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ORIGINAL

EXPLORING THE VALIDITY OF ACDF WITH PEEK CAGES IN SPORTS ACTIVITY PATIENTS WITH CERVICAL SPONDYLOSIS

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ABSTRACT

Background The research aims to determine the outcomes of single or multilevel ACDF with polietereterketon (PEEK) cages in 152 patients (237 cages) with a focus on the cage instability in terms of migration and subsidence that may occur in the early postoperative period.
Method 176 consecutive patients who had undergone single-or multilevel anterior cervical discectomy with PEEK cage for cervical syndolysis (CDDH) from January 2015 to January 2021 were retrospective evaluated.152 patients (237 PEEK cages) who were found to be suitable for the study criteria were included. Results Cage migration was observed in 15 cages in 12 patients without relevant clinical complaints. There was no case of superior migration of the cage into the superior end plate and no posterior or sideways migration. Subsidence was not detected in any cage, and functional radiological examination was present in all cases with maintained intervened disc distance height during the follow-ups. Discussion and conclusion: PEEK cages without anterior plate instrumentation and using postoperative neck collars in single-level and multilevel ACDF provide reliable and valid clinical and radiological results.

Keywords: Anterior cervical discectomy and fusion (ACDF), polietereterketon (PEEK) cage, radiculopathy, myelopathy, Cervical degenerative disc diseases (CDDD)

Introduction

In cervical spondylosis, osteophyte production and involvement of adjacent soft tissue structures are the first signs of degenerative alterations in the intervertebral discs (Binder, 2007). Most patients who complain of neck pain have non-specific neck discomfort, in which the cause of the symptoms is mechanical or postural. Although the term is frequently used to refer to all non-specific neck discomfort, the disease is frequently called cervical spondylosis when mechanical reasons are evident. Chronic neck discomfort is more likely to have mechanical and generative causes (Binder, 2007; McCormack & Weinstein, 1996). Compared to nonsurgical treatment, surgery for moderate to severe or progressive cervical spondylosis has significantly improved functional capacity and overall pain (Sampath et al., 2000). Anterior cervical discectomy and fusion (ACDF) can be used for single or multilevel cervical spondylosis (Jiang et al., 2012)..

Cervical degenerative disc disease (CDDD) is a type of cervical spondylosis, a term used to describe age-related wear and tear of the cervical spine (the neck area of the spine). Cervical degenerative disc diseases (CDDD) include various degenerative conditions often associated with cervical disc herniations (CDHs) that may result in radiculopathy and myelopathy. It is caused by the breakdown of discs between the vertebrae, leading to pain, stiffness, and reduced range of motion in the neck. It can also lead to nerve compression, which can cause tingling, numbness, and weakness in the arms and legs. Clinical findings may include neck pain, radiculopathy, myelopathy, or a combination. Treatment for CDDD typically includes physical therapy, medications, and lifestyle modifications. In some cases, surgery may be necessary. However, surgical treatment is sometimes indicated when a significant neurological deficit or persistent radicular pain is present despite at least 3 months of conservative treatment (Sasso et al., 2005).

The procedures used in the surgical treatment of CDDD are anterior cervical discectomy and fusion (ACDF), anterior cervical corpectomy and fusion, posterior cervical decompression with or without fusion, or cervical disc arthroplasty (Sekhar & Fessler, 2006). In patients who need surgical management, anterior cervical discectomy and fusion (ACDF) is the most accepted and widely performed spinal fusion procedures. Robinson Smith first described ACDF as the most accepted and widely performed spinal fusion procedure (Robinson, 1955). It is generally indicated for the cervical spinal cord decompression in CDDD associated with disc protrusions and posteriorly projecting osteophytes. However, it may also be used for traumatic, neoplastic, or infective diseases of the cervical spine (Bible & Kang, 2016; Gould et al., 2020).

