Preservation of Cervical Lordosis in Patients with Multilevel Cervical Spondylosis: Implantation of Anatomical Cervical Cage

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Abstract

Background data: Degenerative cervical spondylosis (DCS) is a common health problem spine surgeons face in Egypt. This may affect multiple levels with cord or nerve root affection and is associated with changes in cervical lordosis that affect the outcome. Also, its surgical treatment, either by anterior discectomy and fusion by cages only or with an anterior augmentation plate, is a matter of controversy, especially in cases with more than one level of affection.

Purpose: This study aims to look at the outcomes of using a stand-alone anatomical Fidji cervical cage for multilevel anterior cervical discectomy and fusion (ACDF) to treat DCS.

Study design: A prospective clinical case study.

Patients and methods: Between May 2021 and April 2022, 30 patients with symptomatic DCS had multilevel ACDF using a stand-alone anatomical Fidji cervical cage. The surgery took place at the spine unit of Al-Hadara and Al-Moassa Alexandria University Hospital. Fourteen were female, and sixteen were male, with a mean age of 54 ± 12.5 years. An evaluation was conducted to determine their clinical and radiological outcomes. Evaluation parameters were visual analog scale (VAS), bone fusion, cervical lordosis angle, and Odom’s criteria for the outcome.

Results: The mean follow-up was 12 months. The fusion rate was 98.88%, with an incomplete bridging trabecular bone between end plates reported at one level. The mean VAS score for neck pain and arm pain improved from 5.87 ± 0.86 and 5.6 ± 0.73 at the preoperative to 1.6 ± 0.67 and 1.37 ± 0.49 at the last follow-up, respectively. The cervical lordosis improved from 22.03° ± 2.86° to 23.53° ± 3.19° at the last follow-up. Employing Odom’s criteria for ultimate evaluation at the last follow-up showed that the clinical outcome was excellent in 70% of patients, good in 26.6%, and fair in 3.4%.

Conclusion: Using multilevel ACDF with a stand-alone anatomical Fidji cervical cage is a safe and effective way to treat DCS, with a high rate of good short-term outcomes with preservation of cervical lordosis.

Keywords: Multilevel ACDF, Fidji cervical cage, Cervical spondylosis, Cervical lordosis, Stand-alone

Introduction

Degenerative cervical spondylosis (DCS) is characterized by the gradual deterioration of the intervertebral discs and facet joints. Stenosis at multiple levels in the cervical spine poses a difficult situation [1,2]. Various anterior, posterior, and combination methods have been recommended, both with and without instrumentation. The anterior cervical
discectomy and fusion (ACDF) is commonly used for DCS because it relieves pressure on the spinal cord and removes the abnormal structures causing compression [3,4]. The objective of surgery is to attain a sufficient decompression of the spinal cord and nerve root(s), accomplish a stable fusion, restore or preserve sagittal alignment, and prevent the development of kyphosis [5,6].

Previous research demonstrated that the utilization of plate fixation in ACDF can effectively reduce complications such as subsidence and pseudoarthrosis, which are commonly associated with the use of stand-alone cages. Unfortunately, the incidence of problems related to plates like screws or plate dislodgement, soft tissue injury, esophageal and tracheal lesions, spinal cord or nerve injury, and dysphagia ranges from 2.2% to 24% [7].

The Fidji cervical cage is one example of a polyetheretherketone (PEEK) cage that has a trapezoid shape when observed from the side. This shape helps to create a particular degree of lordosis. The cage features tooth-like characteristics on both the upper and lower sides, enhancing its adhesion to the vertebrae. Additionally, it consists of two hollow cylinders filled with bone graft material [8,9].

Autografts exhibit the highest fusion rate compared to all other possible grafts. Local grafting avoids the need for another surgical incision since it allows for the extraction of autografts and the repair of the cervical area with a single incision. This method eliminates the possible challenges associated with extracting autografts from the iliac crest while still preserving the advantages of using one’s bone transplants. The autograft core will serve as the focal point for bone growth, supplying osteogenic, osteoinductive, and osteoconductive components that have not been demonstrated to extend the length of the procedure [10].

