Height of cervical foramina after anterior discectomy and implantation of a carbon fiber cage

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Object. The authors evaluate the effects of implantation of a carbon fiber cage after anterior cervical discectomy (ACD) on the height of the foramen and the angulation between endplates of the disc space.

Methods. Thirteen consecutive patients who were scheduled for standard microscopic ACD and interbody fusion underwent thin-slice (1.5 mm) spiral computerized tomography scanning 1 day preoperatively, 1 day postoperatively, and 1 year postoperatively. Oblique sagittal reconstructions were made through both foramina; the height of each foramen and the angle between the endplates were measured. Because 16 cages were implanted, 32 foramina were investigated. Preoperatively, the mean height of the foramina (± standard deviation) was 8.1 ± 1.5 mm (range 5.7–12 mm), and at 1 day postoperatively it was 9.7 ± 1.4 mm (range 7.5–12.8 mm). This difference reached statistical significance (p < 0.0005). The mean foraminal height after 1 year was 9.4 ± 1.4 mm (range 6.9–12.7 mm). In terms of the preoperative value, the 1-year measurement still reached statistical difference (p < 0.005) but not with the direct postoperative mean foraminal height. Preoperatively the mean value of the angle between the two adjacent endplates was 1.3 ± 2.4˚ (range 0–8˚), and postoperatively it was 7.8 ± 2.9˚ (range 2–12˚), which was statistically significant (p < 0.0005).

Conclusions. The cervical carbon fiber cage effectively increased the height of the foramen even after 1 year, which contributed to decompression of the nerve root. The wedge shape of the device may contribute to restoration of lordosis.

Key Words • anterior cervical discectomy • carbon fiber cage • spinal fusion • neuroforamen

Wether fusion should be performed after ACD remains a matter of debate. Allografts and autografts are available as materials for fusion. Cervical cages have been more recently introduced. The advantages of cages are that they allow for restoration and maintenance of disc height while promoting bone ingrowth and fusion. Initially the cage acts as a spacer between the vertebrae; after the bone has proliferated to the adjacent VBs, the joint becomes stable. The effects of a cage on foraminal height and the angulation between the endplates of the disc space have never been studied. In this report we describe these effects after implantation of a carbon fiber cage (cervical I/F Cage; Depuy Acromed, Rotterdam, The Netherlands).

Clinical Material and Methods

Thirteen consecutive patients with a symptomatic cervical disc herniation and no history of neck surgery were studied. There were five women and eight men (mean age 46.2 years). All patients underwent a standard microscop-
Tuttlingen, Germany) were inserted in the VBs adjacent to the disc space of interest. The posterior ligament was always opened and partially removed. While retaining the slight (certainly not forceful) distraction, the disc space was prepared for introduction of a cage. The test cage should be a close fit and must not be introduced with force (that is, no hammering). Implantation is accomplished by removing the osseous ridges with the high-speed drill. The definitive carbon fiber cage is then introduced; prior to this, the cage should be filled with spongy bone obtained from the right iliac crest. The distraction is released, the posts are removed, and the wound is closed in a standard fashion. Within 2 days the patients are discharged home; no orthotic devices are necessary.

Results

Of the 13 patients, 10 underwent single-level operations and three underwent two-level operations (Table 1). Because 16 cages were implanted, 32 foramina were studied. Preoperatively, the mean height of the foramina was 8.1 ± 1.5 mm (range 5.7–12 mm). The mean height one day postoperatively was 9.7 ± 1.4 mm (range 7.5–12.8 mm). This difference reached statistical significance (p < 0.0005). The mean time between surgery and the last follow-up CT session was 12.4 months. At this time, the mean foraminal height was 9.4 ± 1.4 mm (range 6.9–12.7 mm). Compared with the preoperative value, this also reached statistical significance (p < 0.005). The difference between the immediate postoperative and 1-year postoperative mean heights was not significant. The mean difference between the immediate post- and preoperative values was 1.6 ± 1.3 mm, and between the 1-year postoperative and 1 day preoperative it was 1.2 ± 1 mm.

