An Original Study

Expandable Titanium Cages for Thoracolumbar Vertebral Body Replacement: Initial Clinical Experience and Review of the Literature

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Abstract

Reconstruction of the anterior and middle column after vertebrectomy is essential for restoring stability. Use of expandable implants is supported by an emerging body of literature. Newer expandable cages have some advantages over traditional mesh implants, structural allograft, and polyetheretherketone or carbon fiber cages.

To determine the utility of an expandable titanium cage in spine reconstruction, we conducted a retrospective cohort study of patients who had undergone this reconstruction after single or multilevel thoracic and/or lumbar vertebrectomy. Here we report on our experience using expandable cages at 2 large academic medical centers. Outcome was based on both clinical and radiographic measures with cross-sectional analysis. Thirty-five patients were identified. Of these, 20 had undergone surgery for neoplasm, 8 for trauma, and 7 for infection.

Mean follow-up was 31 months (range, 12 to 50 months). Early postoperative kyphosis correction, restoration of sagittal alignment at 12 months, and reduction in visual analog scale pain score were significant. There was no difference in Oswestry Disability Index or height restoration. Expandable intervertebral body strut grafts appear to be a safe and effective option in spine reconstruction after a vertebrectomy and should be considered a treatment option.

The vertebral bodies in the thoracolumbar spine are vulnerable to neoplastic invasion, infection, traumatic/osteoporotic fractures, and idiopathic/degenerative deformity, all of which can lead to impingement of critical neural structures and biomechanical instability. Often, patients with these conditions require anterior decompression and reconstruction of the anterior and middle columns.[1-3] A body of literature supports use of fixed titanium mesh cages, cadaveric allografts, and synthetic cages (eg, carbon fiber, polyetheretherketone) for stabilization/reconstruction of the anterior and middle columns after corpectomy.[4-13] Use of expandable strut cages for reconstruction of the anterior and middle columns is continuing to increase.[14] These expandable cages offer several advantages over fixed/static cages, including in situ expansion to correct loss of height, maximization of endplate contact with the vertebral bodies, and restoration of sagittal balance and correction of kyphotic deformity without loss of spinal height associated with osteotomies.[15,16] The most common of these expandable interbody/vertebral body titanium strut grafts are composed of 2 telescoping, internally threaded cylinders with large windows to facilitate packing of bone graft material. Distraction is achieved in situ. After the corpectomy, fluoroscopic guidance is used to precisely adjust the length of the implant with optimal distraction to fit the vertebral defect. The endplates of the cage have spikes that facilitate secure docking into the subchondral bone of the adjacent vertebral bodies. The large axial profile of the cage allows maximization of the surface area in contact with the vertebral bodies above and below the operative level. Distraction is applied to vertebral endplates through the cage, as opposed to through supplemental instrumentation.

Materials and Methods

We reviewed the cases of all patients who had undergone anterior column reconstruction with an expandable titanium cage between 2004 and 2007 at the University of California, San Francisco Medical Center (and affiliated institutions) and the University of California, San Diego Medical Center.

Data Collection

Radiographic evaluation included preoperative and serial postoperative anteroposterior and lateral radiographs (Figures 1, 2). Radiographic outcome measures included evidence of radiographic fusion, segmental angulation

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(measured using Cobb method), degrees of kyphosis correction, sagittal realignment, subsidence, and height restoration. Radiographic fusion was assessed by presence of bridging cortical bone on computed tomography (CT) scan or lack of movement on 1-year lateral flexion-extension radiographs as interpreted by a board-certified radiologist not affiliated with this study. Clinical outcome measures included preoperative and postoperative Oswestry Disability Index (ODI)[17] and visual analog scale pain score, neurologic examination, complications, estimated blood loss, and operating time.

