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Anterior cervical discectomy and fusion solely with peek cages ın multilevel cervical spondylotic radiculomyelopathy: single center clinical experience with 58 consecutive patients

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Abstract
Aim of this study was to evaluate the efficacy and safety of fusion solely with polyetheretherketone (PEEK) cages without plates and autogenous bone graft to provide fusion in multilevel cervical spondylosis in selected cases. 58 patients with cervical discogenic disorders in 3-4 levels (38 and 20 patients respectively) underwent multilevel anterior cervical discectomy and fusion (ACDF) operations with PEEK cages for a total of 194 levels. Minimum follow up was 24 months (24-48) postoperatively. Outcome had been established in combination with the evaluation of cervical lordosis, fusion rates and neurological improvement that was assessed by Japanese Orthopedic Association (JOA) scoring system. They were assessed by radiographs, computerized tomography and magnetic resonance imaging studies. Clinical outcomes were based on the issues including length of hospital stay, blood loss, complication rates and functional outcomes. 38 patients underwent three-level, 20 patients underwent four-level operations. Fusion rate was 89.2%. Significant improvement in the JOA scores was recorded postoperatively, and Ishihara Curvature Index (ICI) was preserved. In the follow-up period, no cage migration was experienced and reoperation was not required except for one who later underwent corpectomy and anterior fusion. ACDF with the use of PEEK cages without plates proved to yield good clinical outcome and comfortable postoperative course for the patients with acceptable fusion rates.

Keywords: Anterior cervical discectomy, fusion, cervical disc herniation, cervical spondylosis, pseudarthrosis, radiculomyelopathy

Introduction

Cervical spondylosis is a rather common disorder of the spine and the treatment consists of decompression of the affected neural structures either by multilevel (more than 2 levels) corpectomy or preferably by multilevel discectomy [1-5]. Anterior cervical corpectomy that also allows thorough decompression including resection of osteophytes is usually effective in the management of cervical radiculomyelopathy secondary to cervical spondylosis [6-8]. However, forthcoming complications of corpectomy and titanium cage application, and the morbidity caused by autogenous bone graft harvesting causes propensity to the application of discectomy and fusion with polyetheretherketone (PEEK) cages[9]. The use of spinal cages for spinal fusion in patients with cervical spondylosis and disc disease has been popular because cages aid in increasing cervical foraminal height and they contribute to restoration of cervical lordosis[7]. Besides, ACDF with PEEK cage commits higher rates of fusion with fewer complications. These surgeries are not common unless it's a referral spinal surgery center. Management of multilevel cervical spondylosis via anterior approach is scarcely and incompletely documented, so literature lacks in reporting ACDF without the use of plates or autogenous bone grafts. As the outcomes of 2-level and 3-level surgeries have been published declaring good results with less complications including subsidence, migration, structural failure and non union, surgeons are encouraged to perform 3-to 4-level ACDF solely with PEEK cages without further stabilization in cervical spondylosis[10, 11]. In the past, though non- instrumented ACDF raised much concern for a while, reports about the long-term performance and outcome have not been affirmative. However, the last reports about the long-term performance following ACDF with PEEK cages boded well for surgery concerning multilevel pathologies [7]. It seems that this technique in selected cases will supplant fusion with plates and screws or 360 degree instrumentation. In this study, we report our preliminary experience in ACDF with interbody PEEK cages without plates and autogenous bone grafting in the management of multilevel cervical spondylosis.

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Materials and Methods

This prospective study was conducted in our department between 2007 and 2014. We treated 58 patients consecutively for symptomatic cervical spondylosis and/or radiculomyelopathy. There were 32 male and 26 female patients with an average age of 64.207 years (range, 52-78 years). They presented with intractable radiculopathy, myelopathy or both due to nerve root and cord compression. They had degenerative cervical disc disease (DDD) and spondylosis with radiculopathy or radiculomyelopathy and had preserved anterior subarachnoid space in spite of anterior segmental compression viewed on magnetic resonance (MR) imaging study (Figures 1, 2).

