Implantation of an empty carbon fiber composite frame cage after single-level anterior cervical discectomy for the treatment of cervical disc herniation: preliminary results

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Object. The authors sought to evaluate retrospectively the radiological and clinical outcome of anterior cervical discectomy followed by implantation of an empty carbon fiber composite frame cage (CFCF) in the treatment of patients with cervical disc herniation and monoradiculopathy.

Methods. Twenty-five consecutive patients (12 men, 13 women, mean age 45 years) with monoradiculopathy due to cervical disc herniation were treated by anterior cervical discectomy followed by implantation of an empty CFCF cage. On lateral flexion-extension radiographs segmental stability at a mean follow up of 14 months (range 5–31 months) was demonstrated in all 25 patients, and bone fusion was documented in 24 of 25 patients. The mean anterior or intervertebral body height was 3.4 mm preoperatively and 3.8 mm at follow up in 20 patients. In these patients the mean segmental angle (angle between lower endplate of lower and upper vertebra) was 0.9° preoperatively and 3.1° at follow up. In the remaining five patients preoperative images were not retrievable.

Self-scored neck pain based on a visual analog scale (1, minimum; 10, maximum) changed from a preoperative average of 5.6 to an average of 2 at follow up; radicular pain was reduced from 7.7 to 2.1 postoperatively. Analysis of the SF12 questionnaires showed a significant improvement in both the physical capacity score (preoperative mean 32.4 points; follow up 46 points; follow up 57.5 points).

Conclusions. Implantation of an empty CFCF cage in the treatment of cervical disc herniation and monoradiculopathy avoids donor site morbidity associated with autologous bone grafting as well as the use of any supplementary material inside the cage. Restoration or maintenance of intervertebral height and thus segmental lordosis and a very high rate of segmental stability and fusion are achieved using this technique.

KEY WORDS • anterior cervical discectomy • anterior cervical fusion • interbody cage

C O M P R E S S I V E monoradiculopathy due to cervical disc herniation can be treated by different surgical methods. Controversy exists among spine surgeons and in literature reviews24 as to whether ACD and nerve root decompression should be followed by some sort of disc replacement. Restoration of foraminal height, achieving more rapid segmental stability, and maintenance or reconstruction of physiological cervical lordosis are noted advantages of the latter method.1,3,13,25 Kyphotic malalignment has been shown in one study to promote degeneration in adjacent intervertebral spaces.12 On the other hand prolonged operating time, extrusion of an interbody device, donor site morbidity in autologous bone grafting,20 and unknown infectious risk in allograft,4 artificial bone, or cage material have been discussed as disadvantages of cervical interbody fusion, which has motivated spine surgeons to perform anterior discectomy only.7,11,16,22,26 In the past years new interbody materials have been developed to overcome the disadvantages of bone grafting, graft collapse, or graft extrusion.7–9,10,15,18,19,23,27

At our institution we recently introduced and evaluated the implantation of an empty CFCF cage after single-level cervical discectomy for the treatment of compressive monoradiculopathy. We present the preliminary clinical and radiological results obtained using this new method.

Clinical Material and Methods

Patient Population

This retrospective study was based on a review of patient hospital charts, operative notes, and out-patient clinical and radiographic follow-up data. Between May 1999 and October 2001 25 consecutive patients with compressive monoradiculopathy due to cervical disc herniation were treated by ACD and implantation of a CFCF cage without any filling. There were 12 men and 13 women, and their mean age was 45 years (range 29–60 years). The inclusion criterion was severely symptomatic single-level one-sided compressive radiculopathy due to
cervical disc herniation, which was radiologically con-
ferred by MR imaging in 21 patients and computerized
tomography studies in four patients. Patients with evi-
dence of cervical instability, “whiplash syndrome,” sys-
temic infection, metabolic bone disease, active malign-
nancy, previous surgery of the cervical spine, bilateral or
multilevel symptomatic radicular compression, myelopa-
thy and psychiatric disease have not been reviewed. The
level of operation was C6–7 in 13 patients (52%), C5–6 in
11 (44%), and C7–T1 in one patient (4%). Fourteen disc
herniations were on the right side (56%) and 11 were
on the left (44%). At admission symptoms included neck
pain in 20 (80%) of 25 patients, radicular pain in 23 (92%)
of 25, motor deficit in 21 (84%) of 25, and sensory deficit
in 21 (84%) of 25.

Surgical Technique

Surgery was performed after the patient received a gen-
eral anesthetic. A standard anterior approach to the cervi-
cal spine was followed by microsurgical ACD, disc space
distraction, opening of the posterior longitudinal ligament,
and nerve root decompression. The vertebral endplates
were completely cleaned of any cartilage with curettes or
a high-speed drill. Cortical endplates were carefully pre-
served. After determination of the cage size by means of
a template, an empty CFCF cage (Co-Ligne AG, Zürich,
Switzerland) was inserted with its anterior edge flush or 1
mm deep to the anterior disc space margin, and then the
disc space distractor was removed. The cage is a med-
ical grade composite of long fiber carbon encapsulated
in a PEKEKK (polyetherketonetherketonketon) matrix (Fig.
1); it is 12 mm wide and 12 mm deep and is available in
6, 7, or 8 mm anterior heights and 0 or 5° lordosis. The
mean duration of surgery was 64.6 minutes (range 30–100
minutes). The mean estimated intraoperative blood loss
was 80 to 100 ml.

