PEEK Cages Versus Locked Plate For Multiple Levels Cervical Degenrated Disease

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Abstract: **Background:** Anterior cervical discectomy and fusion (ACDF) is currently the gold standard for surgical treatment of degenerative disc disease of the cervical spine**.** For many years, patients were treated with ACDF using tricortical autogenous bone graft augmented with anterior cervical locked plate . Later, Cages packed with calcium triphosphate bone substitute were the treatment of choice. **Study design:** Aretrospective and prospective study. **Objective:** Compare the outcomes of ACDF using cages alone compared with tricortical iliac autograft augmented with anterior locked plate in treatment of multiple levels cervical degenerated disease (CDD) in 47 patients .**Methods:** We evaluated 47 patients (25patients in the cage group and 22 patients in the locked plate group) at our institution from January 2007 to Sebtember 2010. They were followed up for minimum 2 years. The clinical outcomes (Nurick grade and JOA score), radiographic changes(LKA, fusion, subsidence, and adjacent disc degeneration), and complications were compared between the 2 groups. **Results:** The blood loss was significantly less in cage group (388 cc) than plate group (529.6 cc).Both groups showed significant improvement in LKA postoperatively and at latest follow up with no significant difference. Fusion was 94.1% and 94.4% in cage and plate groups in order. There was insignificant more subsidence in cage (21.4%) than plate group (11.3%). There was significant improvement in Nurick grading of both cage and plate groups as it improved from 3.32 and 3.68 preoperatively to 0.84 and 1.05 at latest follow up in order. There was no significant difference between the two groups . Final outcomes was comparable in both groups : In cage group : excellent in 7 patients , good in 16, and fair in 2. In plate group, excellent in 8 patients , good in 11 ,and fair in 3. **Conclusions:** In multiple levels ACDF, the use of stand-alone PEEK cages results in less blood loss, less adjacent disc degeneration, less complications than the use of autograft augmented with locked plate but unfortunately, more incidence of subsidence . However, there is no significant difference in the postoperative and latest follow up LKA, fusion rate, clinical, and functional outcomes between the cage and plate groups.

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Key words: multiple level CDD, cervical locked plate, cervical PEEK cage.

1.Introduction

Degenerated disease of the cervical spine , in sever cases, could potentially be deblitating disease[1]. Several procedures have been described for the treatment of disc herniation and cervical spondylosis when conservative treatment fails[2-7]. In the past few years , anterior cervical discectomy and fusion (ACDF) is currently the gold standard for surgical treatment of degenerative disc disease of the cervical spine [1,5,8] . Good results have been reported with performing ACDF using cages as regard fusion rate , subsidence **,** and pseudoarthrosis [9-11].

The aim of this study is to evaluate the outcomes of ACDF using PEEK cages alone packed with calcium triphosphate bone substitue compared with tricortical iliac autograft augmented with anterior locked plate in treatment of multiple levels cervical degenerated disease (CDD) in 47 patients .

2. Patients and methods

Patients :

This study included 47 patients with multiple levels cervical degenerated disease (CDD) presented with radiculopathy , myelopathy, radiculomyelopathy. All patients underwent ACDF in Orthpaedic department of Assiut University Hospital between January 2007 and September 2010. First, 22 patients were treated with ACDF using tricortical autogenous bone graft augmented with anterior cervical locked plate (plate group). Later, Cage packed with calcium triphosphate bone substitute were used in 25 patients (cage group). No specific guidelines or indications were used in dividing the patients among the two groups . The demographic data and surgical levels of both groups are shown in **table (1)** .

Methods :

All patients of both groups were assessed neurologically according to Nurick grading [12] preoperatively, postoperatively, and at latest follow up. Posterior neck pain and arm pain (radiculopathy) was described by 10 points – Visual Analogue Scale (VAS) [13] . Plain x-ray and MRI were done for all patients preoperatively. Postoperative clinical (neurology and pain) and radiological (bony fusion , subsidence , instrument failure ,local kyphotic angle , and the degenerated changes of adjacent segments) follow up were carried out at 3 months interval up to 24 months after surgery .

