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Adjacent Segment Degeneration Following Anterior Cervical Discectomy and Fusion Versus the Bryan Cervical Disc Arthroplasty

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Background: Anterior cervical discectomy and fusion (ACDF) is an established treatment for degenerative disease of the cervical disc, but adjacent segment degeneration or instability may develop long term. The aim of this study was to investigate the risk factors for adjacent segment degeneration following ACDF compared with the use of the Bryan artificial disc for cervical disc arthroplasty (CDA).

Material/Methods: A prospective comparative study included 93 patients who underwent ACDF or CDA with the Bryan artificial cervical disc between 2002 and 2004, and who had more than eight years of follow-up. There were 29 cases in the CDA group and 39 cases in ACDF group, with a follow-up rate of 73.12%. Clinical results and imaging data were assessed before and after surgery.

Results: There was no significant difference between the two groups in radiographic parameters at each follow-up time point. There were 19 cases of adjacent segment degeneration (48.72%) in the ACDF group, and 13 cases of adjacent segment degeneration (44.83%) in the CDA group, with no statistically significant difference (P>0.05). Univariate analysis showed that advanced age (OR 1.271, 95% CI 1.005–1.607), low preoperative overall lordosis (OR 0.858, 95% CI 0.786–0.936) and low preoperative segmental lordosis (OR 1.185, 95% CI 1.086–1.193) were significantly correlated with adjacent segment degeneration.

Conclusions: Equally good clinical outcomes were achieved with both the ACDF and the Bryan CDA. Increasing patient age was associated with adjacent segment degeneration in both patient groups.

MeSH Keywords: Intervertebral Disc Degeneration • Spine • Spondylosis • Total Disc Replacement

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Background

Anterior cervical discectomy and fusion (ACDF) was first described by Smith-Robinson and Cloward in the 1950s and became an established treatment for cervical degenerative disease [1]. However, long term, this procedure can be associated with adjacent segment degeneration or instability [2].

Cervical disc arthroplasty (CDA) is currently the major non-fusion surgical method and has been developed to retain as much intervertebral disc height and segmental activity as possible. These developments have reduced the acceleration of adjacent segment degeneration that was associated with ACDF, and the short-term clinical results of CDA have been shown to be good [3–12]. However, the long-term effects of CDA remain uncertain, and these effects still await high level published evidence from controlled clinical studies. Meanwhile, there is no definitive evidence favoring arthroplasty over fusion for the surgical management of degenerative cervical disc disease.

This study was undertaken to investigate the risk factors for adjacent segment degeneration following anterior cervical discectomy and fusion (ACDF) compared with the use of the Bryan artificial disc for cervical disc arthroplasty (CDA). A prospective comparative follow-up study included 93 patients with cervical spondylopathy with the comparison of long-term clinical follow-up and imaging data. The two main aims of the study were to evaluate the long-term clinical effects of ACDF and CDA in the treatment of cervical degenerative disease and to investigate the related factors that affect adjacent segment degeneration.

Material and Methods

Ethics statement

For this prospective study, informed consent was obtained from all subjects and the study was approved by the local Ethics Committee of The Third Hospital of Hebei Medical University (approval number: K2002-001-03).

Patient selection, inclusion and exclusion criteria

Patient inclusion criteria for the study were: (1) the presence of cervical spinal disc herniation; (2) degenerative cervical spinal stenosis; (3) conservative treatment experience of at least three months.

Patient exclusion criteria for the study were: (1) severe facet joint degeneration (bridging osteophytes, intervertebral disc height loss >50%, intervertebral activity <2°); (2) facet joint osteoarthritis; (3)developmental cervical stenosis; (4) ossification of the posterior longitudinal ligament; (5) obviously unstable cervical spine with angular displacement >2° or vertical displacement >2 mm; (6) osteoporosis; (7) cervical abnormalities; (8) cervical vertebral cancer; (9) cervical vertebral infection; (10) osteoarthritic diseases (rheumatoid arthritis, ankylosing spondylitis); (11) a previous history of cervical spine surgery.

Two groups of patients were not randomly selected, all patients were suitable for cervical disc arthroplasty (CDA) surgery or anterior cervical discectomy and fusion (ACDF) surgery. But taking into account the ethical issues and economic capacity of the patients, the final choice of the operation plan was made by the patients after sufficient information and explanation was given before surgery.

