Journal Of Clinical Neurology, Neurosurgery And Spine

SCIENTIFIC LITERATURE

Research Article

Stand-Alone Titanium versus Polyetheretherketone Cage Following One or Two Level Anterior Cervical Discectomy and Fusion for Degenerative Cervical Disc Disease

Kamrul Ahsan*, Shahidul Islam Khan, Sachindra Raj Joshi, Bipin Chaurasia and Shaikh Sadiul Islam

Department of Orthopaedic Surgery, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka

ARTICLE INFO

Received Date: July 02, 2022
Accepted Date: August 04, 2022
Published Date: August 05, 2022

KEYWORDS

Titanium cage
PEEK cage
ACDF and Degenerative Cervical Disc Disease (DCDD)

Citation for this article: Kamrul Ahsan, Shahidul Islam Khan, Sachindra Raj Joshi, Bipin Chaurasia and Shaikh Sadiul Islam. Stand-Alone Titanium versus Polyetheretherketone Cage Following One or Two Level Anterior Cervical Discectomy and Fusion for Degenerative Cervical Disc Disease. Journal Of Clinical Neurology, Neurosurgery And Spine. 2022; 4(1):128

Corresponding author:
Kamrul Ahsan,
Professor of Spinal Surgery, Department of Orthopaedic Surgery, Bangabandhu Sheikh Mujib Medical University (BSMMU). Shahbag, Dhaka-1000,
Email: kahsansps@yahoo.com

ABSTRACT

Background: Titanium (TC) or polyetheretherketone (PEEK) cages are acceptable grafts for Anterior Cervical Discectomy and Fusion (ACDF), restoring disc space height, relieving cord compression, and providing enlargement of previously stenotic neural foramina. Here, we compared the clinical and radiological, outcomes and complications utilizing TC vs. PEEK cages for Degenerative Cervical Disc Disease (DCDD).

Methods: We evaluated 85 cases retrospectively, 50 patients were in the TC group, and 35 were in the PEEK cage group. Variables studied included; clinical, surgical, and radiological data plus various outcome measures [i.e., VAS, Neck Disability Index (NDI), and JOA scores, and Odom's criteria].

Results: Patients in the two groups were followed an average of 28.8 (Titanium) vs. 24.5 (PEEK) months. There were no significant differences between the two groups in terms of NDI, neck and arm pain. Postoperative mean JOA scores improved significantly in both groups, also observed significant improvement in PEEK cage group than TC group (<0.05). Fusion occurred in 92 % of TC vs. 94.28 % of PEEK cage patients. Single level and double level solid fusion were found in 96.87 % and 88.89% of the TC-group, and 96 % and 90 % of the PEEK cage-group. Cage subsidence occurred in 8 (16%) of the TC group and 3 (8.57%) of the PEEK group.

Conclusion: Both TC and PEEK cages proved to be safe and effective. However, PEEK cages outperformed titanium cages regarding extent of postoperative intervertebral height, Segmental Lordotic Angle (SLA), Cervical Lordotic Angle (CLA) maintenance at C2-C7, less subsidence, and better clinical outcomes.

INTRODUCTION

Although iliac cancellous bone grafts are the gold standard for Anterior Cervical Discectomy and Fusion (ACDF), there are attendant two alternative constructs include titanium alloy and polyetheretherketone (PEEK) implants. Titanium Cage (TC) is a biocompatible, with excellent corrosion resistance and low density; however, it has been criticized for producing a poor clinical outcome when compared to bone grafts due to a higher elasticity modulus, resulting in subsidence [1]. PEEK cage is also non-absorbable biopolymers, biocompatible, radiolucent, with an elasticity similar to cortical bone, contributing to its improved load sharing/stress distribution, lower subsidence rate (i.e., less loss of segmental correction), and potentially higher fusion rate [2,3]. Here we examined 85 patients to compare the clinical, functional, and radiological outcomes, along with the complications of single or double leveled ACDF performed utilizing stand-alone titanium vs. PEEK cages.

MATERIALS AND METHODS

This retrospective study was carried out from April 2009 to April 2019, after obtaining institutional departmental (Dept. of Orthopaedic Surgery, BSMMU) ethical committee approval. Total of 85 patients who underwent ACDF for Degenerative Cervical Disc Disease (DCDD) were enrolled in this study after reviewing their medical records, radiological data and have met the inclusion and exclusion criteria (Table 1). Patients who had DCDD with feature of only radiculopathy or myeloradiculopathy or myelopathy and those whose symptoms didn't improved even after fair trial of conservative treatment were opted for ACDF surgery. Informed consent was obtained after the patients were counseled about their disease process, need of the surgery; and risk & complication associated with ACDF surgery. The patients were given sole authority to choose between the TC and PEEK cages for ACDF after they were informed about the advantages and disadvantage of both the cages as well as overall cost of the procedure. TC ACDF were performed in 50 patients averaging 45.3±9.14 years of age at 1-level (32) and 2-Levels (18). PEEK ACDF were performed in 35 patients averaging 48.4±9.34 years of age at 1 level (25) and 2-levels (10). Multiple radiographic (i.e., MRI/ X-ray) and clinical/other variables were analyzed for both groups (Figure 1a,b,c, 2a,b,c,d, 3a,b). To assess clinical outcomes, we utilized; Visual Analogue Scale (VAS) scores, Neck Disability Index (NDI), Japanese Orthopaedic Association scores (JOA), and Odom's criteria (Table 2).