Several clinical trials have studied the reliability and validity of the anterior cervical discectomy and fusion (ACDF) with PEEK cages in patients. Prospective research was conducted on cervical spondylosis patients who undergo anterior cervical discectomy and fusion using titanium or polyetheretherketone (PEEK) cages (Niu et al., 2010).

Along with technological developments, various types of cages used in ACDF surgeries have been developed with distinct advantages, including higher patient satisfaction, shortened duration of postoperative collars (or making it unnecessary), earlier rehabilitation, and lower complication rates. However, besides the advantages mentioned above, there are some disadvantages, including the potential to be embedded in the vertebral body, dislocation, pseudoarthrosis, and cost. In the preoperative evaluations and postoperative follow-up, radiological imaging is very important to assess such complications.

In this study, we aimed to determine the outcomes of single or multilevel ACDF with polietereterketon (PEEK) cages in 152 patients (a total of 237 cages) who have cervical spondylosis with a focus on the cage instability in terms of migration and subsidence that may occur in the early postoperative period.

Material and method

Participants

We retrospectively evaluated 176 consecutive patients who had undergone single-or multilevel anterior cervical discectomy (ACDF) with PEEK cage for cervical spondylosis (CDDH) from January 2015 to January 2021.

Subject

All methods were carried out in accordance with relevant guidelines and regulations. Informed consent has been taken from the patients. The clinical and radiological outcomes were evaluated at 1st and 3rd month**.** Before the operation, at least one but frequently more than one of the conservative treatments, including anti-inflammatory and analgesic therapy, cervical arm support, physical therapy, and rehabilitation, were applied to all of the patients. No significant improvement was observed in the complaints.

Study Criteria

The surgical criteria included; (1) Resistant or recurrent radicular arm pain and neurological deficit associated with a concordant soft disc herniation that does not improve with conservative treatments for at least 3 months. (2) Progressive neurological deficit consistent with neuroradiological findings (without waiting for 3 months). (3) Myelopathy that occurred due to anterior disc compression. The exclusion criteria included; (1) Patients with a history of a previous anterior and posterior cervical spinal surgery either due to CDDD or other reasons like trauma, infection, or tumor. (2) Cases with fracture, dislocation, and instability following cervical trauma. (3) Patients who were not followed clinically for at least 3 months. (4) Patients who did not have lateral plain radiographs at both postoperative 1st and 3rd months.

After evaluating the data of these patients, 152 patients who were found to be suitable for the study criteria were included.

Procedure

ACDF using an intervertebral PEEK cage was performed in all cases by the same neurosurgeon using a standardized technique. The disc space was measured with a trial cage. The cage of appropriate size filled with synthetic bone-like material and selected according to the vertebra sizes measured on preoperative MRIs was placed under fluoroscopy guidance. Care was taken to place the cages equidistant from vertebral margins, at 2 mm behind the anterior margin of the lower vertebra corpus **(fig. 1)** Plaque-screw instrumentations were not used in any of the cases, even in cases with multilevel cage placement. There were no major intraoperative complications related to the surgical procedure. In the early postoperative period, 1000 mg Ca and vitamin D/day were used during the first month.

Figure 1: the normal position of the cage immediately after the surgery.

Measurement

Postoperative follow-up

Postoperatively the patients were placed supine with the head at 20-30 degrees on a pillow. Depending on the distance of the operation, the patient was allowed to get out of bed after 8-12 hours without using a neck brace, and they were discharged from the hospital within 1 to 2 days. Neck collars were not used in any of the patients after the surgery. In order to strengthen the paracervical muscles, a restricted home neck physical exercise program with moving the neck to the right and the left was started on the 4th postoperative day. The desk workers were recommended to return to their daily activities one week after the operation, and the physical workers 3 weeks later. Follow-up time ranged from 3 to 12 months (average 7.7 months). Preoperative and postoperative neck and arm pain were evaluated using the visual analog scale (VAS) (0 =no pain, 10 = the most severe pain). The value indicated by the patient was interpreted as their pain level (Williamson & Hoggart, 2005). The preoperative and 3rd monthly follow-up values of VAS scores were considered for statistical analysis. Self-locking stand-alone PEEK cages were used to treat 3-level cervical spondylopathy in a retrospective study with 2 years follow-up (Chen et al., 2016).

