Online ISSN : 2314-8969
Print ISSN: 2314-8950
www.esj.journals.ekb.eg

The EGYPTIAN SPINE Journal

CLINICAL ARTICLE EgySpineJ 40:65-76, 2021 DOI: 10.21608/ESJ.2022.102741.1200

A Comparison between Standalone Cage and Conventional Cage and Plate in Anterior Cervical Discectomy and Fusion for the Treatment of Cervical Spondylotic Myelopathy: An Ambispective Study

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ABSTRACT

Background Data: Anterior cervical discectomy and fusion (ACDF) is accepted as a standard surgical treatment for cervical spondylotic myelopathy (CSM). The options for instrumentation in fusion include standalone cage (SC) and conventional cage and plate (CCP). However, there is no clear consensus regarding the superiority of the technique.

Purpose: To compare the radiologic and clinical outcomes between SC and CCP in ACDF for the treatment of CSM.

Study Design: Ambispective clinical case study.

Patients and Methods: The patients who underwent ACDF for CSM using SC or CCP between January 2014 and December 2018 were included in the study. Forty-six patients out of 230 eligible patients were included in the study. Twenty-six patients underwent CCP, while 20 underwent SC. They were subjected to detailed neurologic and radiologic examination. Neurologic outcome was measured using the Nurick and mJOA scores and dysphagia using the Bazaz score. Fusion was assessed by the presence of bridging trabeculae and absence of movement between the spinous processes of the fused segments with lordosis by Cobbs' angle. We also reported cage subsidence, adjacent segment degeneration (ASD), and implant complications.

Results: Mean follow-up was for four years. The most common level operated was C5/C6. Neurologic status improved significantly in both groups following surgery. The rate of dysphagia was not different between the groups. Fusion was achieved in 92.3% of the CCP group and 90% of the SC group ($p > 0.05$). The rate of subsidence was higher in the SC group ($p = .026$). ASD changes were present in 57% of the CCP group and 80% of the SC group at final follow-up but were insignificant. In both groups, improved

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Submitted: August 10th, 2021.
Accepted: September 23rd, 2021.
Published: October 2021.

The article does not contain information about medical device(s)/drug(s).
No funds were received in support of this work.
The authors report no conflict of interest.

cervical and segmental lordosis were reported, and although the improvement was greater in the CCP group, it was insignificant.

Conclusion: ACDF using both standalone and conventional cages and plates achieved comparable neurologic improvement in CSM. Even though both had comparable fusion rates, cage subsidence was high with standalone cages. (2021ESJ245)

Keywords: anterior cervical discectomy, fusion, standalone cage, conventional plate, cervical spondylotic myelopathy

INTRODUCTION

Anterior cervical discectomy and fusion (ACDF) for degenerative and traumatic pathologies of the spine was pioneered by Cloward, Smith and Robinson, and Dereymaker in the 1950s.[16,17,39] Anterior approach directly addressed the ventral compression, restored the lordosis, and produced excellent clinical outcome.[14,40,44] The strut grafts, though produced sound fusion, resulted in multiple complications due to migration and subsidence and nonfusion in multilevel surgeries.[1,6,42,45,53] This prompted the development of synthetic cages anterior cervical plates for stabilization.[7,21,46] Presently, the popular translational plates allow controlled loading of the graft and achieve better fusion.[41] However, the use of anterior plates not without complications, including adjacent segment disease (ASD)[2], reoperation[43], dysphagia[27], hoarseness [27], implant-related complications, and high nonunion in multilevel surgery.[43] Standalone cages (SC) were developed to reduce the profile of the plate on the ventral surface of the vertebra, thus reducing the dysphagia and the operative time.[51] Biomechanical studies comparing SC and conventional cage and plates (CCP) revealed comparable biomechanical stability between the two designs.[37] Duan et al.[18] in 2016 reported the higher postop mJOA score for SC than that for the plates and also noted an increased rate of subsidence and lower postop Cobb's angles for the SC group. In a recent metanalysis, Zhang et al.[54] concluded that the SC achieved similar clinical relief compared to CCP and produced fewer complications, whereas using CCP resulted in better maintenance of the cervical lordosis. Presently, the superiority of SC in terms of both clinical and radiologic outcomes along with its complications is not well established.