Table 1: Inclusion and exclusion criteria.

Inclusion criteria 1.Those patients had neck pain or clinical evidence of radiculopathy or myeloradiculopathy, myelopathy 2. Positive radiology or magnetic resonance imaging findings (Figure 2 c, d) 3. Failure of adequate conservative treatment for 6-8 weeks 4. Minimum follow-up of one year. 5. Single or double level involvement.
Exclusion criteria 1. Patients with >2 level involvement 2. Fracture, listhesis or other spinal pathology 3. Previous neck surgery

DIAGNOSTIC STUDY EVALUATIONS

Dynamic X-rays, MRI and CT studies were utilized preoperative and postoperatively.

Table 2: Odam's clinico-radiological criteria for functional assessment after cervical discectomy and fusion.

Results	Criteria
Excellent	Solid fusion on radiograph. No neck or arm pain. Normal finding on neurological examination.
Good	Solid fusion on radiograph. No neck or arm pain. Neurological improvement with mild residual problem
Fair	Solid fusion on radiograph. Persistent neck or arm pain. Post-operative myelogram or magnetic resonance imaging reveals no additional neurological compression
Poor	Continued symptomatic nonunion. Neurological worsening. Need for a reoperation

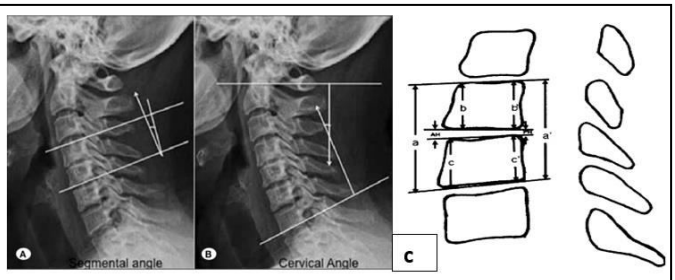

Figure 1: Cervical (A) segmental and (B) lordotic angle measurement, (C) Intervertebral height of the involved segment measurement (anterior height of intervertebral space: AH = a–b–c; posterior height of intervertebral space: PH = a'–b'–c')[24].

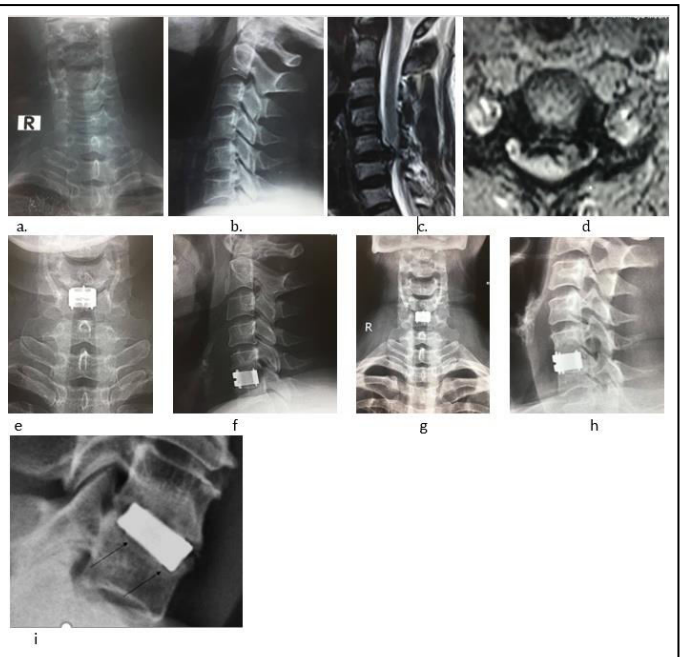

Figure 2: a, b- Pre-operative A-P and lateral X-ray cervical spine, c, d - Pre-operative MRI (sagittal and axial view), e, f - Immediate post-operative. g, h- At 6 months follow up, i- At 12 months follow up shows union and subsidence of a Titanium-cage into the anterior part of the inferior endplate of 43 yr. old female.