The surgical outcome was evaluated by the modified Japanese Orthopaedic Association (JOA) score[14] and the recovery ratio (RR). A recovery rate over 75% is described as excellent, from 51% to 75% is good, from 26% to 50% is fair and equal or less than 25% is unchanged.

$$RR = \frac{\text{Postoperative JOA score} - \text{Preoperative JOA score}}{17(\text{full score}) - \text{Preoperative JOA score}} \times 100$$

Statistics:

A statistician reviewed the data , using the Mann-Whitney tests and Chi-Squard tests. Statistical significance was defined as $P < 0.05$.

Table (1): Demographic data and surgical levels of both groups

	Cage group	Plate group
Number	25	22
Age (years)	47.72(range,35 to 64)	49.27(range,33 to 70)
Sex :		
Male	14	13
Female	11	9
Presentation:		
Radiculopathy	9	7
Myelopathy	6	7
Radiculomylopathy	10	8
Surgical levels :		
Three levels	16	17
Four levels	9	5
(Total levels)	(84)	(71)

3.Results

The minimum follow-up period of both groups was 24 months (range,24 to 48). The average operative time was less in cage group (122.4 minutes ranged from 60 to 180) than plate group (129.6 minutes ranged from 90 to 180) with no significant statistical difference between the two groups (P value = 0.47).The average blood loss was significantly less in cage group (388 cc ranged from 200 to 700) than plate group (529.6 cc ranged from 300 to 800) (P value = 0.01).

Radiological results (Table 2)

LKA (Local Kyphotic Angle):

In cage group, The average LKA improved significantly from 1.32°(range, -5 to 4) preoperatively to -7.08°(range,-12 to -2) immediately postoperative and -5.44°(range,-10 to 0) at latest follow up (P value<0.05). This means the average degree of angle gain was 8.40° postoperatively and that of angle loss was 1.64° at latest follow up.

In plate group, The average LKA improved significantly from 1.05°(range,-3 to 4) preoperatively to -5.91° (range,-10 to 0) immediately postoperative and -4.32° (range,-8 to 1) at latest follow up (P value<0.05) . This means the degree of angle gain was 6.96° postoperatively and angle loss was 1.59°at last follow up . There was no significant difference between the two groups (P value > 0.05).

Fusion

Fusion was considered certain in 79 out of 84 levels (94.1%) at latest follow up of cage group while it was certain in 67 out of 71 levels(94.4%) .There was no significant difference between the two groups (P value= 0.701).

Subsidence

There was relatively more subsidence in cage (21.4%) than plate group (11.3%) without significant statistical difference (P value= 0.338).

Adjacent disc degeneration

Adjacent disc degeneration was defined using the modified Hiliband criteria[15]. It was relatively more in plate group (40.9%) than cage group (28%) without significant statistical difference between the two groups (P value = 0.351).

Clinical results (Table 3)

There was significant improvement in Nurick grading of both cage and plate groups as it improved from 3.32(range,2 to 5) and 3.68 (range,2 to 5) preoperatively to 0.84(range,0 to 5) and 1.05(range,0 to 5) at latest follow up in order (P value < 0.05). There was no significant difference between the two groups (P value > 0.05).

There was significant improvement in VAS of neck pain of both cage and plate group as it improved from 6.64(range,5 to 8) and 7.05(range,5 to 9) preoperatively to 1.68 (range,1 to 4) and 1.55(range,1 to 3) at latest follow up in order (P value < 0.05). Similarly, There was significant improvement in VAS of arm pain as it improved from 5.32(range,0 to 8) and 4 (range,0 to 8) preoperatively to 1.04(range,0 to 3) and 0.77 (range,0 to 4) at latest follow up in order (P value < 0.05).There was no significant difference between the two groups (P value > 0.05).

