Multiple-Level Anterior Cervical Discectomy and Fusion Using PEEK Cages in Cervical Myelopathy. Is Anterior Platting Necessary?

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Abstract

Background Data: The use of anterior cervical discectomy and fusion (ACDF) is common in the surgical treatment of cervical myelopathy and radiculomyelopathy. Additional anterior plating is usually performed in multiple ACDF to overcome several possible complications.

Purpose: To assess the safety and effectiveness of PEEK interbody fusion cages for the treatment of cervical disc disease and their application in multilevel surgery without anterior plating.

Study Design: Prospective study.

Patient Sample: Eight patients with cervical myelopathy and twelve with radiculomyelopathy; the study included fourteen females and six males and the mean age at surgery was 58.4±7.1 (range 50-69).

Outcome Measures: Total blood loss and operative time were recorded. Clinical outcome was assessed by the JOA score and VAS. Fusion was assessed using plain radiographs.

Methods: All patients had multiple levels ACDF using PEEK cages packed with autogenous bone graft obtained from the removed osteophytes.

Results: Postoperatively, radiculopathy improved in all patients, whereas myelopathy improved in nineteen patients. After 12 months, fusion was achieved in 95% and cervical lordosis was restored. Neither cage extrusion nor symptomatic pseudarthrosis were observed.

Conclusions: Stand-alone PEEK interbody cages are effective and reliable to increase segmental stability of the cervical spine and achieve excellent fusion rate even in multilevel disease without the need for anterior platting. (2012ESJ012)

Key Words: cervical disc disease, PEEK cage, anterior cervical discectomy, anterior cervical fusion.
Introduction

Anterior discectomy has proven to be the technique of choice for the treatment of degenerative cervical disc disease. The anterior approach allows direct visualization of the entire disc space and wide decompression of the spinal cord and nerve roots\textsuperscript{20}. Anterior approach for degenerative cervical disc disease was described first by Cloward\textsuperscript{2} using an iliac bone graft to achieve fusion; since then, several modifications were introduced to his original procedure\textsuperscript{4,8,15,17,20,23}.

The most important modification is the use of interbody fusion cages. These are implants with hollow center allowing bone growth within them that were developed to restore normal disc height, avoid loss of lordosis and donor-site morbidity that were common with autologous bone graft. Cages are made of titanium, carbon fiber, or PEEK\textsuperscript{1}. When used at multiple levels, several studies recommended additional anterior plating to improve fusion rates that significantly decrease in multilevel surgery\textsuperscript{6,7,20}.

The aim of this study was to assess the safety and effectiveness of PEEK interbody fusion cages for the treatment of cervical disc disease and their application in multilevel surgery without the use of anterior plating.

Patients and Methods

Between April 2010 and October 2011, a total of 46 cervical discectomies were performed in twenty patients suffering from multiple level cervical disc disease. The study included eight patients with cervical myelopathy and twelve with radiculomyelopathy; all patients had multiple level anterior discectomies and interbody fusion using PEEK cages packed with autogenous bone graft obtained from the removed osteophytes without anterior plate instrumentation. There were fourteen females and six males; the mean age was 58.4±7.1 (range 50-69).

Preoperatively, seven patients suffered from neck pain and twelve from brachialgia; both were graded using a 10-point visual analogue scale (VAS)\textsuperscript{22} with endpoint anchors of “no pain” and “severe pain”. Statistical comparison between pre- and postoperative pain scores was performed. Complete neurological assessment was performed (Table 1) and cervical myelopathy was graded using the Japanese Orthopaedic Association (JOA) score\textsuperscript{12}.

In all patients, surgical treatment was indicated based on clinical and radiological evidence of multilevel disc disease, with correlation between clinical and radiological findings and failure of conservative measures. Preoperatively, all patients had plain X-rays and MR imaging. In seven cases, preoperative X-rays demonstrated loss of cervical lordosis that was measured using modified Ishihara cervical curvature index\textsuperscript{11}. (Figure 1)

A total of 46 levels were surgically treated. In seventeen patients, surgery was at contiguous levels, whereas three underwent surgery at distant levels. Surgery was performed at two levels in fifteen patients, three levels in four patients and at four levels in one patient. The levels affected were at C5-6 (18 patients), C6-7 (14 patients), C4-5 (12 patients) and C3-4 levels (2 patients). (Figure 2)

Clinical evaluation included: recovery of neurological function, recovery rate of JOA scoring for cervical myelopathy, change of neck and brachialgia VAS. Radiological evaluation included: 1 year fusion rate, restoration of cervical lordosis, change in modified Ishihara cervical curvature index and positioning of the cage.

