Two-adjacent-level anterior cervical discectomy and fusion versus one-level corpectomy and fusion in cervical degenerative disc disease: a retrospective cohort study

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Research article

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Abstract

Background: The aim of the present study was to compare whether anterior cervical discectomy and fusion (ACDF) with a polyether ether ketone (PEEK) cage was superior to anterior cervical corpectomy and fusion (ACCF) with a titanium mesh cage (TMC) in the treatment of two-adjacent-level cervical degenerative disease. **Methods:** From May 2014 to December 2015, 47 patients with cervical degenerative disease who underwent ACDF with PEEK or ACCF with TMC were included in this retrospective analysis. Perioperative parameters (hospital stay, blood loss, operation time, and complications), clinical outcomes (Japanese Orthopaedic Association scores and visual analogue scale scores for neck and arm pain), and radiological outcomes (the overall cervical sagittal angle, segmental angle of the treated vertebral level, the height of the treated vertebral level, and fusion status) were evaluated. **Results:** The operative time was significantly shorter ($P = 0.006$) and blood loss was higher ($P = 0.081$) in the ACCF with TMC group. The early hardware failure rate was 4% and 0% in the ACCF with TMC group and the ACDF with PEEK group, respectively. The subsidence rate was higher in the ACCF with TMC group (8%) than in the ACDF with PEEK group (0%). **Conclusions:** The two procedures yielded comparable results in terms of clinical and radiological outcomes during 1-year follow-up. However, when compression at the vertebral level is mild to moderate, we suggest the use of ACDF than ACCF because of the possibility of early hardware failure. Allograft or heterotopic autograft can be avoided in both groups.

Background

Cervical degenerative disease is a common cause for neck pain, neck stiffness, arm paresthesia, and numbness or weakness of the upper limb. Anterior approaches, including anterior cervical corpectomy and fusion (ACCF) and anterior cervical discectomy and fusion (ACDF), have been reported with satisfactory clinical outcomes [1,2]. However, the optimal surgical procedure remains controversial [3,4]. It is difficult for surgeons to decide which is a better surgical option between two-adjacent-level ACDF and one-level ACCF for patients with two-adjacent-level involvement. Compared to ACDF, ACCF can better remove prolapsed discs, osteophytes, and ossified posterior longitudinal ligament [5]. However, ACCF may have subsidence-related complications, including pain, neurologic deterioration, and hardware failure [6-8].

There are several methods for the fusion of the cervical spine following ACDF or ACCF. Autografts harvested from the iliac crest have been considered as the “gold standard”; however, this method leads to donor site morbidity [9]. Allografts that prevent donor site complications may have high rates of pseudarthroses and graft collapse [10]. Interbody cages such as titanium mesh cage (TMC) and polyether ether ketone (PEEK) cage have become popular for anterior cervical reconstruction without harvesting iliac autografts. Furthermore, these cages can provide immediate stability, avoid common donor site pain, and maintain better biocompatibility [11].

The present retrospective study aimed to compare the outcome of two-adjacent-level ACDF with PEEK cages and one-level ACCF with TMC.

Materials And Methods

In this study, we conducted a single-center, retrospective analysis of 47 consecutive patients who underwent either two-adjacent-level ACDF with PEEK cages ($n = 22$) or one-level ACCF with TMC ($n = 25$) for cervical spondylosis. The patients were enrolled between May 2014 and December 2015. The involved vertebral levels were C3-C4-C5, C4-C5-C6, or C5-C6-C7. Patients with recent infection, neoplasm, trauma, rheumatoid arthritis, autoimmune disease, kyphotic deformity, or an ossified posterior longitudinal ligament were excluded from the study. All patients were symptomatic after appropriate conservative management. All operations were performed by the same surgical group. Patients with significant compression from the vertebral level were treated with ACCF, while those with compression from the disc level without compression from the vertebral level were treated with ACDF. When mild to moderate compression existed at the vertebral level and significant compression existed at the disc level, patients received either an ACDF or ACCF approach after a detailed discussion of potential benefits and risks between the patient and the surgeon. The study was performed in accordance with the provisions of the Declaration of Helsinki. Ethical issues concerning patients' rights and interests, safety and health were discussed by the medical ethics committee of The Affiliated Hospital of Xuzhou Medical University and agreed in line with the principles of medical ethics. The permit number is xyfylw2014015. For the retrospective study the patient consent was not necessary.

