Distractable Vertebral Cages for Reconstruction After Cervical Corpectomy

Christian Woiciechowsky, MD, PhD

Study Design. Retrospective study of 20 patients with degenerative cervical spinal canal stenosis who were treated with corpectomy followed by the placement of a distractable titanium cage (anterior distraction device [ADD]) (Ulrich GmbH & Co. KG, Ulm, Germany).

Objective. To investigate the efficacy of distractable titanium cages for reconstruction following decompressive cervical corpectomy.

Summary of Background Data. Anterior corpectomy and reconstruction for extensive spinal canal stenosis are standard techniques. The reconstruction is commonly performed with bone graft and anterior plating. Alternatively, different fusion cages have gained acceptance in spine surgery. However, in traditionally designed cages, an over-distraction of the involved segment is necessary to place the cage into the defect, and to achieve tight contact between cage and endplates. The new designed cage (ADD) can be distracted *in situ*. Therefore, the height of the cage can be adjusted precisely to the size of the corpectomy.

Methods. All patients were treated with corpectomy followed by the placement of an ADD. A cervical plate was added in 13 cases, and an "All-in-one-system" (*i.e.,* a cage with an attached plate with 2 holes for screw fixation on both sides, ADD^{plus}) was used in 7. Follow-up was 18–60 months. Clinical evaluation and radiographs were performed after 3, 6, and 12 months, and then once a year.

Results. In all cases, a stable reconstruction of the anterior column was achieved, with no signs of instability on flexion/extension radiographs. However, there was one incidence of cage subsidence. According to Odom criteria, 11 patients (55%) had excellent outcome, 4 (20%) good, 3 (15%) satisfactory, and 2 (10%) poor.

Conclusions. The results of the study show that distractable cages are useful vertebral body replacements because they can be adjust to the size of the corpectomy *in situ* and provide immediate strong anterior column support, avoiding bone graft site morbidity. The possibility of direct cage fixation without an additional plate simplifies the procedure.

Key words: spinal canal stenosis, cervical spine, myelopathy, fusion cages, vertebral body replacement, corpectomy. **Spine 2005;30:1736–1741**

Address correspondence and reprint requests to Christian Woiciechowsky, MD, PhD, Klinik für Neurochirurgie, Charité, Campus Virchow-Klinikum, Universitätsmedizin Berlin, Augustenburger Platz 1, D-13353 Berlin, Germany; E-mail: christian.woiciechowsky@charite.de

Cervical spondylotic myelopathy is a disease of the cervical spinal cord that results from compression of the degenerative cervical spine. Surgical recommendations must be based on patient characteristics, symptoms, function, and neuroradiologic findings. Extensive surgery in the anterior cervical spine has become more prevalent, involving channel corpectomy and multilevel discectomy, and has created a challenge regarding ensuring stability after reconstruction.[1–4] Today, bone grafting involves iliac crest autograft, allograft, or fibular strut graft. The use of autologous iliac crest bone, once considered the graft material of choice, has been questioned because of its harvesting-related morbidities.[5,6] On the other hand, allograft bone has not been shown to yield comparably high fusion rates, although this point remains controversial.[7,8]

More recently, the usage of cervical cages for reconstruction after discectomy and corpectomy has been described.[9–11] Additionally, by using the autologous bone from the corpectomy, the disadvantages of autograft harvesting, including donor site pain, fracture, and poor bone quality, are avoided. The results are encouraging, with a stability rate up to 100% and low complication rates.[9,10] Although caution is needed in cases of multilevel surgery or osteopenic bone, titanium cages are safe and effective for interbody fusion in the cervical spine.[11–13] However, after corpectomy, implantation of the currently available cages is often demanding because the cage cannot be adjusted to the height of the defect *in situ*. To resolve this problem, different distractable cages have been developed recently. Biomechanical investigations showed similar results for distractable cages compared with iliac crest or nondistractable cages.[14] Here, we report our clinical experience and radiologic investigations using the anterior distraction device (ADD) (Ulrich GmbH & Co. KG, Ulm, Germany) in cervical spine surgery since 1998.

