

Multiple-Level Anterior Cervical Discectomy and Fusion Using PEEK Cages in Cervical Myelopathy. Is Anterior Plating 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 plating. (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 roots²⁰. Anterior approach for degenerative cervical disc disease was described first by Cloward² using an iliac bone graft to achieve fusion; since then, several modifications were introduced to his original procedure^{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 PEEK¹. When used at multiple levels, several studies recommended additional anterior plating to improve fusion rates that significantly decrease in multilevel surgery^{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)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) score¹².

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 index¹¹. (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 mixed with synthetic bone substitute. The cage was gently introduced while applying gentle distraction and a snug fit was assured to increase stability.

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.

Symptom	No. of patients (%)
Clumsiness of the hands	13 (65%)
Upper extremity sensory complaints	10 (50%)
Gait disturbances	6 (30%)
Deficit of upper extremity motor function	12 (60%)
Lower extremity sensory symptoms	5 (20%)
Bowel/bladder dysfunction	1 (5%)
Sign	No. of patients (%)
Hand wasting	3 (15%)
Spastic gait	6 (30%)
Hyperreflexia	16(80%)

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

JOA score	Pre operative	Post operative	P value
Range (Min-Max):	9.5-13.5	12.5-15.5	<0.0001
Median:	12.25	14.3	
Mean ± SD:	12.3±1.3	14.5±1.2	

Table 3. Comparison between pre-operative and post-operative modified Ishihara cervical curvature index.

Modified Ishihara cervical curvature index	Pre operative	Post operative	P value
Range (Min-Max):	-4-10.8	12.5-17.5	0.001
Median:	7.75	12,5	
Mean ± SD:	5.7±4.6	11±3	

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

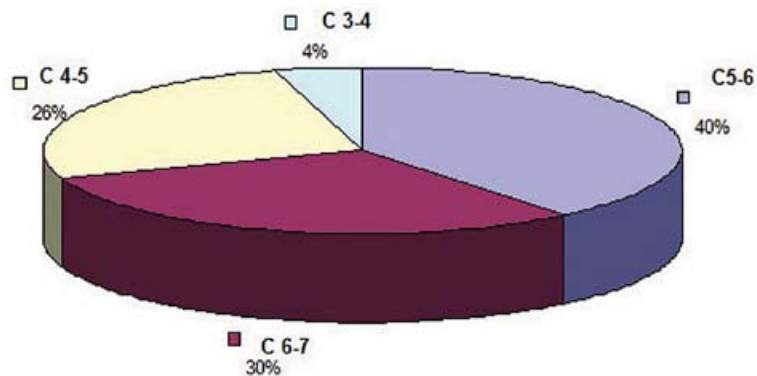


Figure 1. Modified Ishihara cervical curvature index.

