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Clinical Article

Cervical Cage Fusion with 5 Different Implants: 250 Cases

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Summary

Background. Anterior decompression with interbody fusion is the surgical procedure of choice in cervical spondylosis. Graft harvesting complications occuring from classical fusion procedures favoured ongoing development of cage technology. To evaluate efficiency of cage fusion for surgical treatment of discogenic cervical disorders, this six-year retrospective study analyses 250 consecutive cases treated by interbody cage fusion with 5 different implants.

Methods. Indications for fusion concerned degenerative discopathies, disc herniations and selected cases of failed surgery presenting with radiculopathy (228 cases) or myelopathy (22 cases). Screwed threaded titanium cages (149 cases), impacted squared or anatomically shaped Peek cages (59 cases), and impacted titanium cages (42 cases) were used together with local graft or bone substitute. Additional plating was indicated in 16 unstable cases.

Findings. Excellent outcome for neck pain (96%) and radiculopathy (97%) was noted, but a less favourable one for myelopathy (60%). All cases were stabilised at 1 year. Complications leading to reoperation included cage migration and subsidence, adjacent level degeneration and stenotic myelopathy.

Interpretation. Cage technology simplified anterior cervical interbody fusion and proved efficient. The fact there was no graft harvesting saved operating time and hospital stay.

Statement. It is not the intention of the author to indicate material preference in this article.

Keywords: Cervical cage fusion; titanium cages; anterior cervical plating; cervical radiculopathy; cervical myelopathy.

Introduction

The concept of cervical interbody fusion for treating degenerative and unstable disc diseases developed progressively 50 years ago since pioneer the work by Cloward, Dereymaker, and Smith and Robinson using iliac bone graft [12, 14, 30]. Basic idea was to stabilize the operated segment sufficiently long enough to allow new bone ingrowth, maintaining disc height and avoiding graft collapse until fusion occured. A number of complications owing to bad bone conditions or some technical difficulties led to graft collapse and expulsion, pseudarthrosis and de novo neural compression. But mainly graft site morbidity inspired surgeons to try allografts with ensuing bad fusion rates compared to autologous bone [5, 6, 13, 17, 18, 25, 28, 35]. Additional anterior plating to autologous bone grafting or allograft material promoted fusion, but performed on a routine basis seemed overtreatment for degenerative pathology. New complications were observed due to material breakage and migration, also these technical problems improved with recent plate and screw design [3, 8, 10, 17, 33, 34].

Cage fusion technology originated in 1979 from Bagby's work together with veterinary surgeons seeking to treat spondylitic cervical myelopathy in horses. Because of an unacceptable high level of graft harvesting morbidity when using Cloward's procedure, they developed the first interbody fusion cage, the Bagby Bone Basket, a fenestrated hollow cylindrical device made of stainless steel, allowing bone ingrowth [2, 3]. Wagner and De Bowes performed experimental studies showing good fusion potential using the basket [13, 32]. Improved biomechanics as compared to conventional bone grafting were indicated by Butts [9]. In 1988, Bagby published the principle of distraction-compression, the basic principle of stand-alone intervertebral cage fusion [2]. Human application was promoted around 1990, first in the lumbar area by Ray (TFC) and Kuslich (BAK) with threaded cylindrical titanium cages, and by Brantigam (I/F C) with rectangular impacted carbon cages [7, 20, 27]. Smaller versions of cervical devices were introduced in France

with Robert using the CR cage in 1993 [28] and in USA with Kitchel (BAK-C) in 1994 (personal communication).

The aim of this review is to analyse retrospectively the efficiency of cervical cage fusion in a 6-year experience since 1995 with 250 personal cases, managed with 5 different implants consisting of 2 basic types, threaded cylindrical cages (Cloward type procedure) and wedge-shaped impacted cages (Smith-Robinson type procedure). Previous material about threaded cages in cervical and lumbar area has been published by the author [21–24].

Patients and Methods

Operative Material

During the last 6 years, 250 patients were treated with cervical interbody fusion using threaded or impacted cages, 234 cases being handled in a stand-alone mode. Cage material used is shown in Table 1.

Table 1. *Cage Material Used in 250 Cases*

Cage	Number	Type	Material	Graft
BAK	149	threaded (149)	titanium (191)	bone
WING	42	impacted (101)	"	cerasorb
RABEA	15	"	peek (59)	BCP
NOVUS	6	"	"	BCP
CBK	38	"	"	healos

1. First experience came with threaded titanium cages, BAK (Sulzer Spine Tech, Minneapolis MN), screwed into the prepared distracted endplates, using local bone graft from decompression and reaming as osteo-inductive material inside the device. These screwed devices together with a precise instrument set were used in 149 cases, mainly for good autostabilising properties. Impacted cages proved simpler for handling in the following 101 cases (59 Peek and 42 titanium), with preservation of endplate integrity and better restoration of natural lordotic cervical curvature by a wedged profile (Fig. 1). Graft surface appeared larger from cage design, also initial bone contact and primary stability were less, because of impactation compared to screwing, even in the case of a mixed design as for the WING-Cage