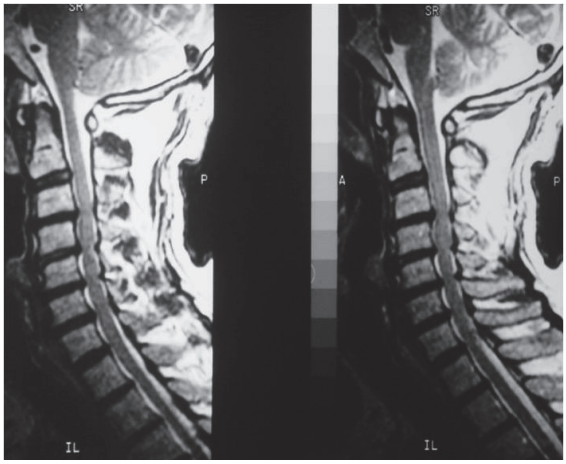

Figure 1 (Left). *MR images on sagittal view discerned degenerative cervical disc disease and spondylosis. Patients had preserved anterior subarachnoid space in spite of anterior segmental compression and patients with posterior compression findings were excluded from the study.*

Figure 2 (Right). Twenty-one patients had radiculomyelopathy identified by high-intensity signal in the spinal cord from the sagittal T2-weighted MR images.

Patients with the history of trauma, infections, neoplasm and rheumatoid arthritis and previous cervical spine surgery were excluded. Patients with posterior cord compression findings were not enrolled in the study. All patients had multilevel ACDF with PEEK cages. Cages were packed with demineralized bone matrix (DBM) mixed with autologous blood and chipped bony material.

In addition to neurological examination, neurologic function was assessed by using the Japanese Orthopedic Association (JOA) scoring system before and after surgery in each patient. Follow-up controls began in the first day after surgery with radiographs and neurological examination.

The operative procedure consisted of removing the disc, posterior longitudinal ligament, and osteophytes, including the posterior part of the uncinate process, via anterior approach. The hollow PEEK cages impacted with DBM and chipped autologous bony particles and blood were placed. Patients wore Philadelphia collar for six weeks postoperatively to avert excessive cervical spine motion and received physiotherapy after removal of the collar to strengthen neck muscles. Antero–posterior and lateral radiographs with neutral and flexion-extension stress views were obtained preoperatively (Figure 3).

Clinical and radiological follow-up was performed at the 3rd, 6th 12th 24th months (Figure 4,5).

Radiographs and MR images were used to assess cervical lordosis and fusion rates. A radiologist blinded to clinical outcome, independently assessed fusion status. The operative segment was accepted as fused if there was no change in position of the fused levels on dynamic views (flexion and extension). Additionally, the radiological images were evaluated using the classification of anterior fusion proposed by Vavruch et al[12].

The Ishihara Curvature Index (ICI) was used for the evaluation of spinal curve on lateral cervical radiographs[13]. Statistical analysis was performed to compare preoperative and postoperative JOA scores and pre- and post-operative alignment of the cervical spine using dependent t-tests.

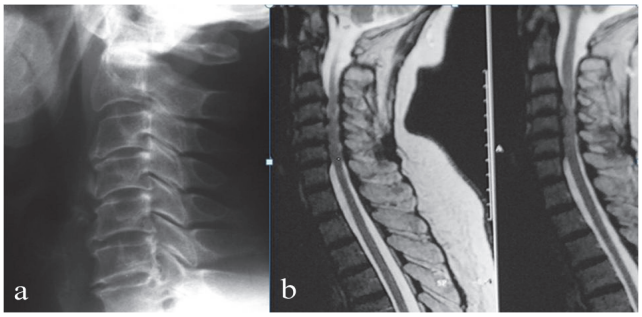

Figure 3. Preoperative radiograph of a 62-year-old female patient with radiculopathy shows disc space narrowing (a), and sagittal preoperative T2 Weighted MR image discerns cervical 3-4,4-5,5-6,6-7 spondylopathy and anterior spinal cord compression (b).

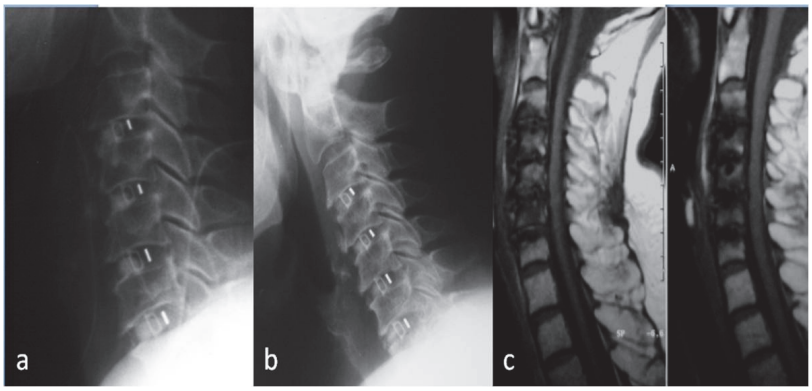

Figure 4 (a,b,c). Cervical radiographs obtained at the first follow-up examination 3 months postoperatively shows the restoration of the height of the disc space and preservation of the cervical spinal lordosis (a,b), and sagittal T1 weighted MR images obtained at the same time discern that the spinal cord had been successfully decompressed anteriorly (c).