The preoperative mean height of the right foramina was 7.9 ± 1.2 mm (range 5.7–9.5 mm) and that of the left side was 8.4 ± 1.7 mm (range 5.8–12 mm). This difference was not statistically significant. The immediate postoperative values were 9.5 ± 1.2 mm (range 7.5–11.8 mm) for the right side and 9.9 ± 1.6 mm (range 7.7–12.8 mm) for the left side. Whereas the difference between the postoperative
values of both left and right foramina was not statistically significant, the pre- and postoperative mean height of the cervical foramina reached statistical significance on the right (p < 0.005) and left sides (p < 0.025). After 1 year, the mean height of the right foramina was 9.1 ± 1.2 mm (range 6.9–10.8 mm), and that of the left foramina was 9.7 ± 1.6 mm (range 6.9–12.7 mm). Comparison of the preoperative values revealed statistical significance on the right (p < 0.05) and on the left sides (p < 0.05). The difference between the immediate postoperative and 1-year postoperative mean foraminal heights was not significant for either side. The mean difference between the postoperative values was 0.3 ± 0.4 mm.

Preoperatively, the mean angle between the two adjacent endplates was 1.3 ± 2.4° (range 0–8°), and postoperatively it was 7.8 ± 2.9° (range 2–12°), which is statistically significant (p < 0.0005). The mean increase of the angle was 6.6 ± 3.3° (range 2–12°). Because at 1-year postoperatively the endplates were not clearly visible, the angles were not measured. In all cases bone growth through and around the cage was seen (Fig. 1).

All patients with preoperative arm pain were free of pain the day after the operation. No recurrence has been reported. Three patients initially complained of severe pain at the donor site (iliac crest). Within 14 days the pain resolved in all patients. No other complications occurred.

**Discussion**

Microsurgical ACD is a standard treatment for degenerative disc disease. The debate whether to perform fusion remains ongoing and is beyond the scope of this article. With varying degrees of success, allografts and autografts have been used. The goals of fusion are to maintain disc height and prevent kyphosis. The restoration of the disc height after discectomy by introducing a graft has an advantageous side effect: it increases the height of the foramen, which contributes to the decompression of the nerve root and alleviation of the arm pain. Because grafts are constructed intraoperatively, however, they will not always fit closely. Therefore, the effects on the foramen cannot be predicted. The grafts are also prone to subsidence, which is a cause of kyphosis, pseudarthrosis, and narrowing of the foramen with eventual renewed compression of the nerve root.

Newer to spine surgery is the practice of cervical anterior or interbody fusion in which carbon fiber cages are implanted. The main advantages of the cage are: 1) immediate restoration and maintenance of disc height; 2) no danger of subsidence; 3) bone fusion through and around the cage; and 4) contribution to the restoration of lordosis. Biomechanical and clinical studies on the effects of these cages have been published, but their effect on the foramen has never been reported. In this study, it is clearly demonstrated that the height of the foramen increased significantly 1 day postoperatively. One year after surgery, this effect was still significantly measurable. After 1 year a statistically insignificant decrease of foraminal height occurred, which is attributable to settlement of the cage. Because cages have standard sizes, the effect on foraminal height can be reliably predicted assuming a proper implantation technique. Overdistraction and forceful introduction must be avoided. The width of the foramen in the sagittal plane is not measurable because a change cannot be attributed to the introduction of the cage. Surgical widening (for example, removing osteophytes) must be held responsible.

Restoration of lordosis is accomplished by achieving an angulation between the upper and lower plate of the cage of 7°, which is similar to the increase of the angle between the upper and lower endplate of the disc.

**Conclusions**

Fusion after ACD remains a topic of debate. Among materials used to assist fusion, interbody cages are relatively new. While allowing for the possibility of bone ingrowth, they also provide some stabilization and do not subside. Immediately postoperatively they merely act as a spacer between vertebrae. Definite stabilization occurs after the bone has proliferated to the adjacent VBs. Moreover, the proper introduction of a cage leads to a significant increase in foraminal height, which is still measurable 1 year after surgery and may contribute to alleviation of the nerve root compression and, therefore, relief of pain. The wedge-shaped cage contributes to the restoration of the lordosis and balance.

**References**


**TABLE 1**

*Summary of involved intervertebral discs fitted with carbon fiber cages*

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<thead>
<tr>
<th>Level No. of Patients</th>
</tr>
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<tr>
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<td>C4–5 1</td>
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<tr>
<td>C5–6 6</td>
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Manuscript received July 27, 1999.
Accepted in final form March 26, 2001.
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