The cervical lordotic (CL) curvature distinctly redistributes the compressive stress compared to the rest of the spine. Specifically, 36% of the compressive load is communicated through the anterior column, while 64% is sent through the posterior facet joints [11]. Hence, restoring CL is crucial in therapy, as neural tissue compression can cause harm [12].

This study aims to clarify the outcomes of using a stand-alone anatomical Fidji cervical cage for multilevel ACDF to treat DCS.

Patients and methods

A prospective study was conducted on thirty patients with symptomatic multilevel DCS who underwent surgery at the spine unit of Al-Hadra and Al-Moassa Alexandria University Hospitals between May 2021 and April 2022. Patients with persistent severe radicular pain not responding to at least six weeks of conservative treatment, myelopathy secondary to DCS that can be decompressed with ACDF, and MRI-documented DCS with compression of the cervical nerve roots or spinal cord at more than one level were included with complete data and minimum follow up of 12 months. Patients who had cervical trauma, tumors, infections, instability, revision cases, or rheumatoid arthritis were not included in the study. All patients were neurologically evaluated, and chronic diseases and comorbidities were assessed. Preoperative clinical parameters included visual analog score for arm and neck pain and Nurick grades of cervical spondylotic myelopathy. Cervical plain radiographs and MRI to detect affected levels were used for all patients for radiological evaluation. The cervical curve was measured using the Cobb C2–C7 method.

A total of 30 patients were eligible for this study according to our criteria. 16 (53.33%) patients were male, and 14 (46.67%) were female, with a mean age of 54 ± 12.5 years (range, 28–74) years. Seventeen patients had radiculopathy, and 13 had myelopathy. Moreover, 89 levels were affected, with the C5–C6 level being the most afflicted (Table 1). There were no missing patients until the end of the study. The study was conducted according to ethical considerations, with ethics approval obtained from the Institutional Review Board of Alexandria University (IRB approval no. 00012098).

Surgical technique

The ACDF procedure was conducted using the conventional Smith-Robinson technique [13]. A solitary transverse cut was made on the skin, followed by a division of the muscle and the platysma along the length of its fibers. The carotid vessels are retracted laterally. The strap muscles were retracted

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
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<tbody>
<tr>
<td>Sex</td>
<td>Male 16 (53.3%) Female 14 (46.7%)</td>
</tr>
<tr>
<td>Age</td>
<td>54.03 ± 12.6</td>
</tr>
<tr>
<td>Comorbidity</td>
<td>DM 3 (10%)</td>
</tr>
<tr>
<td></td>
<td>DM, HTN 2 (6.7%)</td>
</tr>
<tr>
<td></td>
<td>HTN 4 (13.3%)</td>
</tr>
<tr>
<td></td>
<td>Renal, DM 1 (3.3%)</td>
</tr>
<tr>
<td>Presentation</td>
<td>Radiculopathy 17 (56.7%)</td>
</tr>
<tr>
<td></td>
<td>Myelopathy 13 (43.3%)</td>
</tr>
<tr>
<td>Levels of surgery</td>
<td>2 levels 10 (33.3%)</td>
</tr>
<tr>
<td></td>
<td>3 levels 11 (36.7%)</td>
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<td>4 levels 9 (30%)</td>
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to access the cervical spine's front part. A microscopic-assisted discectomy targeted the uncovertebral joints and the posterior longitudinal ligament. The latter was removed when it became hardened or when disc material was located behind the ligament. The endplates were stripped of their outer layer, making removing the bony outgrowths in the back easier and creating a well-supplied area for fusion. Then, the anatomical Fidji cervical cage (Zimmer spine, Bordeaux, and France) (Fig. 1) was filled and inserted with local grafts taken from the operated vertebral bodies at each level (using the osteophytes and the decompressed posterior body edges). Following confirmation of the cage position at the operational levels, a locally closed negative suction drain was introduced and removed after 48 h. A stiff cervical collar was used postoperatively for 3–4 weeks.

