Original Article

Stand-alone polyetheretherketone cages for anterior cervical discectomy and fusion for successive four-level degenerative disc disease without plate fixation

ABSTRACT

Background: Anterior cervical discectomy with fusion became the most frequently performed technique for the treatment of symptoms related to cervical disc prolapse. Multilevel anterior cervical discectomy has been combined with anterior cervical plate application to help maintain the cervical lordosis and enhance fusion. This was associated with more soft-tissue separation and retraction with increased incidence of surgically related complications and postoperative dysphagia.

Aim of the Study: The aim of this study is to evaluate the safety and efficacy of the stand-alone cervical polyetheretherketone (PEEK) cages in four-level discectomy and to determine if it is possible to avoid anterior plate fixation and to achieve satisfactory outcomes.

Methodology: This is a retrospective study which was performed between June 2011 and December 2018 at one institute. The clinical and radiological data were collected from patients who underwent successive four-level anterior cervical discectomy and fusion with PEEK cages for degenerative cervical disc disease without plate fixation.

Results: This study included 66 patients, 35 males and 31 females. The follow-up period was 24 months. Mean Japanese Orthopedic Association scores were 13.3 ± 1.41 preoperative and 15.9 ± 0.86 postoperative ($P = 0.046$). The cervical curvature index "Ishihara" (ICI) was 9.9 ± 5.90 preoperative and the mean of ICI was 10.5 ± 6.65 postoperative, which is insignificant, $P = 0.7$). The lordotic curvature according to these results was preserved till the end of the year and half of the follow-up period postoperative.

Conclusion: Consecutive four-level anterior discectomy with PEEK cage interbody fusion without plate and screw is a safe and effective procedure in the absence of instability, and it may be a reliable alternative for the treatment of multilevel cervical disc.

Keywords: Anterior cervical discectomy, cervical disc, cervical plate, four-level cervical disc

INTRODUCTION

Anterior cervical discectomy and fusion (ACDF) is a widely performed surgical procedure for radiculopathy and myelopathy that result from degenerative cervical disc disease.[1,2] Since the initial procedure by Smith and Robinson, anterior cervical arthrodesis procedure has been tuned for the treatment of degenerative cervical disc disease. However, the failure rates increase as the levels of discectomies increase.[3] Multilevel cervical discectomies are usually combined with plate fixation to keep the spinal curvature and increasing the rate of fusion.[4-7] The insertion of a plate over multiple vertebral bodies requires more tissue retraction which may increase the risk of occurrence of complications, such as screw breakage, pull out, esophageal injury, and recurrent

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laryngeal nerve injury. Such complications can compromise the satisfactory final outcome decompression of the spinal cord and/or nerve roots and bone fusion with maintenance of cervical lordotic curvature.[8-12]

Synthetic cages from polyetheretherketone (PEEK) cages have been designed to restore and keep stability immediately and to promote bone growth inside and around the cage.[11,13-16] Clinical results of using interbody cages without plate fixation for single or two level (s) are encouraging. To our knowledge, ACDF without plate fixation showed a satisfactory fusion rate and neurological outcome after three levels of cervical discectomies,[16,17] which has lowered the complications and decreased the length of stay, pushing the interbody cage fusion without plate to be superior to fusion with plate.[18,19] However, in long multilevel cervical reconstruction with cages, subsidence may occur.[20] The aim of this study is to evaluate the safety and efficacy of the stand-alone cervical PEEK cages in four-level discectomy and to determine if it is possible to avoid anterior plate fixation and to achieve satisfactory outcomes.[21-24]

METHODOLOGY

Study design

A retrospective study was performed between June 2011 and December 2018 at one institute. The clinical and radiological data were collected in patients who underwent successive four-level ACDF with PEEK cages for degenerative cervical disease without plate fixation system. Inclusion criteria were patients suffering from radiculopathy, myelopathy, or a combination of both due to nerve root or cord compression with four-level successive degenerative disc disease, including ossified posterior longitudinal ligament and disc osteophyte complex, while exclusion criteria were patients with previous cervical surgery and cervical instability from the study cohort. Sixty-six patients were enrolled in the study, and radiological and clinical follow-up period was 2 years.

