Adjacent-level vertebral body fractures after expandable cage reconstruction

Report of 4 cases

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Expandable cages are frequently used to reconstruct the anterior spinal column after a corpectomy. The forces that are used to expand these cages can be large, depending upon the mechanism of expansion. To the authors’ knowledge, there have been no reports of adjacent-level vertebral body fracture after placement of expandable cages. The authors report 4 cases of adjacent-level vertebral body fractures after placement of expandable cages. This study found that the fracture pattern in the coronal plane was similar in all cases. (DOI: 10.3171/SPI/2008/8/6/584)

KEY WORDS • cervical spine • expandable cage • fracture • lumbar spine • vertebral body

There are many indications for performing a corpectomy or vertebrectomy in the spinal column, including tumors, trauma, degenerative disease, or deformity. Reconstruction of the vertebral body has ranged from the use of an allograft, to mesh cages, to a tricortical autograft. Use of an autograft remains the gold standard. Harvesting a large piece of tricortical autograft can involve significant morbidity to the patient, and the drawbacks of using allograft bone include longer fusion times, possible immunological rejection by the host, and the extremely small risk of disease transmission.

Mesh cages have been used, but they must be cut to a perfect size; if they are too big they will not fit, and if too small they can become loose.

Recently, expandable cages have gained popularity. Not only can they expand to the appropriate size once placed, but they can also potentially reduce kyphotic deformity and restore height loss. In addition, because of the expanding nature of these cages, they can be wedged very securely between the adjacent vertebral bodies. Long-term subsidence of the cage into the vertebral body leading to instrumentation failure has been reported with the use of expandable cages. To our knowledge, however, there are no reports of adjacent-level vertebral body fractures relatively in the early postoperative period. Four cases of adjacent-level vertebral body fractures after expandable cage placement are presented in this paper. We present these 4 cases not necessarily to discuss their surgical management with expandable cages, but rather to report that these adjacent fractures have all occurred similarly in the coronal plane.

Case Reports

Four patients underwent corpectomies by 3 different spine surgeons at our institution. Various types of cages were used. Fracture of the adjacent vertebral body was discovered in all cases postoperatively within 6 weeks.

Case 1

This 58-year-old male sustained an L-3 compression fracture after a motor vehicle accident. The patient was treated conservatively for 10 months, but he continued to have severe back pain. A kyphoplasty was considered, but the vertebral body had fractured in the coronal plane. The anterior portion of the vertebral body had separated from the posterior portion. This case was reviewed by 3 spine surgeons who believed that a kyphoplasty would not have been safe, and a corpectomy was recommended. The patient underwent an anterior retroperitoneal approach for an L-3 corpectomy. Reconstruction was performed using an expandable cage (Synex, Synthes Spine) and an anterior plate (TSLP, Synthes Spine) from L-2 to L-4. Arthrodesis was performed using vertebrectomy bone. At the 6-week follow-up the patient complained of pain, and a lateral radiograph showed a fracture through the L-2 vertebral body. A CT scan showed a coronal plane fracture through the L-2 vertebral body (Fig. 1).

The patient subsequently underwent anterior revision
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with removal of the cage, an L-2 corpectomy, placement of a larger expandable cage, and posterior segmental stabilization from T-12 to L-5.

Case 2

This 56-year-old female was involved in a motor vehicle accident 5 months prior to presentation. She subsequently developed back pain, and she fell 2 times from standing, exacerbating her pain. She presented to our institution, and a CT scan showed an L-3 burst fracture with 50% height loss and 60% canal compromise. She had severe back pain but no neurological deficit. The patient underwent a left anterior retroperitoneal approach for an L-3 corpectomy with expandable cage reconstruction (VLIFT, Stryker Spine) packed with vertebrectomy bone. A dual-rod anterior construct was placed from L-2 to L-4 (Xia, Stryker Spine). No posterior instrumentation was performed at this initial operation. Kyphosis was minimal. Six weeks later, the patient presented to the clinic with severe back pain. A plain lateral radiograph demonstrated possible cage migration, and a CT scan showed that the cage had actually fractured through the superior endplate of L-4 (Fig. 2). The patient was returned to the operating room for T-12 to L-5 posterior fixation and fusion and had a good outcome with relief of her back pain.

