Multilevel Anterior Cervical Discectomy and Fusion with Polyetheretherketone (PEEK) Cages: Clinical Outcome and Fusion Assessment

KHALED E. MOHAMED, M.D.
The Department of Neurosurgery, Faculty of Medicine, Suez Canal University.

Abstract

Background: Anterior cervical discectomy and fusion with polyetheretherketone (PEEK) cages showed good results for single level discectomy. For multiple levels sound fusion is required to decrease the incidence of pseudoarthrosis, and decrease the risk for re-surgery.

Objective: Is to assess the effectiveness of use of PEEK cages filled with autologous iliac crest bone graft in achieving good fusion, and in relieving the clinical manifestations of more than one level cervical disc disease.

Patients and Methods: The charts of thirty patients operated for anterior cervical disc disease with more than one level were reviewed. Patients were operated and PEEK cages were used. Clinical assessment of pre-operative clinical data and post-operative status using Nurick scale for myelopathy, Odom’s criteria for functional outcome, and Visual Analogue Scale (VAS) for both neck and arm pain. Radiological fusion was assessed by X-ray, and Computerized Tomography CT scan. Operative complications were reported. Follow-up period at least 6 months.

Results: There were 18 patients operated for 2-level discectomy and fusion, and 12 patients operated for 3-level discectomy and fusion. Patients’ age ranged from 38 years to 63 years, a mean ± SD 49 ± 6.77. There were 18 (60%) males and 12 (40%) females. There was improvement of the post-operative Nurick scale record from 2.57 ± 1.22 to 0.7 ± 0.79; p-value was <0.001 (statistically significant). The VAS for radicular pain improved from 7.13 ± 1.5 to be 0.47 ± 0.97, p-value was 0.001 (statistically significant). The VAS for neck pain improved from 7.03 ± 1.43 to 0.9 ± 1.2, p-value was <0.001 (statistically significant). With Odom’s criteria, there were 15 patients (50%) with excellent outcome and 15 patients (50%) with good outcome. Fusion occurred in 24 patients (80%) of the study group, and non-fusion is reported in 6 patients (20%). Out of 72 levels operated, there were 6 non-fused levels (8.3%).

Conclusion: Anterior cervical discectomy and fusion with PEEK cages filled with autologous bone graft for more than one level cervical disc disease achieved good clinical results and accepted fusion rates.

Key Words: Cervical – Discectomy – Polyetheretherketone (PEEK).

Introduction

IN 1955, Robinson and Smith described their technique for treating cervical disc pathologies [1]. Three years later Cloward reported his technique of anterior disc excision and removal of compressive structures [2]. Anterior cervical discectomy and fusion is indicated for the treatment of cervical radiculopathy, myelopathy or radiculo-myelopathy [3]. In single level disease anterior cervical discectomy and fusion (ACDF), with excellent clinical outcome and radiological fusion, can be achieved with only bone graft [4] and as equal as fusion with adding paltes [5] and even, it can be managed with anterior cervical discectomy without fusion with good clinical outcome and without graft site morbidity [6-8]. In multilevel cervical discectomy (more than one level), there were different methods to achieve good clinical outcome and fusion. It can be achieved with discectomies alone without fusion [9] with corpectomy and iliac crest graft without plate in cases of spondylotic cervical myelopathy [10]. Cervical cages of different materials have been used; titanium, Polyetheretherketone (PEEK), and carbon fiber [11-17]. Cervical plates have been suggested for more than one level ACDF [18-21]. Different fusion materials have been used too, as iliac crest autograft [5,11] allograft [22] demeneralized bone matrix [12,23] hydroxyapatite [24,25] and morphogenetic proteins [26]. There are different complications of using graft alone; as graft collapse, extrusion, and pseudoarthrosis [11,18]. Plates means adding hardware with its complications; screw pull
out, extra-time of the operation, extra-cost, and pseudoarthrosis too [28]. Using cages alone avoids the drawbacks of the graft and plates [13,27,29]. This study is to assess the effectiveness of using PEEK cages in multilevel anterior cervical discectomy regarding both clinical outcome and radiological fusion.

