Fracture of the L-4 vertebral body after use of a stand-alone interbody fusion device in degenerative spondylolisthesis for anterior L3–4 fixation

Case report

Yoon-Kwang Kwon, M.D.,¹ Ju-Hee Jang, M.D.,² Choon-Dae Lee, M.D.,¹ and Sang-Ho Lee, M.D., Ph.D.³

Departments of ¹Neurosurgery and ²General Surgery, Daegu Wooridul Spine Hospital, Daegu; and ³Department of Neurosurgery, Wooridul Spine Hospital, Seoul, Korea

Many studies attest to the excellent results achieved using anterior lumbar interbody fusion (ALIF) for degenerative spondylolisthesis. The purpose of this report is to document a rare instance of L-4 vertebral body fracture following use of a stand-alone interbody fusion device for L3–4 ALIF. The patient, a 55-year-old man, had suffered intractable pain of the back, right buttock, and left leg for several weeks. Initial radiographs showed Grade I degenerative spondylolisthesis, with instability in the sagittal plane (upon 15° rotation) and stenosis of central and both lateral recesses at the L3–4 level. Anterior lumbar interbody fusion of the affected vertebrae was subsequently conducted using a stand-alone cage/plate system. Postoperatively, the severity of spondylolisthesis diminished, with resolution of symptoms. However, the patient returned 2 months later with both leg weakness and back pain. Plain radiographs and CT indicated device failure due to anterior fracture of the L-4 vertebral body, and the spondylolisthesis had recurred. At this point, bilateral facetectomies were performed, with reduction/fixation of L3–4 by pedicle screws. Again, degenerative spondylolisthesis improved postsurgically and symptoms eased, with eventual healing of the vertebral body fracture. This report documents a rare instance of L-4 vertebral body fracture following use of a stand-alone device for ALIF at L3–4, likely as a consequence of angular instability in degenerative spondylolisthesis. Under such conditions, additional pedicle screw fixation is advised.

Key words • anterior lumbar interbody fusion • stand-alone cage • complication • spondylolisthesis

Abbreviation used in this paper: ALIF = anterior lumbar interbody fusion.
anulotomy was performed via a retroperitoneal approach to remove the anterior longitudinal ligament. There was no sign of osteoporosis. Using a Cobb elevator, the endplate was prepared by curettage (without endplate violation) for placement of the cage (width 26.32 mm, height 13.5 mm, rotation 12°) in the anterior L3–4 intervertebral disc space. Insertion and screw fixation proceeded without difficulty. Following surgery, the degenerative spondylolisthesis abated and symptoms resolved.

Unfortunately, the patient returned 2 months later with both leg weakness and back pain. By manual muscle testing, significant ankle dorsiflexion (Grade 3) was noted bilaterally. Plain radiographs and CT showed failure of the device due to anterior L-4 vertebral body fracture, and the spondylolisthesis had recurred (Fig. 2 A and B). Bilateral facetectomies were then performed, with reduction and fixation at L3–4 by pedicle screws (Fig. 2C). Again, degenerative spondylolisthesis improved postsurgically and symptoms eased, with eventual healing of the vertebral body fracture.

Discussion

Degenerative spondylolisthesis is characterized by degenerative change of the intervertebral disc and facet joints, with anterior slippage of one vertebral body over another in the presence of an intact neural arch. Surgical intervention is aimed at neural decompression, restoration of stability, and a return to normal lumbar lordosis. In this respect, fusion provides a better clinical outcome than decompression alone. Furthermore, an anterior approach enables direct access to the disc space (with minimal neural disruption), allows a more expansive fusion bed, and minimizes the vulnerability of posterior structures.

Interbody cages have subsequently enjoyed preferential status, surpassing posterior lateral fusion in usage rate. However, targeted studies have questioned the inherent stability of such devices. When Tsantrizos et al. compared the initial segmental stability conferred by 5 assorted stand-alone cages, the multidimensional and complex influence of cages on initial stability was illuminated. Reduced range of motion was routinely found, increasing the neutral zone in all loading directions. It was also apparent that residual range of motion relies on the extent of micromotion at the cage-endplate interface. Prior publications additionally have shown that the stability of a cage is acceptable in axial compression and flexion, but not in extension and rotation. Such destabilization in extension has been ascribed to the postoperative absence of structures otherwise active in loading conditions, such as the anterior longitudinal ligament, the anterior portion of the annulus, and the nucleus pulposus.