Patient information

This study was conducted between December 2002 and December 2004, with more than eight years of follow-up. A total of 93 patients were included in the study. Patients either received the Bryan (Medtronic Sofamor Danek Inc, USA) cervical disc arthroplasty (CDA group; 39 cases) or underwent anterior cervical decompression and fusion surgery (ACDF group; 54 cases). There were 29 cases in the CDA group and 39 cases in ACDF group who completed the final follow-up and who had complete imaging data (follow-up rate 73.12%). The demographic information and baseline data of the two patient groups showed no significant differences, and the two patient groups were considered to be comparable (Table 1). All operations were performed by the same surgeon (the corresponding author).

Two surgical methods: ACDF and the Bryan CDA

Surgery was performed by conventional techniques. A standard right-sided anterior approach was performed, the symptomatic disc was removed, and the posterior longitudinal ligament (PLL) was removed. The Syncage-C (Synthes Co.) or the PEEK-Cage (Depuy Co.) with local decompression bone were inserted before stabilization with an ORION anterior cervical plate in the ACDF group. For the CDA group, the Bryan cervical disc (Medtronic Sofamor Danek Inc, Memphis, TN) was implanted after accurate measurement.

Clinical evaluation following surgery

All patients were required to complete clinical and radiological evaluation before surgery, and at three days, three months, one year, and three years postoperatively, with the last follow-up at more than 96 months. Clinical symptoms such as cervical and arm pain were investigated using JOA (Japanese Orthopaedic Association) 17-point score and the Neck Disability Index (NDI) score. The recovery rate determined by the JOA

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Table 1. Baseline data of ACDF group and CADR group.

Groups	Age (years)	Male *vs.* Female	Disease duration (months)	Follow-up duration (months)
ACDF	48.72±7.33	24: 15	13.49±5.26	104.05±6.04
CADR	48.83±6.70	19: 10	13.24±5.38	103.24±5.57
Statistic	t=0.063	χ^2=0.113	t=0.189	t=0.627
p-value	0.952	0.335	0.851	0.533

ACDF – anterior cervical discectomy and fusion; CADR – cervical artificial disc replacement.

score was calculated according to the following formula: recovery rate=(postoperative score–preoperative score)/(17–preoperative score)*100%.

Radiographic evaluation following surgery

Radiographic parameters included cervical lordosis, operated segmental height, the C2–C7 range of movement (ROM), operated segmental ROM, upper segmental ROM and lower segmental ROM, upper segmental height and lower segmental height. These data were collected in the neutral and dynamic flexion-extension lateral radiographs during each follow-up examination and were evaluated with the PACS software and APACS workstation (Centricity 2.0, General Electrics Medical Systems, Milwaukee, WI, USA).

Evaluation of adjacent segment degeneration

Adjacent segment degeneration was assessed through lateral X-ray films and magnetic resonance imaging (MRI) T2-weighted images. The Kellgren X-ray cervical vertebra degeneration system was used as a method to include evaluation of degenerative changes that included anterior vertebral osteophytes, reduced disc height, endplate sclerosis, and anterior or posterior displacement [13]. The MRI appearance of adjacent segment degeneration showed newly formed intervertebral disc herniation and decreased signal intensity on MRI using Miyazaki classification [14]. All radiologic outcomes were reviewed by an independent spinal surgeon and a radiologist, who were unaware of the patient treatment details. At the time of the last follow-up, the cases whose X-ray and (or) MRI appeared to show adjacent segment degeneration were included in the degeneration group. The remaining patients were included in the non-degeneration group. Then the results of the two groups were statistically compared.

Statistical analyses

Statistical analysis was performed using SPSS for Windows, version 18.0 (SPSS Inc., USA). Data were presented as the mean ± standard deviation (SD) for measurement data. Statistical analysis was performed using the Student's t-test. Numerical data were presented as a percentage, and the chi-squared test was used for data analysis. P values less than 0.05 were regarded as significant with two-tailed tests.

Results

The 91 patients in the two study groups, who underwent either anterior cervical discectomy and fusion (ACDF) or cervical disc arthroplasty (CDA) with the Bryan artificial disc, successfully completed surgery without infection, esophageal injury, hematoma, prosthesis collapse, implant displacement, neural damage, or other complications. In the final follow-up, 19 patients in the anterior cervical discectomy and fusion (ACDF) group and 13 patients in the cervical disc arthroplasty (CDA) group who were found adjacent segment degeneration signals in X-ray and (or) MRI were divided into degeneration group and others into non-degeneration group.