Table (2): Radiological results

	Cage group	Plate group	*P3* value
LKA: **Preoperative** **Postoperative**	 1.32°(range,-5 to 4) -7.08°(range,-12 to -2)	 1.05(range,-3 to 4) -5.91(range,-10 to 0)	 0.648 0.112
P1 value	O,000*	0.000*	
LKA **Latest follow up**	 -5.44°(range,-10 to 0)	 -4.32°(range,-8 to 1)	 0.166
P2 value	0.000*	0.000*	
Fusion	79 out of 84 levels (94.1%)	67 out of 71 levels (94.4%)	0.701 (Chi Square test)
Subsidence	18 out of 84 levels(21.4%)	8 out of 71 levels(11.3%)	0.338 (Chi Square test)
Adjacent disc degeneration	7 patients(28%)	9 patients(40.9%)	0.351 (Chi Square test)

***P*1**: comparison between pre and post in each group (Wilcoxon Signed Rancks test.
***P*2**: Comparison between pre and latest follow up in each group (Wilcoxon Signed Rancks test).
***P*3**: Comparison between cage and plate group (Mann Whitney test and Chi Square test).
* Statistical significant difference ($P < 0.05$).

Table (3): Clinical results

	Cage group	Plate group	*P2* value
Nurick grading: **Preoperative** **Latest follow up**	 3.32(range,2 to 5) 0.84(range,0 to 5)	 3.68(range,2 to 5) 1.05(range,0 to 5)	 0.170 0.515
***P1* value**	0.000*	0.000*	
VAS(neck): **Preoperative** **Latest follow up**	 6.64(range,5 to 8) 1.68(range,1 to 4)	 7.05(range,5 to 9) 1.55(range,1 to 3)	 0.230 0.619
***P1* value**	0.000*	0.000*	
VAS(arm): **Preoperative** **Latest follow up**	 5.32(range,0 to 8) 1.04(range,0 to 3)	 4 (range,0 to 8) 0.77(range,0 to 4)	 0.130 0.230
***P1* value**	0.000*	0.000*	

***P*1**: comparison between pre and last in each group (Wilcoxon Signed Rancks test).
***P*2**: Comparison between cage and plate group (Mann Whitney test).
* Statistical significant difference ($P < 0.05$).

Functional results (Table 5)

In both cage and plate groups, there was significant improvement in modified JOA score from 7.2(range,2 to 10) and 5.27(range,1 to 11)preoperatively to 13.48 (range,9 to 16) and 12.27 (range,8 to 16) in order at latest follow up (*P* value<0.05) with no significant difference between the two groups. Similarly, there was insignificant difference in (RR) between the two groups .

Final outcomes was comparable in both groups :
In cage group : excellent in 7 patients , good in 16, and fair in 2 .
In plate group, excellent in 8 patients , good in 11 ,and fair in 3.

Complications:

Dysphagia more than 3 months in 4 patients (18.2%) and donor site pain more than one year were recorded in 6 patients (27.3%) in plate group.

Table (5): Functional outcomes

	Cage group	Plate group	*P2* value
JOA score: **Preoperative** **Last follow up**	 7.2(range,2 to10) 13.48(range,9 to 16)	 5.27(range,1 to 11) 12.27(range,8 to 16)	 0.107 0.348
***P1* value**	0.000*	0.000*	
RR	66.42(range,46.7 to 87.5)	62.86(range,40 to 88.9)	0.347
Outcomes: **Excellant** **Good** **Fair** **Unchanged**	 7(28%) 16(64%) 2(8%) 0	 8(36.4%) 11(50%) 3(13.6%) 0	

***P*1**: comparison between pre and last in each group (Wilcoxon Signed Rancks test).
***P*2**: Comparison between cage and plate group (Mann Whitney test).
* Statistical significant difference ($P < 0.05$).