Before postoperative discharge, the first and third follow-up months, and postoperatively, plain radiographs in the anterior-posterior (AP) and lateral views were taken. The neck exercises aimed anteriorly and posteriorly were also introduced to the workout regimen after the first month of follow-up. All direct radiographic examinations were performed with a Siemens Multix digital

radiography device (Siemens, Germany and Konica Minolta, Japan) digital imaging unit. Direct radiographs were stored in the image archive of our hospital (Extreme PACS, Turkey). The plain radiographs were evaluated to assess the migration of the cages in any direction & subsidence. The postoperative cervical spinal MRIs performed in some patients were also evaluated in terms of adjacent segment disease. The same neuroradiologist (B.E.) evaluated all the radiological imaging studies.

Statistical Analysis

Descriptive analysis of the data is presented as mean and standard deviation. The Kolmogorov-Smirnov test was used for the assessment of normality. Categorical data were expressed as percentages. A paired t-test was used to evaluate the preoperative and final follow-up VAS scores to analyze the pain and functional capacity. Statistical significance was defined at $p<0.05$.

Results

A total of 152 patients who underwent ACDF treatment with PEEK cages and followed up at least 3 months were made up of our study population. The mean follow-up was 7.7 months. The age of the patients ranged from 25 to 80 years (the mean age was 46.14 years) **(table 1).**

Table 1: Distribution of the patients based on age groups

Age group	Number of patients	Percent (%)
20-29	7	4.6
30-39	44	28.9
40-49	46	30.2
50-59	35	23.0
60-69	12	7.8
70-79	7	4.6
80-	1	0.6

Of the cases, 70 (46.05%) were male, and 82 (53.95%) were female. Complaints detected in all cases were neck pain radiating to the left, right, or both arms. The pain was present in the right arm in 65 cases, in the left arm in 57 cases, and in both arms in 28 cases, with or without associated neck pain. Isolated neck pain was present in 2 patients. In the neurological and physical examination of the cases, dermatomal sensory defects were detected in 122 (80.2%) cases, reflex changes in 83 (54.6%) cases, and paresis of varying degrees in 55 (36.1%) cases. Myelopathy was present in 23 (15.14%) cases.79 patients were operated on from a single distance, 56 patients from 2 distances, and 17 patients from 3 distances. Discectomy and cage fusion was performed in the C3-4 segment in 12 cases, in the C4-5 segment in 48 cases, in the C5-6 segment in 113 cases, and in the C6-7 segment in 64 cases **(table 2).**

Table 2: Distribution of patients based on cervical levels

Cervical levels	
C3-4	12
C4-5	48
C5-6	113
C6-7	64
One level	79
Two level	56
Three level	17

We used PEEK cages ranging from 12 to 14 mm in length, 4 to 7 mm in height, and 12 to 14 mm in width (237 cages in 152 patients) **(table 3).** The clinical and radiological outcomes were evaluated at 1st and 3rd month.

Table 3: Distribution of patients based on cervical levels

Measurements of IV cages	
Number of levels	Cage size (height X depth)
37	4x12 mm
153	5x12 mm
5	6x12 mm
2	7x12 mm
9	4x13 mm
18	5x13 mm
2	6x13 mm
3	4x14 mm
4	5x14 mm
4	6x14 mm
A total of 237 IV cage	

There were no intraoperative or postoperative complications. There was no postoperative hoarseness in any of the patients. Reversible dysphagia was described in 44 patients immediately after the operation; all were improved in the following 2 weeks. Postoperatively, all patients achieved satisfactory results. Preoperative complaints were initially regressed in all patients, and the radicular pain resolved with normal neck movements during the postoperative month. Significant pain relief was expressed by all patients and confirmed by the VAS scores. The preoperative VAS value was 7.67 ± 1.4 for the neck pain, and it was 8.33±1.1 for the forearm pain, which decreased to 1.18 ± 0.7 and 1.4± 2 at the postoperative 3 rd month, respectively, which were statistically significant.

