Int J Clin Exp Med 2016;9(2):3717-3722
www.ijcem.com /ISSN:1940-5901/IJCEM0015804

Original Article

Effect of anterior cervical decompression fusion at different cervical segments on C5 nerve root palsy

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Received September 7 2015; Accepted December 5 2015; Epub February 15, 2016; Published February 29, 2016

Abstract: Objective: This study aimed to investigate the effect of anterior cervical decompression fusion at different cervical segments on C5 nerve root palsy. Methods: A total of 78 patients who received anterior cervical decompression and bone graft fusion due to cervical disease and ossification of the posterior longitudinal ligament of the spine between March 2009 and August 2013 were retrospectively reviewed. Patients were divided into 2 groups: In Group A, patients underwent 1- or 2-segment decompression, and those in Group B underwent 3- or 4-segment decompression. The Japanese Orthopedic Association (JOA) scoring system was used to evaluate the clinical efficacy. The preoperative and postoperative cervical curvature indexes (CCI) and cervical lordosis angle (Cobb angle) were measured. Results: The incidence of C5 nerve root palsy was 2% in Group A and 15.8% in Group B, showing a significant difference ($P<0.05$). In addition, the postoperative CCI change rate was 18.0±16.6% in Group B, which was significantly higher than in Group A (11.5±7.9%), and the postoperative cervical Cobb angle and CCI increased markedly in Group B, as compared to those before surgery ($P<0.05$). The JOA score was comparable between two groups before and after surgery ($P>0.05$). Conclusion: Decompression fusion at several segments may increase the intervertebral disc gap and significantly change postoperative cervical curvature, which is an important cause of C5 nerve root injury.

Keywords: Anterior approach, cervical curvature, C5 nerve root palsy

Introduction

C5 nerve root palsy is a common and important complication of anterior or posterior cervical decompressive surgery, and its pathogenesis has not yet been elucidated. It is imperative to reduce the incidence of post-operative C5 nerve root palsy because it significantly affects the quality of life of patients. To date, most studies focus on the C5 nerve root palsy following posterior cervical decompression, and the C5 nerve root palsy after anterior cervical decompression is less studied. This study summarized the clinical information of patients who received anterior cervical decompression fusion in our department, and the cervical curvature and C5 nerve root palsy were investigated.

Patients and methods

Patients and grouping

A total of 78 patients received the anterior cervical decompression and bone graft fusion due to cervical disease and ossification of the posterior longitudinal ligament (OPLL) of the spine between March 2009 and August 2013. There were 45 men and 33 women with the median age of 45 years (range: 25-80 years). Of these patients, 39 were diagnosed with cervical spondylotic myelopathy, 21 with nerve root cervical spondylosis, and 18 with OPLL of the spine. Patients with cervical tumor and cervical trauma were excluded from this study. Patients were followed up for a median of 15.5 months (range: 8-22 months). Patients were divided into 2 groups. in Group A, patients underwent 1- or 2-segment decompression; there were 23 men and 17 women; the mean age was 53 years (range: 25-78 years); 20 patients were diagnosed with cervical spondylotic myelopathy, 12 with nerve root cervical spondylosis, 8 with OPLL of the spine; 13 received single-segment intervertebral disc decompression, cage bone grafting and titanium plate fixation, and 27 underwent double-segment (C3-C5, C4-C6 and C5-C7) cervical vertebral disc decompression

Table 1. General characteristics of patients in both groups

Group	n	Sex		Age (yrs)	Minimal width of C4/C5 intervertebral foramen (mm)	Patients with hyperintense-signal				Patients with OPLL (n)
		M	F			C3/C4	C4/C5	C5/C6	C6/C7	
A	40	23	17	53.0±13.3	3.9±0.4	3	2	4	2	8
B	38	25	13	56.7±11.4	4.0±0.5	4	3	2	3	10