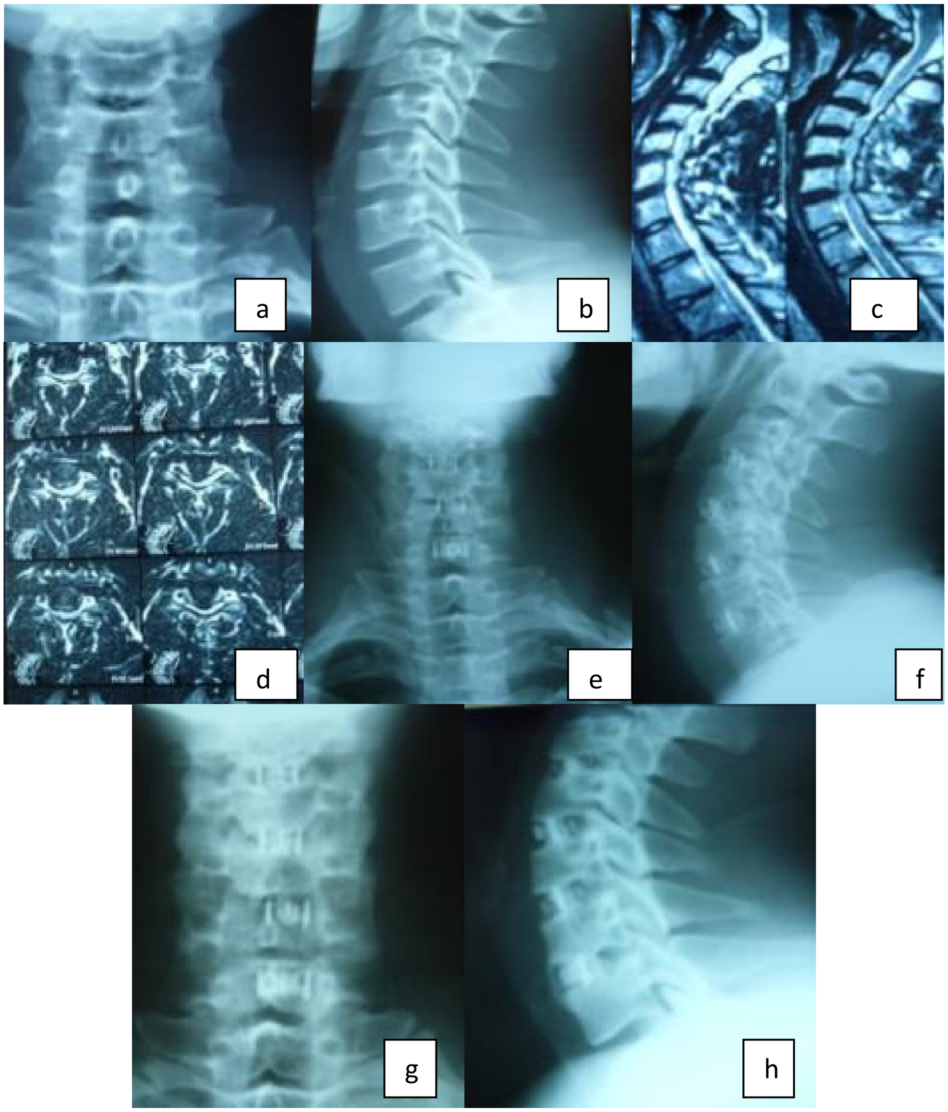
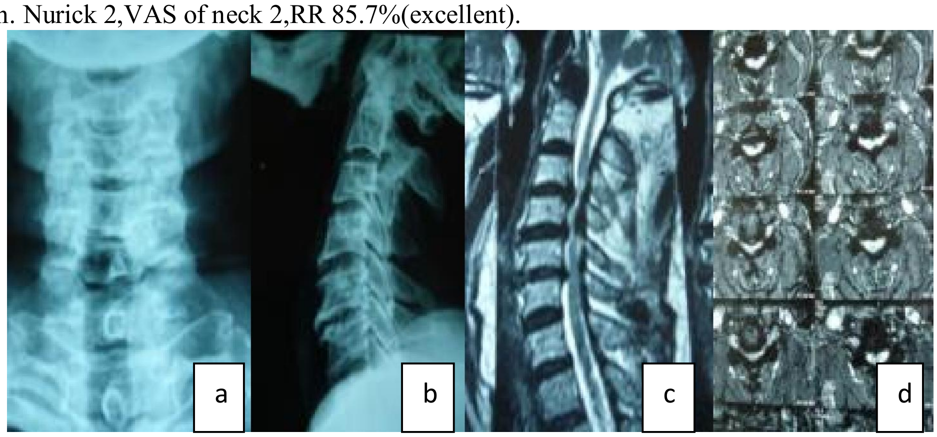