The patients were categorized into two groups according to the type of surgery received: the ACDF group included patients who received two-adjacent-level ACDF, and the ACCF group included patients who received one-level ACCF. Cages were packed with anterior cortical bone of the adjacent vertebra in the ACDF group or autograft from the resected vertebra in the ACCF group. All surgeries were stabilized with a fixed Atlantis anterior fixation plate (Weiman, Tianjin, China). Screws were used in the cranial and caudal vertebra in all patients. Two additional screws were placed in the middle vertebrae in the two-adjacent-level ACDF group. PEEK cages (Weiman) were used as interbody grafts during the ACDF procedure, and TMCs (Weiman) were used as structural grafts during the ACCF procedure. The TMC is open and parallel ends design and the cage is parallel ends design.

The operation time, blood loss, and hospital stay of the included patients were recorded. Follow-ups were conducted at 2 weeks and at 3, 6, and 12 months after the surgery. Visual analogue scale (VAS) was used to evaluate clinical outcome. The Japanese Orthopaedic Association (JOA) score was used to assess functional recovery.

Plain radiography and flexion/extension lateral radiography were performed at preoperative, 2 weeks, and 3, 6, and 12 months after surgery to assess radiological parameters, including the overall cervical sagittal angle (CSA), segmental angle (SA) and the height of the treated level, and fusion status. The CSA and SA were measured by Cobb's method. The CSA was defined as the angle formed by the lines drawn parallel to the lower endplates of C2 and C7 on a neutral lateral radiograph. The SA was defined as the angle formed between the superior margin of the upper vertebral body and the inferior margin of the lower vertebral body of the treated level on a neutral lateral radiograph. Subsidence of more than 3 mm was

considered to be statistically significant [12]. Fusion was defined as the presence of continuous bridging trabeculae between the cage and adjacent endplates and the absence of motion of more than 2 mm between spinous processes on flexion/extension at the treated level [13]. Two independent observers recorded the outcomes.

Statistical analysis was performed using SPSS version 12.0 (SPSS, Chicago, IL, USA). Quantitative data are presented as the mean $\pm$ standard deviation. Chi-square tests were used to analyze differences in preoperative demographic characteristics and in clinical and functional outcomes between the two groups. Fisher's exact test was used to analyze differences in complications between the groups. P-values of <0.05 were considered statistically significant.

Results

The ACDF group comprised 22 patients (11 women and 11 men), and the ACCF group comprised 25 patients (13 women and 12 men) (Figure 1). The average age of patients was 48.9 years in the ACDF group (range 35–65 years) and 51.3 years (range 37–74 years) in the ACCF group (Table 1). No significant intergroup differences were found in terms of age, gender, treated segments, and the baseline JOA and VAS scores (Tables 1–3).

The mean blood loss was 156.4 ± 36.2 and 278.4 ± 67.3 ml ($p = 0.081$) in the ACDF and ACCF groups, respectively. The mean operative time was less in the ACCF group (92.4 ± 16.2 minutes) than in the ACDF group (140.5 ± 30.7 minutes) ($p < 0.01$). The average hospital stay was 13.9 ± 2.2 and 13.8 ± 2.0 days ($p = 0.48$) in the ACDF and ACCF groups, respectively. Successful fusion was achieved in all patients in the ACDF group (22/22). Three patients in the ACCF group developed subsidence and one patient required revisional surgery. One patient experienced hoarseness and two patients developed dysphagia in the ACDF group. Dysphagia also occurred in two patients in the ACCF group. All patients recovered fully from hoarseness and dysphagia. None of the patients developed esophageal injury, cerebrospinal fluid leakage, or infections.