Results

We identified 35 patients who underwent anterior column reconstruction with an expandable titanium cage (VLIFT; Stryker Spine, Allendale, New Jersey) during the study dates. Of these, 20 had undergone surgery for neoplasm, 8 for trauma, and 7 for infection. Of the 35 patients, 5 had placement of the cage through an anterior approach, 22 through a posterior approach, and 8 through a staged combined anterior/posterior approach (Table I). All patients who had an anterior approach for cage placement also had anterior instrumentation. All patients who had a posterior lateral extracavitary approach had supplemental posterior instrumentation to 2 or 3 levels above and below the level of vertebrectomy as needed, based on bone quality and location.

Results are summarized in Table II. Mean follow-up was 31 months (range, 12 to 50 months). Mean preoperative segmental kyphosis was 15°, with statistically significant (P<.002) early postoperative correction to 2°. At 12-month follow-up, kyphosis had reverted to a mean of 8°, resulting in a significant (P = .012) restoration of sagittal alignment. None of the patients experienced neurologic deterioration. Height restoration was not statistically significant (P = .2) at 12-month follow-up. The difference in visual analog scale pain score was significant (P = .008), with a mean reduction of 4.5 points. There was no difference in ODI. One trauma patient in the anterior-only short-segment fixation group demonstrated a progression of kyphosis and required additional posterior supplementation at 4-month follow-up. Fusion rate, as measured by lack

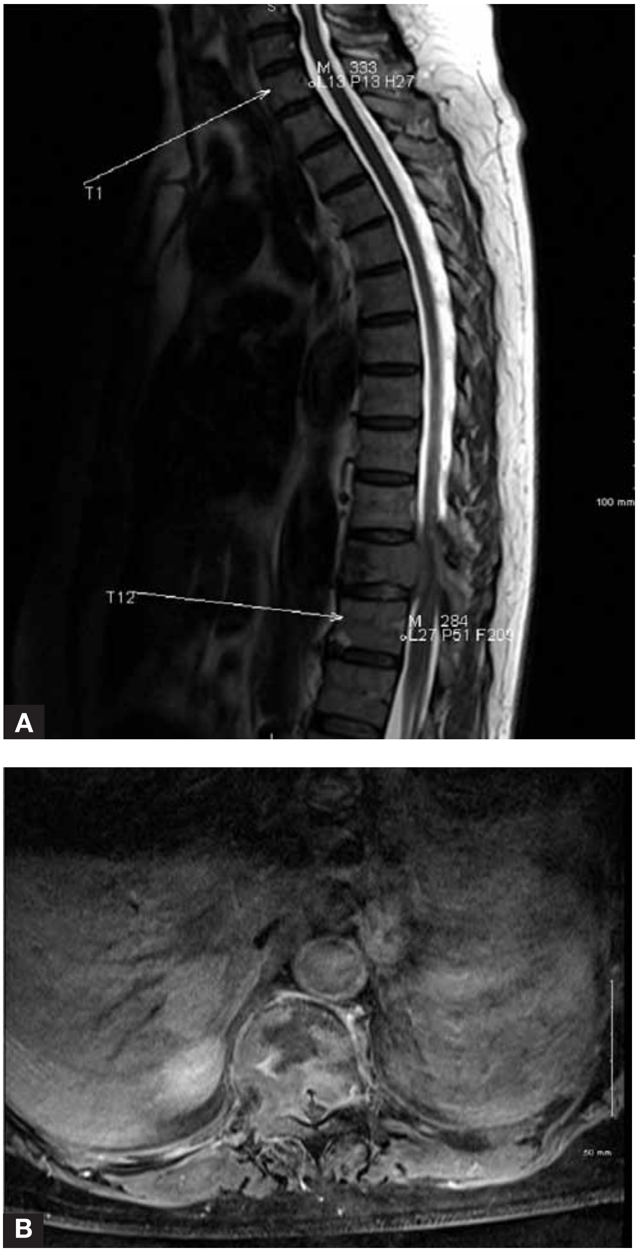

Figure 1. Preoperative sagittal (A) and axial (B) magnetic resonance imaging of T11 solitary spinal metastasis caused by breast cancer. Patient had rapid-onset paresis and lost the ability to walk.

