Original Article

Treatment of multilevel cervical disc disease with standalone cervical cages with or without anterior plating: A prospective randomized comparative study

ABSTRACT

Purpose: The purpose of the study was to compare the results of anterior cervical discectomy and fusion (ACDF) using standalone cages versus cages with anterior plating for multilevel cervical disc disease with a 2-year follow-up.

Background: ACDF is a commonly performed procedure in cases of neural compression caused by osteophytes or disc material. Some spine surgeons have reported unsatisfactory outcomes and fusion rates secondary to a high rate of cage subsidence and pseudoarthrosis. Internal fixation using anterior cervical plate has been developed as an adjunct to ACDF to enhance the stability provided by the intervertebral cages.

Patients and Methods: A total number of 60 consecutive patients diagnosed with multilevel cervical disc disease (two or more) underwent ACDF with or without additional anterior plating, between August 2021 and March 2022. Only 50 patients completed the follow-up which was ranged from 20 to 26 months.

Results: There were no significant differences between the two groups regarding age and sex. Comparing the pre and postoperative Visual Analog Scale (VAS) for both neck pain and brachialgia and neck disability index (NDI) in both groups was statistically significant. There was no significant statistical difference between the two groups regarding the postoperative clinical outcomes. There was a significant statistical difference in the fused segment lordotic angle (FSA) being greater in the plating group.

Conclusion: The use of stand-alone cages in two-level ACDF or more in our study had a shorter operative time and hospital stay when compared to ACDF with anterior plating with greater FSA in the plate group but with no difference in clinical outcome after 2-year follow-up.

Keywords: Anterior cervical discectomy and fusion, anterior cervical plate, cervical lordotic angle, fusion, standalone cervical cages

INTRODUCTION

Cervical spondylosis is a broad term which describes age-related chronic disc degeneration. Chronic disc degeneration results in abnormal mechanical stresses passing through the cervical spinal column, resulting in osteophyte formation and secondary degenerative changes in the surrounding structures, such as the facet joints, the posterior longitudinal ligament, and the ligamentum flavum.[1] The degenerative alterations can lead to a foraminal or central stenosis compromising nerve roots or spinal cord, respectively. These pathologies are termed cervical spondylotic radiculopathy (CSR) and cervical spondylotic myelopathy (CSM), respectively.[2]

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Indications for surgery for CSR include progressive motor deficit, evidence for nerve root compression, symptoms and signs of radiculopathy, and persistent pain despite nonsurgical treatment for at least 3–6 months.[3] Indications for surgery for CSM include progressive myelopathy despite nonoperative care, acute onset, progression of neurological deficits, and definitive evidence of spinal cord compression with moderate-to-severe myelopathic symptoms.[4]

Anterior cervical discectomy and fusion (ACDF) is a commonly performed procedure in cases of neural compression caused by osteophytes or disc material. Some spine surgeons have reported unsatisfactory outcomes and fusion rates secondary to a high rate of cage subsidence and pseudoarthrosis. This may indicate a lack of sufficient fixation in ACDF with stand-alone cages, permitting postoperative micromotions to continuously occur between the contact surface of the cage and vertebrae.[5]

Internal fixation using anterior cervical plate has been developed as an adjunct to ACDF to enhance the stability provided by the intervertebral cages, to help prevent graft dislodgment, and ultimately to promote mature bony fusion of the spinal segment.[6]

This study compares stand-alone ACDF cages with anterior cervical plating enhanced ACDF regarding various clinical and radiological parameters in CSR and CSM with two or more level of affection.

PATIENTS AND METHODS

A total number of 60 consecutive patients diagnosed with multilevel cervical disc disease (two or more) underwent ACDF in Kasr Al Ainy Hospital, Cairo University between August 2021 and March 2022 with a 2-year follow-up. Before the study which received the Ethical Board approval number which is MD-347-2021, all patients consented to the procedure. Only 50 patients completed the follow-up, 25 in each group; (Group I) 25 patients who were treated using standalone cages (PEEK cages), and (Group II) 25 patients treated with PEEK cages with additional anterior plating. Randomization was achieved by the block method using 5 patients for each block being assigned to Group I, the next 5 patients being assigned to Group II, and so on.

