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Risk factor analysis of axial symptoms after single-segment anterior cervical discectomy and fusion: A retrospective study of 113 patients

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Abstract

Objective: This retrospective study was performed to investigate the risk factors for axial symptoms (AS) after single-segment anterior cervical discectomy and fusion (ACDF).

Methods: One hundred thirteen patients with cervical spondylosis who had undergone single-segment ACDF from January 2012 to December 2015 were divided into those with and without AS (n = 34 and n = 79, respectively). Clinical data and radiological evaluation results were recorded.

Results: The occurrence rate of AS was 30.1% (34/113), and the average visual analog scale score was 4.5 points. Bony fusion was achieved in all cases during follow-up. There were no differences in age, sex, disease duration, diagnostic categories, operative segment, Japanese Orthopaedic Association score, or adjacent segment degeneration. However, cervical range of motion (CROM), cervical curvature, and disc space enlargement significantly differed between the groups. Logistic regression analysis revealed that CROM, cervical curvature, and disc space enlargement were independently associated with AS.

Conclusions: AS after single-segment ACDF is not rare. Disc space enlargement is a risk factor for AS, while higher CROM and lordotic cervical curvature are protective factors. Excessive or insufficient disc space enlargement could increase the incidence of AS. Maintaining CROM within the normal range and restoring cervical lordosis might help to prevent AS.

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Keywords

Anterior cervical discectomy and fusion, axial symptoms, cervical lordosis, risk factors, disc space enlargement, cervical range of motion

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Introduction

Anterior cervical discectomy and fusion (ACDF) was first described in the 1950s and has been widely performed for the treatment of cervical spondylosis. This surgical technique not only completely relieves the anterior compression of the spinal cord but also provides immediate cervical stability. Therefore, its efficacy has been acknowledged and the technique is considered the gold standard for the surgical management of cervical spondylosis.[1–4] However, some patients who have undergone ACDF develop axial symptoms (AS), which include neck pain, neck stiffness, shoulder pain, neck dullness, and/or shoulder dullness.[5] AS seriously affect patients' quality of life and even cause adverse impacts on surgical outcomes and postoperative rehabilitation. Kawakami et al.[6] reported that the incidence of AS after ACDF can be as high as 38.3%, but the exact risk factors are still unknown. Additionally, the causes of AS have not been fully clarified. Few studies to date have explored the relationship between ACDF and AS,[6,7] and the risk factors for AS after ACDF are not clear. This retrospective study was performed to investigate the risk factors for AS after single-segment ACDF and suggest eventual prevention methods.

Materials and methods

Patients

Patients with cervical spondylosis who had undergone single-segment ACDF at our medical center from January 2012 to December 2015 were retrospectively reviewed. Patients were included if they had cervical spinal cord compression with accompanying symptoms and signs of cervical spondylotic myelopathy, cervical spondylotic radiculopathy, and segmental-type ossification of the posterior longitudinal ligament. The exclusion criteria were cervical trauma or continuous-type ossification of the posterior longitudinal ligament, significant cervical anatomic deformity, active infection, neoplasm, unavailable preoperative or final follow-up magnetic resonance imaging (MRI) and plain radiographs, or unavailable follow-up data. In this study, persistent pain distributed in the area of the posterior neck and shoulder angle was included among the AS. All patients were classified into two groups based on the presence or absence of AS after surgery. New-onset AS were recorded and evaluated using a visual analog scale. This study was approved by the Ethics Committee of The Third Hospital of Hebei Medical University. Informed consent from the patients was not required because this was a retrospective study and all data were collected and analyzed anonymously.

Surgical management

Each patient underwent standard ACDF by the same surgical team. With the patient under general anesthesia, the affected discs were exposed using a right-sided anterolateral approach. Decompression was accomplished using a high-speed bur, a narrow osteotome, and a micro-Kerrison rongeur to remove the herniated discs, posterior cortices of the vertebrae, endplates, and posterior longitudinal ligament if necessary. A cervical titanium cage filled with autologous bone fragments was then inserted into the intervertebral space to obtain firm interfusion, and an anterior plate system was applied to provide stability until bony fusion. Ambulation was allowed on the second day after surgery, whereas external immobilization of the cervical spine was maintained for 2 months with a cervical collar.

