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Original Investigation

Empty Bladed PEEK Cage for Interbody Fusion after Anterior Cervical Discectomy

Haydar GOK[1], Mehmet Resit ONEN[1], Hatice YILDIRIM[2], Ilker GULEC[3], Sait NADERI[1]

[1]Umraniye Training & Research Hospital, Department of Neurosurgery, Istanbul, Turkey
[2]Umraniye Training & Research Hospital, Department of Radiology, Istanbul, Turkey
[3]Antalya Training & Research Hospital, Department of Neurosurgery, Antalya, Turkey

ABSTRACT

AIM: Cervical disc herniation (CDH) can be treated using different anterior and posterior methods. Anterior cervical discectomy and fusion (ACDF) is currently gold standard and provides bony fusion and good clinical outcome. Recently many studies reported good clinical and radiological outcomes in cases who underwent anterior cervical discectomy (ACD) and reconstruction with empty cage. This study aimed to review our results after cervical microdiscectomy reconstructed with empty polyether ether ketone (PEEK) cage.

MATERIAL and METHODS: Twenty-five cases with single level CDH who underwent microdiscectomy were included to this study. Reconstruction was performed using empty bladed cervical PEEK cages. Clinical (Visual analogue scale (VAS) and Odom scores) and radiological results (intervertebral disc and foraminal heights, mean cervical spine lordosis angle, and fusion rate) were reviewed one day and one year after surgery.

RESULTS: There were 18 males and 7 females, aged between 25 and 54 years (mean: 40.8). Mean neck and arm VAS scores reduced from 2.9 to 1.4, and from 7.2 to 1.8, respectively. Odom scores were found to be 1.6 and 1.4 at 1st day and one year postoperatively, respectively. Subsidence was seen in three cases (12%). There was no significant change in heights of neural foramina and intervertebral discs, and no change in cervical spine lordosis, when compared postoperative 1st day and one year radiographs. Fusion was detected in 92% of cases in one year.

CONCLUSION: Bladed cervical cages are safe with almost no risk of dislocation. Empty cages provide acceptable rates of fusion and subsidence.

KEYWORDS: Anterior cervical discectomy and fusion, Empty cage, Fusion, Cervical disc herniations

INTRODUCTION

Cervical disc herniation (CDH) is an important disorder affecting health care. Many surgical treatment modalities have been used to treat CDH, including anterior cervical discectomy (ACD) (30, 39, 41), anterior cervical discectomy and fusion (ACDF) (1, 3, 6, 8-10, 16, 25-27, 29, 31, 35, 36, 38, 43, 46, 47), anterior foraminotomy (32, 42), keyhole foraminotomy (12, 18, 40, 49), and arthroplasty (5, 19, 36, 41). Each approach has its advantages and disadvantages. ACD has been used for many years and has encouraging results in one level cases with a stable cervical spine. However, long term results of ACD are associated with uncontrolled fusion and cervical kyphosis, particularly in cases with 2 and 3 level CDH (30).

On the other hand, the addition of a disc prosthesis after ACD has some theoretical advantages, including motion preservation, and reduced rate of adjacent segment disease. However, adjacent segment problem, heterotopic ossification and high cost related problems remain (45, 50).

Another technique, anterior cervical foraminotomy, is an effective technique, particularly for foraminal herniations. There is, however, a risk of injury to the vertebral artery and

Corresponding author: Sait NADERİ
E-mail: saitnaderi@yahoo.com

cervical sympathetic trunk. Another foraminotomy technique, keyhole laminoforaminotomy, is also an effective surgical option for treatment of foraminal CDHs, but it requires partial resection of the facet joints, and therefore there is risk of instability in case of aggressive facet resection (48).

Currently ACDF seems to be the most accepted technique for cervical discectomy and reconstruction of the operated level. ACDF preserves cervical lordosis, restores both vertebral disc height and foraminal height, and promotes controlled bone fusion. Disadvantages of ACDF include loss of segmental motion and adjacent level disease (2, 14, 17).