All patients with symptomatic cervical disc disease between C3 and C7 causing either myelopathy or radiculopathy with affection of two or more levels were included. The inclusion age was set to be between 25 and 60 years and only patients who did not respond to an adequate conservative regimen were included. Patients with single-level cervical disc disease and those who did not meet the age criteria were excluded. In addition, patients with systemic or local infection, active rheumatoid arthritis, or any other medical conditions that would represent an increase in surgical risk or interfere with normal healing were excluded.

Intraoperative protocol

General anesthesia was used and IV antibiotic (Ceftriaxone 1gm) was applied after induction of anesthesia. Patients were positioned in the supine position, with their arms tucked to the sides. A small, rolled towel was then placed between the scapulae to extend the neck slightly. Determination of the appropriate levels was achieved through an image intensifier. The Smith–Robinson anterolateral approach was used with a transverse incision following Langer's lines. Once the longus colli muscles had been elevated, the hand-held Cloward retractors were placed directly underneath the longus colli muscles. At this point, the fluoroscope was used to reassure the level with a spinal needle [Figure 1]. A rectangular incision was made through the anterior longitudinal ligament and the outer annulus using a No. 15 scalpel blade on a long handle. After a significant amount of disc material was removed, two Casper pins were inserted and distracted, a small intervertebral body spreader was placed to help with distraction. The remainder of the disc and the cartilage end plates were then removed with curettes under microscopic view.

Group I

The appropriate PEEK cages were filled with autograft from osteophytes and then placed in position and tapped into the disc spaces. A lateral view of the cervical spine was obtained using the fluoroscope to confirm adequate placement of each cage [Figure 2].

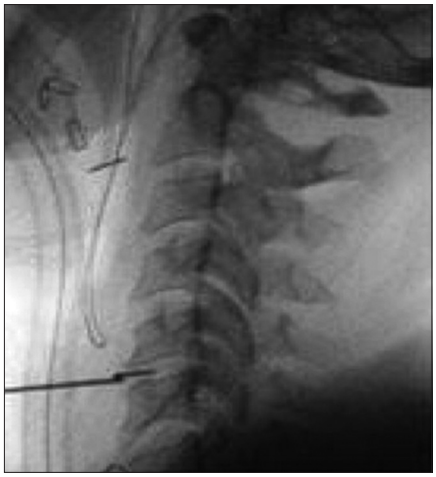

Figure 1: Intraoperative disc level

Group II

After applying the PEEK cages as mentioned in Group I, the precontoured titanium locked plate was used. A lateral view of the cervical spine was obtained using the fluoroscope to confirm adequate placement of both the cage and the anterior plate.

Follow-up measures

Patients were followed up clinically for neck and upper limb pain and disability by the Visual Analog scale (VAS) and neck disability index (NDI), respectively, on 1, 3, 6, 12, and 24-month intervals. Serial postoperative radiographs on each follow-up visit were done, and computed tomography was performed after 6, 12, and 24-month intervals for assessment of fusion and fused segment lordotic angle (FSA) [Figure 3].

Statistics

Data were coded and entered using the Statistical Package for the Social Sciences (SPSS) version 28 (IBM Corp., Armonk, NY, USA). Data were summarized using mean, standard deviation, median, minimum, and maximum for quantitative variables and frequencies (number of cases) and relative frequencies (percentages) for categorical variables. Comparisons between groups were done using unpaired *t*-test in normally distributed quantitative variables, whereas nonparametric Mann–Whitney test was used for nonnormally distributed quantitative variables. For comparison of serial measurements within each patient, the nonparametric Wilcoxon signed-rank test was used. For comparing categorical data, Chi-square test was performed. The exact test was when the expected frequency was <5. $P < 0.05$ was considered statistically significant.

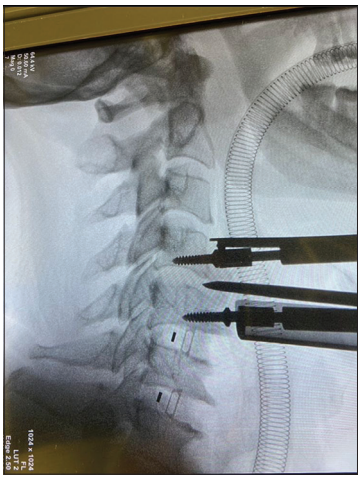

Figure 2: Intra-operative fluoroscopy of a patient in Group one

RESULTS

Fifty patients were included in this study. The patients' age ranged from 29 to 59 years in Group I and 25 to 60 in Group II. No statistical significance was found between the two groups ($P = 0.319$).

