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Evaluation of Subsidence in Stand-Alone Cervical Cage: Incidence, Risk Factors and Effects on Clinical and Radiological Picture

EVALUATION OF SUBSIDENCE IN STAND-ALONE CERVICAL CAGE: INCIDENCE, RISK FACTORS AND EFFECTS ON CLINICAL AND RADIOLOGICAL PICTURE

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Abstract

Background Data: Anterior Cervical Discectomy and Fusion is the gold standard for treating cervical degenerative disc disease associated with radiculopathy and/or myelopathy. When indicated, surgery can achieve neural tissue decompression and biomechanical stabilization through bony fusion. One of the known complications of stand-alone anterior cervical cage is cage subsidence. Published literature however, contains mixed results in terms of rate of cage subsidence, loss of lordosis and its clinical effects.

Purpose: We report our experience in stand-alone anterior cervical cage, our subsidence rate and its effect on loss of lordosis and clinical picture

Study Design: Retrospective clinical case study.

Patients and Methods: we inserted seventy-two cervical cages (in fifty patients), who had Anterior Cervical Discectomy and Fusion using a stand-alone polyetheretherketone (PEEK) cage under our care. We recorded the self-reported Visual Analogue Score for arm and neck pain and measured the total intervertebral height/disc space or cage ratio, segmental Cobb angle, the distance between the anterior rim of the cage and the anterior vertebral body line, superior or inferior end plate violation and anterior or posterior cage migration on lateral X ray film preoperatively and on each follow up visit (day 1, 7-21 days, 3, and 6 months).

Results: Our cage subsidence rate in the studied sample was 23.6% in 6 months (17 out of 62 cages subsided). We found a statistically significant correlation between immediate postoperative disc height and subsidence (the more distraction we applied to the disc space the more likely subsidence would happen). Cage subsidence did not increase the incidence of recurrence of radicular, myelopathic symptoms or neck pain although it resulted in significant loss of the segmental Cobb angle.

Conclusions: Disc space over-distraction in stand-alone anterior cervical cage significantly increases the risk of subsidence. Subsidence significantly affects the segmental Cobb angle but not the clinical outcome. (2015ESJ077)

Keywords: Anterior Cervical Discectomy, Fusion, subsidence, stand-alone, cage

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Introduction

Anterior cervical discectomy and fusion (ACDF) is the gold standard for the treatment of cervical degenerative disc disease associated with myelopathy and/or radiculopathy.[21] Surgery is usually indicated after failure of conservative measures and it aims at neural tissue decompression in addition to achieving biomechanical stability after bony fusion takes place.[4,8,14] Although some surgeons perform anterior cervical discectomy without fusion, it has been associated with the risk of reduced disc height and focal loss of lordosis in addition to foraminal stenosis, which may result in neck pain and recurrence of radiculopathy.[2,7] As a result of this, fusion is increasingly utilised following anterior cervical discectomy.[1,2,7,23]

Historically, surgeons used tricortical iliac crest bone graft for fusion, however, owing to donor site morbidity there has been a trend to use cervical cage fusion.[15,18-20,22] Polyetheretherketone (PEEK) is a popular material used for cervical cages, as its elastic modulus is similar to bone.[5,17] One of the concerns related to insertion of stand-alone cage in ACDF is cage subsidence which could reduce disc height and lordosis and subsequently result in reduced foraminal height and foraminal narrowing which in turn could lead to worse neck pain and/or recurrent radiculopathy.[9] Published literature contains mixed results in terms of rate of cage subsidence and loss of lordosis in ACDF with a stand-alone PEEK cage.[9,17] The aim of this study is to evaluate our cage subsidence rate and risk factors for subsidence and correlate cage subsidence to clinical findings.

Patients and Methods

Patients who had ACDF operation under our care in Ain Shams University Hospitals over a 4-year period between January 2010 and December 2013 were retrospectively screened for suitability for this study. Patients aged 18-years or older who had de novo cervical radiculopathy (that failed medical treatment for at least six weeks) or myelopathy were included. Patients younger than 18 or older than 70, patients who had previous cervical spine surgery and patients who needed plating were excluded. None of these patients underwent surgery for predominantly neck pain. Patients were routinely followed up for at least six months unless they had significant complaints when they had a prolonged follow up period

Surgical Technique:

We operated on all patients under general anaesthesia using a standard technique: premedication with Paracetamol, intravenous induction, tracheal intubation and maintenance with short acting volatile agent. All patients received about 1 L of crystalloids intraoperatively, prophylactic antibiotics and a dose of non-steroidal analgesia. Anti-emetics were routinely prescribed for post-operative nausea.