Table I. Patient Demographics

	Surgical Approach		
Instrumentation	**Posterior (n = 22)**	**Anterior (n = 5)**	**Combined (n = 8)**
Mean age, y	57	46	53
Pathology, No.			
Tumor	13	1	6
Trauma	5	3	0
Infection	4	1	2
Levels of corpectomy, No.			
1	16	5	6
2	6	0	2
Levels of fusion, No.	4.4	2	4.1
Estimated blood loss, mL	970	650	1220
Length of stay, d	5.5	6.2	7.4

Table II. Summarized Results

Outcome Measure	Approach Posterior	Anterior	Combined
Kyphosis, °			
Before surgery	14.1	17.3	13.9
Immediately after surgery	2.6	2.3	1.4
1 year after surgery	7.7	8.2	8.3
Visual analog scale pain score, mean (SD)			
Before surgery	8.6 (0.2)	8.5 (0.5)	8.2 (0.3)
1 year after surgery	3.8 (0.3)	4.1 (0.1)	3.9 (0.5)
Oswestry Disability Index, mean (SD)			
Before surgery	17.2 (12.1)	20.7 (16.5)	19.3 (17.1)
1 year after surgery	22.0 (8.3)	26.0 (10.9)	21.7 (7.5)

of motion on flexion-extension plain radiographs, was 97% (34/35). Two patients demonstrated no motion on flexion-extension radiographs but had incomplete bridging of trabecular bone, resulting in a fusion rate based on CT criteria of 94% (33/35).

Discussion

The vertebral body plays a significant role in maintaining the biomechanical stability of the spine and is responsible for transmitting up to 80% of the axial load applied to the spine.[18] The integrity of the vertebral body may be compromised as sequelae of trauma, neoplasia, infection, or congenital/developmental abnormalities.[18-22] With substantial destruction of the vertebral body, anterior support and reconstruction may be critical for maintaining long-term sagittal alignment and biomechanical stability.[23] With damage to the anterior column without preservation of load sharing, posterior pedicle screw fixation alone may result in high implant strain and may provide insufficient stability.[24] Adding an interbody cage significantly increases construct stiffness and reduces hardware strain.[24] Vertebral body destruction can result in ventral compression of the neural elements and compromise of neurologic stability. Under these circumstances, often indirect decompression of neural elements through ligamentotaxis alone is not as effective as direct anterior decompression.[25,26] These patients may need to undergo vertebrectomy and anterior reconstruction.

Vertebrectomy can be carried out through an anterior or posterior approach. Placement of interbody cages has traditionally been performed through an anterior approach with or without supplementary posterior instrumentation.[27-29] More recently, purely posterior vertebrectomies and instrumentation techniques have been described.[3,16] The goals of operative intervention should be adequate neural decompression with stable internal fixation over the least number of spinal segments. Often, an anterior approach requires an approach surgeon and can be associated with a morbidity rate of 11%.[30] The advantage of an anterior approach is that it allows for direct decompression of neural elements and placement of larger diameter expandable strut cages with a short fusion segment. Expandable cages can be used in the lumbar spine for anterior and middle column reconstruction without sacrifice of lumbar nerve roots.[3] These posterior-only surgical techniques avoid the morbidity associated with anterior transcavitary approaches and potentially may offer equivalent decompression and stabilization.[31-33] However, a posterior approach, especially in the lumbar spine, where the nerve roots cannot be sacrificed, limits the size of the expandable strut graft and requires a longer fusion segment to provide stability. Although with fusion of more segments, a posterior approach will result in more motion lost, the advantage is its utility as a single approach for circumferential decompression and reconstruction. Another consideration is that there is some evidence that posterior-only approaches may have a higher infection rate when compared with anterior approaches.[34-36] The decision to use an anterior, posterior, or combined approach is dictated by individual patient disease and surgeon preference.

