Vertebral Body Replacement Systems with Expandable Cages in the Treatment of Various Spinal Pathologies: A Prospectively Followed Case Series of 60 Patients

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OBJECTIVE: Vertebral body reconstruction after corpectomy has become a common surgical procedure. The authors describe a prospectively followed case series of patients treated with expandable cages for various indications.

METHODS: Sixty patients underwent single or multilevel corpectomy for degenerative stenosis (13 patients), herniated disc (7 patients), deformity (14 patients), traumatic fracture (3 patients), infection (1 patient), or tumor (22 patients). Six different expandable vertebral body systems were used in the cervical spine (41 patients), thoracic spine (15 patients), and lumbar spine (4 patients). All patients were evaluated clinically and radiographically.

RESULTS: Thirty-nine patients underwent single-level corpectomy, 18 patients underwent two-level corpectomy, and 3 patients underwent three-level corpectomy. Anterior reconstruction alone was performed in 30 patients; circumferential reconstruction was performed in 30 patients, 9 of whom underwent reconstruction through a posterior approach only. At the time of the final follow-up examination (mean, 9 mo), the Nurick grade improved significantly. Ninety-five percent of the patients maintained or improved their Frankel score and 67% had good clinical results. The regional angulation was corrected significantly (4.0 ± 9.0 degrees, $P = 0.002$), and the segment height increased significantly (3.5 ± 8.0 mm, $P = 0.002$). Bony fusion was achieved in 93% of the cases. Subsidence was documented in nearly half of the patients (1.4 ± 2.0 mm) and was reduced after circumferential fusion (0.9 ± 1.9 mm, $P = 0.08$). Eighteen patients (30%) had complications and 12 patients (20%) underwent revision surgery.

CONCLUSION: Expandable vertebral body replacement systems can provide solid anterior column constructs with restoration of height and sagittal alignment. Favorable clinical outcome was shown in most patients, although the complication and reoperation rates are rather high.

KEY WORDS: Corpectomy, Deformity, Expandable cage, Metastasis, Spinal reconstruction

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Corpectomy has become a common surgical procedure for spinal metastasis, deformity, instability, degenerative stenosis, infection, and trauma (1, 8, 9, 15, 16). Autogenous bone grafts such as iliac crest or fibula have been used to reconstruct the anterior column despite donor site morbidity; pseudarthrosis and graft dislodgement are well known complications (6, 11, 21). Ideally, a vertebral body replacement system should be stable, resist axial load-bearing, have a large interbody-bone interface to facilitate fusion and prevent migration, and restore height and sagittal alignment (4). Titanium mesh cages have been developed, which eliminate the need for autogenous tricortical bone grafts. However, optimal placement of a nonexpandable spacer can be demanding and challenging. In an attempt to overcome the technical problems of nonexpandable cages, various expandable cages have been developed that can be adjusted in situ to the height of the corpectomy defect. These devices have

ABBREVIATIONS: ADD, anterior distraction device; **CT**, computed tomography; **MRI**, magnetic resonance imaging; **TPS**, telescoping plate spacer already been used successfully for various indications (2, 5, 10, 13, 19, 22, 24–28).

In the present prospectively followed case series, we report our experience with 60 patients who underwent single- or multilevel corpectomy with insertion of expandable vertebral body replacement systems in the cervical, thoracic, and lumbar spine. This study evaluates the surgical techniques, complications, and outcomes of patients treated with 6 different implant systems. To our knowledge, this is the largest series of patients treated with expandable cages.

PATIENTS AND METHODS

Patient Population

Between October 2004 and November 2007, 60 consecutive patients—including 28 men and 32 women with a mean age of 54 years (range, 16–80 yr)—underwent single- or multilevel corpectomy with implantation of an expandable cage. All but 2 surgical procedures were performed by the authors. The indications for corpectomy were stenosis in 13 patients, 2-level disc herniation in 7 patients, kyphotic deformity in 14 patients, traumatic fracture in 3 patients, spinal metastasis in 22 patients, and spinal tuberculosis in one patient, and were localized in the cervical (41 patients), thoracic (15 patients), and lumbar spine (4 patients). The mean duration of symptoms was 51 weeks (range, 0–336 wk) and consisted of neck or back pain in 9 patients, radiculopathy in 10 patients, and myelopathy in 39 patients. Two patients had radiographic tumor progression without symptoms (*Table 1*).

TABLE 1. Demographic data of 60 consecutive patients

	No. of patients (%)
Sex	
Male	28 (46.7)
Female	32 (53.3)
Mean age (yr)	54 (range, 16–80)
Diagnosis	
Stenosis	13 (21.7)
Herniated disc	7 (11.7)
Deformity	14 (23.3)
Fracture	3 (5)
Tumor	22 (36.7)
Tuberculosis	1 (1.7)
Spinal localization	
Cervical	41 (68.3)
Thoracic	15 (25)
Lumbar	4 (6.7)
Symptoms	
Neck or back pain	9 (15)
Radiculopathy	10 (16.7)
Myelopathy	39 (65)
Asymptomatic	2 (3.3)

Symptoms were assessed using the Frankel classification and Nurick grading scale (7, 17). Patients' perceived recovery was measured by the 7-point Likert scale; complete recovery and almost-complete recovery were determined to be good results.