We positioned patients supine with a small sand bag between their shoulder blades to achieve a degree of neck extension. Patients' heads were maintained in a neutral position resting on a head-ring.

We used a standard right-sided incision in all cases but C6/7 levels where our preference was to utilise a left-sided approach. Dissection was performed through the standard plane between sternomastoid muscle medially and strap muscles with the underlying larynx and pharynx/oesophagus medially. We used Cloward® retractor in all cases and the blades were placed under the longus colli muscle to avoid undue retraction or injury to the pharynx, oesophagus, larynx and carotid sheath. We preserved the omohyoid muscle in most single and double level but not in three-level cases. After performing the discectomy in the standard fashion, we drill away the lower anterior lip of the upper vertebral body to improve the line of sight. We used Caspar® retractor in all cases but due care was taken to avoid over-distraction. We operated using surgical microscope and a high-speed drill and excised the posterior longitudinal ligament (PLL) in all cases. Unilateral or bilateral uncoforaminotomy was undertaken as required. We used Polyetheretherketone (PEEK) cages filled with synthetic bone graft (biocompatible calcium phosphate) in all cases. Our bias was towards bigger diameter cages and we placed the cage flush with the anterior vertebral line. Cage position was confirmed with image intensifier (II) in all cases prior to retractor removal. Meticulous haemostasis is then done and the wound is closed in layers. Suction drains were not routinely used.

Post-operative Care:

Following return to the wards, once patients are eating and drinking, we encouraged them to mobilise early. Most patients stayed overnight and less patients spent longer time in hospital. Following discharge, patients were offered a quick postoperative check visit (typically at 7-21 days) and follow-up appointments at 3 and 6 months. We asked the patients to score their neck and arm pain on the Visual Analogue Score (VAS) before the operation and in each subsequent follow-up visit. All data were entered and analysed on the SPSS® statistical package (Statistical Programs for the Social Sciences, UK). Differences in VAS were assessed using paired Student's t-test.

Serial Radiological Evaluation:

Our general practice is to obtain an antero-posterior (AP) and lateral cervical spine X-ray for all patients preoperatively, on postoperative day one (before discharge), during the first follow up visit (7-21 days) then at 3 and 6 months for all patients. We followed the patients up beyond the six months (including radiology) only if they had significant complaints otherwise they were discharged.

On the serial X-rays we measured the total intervertebral height (TIVH)/disc space (DS) or cage ratio (Figure 1) and segmental Cobb angle. We also observed the distance between the anterior rim of the cage and the anterior vertebral body line, superior or inferior end plate violation and anterior or posterior cage migration. X-ray measurements (angles and distance) were obtained using ImageJ® computer software (Laboratory for Optical and Computational Instrumentation – University of Wisconsin-Madison, USA)

Results

We operated on seventy-two cervical levels (in fifty patients). Thirty-nine patients were males. Mean ± Standard Deviation (SD) age at the time of surgery was 43.5±9.14 years (range 30-66) and sixteen patients were smokers (22.2%). Nine patients (18%) presented with myelopathy and forty-one (82%) presented with radiculopathy (13 right – 31.7%, 11 left – 26.8% and 17 bilateral – 41.5%). The mean VAS was 5.36 and 6.04 for neck and arm pain respectively. Preoperative radicular weakness was present in 18 patients (36%) and the mean medical research council (MRC) strength score preoperatively was 4.5/5±0.88. The mean duration of symptoms (in general) preoperatively was 3.69 months (range 1-20).

Sixty-six per cent of the patients (N=33) had a single level ACDF, twenty-four per cent (N=12) had two level ACDF and ten per cent (N=5) had 3 Level ACDF. The operated levels were C3/4 (N=9, 12.5%), C4/5 (N=18, 25%), C5/6 (N=25, 34.7%) and C6/7 (N=20, 27.8%). Twenty-three patients (46%) had soft discs and twenty-seven (54%) had disc/osteophyte complex. We had no CSF leak in any case, two patients developed dysphagia and one patient developed hoarseness of voice. No superficial or deep wound infections or other wound related complications were recorded in any case. None of the patients needed intra or postoperative blood transfusion. The mean self reported VAS was reduced to 1.7 (from 5.36) for neck pain and 0.94 (from 6.04) for arm pain prior to discharge.