Surgical technique:

A standard anterolateral approach was used through a left-sided skin incision; the incision was transverse in double level contiguous affections and was longitudinal if the affected discs were more than two or were non-contiguous.

The affected intervertebral disc was entirely removed back to the vertical fibers of the Posterior Longitudinal Ligament (PLL). Any herniated disk material or compressing osteophytes were excised and the endplates were thoroughly curetted. An appropriately sized PEEK cage was filled with autogenous local bone graft obtained from the removed osteophytes without anterior plate instrumentation. There were fourteen females and six males; the mean age was 58.4±7.1 (range 50-69).

Postoperatively; all patients were placed in a Philadelphia collar and instructed for full-time use for 6-8 weeks. Suction drains were removed by the second postoperative day.

Results

Patients were followed for a minimum of 1
year with JOA scoring and radiological evaluations performed at 1, 3, 6 and 12 months.

**Hospital notes:**
The operative time had a mean of 1:35 h (range 1:15-2:00) in double level cases, 2:05 h (range 1:45-2:30) in triple level cases and 2:25 h in the four level case. The average blood loss was 75 cc (range 50-110 cc).

**Neurological Function:**
All patients suffering from radiculopathy improved after surgery. One patient still complained of moderate sensory loss at 6 months.

**JOA Scoring:**
Postoperatively, 19 patients (95%) had improvement of the JOA scores. (Figure 3) Significant improvement was achieved at 3 months; at 6 months, improvement reached a plateau that was maintained till 12 months (Figure 4). The preoperative JOA score was 12.3±1.3 and improved to 14.5±1.2 at 1-year follow-up (P <0.0001) (Table 2). The mean recovery rate was 52.6±17.3%.

**Pain score:**
The VAS for neck pain improved from a mean preoperative score of 6 to a mean of 2 (P <0.01), while the VAS for brachialgia improved from a mean preoperative score of 5 to a mean of 1 (P <0.01).

**Fusion Rate:**
Complete fusion was confirmed when the endplates disappeared in both adjacent vertebral bodies forming a block, with no radiolucency other than that of the cage itself. Each operative segment was deemed fused if a segmental motion of less than 2° was observed on lateral flexion-extension radiographs (Figure 5). At 1 year, 19 patients (95%) showed complete radiographic fusion.

**Spinal Curvature:**
Cervical lordosis was restored in all nine patients (Figure 6). The mean modified Ishihara cervical curvature index improved from 5.7±4.6 to 11±3 (P <0.001) (Table 3).

**Cage Positioning:**
In 25% of patients, the average subsidence was 1 mm with no apparent symptoms. There were no case extrusions.

**Complications:**
Five cases of dysphagia were observed all patients with triple level surgery; however, this resolved within 1 week. Only one patient in whom fusion was incomplete complained of mild neck pain.

**Table 1.** Preoperative neurological symptoms and signs distribution.

<table>
<thead>
<tr>
<th>Symptom</th>
<th>No. of patients (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clumsiness of the hands</td>
<td>13 (65%)</td>
</tr>
<tr>
<td>Upper extremity sensory complaints</td>
<td>10 (50%)</td>
</tr>
<tr>
<td>Gait disturbances</td>
<td>6 (30%)</td>
</tr>
<tr>
<td>Deficit of upper extremity motor function</td>
<td>12 (60%)</td>
</tr>
<tr>
<td>Lower extremity sensory symptoms</td>
<td>5 (20%)</td>
</tr>
<tr>
<td>Bowel/bladder dysfunction</td>
<td>1 (5%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sign</th>
<th>No. of patients (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand wasting</td>
<td>3 (15%)</td>
</tr>
<tr>
<td>Spastic gait</td>
<td>6 (30%)</td>
</tr>
<tr>
<td>Hyperreflexia</td>
<td>16(80%)</td>
</tr>
</tbody>
</table>

**Table 2.** Comparison between pre-operative and post-operative JOA score.

<table>
<thead>
<tr>
<th>JOA score</th>
<th>Pre operative</th>
<th>Post operative</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range (Min-Max):</td>
<td>9.5-13.5</td>
<td>12.5-15.5</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Median:</td>
<td>12.25</td>
<td>14.3</td>
<td></td>
</tr>
<tr>
<td>Mean ± SD:</td>
<td>12.3±1.3</td>
<td>14.5±1.2</td>
<td></td>
</tr>
</tbody>
</table>
Table 3. Comparison between pre-operative and post-operative modified Ishihara cervical curvature index.