Patients and Methods

This is a retrospective study of the patients operated for more than one level anterior cervical discectomy and fusion with PEEK cages in the period from 2007 and 2011. Patients with degenerative cervical disc disease of more than one level were included at the study. Patients with recurrent disc, cervical traumatic disc, or infection were excluded. There were 30 patients; 18 for two levels ACDF and 12 for 3 levels ACDF. Patients were assessed clinically for their complaints: Type (radiculopathy, myelopathy, and radiculomylopathy), duration of symptoms, Visual Analogue Scale for cervical and radicular pain, Nurick scale for myelopathy [30] pre-operative and post-operative, Odom’s criteria for functional outcome [31]. Patients were investigated for their complaints by X-ray and MRI. They were followed-up radiologically for fusion assessment by X-ray in lateral view post operative and at 3,6,9, and 12 months and at final follow-up. When there is doubt of fusion dynamic cervical X-ray and CT cervical spine at the operated levels were done. Fusion was considered to be happened if there bone trabeculae between the graft and the vertebral end plate and absence of translucency. Pseudoarthrosis was considered if there were no bone trabeculae and the presence of translucency between the graft and the vertebral end plate. Complications were reported as dysphagia, laryngeal nerve injury, CSF leak, cage complications and neurological insult. Patients were instructed to wear a hard collar all the time for 8-12 weeks post operative.

Surgical technique:

Under general anesthesia, patients were positioned supine, with interscapular roll to induce some extension. After opening and marking the space required, a Cloward retractor is positioned, and intervertebral Caspar retractor is inserted. The microscope is brought in, and removal of the discs and osteophytes is performed. Osteophytes were removed by curettes and kerrison up cut, and sometimes pneumatic drill. All required discs are removed. Cancellous iliac crest bone is harvested by a specialized instrument. Cage size is selected and filled with the cancellous bone, then insertion of the cages under the fluoroscope to assess their position. Removal of the retractors and drain is inserted. Patients are allowed to be mobilized from the first post operative day.

Statistical analysis:

All statistical analyses were performed using the SPSS software. Descriptive statistics were applied in mean±standard deviation (SD) for quantitative data and number (%) for qualitative data. Chi-square test was used for association between categorical data. Wilcoxon Signed Rank Test was used for testing significance of pre-and post-operative scores. Multivariate repeated measures analysis (Mixed design ANOVA) was used to test the effect of time and number of treated levels on different scales. Statistical significance was determined at 95% level of confidence.

Results

The study included 30 patients. Eighteen patients were operated for 2 level discectomy and fusion with PEEK cages and 12 patients for 3 levels. There were 18 (60%) males and 12 (40%) females. The age of the patients ranged from 38 years to 63 years, a mean±SD 49±6.77. There were 8 (26.7%) smokers. There were 4 patients (13.3%) with radiculopathy, 9 patients (30%) with myelopathy, and 17 patients (56.7%) with radiculomyelopathy. Regarding the levels operated, there were 12 C3-4 levels, 20 C4-5 levels, 26 C5-6 levels, and 14 C6-7 levels. Duration of symptoms ranged from 4 months to 12 months; mean±SD was 7±2.43 months. The operative time ranged from 110 minutes to 200 minutes; mean±SD 146.3±23.56 minutes. Patients were followed-up for a period of 6 months to 20 months, mean±SD 9.9±3.29 months. Patients with myelopathy were assessed for clinical status using the Nurick scale; there was improvement of the post-operative scale record from 2.57±1.22 to 0.7±0.79, p-value was <0.001 (statistically significant). The VAS for radicular pain improved from 7.13±1.5 to be 0.47±0.97, p-value was 0.001 (statistically significant). The VAS for neck pain improved from 7.03±1.43 to 0.9±1.2, p-value was <0.001 (statistically significant). There is no relation between the clinical improvement (VAS for both neck and radicular pain), and both sex and age. Regarding the functional outcome we used Odom’s criteria, there were 15 patients (50%) with excellent outcome and 15 patients (50%) with good outcome. There were some transient complications; dysphagia is reported in 5 patients (16.7%) and improved within the first 2 weeks, superficial wound infection at the graft site reported in 2
patients (6.7%), and iliac graft site pain in 4 patients (13.3%) and lasted maximally for 2 months. There were no complications related to the cage insertion. Fusion occurred in 24 patients (80%) of the study group, and non-fusion is reported in 6 patients (20%). The average age of the non fusion group (6 patients) was 46.8 ± 5.8, and the average of age at the fusion group (24 patients) was 50.7 ± 6.9, p-value was 0.221 (statistically non significant). Sex did not affect the rate of fusion; of the non fused group there were 2 males out of the 18 males of the study, and 4 females out of 12 females of the study, p-value was 0.184, statistically non significant. There were 8 smokers at the study, 7 of them were at the fusion group, p-value was 1.00, statistically non significant. At the non fusion group, the complaint was mild neck pain in 5 patients (16.7%), and crepitus at one patient (3.3%). The non fused level was the upper one at all the non fused patients. Fusion occurred in 15 patients (83.3%) out of 18 patients treated for two levels ACDF, and in 9 patients (75%) out of 12 patients treated for three levels ACDF, it was not statistically significant.