Case 3

This 84-year-old male presented with severe myelopathy and progressive quadripareisis. The patient had severe spinal cord compression behind the vertebral bodies at C4–5. He underwent a corpectomy of C-4 and C-5 with anterior column reconstruction using an expandable cage (VBR, Ulrich Medical). Anterior fixation was performed using an anterior cervical plate (Atlantis, Medtronic). On the postoperative lateral radiograph obtained the next day, it was noted that the patient had a vertebral fracture through the body of C-3 (Fig. 3). The patient was returned to the operating room 3 days after the initial operation, and the C-3 body was removed. A new expandable cage (VBR, Ulrich Medical) was placed from C-2 to C-6, and an anterior fixation was performed from C-2 to C-6 using a longer cervical plate (Atlantis, Medtronic).

Case 4

This 70-year-old female underwent cervical laminectomy for resection of a foramen magnum meningioma and then received postoperative radiation therapy. She noticed that 6 months later, she began to have difficulty ambulating and experienced leg weakness. A magnetic resonance image showed severe cord compression with kyphotic angulation. Surgery was undertaken to decompress her spinal cord and correct her deformity. She underwent C4–6 corpectomies with correction of kyphosis via anterior cage reconstruction (VBR, Ulrich Medical) and anterior cervical plating from C-3 to C-7 (Atlantis, Medtronic). Posterior

Fig. 1. Case 1. Sagittal CT reconstruction showing fracture in the coronal plane through the cephalad vertebral body.

Fig. 2. Case 2. Sagittal CT reconstruction showing fracture in the coronal plane through the caudal vertebral body.
fixation was planned during the same hospitalization. Lateral radiographs and CT scans after the first stage of surgery had demonstrated that the cage had migrated and fractured through the body of C-7 (Fig. 4). The patient was returned to the operating room 11 days postoperatively for a corpectomy at C-7 and posterior instrumented fusion from C-3 to T-1. Two days later, the patient underwent additional posterior fixation from C-1 to T-2.

**Discussion**

Interbody fusion techniques are increasingly used in the treatment of a variety of disorders such as degenerative disease, trauma, tumor, and infection. Allografts and autografts used alone for interbody fusion were associated with failures, especially of the lumbar segment. Because of these failures and associated donor-site morbidity of autograft harvest, alternative techniques were sought.

Various types of interbody cages were subsequently developed, and published fusion rates with these cages ranged from 78 to 97%. Placement of these fusion cages was not without complications. Subsidence of mesh cages into adjacent vertebral bodies has been documented, especially in the setting of poor vertebral body bone quality.

Initial experiences of vertebral body replacement with expandable cages has yielded good results. As the use of expandable cages increases, however, complications arise. Instrumentation failure has been reported with the use of expandable cages, and in patients with osteoporosis, significant subsidence of the cage (> 5 mm) occurs in as many as 17%. In the 4 patients presented in these case reports, 2 fractures were in the lumbar spine, and 2 were in the cervical spine. Different types of cages were used in the lumbar spine (Synex and VLIFT cages), whereas the VBR cage was used in both cases involving the cervical spine.

The lumbar spinal fractures all occurred relatively soon after surgery. Symptom presentation included severe pain in the back and dislodgement noted on radiographs within 6 weeks. In the lumbar spine there was no vascular injury secondary to fracture and dislodgement. The CT images demonstrated that 3 of the 4 fractures were in the coronal plane, including both involving the lumbar spine, with 1 fracture plane connecting into the inferior fixation holes of the screw rod or screw plate constructs. Two common elements in the lumbar cases are that both were anterior constructs without posterior fixation and both were treated at L-3 for vertebral body fractures. Fractures of the L-3 verte-

**Fig. 3.** Case 3. Immediate postoperative radiograph *(left)* showing the intact C-3 vertebral body and a postoperative radiograph obtained 2 days later *(right)* showing the fracture of C-3 and the failure of the construct.

**Fig. 4.** Case 4. Sagittal CT reconstruction showing a fracture through the C-7 vertebral body.
bral body are common fractures because of its low compressive strength compared with other lumbar levels.\textsuperscript{3,17} In addition, there is increased segmental motion (flexion and extension) at the L3–4 level compared with high lumbar levels.\textsuperscript{3,17} The combination of low compressive strength and increased segmental motion locations may place increased stress at the L-3 level.