■ Materials and Methods

From 1998 to 2002, a total of 20 patients, including 14 men and 6 women, underwent fusion using the ADD after cervical corpectomy. Inclusion criteria were myelopathy with an absolute spinal canal stenosis resulting from spondylosis, degenerative kyphosis, or spondylolisthesis, in which an anterior approach with corpectomy of 1 or 2 levels was indicated. Exclusion criteria were radiologic signs of severe osteoporosis.

The patients' ages at surgery ranged from 45 to 74 years, with a mean of 60. The pathology that required cervical corpectomy was spondylosis in 13 patients, ossification of the posterior longitudinal ligament in 3, degenerative kyphosis in 2, and spondylolisthesis in 2. The leading symptom was severe
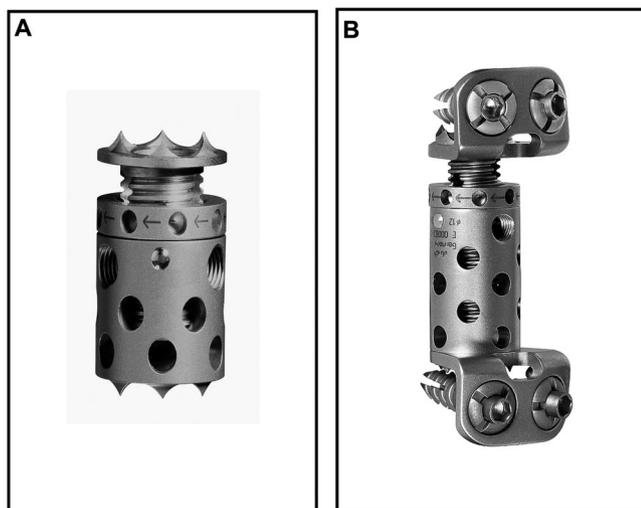
Figure 1. The ADD and ADD^plus. **A**, ADD is a distractable vertebral body replacement to reconstruct the ventral cervical and upper thoracic spine after corpectomy for various indications. The ADD is universally applicable, *in situ* continuously distractable, and has a central cavity for packing. Spikes on both sides provide a firm anchorage of the implant and prevent migration. **B**, ADD^plus has the same characteristics as the ADD. However, the ADD^plus can be fixed directly to the adjacent vertebral bodies by a method of wings (*i.e.,* attached plates with 2 holes for screw fixation), which are on both ends of the cylinder.

myelopathy with radiculopathy in 13 patients and without radiculopathy in 7, respectively. In addition, 14 patients complained of neck pain. All patients were refractory to conservative treatment. Radiographic examinations have been performed before and after surgery, and included plain radiography, magnetic resonance imaging (MRI), computerized tomography (CT), myelography, and lateral tomography.

The cervical approach was through a transverse skin incision. Corpectomies (11, 1-level and 9, 2-level) were performed using a high-speed drill. The posterior longitudinal ligament was removed in all cases. The endplates were machined to remove all cartilage and to prepare them for incorporation of the implant. However, the cortical bone should not be damaged to prevent a collapse of the cage into the vertebral bodies. For reconstruction of the spine, the ADD was applied in 2 different lengths (*i.e.,* 17–26 mm for 1-level and 25–41 mm for 2-level), with a diameter of 14 or 16 mm. There were 2 variants of the ADD used, one with wings (an attached plate with 2 holes for screw fixation on both sides of the cage, ADD^plus) for direct fixation (7 cases), and one without (13 cases), so additional plating (α-plate Stryker®, Cestas, France [10 cases], and ABC-plate, Aesculap, Tuttlingen, Germany [3 cases]) was necessary (Figure 1). For better reconstruction of the spinal profile, we implanted ADDs with an angulation of 6° on the upper side. However, there are also ADDs without angulation available. Additionally, in 10 cases, the cages were filled with β-tricalcium phosphate (TCP), (ChronOS™, Mathys, Bettlach, Switzerland). After surgery, all patients were treated with the same protocol, which consisted of immobilization in a soft collar for at least 6 weeks.