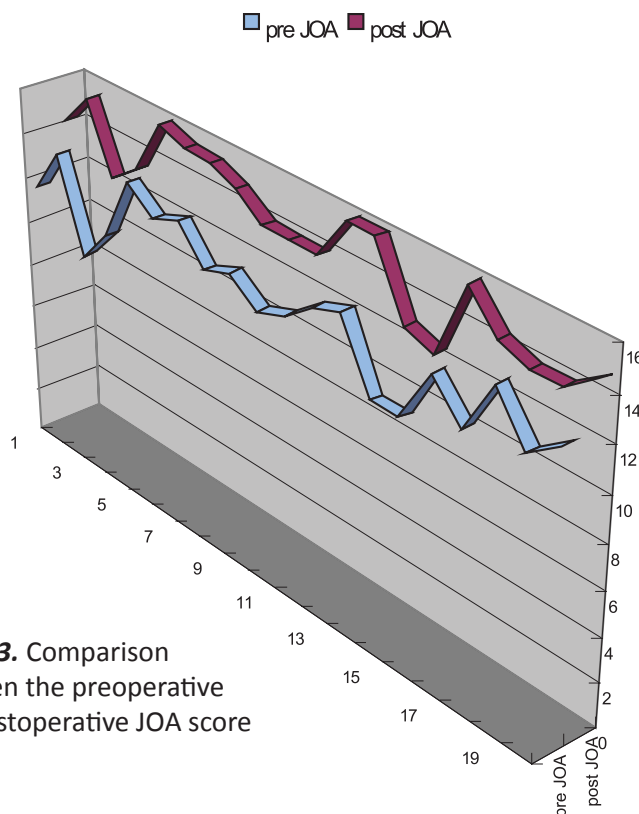
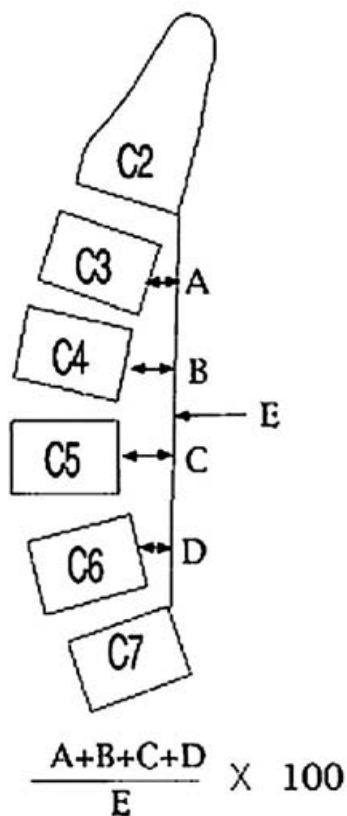