SURGICAL APPROACH

Patient was positioned supine following general anaesthesia and routine modified Smith-Robinson technique for ACDF was

Stand-Alone Titanium versus Polyetheretherketone Cage Following One or Two Level Anterior Cervical Discectomy and Fusion for Degenerative Cervical Disc Disease. Journal Of Clinical Neurology, Neurosurgery And Spine. 2022; 4(1):128.

used for exposure. After anterior decompression the patients were given either a Titanium or a PEEK cage, which was packed with excised local osteophyte and allograft cancellous bone and inserted into the disc space using an impactor (universal or Jesco India Titanium cage with Plasma pore® coating or a PEEK cage) (Figure 2e,f, g,l, 3e,f,g,h,l,j, 4a,b). Both cage types were used in sizes ranging from 4 to 7 mm in height, with a diameter of 14 or 16 mm, a depth of 13 mm, and a 5° angle.

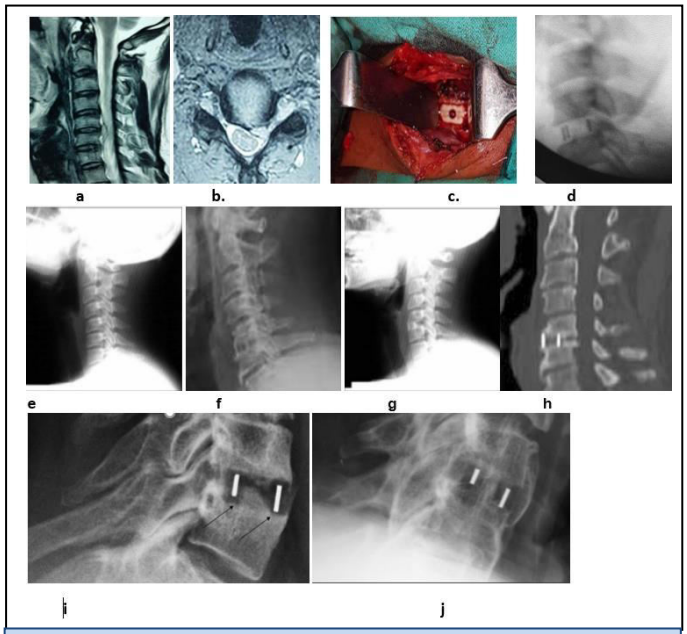

Figure 3: a, b- Pre-operative MRI (sagittal and axial view), c, d- Per-operative pic and immediate post-operative lateral view x-ray. e, f, g, h- pre operative x-ray and at 3 months, 12months post-operative x-ray and CT scan showing fusion, i- At 24 months follow up shows' union and subsidence of a PEEK -cage into the posterior part of the inferior endplate of 45 yr. old male.

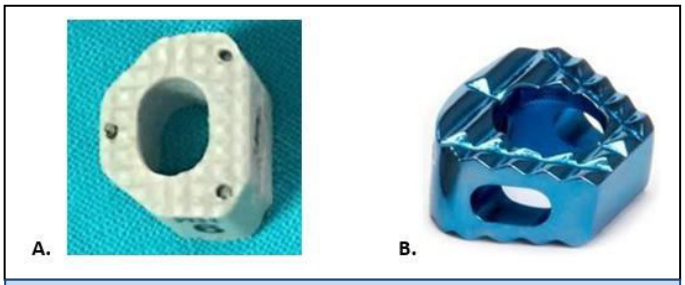

Figure 4: A. PEEK-cage, B. Titanium –cage.

POSTOPERATIVE ANALYSIS

A telephone survey or a mail-in survey was used to assess the outcome of the follow-up. SPSS, version-13.0 software was used for statistical analysis (Chicago, IL, USA). The Mann–Whitney-U-test, Chi-square-test, and Student's t-test were used to analyse clinical and radiological data. A p-value of < 0.05 was deemed statistically significant.

Table 3: Demographic and surgical profile of patients with TC cage and PEEK cage (N=85).