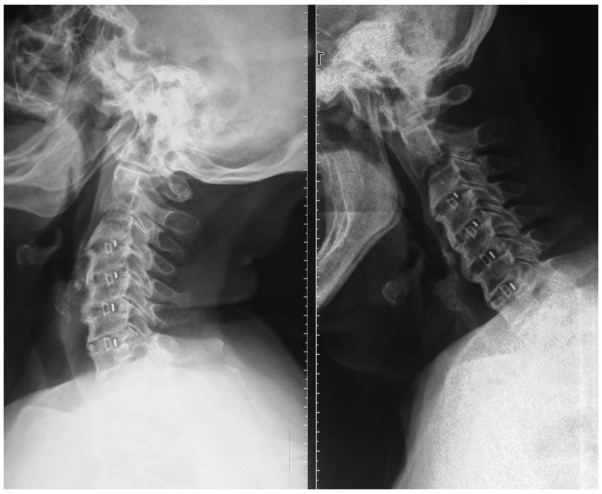

Figure 5. Cervical dynamic radiograph of the same patient obtained 34 months postoperatively shows four-level spinal bony fusion and mechanical stability.

Results

Sagittal MR images showed three-level spinal cord compression in 38 patients and four-level spinal cord compression in 20 patients. C4-C5 and C5-C6 intervertebral disc spaces were the commonest affected levels. A high-intensity signal in the spinal cord from the sagittal T2-weighted MR images was found in twenty-one patients (Figure 2) (Table 1).

38 patients had three-level and 20 had four-level discectomy and fusion (totally 194 levels) (Table 1). Mean hospital stay was 3 days (range, 2-5 days).

In the postoperative period none of the patients suffered permanent neurological deterioration and there were no complications. Two patients had hoarseness in the postoperative period that fortunately resolved in three months. Appropriate positioning of the intervertebral cages was confirmed by radiographs (Figure 6).

JOA scores improved significantly at the last follow-up evaluations compared with the preoperative scores (Table 1). Five patients (patients 1,9,17, 45, 54) who were unable to walk without aid before surgery were able to walk on their own after surgery following an average of three weeks of physiotherapy.

The patients had multiple-segment disc narrowing at the affected levels and preoperative MR images discerned that the posterior disc space osteophytes that caused segmented anterior cervical spinal canal constriction were the major cause of the neural compression. The use of interbody PEEK cages helped preserve the cervical foraminal height postoperatively. In our series, results showed that surgical treatment neither contributed to lordosis, nor caused kyphosis. The difference in ICI was insignificant ($p > 0.05$) (Figure 7).

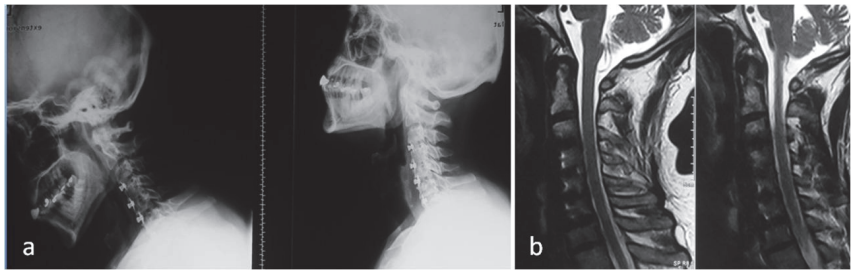

Figure 6. A 60 year-old male patient with 4-level ACDF with PEEK cages with perfect cervical spinal bony fusion on radiographs (a), and sagittal MR image that shows vertebral alignment and successful restoration of ventral subarachnoid space through the span of operated levels.

Table 1. Demographic data of cervical disc diseases. Abbreviations in the table are as follows: M: male, F: female, Pre-op: preoperative, Post-op: postoperative, r: radiculopathy, rm: radiculomyelopathy. Patients' mean age was 64.207 years (range, 52-78), mean follow-up period was 35.655 months (range, 24-48), mean preoperative JOA score was 13.310 (Standard deviation: 1.729), mean postoperative JOA score was 15.5 (Standard deviation: 1.392) Radiologic evaluation at the final follow-up yielded 89.2% fusion rate (21 pseudarthrosis among 194 operated levels).