Surgical procedure

In supine position, intraoperative fluoroscopy was used to confirm the adequate exposure of the required levels, before a transverse incision at the midway level of the required levels or a longitudinal skin incision, medial to right sternocleidomastoid muscle to access the prevertebral space [Figure 1]. Standard macroscopic and microscopic discectomy was done in all patients. The osteophytes were excised with a Kerrison, and both end plates were decorticated. The posterior longitudinal ligament was removed to confirm sufficient decompression. The PEEK cages were packed with artificial bone granules (calcium hydroxyapatite in low crystalline form) and then inserted into the disc space. The cage is formed of PEEK with two serrated retention teeth to prevent migration and markers made of titanium alloy which indicates cage position on X-ray. The implants were available in four heights of 4, 5, 6, and 7 mm with an internal anteroposterior width of 12 or 14 mm. After cages insertion, intraoperative fluoroscopic was used to confirm the proper location of the cages, and submuscular drain was inserted in all cases. All patients postoperative were kept in a Philadelphia neck collar for 6 weeks.

Outcome and follow-up

Postoperative, clinical, and radiological follow-up was done at the 3rd, 6th, 12th, and 24th months. Standard neurological evaluation and the modified Japanese[15] Orthopedic Association (JOA) scoring system were used to assess the clinical outcome. Spinal curves, mobility, and fusion status with X-ray were recorded and evaluated. Anteroposterior, lateral, and flexion/extension images were obtained immediately after surgery and at follow-up intervals after surgery.

The cervical levels were defined to be successfully fused if there was no change in mobility of the fused levels on flexion and extension views obtained at 12–24 months postoperative without pain and with intact hardware. Fusion was assessed by existence of trabecular continuity, bone mass bridging across the disc space, and a cloudy interface between the cage and the end plates. Furthermore, images were assessed according to the classification of Vavruch *et al*. of the anterior cervical fusion;[25] Type 1A is defined as bridging bone anterior and through the disc space, while 1B as bridging bone anterior but not through the disc space, 2A as bridging bone not anterior but through the disc space, and 2B as no bridging bone at all "pseudarthrosis." Fusion group included 1A, 1B, or 2A while the Non-fusion group included 2B. Ishihara Curvature Index (ICI) of the lateral view was used to the degree of spinal curvature;[26] which is the value calculated by adding the distance between 4 lines connecting the posteroinferior border of C2 to the posteroinferior border of C7 and each of the posteroinferior borders of the C3 to C6 "a3-a6", and then divided by the distance of a line extended from the posteroinferior border of the C2 to C7 "CD" (spinal curvature index: [a3+a4+a5+a6]/CD×100). A positive intersection length indicated the degree of lordosis. If negative, it indicates kyphosis, while zero, defined as straight. A 3-mm reduction or more in the interbody height was defined as subsidence in the interbody height on the immediate postoperative and 12th-month follow-up images.

Statistical analyses were done with the IBM SPSS 22 software program (IBM, Armonk, New York, USA). Data are presented as mean ± standard deviation. $P < 0.05$ was considered statistically significant.

RESULTS

There were 35 men and 31 women between the ages ranging from 36 to 68 years, with a mean age of 48. All patients were followed up for at least 24 months [Table 1]. Patients with C3 till C7 discectomies were 59 (89.1%) [Figure 2] and C2 till C6 were 7 (10.9%) [Figure 3]. Postoperative, no neurological deterioration occurred except in two cases who developed transient C5 root palsy and resolved within a month and in other case deterioration of motor power from G4 to G3 according to the Medical Research Council scale which resolved within 6 weeks. Postoperative X-rays confirmed the proper location of the PEEK cages [Figure 2b]. Mean JOA scores were 13.3 ± 1.41 preoperative and 15.9 ± 0.86 postoperative ($P = 0.046$). ICI of the lateral view used for curvature evaluation was 9.9 ± 5.90 preoperative, and the mean of ICI was 10.5 ± 6.65 postoperative. It was insignificant ($P = 0.7$). The lordotic curvature according to these results was preserved till the end of the year and half of follow-up period postoperative.