Characteristics	Titanium cage (n=50)	PEEK cage (n=35)	p-value
Age (years)			
30 – 40	8 (16.00)	5 (14.29)	0.941^{ns}
41 – 50	32 (64.00)	22 (62.86)	
51 – 60	10 (20.00)	8 (22.86)	
Mean SD	45.3 ±9.14 (33 -55)	48.4±9.34 (35 -60)	0.133^{ns}
Sex			
Male	35 (70.00)	24 (68.57)	0.920^{ns}
Female	15 (30.00)	11 (31.43)	
Occupation			
Sedentary worker	25 (50.00)	16 (45.71)	0.974^{ns}
Farmer	6 (12.00)	5 (14.29)	
Service holder	6 (12.00)	4 (11.43)	
Housewife	13 (26.00)	10 (28.57)	
Presentation			
Radiculopathy	26 (52.00)	20 (57.14)	0.891^{ns}
Myelopathy	10 (20.00)	6 (17.14)	
Myelo-radiculopathy	14 (28.00)	9 (25.71)	
Diagnosis			
Disc herniation	30 (60.00)	23 (65.71)	0.764^{ns}
Cervical spondylotic myelopathy	20 (40.00)	12 (34.29)	
Involved level	n (%) [single, double]	n(%)[single, double]	
C3-4 C4-5 C5-6 C6-7	6 (12.00)[4,2] 14 (28.00) [10,4] 24 (48.00) [14,10] 6 (12.00) [4,2]	3 (08.57) [2,1] 8 (22.86) [6,2] 18 (51.43) [13,5] 6 (17.14) [4,2]	0.965^{ns}
Cage size			
4 mm 5 mm 6 mm 7 mm	6 (12.00) 25 (50.00) 16 (32.00) 3 (6.00)	3 (8.57) 18 (51.43) 12 (34.29) 2 (5.71)	0.965^{ns}
Mean ±SD	5.27 ±0.76	5.45 ±0.77	
Surgical length (min)	110 (90-180)	95 (90-165)	0.288^{ns}
Estimated blood loss (ml)	90 (50-140)	85 (70-150)	
Length of hospital stay (day)	5.34 (3-10)	6.34 (4-12)	
Total cost of the procedure	Taka 43675± 5818($510)	Taka 4856± 5818($563)	0.001^{s}

Table 4: Comparison of clinical outcomes of both TC cage and PEEK cage group (N=85).

Clinical outcome	Titanium cage (n=50)	PEEK cage (n=35)	p-value
VAS score (neck pain)			
Pre-operative	7.57±1.05	7.68±0.90	0.602^{ns}
Immediate post-operative	4.90±1.50	4.80±1.52	0.760^{ns}
At 03 months	3.77±1.32	3.85±1.50	0.793^{ns}
At 12 months	3.32±1.35	2.93±1.30	0.184^{ns}
Improvement	4.74±1.96	4.23±1.60	0.192^{ns}
VAS score (arm pain)			
Pre-operative	5.8 ±2.2	5.9±2.7	0.850^{ns}
Immediate post-operative	2.8± 2.3	2.7±2.3	0.844^{ns}
At 03 months	2.8 ± 2.7	2.0±2.0	0.121^{ns}
At 12 months	1.6±2.1	2.3±1.9	0.119^{ns}
Improvement	4.00±00	3.8±00	0.760^{ns}
Disability status (NDI score)			
Pre-operative	39±16	38±16	0.778^{ns}
Immediate post-operative	26 ± 16	22±14	0.225^{ns}
At 03 months	21±16	21±13	1.000^{ns}
At 12 months	16.88 ± 10.24	17.04 ± 9.61	0.940^{ns}
JOA Score			
Pre-operative	9.4± 1.8	9.6±1.8	0.616^{ns}
Immediate post-operative	12.8±1.9	13.1± 1.9	0.476^{ns}
At 03 months	13.1± 1.8	13.4±1.8	0.614^{ns}
At 12 months	13.8± 1.6	15.2±1.6	<0.001^{s}

VAS: Visual Analogue Scale; NDI: Neck Disability Index; JOA: Japanese Orthopaedic Association

Table 5: Radiological findings of the patients TC cage and PEEK cage group (N=85).

Variable	Titanium cage (n=50)	PEEK cage (n=35)	p-value
Intervertebral height of the operated segment (mm)			
Pre-operative	4.3±0.8	4.4±0.9	0.600^{ns}
At 03 months	5.8±0.9	6.0±0.9	0.317^{ns}
At 12 months	4.4±0.6	5.4±0.7	<0.001^{s}
Loss of correction	1.4±0.4	0.6±0.2	<0.001^{s}
Segmental Lordotic Angle (SLA) (°)			
Pre-operative	5.63±8.26	6.35±7.26	0.672^{ns}
At 03 months	14.75± 9.98	15.27±8.45	0.795^{ns}
At 12 months	7.38±8.34	12.34±8.37	0.009^{s}
Loss of correction	7.64± 4.23	3.96±1.34	<0.001^{s}
Cervical Lordotic Angle (CLA) atC_2-C_7			
Pre-operative	6.73±8.72	8.25±7.52	0.393^{ns}
At 03 months	15.48± 10.26	16.65±11.23	0.626^{ns}
At 12 months	7.38±8.34	12.34±8.37	0.009^{s}
Loss of correction	8.58± 4.65	4.82 ±2.36	<0.001^{s}
Segmental subsidence	4.56±3.30	4.27±2.42	0.642^{ns}
Total fusion	46 (92.0)	33 (94.28)	1.000^{ns}
Single level	30 (93.75)	24 (96.00)	
Double level	16 (88.89)	9 (90.00)	

Table 6: Overall outcome and complications (N=85).