Radiographic Evaluation

Magnetic resonance imaging (MRI), computed tomography (CT), and conventional x-ray scans were available pre- and postoperatively in all patients. The regional angulation was determined by measuring the angle between the normal endplate above and below the affected segment. Kyphosis was documented as "positive" and lordosis as "negative" angulation. The segment height was evaluated by measuring the height of the involved vertebral segment, including the 2 adjacent intervertebral discs. In all patients, dynamic x-rays and CT scans were performed 3 months postoperatively to document stability, fusion, subsidence, and possible hardware displacement. Fusion was defined as solid consolidation on CT scan, and no sign of implant dislocation on flexion/extension radiographs. MRI was performed 3 to 6 months after surgery to evaluate adequate decompression of the involved neural structures.

Implant Characteristics

In the present study, we implanted 6 different expandable vertebral body replacement systems for reconstruction of the corpectomy defect.

1) The telescoping plate spacer (TPS) (Interpore Cross International, Irvine, CA) is a rectangular stand-alone device (15 mm wide by 15 mm deep) that is designed for C3 to T3 vertebral body replacement. The end pieces are fixed with 0 degrees of caudal surface and 10 degrees of cranial surface. The flanges prevent the TPS from impelling dorsally and contain two 15-degree and two 45-degree holes for screw fixation. The implant has a large contact area due to open sidewalls and can be packed with bone. The distractor is attached to the TPS implant and, when inserted, the height can range from 22 to 29 mm for one-level corpectomy, and from 34 to 50 mm for 2-level corpectomy.
2) The anterior distraction device (ADD); (Ulrich Medical, Ulm, Germany) is used for reconstructing the anterior column of the cervical and upper thoracic spine from C3 to T3. ADD is available in 3 outer diameters (12, 14, and 16 mm) with 0-degree (or 6-degree) fixed angulation of the cranial end piece and 0-degree fixed angulation of the caudal end piece. The small central cavity can be filled with bone. An expansion instrument is inserted into a bore of the distraction ring, and the cage is distracted by counterclockwise rotation of the ring. The distraction ranges extend from 10 to 13 mm to 39 to 65 mm. Additional anterior plating is necessary.
3) The winged anterior distraction device (ADDplus; Ulrich Medical), has the advantage of an integrated plate system that reduces the risk of migration and sinking in. The implant is anchored with expandable osmium screws. There are 4 different implant heights with an outer diameter of 12 mm; the small central cavity can be filled with bone. The distraction mechanism is similar to the ADD, and the height ranges from 13 to 18 mm and 40 to 65 mm. The angle of the integrated plate is fixed and varies from 0 to 18 degrees.
4) The obelisc vertebral body replacement (Ulrich Medical), is designed for reconstruction of the anterior thoracic and lumbar spine. Obelisc has a standard external diameter of 20 mm, and the central cavity can be filled with bone. The end pieces are available in 3 diameters (20, 24, and 26 mm) with different angles (0, 5, and 10 degrees). There are 6 different sizes, and the distraction height

ranges from 20 to 28 mm and 76 to 132 mm. The implant is fixed to the inserter and the device is expanded by counterclockwise rotation. Additional anterior or posterior fixation is necessary.

5) The VLIFT vertebral body replacement system (Stryker, Kalamazoo, MI) is designed for reconstruction of the corpectomy defect of the thoracolumbar spine (T1 to L5). The device is designed to be inserted through an anterior approach, but a circumferential reconstruction through a single posterior approach is possible. The diameter of the implant is 18 or 22 mm, and the central part can be packed with bone. The end caps of the 18 mm are available in 0, 3, or 8 degrees. The 22-mm implant end caps are also available in 15 degrees to restore lumbosacral sagittal alignment. There are 4 different sizes, which vary from 20.5 to 27.5 mm and 37 to 60.5 mm. Extension pieces can be placed on both ends of the VLIFT to build a longer construct, which can increase the height to 90.5 mm. An expander is used to insert and distract the implant by counterclockwise rotation. Additional anterior or posterior internal fixation is required.
6) The Cervilift expandable cage (Deltacon GmbH, Werneck, Germany) is designed for cervical vertebral body replacement. The diameter of the implant is 11 or 14 mm, the central part can be filled with bone, and the end caps are available in 0, 3, and 5 degrees. There are 2 sizes, which vary from 13 to 20 mm and 18 to 30 mm. Extension pieces of 5 or 10 mm can be placed on both ends to increase the height of the implant. Insertion and expansion of the implant is similar to VLIFT. Supplemental plate fixation is necessary.

The criteria for choosing the type of vertebral body replacement system were based on the localization of pathology, surgical approach, and implant characteristics. In all patients, the central part of the implants was filled with allograft bone.

