ELSEVIER

The Spine Journal 10 (2010) e11–e15

THE SPINE JOURNAL

Case Report

Vertebral body fracture after anterolateral instrumentation and interbody fusion in two osteoporotic patients

Karan Dua, BA, Christopher K. Kepler, MD, MBA, Russel C. Huang, MD*, Anna Marchenko, BA

Department of Orthopaedic Surgery, Hospital for Special Surgery, 535 East 70th St, New York, NY 10021, USA

Received 6 October 2009; revised 8 June 2010; accepted 7 July 2010

Abstract

BACKGROUND CONTEXT: The XLP plate is an anterolateral instrumentation system developed as a part of the eXtreme Lateral Interbody Fusion (XLIF) system for lateral transpsoas interbody fusion, an alternative to anterior interbody fusion.

PURPOSE: To report two cases of atraumatic coronal plane vertebral body fractures in the early postoperative period after interbody fusion using XLIF cages, lateral plating using the XLP plate, and unilateral posterior pedicle screw instrumentation.

STUDY DESIGN: Case report.

METHODS/SUMMARIES: Both patients were septuagenarian women with normal body mass indices and osteoporosis. The patients underwent L4–L5 XLIF with anterolateral instrumentation followed by posterior decompression and fusion using unilateral pedicle screws. In the early postoperative period (≤6 weeks), the patients developed acute onset of severe low back pain without history of trauma. Imaging demonstrated coronal plane vertebral body fracture through the screw hole of the XLP plate in the superior vertebral body in one case and the inferior vertebral body in the other. One patient required kyphoplasty at the L4 level for pain relief. The other was treated conservatively. The nondisplaced fractures went on to union with pain resolution and successful fusion in both patients.

RESULTS: Coronal plane fractures occurred in 2 of 13 patients treated by the senior author using XLIF, the XLP plate, and unilateral pedicle screw instrumentation. Osteoporosis was likely a contributing factor in both patients. One potential mechanism for this unusual fracture pattern is subsidence of the cage with resultant cut-through of the fixed-angle screws through the osteoporotic vertebral body. Alternately, the fracture could have resulted from the stress riser created by the screw hole traversing an area of relative stress concentration directly adjacent to the cage.

CONCLUSION: Coronal plane vertebral fracture may occur in osteoporotic patients treated with XLIF and XLP lateral instrumentation. Unilateral pedicle screw instrumentation does not prevent this complication.

Keywords: Interbody fusion; Vertebral fracture; Complication; XLIF

Introduction

Lateral transpsoas interbody fusion (LTIF) is a minimally invasive technique using a direct lateral retroperitoneal approach for lumbar interbody fusion and instrumentation. A preliminary report demonstrated a low complication rate in a small patient cohort [1]. The interbody cages developed for use with this technique have an inherent stability unlike previous designs. Because of this improved stability as a result of a technique that preserves the anterior longitudinal ligament and allows the cage to rest on apophyseal bone, less robust forms of fixation are being used such as stand-alone cages, unilateral pedicle screw fixation, anterior plating, or some combination thereof.

The XLP plate (NuVasive, Inc., San Diego, CA, USA) is an anterolateral instrumentation system developed for use with the eXtreme Lateral Interbody Fusion (XLIF; NuVasive, Inc.) system for LTIF. Biomechanical data demonstrate that the XLP plate increases construct stiffness when used in conjunction with the XLIF interbody cage

FDA device/drug status: not applicable.

Author disclosures: RCH (other, NuVasive, Inc.).

* Corresponding author. Hospital for Special Surgery, Department of Orthopaedic Surgery, Weill Cornell Medical College, 535 East 70th St, New York, NY 10021, USA. Tel.: (212) 606-1634; fax: (212) 774-7130.

E-mail address: huangr@hss.edu (R.C. Huang)

1529-9430/$ - see front matter
doi:10.1016/j.spinee.2010.07.007

compared with a stand-alone interbody cage [2]. There are data on the efficacy and complications associated with anterolateral lumbar instrumentation [3–7], but the clinical performance of anterolateral instrumentation systems used in association with LTIF has not been reported. This is a case report of two osteoporotic patients who developed coronal plane vertebral body fractures after LTIF with anterolateral plate fixation and posterior unilateral pedicle screw fixation.

