

The Impact of Plate Application on the Sagittal Plane Correction after Anterior Cervical Discectomy and Fusion Compared to Stand-Alone Cage

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ABSTRACT

Background Data: Anterior cervical discectomy and fusion (ACDF) is the treatment of choice for cervical degenerative disc disease, which causes neurological symptoms such as radiculopathy and/or myelopathy. Anterior cervical discectomy and fusion with stand-alone cage (ACDF-CA) is a successful option to treat cervical disc disease, but long-term follow-up showed complications like cage subsidence and pseudoarthrosis. Then, anterior cervical decompression and fusion with cage and plate (ACDF-CP) was developed to decrease complications of the stand-alone cage; however, it showed complications like dysphagia.

Study Design: This is a retrospective clinical case series.

Purpose: To compare the role of anterior plate constructs (ACDF-CP) and stand-alone cage (ACDF-CA) in maintaining sagittal plane correction.

Patients and Methods: We retrospectively reviewed the lateral cervical radiographs of all patients who underwent ACDF-CA or ACDF-CP between 2011 and 2015. Radiological findings (cervical lordosis, segmental lordosis, cage subsidence, and disc height) were compared (preoperatively, immediately, and 6 and 12 months postoperatively).

Results: Sixty-five patients underwent ACDF, including 88 operative disc levels, 29 (44.6%) ACDF-CA, and 36 (55.6%) ACDF-CP. There were 41 (63.1%) males and 24 (36.9%) females, with a mean age of 47.7 ± 9.32 years. Forty percent of the procedures were conducted by orthopedic spine surgeons and 60% by neurosurgeons. The most common operated level was C5-C6 followed by C6-C7. Initially, ACDF-CA showed better surgical correction than ACDF-CP in terms of cervical lordosis and segmental lordosis but did not reach the statistically significant value ($p = 0.692$, CI: [-4.8]-7.28), whereas ACDF-CP maintains these corrections more than ACDF-CA at final follow-up despite being statistically insignificant ($p = 0.506$, CI: [-7.05]-3.54). No difference was detected in disc height and cage subsides between the two groups.

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Conclusion: The data in this study may suggest that the ACDF-CA construct was slightly better than ACDF-CP in the surgical correction of the cervical curve, whereas ACDF-CP maintained the correction at final follow-up despite the insignificant statistical value. (2020ESJ216)

Keywords: ACDF, ACDF-CP, ACDF-CA, plate, cage, cervical disc, spondylosis, lordosis

INTRODUCTION

Anterior cervical discectomy and fusion (ACDF) is the treatment of choice for cervical degenerative disc disease, which can cause neurological symptoms, including radiculopathy and myelopathy.^{19,14} It can be done using multiple techniques that utilize different types of implants, including disc spacers made of autograft or allograft bone, porous metal, polyether ether ketone (PEEK), and anterior plates and screws.¹⁰ Anterior cervical discectomy and fusion with stand-alone cage (ACDF-CA) has proven to be a successful option to treat cervical disc disease, but long-term follow-up showed complications like cage subsidence and pseudoarthrosis.^{3,27} These complications negatively affect the clinical outcome of this method. Another technique that is anterior cervical decompression and fusion with cage and plate (ACDF-CP) was then developed to decrease the complications of the stand-alone cage; however, follow-up showed its own set of complications such as dysphagia.⁵ The purpose of this study is to compare the role of ACDF-CP and ACDF-CA in the maintenance of sagittal plane correction. Radiological findings (cervical lordosis, segmental lordosis, cage subsidence, and disc height) will be compared (preoperatively, immediately, and 6 and 12 months postoperatively).

PATIENTS AND METHODS

This is a retrospective review of all patients who underwent ACDF-CA or ACDF-CP between 2011 and 2015 after obtaining ethical approval from the Medical Research Center, Hamad Medical Corporation, Doha, Qatar. The data of the relevant procedures were retrieved from our

institution's medical records and were tabulated in the standard format. All patients with complete clinical, radiological, and contact data who underwent either ACDF-CA or ACDF-CP for cervical degenerative disc disease were reported, while those with incomplete data, with other pathologies, treated with other procedures, or lost to follow-up were excluded.