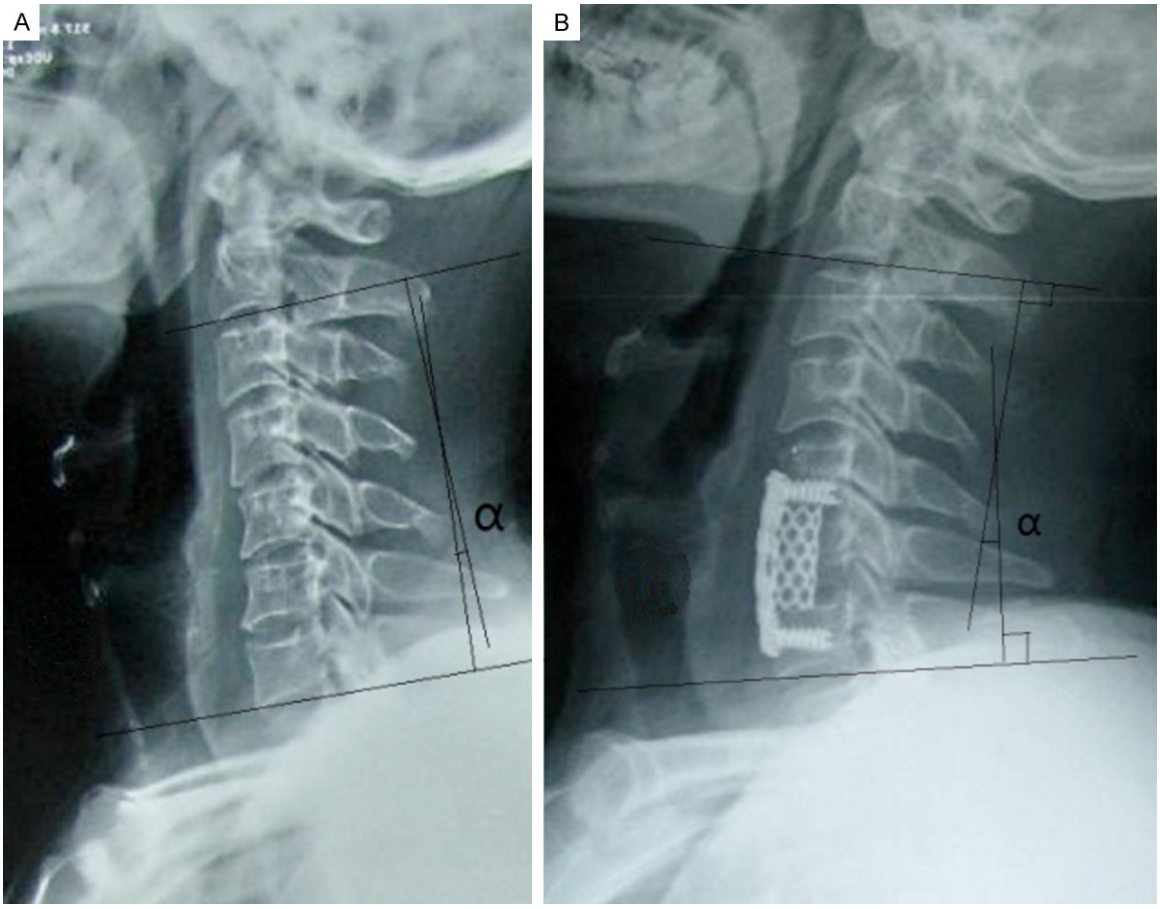

Figure 1. Measurement of cervical Cobb angle: In the neutral position, a cervical lateral radiograph was obtained, and 2 straight lines parallel to the edge of the C3 and C7 vertebral bodies were drawn. The angle between 2 straight lines was measured as Cobb angle. Preoperative (A) and postoperative (B) Cobb angles.

and internal fixation. In Group B, patients underwent 3- or 4-segment decompression; there were 25 men and 13 women; the median age was 56.7 years (range: 32-80 years); 19 patients were diagnosed with cervical spondylotic myelopathy, 9 with nerve root cervical spondylosis, and 10 with OPLL of the spine; 37 patients received 3-segment (C3-C6 or C4-C7) cervical vertebral disc decompression and internal fixation, and 1 underwent 4-segment cervical vertebral disc decompression and internal fixation (C3-C7). A cervical gear was used for 3 months after surgery for all the patients. Before surgery, there were no significant differences in the age, sex, width of intervertebral foramen at C4/C5 for men, number of patients with hyperintense signals at C3/C4, C4/C5, C5/C6 and C6/C7 and number of OPLL of the spine between two groups (P>0.05; **Table 1**).

Diagnostic criteria for C5 nerve root palsy

In cases without serious spinal symptoms, the muscle force of the deltoid and bicipital muscles of the arm declined 1 level or more.