Patients were mobilized on the 1st postoperative day
and no collar application was necessary; however, the pa-
tients were instructed to avoid excessive cervical motion.
Physical therapy to strengthen the cervical paraspinal
muscles was prescribed 3 months after surgery.

Outcome Measures

No patient was lost to follow-up evaluation, which was
at a mean of 14 months (range 5–31 months). Segmental
stability was determined on lateral flexion–extension ra-
diographs and defined as less than 2° motion in the oper-
ated segment, allowing compensation for experimental
error and variation. Bone fusion was assumed if in addi-
tion to segmental stability, less than 50% of the interver-
tebral space was radiolucent or if continuous iso- or hypo-
dense trabecular bridges between the endplates were seen
on lateral radiographs (Fig. 2). The radiolucency of the
CFCF cage is advantageous in the assessment of bone
fusion. The pre- and postoperative anterior intervertebral
body height and the segmental angle on lateral radiog-
raphs were measured. The anterior intervertebral body
height was measured as the vertical distance between the
anterior border of the inferior endplate and the anterior
border of the superior endplate. In postoperative measure-
ments the superior endplate frequently was not visible in
its anterior aspect due to cage subsidence, so a line from
the preserved superior endplate posterior to the cage was
drawn parallel to the inferior endplate of the same verte-
bral body. The segmental angle was defined as the angle
between the inferior endplate of the lower vertebra and the
inferior endplate of the upper vertebra.

Clinical outcome was assessed by using a VAS for neck
and arm pain, SF12 questionnaires, and the patient’s self-
rating.

Statistical Analysis

Comparison between pre- and postoperative scores of
outcome measures, both radiological and clinical, was per-
formed by means of the nonparametric Wilcoxon signed-
rank test. Computation was supported by the statistical
package StatView 4.5 (Abacus Concepts Inc., CA) running
on a Macintosh computer (Apple, Cupertino, CA).

Results

All values are represented as the means ± standard
deviations. Segmental stability was demonstrated in all 25
patients (Table 1). Bone fusion at the time of follow up
was revealed in 24 (96%) of 25 patients. The mean ante-
rior intervertebral body height was 3.4 ± 0.8 mm preop-
eratively and 3.8 ± 2.1 mm at follow-up evaluation in 20
patients; the difference was not significant (Z = −0.795).
Relevant secondary loss of intervertebral height (≥2 mm)
due to cage subsidence was found in four (20%) of 20
patients (Fig. 3). The mean segmental angle in 20 patients
was 0.9 ± 3.3° preoperatively and 3.1 ± 4.5° at follow up
(Z = −2.166, p < 0.03). In the five remaining patients,
preoperative images were not retrievable: at follow up
their mean anterior intervertebral body height was 6.4
mm, and their average segmental angle was 9.4°.

Neck pain as scored using the VAS (1, minimum; 10,
maximum) decreased from a preoperative average of
5.8 ± 4.1 to 2 ± 2.1 at follow up, with a significant dif-
ference between pre- and postevaluation (Z = −3.340,
p < 0.0008). Radicular pain also significantly decreased
from a preoperative mean value of 7.8 ± 2.9 to 1.9 ± 2.1
at follow up (Z = −4.107, p < 0.0001). Motor deficit was
improved in 20 of 21 patients and unchanged in one
patient; four patients had no motor deficit. Sensory deficit

![Fig. 1. Photograph showing an empty CFCF cage.](image-url)
was improved in 20 of 21 patients and unchanged in one patient; four patients had no sensory deficit. Analysis of the results of the SF12 questionnaires revealed significant changes in both outcome measures. Physical capacity score improved from a mean value of 32.3 to 46.6 at follow up ($Z = 4.100, p < 0.0001$); mental capacity score changed from a preoperative mean score of 44.8 to 57.2 at follow up ($Z = 3.143, p = 0.0017$).

Eighteen patients (72%) returned to full-time employment 1 month after surgery, whereas four patients (16%) ceased working after surgery. Self-rating was excellent in 18 patients (72%)

### TABLE 1

Characteristics of 25 patients treated for cervical disc herniation by ACD and empty CFCF cage placement*

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*AIH = anterior intervertebral height; MCS = mental capacity score; PCS = physical capacity score; rad = radicular; SA = segmental angle.