At our institution, the choice of the surgical technique was dependent on the surgeon's preference and experience. The following data were collected by two coauthors: (1) general demographics (age, gender, orthopedic or neurosurgery spine surgeon, surgery level, number of levels, and type of surgery) and (2) radiological measurements on the lateral cervical spine X-ray at different follow-up intervals (preoperatively, immediately, and 6 and 12 months postoperatively) (Figure 1) such as (a) cervical lordosis measured by Cobb's angle between the inferior endplate of the C2 vertebral body and the inferior endplate of the C7 vertebral body; (b) segmental lordosis measured using Cobb's angle between the upper endplate of the most cranial vertebral body and the lower endplate of the most caudal vertebral body in the surgical level; (c) cage subsidence defined as the distance between the midpoint of the upper margin of the upper vertebral body and the lower margin of the lower vertebral body in the surgical level; (d) disc height defined as a vertical distance in the middle of disc space on a surgical level.

We define the surgical correction as the difference in measurements postoperatively and preoperatively, whereas the loss of correction is defined as the difference in measurements between the last follow-up and postoperatively. All measurements were done by two orthopedics residents trained by a senior surgeon.

Statistical Analysis

Descriptive statistics were used to summarize demographic and radiological measurements.

Chi-square test and Fisher's exact test were used to express the associations between two or more qualitative variables as appropriate, whereas unpaired *t*-test was used to compare the quantitative data between the two groups. Frequency (percentage) and mean \pm SD or median and range were used for categorical and continuous values as appropriate. *p* value <0.05 was statistically significant. All statistical analyses were conducted using statistical packages SPSS 23.0 (SPSS Inc., Chicago, IL) and Epi Info™ 2000 (Centers for Disease Control and Prevention, Atlanta, GA)

RESULTS

From a total of 103 patients who underwent ACDF at our institution during the study period, we excluded 22 patients who had had ACDF for other pathologies such as trauma or infection and 16 were also excluded from the study because of inadequate radiographs and follow-up.

A total of 65 patients with 88 operated disc levels who had complete data were included in our study. There were 29 (44.6%) patients who underwent ACDF-CA and 35 (55.4%) ACDF-CP. The mean age was 47.7 ± 9.32 years, where the male/female ratio was 2/1. Most patients (60%) were operated on by neurosurgeons, and the most affected levels were C5-C6 (46.6%), followed by

C6-C7. The mean duration of follow-up was 23.3 months (range, 12–36 months). There were no significant preoperative demographic differences between the two groups. The detailed preoperative demographic data for both groups are presented in Table 1.

Cervical Lordosis. The mean value of surgical correction in ACDF-CA patients was $1.26 + -13.1$ degrees, whereas it was $0.05 + -11.5$ in ACDF-CP patients with no statistical difference between the two groups ($p = 0.692$). The loss of correction was similarly not significant between the two groups ($p = 0.506$). (Table 2 and Figure 2)

Segmental Lordosis. Although the surgical correction of segmental lordosis was better in ACDF-CA ($2.3 + -4.5$ degrees) compared to ACDF-CP ($0.8 + -6.1$ degrees), there was no statistical difference detected between the two groups ($p = 0.283$). The loss of correction was more in ACDF-CP ($-2.5 + -5.1$ degrees), but the difference did not reach statistical difference ($p = 0.281$) (Table 2 and Figure 2).

Disc Height. A similar difference was observed in the disc height between the two groups in terms of surgical correction and loss of the correction ($p = 0.819$ and 0.844 , resp.) (Table 2 and Figure 2).

Cage Subsidence. Although the cage subsidence was less in ACDF-CP patients ($-0.08 + -0.25$ mm) compared to ACDF-CA ($-0.2 + -0.28$ mm), there was no statistical difference detected between the two groups ($p = 0.120$) (Table 2 and Figure 2).

