and shoulder pain, upper extremity radicular pain, numbness of the fingers, feeling of walking on cotton, unsteadiness when walking, clumsy hands, tendon hyporeflexia or hyperreflexia, and positive Hoffmann reflex. Lateral and dual oblique radiographs in flexion and extension positions, CT scan of the cervical spine with reconstruction, and MRI of the cervical spine were performed for each patient before surgery. Unstable cervical segments, severity of intervertebral space narrowing, ossification of the posterior longitudinal ligament at the vertebral body and posterior edge of the intervertebral disc, and cervical spine curvature were evaluated carefully to exclude segments with an intervertebral space <3 mm, developmental spinal canal stenosis, osteoporosis, and significant ossification of the posterior longitudinal ligament. Preoperative MRI data showed cervical intervertebral disc protrusion in C3–C6 or C4–C7, with osteophytes at the vertebral posterior edge compressing the cervical spinal cord or nerve root; in addition, the T2-weighted MRI highlighted compression of the anterior thecal sac. Overall, 10 patients were also found to have slight compression by the ligamentum flavum, and 12 had high-signal changes in the spinal cord. Mean Japanese Orthopaedic Association (JOA) and NDI scores were 9.18 ± standard deviation (SD) 1.22 and 42.68 ± SD 1.83 before surgery, respectively.

2.2. Surgical procedures

Patients were placed in the supine position, and surgery was carried out under general anesthesia with endotracheal intubation. A soft cushion was placed below the patient's shoulders, with a pillow below the neck to maintain the cervical spine in a neutral position. A transverse incision was made at the right anterior neck and extended to the prevertebral fascia along the tissues between the cervical vascular sheath and the visceral sheath; then, C-arm radiographs were taken to clearly display the segments to be operated on. The two ADR segments were ground off to remove osteophytosis at the anterior edge of the vertebral body. A sagittal wedge locator was inserted into the intervertebral space through the midpoint after sufficient decompression, and dual-channel burr drill sets were placed. Cylindrical grinding and disc grinding drills of appropriate lengths were selected to grind the inferior and superior endplates of the upper and lower vertebral bodies, respectively, and an appropriate Bryan artificial disc size was implanted into the intervertebral space. Then, C-arm radiograph imaging was performed to ensure the appropriate positioning of the disc. The intervertebral space to be treated with cage fusion was opened using an intervertebral spreader, and nucleus pulposus forceps and curette were employed to completely remove the protruded nucleus pulposus of the intervertebral disc and osteophytosis at the posterior edge of the upper and lower vertebral bodies. The thecal sac was then exposed, and the upper and lower bony endplates were preserved. Afterwards, the endplates were ground until spotty bleeding was obtained. Then, allogeneic bone was placed in the selected cage, which was later implanted at the appropriate position, followed by insertion of the fixation plate. After careful examination of the surgical field to exclude active bleeding, a drainage tube was placed and incisions were closed layer by layer. Dehydration and antibiotic medications were routinely provided after surgery, with the drainage tube removed 24 hours after surgery. Patients were advised to use a cervical collar for 3–4 weeks to protect the cervical spine, and to exercise the neck and back muscles.

Bryan artificial discs were used in this study; MC+ anterior cervical intervertebral fusion cages (LDR, Troyes, France) were employed.

2.3. Data collection

The JOA scoring system was used to evaluate neurological function [8], and the NDI was used to assess clinical symptom remission and daily activities [9]. Radiographs were taken at 7 days, and 3, 6, 12, and 24 months after surgery. ROM of the replaced segments and overall cervical curvature (Cobb angle of C2–C7) was evaluated by lateral radiograph preoperatively and at 1 week after surgery, as well as at the last follow-up. The Cobb angle of the replaced segments was obtained by measuring the angle between the lower edge of the superior endplate and the upper edge of the inferior endplate of the vertebra. ROM was determined as follows: the overall motion angle of C2–C7 was evaluated on dynamic radiographs as the overall motion range of the cervical vertebra; the angle between the lower edge of C2 and the upper edge of C7 was considered the overall cervical curvature; the overall change in cervical curvature on hyperextension and hyperflexion radiographs before and after surgery was considered the ROM.

2.4. Statistical analysis

The Statistical Package for the Social Sciences version 16.0 software (IBM, Armonk, NY, USA) was used for statistical analyses. Continuous variables including NDI, JOA, and ROM were reported as mean ± SD; a paired t-test was used to compare Visual Analog Scale and NDI values before and after surgery. $P < 0.05$ was considered statistically significant.

3. Results

ADR of 216 segments and cage bone graft fusion of 108 segments was performed in 108 patients. Overall, 83 patients had three-level cervical myelopathy with involvement of C4/C5,