At the final follow-up, the fusion rate of 1A, 1B, and 2A types was 92.4% (244/264 levels), while nonfusion type 2B "pseudarthrosis" 7.6% (20/264 levels) [Figures 3 and 4]. By the end of follow-up time no cage migration or collapse were observed [Figure 2] except in 3 cases (4.5%) belong to the nonfused group 2B in ten patients all were from C3–C7 group; they were all asymptomatic and kept on conservative management as no mobility was detected on flexion–extension images. Subsidence in the interbody height was seen in three cases (4.5%). All were in C3–C7 group seen in two consecutive levels in each case and were asymptomatic till 24 months of follow-up.

DISCUSSION

ACDF is a widely used procedure to treat multiple cervical spinal pathologies, as cervical spondylotic myelopathy, degenerative disc prolapse, and trauma. Regarding single-level ACDF, the studies concluded that it can achieve a variable fusion rate from 92% to 100% and a relief of neurological symptoms, which varied from 70% to 90%.[27,28] In multilevel ACDF an autogenous bone graft usually fail to keep the spinal stability in multilevel discectomies properly and the complications rate related to the usage of autogenous bone graft increase when compared to single level discectomy, such as graft collapse 20%–30% seen in multilevel cases.[3,29-31]

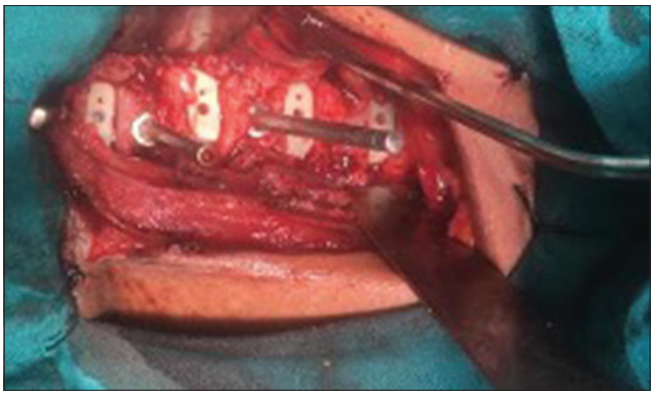

Figure 1: Intraoperative exposure after longitudinal incision and four-cage insertion

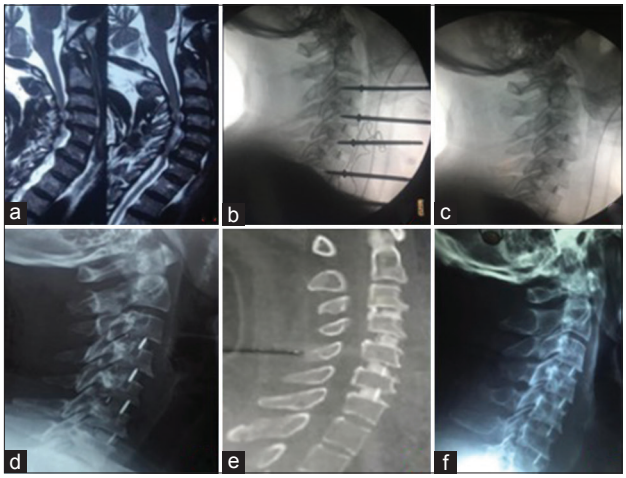

Figure 2: Type 2A fusion case "2A as bridging bone not anterior but through the disc space," (a) MRI of C3–C7 case, (b) intraoperative, (c) immediate postoperative, (d) 3-month follow-up, (e) 3-month follow-up CT scan, (f) 24-month follow-up