Radiological assessments

Anteroposterior and lateral radiographs with neutral and flexion–extension stress views were obtained preoperatively and postoperatively. Preoperative and final follow-up cervical alignments were measured in the profile of neutral plain radiographs by the curvature index, as described by Ishihara[8] (Figure 1)[9]. The curvature index was used for cervical curvature evaluation. "a1" was defined as the distance from the posterior inferior edge of the C3 vertebral body to line "AB"; "a2," "a3," and "a4" were defined using the same method. "AB" was defined as the distance from the posterior inferior edge of the C2 vertebral body to the posterior inferior edge of the C7 vertebral body. A positive intersected length indicates the degree of lordosis. Cervical range of motion (CROM) was measured by the angle of C2 and C7 in flexion–extension stress views, as described by Penning[10] (Figure 2). Enlargement of the disc space (Δh) was measured in the profile of neutral plain radiographs (Figure 3). "H1 or H1'" and "H2 or H2'" was the length of the vertebra at the fused segment preoperatively and postoperatively. The Δh was calculated as follows: $(H1 - H1' + H2 - H2') / 2$. Each patient's Δh was calculated and classified as ≤ 2, 2 to 5, or ≥ 5 mm.[6] Adjacent segment degeneration (ASD) was observed on radiographs and T2-weighted MRI. On radiographs, ASD appeared as new vertebral osteophytes, increased osteophytes, disc space narrowing (>30%), or anterior longitudinal ligament calcification.[11] On T2-weighted MRI, ASD appeared as a newly herniated disc or disc signal changes.[12] Data were measured three times with 200% magnification for accuracy by the first and second authors independently, and the mean value was used for analysis. The intraobserver error was <5%.

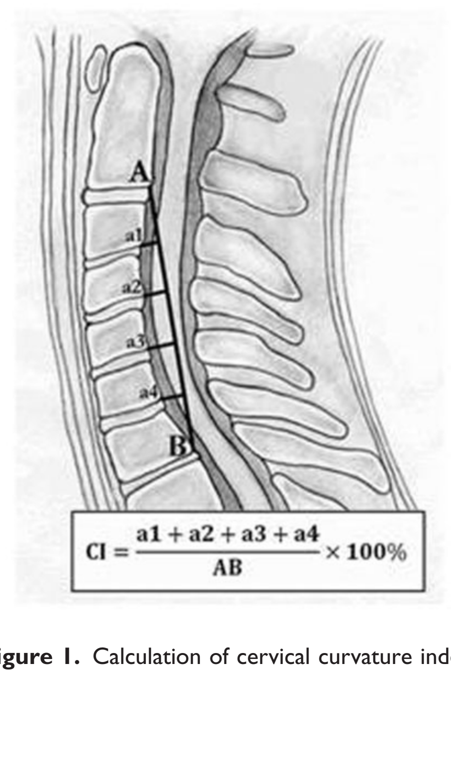

Figure 1. Calculation of cervical curvature index.

Clinical assessments

The neurological status of each patient was evaluated before surgery and at the final follow-up according to the Japanese Orthopaedic Association (JOA) disability scale. The neurological recovery rate was calculated using the method described by Hirabayashi et al.[13]: (postoperative JOA score − preoperative JOA score)/ (17 − preoperative score) × 100%.