<table>
<thead>
<tr>
<th>Modified Ishihara cervical curvature index</th>
<th>Pre operative</th>
<th>Post operative</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range (Min-Max):</td>
<td>-4-10.8</td>
<td>12.5-17.5</td>
<td>0.001</td>
</tr>
<tr>
<td>Median:</td>
<td>7.75</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Mean ± SD:</td>
<td>5.7±4.6</td>
<td>11±3</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1. Modified Ishihara cervical curvature index.

Figure 2. Distribution chart of the disc levels done in the study.

Figure 3. Comparison between the preoperative and postoperative JOA score.
Figure 4. Change of JOA scores postoperatively. JOABO: JOA score before operation; JOA1W: JOA score at 1 week; JOA2W: at 2 weeks; JOA1M: at 1 month; JOA3M: at 3 months; JOA6M: at 6 months; JOA1Y: at 1 year; JOAF: at final.

Figure 5. A male patient 53 years with a triple level C4/5, C5/6 and C6/7 disc herniations. (a) Pre-operative lateral X-rays with modified Ishihara index = 0. (b) Pre-operative sagittal MRI. (c) One year follow-up lateral X-rays with modified Ishihara index=15.
Discussion

Numerous technical variants of anterior cervical discectomy are used to achieve spinal cord and root decompression in patients with cervical radiculopathy and myelopathy\(^8,15,17,20\). Some surgeons believe that anterior fusion after discectomy is not necessary\(^19,21,25\). Wilson and Campbell\(^28\) studied 71 cases of anterior cervical discectomy without bone graft (ACD) and reported good or excellent outcome after ACD alone in 85% of the cases. However, many other studies found a higher incidence of kyphosis in patients in whom no instrumentation was placed\(^18,20\). Martins\(^16\) reported significant kyphosis in 10% of the patients who underwent simple discectomy; sagittal imbalance is believed to accelerate adjacent levels degeneration\(^26,27\).

The Polyether-etherketone (PEEK) cage has a radiolucent hollow frame that is used in a pure form or in conjunction with carbon fiber reinforcement. The upper and lower surfaces contain retention teeth for initial stability. PEEK is a semi-crystalline thermoplastic with excellent mechanical and chemical resistance properties; its Young’s modulus is 3.6 GPa and its tensile strength 90 to 100 MPa\(^3\).

Several in vitro studies have demonstrated the superior biomechanical properties of cages in comparison with an autologous bone graft. The fusion rate using PEEK stand-alone cages is comparable to the published results of autogenous iliac bone graft. Also, the cage provides stability, high fusion rate, and low subsidence. The physical properties of the PEEK material facilitate radiological assessment\(^13,14\).

In this study PEEK cage-assisted fusion allowed restoration of disc space height in all cases with an average subsidence of 1 mm in 25% of patients with no apparent symptoms resulting from such subsidence at 1 year follow up. The preoperative cervical kyphosis improved in all patients in whom it was lost preoperatively; in patients with normal preoperative curvature, cervical lordosis was maintained.

Complications reported from harvesting autogenous iliac bone graft include persistent pain, fracture of the iliac bone, hematoma formation and meralgia paresthetica in up to 25% of patients\(^21\). In our study, there are no donor site-related complications as the bone graft filling the cage was obtained from the removed osteophytes in addition to synthetic bone substitute.

Several studies used alternatives methods to avoid donor site-related complications as allografts, Polymethylmethacrylate and Hydroxapetite\(^9,24\). Allograft bone use had the disadvantage of collapse of the disc space height in 30% of patients, with an average loss of 50% in addition to the risks of infectious agents\(^30\). We avoided these disadvantages by using PEEK cages; the disc height was maintained in all patients with no risk of transmitting infections.