C5 nerve root palsy was diagnosed according to the diagnostic criteria developed by Kim et al. [1]: the muscle strength of the deltoid and/or biceps reduced by 1 or more grades after

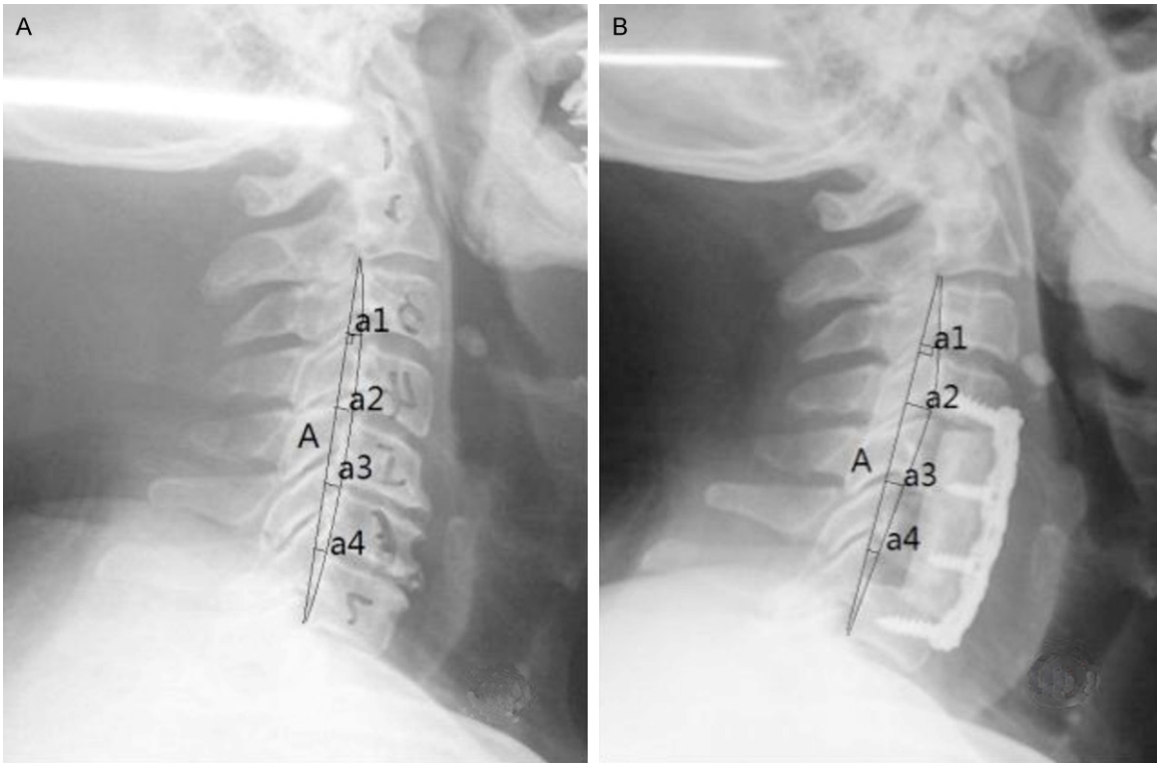

Figure 2. CCI measurement: a lateral radiograph was obtained, and a line connecting the posterior lower corner of C2 and C7 was drawn. The length of this line was A; the distance between the posterior lower corner of different vertebral bodies (C3 and C6) and the former line was al, a2, a3 and a4, respectively; CCI was calculated: CCI = (a1 + a2 + a3 + a4)/A × 100%. A. Preoperative CCI; B. Postoperative CCI.

surgery, with or without hypoesthesia at the shoulder and lateral upper arm and uncontrollable shoulder pain in the absence of deterioration of spinal symptoms.

Neurological function

The Japanese Orthopedic Association (JOA) [2] scoring system was used to assess the neurological function before surgery and at the last follow-up, and the improvement of neurological function was determined as follow: improvement rate = (postoperative score-preoperative score)/(17-preoperative score) × 100%.

Cervical cobb angle [3]

In the neutral position, a cervical lateral radiograph was obtained, 2 straight lines were drawn parallel to the edge of the C3 and C7 vertebral bodies independently, and then the angle between 2 straight lines (Cobb angle) was measured before and after surgery (**Figure 1**).