Radiographic Findings

There was no postoperative cage extraction or fracture in any of our patients. Cage migration was observed in 15 cages in 12 patients without relevant clinical complaints. In 11 patients (11/152; 7.2%), a total of 14 cages (14/237, 5.9%) were found to be migrated at least 2 mm anteriorly up to the margin of the lower vertebra corpus on the 1st-month follow-up **(fig. 2, 3, 4).**

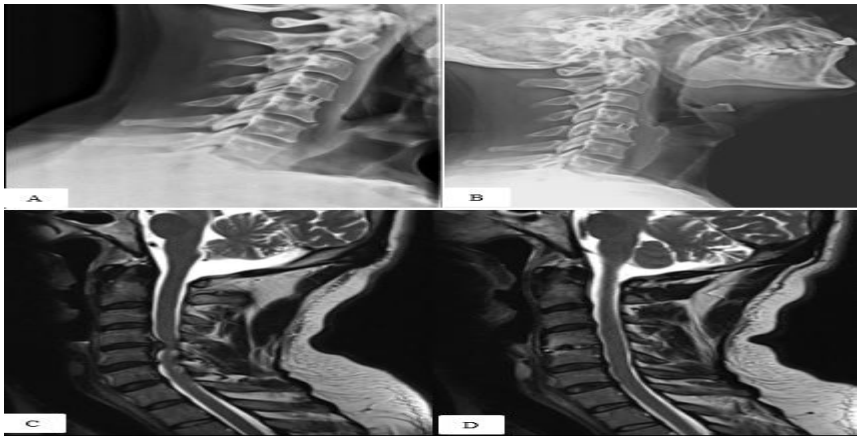

Figure 2: ACDF with PEEK cage at C4-5 **A, B**) sagittal cervical radiographic; **A:** (postoperative 1st month) showing anterior displacement of the PEEK cage and **B:** (postoperative 3rd month) showing no cage distraction despite the neck exercises. **C, D**) Sagittal T2w cervical MR images: **A:** (preoperative) showing spinal cord compression due to the protruding disc herniation (A, arrow) and **B:** (postoperative 6th month) showing the relief

of the spinal cord (B, arrow). No adjacent segment disease was observed.

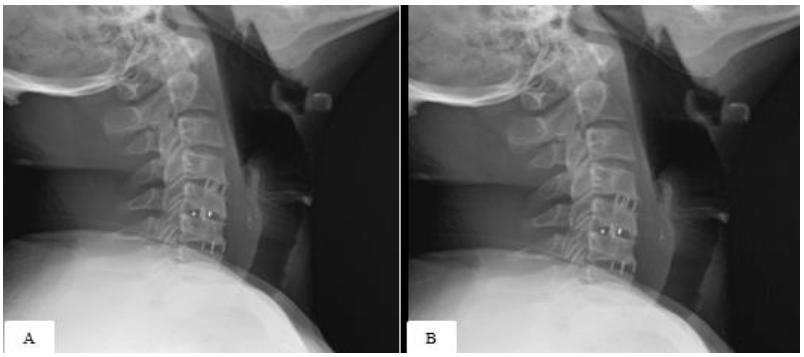

Figure 3: ACDF with PEEK cages at C4-5, C5-6, and C6-7; A: postoperative 1st month and B: postoperative 3rd month showing the anterior displacement of the PEEK cages at the level of C4-5 and C6-7.