Results of the postoperative clinical evaluation

There were no significant differences in the baseline changes in neck disability index or visual analog scale scores for pain. At final follow-up, the JOA (Japanese Orthopaedic Association) scores and the Neck Disability Index (NDI) scores in the ACDF and the CDA group showed a significant improvement compared with the preoperative scores, but there were no significant differences between the groups (Table 2). There was no statistically significant difference in recovery rate between the ACDF group (75.56%) and the CDA group (81.58%).

Overall lordosis angle and overall range of movement (ROM) activity

There were no statistically significant differences in the preoperative overall cervical lordosis angle (C2–C7 angle) and the overall activity or range of movement (ROM) (C2–C7 ROM) between the ACDF group and the CDA group (P>0.05) (Table 3). In the last follow-up, the overall cervical lordosis angle and overall ROM activity in the ACDF group were less than in the CDA

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Table 2. Comparison of JOA and NDI score between ACDF group and CADR group.

Groups	Preoperatively		3 days postoperatively		3 months postoperatively		3 years postoperatively		Last follow-up	
	JOA	NDI	JOA	NDI	JOA	NDI	JOA	NDI	JOA	NDI
ACDF	9.5±1.2	48.6±6.8	15.8±2.5	22.5±3.5	15.2±2.1	23.4±3.7	15.6±2.1	23.8±3.6	15.9±2.4	24.2±3.9
CADR	9.2±1.3	47.3±7.1	16.1±3.1	21.2±3.7	15.7±2.5	22.5±3.1	16.0±2.5	24.1±3.8	16.3±2.7	23.5±3.2
t	0.98	0.383	0.478	0.847	0.265	0.659	0.533	0.469	0.213	0.762
p	0.33	0.261	0.632	0.232	0.736	0.332	0.467	0.573	0.832	0.289

ACDF – anterior cervical discectomy and fusion; CADR – cervical artificial disc replacement; JOA – Japanese Orthopaedic Association; NDI – Neck Disability Index.

Table 3. Overall lordosis angle and overall activity of ACDF group and CADR group.

	Preoperatively		3 months postoperatively		3 years postoperatively		Last follow-up	
	Overall lordosis	C2–C7 ROM	Overall lordosis	C2–C7 ROM	Overall lordosis	C2–C7 ROM	Overall lordosis	C2–C7 ROM
ACDF group	12.5±2.9	43.6±5.9	13.2±2.8	36.5±5.9	13.7±2.2	37.8±6.1	13.6±2.3	39.6±6.5
CADR group	13.2±2.9	44.6±6.1	13.9±3.2	38.3±6.6	14.5±2.5	40.4±7.2	16.5±2.9	42.8±6.9
P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05

ACDF – anterior cervical discectomy and fusion; CADR – cervical artificial disc replacement; ROM – range of motion.

Table 4. Surgical segmental lordosis and activity of ACDF group and CADR group.

	Segmental lordosis	Segmental activity
ACDF group	3.1±5.9	9.4±3.7
CADR group	2.7±5.6	9.5±3.8
t	0.28	0.11
P	0.778	0.913

ACDF – anterior cervical discectomy and fusion; CADR – cervical artificial disc replacement.

group, but with no statistically significant difference (P>0.05) (Table3). At the last follow-up, the overall cervical lordosis angle of the two groups was increased compared with the preoperative findings, but the difference was not statistically significant (P>0.05) (Table3). At the last follow-up, the overall cervical ROM activity of the two groups showed no significant difference compared with preoperative ROM activity (P>0.05) (Table 3).

Segmental lordosis and range of movement (ROM) activity of the surgical segment

The preoperative surgical segmental curvature and ROM activity of the ACDF group and the CDA group showed no significant difference (P>0.05) (Table 4). The surgical segmental activity of ACDF group postoperatively was 0, whereas the segmental ROM of the CDA group decreased from 9.51±3.75° before surgery to 7.00±3.00° three months after surgery and 6.60±4.10° at final follow-up, without significant decrease. Follow-up X-rays showed solid fusion with an absence of movement in all but one case (at 13-month follow-up), who showed slight movement in the operated level despite clinical improvement.

Adjacent segment intervertebral disc height and mobility

The preoperative upper and lower adjacent intervertebral height of the ACDF group and the CDA group had no statistically significant difference (P>0.05) (Tables 5, 6). At the last follow-up, the intervertebral height of the two groups showed no significant changes when compared with the preoperative status (P>0.05) (Tables 5, 6), and there was no statistically significant difference between the two groups. There was no significant

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Table 5. Upper segment height and upper segment ROM.