In the ACDF group, the average preoperative JOA score was 11.1 ± 1.9 , which then increased to 15.3 ± 1.1 at the final follow-up (Table 3). In the ACCF group, the average preoperative JOA score was 10.6 ± 1.5 , which then increased to 15.2 ± 1.2 at the final follow-up. The postoperative JOA scores at 12 months did not differ between the two groups ($p = 0.119$, $p = 0.513$). No significant difference was detected between the two groups in the mean neck VAS scores at 12 months postoperation (1.1 ± 0.8 vs. 1.2 ± 0.7 , $p = 0.478$). The mean arm VAS score at the final follow-up improved significantly from 5.6 ± 2.4 to 1.0 ± 0.9 in the ACDF group and from 6.3 ± 2.0 to 1.2 ± 0.8 in the ACCF group. The difference in the improvement of VAS score between the two groups was not significant.

Figures 2 and 3 show the trends of CSA and SA in both groups. The mean preoperative CSA was $12.1 \pm 8.1^\circ$ and $12.3 \pm 4.9^\circ$ in the ACDF and ACCF groups, respectively (Table 4). The CSA at the final follow-up was $14.3 \pm 8.0^\circ$ and $12.6 \pm 4.3^\circ$ in the ACDF and ACCF groups, respectively. There was no significant difference in the final CSA between the two groups. In the ACDF group, the SA changed from $2.1 \pm 3.3^\circ$ to

$2.7^{\circ} \pm 1.1$ at the last follow-up, while in the ACCF group, the SA changed from $4.8 \pm 2.6^{\circ}$ to $3.3 \pm 1.7^{\circ}$. In the ACDF group, the mean height of the fused level improved from 50.6 ± 4.0 mm preoperatively to 58.6 ± 5.0 mm at 2 weeks postoperation and then returned to 52.8 ± 3.9 mm at the final follow-up. In the ACCF group, the mean height of the fused level changed from 50.5 ± 3.3 mm preoperation to 56.1 ± 5.5 mm at 2 weeks postoperation and then returned to 51.2 ± 3.8 mm at the final follow-up. The mean height of the fused level did not differ significantly between the two groups ($p > 0.05$).

Discussion

Cervical degenerative disease has been successfully managed by ACDF or ACCF for decades. Surgical choice remains debatable for two-adjacent-level cervical degenerative disease. Previous studies compared the two procedures by using an autograft or allograft. However, few studies have focused on these two procedures using TMC or PEEK cage [14,15]. Compared to ACDF, ACCF showed more advantages for spinal cord decompression through resection of the proliferous tissues from the anterior column, but ACCF-related complications, especially TMC subsidence, increase the possibility of re-compression of the cervical spinal cord and nerve roots [16,17].

We evaluated the surgery time, blood loss, and hospital stay for all the patients. Patients in the ACCF group showed shorter surgery time and larger blood loss than those in the ACDF group. A statistically significant difference in hospital stay was not found between the two groups. Previous studies on ACCF and ACDF have reported different outcomes. Oh et al. [14] reported that patients in the ACCF group with iliac bone fusion had longer surgery time than those in the ACDF group. Uribe et al. [18] demonstrated that patients in the ACCF group showed shorter surgery time and increased blood loss than those in the ACDF group. In the study of Uribe et al., TMCs were packed with autograft from the resected vertebra and PEEK cages were packed with local cancellous bone harvested from the sternal manubrium and/or local osteophytes. In our study, TMCs were packed with autograft from the resected vertebra and PEEK cages were packed with cortical bone of the adjacent vertebra. When treating the posterior osteophytes of the vertebra in discectomy, the laminectomy rongeur was used instead of the power drill to ensure the amount of harvested osteophytes. Possible reasons for prolonged surgery time of discectomy than that of corpectomy are narrower operating space and two operating levels. In the ACCF group, bleeding when resecting the vertebra leads to more blood loss than that observed in the ACDF group. Most patients wanted to stay in hospital after the stitches were removed, so the post-operative stay in our department was a little longer.

Clinical outcomes were evaluated on the basis of the JOA and VAS scoring systems. The outcomes were associated with adequate decompression and pathological segment stabilization. Both groups showed improvements in the JOA and VAS scale scores. At the final follow-up, the mean JOA and VAS scale scores were similar between the ACDF and ACCF groups. Restoration of cervical alignment after surgery is essential for a favorable long-term clinical outcome. Katsuura demonstrated a positive correlation between the reduction of cervical lordosis and the development of neck pain after ACDF [19]. In the present study, the CSA and SA of the treated level increased after surgery in both groups and then

decreased gradually during the follow-up period. Loss of the CSA and SA at the final follow-up might be due to subsidence or compensatory effect of the adjacent vertebra level. The high rate of fusion might also reduce the range of motion. There was no significant difference in the CSA and SA at the final follow-up between the two groups. Park et al. reported that corpectomy and discectomy fused with allograft yielded comparable results in terms of cervical lordosis [15].