Follow-up was 21−60 months. Clinical examination and radiographs were performed after 3, 6, and 12 months, and then once a year. Solid arthrodesis was evaluated by flexion/extension radiographs after 6 and 12 months. The operative

segment was deemed fused by the absence of motion between the spinous process on flexion/extension lateral radiographs, and the absence of a radiolucent gap between the cage and the endplate. Because titanium cages have been used, trabeculation between the adjacent segments could not be assessed in our patients.

The aforementioned criteria were also applied in other analyses of fusion using cervical fusion cages.[10,11] However, additional bone formation within the cages was estimated on sagittal CT after 12 months. Hounsfield unit measurement of ingrowing material helped to confirm whether the material inside the cage was bony in nature. According to previous studies, Hounsfield units from 500 to 900 were considered confirmation of the bony nature of the tissue inside the cage.[3,15] Furthermore, the cervical lordosis was measured on lateral radiographs from C2−C7 as an absolute rotation angle formed from lines drawn on the posterior body margins as described by Harrison *et al.*[16] Because it was a retrospective study, the postoperative evaluation of patients was based on clinical data, subjective impressions of the patient, use of pain medications, working status, subjective rating of the pain level, and Odom criteria.[17]

■ **Results**

Of our patients, corpectomies were performed in 5 at the C4 level, in 4 at C5, in 2 at C7, in 1 at C3 + 4, in 3 at C4 + 5, and in 5 at C5 + 6. Follow-up ranged from 21 to 60 months (mean 34). A good decompression was achieved in all patients. This result could be shown on postoperative compared to preoperative MRIs (Figures 2A, B, 3A, B). Implantation of the distractable cages was uncomplicated, and the adjustment of the height could be performed nicely *in situ*. This process prevented overdistraction, which is usually necessary when nondistractable cages are used to get cages under compression. The application of the "All-in-one-system" (ADD^plus), which signifies cage with wings, for direct fixation made a plate unnecessary in 7 cases (Figures 1B, 3D, G).