	AGE	GENDER	CLINICAL SIGN	FOLLOW-UP PERIOD	PRE-OP JOA	POST-OP JOA	OPERATED LEVELS	NON-FUSION LEVELS
1	68	M	rm	42	11	14	3-4,4-5,5-6,6-7	5-6,6-7
2	70	F	rm	42	12	16	3-4,4-5,5-6	
3	52	F	r	24	14	17	3-4,4-5,5-6,6-7	
4	78	M	rm	42	13	15	3-4,4-5,5-6,6-7	
5	73	M	r	36	14	17	3-4,4-5,5-6,6-7	
6	54	M	r	35	11	15	3-4,4-5,5-6	
7	65	M	r	28	13	15	2-3,3-4,4-5,5-6	
8	60	F	r	34	12	14	3-4,4-5,5-6,6-7	
9	54	F	rm	40	11	12	3-4,4-5,5-6,6-7	
10	65	M	r	42	14	14	3-4,4-5,5-6	5-6 Corpectomy
11	67	F	r	40	12	15	3-4,4-5,5-6,6-7	5-6,6-7
12	73	M	r	42	11	13	3-4,4-5,5-6	
13	74	M	r	38	14	14	3-4,4-5,5-6	4-5,5-6
14	56	M	r	41	13	17	3-4,4-5,5-6	
15	60	M	r	41	16	16	3-4,4-5,5-6	
16	61	M	r	40	17	17	3-4,4-5,5-6	
17	77	F	rm	42	12	15	3-4,4-5,5-6,6-7	5-6,6-7
18	53	M	r	36	14	15	3-4,4-5,5-6	
19	66	M	r	24	17	17	3-4,4-5,5-6	
20	65	M	r	34	16	17	3-4,4-5,5-6,6-7	6-7
21	65	M	r	34	13	17	3-4,4-5,5-6	
22	63	M	r	38	12	15	3-4,4-5,5-6	
23	60	F	rm	42	12	17	3-4,4-5,5-6,6-7	
24	76	F	r	42	14	17	4-5,5-6,6-7	
25	54	F	r	28	14	16	4-5,5-6,6-7	4-5,5-6
26	55	F	r	30	13	15	3-4,4-5,5-6	
27	59	M	r	29	15	17	4-5,5-6,6-7	
28	60	M	r	33	12	14	3-4,4-5,5-6	
29	65	F	rm	31	13	13	3-4,4-5,5-6	
30	64	F	rm	25	11	15	2-3,3-4,4-5,5-6	2-3,5-6
31	62	F	r	27	15	17	3-4,4-5,5-6	
32	75	M	r	42	12	12	4-5,5-6,6-7	
33	62	M	r	32	16	16	3-4,4-5,5-6,6-7	
34	65	M	r	32	12	17	3-4,4-5,5-6	
35	73	F	rm	48	11	15	3-4,4-5,5-6,6-7	4-5,5-6
36	62	F	rm	48	16	17	3-4,4-5,5-6	
37	65	F	r	24	14	17	4-5,5-6,6-7	
38	52	F	r	48	12	16	3-4,4-5,5-6	
39	76	M	rm	60	13	16	3-4,4-5,5-6,6-7	4-5
40	61	F	r	48	14	17	3-4,4-5,5-6	
41	60	F	r	36	12	14	4-5,5-6,6-7	
42	66	F	r	24	15	15	4-5,5-6,6-7	
43	69	M	rm	30	14	17	3-4,4-5,5-6,6-7	5-6
44	71	M	rm	24	12	16	3-4,4-5,5-6,6-7	
45	74	M	rm	24	11	14	4-5,5-6,6-7	
46	72	F	r	32	15	15	4-5,5-6,6-7	
47	58	M	rm	36	12	14	3-4,4-5,5-6,6-7	4-5,5-6
48	55	F	rm	27	13	15	4-5,5-6,6-7	
49	68	M	rm	36	12	17	4-5,5-6,6-7	
50	64	F	r	48	15	17	3-4,4-5,5-6	
51	70	M	rm	32	14	14	4-5,5-6,6-7	
52	60	M	rm	32	12	14	3-4,4-5,5-6	
53	54	M	rm	27	11	15	3-4,4-5,5-6,6-7	
54	59	F	r	48	13	15	4-5,5-6,6-7	
55	66	F	r	24	12	16	3-4,4-5,5-6	3-4
56	68	F	r	36	16	16	4-5,5-6,6-7	
57	60	M	r	38	17	17	3-4,4-5,5-6,6-7	
58	65	M	rm	30	15	17	3-4,4-5,5-6	