Because inadequate segmental immobilization during bone healing is claimed as the chief mechanical basis for nonfusion, supplemental posterior fixation via pedicle...
screws or translaminar screw systems has been advocated to bolster stability in extension and rotation. Indeed, such efforts have boosted fusion rates. Stand-alone cages with intrinsic plates and screws have also been developed to address needed restoration of the anterior tension band. Cage stability in flexion, extension, and lateral bending now compares favorably with pedicle screw fixation and is superior with respect to rotation. Strube et al. have affirmed that a stand-alone ALIF device produces better clinical results in degenerative lumbar disease compared with ALIF via pedicle screw fixation. The Synthes SynFix-LR, in particular, is a stand-alone cage approved by the FDA for use in patients with degenerative disc disease in which 1 or 2 contiguous levels from L-2 to S-1 are involved, with no more than Grade I spondylolisthesis at affected sites.

The titanium alloy plate of an interbody cage is typically equipped with an elastic modulus of 110,000 MPa (as opposed to polyetheretherketone spacers of 3500–4000 MPa). Similar to bone, this construct prevents uneven load distribution and thus unwanted remodeling, although higher forces applied to the rigid titanium will trigger bone remodeling. A stress riser then develops at the edges of denser bone, carrying the potential for subsidence or fracture. The highest pressures anticipated are those during flexion, and they are concentrated at the anterior margin of the cage. With extension, the vertebral body tends to lift off from the cage body so that most of the stress is born by screws at the stabilization plate junction. Lastfogel et al. have speculated that a combination of forces on inferior screws may be one of the factors predisposing to failure of this device.

In mapping the structural properties of lumbosacral vertebral endplates, Grant et al.9 discovered that lateral margins were stronger than central areas, both anteriorly and posteriorly. Likewise, inferior lumbar endplates were significantly stronger and stiffer than their superior counterparts. A lack of facet joint resistance to anterior shear force and weakness of the superior endplate of the lower lumbar vertebral body led to lower vertebral body vertical fracture for our patient, even though the cage was positioned in the anterior disc space. Titanium plates should therefore be anchored on the anterior bone cortices of upper and lower vertebral bodies (to be fused), and the screws should be tightly affixed to this cortical bone.

Degeneration of both intervertebral disc and facet joints appears to impact segmental motion in degenerative spondylolisthesis. Sources variably attribute degenerative spondylolisthesis to more sagittal positioning of facet joints and pedicle-facet angles, W-shaped facet joints, facet joint arthropathy, and excess facet joint bulk. Still others view disc degeneration as the initial event in degenerative spondylolisthesis, with a rise in facet joint pressure due to diminished disc height leading to arthropathy and then anterolisthesis through sagittal instability. When slippage does occur, the kinematics of the spine in degenerative spondylolisthesis are significantly altered, culminating in a clearly pathological state and clinical symptoms.

According to Lastfogel et al., the shear force transferred to the disc in isthmic spondylolisthesis actually promotes disc degeneration and slippage of the vertebral body, with loss of the posterior element. Miao et al. also offer evidence that shortened intervertebral disc heights and thus disc motion patterns deviate from normal during flexion and extension in patients with degenerative spondylolisthesis. Similarly, their observed trend toward larger translations in degenerative spondylolisthesis underscores that the motion of discs inferior to slipped vertebrae increases as well, for less efficient limiting of anterior-posterior translation in slipped vertebrae. These findings are supported by contentions of Fujisawa et al. that disc degeneration and facet joint osteoarthritis affect anterior translatory instability and axial rotation, and by Sharma et al., who maintain that facets are important in resisting the anterior shear displacements that accompany flexion and restricting rotations on extension. Finally, work by Serhan et al. on the biomechanics of posterior lumbar articulating elements in turn reveals a much greater contribution by the posterior column than by the anterior column relative to shear stiffness. Hence, angular instability due to degeneration of facet joints in degenerative spondylolisthesis may create excessive compression and shear load anteriorly, resulting in failure of stand-alone cages secured only by intrinsic plates and screws.

Conclusions

This report documents a rare instance of L-4 vertebral body fracture following use of a stand-alone device for ALIF at L3–4, likely as a consequence of angular instability in degenerative spondylolisthesis. Under such conditions, additional pedicle screw fixation is advised. However, further biomechanical study is warranted in this setting.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Jang, Kwon. Acquisition of data: Jang, Kwon. Analysis and interpretation of data: Jang, Kwon. Drafting the article: Jang, Kwon. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Jang. Statistical analysis: Kwon. Administrative/technical/material support: Kwon. Study supervision: Kwon.

References