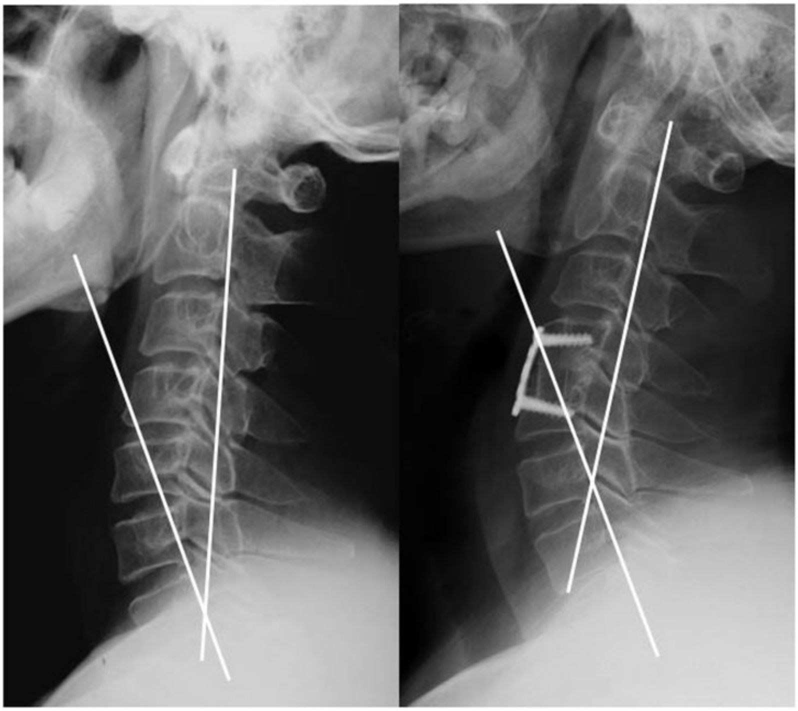

Figure 2. C2–C7 angle between the lines parallel to the posterior margin of the C2 and C7 vertebral bodies.

Statistical methods

Statistical analysis was performed using SPSS 16.0 (SPSS, Inc., Chicago, IL, USA). Univariate analyses were performed to examine the relationship between the outcome at the final follow-up and prognostic factors. Continuous variables were analyzed using Student's t-test, and categorical variables were analyzed using the chi-square test. Variables were included in a logistic regression model if their P value in the univariate analysis was <0.05. The threshold for significance was a P value of <0.05.

Results

In total, 113 patients (67 male, 43 female) were eligible for the final analysis in the present study. The patients' age at the time of surgery ranged from 34 to 69 years (average, 51.6 years), the disease duration ranged from 2 to 23 months (average, 11.7 months), and the follow-up period ranged from 2 to 6 years (average, 3.8 years). A total of 34 patients had AS and 79 patients had no AS. All data regarding age, sex, follow-up period, disease duration, diagnostic categories, and operative segment are presented in Table 1.

There were no significant differences in age, sex, disease duration, diagnostic categories, operative segment, JOA recovery rate, or ASD between patients with and without AS (Table 1). The average neurological recovery rate was 67.0% for all patients. Although no patients had AS preoperatively, 34 (30.1%) patients developed AS postoperatively, with an average visual analog scale score of 4.5 points.

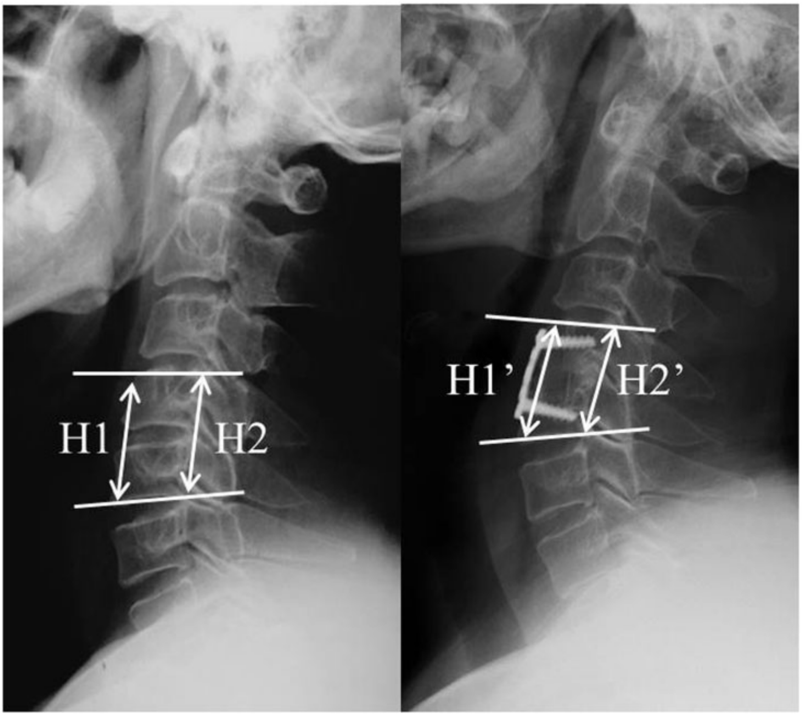

Figure 3. Measurements of disc space enlargement preoperatively and postoperatively.