Criteria	Titanium cage n=50 (%)	PEEK cage n=35 (%)	P-value
Odom's Criteria			
Excellent	14 (28.00)	11 (31.43)	0.988^{ns}
Good	25 (50.00)	17 (48.57)	
Poor	8 (16.00)	5 (14.29)	
Fair	3 (6. 00)	2 (5.17)	
Satisfactory	39(78.00)	28 (80.00)	1.000^{ns}
Complications			
Per operative dural tear	3 (6.00)	2 (5.71)	0.680^{ns}
Transient dysphagia	6 (12.00)	4 (11.43)	0.791^{ns}
Pseudarthrosis	4 (8.00)	2 (5.71)	1.000^{ns}
Subsidence	8 (16.0)	3 (8.57)	0.497^{ns}
Cage displacement/ extrusion	1 (2.00)	0 (0.00)	0.862^{ns}

Table 7: Summary of advantages and disadvantages of Titanium and PEEK cages30.

Property	Titanium cage	Polyetheretherketone (PEEK)
Introduction to market	1980s	1990s
Elasticity	Higher	Lower
Radiodensity	Radiopaque	Radiolucent
Modulus	100–110 GPa	3.5 GPa
Promotion of Osseointegration	Higher	Lower
Subsidence rates	Higher	Lower
Risk of metal allergy	Yes	No

RESULTS

The mean follow-up period was 28.8 (range, 12-60) months in TC group and 24.5 (range,12-55) months in PEEK cage group, mostly affected age group were 41–50 yrs., (64% vs.62.86%) and most common level of involvement were at C5-6 level (52% vs.51.42%) respectively. Forty-six patients (54.11%) had radiculopathy, 16 patients (18.82%) had myelopathy and 23 patients (27.05%) had myeloradiculopathy symptoms. These symptoms were caused by disc herniation 53 (62.35%) patients and cervical spondylotic myelopathy in 32 (37.64%) patients and the 5 mm cage size was the most frequently chosen implant in both groups (50% vs.51.4%). Demographic and surgical data are shown in Table 3 and analysis showed no significant difference of TC group and PEEK cage group (p>0.05). Moreover, average total cost of the TC ACDF procedure was 43675 ($ 510) taka and PEEK ACDF procedure was 48156 ($ 563) taka and showed significant differences between two groups (<0.001) (Table 3). VAS score (for neck and arm pain) and NDI score showed no statistically difference in preoperative, immediate postoperative, 3-month and 12-month follow-up between the 2 groups. The mean pain improvement for neck pain was 4.74± 1.96 vs. 4.23± 1.60 (p=0.208 ns) and arm pain was 4.00±00 vs.3.8±00 and showed no significant difference between 2 groups (p=0.208) (Table 4). The mean postoperative JOA scores improved from 9.4± 1.8 to 13.8± 1.6 in TC group and from 9.6±1.8 to 15.2±1.6 in the PEEK cage group respectively, also observed significant improvement in PEEK cage group than TC group (<0.05) (Table 4). The mean Segmental Lordotic Angle (SLA), Cervical Lordotic Angle (CLA) at C2-C7 and the operated segment of intervertebral height were significantly increased after 3 months of operation in both groups without significant differences between two groups but operated segment intervertebral height as well as Segmental Lordotic Angle (SLA) and cervical lordotic angle (CLA) at C2-C7 showed significant differences between two groups at 12 months follow-up (P<0.05), (Table 5). The intervertebral height loss over 3 mm recorded as subsidence which occurred in 8 (16 %) cages in the TC group and 3 (8.57%) cages in the PEEK group (p >0.05). Mean segmental subsidence was 4.56±3.30 mm in TC group and 4.27±2.42 mm in PEEK cage group during 12-month follow-up. Subsidence occurrence rate was statistically different between the 2 groups (p=0.033) (Table 5).

Solid fusion was seen 46 (92%) in TC group and 33 (94.28%) in PEEK cage group in last follow up. Single level fusion occurred in 30 (93.75%) cases out of 32 and double level fusion occurred in 16 (88.89%) cases out of 18 in TC group and in PEEK cage group single level fusion occurred in 24 (96%) cases out of 25 and double level fusion occurred in 9 (90%) cases out of 10 in last follow up. Overall results and

Stand-Alone Titanium versus Polyetheretherketone Cage Following One or Two Level Anterior Cervical Discectomy and Fusion for Degenerative Cervical Disc Disease. Journal Of Clinical Neurology, Neurosurgery And Spine. 2022; 4(1):128.