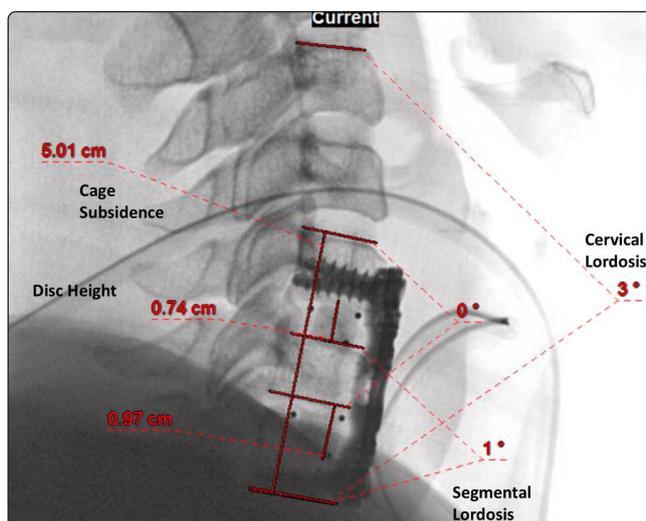


Figure 1.
Radiological
parameters
measurements
reported in
this study.

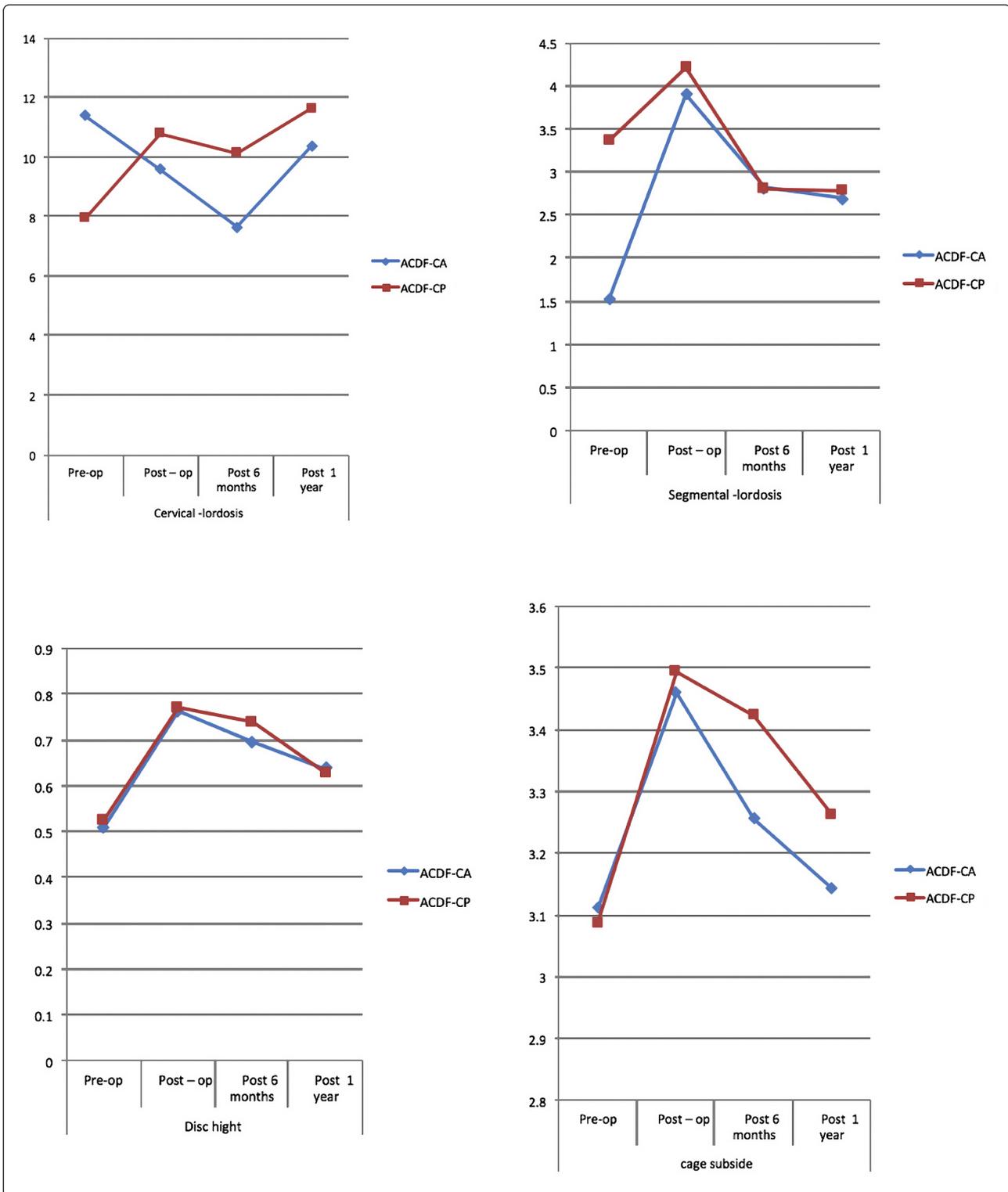


Figure 2. Summary of reported radiological parameters in this study graphically represented.

Table 1. Demographic data of patients reported in this study.

Parameters		total	ACDF-CA	ACDF-CP	p value
Number of patients		65	29 (44.6%)	35 (55.4%)	
Number of levels		88	35	50	
Age/years		47.7±9.32	47.50±9.7	48.02±9.07	0.944
Gender	Male	41 (63.1%)	18 (43.9%)	23 (56.1%)	0.634
	Female	24 (36.9%)	12 (50.0%)	12 (50.0%)	
Surgeon	Orthopedics	26 (40%)	11 (40.7%)	15 (59.3%)	0.585
	Neurosurgery	39 (60%)	19 (47.5%)	20 (52.5%)	
Surgery level	C3-C4	11 (12.5%)	6 (54.5%)	5 (45.5%)	0.722
	C4-C5	17 (19.3%)	6 (42.9%)	8 (57.1%)	
	C5-C6	31 (46.6%)	12 (38.7%)	19 (61.3%)	
	C6-C7	19 (21.6%)	6 (54.5%)	5 (45.5%)	

Table 2. Summary of radiological outcomes parameters in this study.

Parameters	ACDF-CA	ACDF-CP	CI	P value
Cervical lordosis (degree)				
Preoperative	9.92±14.5	9.12±13.4	-5.16,6.76	0.790
Immediately postoperatively	9.6±9.4	10.8±8.9	-5.71,3.29	0.593
6 months postoperatively	7.6±9.4	10.1±6.5	-7.19,2.15	0.284
12 months postoperatively	10.3±5.4	11.6±8.3	-6.90,4.39	0.650
Difference between preoperatively and immediately postoperatively	1.26±13.1	0.05±11.5	-4.86,7.28	0.692