Case 1 (BF)

BF is a 73-year-old woman presenting with bilateral leg pain, neurogenic claudication, and low back pain in October 2007 who had failed nonsurgical treatment. The patient's height was 5′1″ and weight was 117 pounds (body mass index: 22.1). Preoperative radiographs, magnetic resonance imaging, and computed tomography (CT) demonstrated L4–L5 anterolisthesis (Fig. 1) with accentuation of anterolisthesis in the standing position compared with supine and severe L4–L5 central and subarticular lateral recess stenosis. Osteopenia was evident on X-ray and CT. Dual-energy X-ray absorptiometry scanning demonstrated a femoral neck *T* score of −3.6, indicative of severe osteoporosis.

The patient had surgery: L4–L5 LTIF with anterolateral instrumentation and lateral iliac autograft, minimally invasive decompression, and unilateral fusion/instrumentation. Her initial postoperative course was unremarkable, and she mobilized well with resolution of leg pain and mild low back pain. Three weeks postoperatively, without inciting trauma, the patient developed acute severe low back pain and was unable to ambulate because of pain. Computed tomography scan demonstrated coronal plane fracture of the L4 vertebral body through the track of the lateral plate screw (Fig. 2) and approximately 4 mm of subsidence of the cage into the end plate. To speed mobilization, kyphoplasty of the L4 vertebral body was performed (Fig. 3). The patient had prompt improvement in low back pain and mobilized routinely. At 6-week follow-up, she was able to ambulate 30 to 40 minutes without pain. At 1-year follow-up, the patient had lasting resolution of leg pain, mild chronic low back pain, and solid interbody fusion on CT scan (Fig. 4).

Fig. 1. Computed tomography scan image demonstrating preoperative L4–L5 anterolisthesis and intact vertebral bodies before index surgery.

Fig. 2. Computed tomography scan image demonstrating coronal plane fracture of the L4 vertebral body through the track of the lateral plate screw.

Case 2 (BL)

BL is a 74-year-old woman presenting with bilateral leg pain, neurogenic claudication, and low back pain in March 2008 who had failed nonsurgical treatment. The patient's height was 5′1″ and weight was 115 pounds (body mass index: 21.7). Preoperative radiographs, magnetic resonance imaging, and CT demonstrated L4–L5 severe stenosis and anterolisthesis. Osteopenia was evident on X-ray and CT.

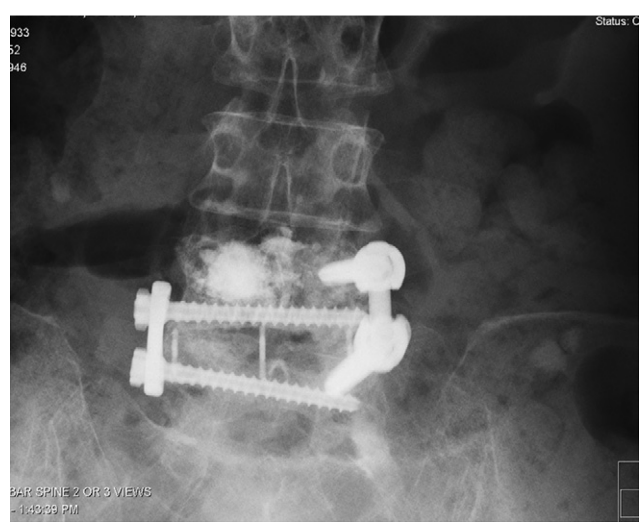

Fig. 3. Radiograph of Patient 1 after kyphoplasty of L4 to address pain associated with fracture.

Fig. 4. (Top) Sagittal and (Bottom) coronal computed tomography scan images demonstrating interbody fusion at L4–L5 at 1 year after the initial surgery.

Dual-energy X-ray absorptiometry scanning demonstrated a femoral neck *T* score of −2.61, indicative of osteoporosis.

The patient had surgery: L4–L5 LTIF with anterolateral instrumentation and iliac crest bone grafting, minimally invasive decompression, and unilateral posterior instrumentation/fusion. Her initial postoperative course was unremarkable, and she mobilized well with resolution of leg pain and mild low back pain. Six weeks postoperatively, without inciting trauma, the patient developed acute severe low back and left-sided pelvic pain. Ambulation was possible but limited because of pain. Computed tomography scan at that time demonstrated a nondisplaced fracture of the ilium propagating from the iliac crest harvest site, a nondisplaced coronal plane fracture of the L5 vertebral body propagating from the lateral plate screw track, and subsidence of the cage into the L5 vertebral body by 3 mm. The patient had improvement in low back and pelvic pain and mobilized gradually. At 3-month follow-up, low back and pelvic pain were mild. At 6-month follow-up, pelvic pain was resolved and low back pain was mild. At 1-year follow-up, the patient's leg pain has resolved and she had mild low back pain. The patient recently underwent CT scan, which demonstrated solid fusion at L4–L5.