In the present study, we compare the outcomes between SC and CCP in patients who underwent ACDF for cervical spondylotic myelopathy (CSM).

PATIENTS AND METHODS

This study was designed as an ambispective comparative study pattern and was approved by Institutional Ethics Committee. Patients who underwent ACDF at one or two levels for CSM in the department were considered for the study. Inclusion criteria were patients with signs and symptoms suggestive of CSM, concordant findings suggestive of root or cord compression on MRI, and failure of conservative treatment for six weeks. Exclusion criteria were those with a history of previous cervical spine surgery, patients with congenital anomalies of the spine or ossified posterior longitudinal ligament, and patients who needed a posterior approach in addition to an anterior approach.

The patients who fulfilled the criteria were contacted telephonically and informed about the study. The patients underwent detailed neurologic examinations and cervical spine X-rays. Their hospital records, preoperative MRI cervical spine images, preoperative and postoperative cervical spine X-rays including dynamic views, and records of the follow-up visit were examined.

Among the 230 eligible patients who underwent the operation during the study period, 153 patients were contacted over the phone and invited for the

study. Forty-six patients who had complete data and were willing to participate were included in the study. Overall follow-up was 20% in our study.

Surgical Procedure:

The involved levels were approached through the right side using an oblique or a transverse neck incision after confirming the level preoperatively with the C arm. The Caspar retractor system was used to retract the great vessels of the neck and the tracheoesophageal complex. The longus colli was detached from the anterior vertebral surface. After annulotomy, a discectomy was done under microscopic assistance. The disc space spreader was used to retract the disc space using discectomy. After complete discectomy, posterior longitudinal ligament (PLL) was inspected for any defect and fragments posterior to the PLL were also removed. The osteophytes were thinned using a drill and removed using Kerrison punches, confirmed using the C arm. After satisfactory decompression of the cord, the endplates were prepared, and appropriately sized titanium cages (Cedix cage, Jayon, Kerala, India) or SCs (Cedix P, Jayon, Kerala, India), filled with bone from excised local osteophytes, were impacted into the disc space while avoiding over distraction. The SC with a flange is allowed by placing a single screw into the adjacent vertebral bodies through a screw hole in the flange. For those with CCP, a contoured plate (Acelock, Jayon, Kerala, India) of appropriate length was placed over the adjacent segment and fixed using four screws, 2 in each adjacent body (Figures 1–3).

Patients received intravenous antibiotic prophylaxis for 48 hours postoperatively. Patients were usually discharged on the 5th postoperative day. In the postoperative period, they were given a semirigid collar. All of them underwent rehabilitation in the physiotherapy department. The follow-up visits were at 6 weeks, 3 months, 6 months, and 1 year and annually thereafter. Follow-up cervical spine X-rays were obtained at 3 months, 6 months, and 1 year.

Clinical and Radiologic Outcome Parameters:

Nurick grade and mJOA (modified Japanese Orthopedic Association Grade) scores were used to assess the neurologic status preoperatively and

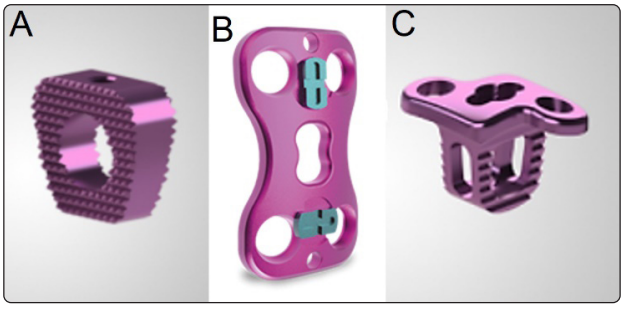

Figure 1. (A) Conventional titanium cage, (B) anterior cervical locking plate, and (C) standalone cervical titanium cage (Jayon, Kerala, India).