Figure 3. Comparison between the preoperative and postoperative JOA score

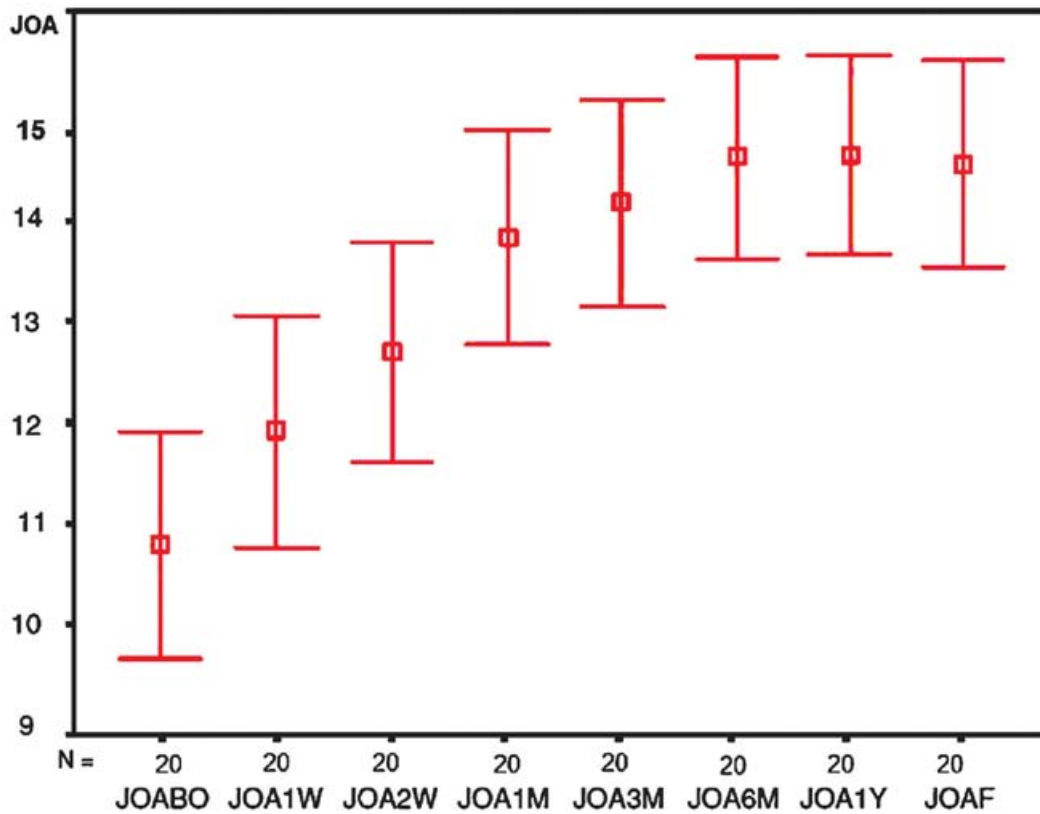
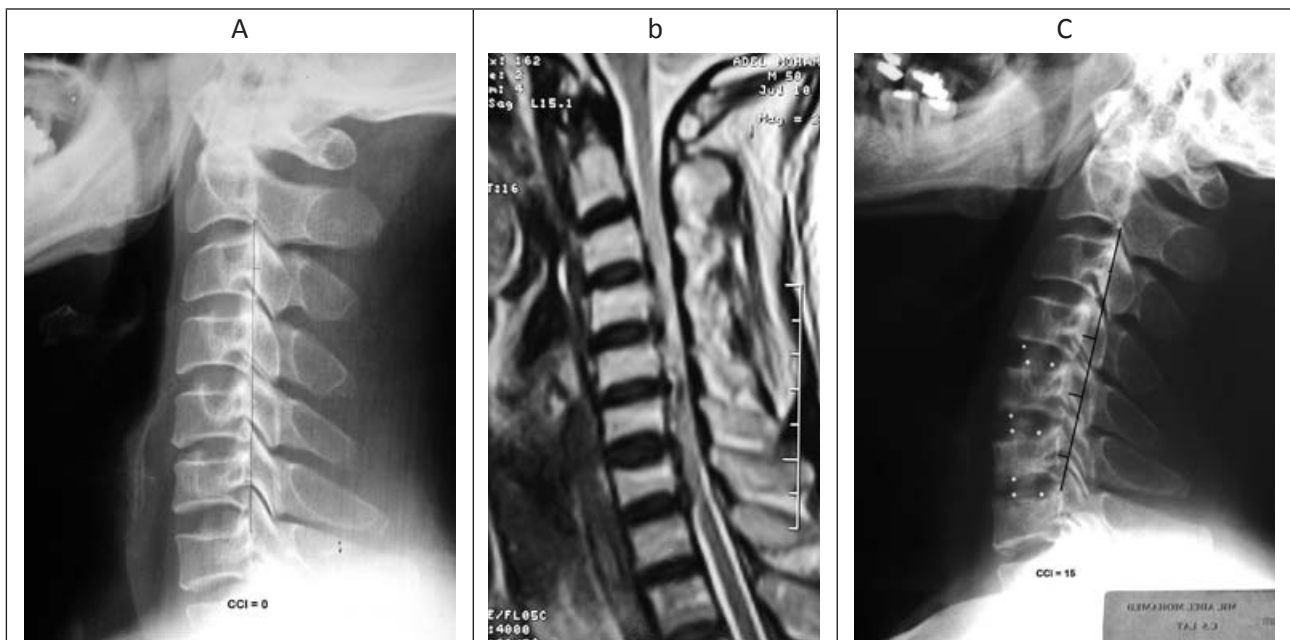


Figure 4. Change of JOA scores postoperatively. JOABO: JOA score before operation; JOA1W: JOA score at 1 week; JOA2W: at 2 weeks; JOA1M: at 1 month; JOA3M: at 3 months; JOA6M: at 6 months; JOA1Y: at 1 year; JOAF: at final.

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.