The flexion/extension radiographs after 6 months did not show any motion in the operated segment in all cases. However, in 7 cases (35%) there was still a radiolucent gap visible between the cage and the endplate. In all cases a solid fusion was achieved with no signs of instability on flexion/extension radiographs, and no signs of radiolucency between the implant and the endplate 12 months after surgery (Figures 2D, 3D, 4). Furthermore, 10 patients (50%) had no change, and 9 (45%) had an improvement of the sagittal contour. The patients who had proper lordosis after surgery, gained an average of 6.7° (range 3°–13°). There was one incidence of cage subsidence, with a resulting mild kyphosis, but no incidence of migration. This one patient had signs of osteoporosis, which probably provoked cage subsidence. However, this patient had a satisfactory clinical outcome and no pain, so that revision was not necessary. There were no plate/screw-related complications. In addition, sagittal CT showed tight contact between the endplates and the cage (Figures 2E, 3E). Of the 10 patients with those cages that were filled with β-TCP, 8 had Hounsfield units for
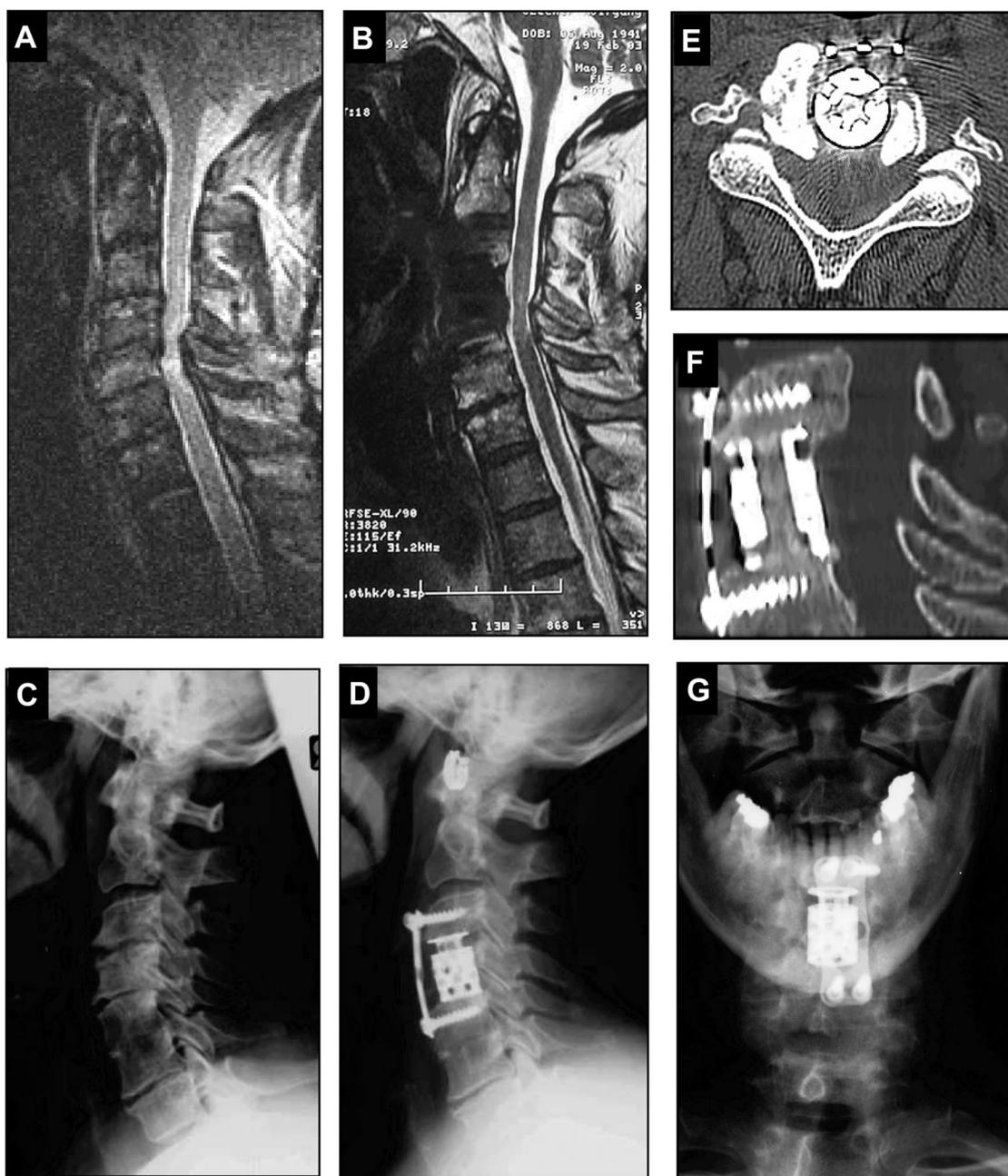
Figure 2.   One case with severe cervical stenosis (**A**) resulting from spondylosis (**C**). The surgical procedure was ventral corpectomy and fusion using the distractable vertebral body replacement ADD and an α-plate. Postoperative MRI shows a sufficient decompression (**B**). Lateral (**D**) and anteroposterior (**G**) cervical radiographs show a correct position of the implant, and signs of fusion that signify no evidence of radiolucency between the implant and the endplate. Axial and sagittal CT show bone formation within the cage (**E** and **F**).

the ingrowing material that ranged from 500 to 900. This effect was considered bone formation within the cage (Figure 2F). However, there was no comparison of radiographic results with those of histologic examination. Therefore, bone formation could not be definitely proved.