ACDF can be performed using bone graft (8, 10), or a variety of titanium (11, 29, 31, 52), carbon fiber (4, 6, 9, 26, 35, 38, 43, 46, 47) or PEEK cages (24, 27, 31). Recently, PEEK cages with pins and blades have been popular. These cages have no metalic artifacts, and do not prevent postoperative imaging. Therefore, PEEK cages, filled with bone and/or demineralised bone matrix, are used widely in current cervical spine surgery practice worldwide.

Regardless of type of surgical procedure, most surgical options may result in fusion. The rate of fusion has been reported to be 95-100% after ACDF (3, 6, 8-10, 26, 27, 29, 31, 35, 36, 38, 43, 46, 47), up to %70 after ACD (30, 41), and 20-70% after cervical spine arthroplasty (5, 19, 36, 51). The likelihood of high fusion rates in ACD and even in arthroplasty cases is of interest. Therefore, the necessity of application of arthrodesis procedure using autologous bone or expensive biomaterials should be questioned.

On the other hand, the area required for optimal fusion should also be clarified. It is known that fusion occurs not only inside of small cages, but also anterior and posterior to the cage (6). Therefore, the necessity of filling small areas inside the cages with biomaterials or bone for successful fusion should be questioned. The aim of this study was to analyse the clinical and radiological results of ACD followed by placement of empty bladed PEEK cage into the intervertebral disc space.

■ MATERIAL and METHODS

Twenth-five cases with one-level CDH were included in the study. All patients presented with cervical radiculopathy and underwent standard ACD, and reconstruction using empty bladed cervical PEEK cage. It is of note that the endplates of the vertebrae were thoroughly decorticated, exposing the center of the PEEK device to the bleeding cancellous portion of the vertebrae.

The radiological and clinical outcomes of the patients were investigated prospectively.

The clinical outcome was assessed using the Odom score, one day and one year after surgery. Neck and arm pain was assessed using the Visual Analogue Scale (VAS) scores before and one year after surgery.

Many radiological parameters were analysed (Table I). Radiological studies were performed immediately one day and one year after surgery to assess the fusion rate, subsidence, the height of the neural foramina and of the anterior and posterior disc heights at the operated level, upper and lower adjacent levels, as well as cervical lordosis.

Heights of intervertebral disc and neural foramina were measured on computed tomography (CT). Cervical lordosis angles were measured on lateral plain radiographs using two different methods, including Cobb's and Harrison posterior tangent methods.

Fusion was assessed using plain lateral flexion / extension radiographs and CT. Fusion was assessed and determined by the radiologist if there was obvious bridging bone inside or outside of the cage on CT, and if there was < 2° of segmental motion on flexion / extension radiographs.

Subsidence was assessed in the postoperative one-year radiological evaluation.

The mean follow up rate was 16 months (range 12 to 23 months). Statistical analysis was performed using the paired samples test.

■ RESULTS

There were 18 males and 7 females, aged between 25 and 54 years (Mean age: 40.8±8.07 years). There were one C3-4, one C4-5, 11 C5-6, and 12 C6-7 disc herniations.

The mean preoperative and postoperative neck VAS scores were found to be 2.9 and 1.4, and mean preoperative and postoperative arm VAS scores were found to be 7.2 and 0.8, respectively.

Odom scores were found to be 1.6 and 1.4 one day and one year after surgery, respectively.

Detailes of radiological analyses were shown in Table II, III. Anterior disc heights of operated levels were found to be 6.372±1.022 mm and 5.480±1.274 mm, one day and one year after surgery, respectively (p=0.032). Posterior disc heights of operated levels were found to be 4.144±0.952 mm and 3.376±0.964 mm, one day and one year after surgery, respectively (p=0.050).

Anterior disc heights of adjacent upper levels were found to be 3.480±1.061 mm and 3.192±1.090 mm one day and one year after surgery, respectively (p=0.000). Posterior disc heights of adjacent upper levels were found to be 2.680±0.681 mm and 2.956±0.711 mm, one day and one year after surgery, respectively (p=0.001).