Cervical curvature index (CCI) [4]

CCI was measured as follows: a lateral radiograph was obtained, and a line connecting the posterior lower corner of C2 and C7 was drawn. The length of this line was A; the distance between the posterior lower corner of different vertebral bodies (C3 and C6) and the former line was a1, a2, a3 and a4, respectively; CCI was calculated: CCI = (a1 + a2 + a3 + a4)/A × 100% (**Figure 2**).

Statistical analysis

Data with normal distribution are expressed as mean ± standard deviation ($\bar{x} \pm s$). Quantitative data were compared with t test and qualitative data with chi square test. A value of $P<0.05$ was considered statistically significant. Statistical analysis was performed with SPSS version 18.0.

Results

Incidence of C5 nerve root palsy

In Group, C5 nerve root palsy was found in 1 patient (2.5%, 1/40) and only involved the deltoid muscle. In Group B, C5 nerve root palsy was found in 6 patients (15.8%, 6/38) and affected both deltoid muscle and biceps in 2

Table 2. Cervical curvature in both groups before and after surgery

Group	n	Patients with 5 nerve root palsy (n)	Cobb angle (degrees)		CCI (%)		
			Preoperative	Postoperative	Preoperative	Postoperative	CCI change rate
A	40	1	14.3±2.9	13.8±3.1	14.2±2.2	12.9±2.5	11.5±7.9
B	38	6	13.3±3.3	15.6±2.9	13.5±2.4	15.2±1.8	18.0±16.6

Table 3. JOA score before surgery

Group	n	Patients with C5 nerve root palsy (n)	JOA score		
			Preoperative	Postoperative	Improvement rate
A	40	1	10.1±2.3	13.4±1.7	45.8±18.3
B	38	6	10.2±2.3	13.7±1.4	50.7±19.3

patients, and only involved deltoid muscle in 4 patients. Significant difference was observed in the incidence of C5 nerve root palsy between groups ($\chi^2 = 4.21$, $P<0.05$; **Table 2**).

In both groups, only unilateral C5 nerve root palsy was found, and the muscle strength was I-IV. At the last follow up, the muscle strength recovered to IV-V. C5 nerve root palsy occurred at 1 day to 1 week after surgery.

Cervical cobb angle and CCI

After surgery, the cervical Cobb angle was 15.6°±2.9°, and the CCI change and CCI change rate were 15.2%±1.8% and 18.0%±16.6%, respectively, in Group B, which were significantly higher than in Group A (13.8°±3.1°, 12.9%±2.5%, and 11.5%±7.9%, respectively) ($P<0.05$; **Table 2**).

JOA score

The preoperative and postoperative JOA score was 10.1±2.3 and 13.4±1.7, respectively in Group A, and 10.2±2.3 and 13.7±1.4, respectively in Group B. The postoperative improvement rate in JOA score was 45.8%±18.3% in Group A and 50.7%±19.3% in Group B, although significant difference was not observed ($P> 0.05$; **Table 3**).

Discussion

C5 nerve root palsy is frequently found after a cervical decompression. Its classic symptom includes the movement dysfunction of the deltoid and or biceps without deterioration of spinal symptoms. Most patients develop mild amyasthenia, and a few patients have concomitant sensory disturbance and/or pain at the C5 innervated area [4]. In 1961, Scoville et al. [5] and Stoops et al. [6] for the first time reported C5 nerve root palsy. Since then, increasing studies have been conducted to investigate C5 nerve root palsy. It has been reported that the incidence of C5 nerve root palsy as a complication of anterior or posterior cervical decompression is 0-30% [4, 7]. C5 nerve root palsy may occur immediately after surgery, but often occurs within 1 week after surgery. Several patients may develop C5 nerve root palsy at 2 to 4 weeks after surgery. It is also possible that patients develop C5 nerve root palsy at 2 months after surgery. In addition, 92% of patients have unilateral involvement and 8% develop bilateral C5 nerve root palsy [4, 8]. Currently, the pathogenesis of C5 nerve root palsy is still poorly understood. There are 5 possible causes: 1) intraoperative direct injury to the nerve root; 2) retraction of the nerve root due to spinal cord drift after decompression results in the tethered effect; 3) the reduced blood supply to radicular arteries leads to spinal cord ischemia; 4) segmental spinal cord dysfunction; 5) spinal cord ischemia-reperfusion injury. Posterior cervical decompression is the first surgery used for the therapy of cervical spondylosis. For patients with spinal cord lesions involving 3 or more segments, Posterior cervical decompression is recommended. The backward shift of the spinal cord drift may avoid the pressure due to the anterior spinal cord. However, the posterior cervical decompression fail to relieve the anterior spinal cord compression, spinal epidural scar is easy to form on the spinal cord after lamina excision leading to the dynamic compression and retraction of the spinal cord [9]. Moreover, the backward shift may cause the retraction of nerve root, resulting in tethered effect [10]. Anatomically, the C5 nerve root is shorter than other nerve roots and C5 is the highest site of decompression regions. Thus, the spinal cord shift is larger which is easy to cause C5 nerve root