There was an overall increase in the TIVH/DS ratio from 4.83±0.81 mm preoperatively (range 3-7) to 4.91±0.83 mm on the immediate postoperative X-ray (range 3-8) denoting disc height restoration and in some cases over-distraction although this difference was not significant (P value = 0.298) (Table 1)

Cage Subsidence:

Subsidence (which we defined as sinking of the cage into the superior and/or inferior end plate by more than 2 mm) occurred in a total of 17 out of 72 cages (23.6%) at 6 months.

On the first postoperative day, one cage (1.4%) showed minor violation of the inferior end plate less than 2 mm. By the next follow up visit (7-21 days), sixteen cages (22.22%) had shown variable degrees of end plate violation: four cases (5.6%) showed actual subsidence of more than 2 mm into the inferior with intact superior end plate, ten cages (13.9%) showed a minor settlement into the inferior end plate (less than 2 mm) and two cages (2.8%) showed minor violation of the superior end plate.

On the three-month X-ray, eight cages (11.11%) showed subsidence into the inferior end plate of which one cage had also caused a minor settlement into the superior end plate and nineteen cages showed minor end plate settlements (2 into the superior and 17 into the inferior end plate).

On the six-month X-ray, seventeen cages had subsided (thirteen (18%) inferior subsidence (Figure 2) of which four showed a minor settlement in the superior end plate, three cages (4.2%) had both superior and inferior subsidence (Figure 3) and one (1.4%) superior subsidence with intact inferior end plate). There was a statistically significant inferior end plate subsidence where 76.4% of the subsided cages were into the inferior end plate with intact superior end plate (P value = 0.002). The six-month X-ray also showed minor violation of less than 2 mm in twenty-three cages (16 superior, 5 inferior and 2 superior and inferior end plates) leaving only 32 cages (44.4%) with completely intact superior and inferior end plates (Table 2).

There was a statistically significant correlation between immediate postoperative disc height and subsidence with a P value of 0.001 (Table 3) i.e. the more distraction we applied to the disc space (as represented by the immediate postoperative disc height) the more likely subsidence would happen.

The mean preoperative segmental Cobb angle in our series was 1.01^o (range= -10.430^o to 11.8^o). The angle was kyphotic in twenty-seven discs (37.5 %) and lordotic in forty-five discs (62.5%).

On the immediate postoperative X-ray (day-1), the mean Cobb angle became 6.95^o, (range=1.5^o to 21.6^o) denoting restoration of segmental lordosis. This restoration however was partially lost on serial X-rays to reach a mean of 5.4^o (range= 0^o to 16^o) on the six-month X-ray. This latter change was statistically significant (P=0.001) (Tables 4 and 5).

There was no statistically significant correlation between cage subsidence and age (P-value= 0.642), gender (P-value= 0.830), smoking (P-value= 0.183), operated level (P-value= 0.540), the number of levels in each patient (P-value= 0.861) or distance between the anterior rim of the cage and the anterior vertebral line (P-value= 0.471). Cage subsidence did not increase the incidence of recurrence of radicular, myelopathic symptoms or neck pain although it resulted in significant loss of the segmental Cobb angle.

Figure 1. Postoperative X ray lateral view of a patient who had C4/5 stand-alone Anterior Cervical Discectomy and Fusion demonstrating total intervertebral height (TIVH) and disc height (DH)

Figure 2. Postoperative X ray lateral view of a patient who had C6/7 stand-alone Anterior Cervical Discectomy and Fusion demonstrating inferior cage subsidence

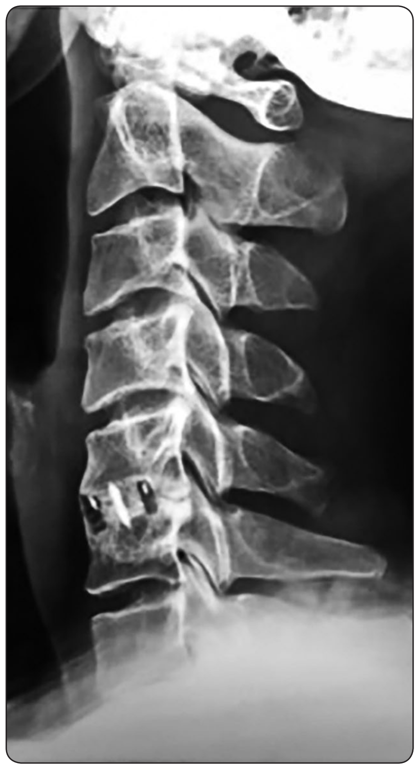

Figure 3. Postoperative X ray lateral view of a patient who had C5/6 stand-alone Anterior Cervical Discectomy and Fusion demonstrating superior and inferior cage subsidence

Table 1. Paired Samples Test Total Intervertebral Height/ Disc Height (TIVH/DH) Ratio.