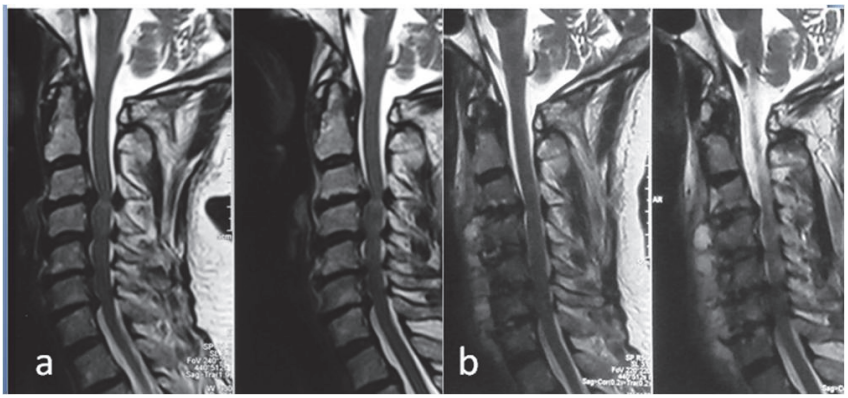

Figure 7. MR images of the 77 year-old female patient with radiculomyelopathy discerned high intensity signal on T2 weighted scans a), and postoperative MR images showed decompression of the neural structures. JOA score of the patient improved from 12 to 15 postoperatively (b).

Follow-up examinations in the 24th month showed that preoperative lordosis was preserved. No instrumentation-related complications including cage failure or dislodgement and end plate collapses occurred. Two patients had protracted difficulty in swallowing and hoarseness that resolved completely three months after the operation.

At the final follow-up, the fusion rate (Types 1A, 1B, and 2A) was 89.2 % (173/194 levels) (Table 1). Thirteen patients had pseudarthrosis. C5-6 was the most frequently non-fused level (Figure 8).

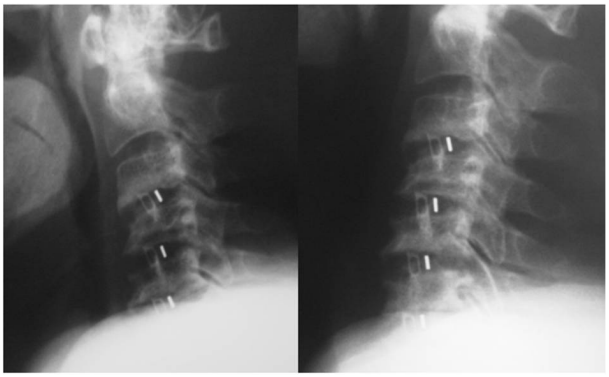

Figure 8. Dynamic lateral radiograph of a 76 year-old male patient with pseudarthrosis at C4-5 level at his final follow-up examinations. There was no instability and pain so the asymptomatic patient did not undergo a redo surgery.

We did not detect mobility on cervical dynamic radiographs and none of the non-fused levels required redo surgery. But one female patient did not improve and we had to perform anterior corpectomy and fusion with plate and screws four years after her ACDF operation. Her JOA score remained the same.

Discussion

Cervical radiculomyelopathy secondary to cervical spondylosis is one of the most common reasons of spinal neural dysfunction in patients over 50 years of age [14]. Their history usually involves an insidious course, and neurologic status is usually good in the early period. However, when the neurologic deterioration will occur is unpredictable and unmeasurable by any method or sign, therefore, mild- or moderate-degree myelopathy has been an indication for surgery. The optimal surgical procedure for multilevel cervical myelopathy remains controversial.

Laminectomy and laminoplasty have been popular surgical procedures for the treatment of cervical degenerative pathologies. Heller et al suggested that, compared with laminectomy, laminoplasty involved fewer complications but more axial neck pain[15], and in selected cases laminoplasty resulted in a better preserved range of motion of the neck. However, posterior procedures are associated with significant postoperative axial pain and are contraindicated in kyphotic cervical spine.