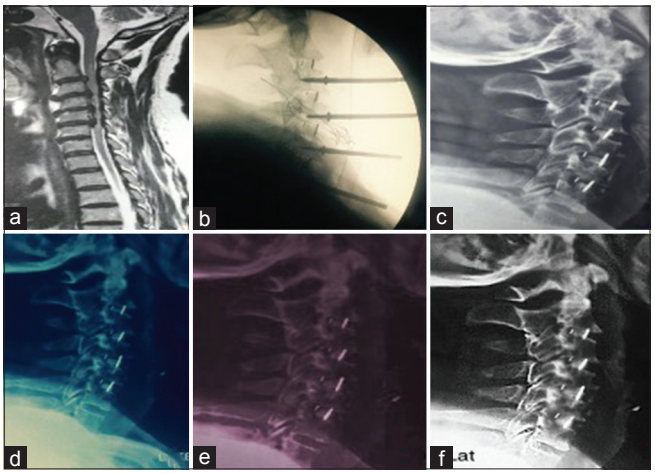

Figure 3: Type 1A fusion case "1A is defined as bridging bone anterior and through the disc space," (a) magnetic resonance imaging of C2–C6 case, (b) intraoperative, (c) immediate postoperative, (d) 3-month follow-up, (e) 12-month follow-up, (f) 20-month follow-up

Table 1: Patients' demographics (*n*=64)

Demoghraphic data	Value
Mean age	48
Male	35
Female	31
C2-C6	7
C3-C7	59

Many literature had reported an increasing rate of nonfusion as the number of level discectomies increases 10%–12% for 1 level, 20%–25% for 2 levels, and about 30%–55% for 3 levels of fusions.[18,32-34] Hence, when a multilevel ACDF is being done, an augmentation with plate system for fixation seems to be preferred based on the fact that it may decrease the micromotion between consecutive levels and promote fusion rate and restoration of physiological sagittal lordosis. It has been reported that ACDF with plate fixation leads to better symptomatic pain relief and a higher fusion rate.[29,31] However, the rate of pseudoarthrosis was 6%–8% for one level and 25% for treatment of several levels in a retrospective study by Das *et al*.[35] Furthermore, in three- and four-level ACDF, the fusion rates decreased to 35%, even when plates were used. The plate-associated morbidities varied from 2% to 20% as screw pullout, breakage, laryngeal nerve, esophageal injury, and root injuries. Longer operative time and hospital stay are reported as well.[24,36,37] Such morbidity of the basic fusion techniques favored the cage technology. ACDF with cage was proved to be effective treatment of degenerative cervical disc pathologies, with high fusion rates ranging from 90% to 100%.[38,39]

Stand-alone cage concept was used by Bag for the 1st time,[40] and then, it achieved an excellent outcome globally. Furthermore, the use of multiple cages for multilevel myelopathy and radiculopathy showed good outcome till 4 years of follow-up.[41] In our study, the fusion rate was 92.4%, comparable to pervious similar studies in literature.[3,30] The pseudarthrosis (fusion failure) in our study represented 7.6% (20/264 levels), while Chang *et al*. reported 0.04% of pseudarthrosis of 440 levels.[42] However, these ten patients had no clinical symptoms observed during the 24-month follow-up period.