A Mixed design ANOVA analysis to examine the effect of number of treated levels (two/three) and time of assessment (pre-/post-operative) on the Nurick score. It revealed a main effect of time; F (1,28)=144.4, p<0.001, η_p^2 =0.84, and the number of treated levels; F (1,28)=1.97, p=0.172, η_p^2 =0.07, that were qualified by interaction between both time and number of treated levels F (1,28)=5.78, p=0.023, η_p^2 =0.17.

Regarding to VAS score for neck pain, the main effect of time; F (1,28)=428.4, p<0.001, η_p^2 =0.94, and number of treated levels; F (1,28)=0.74, p=0.393, η_p^2 =0.03, that were not qualified by interaction between both time and number of treated levels F (1,28)=0.72, p=0.402, η_p^2 =0.03.

In VAS score for radicular pain, the main effect of time; F (1,28)=455.02, p<0.001, η_p^2 =0.94, and number of treated levels; F (1,28)=0.05, p=0.821, η_p^2 =0.002, that were not qualified by interaction between both time and number of treated levels F (1,28)=0.199, p=0.659, η_p^2 =0.007.

Then, the Nurick, VAS (Neck) and VAS (Radicular) scores were influenced by the time of assessment (statistically significant post-operative improvement) and not by the number of treated levels. Nurick score was further qualified by the interaction between both time and number of treated levels, however, VAS (Neck) and VAS (Radicular) scores were not qualified by this interaction.

**Table (1): Nurick Scale** [30]. A six grade system (0-5) based on the difficulty in walking.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Signs or symptoms of root involvement but without evidence of spinal cord disease.</td>
</tr>
<tr>
<td>1</td>
<td>Signs of spinal cord disease but no difficulty in walking.</td>
</tr>
<tr>
<td>2</td>
<td>Slight difficulty in walking which does not prevent full-time employment.</td>
</tr>
<tr>
<td>3</td>
<td>Difficulty in walking which prevented full time employment or the ability to do all housework, but which was not so severe as to require someone else’s help to walk.</td>
</tr>
<tr>
<td>4</td>
<td>Able to walk only with someone else’s help or with the aid of a frame.</td>
</tr>
<tr>
<td>5</td>
<td>Chairbound or bedridden.</td>
</tr>
</tbody>
</table>

**Table (2): Odom’s criteria** [31].

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>All pre-operative symptoms relieved, abnormal findings improved.</td>
</tr>
<tr>
<td>Good</td>
<td>Minimal persistence of pre-operative symptoms, abnormal findings unchanged or improved.</td>
</tr>
<tr>
<td>Fair</td>
<td>Definite relief of some pre-operative symptoms, other symptoms unchanged or slightly improved.</td>
</tr>
<tr>
<td>Poor</td>
<td>Symptoms and signs unchanged or worse.</td>
</tr>
</tbody>
</table>