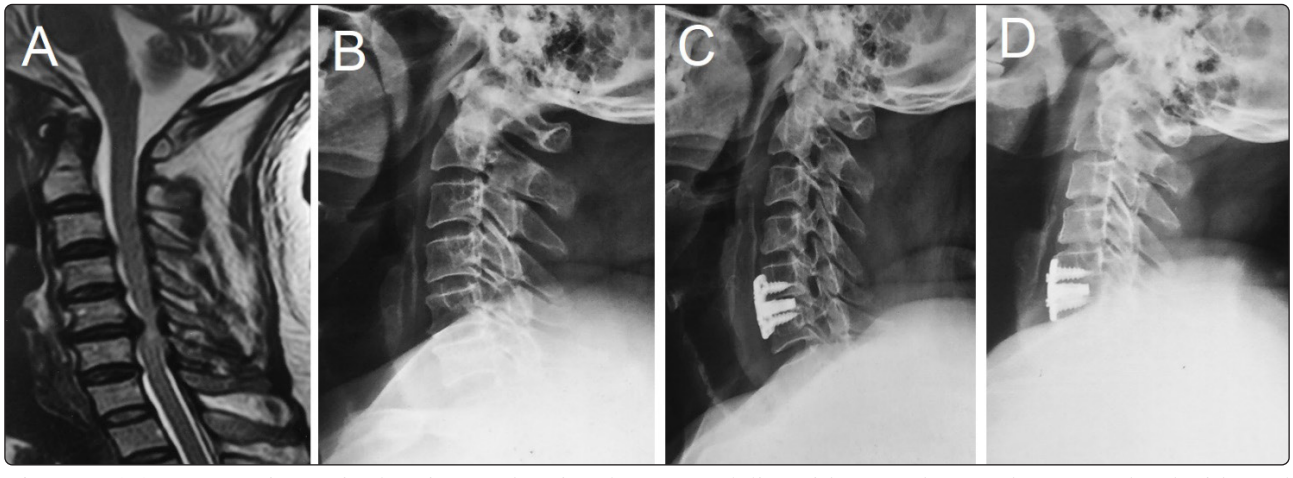

Figure 2. (A) Preoperative sagittal T2 image showing degenerated disc with osteophyte at the C5/C6 level with cord signal changes. (B) Lateral view X-ray showing decreased disc height and posterior osteophyte at the same level. (C) Postoperative lateral X-ray showing fusion with conventional cage and plate. (D) Follow-up X-ray at two years showing sound bone fusion.