The mean operative time in Group I was 2:02 ± 0.32 h (range: 1–3), and in Group II was 2:23 ± 0.36 h (range: 1:30–3:30). The mean hospital stays in Group I was 1.88 ± 0.73 days (range: 1–3), and in Group II was 2.44 ± 0.82 (range: 1–4).

The duration of illness in Group I patients was 7.44 ± 2.6 months with left-sided radicular pain at about 36%, whereas right-sided pain at 36% and bilateral radicular pain in 28% of patients, whereas the duration of illness in Group II patients was (8.52 ± 2.5 months) with left-sided radicular pain about 32%, whereas right-sided pain in 56% and bilateral radicular pain in 12% of patients.

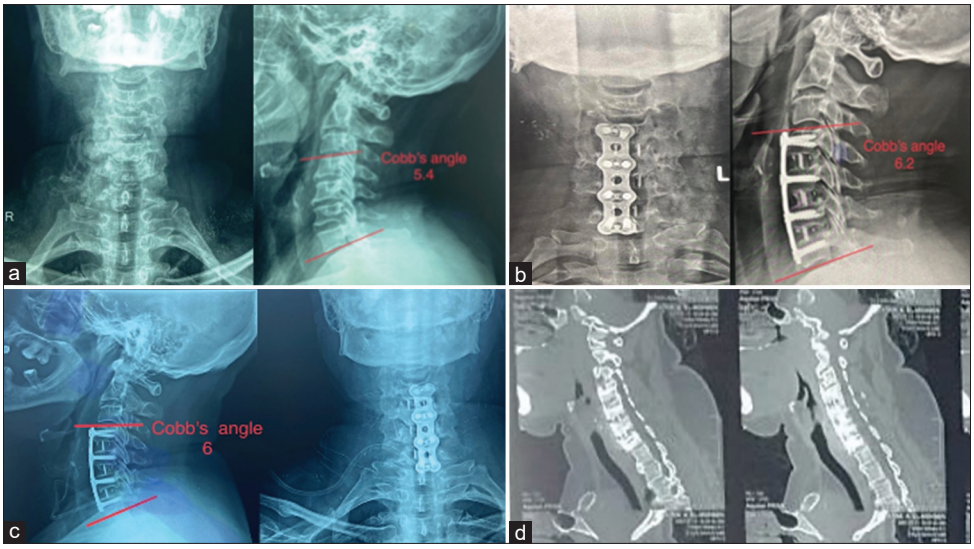

Figure 3: A patient in group two: (a) Pre-operative x-rays, (b) Post-operative x-rays, (c and d) X-rays and CT at final follow-up

The mean neck VAS score in Group I was 7.52 ± 1.36 standard deviation (SD) preoperatively, improved to 5.60 ± 0.1.04 SD at 1 month, to 2.96 ± 0.84 SD at 12 months, finally to 1.96 ± 0.73 SD at 2-year follow-up. While in Group II, mean neck VAS score was 7.32 ± 7.32 SD preoperatively, improved to 6.08 ± 1.08 SD at 1 month after surgery, to 2.88 ± 0.733 SD at 12 months, and to 2.12 ± 0.97 SD at 2-year follow-up. There was a highly significant decrease in terms of VAS neck between preoperative and postoperative measurements ($P < 0.001$) in both groups [Table 1].

There was a significant decrease in VAS of the upper limb scale in the two groups starting from the 1st month postoperatively up to the 24th month of follow-up. There was a significant statistical difference between the two groups after 1 month with *P* value (0.021). Furthermore, there was a highly significant difference ($P < 0.001$) between pre- and postoperative measurements in both groups [Table 2].

The mean NDI score in Group I was 32.60 ± 7.26 SD preoperatively, improved to 23.20 ± 3.34 SD at 1 month postoperatively, to 15.88 ± 1.99 SD at 6 months, and 12.64 ± 1.75 SD at 12 months, finally to 11.84 ± 1.65 SD at 2-year follow-up. While in Group II, the mean NDI score was 36.92 ± 6.05 SD preoperative, improved to 26.28 ± 2.32 SD at 1 month after surgery, improved to 17.56 ± 2.14 SD at 6 months, to 12.20 ± 1.66 SD at 12 months and to 11.48 ± 1.42 SD at 2-year follow-up. There was a statistically significant decrease in terms of NDI between pre- and post-operative (at 1, 6, and 12 months and at the 2-year follow-up) measurements ($P < 0.001$) in each group [Table 3].