complications were shown in Table 6. According to Odom's criteria results were excellent (28% vs. 31.43%), good (50% vs.48.57%), fair (16% vs.14.28%), poor (6% vs. 5.71%) and overall satisfactory outcome were (78% vs. 80%) patients in TC and PEEK cage group respectively. Complications included dural tear (6 % vs.5.71%), transient dysphagia (12% vs. 11.43%), pseudoarthrosis (8% vs.5.71%), subsidence (16 % vs. 8.57%) and cage displacement (2% vs. 0%) respectively in TC and PEEK cage group. The dural tear and transient dysphagia resolved spontaneously within 7 days postoperatively. Six cases of pseudoarthrosis and 11 cases of subsidence were observed; fortunately, these patients did not experience any symptoms during the follow-up period. Displacement of one cage occurred after 4 weeks of operation, in double fusion of TC group, which produced symptom e.g., dysphagia and required revision surgery.

DISCUSSION

ACDF has been widely used as an ideal surgical treatment method for DCDD. Tricortical Iliac Crest Bone (TICB) grafting is still considered as a gold standard inter-body fusion material that has excellent biocompatibility, no risk of disease transmission, and no immunogenicity. It can maintain the disc height as well as patency of the neuroforamen and show perfect bony fusion. Unfortunately, bone harvesting results in longer operative time, greater blood loss, longer hospital stays, and donor-site complications such as subcutaneous hematomas, infections, and chronic wound pain [4]. To avoid these donor site complications and minimize operative time, some interbody fusion devices such as titanium, carbon fiber, and PEEK cages have been developed which claimed advantages of comparable fusion rate [5].

TC was chosen for its excellent corrosion resistance, low density and its ability to enhance cell adhesion and osseointegration and favorable fusion rates [6]. But most of which were non-porous, had greater risk of subsidence [6,7]. PEEK cages on the other hand have a modulus of elasticity, biomechanically closely resembling that of cortical bone, which might lead to advantages in load sharing and stress distribution, results in lower subsidence and potentially higher fusion rate [2]. PEEK cages are chemically inert and does not allow for protein absorption and promotion of cell adhesion and bone contact [8]. The characteristics of TC and PEEK cage type were summarized in Table 7.

The analysis of demographic data and surgical data did not show any significant differences of TC group and PEEK cage group ($p>0.05$). The patient's clinical outcome assessed by VAS and NID score also did not show any significant differences in preoperative, immediate postoperative, 3-month and 12-month follow-up between the 2 groups ($p>0.05$) but JOA score in the TC group was significantly inferior to the PEEK group (<0.05) (Table 3). Similar clinical outcomes have been reported in many publications where ACDF was carried out using PEEK cage [9,10]. In our study no significant differences could be found between the two groups in terms of clinical recovery (78% vs. 80%, $p<0.05$) (Table 3) which were similar to studies by Niu CC [6], Chen Y [1]; and Cabraja M [11] but their study enrollments were different (at three level ACDF vs. single level ACDF vs. single or two leveled ACDF.

In the current study, a solid fusion was achieved without donor-site morbidity 92% in TC and 94.28% in PEEK cage group packed with excised local osteophytes and allograft cancellous bonein last follow up. Single level fusion occurred in 93.75% cases and double level fusion occurred in 88.89% cases in TC group and in PEEK cage group, single level fusion occurred in 96% cases and double level fusion occurred in 90% cases (Table 4). Literature review showed that the fusion rate was more in PEEK cage group than TC group (94 -100% vs. 84 - 98%) [6,12-14] as because PEEK cage has corrosion resistant ability [15] absence of cytotoxicity and mutagenicity [16] and a close elasticity modulus to bone which were almost similar to our study.

The occurrence of cage subsidence after surgery is a crucial problem. Subsidence varies from 13 to 45 % in titanium cages in larger series [14,17] and 8 to 15 % in PEEK cages [7,18]. This shows that even the PEEK cage has favorable modulus of elasticity does not prevent a cage subsidence. The different rate of cage subsidence in various studies dealing with synthetic cages might be also due to different criteria (1 or 2 mm) and measurement methods [14,17]. In our series cage subsidence occurred in 16 % in the titanium group and 8.57 % in the PEEK cages group ($p>0.05$). Endplate preparation, size of the contact area between implant and endplate, over-distraction of the involved segment, and the bone mineral

Stand-Alone Titanium versus Polyetheretherketone Cage Following One or Two Level Anterior Cervical Discectomy and Fusion for Degenerative Cervical Disc Disease. Journal Of Clinical Neurology, Neurosurgery And Spine. 2022; 4(1):128.

density of the vertebral body are also other important risk factors related to the cage subsidence. However, properties of cage material itself are the most important factor resulting in subsidence. The modulus of the elasticity of PEEK is lower than that of titanium cage but similar to that of bone which might be responsible to reduce cage subsidence of PEEK cage in compared to titanium cages.