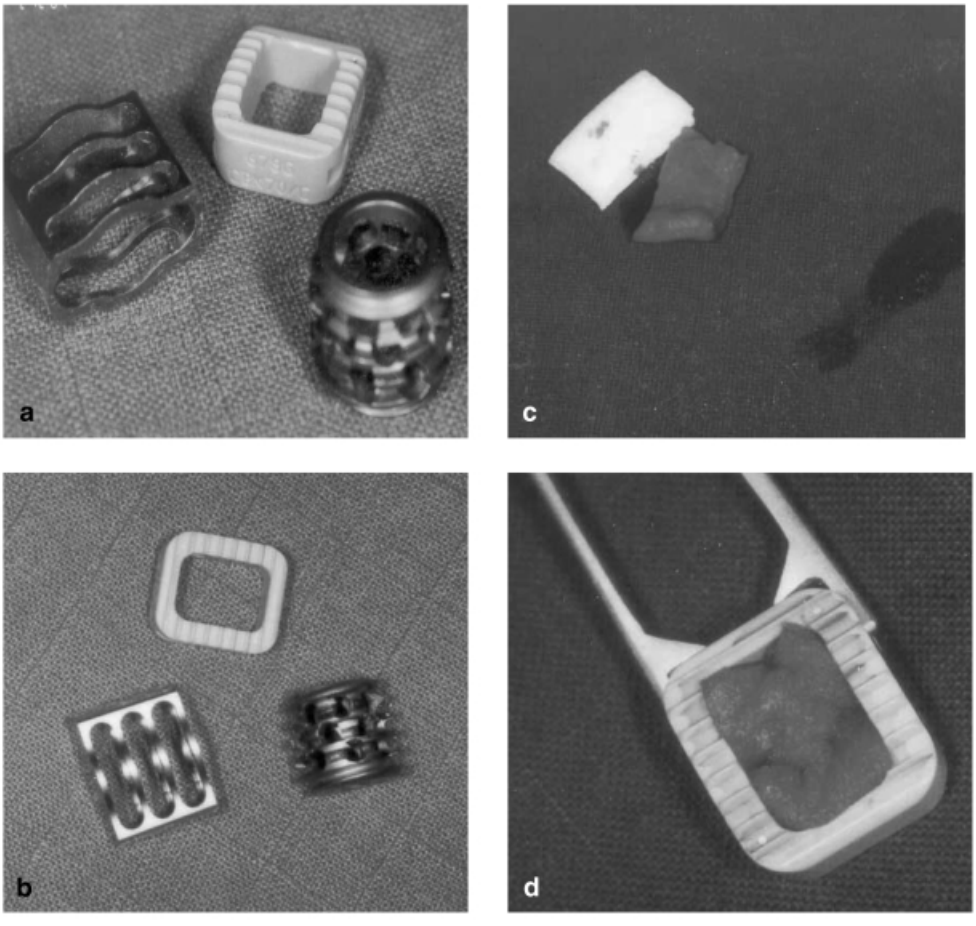

Fig. 1. *Cage material.* (*a,b*) Lateral and superior view showing shape and graft surface of 3 cage-types: threaded cylindrical BAK (titanium), impacted oval WING (titanium) and wedge-shaped CBK (Peek). (*c*) Healos becomes malleable after blood contract to adapt to cage size. (*d*) Note large graft surface, increased by putting more bone substitute lateral and anterior to the impacted cage

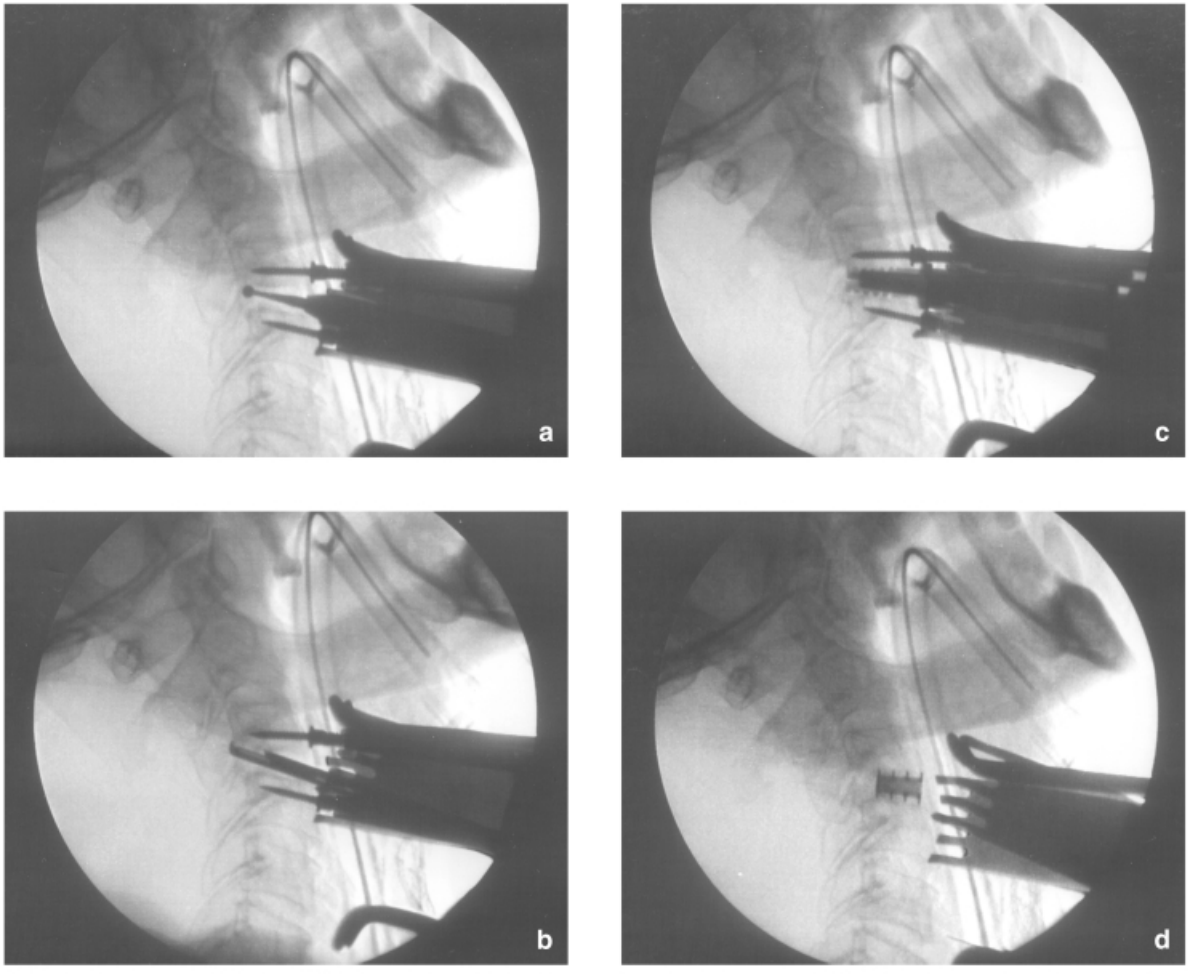

Fig. 2. *Surgical technique.* Fluoroscopy showing posterior decompression with micro-drill (*a*) and micro-punch (*b*), reaming the endplates (*c*) and WING cage impaction (*d*) using CASPAR vertebral distraction screws