Subsidence was seen in three cases of C3–C7 group seen in two levels from the four levels and was asymptomatic. When anterior cervical plates are not used the subsidence is a common complication in multilevel, 9%–16.5% per level, while subsidence decrease during occurrence of fusion when plates are used due to its curve, In another study, the rate was 13/104 per level.[43,44]

No cage-related complications occurred, and the usage of the cages was found to keep the sagittal balance

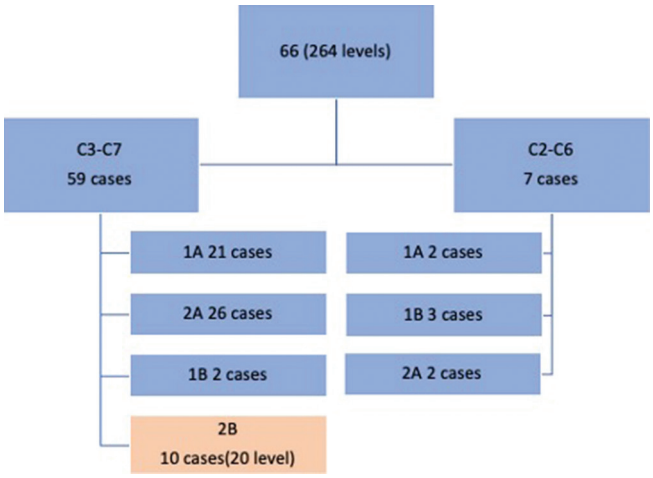

Figure 4: Result distribution according to the level based on the classification of Vavruch *et al*. of the anterior cervical fusion;[25] Type 1A is defined as bridging bone anterior and through the disc space, while 1B as bridging bone anterior but not through the disc space, 2A as bridging bone not anterior but through the disc space, and 2B as no bridging bone at all. Fusion group included 1A, 1B, or 2A while the Non-fusion group included 2B

spinal (lordosis) and preserved the height of the cervical foramina as well. The insertion of cervical cage increases the foraminal height, which helps in nerve root decompression. Hwang *et al*. results match with our finding that PEEK cages alone for three or four levels without plate fixation had less postoperative morbidity.[45] Furthermore, the wedge-shaped cage design restores the lordosis. In our study, we found that using multiple PEEK resulted in keeping and restoration of the preoperative lordotic curvature as calculated using ICI, which was 9.9 ± 5.90 preoperative and 10.5 ± 6.65 postoperative.

PEEK cages were used for multilevel ACDF as complication rates are less when compared to the other modalities. PEEK is a polymer, which provides a strength, stiffness, and resistance to compression as seen in biomechanical studies.[8,46-48] Furthermore, PEEK cage has more elastic properties than the other cages made from metals, decreasing the incidence of subsidence into the surrounding vertebrae. Regarding biocompatibility, PEEK cage has a stimulatory effect on osteoblasts, osteocalcin synthesis, and fibroblast proliferation.[49] The cage design with titanium spikes on the upper and lower surfaces of the cage helps to anchor the cage offering somehow a similar function of plate and screws. The imaging criteria of PEEK being radiotransparent, which help in the evaluation of bone fusion and its artifacts, are negligible in magnetic resonance imaging and computed tomography scans.[29,30,50-52]

The complications related to the usage of autologous tricortical iliac bone graft reduced markedly with the usage of PEEK cages. In most of the previous studies, PEEK cages were

packed with cancellous bone; in our study, we used calcium hydroxyapatite in low crystalline form (bone granules) mixed with autologous blood.[46,49,53]

To our knowledge, our clinical series of consecutive four-level ACDF without plating have not been reported in literature before with providence of such number of cases. Our results provides an evidence that usage of stand-alone cages without plate in ACDF procedures for consecutive four-level degenerative disc disease without the presence of instability is safe and effective. This is guided by intraoperative fluoroscopy for observation of the restoration of the lordotic curve and avoidance of excess removal of end plate to avoid subsidence.

CONCLUSION

Consecutive four-level anterior discectomy with PEEK cage interbody fusion without plate and screw is a safe and effective procedure in the absence of instability, and it may be a reliable alternative for the treatment of multilevel cervical disc. It keeps the spinal biodynamics and decreases the risk of complications related to screw and plate fixation systems.

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Nil.

Conflicts of interest
There are no conflicts of interest.

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