Preoperative and post-operative radiological parameters analysis in our study showed no significant differences between two groups but operated segment intervertebral height as well as Segmental Lordotic Angle (SLA) and Cervical Lordotic Angle (CLA) at C2-C7 showed significant differences between two groups at 12 months follow-up ($P<0.05$, Table 4). Preoperative and postoperative comparison of SLA and CLA measurements demonstrated that both techniques are also useful in order to recover cervical sagittal alignment. In addition to high fusion rate, it was reported in the literature that successful treatment is based on disc height and protection of SLA and CLA [19,20]. In the literature review showed there is a relationship between clinical outcome and subsidence with loss of intervertebral height and kyphotic deformity [6,17,21]. Some authors disagree that case subsidence did not necessarily mean loss of segmental and general cervical lordosis. The segmental lordosis would be preserved, if the collapse of the anterior part of involved disc space was less than that of the posterior part. Niu et al. [6] compared clinical and radiological results in their study and showed the cage subsidence in the titanium group was significantly higher, but there was no significant difference between two groups in loss of cervical lordosis and clinical outcome. Barsa and Suchomel [17] prospectively analyzed 100 consecutive patients, who underwent ACDF with box-shaped titanium cages and reported that the subsidence of the device was associated with segmental loss of lordosis; however, the overall alignment between C2 and C7 did not change significantly.

Pseudoarthrosis is an uncommon, but known complication after ACDF that leads to persistent unresolved symptoms, which often re¬quires revision surgeries [4,22]. The rate of pseudoarthrosis was 8% in the TC and 5.71% in the PEEK group in our study which were asymptomatic and almost similar to Cabraja et al. (6.8% vs. 11.9%) study [11]. The exact etiology of pseudoarthrosis is not known to ascertain which given high rates of asymptomatic patients, but there are some known risk factors related to pseudoarthrosis such as diabetes, smoking, multilevel fusions, instrumentation choice and bone grafts used [4]. Adjacent segment disease is another complication caused by fusion in the postoperative follow-up of cervical discectomy cases but no significant difference was found among different fusion options (PEEK cage, titanium cage, autograft, plate, and arthroplasty etc.) in the meta-analysis study done by Anderson et al. [23] .In our study, adjacent segment disease was not assessed.

Although, review of literature doesn't show any study that compared the cost effectiveness of TC ACDF and PEEK ACDF procedure but Virk et al. [24] in their comparative study of autograft, allograft and PEEK cages for cervical fusion showed PEEK is not a cost-effective option compared with allograft or autograft for use in ACDF. In this study PEEK ACDF procedure showed significantly higher cost than TC ACDF procedure.

There were some limitations to this study. The follow up period was short to comment largely and it was retrospective study showing somewhat selection bias. Bone fusion was assessed using radiography; computed tomography was not routinely used. Further prospective randomized studies are necessary to determine whether TC or PEEK cage packed with cancellous allograft bone is superior following ACDF for DCDD. Another weakness of this study is that we did not considering the other clinical symptoms like myelopathy and radiculopathy except pain. In our study we have focused only the radiological results.

CONCLUSION

Single or double level ACDF using stand- alone titanium or PEEK cage packed with cancellous allograft bone reconstruction for degenerative cervical disc disease are safe and effective procedure which provides shorter convalescence and rapid return to activity. Though both cages maintain better clinical function as well as bony fusion, PEEK cage is superior to titanium cage in terms of maintaining of intervertebral height as well as Segmental Lordotic Angle (SLA) and Cervical Lordotic Angle (CLA) at C2-C7 and less occurrence of subsidence.