(Medinorm, Quierschied Germany). With this implant, the initial central endplate reaming should enhance fusion and the lateral wings should prevent intravertebral device subsidence. Because of better elasticity and radioluency, Peek was exclusively used in the more recent years, as the RABEA-Cage (Signus, Alzenau Germany) or the NOVUS-Cage (Sofamor Danek, Memphis TN), and mainly an anatomical shaped type fitting more conviently to the cervical intervertebral anatomy, enhancing primary stability (CBK Scient'X, Paris France). In the whole series, only 16 cases needed additional anterior plating (CERVILOK, Sulzer; ATLANTIS, Sofamor Danek; CERVIPLAQUE, Scient'X) for acute traumatic disc herniation or for chronic instability in some revision operations, with segmental kyphosis and/or subluxation.

Operative Indications

Indications for cage fusion concerned degenerative discopathies, disc herniations and selected cases of failed surgery (recurrent disc herniation, degenerative segmental stenosis, chronic instability and pseudarthrosis) from C3 to T1. Active infection, severe osteoporosis, vertebral tumoral and traumatic lesions were excluded. Clinical requirements were cervical radiculopathy in 228 patients and cervical myelopathy in 22 patients. Minimum investigations included X-rays with flexion-extension views to detect kyphosis or instability, CT and/or MR for the simple case of disc herniation. Myelo-CT was often superior to MR for demonstrating nerve root compression in stenosed foramina, and could be completed with dynamic views, also important in some unstable myelopathies. But only MR was able to visualize cord lesions in myelopathy, and rule out a differential diagnosis, together with neurological examination and some times electrophysiological studies. Good preoperative patient evaluation reduced multilevel operations to 30% (1 level = 181 p, 2 levels = 65 p, 3 levels = 4 p).

Surgical Technique and Details

The surgical technique in brief was a standard anterior discectomy approach using slight lordotic neck position under lateral fluoroscopic control. Except for the BAK system with its special interbody distractor, I always used Caspar screws for progressive opening of the intervertebral space to do a complete discectomy in an unobstructed view. Internal decompression using a microdrill seemed the most important step in these generally degenerative lesions, whatever material implanted (Fig. 2). The posterior longitudinal ligament was

only resected in the case of calcification or when seeking for free disc fragments according to preoperative studies, otherwise it was preserved as a tension bend. Adapted distraction in general was more a feeling then an impression realized from fluoroscopy, and needed some experience at the beginning. When using threaded cages, asymetrical reaming could result in endplate weakening and later subsidence. Again, techniques proved simpler with impacted cages respecting subchondral bone and mainly the most supporting anterior rim. Wedged implant shape added lordotic properties. Sufficient local graft material could be saved from decompression and mainly from a specially designed reamer with the BAK system. These cages shave more spongious bone inside the porous cylinder upon insertion (self-packing). Bone substitude was used in the other cases, either hydroxyapatite with calcium phosphate (BCP, Technimed France; CERASORB, Curasan Germany) or mineralised collagen matrix with biochemical properties similar to bone (HEALOS, Orquest USA) in the last 38 cases (Fig. 1). A slight bleeding endplate seemed essential to obtain osteoblasts and growth factors inducing new bone formation. Final cage position and cervical curvature were always checked on fluoroscopy. If requested, anterior plate fixation was added at this stage. No cervical collar was used.

Results

Hospital Data

Operative time was 45 to 60 minutes in one-level and 60 to 90 minutes in two-level operations, which was significantly faster compared to Cloward's procedure in our unit with 90 to 120 minutes (patients operated on in same time span by other surgeons or previously by myself). Blood loss was minimal in 246 cases (<100 ml) and acceptable in 4 cases (<250 ml). Mean hospital stay was 4 days (3 to 6) compared to 6 days with Cloward's operation, that means a significant difference related to the absence of iliac graft harvesting and resulting local pain or other complications.

Clinical Results

Results were evaluated on a ten point analogue scale including neck and radicular pain together with neurological examination for radiculopathy and myelopathy. Minimal follow-up at 1 year in nearly 99% of patients (only 2 were lost after 6 months follow-up) showed good to excellent results in 96% of cases for neck pain and in 97% for radiculopathy. Typical radicular pain and deficit was relieved completely for all patients but a very few complained of residual paresthesias. Neck discomfort cleared normally at 3 to 6 months. In contrast, resolution of neurological symptoms and signs was not as good in stenotic myelopathy. Thirteen out of 22 patients with myelopathy (60%) had complete recovery from preoperative symptoms and signs, and 3 of these only after further decompressive surgery. Incomplete resolution at 1 year was noticed in 6 patients, with slight improvement after years. Two patients with unresolved myelopathy had already established spinal cord lesions on preoperative MR. Operation at this stage of disease should only prevent further neurological deterioration, which is clinically significant.

Radiological Results

Radiological analysese showed good stabilisation in all cases at 1 year according to the following criteria: no mobility in flexion-extension radiography, and no radioluency surrounding the cage. Direct visualization of bony fusion is easier with Peek, and typically difficult to assess in the face of a metallic interbody implant where it would require a 3D scan reconstruction, obviously too expensive for routine screening. In the rare instances we did this examination, we could prove a similar density to surrounding bone inside the cage, whatever implant was used (Fig. 4). Fusion around a titanium cage (bony bridging) is regularly recognised on standard radiographs at one-year follow-up, leading later to complete space union as observed in some long-term controls (Fig. 3). Some cases of 1 to 2 mm clinically asymptomatic cage subsidence into the vertebral endplates was also observed on these radiographic studies, without a significant impact on sagittal balance. No pseudarthrosis and no significant kyphosis (>10°) was detected in the whole series. In myelopathies who did not recover, we observed at MR follow-up a persistent cord hyperintensity, and in some cases a residual stenosis needing further surgery. MR screening in late recurrent cervico-brachial pain syndromes detected accelerated degeneration adjacent to fused levels.