Outcomes assessment

A postoperative assessment was conducted during routine outpatient follow-up visits at 3, 6, and 12 months after the surgery. The clinical outcomes were assessed using the VAS for arm and neck pain, Nurick grades of cervical spondylotic myelopathy, and Odom’s criteria during the regular follow-up period. Cervical spine radiographs were taken before discharge, followed by routine plain radiographic examination during the regular follow-up period to cervical curve and assess fusion. Fusion was evaluated based on the presence of trabecular continuity, the formation of bone mass connecting across the disc space, and the appearance of a hazy interface between the cage and the endplates (Fig. 2).

Statistical analysis

They were examined using an IBM-compatible personal computer equipped with the SPSS software package (version 20.0; IBM Corp., Armonk, New York, USA). The statistical analysis was descriptive statistics, which involved summarizing and describing the data. Quantitative data were reported using the mean and standard deviation (SD). Qualitative data were presented using numerical values and percentages. The Wilcoxon Signed-Rank test assessed the differences in mean values following a 12-month intervention for quantitative variables. The statistical significance was determined at a significance level of 0.05.

Results

All 30 patients underwent ACDF using stand-alone Fidji cervical cage filled with local bone graft for managing DCS. 10 patients (33.3%) underwent two levels of ACDF, 11 patients (36.7%) underwent three levels, and nine patients (30%) underwent four levels.

Clinical outcomes

According to Odom’s criteria, the overall results in this study at the last follow-up were as follows: excellent in 21/30 (70%) patients, good in 8/30 (26.6%) patients, and fair in 1/30 (3.4%) patients (Table 2). VAS for arm pain has improved from 5.7 ± 0.73 to 1.37 ± 0.49 at the final follow-up, indicating significant improvement in pain after the surgery (p value < 0.001). VAS for neck pain has improved from 5.87 ± 0.86 to 1.6 ± 0.67 at the final follow-up, indicating significant improvement in pain after the surgery (p value < 0.001; Table 3). There was a statistically significant improvement in the Nurick grade of cervical spondylotic myelopathy, as shown in the 13 individuals who first...
presented with myelopathy. Two patients experienced a substantial improvement in their condition from grade 4 to grade 2. A single patient's condition improved from grade 4 to grade 3. Seven patients experienced an improvement in their condition, from grade 3 to grade 1. Two patients experienced a significant improvement, from grade 2 to grade 0, and one from grade 2 to grade 1. Before surgery, most patients (53.84%) had a Nurick grade of 3, while after surgery, there was a significant improvement in Nurick grades, where most patients (61.5%) had a Nurick grade of 1 at a final follow-up. The mean Nurick grade improved significantly, from 3 before surgery to 1.15 ± 0.8 at the final follow-up. There was a significant improvement in myelopathy symptoms as well. The Z-score of 3.42 with a p-value of 0.001 suggests that the improvement in Nurick's grades was statistically significant (Table 4).

**Radiological outcomes**

There is a significant difference in the degree of cervical angle between the preoperative 22.03 ± 2.86, immediate postoperative 23.13 ± 3.18, and 12-month follow-up measurements 23.53 ± 3.19 (Table 5). The immediate postoperative angles were significantly better than the preoperative angles (p = 0.001). Also,