Fig.6: Female patient,53 year old, ,Nurick 4,VAS of neck 7.Preoperative plain X ray (a)anteroposterior(b)lateral views shows LKA -5. MRI(c)sagittal and (e)axial views shows multiple disc:C34,C45,C56,C67.Postoperative plain X ray (e)anterposterior and (f)lateral views show LKA -12. Latest follow up plain X ray (g)anterposterior and (h)lateral views show LKA -10,no subsidence, certain fusion. Nurick 2,VAS of neck 2,RR 85.7%(excellent).



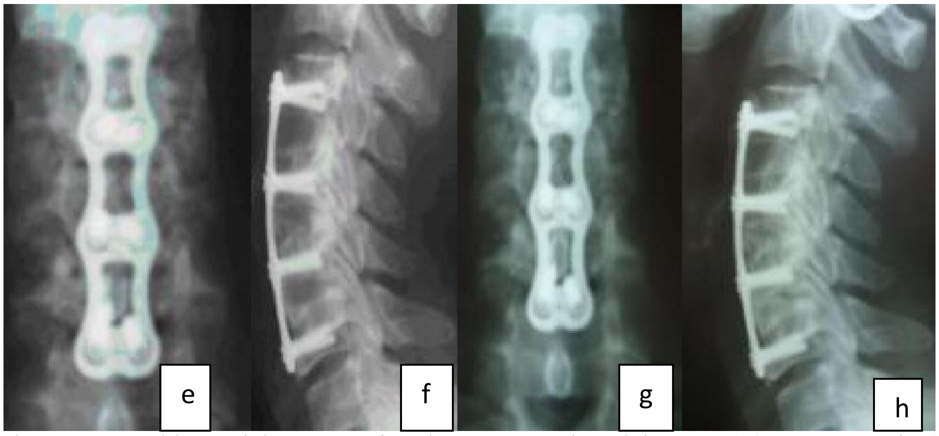


Fig.6: Male patient,65 year old, ,Nurick 4,VAS of neck 6.Preoperative plain X ray (a)anteroposterior(b)lateral views shows LKA -3. MRI(c)sagittal and (e)axial views shows multiple disc:C34,C45,C56.Postoperative plain X ray (e)anterposterior and (f)lateral views show LKA -10 . Latest follow up plain X ray (g)anterposterior and (h)lateral views show LKA -8 ,no subsidence, certain fusion.Nurick 3,VAS of neck 3,RR 88.5%(excellent).