Difference between immediately and 12 months postoperatively	-0.7 ±8.6	1.05±7.2	-7.05,3.54	0.506
Segmental lordosis (degree)				
Preoperatively	1.5±6.1	3.3±5.1	-4.65,0.97	0.196
Immediately postoperatively	3.9±4.7	4.2±4.1	-2.46,1.8	0.770
6 months postoperatively	2.8±5.6	2.8±4	-2.80,2.82	0.994
12 months postoperatively	2.6±4.6	2.7±4.5	-3.74,3.55	0.958
Difference between preoperatively and immediately postoperatively	2.3±4.5	0.8±6.1	-1.25,4.21	0.283
Difference between immediately and 12 months postoperatively	-0.8±3.5	-2.5±5.1	-1.3,4.6	0.281
Disc height (cm)				
Preoperatively	0.5±0.14	0.5±0.16	-0.09,0.06	0.678
Immediately postoperatively	0.7±0.15	0.7±0.14	-0.07,0.06	0.863
6 months postoperatively	0.6±0.14	0.7±0.2	-0.15,0.05	0.383
12 months postoperatively	0.6±0.18	0.6±0.16	-0.13,0.15	0.894
Difference between preoperatively and immediately postoperatively	0.26±0.19	0.25±0.17	-0.8,0.1	0.819
Difference between immediately and 12 months postoperatively	-0.12±0.12	-0.12±0.14	-0.08,0.1	0.844
Cage subsidence (mm)				
Postoperatively	3.4±0.31	3.4±0.44	-0.22,0.16	0.729
6 months postoperatively	3.2±0.35	3.4±0.52	-0.42,0.09	0.209
12 months postoperatively	3.1±0.31	3.2±0.49	-0.44,0.21	0.465
Difference between immediately and 12 months postoperative	-0.2±0.28	-0.08±0.25	-0.88,0.03	0.120