Discussion

Lateral transpsoas interbody fusion is a minimally invasive technique for lumbar interbody fusion via lateral retroperitoneal approach. The interbody cage developed for LTIF is biomechanically distinct from cages used for anterior or posterior lumbar interbody fusion. This is the first report, to our knowledge, of instrumentation complications after LTIF.

The polyetheretherketone cage used with XLIF is placed from the lateral aspect of the vertebral body and is wide enough to span the entire width of the vertebra so that it rests on apophyseal bone on either side. This provides a biomechanical advantage as the peripheral apophyseal bone is significantly stronger than the central cancellous bone [8,9], which is used to provide support for interbody fusion devices used in posterior or anterior approaches. In contrast to the anterior approach to the spine, LTIF additionally allows preservation of the anterior longitudinal ligament. Because of the XLIF implant's inherent stability, many surgeons use the cage with alternative forms of fixation, including anterior plate fixation or unilateral posterior pedicle screw fixation, or as a stand-alone implant. In both cases reported above, interbody fusion using the XLIF cage was recommended to increase fusion rate in comparison to posterolateral fusion and to indirectly decompress severe foraminal stenosis because of disc collapse associated with spondylolisthesis.

Both clinical cases outlined in this report used the XLP lateral plate (NuVasive, Inc.), which is designed for use with the XLIF cage. Both patients had unilateral posterior pedicle screw instrumentation. The XLP lateral plate is made of titanium and is fixed to the lateral vertebral bodies using two screws that lock into the plate, creating a fixed-angle construct. No data have been published on the clinical efficacy of this plate because of its recent introduction. Unilateral posterior fixation was used in patients undergoing a single-level lumbar fusion, which was amenable to LTIF based on the level (above L5–S1) without spondylolisthesis, which would have precluded placement of either the XLIF cage or the XLP plate because of insufficient anteroposterior overlap and bony support between adjacent vertebral bodies. Previous clinical studies have demonstrated the efficacy of unilateral posterior fixation in single-level lumbar fusion [10,11]. Because of the stability and fixation provided by the lateral plate on one side of the vertebral body, unilateral pedicle screw fixation was used on the nonplated side to provide additional contralateral stabilization. In addition, posterior screws are harder to place on the plated side because of the potential for interference with the screws and screw trajectory of the lateral plate fixation.

The senior author (RCH) has treated 13 patients using the XLIF cage with the XLP plate and posterior unilateral pedicle screw fixation. Of these 13 patients, 2 (15%) developed coronal plane fractures in the early postoperative period. Both patients had osteoporosis, a likely contributing factor.

Two biomechanical scenarios may have resulted in this fracture pattern. As shown by Palm et al. [12], interbody fusion cages concentrate stress at the interface between the cage and the adjacent end plates. When using the XLP, screws are placed in close proximity directly above and below the cage. This places a stress riser in an area of stress concentration, possibly resulting in fracture.

A second explanation for the coronal plane fracture seen in these patients is related to the fixed-angle nature of the XLP plate. If the XLIF cage subsides into the vertebral end plates, some settling of the instrumented segment and loss of disc height will result. The XLP plate screws are rigidly locked to the plate and cannot toggle or settle. As the disc space loses height, the screws would tend to cut through the vertebral bodies in the coronal plane, leading to fracture. In a cadaveric study comparing fixed-angle with non–fixed-angle anterior plating, Disch et al. [13] observed a similar pattern of fixation failure after fixed-angle plating.

Although there are limited data on the failure of anterior instrumentation in osteoporotic bone, the performance of pedicle screws with variations in bone mineral density has been described. Halvorson et al. [14] reported on the pullout force of pedicle screws in normal and osteoporotic cadaveric spines. The pullout force for screws in spines with normal bone mineral density was more than seven times higher than the force needed for uniaxial screw failure in osteoporotic bone regardless of whether the screw hole was tapped before insertion. Burval et al. [15], Cook et al. [16], and Coe et al. [17] have found similar relationships between pedicle screw pullout strength in osteoporotic versus normal cadaveric spine specimens although the magnitude of this effect varied. Screw fixation in vertebral bodies relies heavily on cancellous bone density [18], the portion of bone most severely affected by osteoporosis.