Anterior disc heights of adjacent lower levels were found to be 3.496±0.849 mm and 3.564±1.096 mm, one day and one year after surgery, respectively (p=0.000). Posterior disc heights of adjacent lower levels were found to be 2.720±0.645 mm and 2.644±0.659 mm, one day and one year after surgery, respectively (p=0.006).

When we compared foraminal heights at operated levels at postoperative 1st day and 1st year, foraminal heights changed from 9.968±1.378 mm to 9.880±1.358 mm on the right side (p=0.000), and from 9.768±1.594 mm to 9.552±1.481 mm, at the left side (p=0.000).

Right foraminal heights of adjacent upper levels were found to be 9.728±1.621 mm and 9.892±1.584 mm, one day and one year after surgery, respectively (p=0.000).

Left foraminal heights of adjacent upper levels were found to be 9.932±1.417 mm and 9.988±1.673 mm, one day and one year after surgery, respectively (p=0.052).

Right foraminal heights of adjacent lower levels were found to be 9.960±1.328 mm and 9.716±2.264 one day and one year after surgery, respectively (p=0.018).

Left foraminal heights of adjacent lower levels were found to be 9.940±1.306 mm and 9.988±1.673 mm, one day and one year after surgery, respectively (p=0.001).

Mean cervical lordosis angle using the Cobb method were found to be 7.360°±5.040 and 7.560°±6.053, one day and one year after surgery, respectively (p=0.876).

Table I: List of Analysed Parameters

Clinical parameters
Odom
Neck VAS
Arm VAS
Radiological parameters
Anterior and posterior disc heights of operated levels after surgery
Anterior & posterior disc heights of upper levels after surgery
Anterior & posterior disc heights of lower levels after surgery
Right & left foraminal heights of the operated levels after surgery
Right & left foraminal heights of upper levels after surgery
Right & left foraminal heights of lower levels after surgery
Mean cervical spine lordosis angle (Cobb)
Mean cervical spine lordosis angle (Tangent)
Subsidence rate
Fusion rate

Mean cervical lordosis angle using the Tangent method were found to be 12°±7.863 and 13.8°±7.592, one day and one year after surgery, respectively (p=0.198).

Subsidence was detected in three cases (12%). Fusion was detected in 23 cases (92%) at one year (Figure 1A-D).

■ DISCUSSION

This study revealed acceptable rate of fusion, subsidence, and good clinical outcome after ACD, reconstructed with empty bladed PEEK cage. This study also confirmed maintenance of cervical lordosis, and disc and foraminal heights one year after surgery.

There are many reports on the high fusion rate after the use of titanium, carbon fiber, and PEEK cages filled with bone and/or bone substitutes (1, 6, 9, 10, 25, 27). The main disadvantages of the cages include donor site morbidity (in case of the use of autograft), high cost (in case of bone substitutes), and subsidence.

In order to avoid donor site morbidity, some authors used local bone harvested from local osteophytes, and others used biomaterials. The former is not commonly enough, because there is not enough bone to pack whole the cage, and the latter has high cost. Therefore, in order to achieve an acceptable fusion rate, many surgeons prefer to pack the cage with both resected bone from surgery site and biomaterials.

On the other hand, there are some studies confirming similar fusion rates after ACD (30, 41), after the use of an empty cage (Table IV) (7, 13, 20-23, 33, 34, 44, 52), and even after the use of a cervical disc prosthesis (5, 19, 37, 51). That means fusion does not relay only to the presence or absence of bone graft. Schröder et al, demonstrated large solid bony fusion within the cage in a case who underwent ACD and reconstruction with an empty cage (40). Similarly, Mondorf et al. used an empty cage in cases with discitis and reported successful fusion (28).

There exists also another fact supporting the idea of empty cage usage after ACD. It is known that bony fusion does not occur only within the cage, but also around a cage (6). This is not surprising, because the fusion area inside the cages, particularly in expandable cages, is too small for a successful bony fusion.