4.Discussion

Anterior cervical discectomy and interbody fusion (ACDF) has been the standard treatment for cervical degenerated disease (CDD) for more than 50 years [8]. There is no clear consensus regarding the optimal surgical procedure for CDD [16-18]. Multiple levels ACDF still remains a difficult problem. Autogenous iliac bone graft does not maintain spinal stability very well and the complications are higher than at the single level [19,20]. More over, it has been reported that even with solid fusion, kyphosis often develops in multilevel discectomies with autogenous iliac bone graft fusion [19,21]. Augmentation with plate fixation may be preferable in multilevel ACDF as plate fixation may decrease the micromovement of the cervical spine, enhance the fusion rate and correct spinal curve to physiological lordosis) [22,23] . However, plate complication rate varies from 2.2-24% [24-27] . These complications favoured ongoing development of cage technology. Different types of cages are available to perform ACDF; including titanum cage, carbon fiber reinforced polymer (CFRP) cages, and polyether ether ketone (PEEK) cages. The absence of cytotoxicity and mutagenicity were demonstrated for PEEK cage in an *in vitro* study. It provides combination of strength, stiffness, toughness, and environmental resistance [29] . Moreover, the modulus of elasticity of PEEK is similar to that of bone and the volume related stiffness of the PEEK cage is higher than that of iliac bone in all direction. These results show that polyetheretherketone could be manufactured as the optimal interbody spacer, providing an adequate volume for bone refilling and immediate mechanical stability in ACDF [30-32] . Additionally, the BEEK cage cage is radiolucent and allowing the surgeon to evaluate easily fusion status on radiograph or CT scans [29] .

Because of these previous advantages of PEEK cage, we used it in last 25 patients in this study compared with locked plate in ACDF technique for treatment patients with multilevel cervical degenerated disease.

In this study, there was significant correction of LKA in both cage and plate groups postoperatively and latest follow up with no significant difference between the two groups. This was comparable with Yong *et al.,* series [33] . Barsa *et al.,* [34] observed cage subsidence rate (14%). Higher cage subsidence rate (44.8%) was reported in the series of Schmieder *et al.,* [35] who used titanum cages . However, non of their cases required revision surgery despite of their higher subsidence rate because cervical lordosis was radiologically present throughout follow up. These reports illustrated a possible discrepancy between radiological apparent cage subsidence and clinical relevance of these findings. This study reported relatively more subsidence incidence in cage group (21.4%) than plate group (11.3%) without significant statistical difference. This may attributed to increased stability and maintenance of cervical lordosis with the use of plate fixation . Yong *et al.,* [33] reported insignificant difference in fusion rate between cage (90.9%) and plate (95%) groups. Similar results was reported in this study in which fusion rate was (94.1%) and (94.4%) in both cage and plate groups in order. Reversely, many authors [28,34] reported better fusion rate in plate group. They believed that insufficient fixation power of cage alone in multiple levels ACDF allowing continuous postoperative micromotion preventing the induction of bone fusion . However, this postoperative micromotion decreases insignificantly the incidence of adjacent disc degeneration in cage group (28%) compared with plate group (40%) in our study. Song *et al.,* [36] reported that rigid fixation with plate reduces segmental motion and causes high stress on the disc below and above the fusion site during cervical motion which leads to adjacent level degeneration.

This study reported significant clinical improvement in Nurick grade, and VAS of neck and arm pain of both cage and plate groups at latest follow up compared with preoperative scores without significant difference between the two groups. Similarly, there was insignificant difference in operative time . However, there was significant less blood loss in cage than plate group . Yong *et al.,* [33] reported shorter operative and less blood loss in cage group.

Previous studies have reported donor-site morbidity from 9.4% to 49% including pain, infection, seroma, and fracture etc [37,38].In this study, 6 patients (27.3%) demonstrated postoperative donor-site pain which improved within one year and 4 (18.2%) developed dysphagia which improved within 4 months in plate group. Similarly, Kyung *et al.,* ([39]) who used plates in his series reported 4 patients(4.8%) developed dysphagia which improved within 3 months.

As a result of this significant radiological and clinical improvement, the final functional outcomes including, Japanese Orthopaedic Association (JOA) score and recovery ratio (RR) improved significantly in both groups at latest follow up without significant statistical difference .

5. Conclusion

In multiple levels ACDF, the use of stand-alone PEEK cages results in less blood loss, less adjacent disc degeneration, less complications than the use of autograft augmented with locked plate but unfortunately, more incidence of subsidence . However, there is no significant difference in the postoperative and latest follow up LKA, fusion rate, clinical, and functional outcomes between the cage and plate groups.

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