Statistical Analysis

Student's paired 2-tailed *t* tests were used to compare pre- and postoperative Nurick grades, regional angulations, and segment heights. Pearson's χ^2 tests were used to calculate differences in outcome assessments between groups. Results are presented as the means ± standard deviations. A *P* value less than 0.05 was considered statistically significant. Statistical analysis was performed with SPSS software (version 15; SPSS Inc., Chicago, IL).

RESULTS

Clinical Results

The mean follow-up period was 9 months (range, 1–28 mo). Eight patients died after a mean survival time of 9.9 months (range, 1–27 mo); cause of death was progression of disease in 6 patients, respiratory insufficiency in 1 patient, and sepsis due to lower limb infection in 1 patient.

One-level corpectomy was performed in 39 patients, 2-level corpectomy in 18 patients, and 3-level corpectomy in 3 patients (*Fig.1*). In 30 patients, an anterior reconstruction was performed without posterior instrumentation. Circumferential reconstructions were performed in 30 patients, in 9 of whom a posterior approach only was used (*Fig.2*). The distribution of implants used was ADD in 1 patient, ADDplus in 16 patients, obelisc in 3 patients, TPS in 27 patients, VLIFT in 11 patients, and Cervilift in 2 patients. The mean duration of surgery was 340 minutes (range, 100–950 min), and the mean blood loss was 1728 mL (range, 100–16000 mL) (*Table 2*).

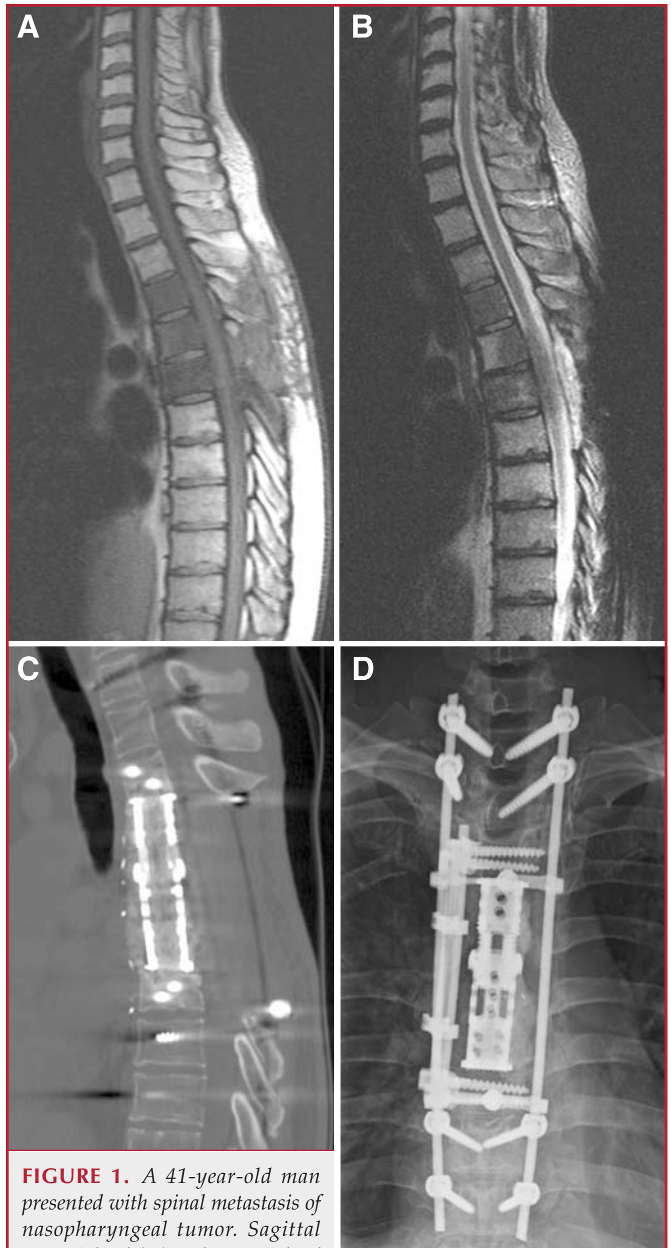

FIGURE 1. *A 41-year-old man presented with spinal metastasis of nasopharyngeal tumor. Sagittal T1-weighted (**A**) and T2-weighted (**B**) magnetic resonance imaging scans showing metastasis from T4 to T6 extending posteriorly. Transthoracic 3-level corpectomy with implantation of VLIFT (Stryker, Kalamazoo, MI) and additional anterior fixation at T3 to T7 was performed. Second-stage posterior surgery included resection of posterior elements at T4 to T6, and pedicle screw fixation at T1 to T9. Postoperative sagittal computed tomography (**C**) and anteroposterior x-ray (**D**) showing solid fusion with stable circumferential construction.*

The mean preoperative Nurick grade was 1.9 ± 1.7, which improved significantly to 1.0 ± 1.6 postoperatively ($P < 0.001$). The majority (95%) of patients maintained or improved their Frankel score. Forty (67%) patients had good clinical results according to the Likert scale (*Table 3*).