Optimization of the treatment based on each patient is the current interest of global spine surgeons. Although ACCF is designed to yield a more extensive decompression range, it is more prone to TMC subsidence. The contact interface is small between TMC and endplates, which contributes to greater intensity pressure at the contact surface. It eventually results in excessive insertion onto the vertebra. The subsidence can lead to recompression of the spinal cord and nerve roots. Daubs et al. [20] reported an early subsidence rate of 26% in ACCF. Either ACDF or ACCF is an appropriate therapeutic strategy for patients with severe compression at the disc or vertebra level. When patients are diagnosed to have mild or moderate compression, the surgical choice can be debatable. In the present study, we observed whether patients in the ACDF group showed similar clinical and radiological outcomes compared to those in the ACCF group. The ACDF group exhibited a lower rate of subsidence than the ACCF group (0% vs. 8%). One patient in the ACCF group received a revision operation because of anterior recompression of the spinal cord. Published studies showed that functional outcomes were not significantly different between corpectomy and discectomy [14,21]. Considering the possibility of early hardware failure, we suggest ACDF over ACCF for treating two-adjacent-level cervical degenerative disease when compression at the vertebral level is mild to moderate. Previous study has used either allograft or autograft for anterior reconstruction after discectomy [22]. Autograft has also been associated with donor site morbidity. In the present study, fusion rates were high in both groups. These results showed that the amounts of osteophytes harvested from anterior and posterior vertebra were adequate to ensure solid fusion after discectomy. Thus, allograft or donor site complications can be avoided.

The limitations of this study are the inherent disadvantages of a retrospective study. A prospective, randomized control trial can strengthen the results. Moreover, the number of patients included in the present study was small. A long-term follow-up to compare the degenerative changes of segments above and below the fused level is necessary for future studies. Bone fusion was assessed by X-ray in the present study, which is a limitation related to fusion evaluation. Furthermore, the potential for surgeon bias in patient selection may exist. However, we tried our best to provide a clue to the surgeon to decide between ACDF and ACCF as a suitable approach for treating two-adjacent-level cervical degenerative disease. In future studies, we would recruit more patients and increase the follow-up time to further investigate which method is superior.

Conclusions

On the basis of our findings, we believe that both ACCF and ACDF procedures yield comparable results for treating two-adjacent-level cervical degenerative disease. When compression at the vertebral level is

mild to moderate, we suggest ACDF over ACCF because of the possibility of early hardware failure. Allograft or heterotopic autograft can be avoided in both procedures.

Abbreviations

ACDF: anterior cervical discectomy and fusion.

PEEK: polyether ether ketone.

ACCF: anterior cervical corpectomy and fusion.

TMC: titanium mesh cage.

VAS: visual analogue scale.

JOA: Japanese Orthopedic Association.

CSA: cervical sagittal angle.

SA: segmental angle.

Declarations

Trial registration: Research Registry UIN: research registry 3848. Name of registration was "Two-Adjacent-Level Anterior Discectomy Versus One-Level Corpectomy in Cervical Degenerative Disease: A retrospective cohort study." Date of registration was March 20, 2018, retrospectively registered. URL of trial registry record: <https://www.researchregistry.com/browse-the-registry#home/registrationdetails/5ab0d63eb72c2e0e34371fe2/>

Availability of data and materials

The data used during the present research are available from the corresponding author on request.

Competing interests

The authors declare that they have no competing interests.

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Tables

Table 1. Demographic and perioperative parameters. ACDF: anterior cervical discectomy and fusion. ACCF: anterior cervical corpectomy and fusion.