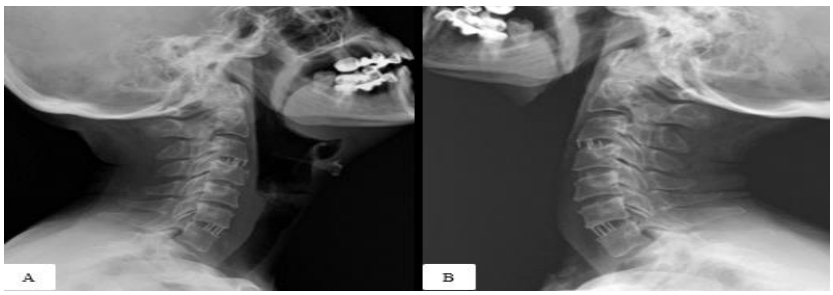

Figure 4: ACDF with PEEK cages at C3-4 and C6-7; A: postoperative 1st month and B: postoperative 3rd month showing the anterior displacement of the PEEK cages at the level of C3-4.

The same neck exercises directed anteriorly and posteriorly were also added to the program of these patients. On the second follow-up radiographs in the 3 rd month, no further displacement was observed in any of these 14 cages despite the same exercise program and not using a neck collar. There were also no other newly developed complications in these patients. In 1 patient other than these 11 patients, the PEEK cage migrated inferiorly into the inferior end plate **(fig. 5).**

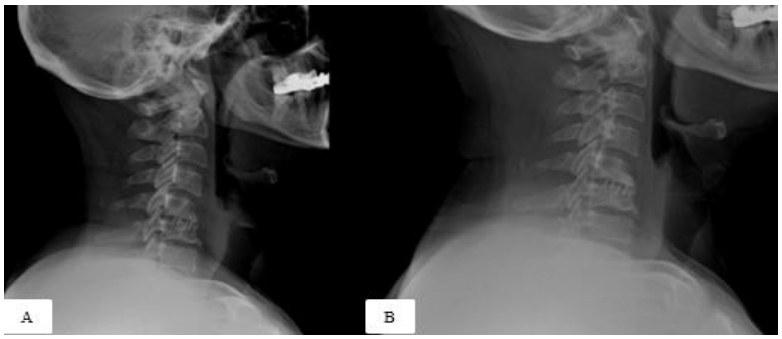

Figure 5: ACDF with PEEK cage at the level of C5-6; A: postoperative 1st month and B: postoperative 3rd-month showing inferior cage migration without relevant complaint on the 1st and 3rd-month follow-up imaging.

There was no case of superior migration of the cage into the superior end plate and no posterior or sideways migration. Subsidence was not detected in any cage, and functional radiological examination was present in all cases with maintained intervened disc distance height during the follow-ups. No segmental motion or newly developed kyphosis was observed in these cases.

There was no recurrence of radiculopathy in any of the study patients.

DISCUSSION

Anterior cervical approaches, which allow perfect exposure of the anterior spinal cord and provide complete removal of the disc and osteophytes without touching the neural structures, are the most commonly used surgical interventions in treating CDDD (Caspar et al., 1989; Ha et al., 2008). The main aim is to decompress the spinal cord & nerve roots and maintain stabilization of the spine. ACDF with PEEK cages is a surgical procedure used to treat cervical spondylosis, a degenerative spine condition. A PEEK cage is inserted in order to stabilize the spine and provide support to the vertebrae The reliability of the ACDF with PEEK cages has been evaluated by several studies, which have found that the procedure is highly reproducible and has low complication rates (Chen et al., 2016; Niu et al., 2010). The good surgical outcome following ACDF depends on good decompression, rapid and robust bone fusion, and biomechanical restoration closest to the normal. ACDF has a success rate of 90% in reducing pain and more than 80% in restoring neurological functions (Goffin et al., 1995; Hilibrand et al., 1999). In their series of 146 patients who applied ACDF, Galera et al. (1968) reported the rate of pain relief in the early postoperative period as 78 % (Galera & Tovi, 1968). Results from these studies suggest that ACDF with PEEK cages is a safe and effective procedure for treating cervical spondylosis. The reported success rate is generally high, ranging from 78-98%. Achievement of fusion without associated cage complication is the most favorable result in radiological examinations. On the other hand, radiological fusion is not a reliable parameter of clinical success, and should be correlated with clinical outcome. Despite incomplete decompression, fusion can still be achieved radiologically.