REFERENCES

1. Yu Chen, Xinwei Wang, Xuhua Lu, Lili Yang, Haisong Yang, et al. (2013). Comparison of titanium and polyetheretherketone (PEEK) cages in the surgical treatment of multilevel cervical spondylotic myelopathy: a prospective, randomized, control study with over 7-year follow-up. Eur Spine J. 22: 1539-1546.
2. Cho DY, Liau WR, Lee WY, Liu JT, Chiu CL, et al. (2002). Preliminary experience using a polyetheretherketone (PEEK)cage in the treatment of cervical disc disease. Neurosurgery. 51: 1343-1349.
3. Chong E, Pelletier MH, Mobbs RJ, Walsh WR. (2015). The design evolution of interbody cages inanterior cervical discectomy and fusion: a systematic review. BMC Musculoskeletal Disord. 16: 99.
4. Lin W, Ha A, Boddapati V, Yuan W, Riew KD. (2018). Diagnosing Pseudoarthrosis After AnteriorCervical Discectomy and Fusion. Neurospine. 15: 194-205.
5. Matge G. (2002). Cervical cage fusion with 5 different implants: 250 cases. Acta Neurochir (Wien). 144: 539-549.
6. Niu CC, Liao JC, Chen WJ, Chen LH. (2010). Outcomes of interbody fusion cages used in 1 and 2-levels anterior cervical discectomy and fusion: titanium cages versus polyetheretherketone (PEEK) cages. J Spinal Disord Tech. 23: 310-316.
7. Kulkarni AG, Hee HT, Wong HK. (2007). Solis cage (PEEK) for anterior cervical fusionPreliminary radiological results with emphasis on fusion and subsidence. Spine J. 7: 205-209.
8. De Bartolo L, Morelli S, Bader A, E Drioli. (2001). The influence of polymeric membrane surface free energy on cell metabolic functions. Journal of Materials Science. Materials in Medicine. 12: 959-963.
9. Oh JK, Kim TY, Lee HS, You NK, Choi GH, et al. (2013). Stand-alone cervical cages versus anterior cervical plate in 2-level cervical anterior interbody fusion patients: clinical outcomes and radiologic changes. J Spinal Disord Tech. 26: 415-420.
10. Pechlivanis I, Thuring T, Brenke C, Seiz M, Thome C, et al. (2011). Non-fusion rates in anterior cervical discectomy and implantation of empty polyetheretherketone cages. Spine (Phila Pa 1976). 36: 15-20.
11. Cabraja M, Oezdemir S, Koeppen D, Kroppenstedt S. (2012). Anterior cervical discectomy and fusion: comparison of titanium and polyetheretherketone cages. BMC Musculoskelet Disord. 13: 172.
12. Rao PJ, Pelletier MH, Walsh WR, Mobbs RJ. (2014). Spine interbody implants: material selection and modification, functionalization and bioactivation of surfaces to improve osseointegration. Orthop Surg. 6: 81-89.
13. Schmieder K, Wolzik-Grossmann M, Pechlivanis I, Engelhardt M, Scholz M, et al. (2006). Subsidence of the wing titanium cage after anterior cervical interbody fusion: 2-year follow-up study. J Neurosurg Spine. 4: 447-453.
14. Seaman S, Kerezoudis P, Bydon M, Torner JC, Hitchon PW. (2017). Titanium vs. polyetheretherketone (PEEK) interbody fusion: Meta-analysis and review of the literature. 44: 23-29.
15. Toth JM, Wang M, Estes BT, Scifert JL, Seim HR, et al. (2006). Polyetheretherketone as a biomaterial for spinal applications. Biomaterials. 27: 324-334.
16. Verhaegen AP, Van Middelkoop M, Rubinstein SM, Ostelo R, et al. (2013). Effect of various kinds of cervical spinal surgery on clinical outcomes: A systematic review and meta-analysis. PAIN. 154: 2388-2396.
17. Barsa P, Suchomel P. (2007). Factors affecting sagittal malalignment due to cage subsidence in standalone cage assisted anterior cervical fusion. Eur Spine J. 16: 1395-1400.
18. Wang X, Chen Y, Chen D, Yaun W, Chen X, et al. (2009). Anterior decompression and interbody fusion with BAK/C for cervical disc degenerative disorders. J Spinal DisordTech. 22: 240-245.
19. FaldiniC, Pagkrati S, Leonetti D, Miscione MT, Giannini S. (2011). Sagittal segmental alignment as predictor of adjacent-level degeneration after a Cloward procedure. Clin Orthop Relat Res. 469: 674-681.
20. Wu WJ, Jiang LS, Liang Y, Dai LY. (2012). Cage subsidence does not, but cervical lordosis improvement does affect the long-term results of anterior cervical fusion with stand-alone cage for degenerative cervical disc

disease: a retrospective study. Eur Spine J. 21: 1374-1382.

21. Yang JJ, Yu CH, Chang BS, Yeom JS, Lee JH, et al. (2011). Subsidence and nonunion afterAnterior cervical interbody fusion using a stand-alone polyetheretherketone (PEEK) cage.Clin Orthop Surg. 3: 16-23.
22. Brodke DS, Zdeblick TA. (1992). Modified Smith-Robinson procedure for anterior cervical discectomy and fusion. Spine (Phila Pa 1976). 17: S427-S430.
23. Anderson PA, Sasso RC, Hipp J, Norvell DC, Raich A, et al. (2012). Kinematics of thecervical adjacent segments after disc arthroplasty compared with anterior discectomy and fusion: A systematic review and meta-analysis. Spine (Phila Pa 1976). 37: 85-95.
24. Virk SS, Elder JB, Sandhu HS, Khan SN. (2015). The Cost Effectiveness of Polyetheretheketone (PEEK) Cages for Anterior Cervical Discectomy and Fusion. J Spinal Disord Tech. 28: E482-E492.