	ACDF	ACCF	<i>P</i>
Number	22	25	
Average age (years)	48.9 ± 8.0	51.3 ± 10.1	0.111
Sex (n)			
Female	11	13	-
Male	11	12	-
Hospital Day (days)	13.9 ± 2.2	13.8 ± 2.0	0.48
Bleeding (ml)	156.4 ± 36.2	278.4 ± 67.3	0.006
Surgery time (minutes)	140.5 ± 30.7	92.4 ± 16.2	0.081
Fusion rate (%)	100 [22/22]	96 (24/25)	-

Table 2. Number of disc levels treated in both the groups.

Treated levels	Group 1 (ACDF) n = 22	Group 2 (ACCD) n = 25
C2-3, C3-4	0	0
C3-4, C4-5	2	3
C4-5, C5-6	15	15
C5-6, C6-7	5	7

Table 3. Functional outcomes in each group. JOA: Japanese Orthopedic Association. VAS: visual analogue scale.

	Groups	Pre-operation	2 wks post-op	3 mo post-op	6 mo post-op	1 yr post-op
JOA score	ACDF	11.1 ± 1.9	14 ± 1.2	14.4 ± 1.1	15 ± 1.1	15.3 ± 1.1
	ACCF	10.6 ± 1.5	12.1 ± 0.9	13.2 ± 1.4	14.4 ± 1.3	15.2 ± 1.2
<i>P</i>		0.119	0.098	0.642	0.249	0.513
VAS neck	ACDF	6.2 ± 1.8	2.5 ± 1.1	1.8 ± 0.9	1.3 ± 0.7	1.1 ± 0.8
	ACCF	6.4 ± 2.0	3.0 ± 0.9	1.9 ± 0.8	1.6 ± 0.7	1.2 ± 0.7
<i>P</i>		0.306	0.095	0.323	0.771	0.478
VAS arm	ACDF	5.6 ± 2.4	2.5 ± 1.1	1.9 ± 1.1	1.3 ± 0.9	1.0 ± 0.9
	ACCF	6.3 ± 2.0	2.5 ± 0.9	2.1 ± 0.8	1.7 ± 0.8	1.2 ± 0.8
<i>P</i>		0.222	0.221	0.084	0.432	0.980

Table 4. Radiographic outcomes in each group. CSA: cervical sagittal angle. SA: segmental angle.

	Groups	Pre-operation	2 wks post-op	3 mo post-op	6 mo post-op	1 yr post-op
CSA	ACDF	12.1 ± 8.1	19.2 ± 8.2	16.4 ± 8.1	15.0 ± 7.9	14.3 ± 8.0
	ACCF	12.3 ± 4.9	18.9 ± 4.1	15.3 ± 4.2	13.8 ± 4.1	12.6 ± 4.3
<i>P</i>		0.133	0.170	0.060	0.084	0.076
SA	ACDF	2.1 ± 3.3	5.0 ± 3.0	3.6 ± 1.9	2.9 ± 1.2	2.7 ± 1.1
	ACCF	4.8 ± 2.6	3.8 ± 2.4	3.4 ± 2.1	3.2 ± 1.6	3.3 ± 1.7
<i>P</i>		0.496	0.733	0.800	0.388	0.085
Height of the treated level	ACDF	50.6 ± 4.0	58.6 ± 5.0	54.7 ± 4.0	53.7 ± 3.7	52.8 ± 3.9
	ACCF	50.5 ± 3.3	56.1 ± 5.5	53.8 ± 4.6	52.1 ± 4.1	51.2 ± 3.8
<i>P</i>		0.411	0.777	0.692	0.748	0.901

Figures

Figure 1

A. A 49-year-old male underwent discectomy with PEEK cages. The preoperative cervical X-ray examination and CT and MRI scan show spinal cord compression resulting from C3/4 and C4/5 disc

herniation. The immediate postoperative lateral X-ray examination shows C3/4 and C4/5 discectomy and two PEEK cages used for reconstruction. B. A 59-year-old female underwent corpectomy with a TMC. The preoperative cervical X-ray examination and CT and MRI scan show spinal cord compression resulting from C3/4 and C4/5-disc herniation. The immediate postoperative lateral X-ray examination shows C4 corpectomy and a TMC used for reconstruction.

Figure 2

Trend of cervical sagittal angle in both groups during the follow-up (values in degrees).

Figure 3

Trend of sagittal angle in both groups during the follow-up (values in degrees).