According to Odom criteria, 11 patients (55%) had excellent outcome, 4 (20%) good, 3 (15%) satisfactory, and 2 (10%) poor. All 5 patients who worked before surgery returned to their previous jobs within 12 months after surgery. No patient needed permanent pain medication beyond the sixth postoperative week. However, 5

patients used sporadic nonsteroidal antiinflammatory drugs for some residual neck pain, which was less than 3 according to the 10-pont visual analog scale.

■ **Discussion**

Various procedures are applied in cervical spine surgery, including multilevel discectomy, corpectomy; laminoplasty, or laminectomy. For myelopathy resulting from ventral compression, many surgeons prefer channel corpectomy. However, there is some controversy about the best method to provide anterior column support after corpectomy. Nevertheless, the use of a tricortical iliac

Figure 3.   One case with severe cervical stenosis (**A**) resulting from ossification of the posterior longitudinal ligament between C5−6 and C6−7 (**C**). The surgical procedure was ventral corpectomy and fusion using the distractable vertebral body replacement ADD^{plus}. The ADD^{plus} was directly fixed to the adjacent vertebral bodies over wings, which form a unit with the cage (Figure 1B). Postoperative MRI shows a sufficient decompression (**B**). Lateral (**D**) and anteroposterior (**G**) cervical radiographs show correct position of the implant and signs of fusion that signify no evidence of radiolucency between the implant and the endplate. Axial and sagittal CT also show adequate decompression and correct position of the cage (**E** and **F**).

crest graft is most common and was the gold standard for many years.

The concern about donor site-related complications led many surgeons to consider using allograft material for cervical fusion. Although the morbidity associated with harvesting donor bone is avoided, fusion rates have not been comparable with those achieved in patients in whom autologous bone grafts are used. In a prospective randomized study, An et al[18] reported that pseudarthrosis developed in 46.2% of patients who underwent fusion with allograft demineralized bone matrix, whereas pseudarthrosis occurred in 26.3% in whom autograft-assisted fusion was performed. A meta-analysis of cases involving 1 and 2-level anterior cervical interbody fusion

in 310 patients showed that autografts were associated with a significantly higher fusion rate than allografts.[8]

The refinement of graft material for cervical fusion has continued over the years. Most recently, cages have been used for cervical reconstruction after discectomy and corpectomy, and the preliminary results have been promising.[7,12] In our study we found a fusion rate of 100%, which is excellent. However, because we used titanium implants, direct radiologic conformation of fusion could not be performed. Therefore, we have only indirect signs like absence of instrumentation failure or graft lucencies on radiograph films as well as sagittal CT. Das et al[19] also reported a 100% fusion rate in 28 patients who underwent discectomy and 10 who under-
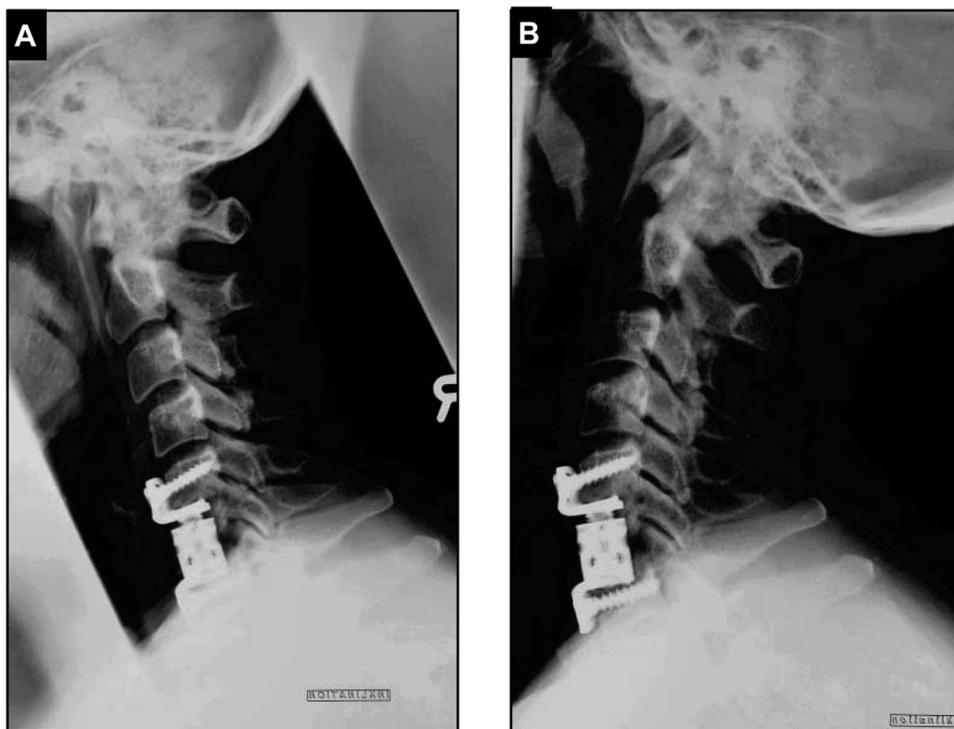
Figure 4. Lateral flexion (**A**) and extension (**B**) radiographs of a 55-years-old patient (same as in Figure 3) showing no motion between the spinous process.