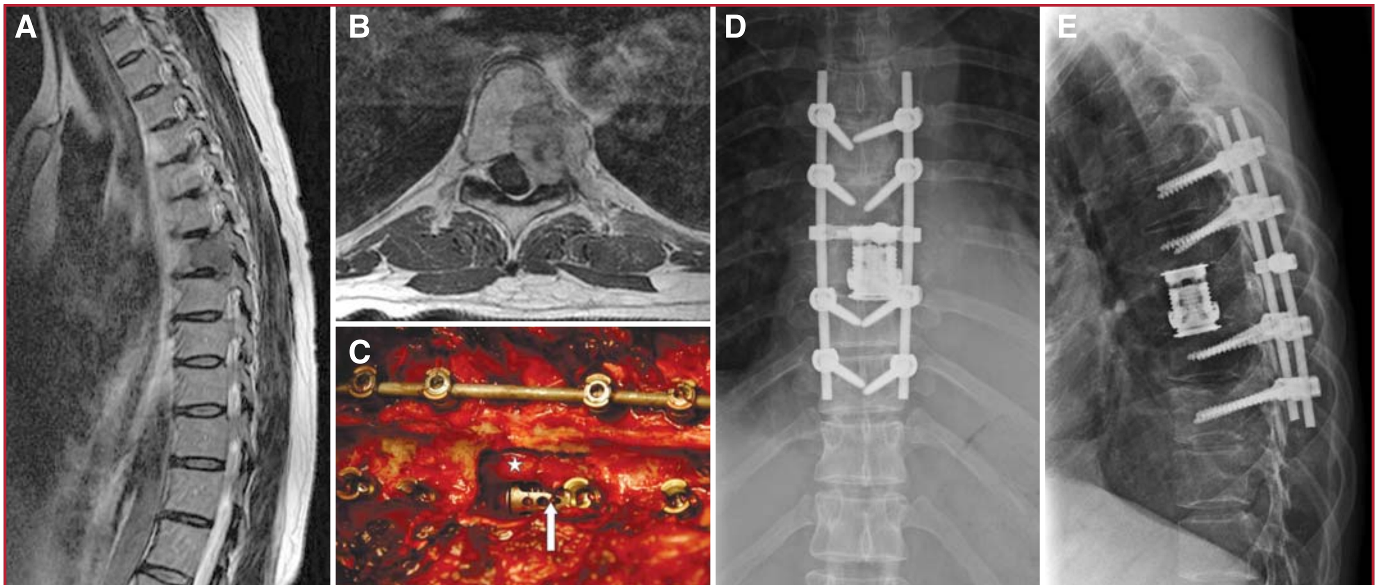

FIGURE 2. *A 38-year-old woman with solitary spinal metastasis of leiomyosarcoma. Sagittal T2-weighted (**A**) and axial T1-weighted (**B**) magnetic resonance imaging scans showing posterolateral located metastasis of T7. Left-sided costotransversectomy and partial corpectomy were performed, followed by posterolateral insertion of VLIFT and pedicle screw fixation at T5 to T9. **C**, rhizotomy of the nerve root at T7 (*arrow*) was necessary to insert the cage; the spinal cord is marked with a *star*. **D** and **E**, postoperative x-rays showing solid circumferential fixation at T5 to T9 through a single-stage posterior approach.*

Radiographic Results

The mean preoperative regional angulation was 7 ± 12.2 degrees, which was significantly corrected to 3.3 ± 13.9 degrees ($P = 0.002$) (*Fig. 3*). The mean segment height increased from 27.4 ± 14.8 mm and 30.8 ± 16.8 mm, which was also statistically significant ($P = 0.002$) (*Fig.4*). Bony fusion was achieved in 93% of the patients. The fusion rate decreased to 87% whenever fusion was based on the intention-to-treat principle, and hardware failures with consequent revision surgery were considered as fusion failures. There was no relation between nonunion and type of implant ($P = 0.7$). Cage subsidence was documented in nearly half of the patients (42.6%). The mean subsidence of all patients was 1.4 ± 2.0 mm. In patients treated with anterior reconstruction alone, the mean subsidence was 2.0 ± 2.1 mm; in those with circumferential fusion, the mean subsidence was 0.9 ± 1.9 mm. This difference did not reach statistical significance ($P = 0.08$). There was no significant difference between type of implant and subsidence rate ($P = 0.53$). The subsidence rate between 1-level, 2-level, or 3-level corpectomy was not statistically significant ($P = 0.52$). In all patients, postoperative MRI scans documented adequate decompression of neural structures.

Surgery-related Complications

Perioperative complications occurred in 18 patients (30%) (*Table 2*). Hardware displacement was observed in 5 patients. Three patients had progressive dysphagia because of anterior displacement of a screw (1 patient) or anterior migration of the implant (2 patients). The patients recovered completely after removal of the screw or repositioning of the cage, respectively (*Fig. 5A*). In one patient, the implant was under-distracted and had no contact with the adjacent endplates. However, consolidation in and around the cage was documented, and the construct was shown to be stable on dynamic radiographs. In one patient, the caudal screw was placed too steeply and crossed the adjacent intervertebral disc without clinical consequences.