injury [11]. Therefore, available studies on C5 nerve root palsy mainly focus on the posterior cervical decompression, and anterior cervical decompression is less reported.

In view of the disadvantages of posterior cervical decompression, anterior cervical decompression is introduced for the therapy of cervical spondylosis. However, C5 nerve root palsy is also present after anterior cervical decompression as in posterior cervical decompression, and the reported incidence of C5 nerve root palsy after anterior cervical decompression varies between studies. In particular, Li et al. [12] reported an incidence of 5.2% (1.4%-10.6%) for C5 nerve root palsy after anterior decompression, which was lower than that after posterior cervical decompression. However, Gandhoke et al. [13] found there was no marked difference in the incidence of C5 nerve root palsy between anterior vertebral body subtotal resection and posterior laminoplasty in patients with cervical stenosis. Liu et al. [14] treated cervical spondylotic myelopathy with 3 reconstruction methods: long segmental anterior cervical corpectomy and fusion, mixed n anterior cervical decompression and fusion and anterior cervical decompression and fusion, and the incidence of C5 nerve root palsy was compared. Their results showed that the incidence of C5 nerve root palsy was the highest after long segmental anterior cervical corpectomy and fusion (11.49%). Yonenobu et al. [15] also reported that the incidence of C5 nerve root palsy increased after anterior subtotal corpectomy of ≥3 vertebral bodies, which was mainly ascribed to the increased forward drift of the spinal cord after expanded cervical decompression and subsequent shift of the bone graft or the intervertebral foramen stenosis due to cervical hyperextension. However, the mechanism underlying the effect of forward drift of the cervical spinal cord on the C5 nerve root is still unclear. Theoretically, anterior cervical decompression relieve the anterior compression, leading to the forward shift of the spinal cord, which reduces the tension of the C5 nerve root and thus decreases the incidence of C5 nerve root palsy. However, Saunders et al. [16] proposed that the forward displacement of the spinal cord to a certain extent could easily lead to the retraction and entangling of C5 nerve root, eventually resulting in C5 nerve root palsy. When the vertebral body slot width decreases, the ventral drift of the spinal cord reduces, which significantly decreases the incidence of C5 nerve root palsy [17].

In the present study, there were no marked differences in the age, sex and preoperative characteristics between two groups (P>0.05). After surgery, C5 nerve root palsy was found in 1 patient of Group A (2.5%) in which patients received 1- or 2-segment decompression-fusion. C5 nerve root palsy was noted in 6 patients (15.8%) in Group B in which patients received 3- and 4- segment decompression-fusion. Significant difference was observed between 2 groups (P<0.05). With the increase in the cervical segments undergoing decompression and fusion, the change in the cervical curvature also increased. In Group B, the post-operative CCI change rate was greater than in Group A, and the cervical Cord angle and CCI in Group B increased significantly after surgery when compared with those before surgery (P<0.05). However, the JOA score before and after surgery was comparable between two groups (P>0.05). We speculate that the anterior cervical titanium plate increase the change in cervical curvature with the increase in the number of segments undergoing decompression, and the increased intervertebral space may increase the ventral drift of the spinal cord, resulting in the nerve root retraction and injury to the C5 nerve root.

Our results indicate that the anterior cervical decompression is an effective modality for the treatment of cervical spondylosis. C5 nerve root palsy is a complication of cervical decompression and caused by many factors. The increased cervical curvature secondary to decompression-fusion at several cervical segments is a major cause of C5 nerve root palsy and the tethering of C5 nerve root is one of important mechanisms underlying the pathogenesis of C5 nerve root palsy. However, this study was a retrospective one, and the sample size was still small. Thus, further prospective studies with large sample size are required to investigate and elucidate the risk factors related to C5 nerve root palsy.

Disclosure of conflict of interest

None.

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