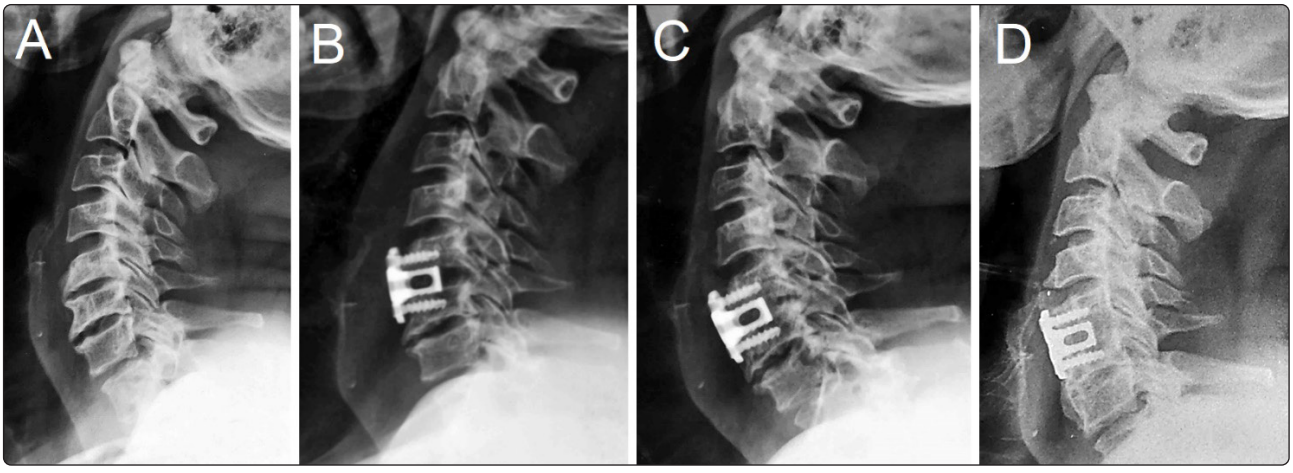

Figure 3. Cervical spine lateral radiographs of a patient who underwent C5/C6 ACDF with standalone cage. (A) Preoperative image showing reduced disc height with anterior and posterior osteophyte at C5/C6 level. (B) Immediate postoperative image. (C) One year after surgery showing implant subsidence. (D) Four-year follow-up showing sound bone fusion.

at follow-ups. Dysphagia was assessed using the Bazaz score. Radiologic outcomes were assessed using neutral and dynamic X-rays. The criteria used for fusion were movement of <2 mm between spinous processes of the fused segments and absence of radiolucency between the implant and the bony surface on lateral X-rays. Subsidence was interpreted as migration of the cage more than 2 mm into the adjacent bodies.[48] The ASD was assessed using criteria proposed by Chung et al.[15] The implant complications were defined by the presence of any of the following; screw pull out, screw breakage, plate loosening, and plate breakage. Cervical lordosis was measured as the Cobb angle between inferior endplates of C2 and C7.[12] Segmental angle was defined as the angle between the superior endplate of the superior vertebra and inferior endplate of the inferior vertebra at the fused level.[12]

Statistical Analysis:

Categorical and quantitative variables were expressed as frequency (percentage) and mean ± SD, respectively. Chi-square test and Fisher's exact test were used to find an association between categorical variables. Mann–Whitney *U* test was used to compare selected quantitative parameters between the types of surgery. For all statistical interpretations, $p < 0.05$ was considered the threshold for statistical significance. Statistical analyses were performed using a statistical software package SPSS, version 20.0.

RESULTS

Forty-six patients underwent discectomy, of which 26 were in the CCP group and 20 in the SC group. The follow-up duration for the entire group ranged from 2 to 6 years. There was no difference in demographic and baseline data between the two groups. The mean age of the CCP group was 45.62 ± 11.32 (range, 26–70) years and 49.10 ± 9.82 (range, 30–67) years for the SC group. The baseline data of each group is given in (Table 1).

The most common level operated was C5/C6 in both groups, including 16 and 10 in the CCP and SC groups, respectively. The neurologic status of patients in both groups improved significantly from their initial preoperative scores. However, there was no significant intergroup difference at any point in time (Table 2). Dysphagia was assessed using the Bazaz grade. Transient mild dysphagia was present in the immediate postoperative period in three patients and two patients in the CCP and SC group, respectively, which resolved spontaneously in 4 weeks (Table 3).

Fusion was achieved in 92.3% of patients in the CCP group, while this was 90% in the SC group and the difference was not statistically significant ($p > 0.05$). The cervical lordosis had increased at 6 months postoperatively from the initial preoperative level. However, both groups tended to partly lose this gain at the end of the follow-up (Table 4).

Table 1. Demographic and baseline clinical variables.

Parameters	Conventional group (n = 26)	Standalone group (n = 20)
Age/years	45.62 ± 11.32 (26–70)	49.10 ± 9.82 (30–67)
Sex (male/female)	21/5	11/10
Comorbidities (%)	10 (38.5)	6 (30.0)
Smoking (%)	10 (38.5)	4 (20.0)
Associated radiculopathy (%)	12 (46.2)	10 (50.0)
Single-level ACDF (%)	16 (61.5)	15 (75.0)
Double-level ACDF (%)	10 (38.5)	5 (25.0)
Details of operated levels (%)		
C3/C4	4 (11.1)	4 (16)
C4/C5	5 (13.9)	6 (24)
C5/C6	16 (44.4)	10 (40)
C6/C7	11 (30.6)	5 (20)

Table 2. Neurologic outcome in both groups of study's patients.