	Preoperatively		3 months postoperatively		3 years postoperatively		Last follow-up	
	Upper segment height	Upper segment ROM	Upper segment height	Upper segment ROM	Upper segment height	Upper segment ROM	Upper segment height	Upper segment ROM
ACDF group	12.5±1.9	9.6±1.3	11.6±1.6	7.3±1.1	12.8±1.4	8.1±1.3	12.4±1.5	7.8±1.1
CADR group	13.2±2.1	10.2±1.4	13.3±1.8	9.0±1.4	14.5±1.7	10.5±1.5	13.5±1.6	9.7±1.3
P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05

ACDF – anterior cervical discectomy and fusion; CADR – cervical artificial disc replacement; ROM – range of motion.

Table 6. Lower segment height and lower segment ROM.

	Preoperatively		3 months postoperatively		3 years postoperatively		Last follow-up	
	Lower segment height	Lower segment ROM	Lower segment height	Lower segment ROM	Lower segment height	Lower segment ROM	Lower segment height	Lower segment ROM
ACDF group	11.6±1.41	9.0±1.16	12.3±1.47	7.6±1.10	10.9±1.28	8.3±1.15	11.1±1.38	8.1±1.24
CADR group	12.7±1.46	9.8±1.25	13.6±1.55	8.7±1.23	11.8±1.37	9.6±1.34	12.4±1.52	9.1±1.33
P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05

ACDF – anterior cervical discectomy and fusion; CADR – cervical artificial disc replacement; ROM – range of motion.

Table 7. ASD incidence rate of ACDF group and CADR group.

	Adjacent segment degeneration	Upper segment segeneration		Lower segment segeneration	
		X-ray	MRI	X-ray	MRI
ACDF	19 (48.72%)	6	12	4	9
CADR	13 (44.83%)	4	9	2	6
P	>0.05	>0.05	>0.05	>0.05	>0.05

ACDF – anterior cervical discectomy and fusion; CADR – cervical artificial disc replacement; ASD – adjacent segment degeneration.

difference between the adjacent upper and lower segmental mobility between the ACDF group and the CDA group before the operation. At the last follow-up, the upper and lower segmental mobility had reduced when compared with the preoperative mobility in both groups, but there was no statistically significant difference between the two groups (P>0.05).

Adjacent segment degeneration

In this study, lateral cervical X-ray and MRI T2-weighted imaging were used to evaluate adjacent segment degeneration. When an increase in at least one grade in any of the radiographic parameters was detected between the two time points, the progression of disc degeneration was judged as present at the level of interest. At the last follow-up patients with an X-ray and (or) MRI that showed degeneration were divided into a degeneration group; otherwise they were classified as a non-degeneration group. The incidence of adjacent segment degeneration in the CDA group was lower than ACDF group, but there the difference was not statistically significant (P>0.05) (Table 7).

We compared the degeneration group with the non-degeneration group and found that the gender, disease duration, surgical approach, and follow-up period showed no significant difference (P>0.05) (Table 8). However, the patients in the degeneration group were older than the patients in the non-degeneration group (P<0.05) (Table 9). In the degeneration group, the preoperative cervical sagittal lordosis angle and the surgical segmental lordosis angle were less than those of non-degeneration group (P <0.05) (Table 9). Univariate analysis showed that an older age (OR=1.271; 95% CI, 1.005–1.607), low

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Table 8. Baseline data comparison of ASD group and non-ASD group.

	Age (years)	Sex (Male: Female)	Disease duration (months)	Surgical method (ACDF: CADR)	Follow-up period (months)
ASD (32 cases)	52.5±7.7	21: 11	13.4±5.9	19: 13	102.7±4.2
Non-ASD (36 cases)	44.5±6.5	22: 14	13.3±4.7	20: 16	104.5±5.9
P	0.03	0.315	0.936	0.823	0.158

ACDF – anterior cervical discectomy and fusion; CADR – cervical artificial disc replacement; ASD – adjacent segment degeneration.

Table 9. Preoperative radiographic parameters of ASD group and non-ASD group.