FIG. 2. Neuroimaging performed in a 40-year-old woman with right-sided C5–6 disc herniation. **Left:** Preoperative sagittal T2-weighted MR image demonstrating a degenerated C5–6 disc with right-sided herniation. **Center:** Lateral radiograph obtained 3 days postoperatively, revealing good restoration of intervertebral height at C5–6. **Right:** Lateral radiograph obtained at 14-month follow up, demonstrating hypo- to isodense bone fusion at C5–6 without loss of intervertebral height.

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Mean hospitalization time was 5.4 days (range 3–10 days). There were three perioperative complications: one patient experienced postoperative Claude-Bernard-Horner syndrome with partial recovery at follow up; another patient developed a deep wound infection, which was successfully treated with computerized tomography–guided aspiration of a prevertebral fluid collection and then treated with intravenous antibiotics; and one patient presented with dysphagia for 1 week, which spontaneously resolved without further treatment.

Discussion

An important development in degenerative cervical interbody surgery has taken place in the past several years. Donor site morbidity with long-term discomfort has been seen in a substantial percentage of patients; thus, the use of traditional tricortical iliac crest bone grafting introduced by Robinson and Smith and Cloward has recently given way to interbody cages. Such cages are usually made of titanium or carbon fiber, and most surgeons fill them with autologous iliac crest or cancellous bone.
Empty CFCF cage placement after cervical discectomy

therefore requiring a second incision and causing certain donor site morbidity. Other surgeons fill the cages with allogenic bone or hydroxyapatite,\textsuperscript{2,16,22} which theoretically increases the risk of infection by adding a second foreign material to the cage. Authors of one recent study reported filling carbon fiber cages with local bone harvested from local osteophytes or with bone dust acquired during drilling.\textsuperscript{18} Other authors reported good long-term clinical results in 249 patients who underwent polymethylmethacrylate interbody fusion;\textsuperscript{10} however, after a minimum of 2 years of follow up the “complete fusion rate” was only 53.8% and the “partial fusion rate” 7.7%.

Based on the finding of new bone formation around a biocompatible osteoconductive polymer\textsuperscript{14} laboratory evidence of bone growth around removed lumbar carbon fiber interbody cages,\textsuperscript{23} and a study reporting bone formation around a carbon fiber cage filled with iliac crest bone,\textsuperscript{3} we hypothesized that bone ingrowth through and around an empty CFCF cage should occur and lead to segmental stability. Whether the cage actually has osteoinductive qualities in addition to osteoconductive properties remains an open question.

We observed segment stability in all of our 25 patients and bone fusion in 24. The one patient in whom we did observe bone fusion was followed for only 5 months, at which time bone ingrowth into the intervertebral space was seen from the lower and upper endplates without continuity (Fig. 4). We assume that further ingrowth will occur in the following months. After interbody fusion with autologous bone graft, isodense bone is seen on postoperative lateral radiographs, whereas usually only hypodense filling of the intervertebral space is visible on follow-up images after implantation of an empty CFCF cage (Figs. 2 and 3). We conclude that trabecular bone is formed through and/or around the CFCF cage, which is less dense than iliac crest bone grafts.

Cage subsidence in the months after implantation has been our biggest concern (Fig. 3). We have observed significant loss (≥2 mm) of anterior intervertebral height in four (20%) of our 20 patients. Although great care was taken in preserving the cortical endplates after complete removal of the cartilage, cage subsidence did occur, most commonly into the upper endplate of the lower vertebra. We are currently changing the design of the cage by increasing the size and support surface.

No anterior or posterior cage migration or cage break-down was observed. Operative time and hospitalization time compare favorably with those for cervical discectomy alone as well as those for interbody bone grafting and the procedure is technically feasible and uncomplicated.

According to our literature research there is one study in which the authors have reported on implantation of empty cages after cervical discectomy.\textsuperscript{27} They report on 18 patients with cervical disc disease in whom implantation of an empty titanium cage was performed and compared the results with 18 patients who were treated with iliac crest autograft. At 1-year follow up they observed a 87% stability rate in the cage-treated group, defined as less than 2° motion on lateral flexion-extension radiographs. It was not possible to assess fusion because of the radiopacity of titanium. They describe cage subsidence of more than 2 mm in eight of the 23 operated levels in their series, which was more frequently seen at the beginning of the study (first four of five patients) because of extensive cortical endplate removal.

The limitations of our series are its retrospective nature, the heterogeneous follow-up times, the limited number of patients, and the lack of a comparative gold standard. Our preliminary clinical and radiological results are very clear and encouraging; therefore, we recently began a prospective randomized study in which we compare the results of implanting an empty CFCF cage with those for the Smith–Robinson technique.

Conclusions

Our preliminary retrospective evaluation of the first 25 patients shows that implantation of an empty CFCF cage in the treatment of cervical discogenic compressive monaradicolopathy is a safe and technically feasible procedure with excellent clinical and radiological results. This method avoids donor site morbidity due to autologous bone grafting as well as the use of supplementary material inside the cage. Restoration or maintenance of intervertebral disc height and a very high rate of segmental stability and fusion are achieved.

References


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