<table>
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<th>Parameters</th>
<th>Preoperative</th>
<th>Final follow-up</th>
<th>P-value</th>
</tr>
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<tbody>
<tr>
<td>VAS neck pain</td>
<td>5.87 ± 0.86 (4–7)</td>
<td>1.6 ± 0.67 (1–2)</td>
<td>0.001</td>
</tr>
<tr>
<td>VAS arm pain</td>
<td>5.7 ± 0.73 (5–8)</td>
<td>1.37 ± 0.49 (1–3)</td>
<td>0.001</td>
</tr>
<tr>
<td>Nurick grade</td>
<td>3 ± 0.71 (2–4)</td>
<td>1.15 ± 0.8 (0–3)</td>
<td>0.001</td>
</tr>
<tr>
<td>Cervical lordosis*</td>
<td>22.03 ± 2.86 (18–28.2)</td>
<td>23.53 ± 3.19 (18.3–31.4)</td>
<td>0.004</td>
</tr>
<tr>
<td>Final Odom criteria</td>
<td>Excellent</td>
<td>21 patients (70%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Good</td>
<td>8 patients (26.6%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fair</td>
<td>1 patient (3.4%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Poor</td>
<td>0</td>
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</table>

**VAS:** Visual analog scale. The P value is less than 0.05, which is statistically significant.

**Table 3. Comparison of VAS of neck and arm among the pre-, 3M, 6M, and 12M follow-up.**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Preoperative</th>
<th>3M follow-up</th>
<th>6M follow-up</th>
<th>Postoperative</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAS arm</td>
<td>5.7 ± 0.73 (5–8)</td>
<td>3.8 ± 0.89 (2–6)</td>
<td>2.03 ± 0.81 (1–4)</td>
<td>1.37 ± 0.49 (1–3)</td>
</tr>
<tr>
<td>P-value</td>
<td>0.002&lt;sup&gt;a&lt;/sup&gt;</td>
<td>&lt;0.001&lt;sup&gt;b&lt;/sup&gt;&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.27</td>
<td>&lt;0.001&lt;sup&gt;d&lt;/sup&gt;&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>VAS neck</td>
<td>5.87 ± 0.86 (4–7)</td>
<td>3.07 ± 0.74 (1–4)</td>
<td>1.7 ± 0.47 (1–2)</td>
<td>1.6 ± 0.67 (1–2)</td>
</tr>
<tr>
<td>P-value</td>
<td>0.001&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.001&lt;sup&gt;b&lt;/sup&gt;&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.32</td>
<td>&lt;0.001&lt;sup&gt;d&lt;/sup&gt;&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup> Pairwise comparison between Pre- and 3M follow-up.
<sup>b</sup> Pairwise comparison between 3M and 6M follow-up.
<sup>c</sup> Pairwise comparison between 6M and 12M follow-up.
<sup>d</sup> Pairwise comparison between Pre- and 12M follow-up.
<sup>e</sup> Significant at <0.001.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Preoperative</th>
<th>3M follow-up</th>
<th>6M follow-up</th>
<th>12M follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 2</td>
<td>3 (100%)</td>
<td>2 (28.6%)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Grade 3</td>
<td>0</td>
<td>5 (71.4%)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Grade 4</td>
<td>0</td>
<td>0</td>
<td>2 (66.7%)</td>
<td></td>
</tr>
<tr>
<td>Grade 0</td>
<td>3 (100%)</td>
<td>2 (28.6%)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Grade 1</td>
<td>0</td>
<td>5 (71.4%)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Grade 2</td>
<td>0</td>
<td>0</td>
<td>2 (66.7%)</td>
<td></td>
</tr>
<tr>
<td>Grade 3</td>
<td>0</td>
<td>0</td>
<td>1 (33.3%)</td>
<td></td>
</tr>
<tr>
<td>Grade 0</td>
<td>2 (66.7%)</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Grade 1</td>
<td>1 (33.3%)</td>
<td>7 (100%)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Grade 2</td>
<td>0</td>
<td>0</td>
<td>2 (66.7%)</td>
<td></td>
</tr>
<tr>
<td>Grade 3</td>
<td>0</td>
<td>0</td>
<td>1 (33.3%)</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> Significant at 0.001.
the 12-month follow-up angles were considerably better than the postoperative \( (p = 0.004) \). There was also a significant difference in the degree of segmental cervical angle between the preoperative \( (53.22 \pm 17.97) \), immediate postoperative \( (49.6 \pm 15.3) \), and 12-month follow-up measurements \( (49.19 \pm 15.9) \). The immediate postoperative angles were significantly better than the preoperative angles \( (p = 0.001) \). The 12-month follow-up angles were substantially better than the immediate postoperative angles \( p\)-value \( (0.037) \) but not to the same degree as that between immediate postoperative and preoperative values \( (Fig. 3) \). Out of 89 operated levels, fusion has been achieved in all levels except one level (C6–C7) in a four-level ACDF case, with the fusion rate reported as 98.87%. Breakage of one Caspar screw occurred in 1/30 \((3.4\%)\) patients. The broken screw was left in the vertebral body and did not have any consequences after that \( (Fig. 4) \).