DISCUSSION

ACDF has been accepted as the gold standard for the management of cervical degenerative disease¹⁹; however, controversy remains with regard to the choice of the technique utilized. There is no clear verdict on whether ACDF-CP is superior to ACDF-CA. In this study, we compared plated (ACDF-CP) to nonplated (ACDF-CA) techniques performed on patients with degenerative cervical disc disease at a tertiary care hospital by contrasting radiologic outcomes with a follow-up duration of 1 year. We also provided a review of clinical outcomes, complications, and cost analysis of the two approaches.

Sagittal alignment is essential for preventing vertebral degenerative changes postoperatively;¹⁴ therefore, its calculation has been an appropriate proxy for the evaluation of the outcome of either approach. For assessment of cervical lordosis, we used the modified Cobb's angle approach between C2 and C7, as it has been shown to have high interexaminer reliability. Our results indicate that ACDF-CP and ACDF-CA are both equally effective in maintaining cervical lordosis and segmental lordosis up to 1 year after the operation. In both approaches, the pattern of cervical angle change was such that an increase in cervical lordosis was observed between the periods of 6 months and 1 year postoperatively. This was observed in other studies as well and is explained by the process of isolated posterior subsidence of vertebral bodies, which does not occur until late in the postoperative period, explaining the delayed change in the angle. Segmental angle change, on the other hand, had a pattern of decrease in the period between 6 months and 1 year. This has been hypothesized by Jagannathan et al.¹⁰ to be the result of instrumentation causing a kyphotic change at the segmental level, accompanied by compensatory lordotic changes at the uninvolved cervical levels.

There are varying results in the literature comparing ACDF-CA to ACDF-CP with regard to cervical

lordosis, and a mix of studies show disagreement on the presence of significant difference in cervical lordosis.^{5,27} However, other studies showed no significant difference between CP and CA which is in agreement with our results.^{12,17}

Disc height was also assessed in this study. It was included as a parameter because of its direct association with the vertical distraction of the anterior column that contributes to spinal cord decompression.¹ We found that there was no significant difference in disc height between the two techniques. Additionally, they both showed a similar and predictable trend of increase in height immediately postop, followed by a small decrease at last follow-up. One-year follow-up disc height was still maintained at higher levels than preop, which is desirable for decompression.

The literature on disc height and cage subsidence is also conflicting. Some studies showed a higher rate of subsidence in ACDF-CA and explained that cage alone does not provide sufficient stabilization of the cervical spine.^{26,20} However, more recent studies have reflected similarities in radiologic outcomes between ACDF-CA and ACDF-CP. A study of 54 patients showed no significant differences in disc height between patients undergoing the two different operative techniques.^{12,17}

There is a consensus in the literature that ACDF is an effective surgical intervention as it has been shown to improve clinical outcomes.¹⁸ A common grading scale for clinical outcomes of ACDF is Robinson's criteria, which classify outcomes qualitatively as viewed by the patient and use the categories Excellent, Good, Fair, and Poor.¹⁹ An excellent outcome is defined as resolution of symptoms without the need for NSAIDs use and with no impairment of daily living.