Complications and Reoperations (Table 2)

Few complications occurred in this series. There were no deep infections, no hematoma formation and no device failures. One patient had a persistent neurological worsening resulting from decompression and possible cord contusion. Early reoperations (<1 month) were necessary for cage migration or for significant subsidence, and later reoperations (>6 months) were indicated for adjacent level degeneration or for stenotic canal conditions in myelopathy.

Cage Migration. Only one asymptomatic *anterior*

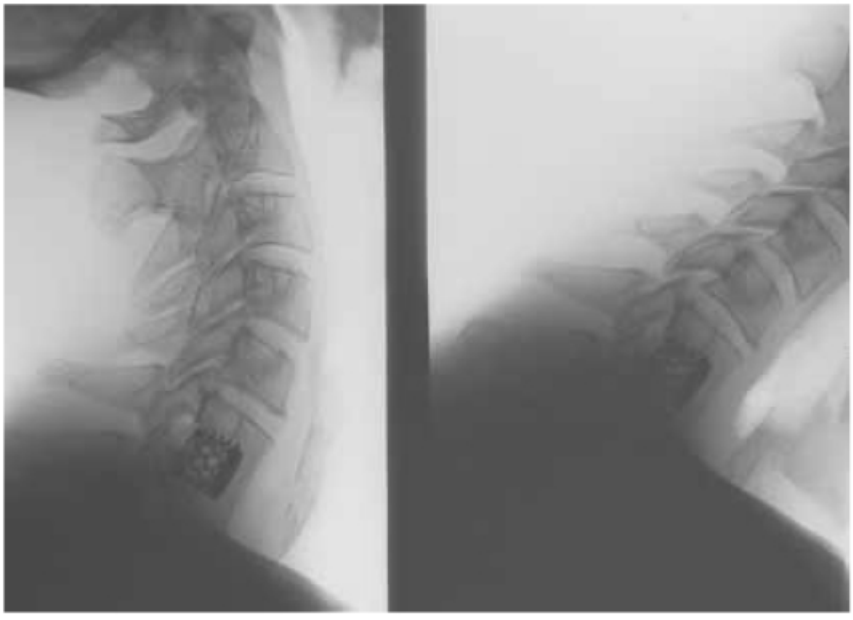

Fig. 3. *Cage fusion.* Flexion-extension views after two-years follow-up with BAK interbody cage fusion. Note complete fusion

Table 2. *Complications and Reoperations*

Complication		Reoperation	Implant related
Infection	1	1	–
Deficit	1	–	–
Cage migration	5	3	+
– anterior	2	2	
– posterior	1	1	
– lateral	2	–	
Cage subsidence	2	1	+
Adjacent levels	8	8	±
Stenotic myelopathy	6	6	–

cage migration was detected on postoperative radiographs in 149 stabilizations with BAK requiring prophylactic device repositioning without influence on a good outcome. The technical fault was too short a distance reaming with bone thread cutting upon cage insertion. A second anterior extrusion with a NOVUS cage had been corrected with a plate stabilisation after repositioning because of cervical pain. This patient was lost to long-term follow-up.

A *posterior* intracanal migration with the same device was detected 6 months after operation when the patient living abroad came back with myelopathic symptoms and signs. Although the device seemed perfectly fused, there was an anterior canal stenosis with cervical cord compression through a recessed device compared to postoperative imaging. The fusion and the Peek cage were drilled out, and new stabilisation performed with a bigger WING cage and an anterior plate (Fig. 4). Clinical outcome was good, but this patient was the only one having a superficial infection through a foreign body left which needed reoperation in the muscular planes. Outcome was not good from the psychological point of view, although myelopathy completely subsided at one year. As two out of 6 NOVUS Peek cages had moved, which may be related to the design with 2 rails for improved lateral instead of sagittal stability, this implant was no longer used. No migration occurred with RABEA (improved anchorage) or CBK (anatomical design) cages.

A significant *lateral* displacement near the foramen was recognised twice with the WING system without neurological complication, but transient unilateral cervico-scapular discomfort. This impacted cage, a compromise between a Cloward and Smith-Robinson type implantation seemed to me to have less primary lateral stability.

Cage Subsidence. Significant subsidence was seen in 2 patients treated with the BAK system. An older osteoporotic lady needed reoperation with plate fixation for recurrent cervical and brachial pain in the first postoperative week when detecting major subsidence (kissing cages) on radiographs. She improved immediately and had good fusion later on. The second case, a young lady, had clearly an asymmetrical endplate drilling resulting in cage sinking in to the inferior vertebra without inducing kyphosis. She had 3 months neck pain treated with a collar and finally had a good outcome. Minor subsidence, between 1 and 2 mm, was