Rebleeding occurred in 2 patients. One patient developed an acute hypotensive shock due to cage migration and consequent rupture of the aorta. Immediate surgery with hardware removal, suturing of the vascular rupture, and second-stage implantation of a smaller cage resulted in complete recovery. The other patient developed progressive tetraplegia due to an epidural hematoma with spinal cord compression. The patient recovered without neurological deficit after acute evacuation of the hematoma and re-implantation of the distractable cage in a later stage.

Neurological deficit occurred in 3 patients. One patient developed a right-sided C5 palsy, which resolved completely after 6 months. One patient had L1 radiculopathy, and 1 patient developed partial paresis of 1 leg. Both patients died due to disease progression and, as far as we know, the neurological deficit was unchanged. Transient vocal cord paralysis occurred in 1 patient.

Three patients developed progressive kyphosis; 2 of them were reoperated with additional posterior instrumentation. One patient experienced a deep infection with consequent hardware removal. Two patients developed cerebrospinal fluid

TABLE 2. Summary of surgical procedures and complications[a]

	Patients (%)
Corpectomy	
1-level	39 (65)
2-level	18 (30)
3-level	3 (5)
Approach	
Anterior	30 (50)
Anterior and posterior	21 (35)
Posterior	9 (15)
Mean blood loss (mL)	1728 (range, 100–16000)
Mean duration of surgery (min)	340 (range, 100–950)
Implanted device	
ADD	1 (1.7)
ADDplus	16 (26.7)
Obelisc	3 (5)
TPS	27 (45)
VLIFT	11 (18.3)
Cervilift	2 (3.3)
Complications (total)	18 (30)
Hardware displacement	5 (8.3)
Rebleeding	2 (3.3)
Neurological deficit	3 (5)
Vocal cord paralysis	1 (1.7)
Cerebrospinal fluid leakage	2 (3.3)
Infection	2 (3.3)
Progressive angulation	3 (5)
Reoperations	12 (20)

[a] ADD, anterior distraction device; TPS, telescoping plate spacer

TABLE 3. Pre- and postoperative Frankel grade and Nurick grade and postoperative patients' perceived recovery

	No. of patients preoperatively (%)	No of patients postoperatively (%)
Frankel grade		
A	3 (5)	0
B	1 (1.7)	4 (6.7)
C	5 (8.3)	4 (6.7)
D	22 (36.7)	9 (15)
E	29 (48.3)	43 (71.7)
Nurick grade		
0	20 (33.3)	38 (63.3)
1	10 (16.7)	7 (11.7)
2	10 (16.7)	6 (10)
3	8 (13.3)	1 (1.7)
4	6 (10)	2 (3.3)
5	6 (10)	6 (10)
Likert scale		
Complete recovery		19 (31.7)
Almost-complete recovery		21 (35)
Some recovery		5 (8.3)
Unchanged		10 (16.7)
Some worsening		1 (1.7)
Serious worsening		2 (3.3)
Worse than ever		2 (3.3)

leakage; reexploration and dural reconstruction was necessary in both cases. In total, 12 (20%) patients underwent reoperation for implant-related complications.

DISCUSSION

Removal of one or more vertebral bodies followed by spinal column reconstruction continues to evolve. Traditionally, implantation of autologous tricortical iliac bone graft was the "gold standard" to reconstruct the corpectomy defect. We presented the results of 60 patients treated with 6 different expandable cage systems throughout the spinal column. To our knowledge, this is the largest series on vertebral body replacement.

Correct positioning of non-expandable cages can be challenging. Some distraction forces and shaping of the endplates may be necessary to insert a rigid implant. Even then, the position of the implant can be inadequate; endplates can weaken with consequent subsidence, and restoring sagittal alignment can be

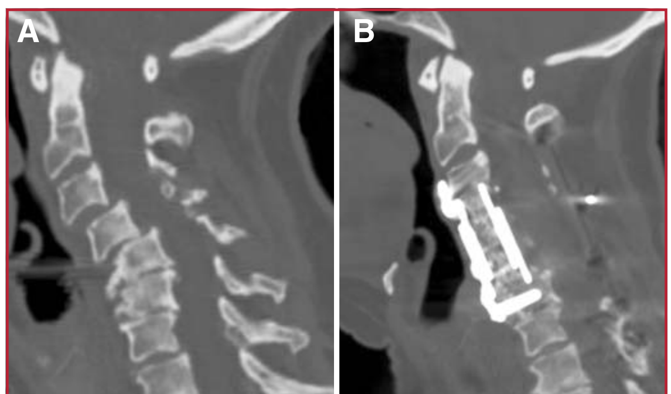

FIGURE 3. A, *a 67-year-old woman presented with "staircase deformity" and severe cervical spondylogenic myelopathy. The patient underwent cervical traction to achieve better alignment, followed by corpectomy of C4 and C5 with insertion of a telescoping plate spacer (TPS) cage and additional posterior fixation from C2 to T1.* **B**, *postoperative sagittal computed tomographic reconstruction showing solid fusion with improvement of segmental angulation from 18 to 0 degrees kyphosis.*