**Table (3): Nurick & VAS scales (n=30).**

<table>
<thead>
<tr>
<th>Score (Mean±SD)</th>
<th>Pre-operative</th>
<th>Post-operative</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nurick scale</td>
<td>2.57±1.22</td>
<td>0.7±0.79</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>VAS: Neck pain</td>
<td>7.03±1.43</td>
<td>0.9±1.2</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>VAS: Radicular pain</td>
<td>7.13±1.5</td>
<td>0.47±0.97</td>
<td>&lt;0.001*</td>
</tr>
</tbody>
</table>

* Statistically significant at p<0.05. Wilcoxon signed rank test.
Table (4): Multivariate analysis of Nurick & VAS scales regarding treated levels (n=30).

<table>
<thead>
<tr>
<th>Scales &amp; Time of assessment</th>
<th>No. Treated Levels</th>
<th>N</th>
<th>Mean±SD</th>
<th>F (df)</th>
<th>p-value</th>
<th>Partial Eta, Squared (η^2_p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-operative Nurick</td>
<td>Two</td>
<td>18</td>
<td>2.2±1.4</td>
<td>5.8 (1,28)</td>
<td>0.023 *</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>Three</td>
<td>12</td>
<td>3.1±0.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-operative Nurick</td>
<td>Two</td>
<td>18</td>
<td>0.7±0.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Three</td>
<td>12</td>
<td>0.8±0.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-operative VAS: Neck pain</td>
<td>Two</td>
<td>18</td>
<td>7.0±1.2</td>
<td>0.72 (1,28)</td>
<td>0.402</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>Three</td>
<td>12</td>
<td>7.1±1.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-operative VAS: Neck pain</td>
<td>Two</td>
<td>18</td>
<td>0.7±0.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Three</td>
<td>12</td>
<td>1.3±1.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-operative VAS: Radicular pain</td>
<td>Two</td>
<td>18</td>
<td>7.2±1.3</td>
<td>0.199 (1,28)</td>
<td>0.659</td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td>Three</td>
<td>12</td>
<td>7.0±1.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-operative VAS: Radicular pain</td>
<td>Two</td>
<td>18</td>
<td>0.4±1.04</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Three</td>
<td>12</td>
<td>0.5±0.9</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. (1): X-ray image postoperative for a male patient operated for ACDF with PEEK cages for 2 levels, shows complete fusion of the lower level where as the upper level shows near complete fusion, no movement at the flexion and extension images.

Fig. (2): X-ray of a patient operated for 3 level cervical discectomy, shows fusion at the lower two levels and translucency of the upper border of the upper level.
Discussion

Anterior cervical discectomy and fusion is considered ideal for treating cervical disc prolapse in terms of clinical improvement, restoration of cervical lordosis, bone fusion, and in long term follow-up [4]. In cases of acute single level soft disc prolapse with either radiculopathy or myelopathy, some authors reported good clinical results with good alignment without fusion and without graft site morbidity [6-8]. Few studies reported this success without fusion in cases of multilevel cervical disc disease management [9].

In a study comparing plated and non plated patients operated for single and multiple level cervical disc disease, it is found that the plated patients showed higher fusion rates and lower complications. Whereas the non plated patients showed complications related to the graft as; extrusion, kyphosis, collapse, foraminal stenosis, and 10% of them required re-surgery [18].

In a study of comparison between different fusion modalities: Titanium cage, PEEK cage, and iliac crest graft, it was found that; fusion was better with PEEK cages, complications were higher with titanium cages, and lower fusion with iliac crest graft [11]. PEEK cages are associated with high fusion rates, low subsidence, feasibility to follow
fusion through its translucent nature, and titanium spikes allow follow-up their position [13]. Carbon cages have higher pseudoarthrosis and their modulus elasticity decreases their stress shielding [13,14]. In a study comparing both ACDF with cages with adding plates for 2 level ACD; it showed no difference regarding clinical outcome, radiological fusion, subsidence, kyphotic angle, and the advantage of shorter operation time, minimal blood loss, relative simplicity of the procedure, all are with the use of cages alone with no benefit of adding plates [28].