Neurologic status		Conventional group	Standalone group	*p* value
Nurick Grade	Preoperatively	3.00 ± 1.02	2.90 ± 1.02	0.743
	6 months postoperatively	2.35 ± 1.41	2.15 ± 1.14	0.615
	Final follow-up	1.19 ± 0.69	1.2 ± 0.41	0.743
mJOA Score	Preoperatively	12.46 ± 2.90	13.15 ± 1.98	0.368
	6 months postoperatively	13.12 ± 3.10	14.20 ± 2.59	0.214
	Final follow-up	16.15 ± 2.27	16.85 ± 1.27	0.226

Table 3. Bazaz's grading for dysphagia.[5]

Symptom severity	Liquid food	Solid food
None	None	None
Mild	None	Rare
Moderate	None or rare	Occasionally
Severe	None or rare	Frequent (majority of solid foods)

Table 4. Cervical lordosis and segmental angle in both groups of study's patients.

Radiological parameters		Conventional group	Standalone group	*p* value
Cervical lordosis	Preoperatively	19.52 ± 6.13 (12–33)	18.00 ± 7.36 (0–30)	0.454
	6 months postoperatively	25.00 (15–37)	21.50 (4–40)	0.130
	Final follow-up	23.00 (15–33)	20.00 (3–30)	0.088
Segmental angle	Preoperatively	3.68 ± 1.93 (0–9)	3.50 ± 3.03 (2–10)	0.810
	6 months postoperatively	5.08 ± 1.55 (2–9)	4.45 ± 2.91 (0–10)	0.352
	Final follow-up	4.23 ± 2.29 (0–8)	3.20 ± 2.12 (0–7)	0.125

Preoperative radiologic evidence of ASD degenerative changes was present in preop X-rays of 34.6% of the CCP group, while this was 55% in the SC group. Radiographic ASD changes were present in 57% of the CCP group, while this was 80% in the SC group at final follow-up and this was not statistically significant ($p > 0.05$). Two patients in the CCP group and one in the SC group had implant-related complications. All of those were screw pullouts. Subsidence, defined as the migration of the cage into the adjacent vertebral body, was present in 5 patients in the SC group, whereas none in the CCP group showed subsidence, which was significant ($p = 0.026$). Four of these SC subsided cranially, while SC subsided both cranially and caudally in the fifth SC patient. In three patients, subsidence occurred within three months postop, while two patients developed subsidence after three months. However, these patients were not symptomatic for subsidence and eventually achieved fusion without any additional treatment.

There was no incidence of any wound infection, vascular or esophageal injury, or CSF leak in any of the study patients. One patient in the SC group had developed quadriparesis due to postoperative hematoma, which needed urgent evacuation. The patient improved following the evacuation of the hematoma.

DISCUSSION

The reported improvement in neurologic status in both groups is reflected in mJOA and Nurick scores at 6 months postoperatively and at the final follow-up. This points to the effectiveness of the ACDF in addressing the pathology and achieving a thorough decompression in CSM patients. This is in line with the results from numerous studies[3,10,17,19,20,28] in the literature.

Dysphagia is a relatively common occurrence after ACDF with varying rates from 2% to 67%. Bazaz et al.[5] have reported an incidence of chronic dysphagia beyond three months in 12%–35% following ACDF. The possible causes of dysphagia include soft tissue edema, postoperative hematoma, esophageal adhesion following surgery, multiple levels operated, and the thickness and design of plates.[32,36] SC has been associated with a low incidence of dysphagia compared to CCP.[11,49,50] However, our study did not find any difference in dysphagia among the groups (2 in CCP groups vs. 3 in SC group). All those patients had transient mild postoperative dysphagia, which resolved completely in 4 weeks.

At final follow-up, radiographic fusion was achieved in 92.3% in the CCP group and 90% in the SC group. The difference between the groups was not significant. However, the patients who did not achieve radiographic fusion were clinically asymptomatic. There have been contrasting reports of the correlation between clinical outcomes and nonunion. Philips et al.[35] concluded that nonunion is frequently associated with poor outcomes and revision surgery improved the eventual outcome. However, Shiban et al.[38], in a retrospective analysis of 194 patients, who underwent ACDF with SC, with a mean follow-up of 36 months, stated that the clinical outcome is unaffected by fusion status. Noordhoek et al.[34], in a systematic review evaluating fusion after ACDF, reported 15 studies that found no association between bony fusion and clinical outcome. This lack of symptoms can be due to stable fibrous union, whereas mobile nonunion can lead to symptoms.[30] Thus, the nonunion group in the present study needs further long-term follow-up to ascertain whether they will become symptomatic in the future.