	Overall lordosis	C2–C7 ROM	Upper segment height	Upper segment ROM	Lower segment height	Lower segment ROM	Segmental lordosis	Segmental activity
ASD (32 cases)	7.5±2.1	42.3±5.7	11.6±1.8	8.3±1.2	10.6±1.3	7.8±1.1	5.9±1.5	9.3±3.5
Non-ASD (36 cases)	15.3±3.1	44.9±6.6	13.5±2.0	10.6±1.5	13.3±1.5	8.4±1.2	7.3±2.3	9.6±3.6
P	<0.0001	>0.05	>0.05	>0.05	>0.05	>0.05	0.0046	>0.05

ASD – adjacent segment degeneration; ROM – range of motion.

Table 10. Results of univariate analysis.

Clinical factors	OR	95% CI for OR	p-value
Age	1.271	1.005–1.607	0.045
Preoperative OL	0.858	0.786–0.936	0.018
Preoperative SL	1.185	1.086–1.193	0.023

OL – overall lordosis; SL – segmental lordosis; CI – confidence interval; OR – odds ratio.

preoperative overall lordosis (OR=0.858; 95% CI, 0.786–0.936) and low preoperative segmental lordosis (OR=1.185; 95% CI, 1.086–1.193) were statistically correlated with adjacent segment degeneration (Table 10).

Discussion

The findings of this study showed that the long-term clinical effectiveness of anterior cervical discectomy and fusion (ACDF) compared with cervical disc arthroplasty (CDA) with the Bryan artificial cervical disc were comparable in clinical outcome in a study that included 91 patients with degenerative cervical disc disease. The postoperative neurological function scores for both surgical groups were significantly improved from their preoperative scores, and there was no significant difference between the two groups at different time points during postoperative follow-up.

Previously published controlled clinical studies have shown that the short-term effects of CDA were comparable with ACDF surgery, which supports the findings of this study [15–17]. The common approach of the two procedures is that after thoroughly and complete decompression of the intervertebral disc space, either an implant or interbody fusion is carried out, and recovery of neurological function is related to how thoroughly intra-operative decompression is performed, rather than on the surgical method.

Regarding adjacent segment degeneration due to ACDF surgery, long-term follow-up following surgery has indicated that there were many complications, such as subsequent instability, loss of physical activity, and adjacent segment degeneration. The pathological changes of adjacent segment degeneration mainly include cervical spondylosis, cervical osteophyte formation around the vertebral body, disc space narrowing, vertebral slipping, disc herniation, ligament hypertrophy and ossification on X-ray and (or) magnetic resonance imaging (MRI). These degenerative changes can lead to cervical stenosis, and

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degeneration of the fused and adjacent segments, resulting in spinal cord injury and neurological symptoms [18]. Adjacent segment degeneration has a direct impact on the long-term outcome of patients with anterior cervical surgery and is a major complication.

ACDF surgery changes the original mechanical behavior of the spine at the expense of the activity of the fusion segment. In theory, ACDF surgery may cause the distribution of stress to the adjacent vertebrae, including stress concentration of adjacent segments, resulting in instability. However, the association between so-called 'adjacent segment degeneration' and ACDF surgery remains theoretical and requires supporting experimental or clinical data. It is unclear whether adjacent segment degeneration following ACDF surgery occurs due to segmental fusion or the normal physiological degeneration of the spine. Some researchers believed that the biomechanical changes cannot completely explain cervical adjacent segment degeneration. Goffin et al. [19] found that among patients undergoing ACDF surgery, patients suffering from cervical spondylosis had an increased incidence of adjacent segment degeneration when compared with patients with cervical trauma or tumor. Accordingly, they that believed fusion surgery only played a promoting role in adjacent segment degeneration and was not the main reason. Sasso et al. [20] found that after ACDF surgery, there was no significant increase in adjacent segment disc pressure and activity, and they believed that adjacent segment degeneration following ACDF surgery might be part of the natural course of cervical spondylosis.

In previous studies, the adjacent segments following cervical surgery were observed using X-ray, but X-ray films cannot directly show the posterior margin, spinal cord compression, and other important changes. In our study, MRI was found to be the best way to show intervertebral disc degeneration and spinal cord compression and to observe the adjacent segments. We analyzed the MRI results from various aspects, including disc, the spinal cord sagittal diameter, and anterior and posterior compression. The results of this study showed that the application of MRI combined with X-ray was a good method to observe the cervical segment degeneration, showing that 44.83% (13/29) of the CDA adjacent segments were degenerative, and adjacent segment degeneration due to ACDF was seen in 48.72% (19/39), which was a similar incidence.