Radiological assessment of fusion was carried out at 6 months and 1 year. Fusion was assessed according to the Brantigan and Steffee criteria[7] for fusion:

1. The presence of bridging trabecular bone between the endplates
2. The absence of a radiolucent gap between the graft and the endplate
3. Motion between vertebral bodies on flexion–extension radiographs was <3 mm of translation
4. Motion between the spinous processes seen on flexion–extension radiographs >2 mm of motion between the spinous processes.

Fusion was attained in ten out of 25 cases (40%) in Group 1 and in 11 out of 25 cases (44%) in Group 2 by the 6th month ($P = 0.774$). At 1 year, fusion was present in 21 out of 25 cases (84%) in Group 1 and in 22 out of 25 (88%) ($P = 1$). These numbers did not change at 2-year follow-up.

Table 1: Visual Analogue Scale neck in the two studied groups

	Standalone cage (Group I), mean±SD	Cage with plate (Group II), mean±SD	*P* value between groups
Preoperative VAS of the neck	7.52±1.36	7.32±1.25	0.590
Postoperative VAS of neck at 1 month	5.60±1.04	6.08±1.08	0.116
Postoperative VAS of neck at 12 months	2.96±0.84	2.88±0.73	0.748
Postoperative VAS of neck at 24 months	1.96±0.73	2.12±0.97	0.629
P value within group	<0.001	<0.001	

SD - Standard deviation; VAS - Visual Analogue Scale

Table 2: Visual Analogue Scale upper limb in the two studied groups

	Standalone cage (Group I), mean±SD	Cage with plate (Group II), mean±SD	*P* value between groups
Preoperative VAS of ULP	7.84±1.03	7.32±1.14	0.097
Postoperative VAS of ULP at 1 month	5.12±1.17	5.80±0.82	0.021
Postoperative VAS of ULP at 12 months	3.52±1.12	3.00±0.82	0.089
Postoperative VAS of ULP at 24 months	2.04±0.89	1.84±0.75	0.491
P value within group	<0.001	<0.001	

VAS - Visual Analogue Scale; ULP - Upper limb pain; SD - Standard deviation

Table 3: Neck disability index in the two studied groups

	Standalone cage (Group I), mean±SD	Cage with plate (Group II), mean±SD	*P* value between groups
Preoperative NDI	32.60±7.26	36.92±6.05	0.027
Postoperative NDI at 1 months	23.20±3.34	26.28±2.32	<0.001
Postoperative NDI at 6 months	15.88±1.99	17.56±2.14	0.006
Postoperative NDI at 12 months	12.64±1.75	12.20±1.66	0.366
Postoperative NDI at 24 months	11.84±1.65	11.48±1.42	0.412
P value within group	<0.001	<0.001	

SD - Standard deviation; NDI - Neck disability index

Lordosis was determined at the operative level by measuring the angle between the superior endplate of the superior vertebral body and the inferior endplate of the inferior vertebral body. The mean FSA was 5.14° ± 0.21° SD in Group I preoperatively, 5.78° ± 0.34° SD at 6 months after surgery, and 5.63° ± 0.26° SD at the one-year follow-up examination, while in Group II the mean FSA was 5.46° ± 0.23° SD before surgery, 6.26° ± 0.26° SD at 6 months after surgery, and 6.17° ± 0.24° SD at the 1-year follow-up examination. Furthermore, the measures were the same at 2-year follow-up. There was a significant increase in terms of FSA between preoperative and postoperative measurements ($P < 0.001$) [Table 4].

Two patients developed superficial wound infection, one in each group which improved on broad-spectrum antibiotics and serial dressings. In Group I, we had four cases of pseudoarthrosis, and three cases in Group II. This was diagnosed with the follow-up CT after 1 and 2 years. Nevertheless, all patients were asymptomatic, and they were prescribed Vitamin D3 and supplementary calcium. There was hoarseness of voice in one case in Group I and two cases in Group II. This hoarseness improved spontaneously within 2 weeks and did not need any further intervention after ENT consultation. We had three cases in each group who developed dysphagia postoperatively, those patients were instructed to start warm oral fluids and they improved within a few days. In Group II, one patient presented with postoperative C5 palsy manifested by weak shoulder abduction and weak elbow flexion, both Grade 2. This patient was prescribed cerebrolysin 1 mg (IM) for 3 weeks and started physiotherapy from the first postoperative day and showed complete recovery after 2 months.