went corpectomy, in whom titanium mesh cages and anterior plating have been used. Majd *et al*[12] retrospectively reviewed the data of 34 patients in whom corpectomy was followed by the placement of a titanium cage packed with autologous bone. The fusion rate in these patients was 97%. The investigators used the same indirect fusion signs, which were also applied in the present study.

Complications reported in association with cervical cage implants have included subsidence and kyphotic deformity of the involved segment. We also observed in our series one subsidence with a resulting mild kyphosis but without problems for the patient. The advantage of the cages lays in the structural support they confer, as shown by their use in the lumbar and thoracic spine, by providing distraction and restoring physiologic height, However, in traditional cages the cage height is determined by measuring the size of the corpectomy defect. Therefore, to achieve an adequate placement of the cage into the defect, some over-distraction is necessary. In different situations, this may lead to a nonoptimal cage height determination with a resulting weak compression. This effect may provoke cage migration, as it was described in some reports.[20,21] Using distractable cages, a precise adjustment of the cage height to the size of the corpectomy is possible with the guarantee of good contact between the cage and endplates under a well-defined pressure. This effect may prevent migration and improve integration of the cage to the endplates. Because of the low extension and rotational stiffness, according to biomechanical studies, the ADD cannot be recommended as a stand-alone device. Additional anterior plating pro-

vides sufficient stability and increases stiffness, especially in extension.[14] Furthermore, the newly developed ADD[plus] allows direct fixation of the cage to the adjacent vertebral bodies, making migration nearly impossible and may increase construct stiffness.

A supposed disadvantage of the distractible cages compared to mesh cages might be the smaller central cavity, limiting the possibility of packing bone. However, the use of β-TCP makes bone ingrowth possible, as could be shown in our patients. Finally, in our series with a fusion rate of 100%, there were no differences between filled and unfilled cages. Nevertheless, in cases of low bone quality, we would suggest using bone substitutes like β-TCP.

■ **Conclusion**

The results of this study support the use of distractable cages in cervical spine surgery. It could be shown that *in situ* distractable cages improve the adjustment of the cage to the corpectomy defect and optimize the pressure that is exerted on the endplates, avoiding over-distraction. Fusion cages with wings (All-in-one-system) allow direct fixation of the cage to the adjacent vertebral bodies, making additional plating unnecessary.

■ **Key Points**

● Degenerative cervical spine disease with myelopathy is a surgical problem where different decompression techniques are applied.

- Cervical corpectomy for severe spinal canal stenosis has become more prevalent and has created a challenge regarding stability and reconstruction.
- *In situ* distractable cages can be adjusted to the height of the defect, avoiding overdistraction and allow good anterior column support.

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