After a simple ACD, removing the disc material causes cervical spine instability due to the lack of support to the anterior column In addition, new symptoms of cervical nerve root compression may develop due to the reduced cervical foraminal region (Ha et al., 2008). Therefore, to maintain cervical lordosis and the height of the disc space, the addition of fusion to the ACD operations was prompted (Brantigan et al., 1994; Lange et al., 2000). In the 1950s, when the ACDF first became a well accepted procedure, it was performed using autologous bone grafts derived from the anterior iliac crest. However, graft-related complications observed with this traditional fusion technique, including graft dislocation or collapse, pseudoarthrosis, and donor site morbidity, have supported the development of cage fusion technology (Erok et al., 2022). After the 1980s, interbody fusion cages containing synthetic materials like titanium, carbon, and PEEK have been started to be used (Weinstein & Rengashary, 1993). These artificial cages used in practice today create fusion in the vertebral bodies, maintain disc height and lordosis, and prevent graft collapse (Hacker et al., 2000; Savolainen et al., 1998). Another advantage of the cages is that they stop the formation of osteophytic spurs due to interbody fusion; they prevent the ligamentum flavum from folding and reduce postoperative pain (Hacker, 2000). In uninstrumented fusion, the grafts can be easily displaced after the operation unless stabilization is achieved.

On the other hand, grafts with cages were less likely to slip. A front plate has been used to reduce these problems. In the past, many reports claimed the advantages of stand-alone cervical cages (Matge & Leclercq, 2000; Profeta et al., 2000). With the advances in technology, cages that better adhere to the vertebral end plates, and minimize the need for anterior plates, have been produced. In a retrospective study comparing the efficacy of 2-level ACDF with cage alone and with cage and plate construct in 54 consecutive patients, the use of cage and plate construct in 2-level ACDF was reported to be associated with a shorter fusion duration and a lower subsidence rate than that of cage alone In a prospective study conducted on 127 cases to evaluate the complications related to PEEK cages following single-level ACDF, cage-related complications were observed in 12 patients with a mean follow-up duration of 15 months, five cases of case migration, three cases of subsidence, one case of kyphotic deformity and one case of pseudoarthrosis were reported (AHMED ZOHDI et al., 2021). Our study found 12 cases of cage migration (a total of 15 cages) without any subsidence and newly developed kyphotic angulation. In a study, an increased risk of cage collapse was shown in association with a larger cage height; a cage size of 6.5 mm or 7.5 mm had a significantly higher rate of cage collapse than 4.5 mm or 5.5 mm (Yamagata et al., 2012). Another study showed a reduced risk of collapse with a larger size of the contact surface of the cage; using 14 mm diameter cages led to a lower risk of collapse than using 12 mm diameter (Yang et al., 2011). In some other studies, no correlation has been found between the size or height of the cage and the occurrence of subsidence (Cabraja et al., 2012; van Jonbergen et al., 2005).

The limitations of our study include the following 1) it is a retrospective study, 2) although any newly developed kyphotic angle was not detected in our patients, we didn't measure and compared the angle of lordosis on preoperative and postoperative radiographs.

CONCLUSION

PEEK cages without anterior plate instrumentation and using postoperative neck collars in single-level multilevel ACDF provide satisfactory clinical and radiological results. Overall, the evidence suggests that the ACDF with PEEK cages is a safe and effective procedure for treating cervical spondylosis. The procedure has a high success rate and is reliable and valid, as measured by patient-reported pain and functional improvements. The cage-related complications can be avoided by careful clinical examination and appropriate use of cages confirmed by preoperative radiological imaging. In addition, radiological follow-up of the cages is also important to detect early complications related to the cage position.

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