DISCUSSION

ACDF is widely used as a surgical treatment for cervical spinal disorders, including spondylosis, myelopathy, herniated discs, trauma, and degenerative disc disease. The consensus holds that the success of this procedure relies on thorough decompression and the development of solid osseous fusion. Yet, the use of autologous bone grafts, allografts, bone substitutes, internal fixation, or any graft remains controversial.[2]

The AO Spine Systematic Review and Meta-Analysis by Cheung *et al*.,[8] about the comparison of ACDF with a standalone cage versus a conventional cage plate remains one of the largest meta-analyses conducted to evaluate the impact of surgical management on clinical and radiological outcomes. This study included 19 studies which met the inclusion criteria. They found that patients who underwent ACDF with a cage-only technique had significantly lower rates of postoperative dysphagia and adjacent segment disease compared with patients who underwent ACDF with a cage-plate technique. However, patients who underwent ACDF with a cage-plate technique had better radiographic outcomes with significantly less subsidence and better restoration of cervical lordosis. There were no other significant differences in outcomes or postoperative complications.

In our study, the mean age of presentation was between 40 and 60 years. These results are analogous to the results of Fayed *et al*.,[9] study in which the mean age of patients who underwent ACDF surgery was 58.1 ± 1.9 years in the standalone group, 57.7 ± 0.7 years in the plated group, and 57.8 ± 0.6 years overall. This suggests that symptoms of cervical disc degeneration are most found in individuals aged 40–60 years.

Considering the operative evaluation findings of our study, the operative time (min) was significantly lower in the standalone group than in cage with plate group with $P = 0.045$. Furthermore, the mean hospital stay was significantly longer in the cage with plate group compared to the standalone cage group with $P = 0.018$.

In contrary to that, Fayed *et al*.,[9] reported that there was no significant statistical difference between the two groups regarding the operative time which was 147 ± 7 min in the stand-alone group and 151 ± 3 min in the plated group ($P = 0.800$). In addition, there was no significant statistical difference regarding the hospital stay with a mean of 3.6 ± 0.9 days in the stand-alone group and 2.5 ± 0.2 days in the plated group ($P = 0.270$). Furthermore, another study by Zavras *et al*.,[10] showed similar statistical results as Fayed *et al*.,[9] regarding the operative time

Table 4: The lordotic angle preoperatively and at 6 and 12 months postoperatively in both groups

	Standalone cage (Group I), mean±SD	Cage with plate (Group II), mean±SD	*P* value between groups
Preoperative FSA	5.14±0.21	5.46±0.23	<0.001
Postoperative FSA at 6 months	5.78±0.34	6.26±0.26	<0.001
Postoperative FSA at 1 year	5.63±0.26	6.17±0.24	<0.001
Postoperative FSA at 2 years	5.63±0.26	6.17±0.24	<0.001
P value within group	<0.001	<0.001	

SD - Standard deviation; FSA - Fused segment lordotic angle

between the standalone cage and cage with plate group with no significant difference.

Regarding the VAS of neck pain, our results are comparable to a study by Keyvan Eghbal *et al*.,[11] in which the postoperative results of neck pain measured by VAS score was significantly decreased over time ($P < 0.05$) in the 18-month follow-up in both groups (from 6.14 to 1.14 in stand-alone group and from 6.50 to 0.35 in cage with anterior plate group). Similar results were published by Shiuh-Lin Hwang *et al*.[12] with VAS pain scores (preoperatively 8.8 ± 0.9 and 8.5 ± 1, postoperatively 3.1 ± 2.1 and 2.8 ± 1.8, respectively).

When analyzing the VAS of upper limb pain, there was no statistically significant difference between the two groups in our study, but both groups showed significant improvement in upper limb pain VAS postoperatively ($P = 0.003$). Our results are similar to the findings of other studies. In the study published by Sam Yeol *et al.*,[13] the pre-operative mean VAS score was 7.67 in the stand-alone group and 6.5 in the cage-with-plate group. The follow-up mean VAS at 12 months was 3.57 in the stand-alone group and 5.12 in the cage-with-plate fixation group. Although the VAS score was significantly lower in the standalone group after 12-month follow-up ($P = 0.026$), the follow-up mean VAS at 24 months was not significantly different.