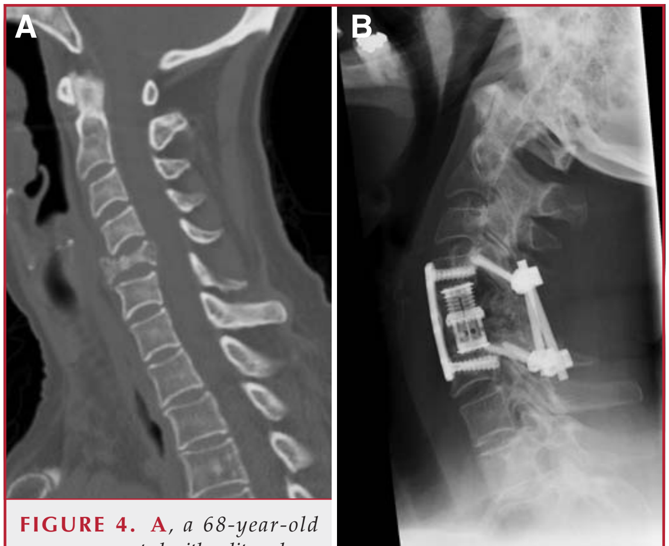

FIGURE 4. **A**, *a 68-year-old woman presented with solitary lung metastasis with destruction of C5.* **B**, *corpectomy of C5 with implantation of Cervilift (Deltacon GmBH, Werneck, Germany) and additional plating, and resection of posterior elements followed by lateral mass screw fixation was performed from C4 to C6. The segment height increased from 16 to 23 mm.*

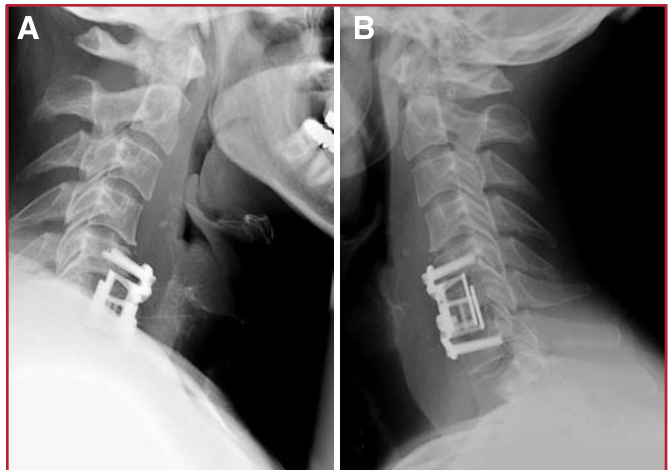

FIGURE 5. **A**, *lateral fluoroscopic image of a 51-year-old man with anterior stenosis at C5 to C7 who was treated with corpectomy at C6 and implantation of TPS. The central gutter was too narrow with consequent anterior position of the implant.* **B**, *during reexploration the next day, the posterior part of the vertebral defect was extended in the lateral direction and the implant was repositioned.*

insufficient (12). One of the main advantages of expandable cages for vertebral body replacement is easy, non-distracted insertion of the cage. The height can be adjusted to the corpectomy defect in situ, and correction of deformity and restoring height can be achieved. Similarly, in the present study we have achieved a mean improvement of segment height by 3.5 mm and sagittal correction by 4.0 degrees. However, one of the pitfalls of expandable cages is over-distraction. The mechanical properties of the implant allow smooth and easy distraction, and the surgeon should not maneuver against too much resistance to prevent traction injury of the segmental nerves. In our series, one patient developed transient C5 palsy because of overdistraction, which has been documented previously (20).

The fusion rate in our study was high and in accordance with the literature (2, 5, 13, 19, 26, 28). There was no relation between occurrence of non-union and type of implant. The central cavity of the ADD, ADDplus, and obelisc is relatively small, with consequent limited interbody-bone interface. However, consolidation around the implants was visible, and signs of instability were not observed. TPS, VLIFT, and Cervilift have a better implant-bone interface because of the large central cavity that can be filled with bone.

In the present case series, implant subsidence was documented in nearly half of the patients, which was remarkably high in terms of our relatively short follow-up period. It is possible that the adjacent end plates were cleaned and flattened too rigorously, or the endplates were weakened primarily, since most of the cases involved spinal metastasis. Coumans et al. (5) investigated 15 patients who underwent placement of TPS. No patient showed subsidence, and their mean follow-up was short as well. Auguste et al. (2) documented a significant subsidence rate in 22 patients treated with Synex expandable cages (Synthes Spine, West Chester, PA). In accordance with Auguste et al. (2), we observed a correlation between additional posterior instrumentation and reduced subsidence rate, although this was not statistically significant.