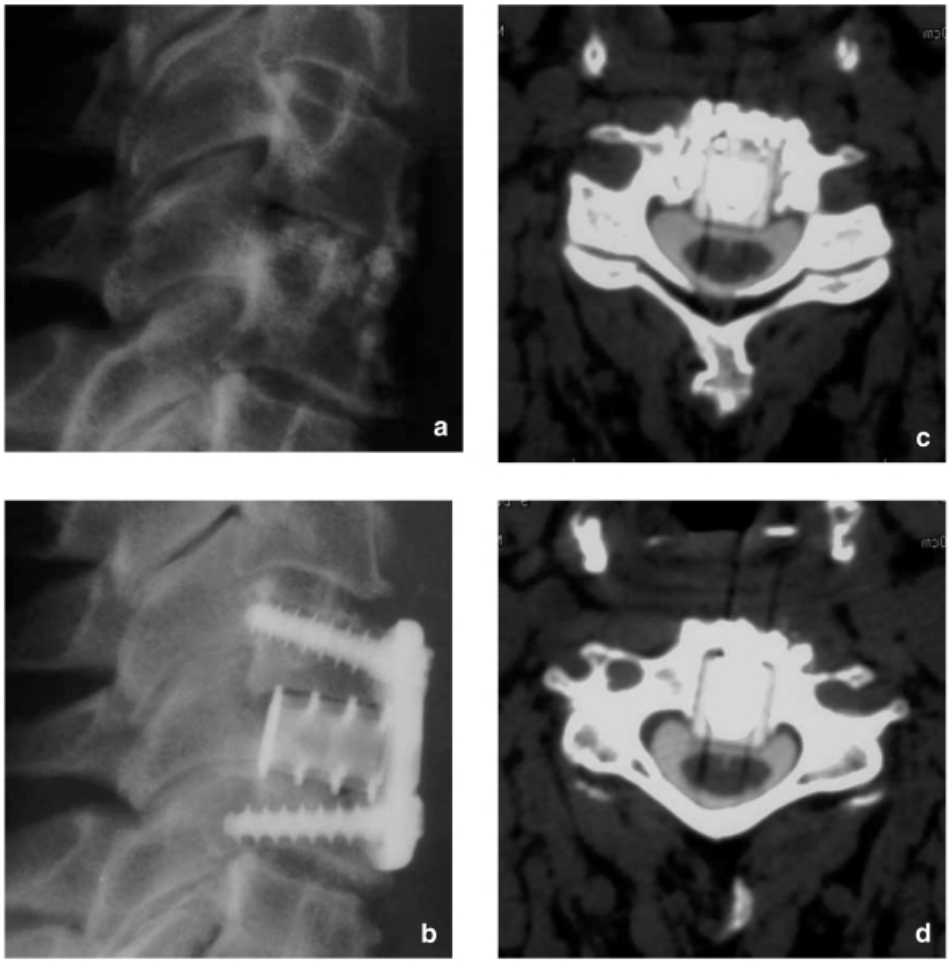

Fig. 4. *Cage migration.* Lateral X-ray (*a*) and CT-scan (*c*, *d*) 6 months following fusion with NOVUS Peek cage and BCP hydroxyapatite graft, when patient presented beginning myelopathy. Note recessed cage compressing anterior cord space, but good fusion in and anterior to the implant, and identical bone density in and outside the cage confirming fusion. (*b*) Revision surgery with drilled out implant and graft, and new stabilisation with a larger WING cage and an ATLANTIS plate

frequently observed at 1-year follow-up with BAK and to a lesser degree with WING cages, but without clinical incidence, and with only insignificant loss of initial lordosis. Globally, impacted cages allowed better sagittal balance preservation or correction because of a lesser tendency to subside.

Adjacent Level Degeneration. Another level cage operation had to be performed in 8 patients for ongoing degeneration or for new disc herniation, probably accelerated at levels adjacent to a fused segment, clearly a shortcoming of this technology. Although the number was low and there were no major problems with even two more levels stand-alone cages adjacent to a former fusion, we feel now that additional plating in these cases shortens clinical recovery and improves long term lordosis, but at the expense of greater rigidity (Fig. 5).

Stenotic Myelopathy. Clearly, myelopathic patients had a worse outcome, mostly related to irreversible cord lesions. But a subgroup seemed incompletely decompressed at follow-up MR, a two-stage operation being planned at the beginning in most cases, that means a selective anterior intervention at the most affected level(s) followed by a wider posterior approach when interbody fusion had occurred. Five patients were treated and improved after a second operation for residual hard (bone) or soft (disco-ligamental) stenosis, four with 3 to 4-level laminectomies and one with a two-level corpectomy. This last patient had an insufficient decompression when stabilized with BAK one year previously at the level C6C7 for myelopathy with small muscle hand atrophy, and incomplete neurological recovery. Complete interbody fusion was not really realized at preoperative imaging, but persistent

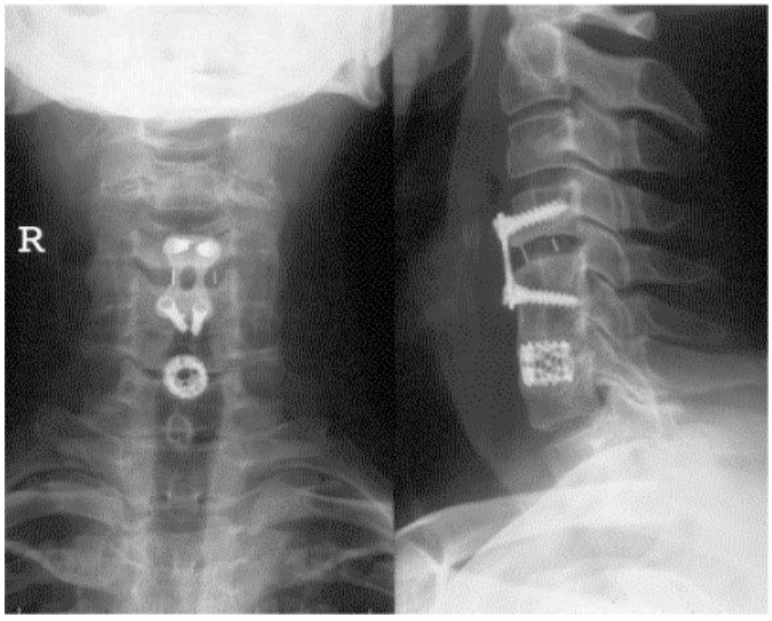

Fig. 5. *Adjacent level degeneration.* Twelve-years evolution of cervical spine degeneration treated with different operative techniques: Cloward C5C6 in 1989 with loss of lordosis (note spinous process spacing), BAK C6C7 in 1996 with good fusion and maintained lordosis, and CBK C4C5 in 2001 stabilised on CERVIPLAQUE to improve preoperative kyphosis