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	STD	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Preop & Day-1 TIVH/DH Ratio	-0.1400	1.13299	0.133524	-0.406239	0.126239	-1.049	71	0.298

Table 2. Cage Subsidence and Endplate Settlement.

Pattern of violation	Day-1		7-21 days		3 months		6 months	
	Number	%	Number	%	Number	%	Number	%
Intact end plate	71	98.6	56	77.8	45	62.5	32	44.4
Superior settlement	0	0	2	2.8	2	2.8	5	6.9
Inferior settlement	1	1.4	10	13.9	16	22.2	17	23.6
Superior & inferior settlement	0	0	0	0	0	0	2	2.8
Superior subsidence	0	0	0	0	0	0	1	1.4
Inferior subsidence	0	0	4	5.6	7	9.7	9	12.5
Superior & inferior subsidence	0	0	0	0	0	0	3	4.2
Inferior subsidence & superior settlement	0	0	0	0	1	1.4	4	5.6
Total	**72**	**100**	**72**	**100**	**72**	**100**	**72**	**100**

Table 3. Correlation between day-1 Total Intervertebral Height/ Disc Height (TIVH/DH) & Subsidence at 6 Months

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	STD	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	TIVH/DH Ratio Day-1-Violation at 6 mos	2.925278	2.437608	.287275	2.352468	3.498088	10.183	71	.001

Table 4. Changes in Segmental Cobb Angle, Descriptive Statistics.

	N	Min	Max	Mean	STD
Cobb Angle Day-1	72	1.500	21.600	6.94597	3.704793
Cobb Angle Day 7-21	72	.020	17.000	6.21547	3.264790
Cobb Angle 3 Months	72	.800	16.000	5.82500	3.188348
Cobb Angle 6 Months	72	.000	16.000	5.36846	3.319887
Valid N (listwise)	72				

Table 5. Change in Segmental Cobb Angle between Day-1 and 6 Months Postop - Paired Samples Test.

		Paired Differences					t	Df	Sig. (2-tailed)
		Mean	STD	Std Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Day-1/6 mos Segmental Cobb Angle	1.577514	3.234950	.381243	.817338	2.337690	4.138	71	.001

Discussion

Anterior cervical discectomy and fusion (ACDF) is currently considered the gold standard for treating symptomatic degenerative disc disease presenting with radiculopathy and/or myelopathy[21] although ACD without fusion is still the practice of some surgeons.[10] Cage Subsidence is one of the concerns after ACDF with a stand-alone cage and is defined as the sinking of a body with a higher elasticity modulus (e.g., graft, cage, spacer) into a body characterized by a lower elasticity modulus (e.g., vertebral body), resulting in changes in spinal geometry.[9,11-13,16]

Different rates of cage subsidence are present in published literature. In their study, Gercek et al,[9] found a very high rate of cage subsidence of 62.5% with loss of disc space height and subsequent foraminal stenosis and suggested that this could lead to recurrence of symptoms although it actually happened in only one patient. Their study however had its limitations including the small number (eight patients). Other studies[2,24] failed to show any significant correlation between cage subsidence and clinical picture. Bartels et al,[3] studied cage subsidence in stand-alone carbon fibre cages and although their rate of subsidence was higher than other studies (nearly 30%). Our subsidence rate although in keeping with published literature, is relatively high (26.3% in 6 months). Other studies[5] however had much lower rates of cage subsidence or no subsidence at all.

In keeping with Bartels et al,[3] findings and unlike Gercek e al,[9] suggestions, our relatively high cage subsidence rate had no significant effect on the overall clinical outcome.

Of the studied factors that could lead to worse cage subsidence, Bartels et al,[3] only found a relation between cage subsidence and smoking albeit statistically non-significant and they reported that cages implanted at C6/7 level were more likely to subside. This was different to our findings where in our series; there was no significant relationship between the operated level and subsidence and also no correlation between smoking and subsidence.

El-Tantawy[6] suggested avoiding Caspar® distraction and using skull traction instead to reduce subsidence as he identified over-distraction as one of the main factors leading to subsidence. He also found avoiding PLL excision useful in reducing over-distraction which could improve subsidence rates (only 8.5% in his study). Barsa and Suchomel[2] found no statistically significant correlation between disc space over-distraction and subsidence. They however concluded that the more the cage is posteriorly placed in relation to the anterior vertebral line, the more likely it would subside. In contrary, we found a statistically significant correlation between the disc space height on the first postoperative day (denoting over-distraction) but not the posterior cage placement and cage subsidence. Our general tendency to use over-sized cages in some cases was mainly for fear of cage migration and dislodgement.