Concerning the NDI, our study showed marked improvement in both groups from a mean of 32.6 ± 7.62 preoperatively to 11.84 ± 1.65 in Group I and from 36.92 ± 6.05 to 11.48 ± 1.42 in Group II, after 24 months with no significant statistical difference between the two groups ($P = 0.412$). Our results reaffirm the study published by Zavras *et al*.[10] In this study, there was no significant statistical difference regarding the NDI after 12 months between the two groups. Accordingly, Yu Chen *et al*.[14] reported similar results regarding the NDI.

Contrary to our results, Etemadifar, *et al.*[15] found that there was a significant difference between the groups according to the NDI scores in the postoperative period, as the postoperative NDI scores in the stand-alone group were lower than the other groups ($P < 0.0001$).

As a result of cervical degeneration, intervertebral height and cervical lordosis decrease. The reconstitution of cervical lordosis by ACDF has been reported by pulling the involved vertebral bodies toward the lordotic ventral plate. Regarding the postoperative radiologic evaluation in our study, both FSA and rate of fusion were evaluated preoperatively and postoperatively at 6, 12, and 24 months. Our study showed that the postoperative FSA was higher in the plate group with significant statistical difference with $P < 0.001$. According to our study, it was believed that the core technique was to distract and restore disc height, which could correct the in-buckling of the ligamentum flavum and restore the alignment of the cervical spine.

In the meta-analysis by Cheung *et al*.,[8] ten studies reported pre- and postoperative C2-C7 Cobb angles. The cage-only group had a significantly smaller postoperative C2-C7 Cobb angle than the cage-plate group (mean difference 1.44, $P = 0.04$).

Paolo *et al*.[16] reported that the use of anterior plate fixation versus stand-alone cage was associated with greater segmental lordosis ($-7.68 \pm 4.82°$ versus -0.02 ± 8.44, $P < 0.0001$). In addition, Wang *et al*.,[17] showed comparable results; the amount of kyphotic deformity of the fused segment was 0.4 in patients with plating compared with 4.9 in those without plating ($P = 0.0001$). Yu Chen *et al*.[14] also found that the loss in the fused segment angle was significantly greater in Group A (3.1 ± 2.7) than Group B (1.7 ± 2.1) ($P = 0.039$). On the other hand, Fayed, *et al*.[9] reported opposite results. There was no significant difference between the two groups in cervical lordosis after follow-up ($P = 0.366$). We concluded that the actual significance of preserving the normal contour of the cervical spine is not known. A kyphotic posture of the cervical spine may lead to the development of adjacent segment degeneration. However, a longer follow-up period is needed to confirm a relationship.

Maintaining the stability of the cervical spine is an essential purpose for ACDF. No matter what kind of fixation is used, the final goal is to achieve fusion and improve the fusion rate. In this study, we carried out a radiological assessment of fusion at 6 months, 1 and 2 years. Assessment of fusion was done according to Brantigan and Steffee criteria.[7] There was no significant difference between both studied groups regarding radiological fusion, *P* value (0.774 and 1), respectively. Fusion rate in Group I was present in 10 of 25 cases (40%) by 6th month and 21 of 25 cases (84%) by 1 year. Four cases developed pseudoarthrosis. In Group II, fusion was present in 11 of 25 cases (44%) by the 6th month and in 22 of 25 cases (75%) by 1 year, whereas 3 cases showed pseudoarthrosis.

The study by Jae Keun Oh *et al*.,[18] included 54 consecutive patients who underwent 2-level ACDF-CAGE or ACDF-PLATE. They found that solid fusion was achieved in 96.43% (27/28) in Group A and in 96.15% (25/26) in Group B with no significant statistical difference between the two groups.

Correspondingly, the study by Sam Yeol *et al.*[13] revealed similar results as fusion rates in the two-level patients were similar between groups (cage-only, 83.3%; cage-with-plate fixation, 95%; $P = 0.31$).

Opposite to our results, the study by Wang *et al*.,[17] showed significantly less graft collapse and resultant kyphosis of the fusion segment occurred in the patients treated with cervical plating than in patients without plates in whom a pseudarthrosis developed.

CONCLUSION

In our study, we have found that the use of stand-alone cages in two-level ACDF or more had a shorter operative time and hospital stay when compared to ACDF with anterior plating. After 1 year, we identified a greater FSA in the plate group. However, there was no significant statistical difference in the clinical outcome after 1-year follow-up between the two groups.

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Nil.

Conflicts of interest
There are no conflicts of interest.

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