The complication and reoperation rates in our series are remarkably high and will be discussed in more detail. Surprisingly, hardware displacement was the most documented complication. Expandable cages were developed for easier use and less effort in spinal column reconstruction. However, some basic biomechanical principles and spinal surgical experience are recommended. In our series, all 5 patients with hardware displacement were operated during the first period, and 2 procedures were performed by surgeons who had no experience in vertebral body reconstruction. All these cases involved TPS cages. The TPS has a rectangular shape; therefore, the central gutter in the vertebral body has to be drilled straight or somewhat divergent to insert the implant properly and prevent anterior displacement (*Fig. 5*). The other implants used are rounded and, therefore, the carpentry can, be less precise. In addition, TPS has fixed end caps that require accurate preparation.

Another biomechanical complication we documented in 3 patients was progressive kyphosis. Two of them had multilevel degenerative stenosis with kyphosis and underwent 2-level corpectomy with circumferential spondylodesis. However, the posterior construct involved the same vertebral segments as the anterior construct, and progressive kyphosis developed at the adjacent cervicothoracic junction (*Fig. 6*). Secondary surgery with extension of the posterior construct to the upper thoracic spine was necessary, which would have been prevented if the primary construct were made longer.

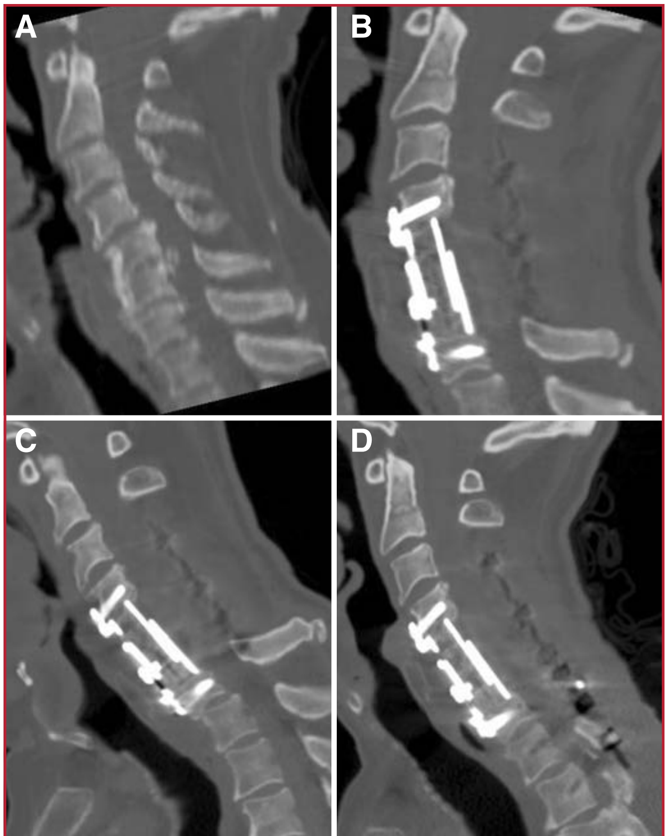

FIGURE 6. A, *sagittal computed tomographic reconstruction of a 73-year-old male with spondylotic myelopathy based on stenosis at C4 to C7 with anterior and posterior compression.* **B**, *corpectomy at C5 to C6 with TPS implantation and posterior decompression at C3 to C6 with lateral mass screw fixation at C3 to C6 were performed.* **C**, *1 year postoperatively, anterolisthesis with kyphosis at the cervicothoracic junction was demonstrated.* **D**, *posterior revision surgery with additional pedicle screw fixation and extension of the construct to T2 were performed.*

In our study, more than one-third of the patients had spinal metastasis, and half of the cases with complications involved metastasis. This might bring our complication rate into perspective. Patients with spinal metastasis are at high risk regarding complications because of steroid use, previous radiotherapy, weight loss, or metastasis elsewhere. Therefore, it is of utmost importance to estimate a patient's life expectancy a priori when considering extensive spinal surgery with instrumentation (3).

Spinal metastases often require corpectomy through an anterior approach followed by posterior column resection and subsequent instrumentation. This circumferential reconstruction is often demanding and is associated with significant risks (14, 18, 23). In 9 patients, we performed a corpectomy with circumferential reconstruction through a single posterior approach, which has been described before (22, 24, 25). Wide unilateral costotransversectomy allowed extracavitary decompression of the dura across the midline to the contralateral pedicle. Depending on the pathology, resection of the vertebral body was approached unilaterally or bilaterally, which obviated the transcavitary-associated risks. However, rhizotomy of 1 segmental nerve root could be necessary to insert the smallest nondistracted expandable cage (*Fig. 2C*). Neurological deficit after rhizotomy of a single spinal thoracic nerve root is usually limited due to extensive overlap of distributions, as shown in our patients. In cases of lumbar spine involvement, the implant can be inserted horizontally and then rotated vertically when in position. This can allow insertion of the implant without sacrificing the nerve root (24).