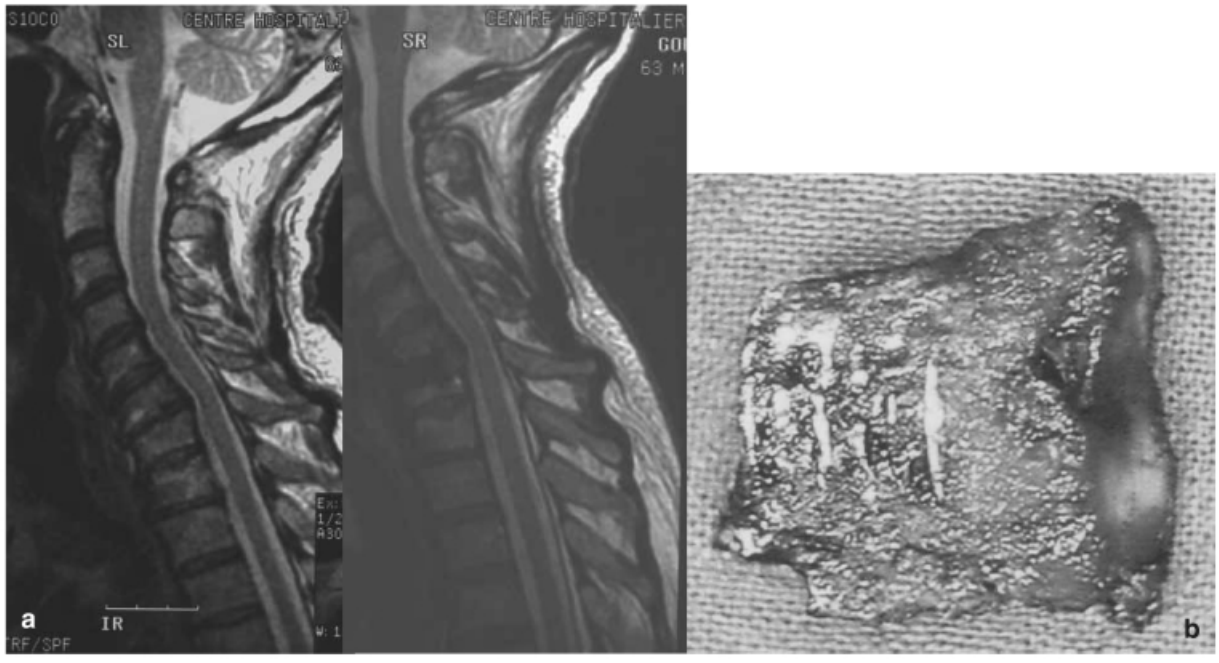

Fig. 6. *Stenotic myelopathy.* (*a*) Preoperative MR and one-year postoperative view of an insufficiently decompressed and kyphotic myelopathy. (*b*) Explanted BAK cage during C6C7 corpectomy showing impressive fusion

anterior stenosis with kyphotic balance. At revision surgery, a two-level corpectomy including the cage allowed complete freeing of anterior dura and nerve roots, followed by an iliac strut graft and plate reconstruction and fixation. As the posterior elements seemed also fused, the ideal sagittal balance could not be restored. Clinical recovery was good. The explanted speciment proved impressive fusion, demonstrating that radiographic fusion is late compared to clinical and experimental observation (Fig. 6). In a more recent case, a three-level stenotic myelopathy with one-level disc herniation was treated through a combined approach. First step was a posterior C4 to C6 decompressive laminoplasty using a limited muscle splitting

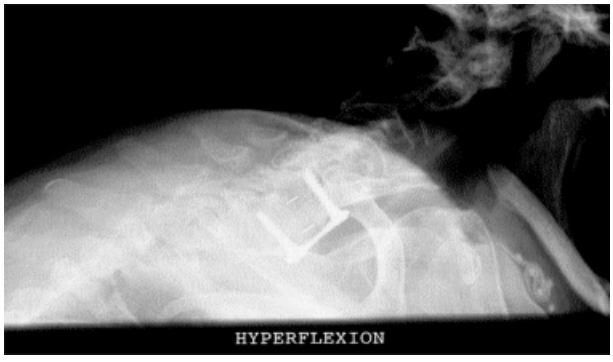

Fig. 7. *Combined surgery in myelopathy.* Three-months control in hyperflexion, showing interbody fusion at C5C6 with a CBK cage and CERVIPLAQUE plate, respected sagittal balance and recognisable laminoplasty C4C7 (slightly recessed base of spinous processes)

and midline sparing technique (paramedian transmuscular approach). After returning the patient, the anterior C5C6 hard disc herniation was removed together with drilling the osteophytes. Stabilization was realized on a CBK cage (with HEALOS in and around the device) and on a C5C6 plate (CERVIPLAQUE). Operation was much better supported then with the classical laminectomy technique and the patient could be rapidly mobilized without a collar because of little neck pain. Figure 7 shows imaging at 3 months postoperatively when the patient had nearly recovered from myelopathy under intensive physiotherapy.

Discussion

Since first descriptions in the 1950's, anterior interbody decompression and fusion in the same session became slowly the procedure of choice in the care of patients presenting with discogenic cervical radiculopathy or myelopathy [8, 12, 14, 16, 30, 36]. Mainly Cloward recognized the necessity to fuse a destabilized segment after discectomy, together with a good decompression technique in this more often degenerative pathology. Anterior decompression alone could relieve neurological symptoms and signs, but lasting neck pain with chronic kyphotic deformity among some patients (later on cured by a secondary stabilization procedure) suggested the need for routine ancillary fusion techniques. Although some indications remained for a posterior approach in selected cases of soft disc herniation, there was a trend to anterior surgey, avoiding painful muscle splitting, and addressing directly to the anterior situated discal or osteophytic offending lesions [1, 5, 15, 31].