Several studies demonstrated improvement in neck pain and brachialgia; 126 patients were followed...
to 2 years; a successful fusion at 12 months was achieved in 97.9% and the overall complication rate was 11.8%. In another study done on 100 patients treated by carbon fiber cages (CFC) filled with bone graft obtained from osteophytes at the surgical site. Radiological x-ray evaluation with dynamic views done 1 year postoperatively revealed that the cervical lordosis was corrected or maintained and disc height was restored in all cases. Fusion was achieved in 98% of cases. There were no cage-related complications or cage failure; the authors concluded that CFC application was safe, effective, and technically feasible. In a retrospective study done on 67 patients with single to two-level degenerative cervical disc disease treated by stand-alone cervical PEEK cage, Iampreechakul and coworkers found that there was significant improvement of clinical outcome and restoration of cervical lordosis with fusion rate of 97%.

According to the literature, fusion rates decrease significantly with multiple level surgery, and the rate of pseudarthrosis is higher in two-level compared with one-level surgery. Fusion rate of 90% were reported with implanting freeze-dried allografts in one-level discectomy that decreased to 72% after two-level fusions.

To the best of our knowledge, our study is the first to focus on multiple level disc affections. At 1-year follow, a fusion rate of 95% in multiple level surgeries up to four levels with no cases of symptomatic pseudarthrosis observed.

Some authors recommend supplemental plating to improve fusion rates, allowing earlier return to work, and limiting subsidence and kyphotic deformity. Greater incidences of postoperative kyphosis, failed fusion, and subsidence were observed in patients treated with discectomy and iliac crest bone graft compared with allograft and plate fixation with early return to work in the second group. In another series a slightly better 6-month fusion rate in patients with plate-assisted single level fusion was observed compared with those in whom plates were not used, but this difference had disappeared at 4-year follow up. Zdeblick et al. in their animal study found that, although the supplemental plating prevented graft extrusion, it failed to increase the histological union rate significantly or to prevent graft collapse reliably.

In this study, the PEEK cages provided adequate stability and restoration of cervical lordosis. There were no cases of cage displacement and stability was maintained until fusion developed even in multiple level surgeries.

**Conclusion**

PEEK cage constructs achieve immediate segmental stability while providing structural support for bone growth inside and around the cage itself. The cervical PEEK cages achieve high fusion rates, even in multilevel surgery; additionally, even without plating excellent to good clinical outcomes can be achieved with minimal complications. Donor-site related complications are completely avoided.

**References**

8) Hacker RJ. A randomized prospective study of an anterior cervical interbody fusion device.


المقدمة: إن استئصال الغضروف العنقى إماميا وثبت الفقرتين بالنظام عظمى أسلوب شائع لعلاج الاعتلال النخاعي والعصبى العنقى الانحلالي. وقد نصحت بعض الدراسات بإضافة الشراح الأمامية عند تعدد مستويات الجراحة لزيادة فرص الالتئام العظمى والذي تقل فرصه في مثل هذه الحالات. ولكن دراسات قليلة فقط هي من تحدثت عن بدون استخدام الشراح الأمامية في الانحلال العنقى متعدد المستويات.

الهدف: تقييم استخدام أقفاص البولى أيثر كيتون العنقية من حيث الكفاءة والأمان في أمراض الغضروف العنقى واستخدامها في أكثر من مستوى بدون استخدام الشراح الأمامية.

الوسائل: تم علاج عدد عشرين مريضا بالاعتلال النخاعي والعصبى العنقى الانحلالي متعدد المستويات باستخدام أقفاص البولى أيثر كيتون العنقية بدون استخدام الشراح الأمامية في الفترة بين ابريل 2010 وأكتوبر 2011. ثمانية منهم يعانون من اعتلال النخاعي واثنا عشر يعانون من اعتلال نخاعي وعصبي وعمرهم متوسط اعمارهم اربعون عاما أربعة عشر منهم اناث وستة ذكور وتمت متابعتهم لمدة عام.

النتائج: تحسن الاعتلال العصبي في جميع المرضى بعد العملية بينما تخس الاعتلال النخاعي في تسعة عشر مريضا 95٪. تم الالتئام العظمي بين الفقرات في تسعة عشر مريضا 95٪ في نهاية العام كما تبين ذلك من أفلام اشعة اكس. تحسن درجة تقعر الفقرات العنقية في جميع المرضى الذين سكانوا يعانون من التحدب العنقى. ولم تسجل أي حالة لفظ للقفص أو تمفصل زائف.

الاستنتاج: استخدام أقفاص البولى أيثر كيتون العنقية بدون استخدام الشراح الأمامية يتميز بالكفاءة العالية والانماط الكافية لزيادة الصلاحية الجزئية للفقرات العنقية والكافي للحصول على معدل التنام ممتاز حتى في حالات تعدد المستويات.