It has been previously hypothesized that adjacent segment degeneration due to surgical fusion could cause increased stress on the adjacent segments and accelerate their degeneration. Therefore, the technique of the non-fusion operation was developed to preserve movement and decrease the physical stress of the adjacent segments. In the first decade of the 21st century, non-fusion operations, such as cervical disc replacement have improved. In theory, CDA should decrease the likelihood of developing adjacent segment degeneration and segment breakdown by maintaining normal disc kinematics. In biomechanical cadaveric studies, cervical arthroplasty has also been shown to maintain motion and mechanics within physiologic ranges at the index segment and decrease stress on adjacent segments [21,22].

The findings of this study have shown that, when compared with the ACDF group, the Bryan CDA surgery had no significant difference in the incidence of adjacent segment degeneration. Clinical studies of Robertson et al. [23] suggested that the CDA surgery, which retained movement activities when compared with intervertebral fusion surgery, could significantly reduce clinical and imaging performance of adjacent segment degeneration. Nunley et al. [24] showed that CDA surgery and ACDF surgery had the same incidence of adjacent segment degeneration after 38 months follow-up postoperatively. In our study, based on lateral X-ray and MRI T2-weighted images, adjacent segment degeneration incidence after ACDF surgery was the same as for CDA surgery. The different findings from the previous studies may be explained by the fact that, at present, adjacent segment degeneration has no unified standard of assessment. In this study, we chose to evaluate adjacent segment degeneration with a combination of X-ray and MRI, which we believe is a more accurate method of evaluation.

There are many complicated reasons for developing adjacent segment degeneration after anterior cervical surgery, mainly including the increased adjacent vertebral sagittal activity [25], the fusion segment number [26], the segment locations [26], operation segmental kyphosis [27], and the influence of each factor on the other. Recently, Yu et al. [28] found that the age, the postoperative cervical arc chord distance, and the plate-to-disc distance, were risk factors for adjacent segment degeneration following ACDF because ACDF may increase the stress of fused adjacent segments, which is the reason for adjacent segment degeneration. But if ACDF operation can preserve or even reconstruct segmental lordosis, it will reduce the incidence of adjacent segment degeneration [27]. Following ACDF surgery segmental kyphosis may appear during maintaining the original stress and induce the incidence of adjacent segment degeneration.

The reduction in cervical curvature is considered closely related to the occurrence of adjacent segment degeneration. Katsuura et al. [29] followed up 42 ACDF surgery patients for 9.8 years after surgery; 13 patients had local kyphosis, of which 10 cases had adjacent segment degeneration ($P<0.05$). Some authors reported that there was an association between postoperative kyphosis and axial symptoms, and also adjacent segment degeneration and cervical spine instability so that it is important to maintain and reconstruct cervical lordosis [30]. In our study, we conducted a prospective study to investigate cervical lordosis before and after Bryan CDA versus ACDF surgery and found that the Bryan prosthesis also maintained overall

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lordosis. This finding requires further study. Between the degeneration group and the non-degeneration group, preoperative cervical lordosis showed a statistically significant difference. However, the adjacent segment degeneration ratio of the two surgery methods was similar, which shows cervical curvature, rather than a specific surgical procedure, determines the development of adjacent segment degeneration.

In our study, we found that degeneration group had an average age of 52.75 years; the non-degeneration group had an average age of 44.89 years, and there was a statistically significant difference. For the two study groups, gender, disease duration, surgical approach, follow-up time and other clinical findings had no significant differences.

There were several limitations to this study. Firstly, the ACDF surgery and CDA surgery cases were not randomly selected. All enrolled patients were suitable for each of the two procedures, but the final surgical option was determined by the patients themselves. Non-randomization would have caused some selection bias, but the baseline and demographic data of the two groups had no statistically significant differences and had good comparability. The small study sample size was also a limitation of this study. Further studies should give full consideration to these issues. In addition, this study was a prospective comparative study, including 93 patients who underwent ACDF or CDA for cervical degenerative diseases. During the long-term follow-up period of more than eight years, some cases were unavoidably lost to follow-up. Finally, most of the cases (68 cases) completed the whole follow-up period, with a follow-up rate more than 73%. Attrition bias existed in the study, but this is inevitable in a prospective clinical study.

Conclusions

Anterior cervical discectomy and fusion (ACDF) surgery and the Bryan artificial disc for cervical disc arthroplasty (CDA) for cervical single-level degenerative diseases have achieved equally good clinical results in this study. Postoperative adjacent segment degeneration of the two groups showed no significant differences.

Conflict of interest

None.

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