Multiple studies reported no significant difference in the number of patients achieving an excellent or good clinical outcome with regard to radiculopathy symptoms.^{20,17} Mobb et al.¹⁶ conducted a study of 242 patients, compared the clinical outcomes between ACDF with cage alone and with plate augmentation, and found no significant difference

in the number of patients achieving an excellent outcome in both groups.

Another form of assessment of clinical outcomes is the Visual Analogue Scale (VAS) that considers neck and arm pain. In their study, Bhadra et al.² assessed clinical outcomes using VAS and found no difference in clinical outcomes. An interesting study proposed that decreased cervical lordosis is associated with local symptoms such as neck pain and stiffness and not with radicular symptoms. This is due to the effect of cervical lordosis on the alignment of muscles and ligaments of the neck, while the relief of radicular symptoms is dependent on spinal root decompression.²²

Even though ACDF has an excellent outcome, occasionally, some complications are encountered. Postoperative dysphagia, hematoma, and recurrent laryngeal nerve palsy were the most common complications.⁹ ACDF-CP has complications related to the plate, such as hardware fractures, screw back-out, migration, and poor positioning.^{21,13}

The prevalence of complications is low, making it difficult to adequately compare them between ACDF-CA and ACDF-CP, given that most studies look at a limited number of patients. However, the majority of studies report that dysphagia occurred more frequently in patients undergoing ACDF-CP.^{16,26,12,8} This is thought to be due to the more vigorous manipulation that occurs intraoperatively in the plated approach. However, most cases of dysphagia are transient, all resolving within 6 months or less.²⁰ In one study, pseudoarthrosis was observed more commonly in the cage alone approach; however, it was still associated with a lower incidence of graft collapse compared to the plate augmented approach.²³ A study conducted by Connolly et al.⁴ showed that the rate of complications with plate was as high as 24% of patients.

A group of studies that had a relatively prolonged follow-up period were able to assess the incidence of adjacent level disease. Song et al.²⁰ showed that adjacent level disease occurred in 12.5% of individuals who underwent ACDF-CP compared

to 7.9% in those who underwent ACDF-CA. Other studies reported similar findings and explained that this finding is likely due to the immobilization of the vertebral by the plate, which puts higher stress on the levels adjacent to the fused vertebra.^{12,11}

The rates of patients requiring reoperation after ACDF have been variable but are commonly due to graft extrusion or pseudoarthrosis.⁶ Epstein et al.⁷ conducted a study comparing the preoperative rates between cage alone and cervical plate augmentation and did not find a significant difference in the number of patients requiring reoperation in the two groups. On the other hand, Mobbs et al.¹⁶ found ACDF-CA patients to require a significantly higher rate of reoperation with the addition of plate fixation to these patients.

In previous studies, it has been shown that the cage alone technique is a less costly approach.²⁴ However, since complication rates and reoperation rates are variable in different studies, a clear cost analysis is hard to extrapolate. The UK published paper carried a cost analysis for multiple approaches to cervical radiculopathy, which included cage only and cage and plate constructs.² The cost of ACDF-CP was 50% higher than that of using ACDF-CA. The higher cost was attributed to the longer inpatient stays for patients undergoing plated augmentation and the higher cost of the operation. The study found that patients undergoing plated augmentation required an average of 5 days of inpatient stay compared to 2.5 days for patients undergoing the cage only approach. None of the patients included in the study required reoperation; therefore, the aspect of reoperation costs was not a part of their analysis. Another study conducted by McLaughlin et al.¹⁵ showed that the cost of addressing complications is higher for the ACDF-CP. The study also showed that operative times were longer in ACDF-CP, increasing both the cost of operation and anesthesia.

In view of the findings of our study and the review of literature, the ACDF-CA construct was found to be slightly better than ACDF-CP in the short term. Despite the lack of consensus on radiologic

findings, it is the clinical outcome that determines the effectiveness of a procedure. Additionally, the lower incidence of complications, lower cost, and shorter operative time further support opting for ACDF-CA over ACDF-CP.