The present case series has several limitations. The mean follow-up period of 9 months is short, particularly in the light of the high complication and subsidence rates. It would appear necessary to have longer duration of follow-up to determine if any late complications have occurred as well, and to evaluate long-term subsidence. Secondly, the patient population is heterogeneous, various pathologies were treated, and different expandable implants were used. However, in our opinion, the basics of vertebral body replacement and reconstruction remain the same in all of our cases. Finally, we presented a case series, and this study was not designed to compare expandable cages with other forms of reconstruction, such as the traditional bone grafting with plating.

In the present series, we have implanted 6 different expandable vertebral body replacement systems. Each device has its pros and cons. The main advantage of TPS, VLIFT, and Cervilift is the large central part of the implant with the possibility of bone filling. This is limited in ADD, ADDplus, and obelisc. The disadvantage of TPS is the fixed end cap and the bulky square shape of the implant. The carpentry of the end plates and remaining vertebral body to prevent anterior displacement can be challenging. In the upper thoracic spine, insertion of VLIFT can be problematic because of the relative large diameter; therefore, we prefer the smaller Cervilift or ADDplus in this region. Cervilift, ADD, obelisc, and VLIFT require supplemental instrumentation, but direct connection to these implants is not possible. TPS and ADDplus, on the other hand, have an integrated wing fixation to the adjacent vertebral bodies, which eliminates the need for additional plating. All implants lack the possibility to restore a large 3- or more level corpectomy defect without 1 or 2 extension pieces. In such a construct, however, the biomechanical properties might be questionable.

CONCLUSION

Vertebral body resection with implantation of expandable cages can be performed in the cervical, thoracic, and lumbar regions for the treatment of various spinal pathologies. The main advantage is in situ adjustment to the height of the corpectomy defect, which eliminates the need for extensive carpentry. Different devices are available, and all have the potential of restoring height and correction of sagittal alignment. In the present prospectively followed case series of 60 patients, the construct appears stable, although the subsidence rate is high. The neurological function improves significantly, and the majority of patients have good clinical results. However, the complication rate and incidence of revision surgery are high.

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COMMENTS

The material used to replace a vertebral body after a corpectomy has changed from autograft, allograft, and methylmethacrylate to fixed cages to the current use of expandable cages. Arts and Peul used six different types of expandable cages to replace vertebral bodies removed for a variety of reasons. They found the ability to expand the cages helpful, especially when they were placed from a posterolateral approach.

Their relatively high complication rate (21.7%) emphasizes the fact that surgical experience is needed to ensure good outcomes after placement of spinal cages. However, their patient population included 22 patients with primary or secondary tumors, and surgical treatment in such patients is known to be associated with a high complication rate.

Compared with the previous devices, expandable cages are elegant and offer many advantages. Nonetheless, most of the devices occupy the space at the endplates where placement of graft material is usually preferred. The cages are also expensive. This article emphasizes the pros and cons of these cages.

Volker K.H. Sonntag
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Arts and Peul provided a relatively large clinical series that assessed use of expandable cage vertebral body replacement systems for a variety of spinal pathological lesions. Their assessment and their experience provide valuable insight for the complex spine surgeon. Most notably, the complication rate is not insignificant. With this in mind, the advantages and disadvantages of such a clinical strategy can be appropriately determined preoperatively. They have provided an honest and meticulous report.

Edward C. Benzel
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Arts and Peul reported their experience with expandable cages for reconstruction of the anterior column in 60 prospectively followed patients. The cohort is very heterogeneous in that the pathological lesions were varied, cervical, thoracic, and lumbar procedures were included, and six different types of expandable cages were used. All cages were filled with allograft. Fusion was determined using dynamic films and computed tomography, and the rate is stated to be 93%. Unfortunately, the imaging was performed at 3 months postsurgery which is too soon to verify a true arthrodesis.

Expandable cages can be very helpful in the thoracic and lumbar regions, but they offer less advantage in the cervical spine compared with other techniques. In this study, 68% of the subjects had cervical cages placed.

Perhaps the most important finding is the complication rate of 30%. Although some of these were fairly minor, a number of them were very serious. It is notable that although only one-third of the patients in this study were treated for spinal metastasis, this subgroup accounted for half of all complications. The discussion reviews a number of important points that should help minimize adverse events and should be carefully read by all interested in using these devices.

Vincent C. Traynelis
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Arts and Peul presented their extensive case series of patients (N = 60) who underwent vertebral body reconstruction with expandable metallic cages. A number of different devices from three separate manufacturers were used, but all of the prostheses were similar in design and application. The results were quite acceptable with a 93% radiographic fusion rate, and a number of complications were encountered owing to the severity of pathological lesions treated.

The introduction of these devices has significantly expanded the surgical armamentarium. These cages have made anterior column reconstruction after a posterolateral corpectomy much more feasible, as they can be lengthened in situ after insertion ventral to the spinal cord. However, they have substantial metallic bulk and thus create significant artifacts on postoperative magnetic resonance imaging. In addition, in the United States, these devices add a large implant cost to the surgical procedure compared with allograft or static mesh cages. Whether their added expense can be justified in all patients remains to be proven, and in my practice their use has been limited to those challenging situations in which their in situ expansion capabilities are truly beneficial.

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