Bony fusion was achieved in all patients during the follow-up period. ASD was observed in 22 (19.5%) patients. There were significant differences in the CROM (patients with AS: 32.2° vs. patients without AS: 37.0°, P = 0.003), cervical curvature (patients with AS: lordotic = 38.2%, straight = 32.4%, kyphotic = 29.4%; patients without AS: lordotic = 58.2%, straight = 30.4%, kyphot ic = 11.4%; P = 0.04), and disc space enlargement (P = 0.01) between patients with and without AS (Table 1). Furthermore, a 2- to 5-mm enlargement of the disc space was observed less frequently in patients with than without AS (29.4% vs. 59.5%, respectively).

Logistic regression analysis showed that CROM [odds ratio (OR), 0.343; 95% confidence interval (CI), 0.28–0.539; P < 0.0001] and cervical curvature (OR, 0.218; 95% CI, 0.064–0.744; P = 0.02) were protective factors for AS, while disc space enlargement was a risk factor for AS (OR, 3.619; 95% CI, 1.174–11.157; P = 0.03) (Table 2).

Discussion

The development of AS is reportedly one of the most frequent complaints after cervical laminoplasty.[14,15] In the present study, 30.1% of the patients developed AS after single-segment ACDF, which is consistent with the results of a previous study (38.3%).[6] At present, the risk factors for AS after ACDF are not clear in the literature. The incidence of AS is not related to the neurological recovery rate. Therefore, we attempted to investigate the risk factors for AS after single-segment ACDF in this study. The univariate analyses showed no relationships between

Table 1. Univariate analyses of 113 patients with or without AS after single-segment ACDF.

Variable	Total (n = 113)	AS (n = 34)	No AS (n = 79)	P value
Age, years[a]	51.6 ± 10.2	49.2 ± 12.6	52.7 ± 9.4	0.491
Sex[b]				
Male	67 (59.3)	20 (58.8)	47 (59.5)	0.947
Female	46 (40.7)	14 (41.2)	32 (40.5)	
Disease duration, months[a]	11.7 ± 6.0	13.3 ± 6.2	11.1 ± 5.1	0.396
Diagnostic categories, number of cases[b]				
Cervical spondylotic myelopathy	59 (52.2)	17 (49.9)	42 (53.1)	0.933
Cervical spondylotic radiculopathy	36 (31.9)	11 (32.4)	25 (31.7)	
Ossification of posterior longitudinal ligament	18 (15.9)	6 (17.7)	12 (15.2)	
Operative segment				
C3/4	16 (14.1)	4 (11.8)	12 (15.2)	0.244
C4/5	22 (19.5)	7 (20.6)	15 (19.0)	
C5/6	42 (37.2)	13 (38.2)	29 (36.7)	
C6/7	33 (29.2)	10 (29.4)	23 (29.1)	
JOA recovery rate, %[a]	67.0 ± 8.0	63.9 ± 8.2	68.3 ± 7.6	0.237
CROM, degrees[a]	35.6 ± 3.7	32.2 ± 3.2	37.0 ± 2.9	0.003
Cervical curvature[b]				
Lordotic	59 (52.2)	13 (38.2)	46 (58.2)	0.04
Straight	35 (31.0)	11 (32.4)	24 (30.4)	
Kyphotic	19 (16.8)	10 (29.4)	9 (11.4)	
Disc space enlargement[b]				
≤2 mm	26 (23.0)	11 (32.4)	15 (19.0)	0.013
2–5 mm	57 (50.4)	10 (29.4)	47 (59.5)	
≥5 mm	30 (26.6)	13 (38.2)	17 (21.5)	
Adjacent segment degeneration[a]	22 (19.5)	8 (23.5)	14 (17.7)	0.475

Data are presented as mean ± standard deviation or n (%).
AS, axial symptoms; JOA, Japanese Orthopaedic Association; CROM, cervical range of motion.
[a]unpaired *t*-test; [b]chi-square test.

Table 2. Binary logistic regression analysis of factors associated with axial symptoms after single-segment anterior cervical discectomy and fusion.

Variable	P value	OR	95% CI
Cervical range of motion	<0.0001	0.343	0.218–0.539
Disc space enlargement	0.025	3.619	1.174–11.157
Cervical curvature	0.015	0.218	0.064–0.744

OR, odds ratio; CI, confidence interval.