The 2 cervical spine fractures also occurred relatively soon after surgery. In both cases, multilevel corpectomies had been performed, and the fractures were identified within days. Posterior instrumentation had not yet been performed but had been planned in these cases. The multilevel corpectomies, coupled with the osteoporotic bone, would necessitate posterior instrumentation. Given the extreme forces generated by these cages, posterior instrumentation should be considered during the same anesthesia procedure.

We hypothesize that these fractures occur for 3 reasons. The first reason is the expandable nature of these cages. The forces that are generated by these cages can be quite significant, and this force ultimately may result in failure of the endplate to resist it.

The second reason is the actual placement of the cage against the endplate. Because of the expandable nature of these cages, these cages can be placed quite securely with only 1 corner of the cage against the vertebral body. The entire footprint of the cage does not necessarily need to be against the endplate for the cage to expand and wedge securely. This feature applies a tremendous amount of concentrated force at 1 point on the endplate instead of distributing it over a larger area, which may create a stress riser. In addition, the screw fixation below or above the cage also may create a point of weakness in the bone immediately subjacent to the stress riser, resulting in the fracture through this area (Fig. 5). This scenario probably accounts for the coronal nature of the fracture through the vertebral body. In a biomechanical study by Kumar and colleagues,\textsuperscript{10} the greatest resistance to penetration of a vertebral body was determined to be the first 4 mm of depth and the endplate was found to be strongest at the periphery closer to the cortical margin. If the edge of a cage end-cap breaches this depth due to the proposed scenario, the weaker, trabecular bone would be encountered, potentially resulting in fracture (Fig. 6). The failure pattern observed with these expandable cages is a coronal plane vertebral body fracture with essentially complete destruction of the structural integrity of the adjacent vertebral body, which is in contrast to the failure pattern noted with nonexpandable cages (subsidence and endplate kick-out).

The third possible reason is bone quality. Nearly all of these patients had some component of osteoporosis or osteopenia, and this probably contributed to the fracture. In fact, in a recent report of anterior expandable cage replacement for osteoporotic vertebral body collapse,\textsuperscript{16} subsidence of the expandable cage into the adjacent vertebral body was observed in 4 of 28 patients. It is conceivable that a combination of osteoporosis, cage placement against the endplate, and significant force from expansion all contributed to adjacent-level vertebral body fracture. In patients who are osteoporotic, the additional use of posterior instrumentation should be seriously considered. In our 2 cases of lumbar fracture, immediate posterior fixation may have helped prevent the fractures.

Although further studies need to be performed to analyze the exact cause of these adjacent-level fractures, we have now made some adjustments to our practices for placing expandable cages. We now expand the cage to securely wedge the cage, but we try not to overexpand it by forcing the cage open beyond a reasonable level. One potential reason for these fractures is that we routinely expand these cages to either restore height or correct kyphosis. This expansion results in tremendous forces and most likely contributed to the fractures. We also thoroughly ensure proper endplate preparation for increased endplate-to-footprint contact. There is a balance between shaving off too much endplate and not having the cage seated properly, but we believe that better endplate contact may ultimately help prevent these fractures. Finally, many of the newer cage designs offer greater varieties of endplate angulation that may also be helpful in this area. In patients who are osteoporotic with poor bone quality, posterior fixation is also considered. In cases of severe osteoporosis, anterior vertebral cement augmentation can be performed prior to cage expansion to further prevent cage fracture and subsidence.
General considerations should be undertaken when considering the use of expandable cages. Many expandable cages have set lordotic angles, and this may preclude proper endplate-to-cage contact. If only a small part of the cage contacts the endplate, it could create a stress riser, which could lead to a fracture. This should be considered in very lordotic areas such as L-5 or S-1. Cage expansion should be extremely gentle in patients who are osteoporotic. If 1 of these fractures were to necessitate a revision, then a corpectomy of the fractured adjacent segment is usually performed. This operation could prove to be a difficult approach in the retroperitoneal area, and surgery (if chosen) should be performed early before much scar tissue forms. Posterior instrumentation should also be performed if a fracture needs to be revised.

Conclusions

Expandable cages can cause adjacent-level vertebral body fractures. The mechanism for this fracture is probably multifactorial, and further studies need to be performed. The failure pattern in expandable cages appears to be more destructive than the failure pattern observed with nonexpandable cages. Care should be taken to avoid aggressive cage expansion, especially in patients who are osteoporotic and in cases in which the cage-to-endplate contact is less than ideal.

References


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