Finally, the limited follow-up time, small patient population, and the retrospective nature of this study limit the effectiveness and generalization of our conclusions. Also, another limitation is that we did not correlate radiological and clinical outcome parameters in our patients. Therefore, further follow-up studies with a larger patient population and a more prolonged follow-up period in this field are highly needed.

CONCLUSION

The data in this study may suggest that the ACDF-CA construct was slightly better compared to ACDF-CP in the surgical correction of the cervical curve, whereas ACDF-CP maintained the correction at final follow-up despite the insignificant statistical value.

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الملخص العربي

تأثير الشريحة العنقية على تصحيح المستوى السهمي بعد استئصال الغضروف العنقي الأمامي والالتحام مقارنةً بالقفص المستقل.

البيانات الخلفية: استئصال الغضروف العنقي الأمامي والالتحام هو العلاج المختار لمرض الغضروف التنكسي العنقي الذي يسبب أعراضاً عصبية مثل اعتلال الجذور أو اعتلال النخاع. يعتبر استئصال الغضروف العنقي الأمامي والالتحام مع القفص المستقل هو خياراً ناجحاً لعلاج مرض الغضروف العنقي، لكن المتابعة طويلة المدى أظهرت مضاعفات مثل هبوط القفص والتهاب المفاصل الزائف. بعد ذلك، تم تطوير تخفيف ضغط عنق الفقرات العنقية الأمامي والالتحام مع القفص والصفحة الحاملة لتقليل مضاعفات القفص القائم بمفرده ولكنه أظهر مضاعفات مثل عسر البلع.

تصميم الدراسة: سلسلة حالات سريرية بأثر رجعي.

الغرض: لمقارنة دور تركيبات الشريحة الأمامية والقفص المستقل في الحفاظ على تصحيح المستوى السهمي **المرضي و الطرق:** راجعنا بأثر رجعي الصور الشعاعية الجانبية للفقرات العنقية لجميع المرضى الذين خضعوا لاستئصال الغضروف العنقي والالتحام عن طريق قفص أو قفص و صفحة قائمة بذاتها بين عامي 2011 و 2015. تمت مقارنة النتائج الإشعاعية (قعس الفقرات العنقية، قعس قطعي، هبوط القفص، ارتفاع القرص) (قبل العملية، 3-6 أشهر بعد العملية، 12 شهراً بعد العملية).

النتائج: خضع 65 مريضاً للاستئصال الغضروف العنقي والالتحام، و 88 مستوى جراحياً، و 29 (44.6%) باستخدام قفص مستقل و 36 (55.6%) باستخدام قفص و شريحة. كان هناك 41 (63.1%) من الذكور و 24 (36.9%) من الإناث، متوسط العمر 47.7 سنة (40%)، SD: 9.32، قام بها جراح العمود الفقري العظمي و 60% بواسطة جراح الأعصاب. المستوى الأكثر شيوعاً هو C5-C6 يليه C6-C7. أظهر القفص المستقل تصحيحاً جراحياً أفضل من القفص و الشريحة فيما يتعلق بقعس الفقرات العنقية والقعس القطاعي ولكنه لم يصل إلى الدلالة الإحصائية (قيمة -7.28، CI: [-4.8]، p: 0.692) حيث يحافظ القفص و الشريحة على هذا التصحيح أكثر القفص المستقل في المتابعة النهائية على الرغم من عدم أهميتها إحصائياً (قيمة -3.54، CI: [-7.05]، p: 0.506). لم يتم الكشف عن اختلاف في ارتفاع الغضروف و هبوط القفص بين مجموعتين.

الخلاصة: وجد أن استئصال الغضروف العنقي والالتحام مع بناء القفص المستقل مفضل مقارنةً باستخدام قفص مع الشريحة في التصحيح الجراحي والحفاظ على التصحيح في المتابعة النهائية على الرغم من عدم وجوده إحصائياً