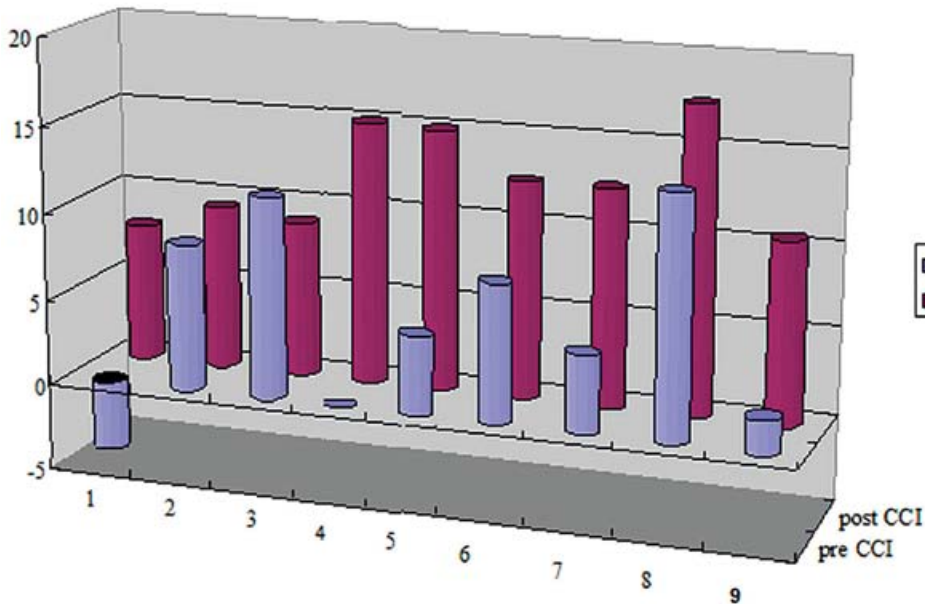


Figure 6. Change of modified Ishihara index postoperatively. **pre CCI:** preoperative modified Ishihara cervical curvature index, **post CCI:** postoperative modified Ishihara cervical curvature index.

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 Campbell²⁸ 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}. Martins¹⁶ 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 MPa³.

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 patients²¹. 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 agents³⁰. 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%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 feasible¹³. 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%¹⁰.

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 surgery²⁹. Fusion rate of 90% were reported with implanting freeze-dried allografts in one-level discectomy that decreased to 72% after two-level fusions¹⁶.

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^{5,7,20}. 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 group⁶. 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 up²⁰. Zdeblick et al,^{29,31} 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.

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الملخص العربي

مقدمة: ان استئصال الغضروف العنقى اماميا وتثبيت الفقرتين باللتئام عظمى اسلوب شائع لعلاج الاعتلال النخاعى والعصبى العنقى الانحلالى. وقد نصحت بعض الدراسات باضافة الشرائح الامامية عند تعدد مستويات الجراحة لزيادة فرص الالتئام العظمى والذى تقل فرصه فى مثل هذه الحالات . ولكن دراسات قليلة فقط هى من تحدثت عن بدون استخدام الشرائح الامامية فى الانحلال العنقى متعدد المستويات.

الهدف: تقييم استخدام اقفاص البولى ايثر ايثر كيتون العنقية من حيث الكفاءة والأمان فى أمراض الغضروف العنقى واستخدامها فى اكثر من مستوى بدون استخدام الشرائح الامامية.

الوسائل: تم علاج عدد عشرين مريضا بالاعتلال النخاعى والعصبى العنقى الانحلالى متعدد المستويات باستخدام اقفاص البولى ايثر ايثر كيتون العنقية بدون استخدام الشرائح الامامية فى الفترة بين ابريل ٢٠١٠ وأكتوبر ٢٠١١ ثمانية منهم يعانون من اعتلال النخاعى واثنا عشر يعانون من اعتلال نخاعى وعصبى وكان متوسط اعمارهم اربعون عاما اربعة عشر منهم اناث وستة ذكور وتمت متابعتهم لمدة عام.

النتائج: تحسن الاعتلال العصبى فى جميع المرضى بعد العملية بينما تحسن الاعتلال النخاعى فى تسعة عشر مريضا ٩٥% . تم الالتئام العظمى بين الفقرات فى تسعة عشر مريضا ٩٥% فى نهاية العام كما تبين ذلك من افلام اشعة اكس. تحسنت درجة تقعر الفقرات العنقية فى جميع المرضى الذين كانوا يعانون من التحذب العنقى. ولم تسجل اى حالة لفظ للقفاص او تمفصل زائف.

الاستنتاج: استخدام اقفاص البولى ايثر ايثر كيتون العنقية بدون استخدام الشرائح الامامية يتميز بالكفاءة العالية والثبات الكافى لزيادة الصلابة الجزئية للفقرات العنقية والكافى للحصول على معدل التئام ممتاز حتى فى حالات تعدد المستويات.