Anterior decompression and fusion is the commonest surgical option today. Cervical corpectomy, which is another way of managing cervical spondylosis in the elderly, is well described and sound procedure. It allows removing spinal cord compression caused by osteophytes, discs and ossified posterior longitudinal ligament (PLL) [16,17]. Bone graft donor site morbidity and mechanical failure, however, are common and unbearable complications. Hee, et al., reported a 19% incidence of plate-related problems in multilevel corpectomy (four of 21 patients) and the risk of complications increased as more levels were decompressed [18]. Plate complication rate varies from 2.2–24.0% and includes screw pullout, screw breakage, esophagus perforation, injury of neural structures and vertebral artery, and wound infection in addition to the prolonged operative time [19,20].

In the Cloward procedure, the best results have been reported for young male patients with single-level soft disc disease. Acceptable fusion rates have been reported for cervical spondylosis [12,21,22]. However patients confronted prolonged operation time and increased rate of pseudarthrosis that tarnished its preferability.

After all, ACDF using PEEK cages is an efficacious procedure used to treat a variety of cervical spinal disorders, including spondylosis, myelopathy, herniated discs, trauma, and degenerative disc disease [1,3,6,7,10]. This surgical method may not be effective for spinal cord decompression when the main pathology is behind the vertebral bodies, consequently, complete neurological recovery fails [23-25]. Therefore appropriate case selection is centerpiece factor in achievement of this procedure and neurological recovery. Hence, ACDF with PEEK cages is a commendable surgical technique in the management of patients presenting with spondylosis causing anterior segmented structural changes and without posterior compression findings. However, the success of multilevel ACDF depends on complete decompression and development of solid osseous fusion of the relevant disc spaces. The elastic modulus of the PEEK cage is close to that of bone, which increases bony fusion, and cage exhibits a stimulatory effect on protein content of the osteoblasts [26]. The PEEK cage is more elastic than titanium that reduces the possibility of cage subsidence into the vertebral corpus. Furthermore, the surface pins of the cage enhance its anchoring to the surface of the adjacent vertebral bodies of the related disc space. Application of cages restores the foraminal height and provides vertebral alignment with an optimal security of fixation relying on the intrinsic properties of the posterior osseous and ligamentous structures [26]. Packing the PEEK cages with DBM precluded donor site complications and diminished mean hospital stay as to 2 days. Fusion usually occurs approximately 3-6 months after surgery. If the fusion fails and pseudarthrosis develops, the usual outcome is long-term pain. Following a successful surgery, pain resolves first, then motor function returns, and sensory function is restored last, with regard to clinical outcome [21,27,28]. Patients who undergo these procedures must be followed until radiological studies confirm bone union. The use of lateral flexion and extension radiographs is advised for assessing union because, although plain lateral radiographs may indicate solid fusion, radiolucency can often be detected at the vertebral interface. Further, long-term follow-up is important, since some authors have reported that fusions that appeared solid on radiographic studies 3 to 4 months postoperatively later could develop pseudarthrosis. The literature also reports a consistent rate of 10–12% non-fusion for single-level anterior discectomy and autogenous bone fusion, 20–27% for two-level, and approximately 30–56% for three-level fusions [28]. It is clear that the success rates decline as the number of levels increases. In ACDF, additional plate fixation has been reported to result in a higher fusion rate[2,20,21,27]. However, Das et al, reported a rate of pseudarthrosis around 15-46% for more than one level fusion surgeries and they also reported that this rate increased to 18-82% for multilevel fusions despite the use of cervical spine locking plate[29]. Once the non-union has been detected, mechanical stability by dynamic radiographs should be monitored. Patients who have been asymptomatic with mechanically stable pseudarthrosis do not require further stabilization surgery unless they have severe pain. In our study group, none of the patients with non-fused levels required a redo surgery. Because of the unsatisfactory fusion rates of further instrumentation as reported to date, in our study, we preferred anterior decompression and fusion solely with PEEK cages in a selected patient population.

Conclusion

Multilevel cervical spinal decompression and fusion is problematic and had better be preserved for a minority of patients. ACDF with PEEK cages seems to be an ideal and effective surgical procedure for the treatment of radiculomyelopathy that yielded acceptable fusion rates and good clinical outcome and bearable postoperative course. Moreover, the potential complication risks of plates and autogenous bone grafts were obviated. Aforescribed surgical technique promises admirable clinical course if applied to the properly selected group of patients.

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