**Discussion**

Recently, there has been a significant increase in the utilization of ACDF in the surgical management of multilevel DCS. These procedures provide direct relief from the pressure exerted on the spinal cord and nerve root due to disc herniation or ossification \[14\]. When considering the option of surgical intervention for DCS, it is crucial to evaluate aspects such as the patient’s age, severity of symptoms, baseline functionality, and overall health status \[15\]. According to a meta-analysis, the multilevel ACDF yields marginally superior restoration of neural

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**Table 5. Cervical lordosis at follow-up.**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Preoperative</th>
<th>Immediately postoperative</th>
<th>3M follow-up</th>
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<tbody>
<tr>
<td>Cervical lordosis</td>
<td>22.03 ± 2.86</td>
<td>23.13 ± 3.18</td>
<td>23.63 ± 3.4</td>
<td>23.4 ± 2.98</td>
<td>23.53 ± 3.19</td>
</tr>
<tr>
<td></td>
<td>((18–28.2))</td>
<td>((18.5–30.2))</td>
<td>((18.6–32.8))</td>
<td>((18.7–29.2))</td>
<td>((18.3–31.4))</td>
</tr>
<tr>
<td>P-value</td>
<td>0.009</td>
<td>0.037</td>
<td>0.54</td>
<td>0.81</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

*Pairwise comparison between immediately postoperative and 3M follow-up.*

*B Pairwise comparison between 3M and 6M follow-up.

*C Pairwise comparison between 6M and 12M follow-up.

*D Pairwise comparison between pre- and 12M follow-up.

**Discussion**

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<td>((18.7–29.2))</td>
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</tr>
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<td>P-value</td>
<td>0.009</td>
<td>0.037</td>
<td>0.54</td>
<td>0.81</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

*Pairwise comparison between pre- and immediately postoperatively.*

*Pairwise comparison between immediately postoperative and 3M follow-up.*

*Pairwise comparison between 3M and 6M follow-up.*

*Pairwise comparison between 6M and 12M follow-up.*

*Pairwise comparison between pre- and 12M follow-up.*

*Significant at <0.001.*
function compared to the posterior approach in individuals diagnosed with multilevel CSM [3,16].

Cage-assisted ACDF is a secure and efficient method as it avoids the collapse of the graft and facilitates indirect decompression of the foraminal space by restoring the height and curvature of the intervertebral disc [17]. Bag introduced the first stand-alone cervical cage in 1988, which subsequently gained global popularity [18]. The use of a stand-alone cage without plating in ACDF has resulted in a positive outcome. Employing numerous independent PEEK cages for the treatment of DCS has resulted in favorable results in the medium term, namely at the four-year mark [19,20].