Conclusion

Cage subsidence following stand-alone ACDF is common. Of the studied factors, we only found over-distraction (represented as immediate postoperative increase in disc height) to significantly increase cage subsidence. No significant correlation was found between subsidence and age, gender, smoking, operated level or posterior cage placement. Cage subsidence didn't affect the clinical outcome during the study period but significantly affected the segmental Cobb angle. A prospective study with longer follow up is recommended to define the long-term effect particularly of loss of segmental Cobb angle on the clinical picture and adjacent segment.

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الملخص العربي

تقييم التغول في حالات تثبيت الفقرات العنقية بقفص منفرد: معدل حدوثه و العوامل المؤدية إليه وتأثيره على الحالة الأكلينيكية و التقييم الإشعاعي

البيانات الخلفية: يعد استئصال الغضروف العنقي الأمامي مع دمج الفقرات العلاج الأمثل حاليا في حالات انزلاق الغضروف الضاغط على جذور الأعصاب أو النخاع الشوكي مؤديا إلى آلام بالذراع أو الاعتلال النخاعي. تؤدي الجراحة إلى رفع الضغط عن الأنسجة العصبية مع تثبيت و دمج الفقرات مما يؤدي إلى استقرار العمود الفقري. اعتاد الجراحون في الماضي على استئصال الغضروف بدون دمج الفقرات إلا أن ذلك قد يؤدي إلى فقدان ارتفاع الغضروف والضغط على جذور الأعصاب وقت مغادرتها للقناة العصبية عن طريق الثقب العصبي مما حدا بالكثير من جراحي العمود الفقري إلى إضافة دمج الفقرات لكل جراحات استئصال الغضروف العنقي الأمامي. شاع استخدام عظمة الحوض في الماضي لدمج الفقرات لكن بسبب الآلام الناتجة عن ذلك اتجه الكثير من الجراحين إلى استخدام القفص. من عيوب هذه الجراحة تغول القفص داخل الجسم الفقري مما قد يؤدي لفقد زاوية التقعس أو حتى الوصول لدرجة تحدب العمود الفقري العنقي مع إمكانية أن يؤدي ذلك إلى ضيق الثقوب العصبية والضغط على جذور الأعصاب.

الغرض: هدف من هذا البحث دراسة معدل تغول القفص داخل الفقرات العنقية بعد الجراحة والأسباب المؤدية إليه مع ربط هذه النتائج بالفحص الأكلينيكي.

المرضى و طرق البحث: قمنا بتحليل الحالات التي أجري لها عمليات استئصال الغضروف العنقي الأمامي مع دمج الفقرات في مستشفيات جامعة عين شمس تحت إشرافنا في الفترة ما بين عامي ٢٠١٠ و ٢٠١٣ بأثر رجعي ومناظرة أشعات العمود الفقري العنقي الخاصة بها مع دراسة قدر التغول القفصي داخل الجسم الفقري و أثر ذلك على زاوية تقعس الفقرات العنقية وربط ذلك بالفحص الأكلينيكي.

النتائج: تحسنت آلام الأطراف والرقبة عند المرضى بشكل دال إحصائيا بعد الجراحة كما تحسنت زاوية التقعس العامة للرقبة بعد الجراحة وزاد متوسط ارتفاع فراغ الغضروف بشكل دال إحصائيا كذلك. وجدنا أن حدوث التغول القفصي داخل الجسم الفقري يزيد بشكل دال إحصائيا مع المبالغة في زيادة ارتفاع فراغ الغضروف أثناء الجراحة بينما لم نجد زيادة مماثلة مع النوع والسن والتدخين وعدد الفقرات المجرى الجراحة فيها.

الاستنتاج: أهم أسباب زيادة تغول القفص داخل الجسم الفقري بعد جراحة استئصال الغضروف العنقي من الأمام ودمج الفقرات هو المبالغة في زيادة ارتفاع فراغ الغضروف أثناء الجراحة مما يؤدي لزيادة زاوية التحدب العنقي لكنه لا يؤثر سلبا على الحالة الأكلينيكية. نقترح عمل أبحاث مماثلة بعدد حالات أكبر لتأكيد أو نفي نتائج البحث وتلافي تأثر النتائج بصغر حجم العينة البحثية وتحليل النتائج بأثر رجعي.