With expandable cages, it is important to remember that the mechanical advantage afforded by the insertion

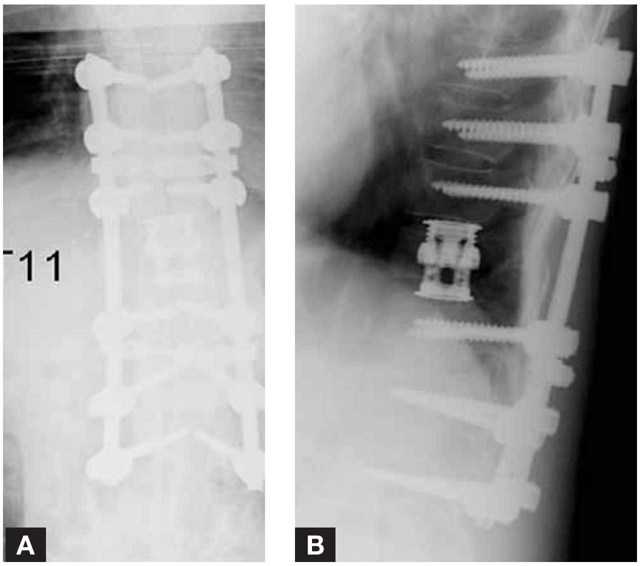

Figure 2. Postoperative lateral (A) and anteroposterior (B) plain radiographs obtained after posterior decompression, stabilization, and placement of cage through posterior lateral extracavitary approach. Patient regained ability to walk and was then treated with adjuvant spinal radiosurgery.

devices is substantial, and it is easy to overdistract the interbody space to a clinically significant degree. Use of intraoperative fluoroscopy and neuromonitoring is critical to determine the optimal amount of distraction to prevent injury to the spinal cord and other neural elements.

Certain considerations must be discussed with respect to expandable cages. Correction of lordosis is difficult with expandable cages. Use of lordotic end caps can somewhat mitigate this limitation, but, in our experience, this effect is mild. Expandable cages are more expensive than allograft or rigid titanium strut grafts. We believe the reduced surgical time and reduced surgical morbidity will outweigh the initial higher cost of the procedure. However, further study is warranted to address this concern.

Complete decompression and reconstruction of the anterior spinal column in the upper thoracic spine and lumbosacral junction can be difficult.[37-39] Fusion rates between expandable cages in the cervical, thoracic, and lumbar spine are comparable.[40,41] Pflugmacher and colleagues[42] conducted an in vitro biomechanical study that offered support for the theory that expandable cages are superior to static cages in anterior reconstruction of the vertebral body. The explanation put forth by the authors was that, because the cage can be precisely adjusted in situ to match the fusion site, this obviates the need to trim the cage and results in a better fitting implant. Proper fit of the cage and gentle axial loading may create biomechanically and biologically favorable conditions for fusion. The large endplate of the expandable cage maximizes the surface area for fusion to the adjacent endplates. Subsidence appears to be related less to cage construct and more to surgical technique—namely, excessive resection of the adjacent vertebral body subchondral bone. If the subchondral bone is completely resected, the implant is more likely to subside into the vertebral body.[41] In our experience, bony growth across the expandable cage is not necessary for a long-term, biomechanically sound construct. Bony fusion at the implant–vertebral body interface is sufficient for a solid reconstruction. Our resulting data are in agreement with previous studies that suggest expandable cages provide a robust and durable biomechanical construct suitable for restoring kyphosis and sagittal balance. Pain control was significant, and the ODI trended toward improvement, though these results did not reach statistical significance.

Conclusion

Expandable intervertebral body strut grafts may be a safe and effective treatment option when reconstruction of the anterior spinal column is needed. These cages offer some advantages over earlier methods. The devices can be placed through an anterior, posterior, or combined approach. However, patient disease and surgeon preference dictate the surgical technique used in optimally treating these challenging cases. Longer term follow-up and in-depth cost analysis are warranted in the investigation of these devices.

Authors' Disclosure Statement

Dr. Aryan is a consultant for Stryker Spine. He does not receive royalties or benefits from the sale of products discussed in this article. The other authors report no actual or potential conflict of interest in relation to this article.

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