Anterior cervical corpectomy and fusion (ACCF) was initially used to treat 4-level DCS [21]. However, a comparative evaluation of three reconstructive procedures revealed that ACCF exhibited substantial blood loss, a low fusion rate, a high occurrence of postoperative problems, and relatively inadequate restoration of CL. According to these data, ACCF is no longer regarded as the primary option for treating multilevel DCS [22]. Different studies have demonstrated that using stand-alone cages for 3 and 4 levels of ACDF yields superior outcomes compared to plate fixation, resulting in reduced postoperative problems and shorter hospital stays [23,24].

Bucciero et al. [25] have verified this outcome by utilizing independent PEEK cages in four cervical disc levels. They have determined that this approach is a successful technique for treating DCS in four levels of disease. Song et al. [26] reported that adding an anterior plate may improve cervical lordosis and fusion rate in one- or two-level ACDF compared to using cages that are not attached to anything else. However, there was no significant difference in terms of clinical outcomes. Also, Fraser et al. [27] document an increased fusion rate (92.1%) with the use of an additional anterior plate, either single-level or multilevel ACDF. This was comparable to our study’s fusion rate of 98.87%.

Using a stand-alone Fidji cervical cage avoids plate-related complications in multilevel ACDF, as plates don’t lead to significant differences as documented, and this was comparable to the Li et al. [28] study. Failure to restore cervical lordosis affects the functional outcome and leads to axial pain and late neurological deterioration [29,30]. Also, the loss of corrected lordosis and cage subsidence documented in some studies [31–33] associated with stand-alone cages and less with plate-augmented cages. In another study, the subsidence and correction loss were higher with the plate group and explained to be technique-related, and this was supported by recommendations for non-vigorous endplate preparation and non-forceful cage application to minimize this risk and to allow support for a stand-alone Fidji cervical cage to keep and maintain the correction in multilevel ACDF until the follow-up period [24].

The outcome based on Odom’s criteria was satisfactory in 29 (96.7%) patients, including 21 excellent and eight good patients, and unsatisfactory or fair in 1 (3.3%) patient, and this was comparable to Fountas et al. [34] who followed up results up to five years. Our work showed an improved VAS score for the neck and arm, and this was comparable to Wang et al. [35] and El-Sayed et al. [33], as the VAS improved to 6.84 ± 3.6 and 2.15 ± 0.58, respectively. As we noted improved and maintained cervical global lordosis and segmental lordosis and in other studies, our results were comparable to Wang et al. [35] and Katamura et al. [36]. Also, improved Nurick grade for myelopathic patients managed by the anatomical Fidji cervical cage was comparable to the outcome achieved by Profeta et al. [37] (69% improvement) and Matge et al. [38] documented a 50% improvement in myelopathic patients managed by cages. Breakage of one Caspar screw occurred in 1/30 (3.4%) patients. The broken screw was left in the vertebral body and did not have any consequences after that. This study reported a fusion failure rate of only 1.12% across 89 levels, whereas the study of Chang SW et al. [13] reported a fusion failure rate of 0.04% across 440 levels.

The study may not have fully captured the long-term effects or issues related to the anatomical cervical cage intervention due to the short follow-up period. Furthermore, the absence of randomization or allocation to different patients may limit the ability to establish a relationship between the intervention (implantation of anatomical cervical cage) and the observed outcomes. So, we recommend further studies with large sample sizes, probably from multicenter groups with long-term follow-up and recruiting control groups for comparison purposes.

Conclusion

This study provides evidence that the use of anatomical Fidji PEEK cages in multilevel ACDF leads to significant improvements in neck and arm pain scores and maintenance of cervical lordosis in patients with DCS with a significantly low rate of complications.

Ethics information

The article does not contain information about medical device(s)/drug(s).
Author declaration of funding statement
No funds were received in support of this work.

Conflict of Interest
The authors report no conflicts of interest.

List of abbreviations
ACCF  Anterior cervical corpectomy and fusion
ACDF  Anterior cervical discectomy and fusion
CL    Cervical lordotic
DCS  Degenerative cervical spondylosis
PEEK Polyetheretherketone
VAS  Visual analog scale

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