Table II: Anterior and Posterior Heights of Disc Spaces at Operated Level, and Adjacent Upper and Lower Levels

Parameters	Day 1 (mm)	One year (mm)	p
Anterior heights of disc spaces at operated levels	6.372±1.022	5.480±1.274	0.032
Posterior heights of disc spaces at operated levels	4.144±0.952	3.376±0.964	0.050
Anterior heights of disc spaces at upper levels	3.480±1.061	3.192±1.090	0.000
Posterior heights of disc spaces at upper levels	2.680±0.681	2.956±0.711	0.001
Anterior heights of disc spaces at lower levels	3.496±0.849	3.564±1.096	0.000
Posterior heights of disc spaces at lower levels	2.720±0.645	2.644±0.659	0.006

Table III: Right and Left Foraminal Heights of Disc Spaces at Operated Level, and Adjacent Upper and Lower Levels

Parameters	Day 1 (mm)	One year(mm)	p
Right foraminal heights at operated levels	9.968±1.378	9.880±1.358	0.000
Left foraminal heights at operated levels	9.768±1.594	9.552±1.481	0.000
Right foraminal heights at upper levels	9.728±1.621	9.892±1.584	0.000
Left foraminal heights at upper levels	9.932±1.417	9.988±1.673	0.052
Right foraminal height at lower levels	9.960±1.328	9.716±2.264	0.018
Left foraminal heights at lower levels	9.940±1.306	9.988±1.673	0.001

Table IV: Fusion and Subsidence Rate After the Use of Empty Cervical Cages in Different Reported Series

Author	Year	Cage type	#	Follow up	Outcome	Subsidence	Fusion rate
Lange	2002	Titanium	153	23m	90%	-	-
Zevgaridis	2002	Titanium	18	12m	83%	34%	83%
Payer	2003	C. fiber	25	12m		20%	96%
Thome	2006	Titanium	50	12m	74%	18%	79%
Frederic	2006	C.fiber	36	12m		33%	96%
Krayenbühl	2008	Titanium	45	48m	75%	2%	57%
Kast	2009	PEEK1 PEEK2		6m 6m	94% 94%	6.8% 1.4%	76% 76%
Pechlivanis	2010	PEEK	52	12m	80%	-	71.7%
Lemcke	2011	PEEK1 PEEK 2	181 154	12m 12m	83% 83%	13.3% 8.4%	- -
Cabraja	2012	Titanium PEEK	44 42	30m 26m	75% 64.3%	20.5% 14.3%	93.2% 88.1%

Figure 1: Postoperative sagittal CT of a case with C6-7 disc herniation reconstructed with empty cage, showing fusion process with the time. **A)** Postoperative day 1, **B)** One month after surgery, **C)** Six months after surgery, and **D)** One year after surgery.

The current study showed 92% fusion, a rate comparable with cages filled with bone and biomaterials. The fusion in the cases of the current series occurred both inside the cage and posterior to the cage. Therefore, this study confirmed the idea of the use of empty bladed cage.

The advantages of the use of empty cages included short operative time, no need for bone harvesting from donor site, and no cost for biomaterials. There was a significantly short operative time in current series and the mean duration of surgery was 61 minutes. Similarly, the hospitalization time was also significantly short (only one day).

Cage subsidence in the months after implantation is also an important concern. The rate of subsidence ranges from 2% to 33% (3, 4, 11, 15, 20). Subsidence results from several reasons, including over-curettage of the endplate, over-distraction with too tall cage, cage geometry, and cage material. Careful curettage, and careful selection of the cage may reduce the rate of subsidence. We have observed subsidence in three (12%) of our 25 patients. The incidence of cage subsidence may be affected by the differences in modulus of material elasticity too (10,31). PEEK cages have an elastic modulus close to the bone. This fact may be a factor decreasing the rate of subsidence in the current series.

On the other hand, subsidence of cage may affect foraminal and disc height, and as a result the segmental angle. The low rate of subsidence the in current series was associated with better radiological results. There was preservation of cervical lordosis and an acceptable rate of disc and foraminal heights at the operated level and at adjacent levels even one year after surgery.

■ CONCLUSION

It is concluded that implantation of empty bladed cervical cage in the treatment of CDHs provides acceptable rate of fusion, subsidence, and good clinical outcome, as well as avoidance of the high cost necessary for biomaterials.

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