The graft related complications of conventional fusion techniques certainly favoured the development of cage fusion technology [2, 3, 26, 32]. Until now, autogenous graft material harvested from the iliac crest was considered the gold standard for interbody fusion. This second incision prolonged operating time by up to half an hour, if not performed by an assistant surgeon. Numerous complications happened at the iliac site: hematoma formation, infection, peritoneal perforation, enteric herniation, fracture of the ilium, nerve and arterial injury. But local pain was the major shortcoming prolonging hospitalisation, generally by 2 days in our experience. This pain could be long-lasting (meralgia paraesthetica) and represented a major drawback of published patient series [5, 6, 17, 18, 25, 35]. Typically, patients complained much more from iliac wing harvesting than from the cervical wound. There was also the cosmetic defect and the poor bone quality in elderly patients [29]. At the cervical site, graft collapse and expulsion, and pseudarthrosis formation occurred more frequently with allografts compared to autologous bone, but the former obviated harvesting complications. Adding anterior plating to enhance stability and fusion, mainly with allografts, and in more than one-level spondylodeses with autografts, had new limitations due to material breakage and migration [17, 18, 25, 33, 35]. In fact with newer plate and screw design, and with reasonable implantation technique, this should rarely happen. But greater stiffness of the construct could induce accelerated degeneration at adjacent levels to the fusion site [1, 10, 27, 31].

Cage stand-alone technology, as presented by Bagby, was founded on the principle of distraction-compression and confirmed in biomechanical studies by Butts [2, 3, 9, 26]. A sufficiently distracted intervertebral space after discectomy could be stabilized for multidirectional movement by tension forces of residual annulus and ligaments. Cages filled-up with autologous material, allograft or bone substitute would resist disc space collapse and should not migrate until fusion occurred, allowing biological bone healing in an incompressible spacer. In clinical practice, distraction with restoration of disc height in degenerative spine increased neuroforaminal volume and contributed to nerve root decompression as measured experimentally [11]. Optimal endplate preparation with a slight bleeding bone bed should improve the fusion rate.

With threaded cage instrumentation as the BAK system, reaming and tapping prepares a precise hole

into the vertebral endplates creating intimate spongious bone contact upon screwing the device filled-up with local autologous bone. Excellent fusion has been observed with long-term controls up to 6 years in our experience. The only explanted device, one year following operation in a myelopathic patient, confirmed that impression, although this fact was not realized on radiographs (Fig. 6). Because of pullout strength enhancement by threads, these cages did not migrate, unless a technical fault occurred (cutting bone threads), as observed in one case. On the other hand, threaded cages showed more subsidence, certainly in relation to endplate weakening and an oblique angle support between implant and bone compared to flat impacted devices. An experimental study by Kettler demonstrated that subsiding cervical BAK cages partially supported stability whereas WING cages and others did not, a relation seeming to depend on the implant design [19]. Sagittal balance was not as nicely restored as with impacted cages. Other threaded systems exist now with a wedge shape to improve lordosis. Compared to Cloward's procedure that I performed years ago, and where I noticed regularly some segmental loss of lordosis on radiographs (see Fig. 5), I think that the operation with the BAK system is easier and quicker with less postoperative pain and shorter hospital stay for the patient.

Most impacted cages are now made of Peek because of elasticity behaviour near that of cortical bone and because of radioluency allowing better radiographic control of fusion [7]. There is also no significant distortion of MR signal, a point to consider in follow-up of myelopathies. Posterior decompression needs the same attention whatever system is used, and may be the most important step during operation. The author's feeling is that deep visualization of neuronal offending structures is improved with the Smith-Robinson type exposure using a screwed Caspar distractor with progressive space opening as drilling down the osteophytes proceeds. Respecting and distracting posterior longitudinal ligament and lateral annulus serves as a tension band for cage stability, eventually more important with impacted implants were the wedge shape designed to improved lordosis could favour anterior migration. This was not the case with an anchoring surface design or an anatomical shaped model, but with a model presenting two lateral rails entering the endplates. As also a posterior migration happened with this last type, this implant was disregarded for further use in this series. Actually, the anatomical design with a larger graft surface is preferred, using a bone substitute consisting of a mineralised collagen matrix with biochemical properties similar to bone (HEALOS). This substitute needs contact with bone marrow (osteoblasts and growth factors locally present in the prepared endplates) for osteoinduction [4]. The malleable substance can be placed inside and around the cage to enhance fusion (Fig. 1). Compared to Smith-Robinson procedure done in our unit, the CBK cage fusion technology allows faster operating time for the surgeon, and shorter hospital stay and smoother recovery for the patient. WING cages, a compromise of the two basic systems, did not have a major advantage in our experience. Subsidence was not eliminated and some lateral migration was observed, may be in relation with implant design, the ovoid central part facing a weakened drilled endplate, and the flat lateral part presenting no anchorage. There was no anterior or posterior migration observed in this group.

Additional anterior plating seemed necessary in only 16 of 250 cases, with traumatic or degenerative subluxation and segmental kyphosis. Because of discoligamental disrupture or incompetence, a stand-alone cage fusion would fail. But impacted Peek cages between distracted intact endplates seemed helpful to restore disc height and lordosis, and stabilize further the plate construct. A radiolucent implant is obviously an advantage to demonstrate ongoing fusion in these unstable cases (Fig. 8).

In agreement with published series, clinical outcome was good to excellent for most patients (97%) presenting with cervical radiculopathy. In cases of myelopathy, only 60% recovered completely, 30% had incomplete resolution of neurological signs, and 10% did not improve because of an apparent chronic spinal cord lesion (myelomalacia). Operation at this late stage of disease may only prevent further neurological deterioration, which has clinical relevance, but has to be explained preoperatively to patients.