Subsidence, defined as the migration of the cage into the adjacent vertebral body through weakened endplate, is another complication seen with cages, with rates up to 61% in SCs. However, various studies have used different criteria for subsidence.[3,25,43] The differing incidence of subsidence in various studies should be interpreted with this in mind. The opinion is varied as to the impact of subsidence on clinical outcomes. In a retrospective study comparing SC and CCP, Jin et al.[26] reported that the occurrence of subsidence had

no impact on the fusion or clinical outcome. The reported risk factors include damaged endplate during endplate preparation, over the distraction of the disc space with oversized cages, titanium cages, bone mineral density, and preoperative cervical alignment.[3,25,43]

In our series, the subsidence occurred in 5 patients (20%) in the SC group, whereas there was no subsidence in the CCP group, which was significant ($p = 0.026$). Four of these SC subsided cranially, while in the fifth SC patient, SC subsided both cranially and caudally. We attribute this to two factors: the use of titanium cages and the absence of stress shielding in SCs. The anterior cervical plates, with its cantilever effect, produce stress shielding on the implant and only partial loading of the cage, thereby resulting in controlled subsidence, which does not occur in SC. The titanium cages have different modulus of elasticity compared to the comparable modulus of vertebral bone. Due to resultant modulus mismatch, the endplates are exposed to greater load, leading to endplate failure.[22] Thus, the repeated loading and stiffer titanium cages might have contributed to the higher incidence of subsidence in our series. The anterior overhang of the superior endplate exposes the anterior part of the endplate to greater load from the cages during flexion movements. This can also predispose to subsidence.

Increased lordotic curvature of the cervical spine in the postoperative period is reported to be associated with better neurologic outcome[47]. Katsuura et al.[29] concluded that patients with postoperative kyphosis were more prone to ASD than patients with normal curvature. These findings suggest the importance of achieving lordosis during surgery. Restoration of cervical lordosis is one of the highlights of the anterior cervical fusion compared to the posterior approach [52]. This gain in lordosis is greater in multilevel fusion.[4,31] Although there is a lack of consensus, many authors have observed that the lordosis achieved with SC is less than that with CCP.[8,13] The clinical implication of this finding on the long-term outcome of the patient is not yet clear. In the present study, fusion with both types of implants improved global cervical and segmental lordosis in respective groups, more so in the CCP group. Both groups lost part of this gain over some time till the final follow-up. This can be due to the progression of the original pathology. Although this was not significant, the tendency for improvement in cervical lordosis was visible more so in the CCP group.

Adjacent segment degeneration is a well-known complication after ACDF. There is no consensus on the etiology of ASD as to whether it is the result of the fusion surgery or the result of the progressive degenerative process. The reported rate of ASD ranges from 25% to 92%.[23] Hilibrand et al.[24] reported an annual incidence of ASD of 2.5% per year with a 10-year cumulative incidence of 25.9%. However, the authors differentiated between two entities: radiologic ASD and clinically symptomatic ASD. Various risk factors for ASD include age, cervical alignment, range of motion (ROM), excessive distraction, and long plate extending to adjacent disc space.[9,33] One of the reported advantages of the SC over CCP is decreased incidence of ASD. In our study, we did not observe any difference in the occurrence of ASD between the SC group and CCP group. Radiologic evidence of ASD increased from 34.6% in the preoperative period to 57% at final follow-up in the CCP group, while these were 55% and 80 % in the preoperative and final follow-up, respectively, for the SC group. The intergroup difference was not statistically significant at the final follow-up. These patients were clinically asymptomatic and were managed expectantly.