In our results there were 6 patients showed non fusion in a single level for each, and it was the upper level for all. These patients were four females, and two males. Three patients were at the two level ACDF group, and three patients at the 3 level ACDF group. There were four patients out of the sixth at the fifth decade, one patient at the fourth decade and one patient was at the sixth decade. Most of our patients were at the fifth decade (16 patients), followed by the 6th decade (11 patients). So four of 16 patients have non fusion, this was statistically insignificant. So age has no correlation with fusion. In a study of Chagas et al. [10], they found better results with patients younger than 60 years. In a study of Lied et al. they found no correlation between the symptom reduction and age, sex, and number of levels fused [29].

Our study on thirty patients with cervical disc disease showed clinical improvement of the pre-operative symptoms. There is improvement of the radicular pain from pre-operative VAS 0.9 ± 1.16 to 0.47±0.97 that was statistically significant, p-value was 0.019. The procedure is known to have the benefit of relieving radicular pain [29]. Regarding the Nurick scale; there was improvement from the pre-operative scale record from 2.57 ± 1.22 to post-operative record of 0.7 ±0.79, p-value was <0.001 (statistically significant). There is improvement of the functional state post-operative. Odom’s criteria, 50% of the patients were excellent and the other half were good. There is no difference between these results of clinical outcome when compared with the other results at the literature using either similar or different methods of fusion [32-34].

Pseudoarthrosis without motion (fibrous union) means no abnormal motion, lucency, and no bony bridging or trabeculation at the fusion site, and pseudoarthrosis with motion (instability) indicates abnormal motion, lucency, and no bridging trabeculation at the fusion site [20]. Our results showed overall fusion rate of 80% and fusion of 83.3% at 2 level discectomy and of 75% for three levels. We operated on 72 disc levels, 6 levels only (8.3%) showed non fusion, and the remaining 91.7% of the levels fused. Fusion was not related to any of the parameters examined as, age, sex, and smoking. Pseudoarthrosis was noticed by the presence of translucency between the cage and the end plate. Pseudoarthrosis presented by mild neck pain in 5 patients and crepitus in one patient. These cases did not require surgery for these complaints. There were no cage related complications as erosion of the endplates, subsidence, or extrusion. Chang et al. achieved 98.2% fusion at their study on 23 patients with a total 56 levels [28]. Yang et al. reported non union in 35% of their patients at two level surgeries [18]. On the other hand, PEEK cages filled with biphasic calcium phosphate ceramic (Triosite) showed 100% fusion at one year follow-up, and considered a good alternative of autologous iliac crest graft [11].

Even though with plates there is an incidence of pseudoarthrosis. Bolesta et al. found that the nonunion rate in the plated two level patients was 4 patients out of 19 patients whom required posterior arthrodesis later [19]. In a study comparing four techniques for single level ACD; plate with autograft, cage with plate, cage alone, and disc arthroplasty, it is found cage alone is the cheapest, and all has comparable clinical and radiological outcome [35]. The addition of plate with the cage can be beneficial in elder patients with osteoporotic spine for three level discectomy as it reduces the pseudoarthrosis and the adjacent segment degeneration [36].

In our study there were no complications related to the cages as extrusion, cage sinking at the vertebral bodies. We did not use the known measure to assess cage subsidence as there was no constant scale for all the images. Subsidence is more associated with titanium cages than PEEK cages [11,37,38]. Size and position of the cage affect the subsidence. It is important to keep the integrity of the endplate and to avoid over-distraction, and not to use small anterior-posterior diameter of the cage [15,35].

We had minor transient complications. Pain at the graft site was the most frequent. The use of demeneralized bone matrix [12] or tricalcium phosphate hydroxyapatite [24,25] avoids this complication with higher fusion rate.
Conclusion:
There is agreement of the effectiveness of the anterior cervical discectomy and fusion in achieving good clinical outcome and accepted fusion results. The fusion results were lower than the reported, but the accepted complaints from pseudoarthrosis may be overcome this level. The clinical improvement and the high functional outcome with the lower morbidity are the benefit from such approaches.

References