AS and age, sex, disease duration, diagnostic categories, operative segment, JOA recovery rate, or ASD. However, the CROM, cervical curvature, and disc space enlargement were associated with the development of AS after single-segment ACDF.

Kawaguchi et al.[5] reported that the incidence of AS after ACDF was significantly lower in patients who maintained CROM in the normal range than that in patients without AS. Kowatari et al.[16] suggested that the patients' CROM significantly decreased while the incidence of AS significantly increased after cervical laminectomy. Kawaguchi et al.[17] revealed that early neck rehabilitation exercises after surgery could maintain CROM within the normal range, which decreased the incidence of AS. Consistent with these previous studies, the present study showed that increased CROM was a protective factor against AS after ACDF. Therefore, these results suggest that patients should perform early neck rehabilitation exercises after ACDF to maintain CROM within the normal range and prevent cervical muscle atrophy that may result in AS.[18] However, further studies are necessary to fully elucidate the effects of neck rehabilitation exercises on neck outcomes after ACDF.

Konduru and Findlay[19] reported that cervical kyphosis was a common phenomenon after ACDF. Patients with kyphosis were more prone to develop AS than patients with cervical lordosis. Liu et al.[20] showed that the severity of AS was closely associated with the cervical curvature. When cervical lordosis changes or kyphosis deteriorates, the neck muscles, cervical ligament structures, and joint capsule tissues are pulled and maintained in a tension state for a long time, which may be the main cause of AS. The results of the present study showed that cervical curvature was one of the protective factors against AS after ACDF. Therefore, for patients with kyphotic deformity, surgeons should try to restore the normal cervical lordosis and avoid AS caused by the loss of cervical lordosis.

At our center, ACDF is performed by distracting the vertebral disc space of the fused segment using a Caspar distractor set, which can enhance surgical exposure for subsequent decompression and allow graft insertion.[21,22] However, the appropriate amount of distraction is not well described in the literature. When the enlargement of the disc space (Δh) is ≥ 5 mm,[6] surgeons are more likely to over-distract the vertebral bodies, causing abnormal tensile load on the facet joints; this abnormal tensile load can be injurious to the contracted facet joints posteriorly.[23] We presume that this distraction injury may be the main cause of postoperative neck pain and disability. Park et al.[24] suggested that if the enlargement of the disc space (Δh) is >6 mm, the spinal cord can be pulled and the neurological recovery rate will decrease postoperatively. When enlargement of the disc space (Δh) is ≤ 2 mm,[6] the intervertebral height and cervical lordosis cannot be restored, resulting in cervical instability and an increased incidence of AS. In the present study, disc space enlargement was a risk factor for AS after single-segment ACDF. Moreover, disc space enlargement of 2 to 5 mm and selection of a suitably sized graft or fusion cage can not only restore the intervertebral height and improve neurological recovery but can also help to prevent AS.

Numerous studies have been performed to examine whether cervical fusion is an important factor in the development of ASD and adjacent segment disease. Katsuura et al.[25] observed 42 patients who underwent ACDF with a mean follow-up time of 9.8 years, and 43% of these patients developed ASD. Baba et al.[26] assessed >100 patients undergoing anterior cervical fusion for cervical myelopathy with an average follow-up of 8.5 years, and 25% of these patients subsequently developed new spinal canal stenosis on the adjacent fused segments. In a retrospective study, Wang et al.[27] showed that 6.2% of patients undergoing single-segment ACDF developed adjacent segment disease. In the present study, ASD was observed in only 22 (19.5%) patients at the final follow-up, but its occurrence was not associated with AS.

The present study has some limitations. Patients with preoperative AS and more than one fused segment were not included in this study. Moreover, the number of patients with AS was relatively low. Therefore, selection bias may have occurred. A large-sample multicenter study is needed to further confirm our results.

Conclusions

The incidence of AS after single-segment ACDF is not rare. Excessive or insufficient enlargement of the disc space could increase the incidence of AS. CROM and cervical curvature were protective factors for AS. Maintaining the CROM within the normal range and restoring cervical lordosis might help to prevent AS.

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Declaration of conflicting interest

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