Complications were few in this series concerning the anterior cervical approach. There was no major bleeding, no persistent hoarseness or Horner syndrome. Neurological worsening happened in one patient from decompression. Only one patient had on extra-osseous infection cured by operation. Cage related complications needing early reoperations occurred seven times, actually implant migration and subsidence, depending on cage design. Globally, threaded cages tended to subside more and impacted ones to migrate more also

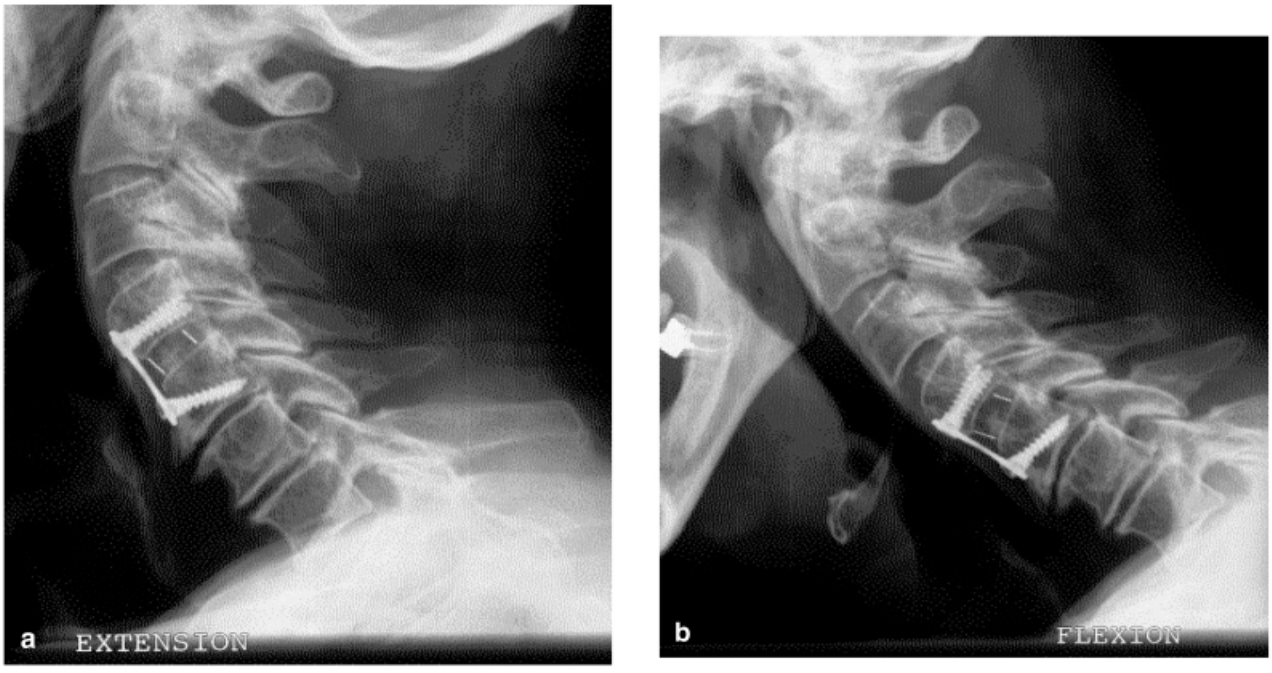

Fig. 8. *Interbody peek cage fusion.* Six months fusion easily recognized with Peek in this traumatic disc herniation and C4C5 luxation, completely reduced with anterior plating in compression

this anterior-posterior displacement was more specific for one design. Lateral migration was recognized with WING cages only. Anatomically shaped Peek cages (CBK) seemed best adapted to the cervical intervertebral space in our experience.

Late reoperations were encountered in 8 patients in adjacent level degeneration to fusion sites, perhaps accelerated compared to the natural evolution process of cervical degeneration, in my experience no different from classical bone fusion procedures, but probably less pronounced than with the more rigid construct of plate fixation. This concept is in favour of standalone cages whenever possible, and the use of additional plating only in demonstrated instabilities, of traumatic origin or in unstable revision operations needing sagittal balance correction, as kyphosis with or without subluxation. In these more difficult and time-consuming cases, stability must be restored to avoid lasting pain, even at the expense of accelerated adjacent degeneration.

Late reoperations were also indicated in stenotic myelopathy, 25% in this series, with a planned strategy to operate first at the most offending one or two levels by an anterior cage fusion. According to clinical recovery and MR control, a decompressive posterior operation (multilevel laminectomy), if deemed necessary, was added as the anterior fusion had already been performed. One patient had a two-level corpectomy for insufficient decompression and kyphosis with persistent myelopathy one year following initial cage fusion. Stabilization on an iliac strut grafting and a plate allowed neurological recovery, but sagittal balance could not be restored because posterior elements had already fused. Retrospectively, an anterior plate-cage construct during the first operation would have been indicated, together with a more aggressive drilling of posterior osteophytes. Recently, we have changed operative philosophy for these cases with a one session procedure doing first multilevel laminoplasty followed by decompression and cage fusion of the most offending anterior lesion (Fig. 7). The minimal invasive paramedian transmuscular procedure, respecting sensitive midline structures, is well supported and may avoid kyphotic complications seen with laminectomies.

In this series, satisfying stabilisation was achieved in all cases at one-year follow-up. Early direct visualizing of radiological fusion was not as easy with metallic compared to Peek cages, but could be realized in long-term screening. Impressive fusion has been demonstrated in the unique case of an explanted device. Future technology may even improve the results if fusion stays the primary goal of the implants. Non-fusion technologies as nucleoplasty, dynamic stabilization systems and disc protheses have to be explored

now in the earlier stages of cervical degeneration in order to preserve movement and to reduce adverse effects on adjacent segments [10]. But irreversible degeneration of discs and facet joints will continue to be fused.

Conclusion

At this stage of experience, cervical cage fusion seems an established technology with equivalent results to conventional grafting procedures, without harvesting complications, saving operative time and shortening hospital stay. Cost efficiency has to be proved. Future directions of surgical treatment have to be explored, to improve results and avoid shortcomings of fusion technologies.

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Comment

Fusing of the vertebral bodies with help of a variety of implantable devices designed to replace autologous bone implants is a common procedure in today's practice.

There is a wide range of cages and plates to be placed between the vertebral bodies on the market and many reports on their use. This paper by a well designed comparison of the effectives of the fusion with 5 types of devices evaluated clinically and radiologically, by ease of operative procedure and surgical complications.

Presented results should arouse interest among neurosurgeons performing this type of surgery and give them large experience based recommendations for their own practice.

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