Screw pullout was noted in three patients: 2 in the CCP group and one in the SC group, which was not significant. All of them had achieved bony fusion after surgical removal of the backed-out screws.

This study has some limitations. It was designed as an ambispective pattern and the patient response rate was 20%. The restriction on travel due to the COVID-19 pandemic and the patient apprehension about attending the clinic in the hospital, which was a COVID treating center,

can be among the reasons for the low response rate. Patients underwent operations by different surgeons, which can introduce heterogeneity in the population. The study results should be interpreted while keeping the small sample size in mind.

CONCLUSION

ACDF using both standalone and conventional cages and plate achieved comparable neurologic improvement in cervical spondylotic myelopathy. Although both had comparable fusion rates, cage subsidence was high with SCs.

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LIST OF ABBREVIATIONS

ACDF: Anterior Cervical Discectomy and Fusion
ASD: Adjacent Segment Degeneration
CCP: Conventional Plate
CSM: Cervical Spondylotic Myelopathy
mJOA Score: modified Japanese Orthopedic Association Score
PLL: Posterior Longitudinal Ligament
ROM: Range of movement
SC: Standalone Cage

الملخص العربي

مقارنة بين القفص المستقل والقفص التقليدي والشريحه في استئصال القرص العنقي الأمامي والانصهار لعلاج اعتلال النخاع الفقاري العنقي: دراسة غامضة.

البيانات الخلفية: يتم قبول استئصال القرص العنقي الأمامي والاندماج (ACDF) كعلاج جراحي قياسي لاعتلال النخاع الفقاري العنقي (CSM). تشمل خيارات العلاج والاندماج القفص المستقل (SC) والقفص والشريحه التقليدي (CCP). ومع ذلك، لا يوجد إجماع واضح بشأن تفوق أي تقنية.

الغرض: مقارنة النتائج الإشعاعية والسريرية بين SC و CCP في ACDF لعلاج CSM.

تصميم الدراسة: دراسة حالة سريرية غامضة.

المرضى والطرق: تم تضمين المرضى الذين خضعوا لـ ACDF لـ CSM باستخدام SC أو CCP بين يناير 2014 حتى ديسمبر 2018 في الدراسة. تم تضمين ستة وأربعين مريضا من أصل 230 مريضا مؤهلا في الدراسة. خضع 26 مريضا لـ CCP بينما خضع 20 لـ SC. تم إخضاعهم لفحص عصبي وأشعاعي مفصل. تم قياس النتيجة العصبية باستخدام درجات Nurick و mJOA وعسر البلع باستخدام درجة Bazaz. تم تقييم الانصهار من خلال وجود ترابيق الجسر وغياب الحركة بين العمليات الشائكة للقطاعات المنصهرة أثناء القعس بزاوية كوبس. أبلغنا أيضًا عن هبوط القفص وانحطاط الجزء المجاور (ASD) ومضاعفات الزرع.

النتائج: تمت المتابعة لمدة 4 سنوات. كان المستوى الأكثر شيوعًا هو C5 / 6. تحسنت الحالة العصبية بشكل ملحوظ في كلا المجموعتين بعد الجراحة. كان معدل عسر البلع لا يختلف بين المجموعات. تم تحقيق الاندماج في 92.3٪ من مجموعة CCP و 90٪ من مجموعة SC (p> 0.05). كان معدل الهبوط أعلى في مجموعة SC (ع = 026.). كانت تغييرات ASD موجودة في 57 ٪ من مجموعة CCP و 80 ٪ من مجموعة SC في المتابعة النهائية ولكنها لم تكن مهمة. في كلتا المجموعتين تم الإبلاغ عن تحسن قعس عنق الرحم والقطعي وعلى الرغم من أن التحسن كان أعلى في مجموعة CCP إلا أنه كان ضئيلاً.

الخلاصة: استخدام ACDF مع كل من الأقفاص المستقلة والشريحه التقليدية حقق تحسنًا عصبيًا مشابهًا في CSM. على الرغم من أن كلاهما كان لهما معدلات اندماج مماثلة ، إلا أن هبوط القفص كان مرتفعًا في الأقفاص المستقلة.