Complications after anterior spinal instrumentation have been reported by other authors. Kaneda et al. [3] described 150 patients who underwent lateral instrumentation using the Kaneda device after corpectomy for burst fracture. Although the series included nine patients who had instrumentation failure (all with hardware breakage), there were no vertebral body fractures reported. Chou et al. [19] reported four patients who had adjacent-level coronal plane vertebral body fractures after corpectomy reconstruction with expandable cages. The two lumbar fractures in this series occurred after placement of expandable cages with anterolateral instrumentation. The authors attributed the fractures to high axial compressive loads transmitted to the end plates by expandable cages and the stress riser created by screw holes adjacent to the end plate, one of the mechanisms proposed for the fractures described in the present report. Additionally, the patients included in the Chou series had low bone mineral density. The authors recommended posterior instrumentation or vertebral cement augmentation in osteoporotic patients to reduce the incidence of fracture.

The cases presented here, however, suggest that posterior instrumentation alone may not prevent coronal plane vertebral fractures. The stability provided by bilateral pedicle screw fixation may be sufficient as to render additional anterior fixation unnecessary and avoiding creation of a stress riser in the vertebral body although this statement has not yet been proven by biomechanical or clinical investigation. Based on our experience, anterior plating should be used with caution in osteoporotic patients because of the risk of vertebral body fracture.

Conclusion

We report two cases of coronal plane vertebral body fracture after LTIF, lateral fixed-angle instrumentation, and unilateral pedicle screw fixation. Lateral plate instrumentation should be used with caution in osteoporotic patients.

References

[1] Ozgur BM, Aryan HE, Pimenta L, Taylor WR. Extreme lateral interbody fusion (XLIF): a novel surgical technique for anterior lumbar interbody fusion. Spine J 2006;6:435–43.

[2] Bess RS, Bachus KN, Vance R, et al. Biomechanical evaluation of lumbar constructs using eXtreme lateral interbody fusion (XLIF®). 2007. Abstract presented at International Meeting on Advanced Spine Techniques, Paradise Island, Bahamas, July 2007.

[3] Kaneda K, Taneichi H, Abumi K, et al. Anterior decompression and stabilization with the Kaneda device for thoracolumbar burst fractures associated with neurological deficits. J Bone Joint Surg Am 1997;79:69–83.

[4] Thalgott JS, Kabins MB, Timlin M, et al. Four year experience with the AO anterior thoracolumbar locking plate. Spinal Cord 1997;35:286–91.

[5] Klopfenstein JD, Kim LJ, Feiz-Erfan I, Dickman CA. Retroperitoneal approach for lumbar interbody fusion with anterolateral instrumentation for treatment of spondylolisthesis and degenerative foraminal stenosis. Surg Neurol 2006;65:111–6; discussion 116.

[6] Scheufler KM. Technique and clinical results of minimally invasive reconstruction and stabilization of the thoracic and thoracolumbar spine with expandable cages and ventrolateral plate fixation. Neurosurgery 2007;61:798–808; discussion 808–9.

[7] Aryan HE, Lu DC, Acosta FL Jr, Ames CP. Stand-alone anterior lumbar discectomy and fusion with plate: initial experience. Surg Neurol 2007;68:7–13; discussion 13.

[8] Rockoff SD, Sweet E, Bleustein J. The relative contribution of trabecular and cortical bone to the strength of human lumbar vertebrae. Calcif Tissue Res 1969;3:163–75.

[9] Steffen T, Tsantrizos A, Aebi M. Effect of implant design and endplate preparation on the compressive strength of interbody fusion constructs. Spine 2000;25:1077–84.

[10] Kabins MB, Weinstein JN, Spratt KF, et al. Isolated L4-L5 fusions using the variable screw placement system: unilateral versus bilateral. J Spinal Disord 1992;5:39–49.

[11] Suk KS, Lee HM, Kim NH, Ha JW. Unilateral versus bilateral pedicle screw fixation in lumbar spinal fusion. Spine (Phila Pa 1976) 2000;25:1843–7.

[12] Palm WJ IV, Rosenberg WS, Keaveny TM. Load transfer mechanisms in cylindrical interbody cage constructs. Spine 2002;27:2101–7.

[13] Disch AC, Knop C, Schaser KD, et al. Angular stable anterior plating following thoracolumbar corpectomy reveals superior segmental stability compared to conventional polyaxial plate fixation. Spine 2008;33:1429–37.

[14] Halvorson TL, Kelley LA, Thomas KA, et al. Effects of bone mineral density on pedicle screw fixation. Spine 1994;19:2415–20.

[15] Burval DJ, McLain RF, Milks R, Inceoglu S. Primary pedicle screw augmentation in osteoporotic lumbar vertebrae: biomechanical analysis of pedicle fixation strength. Spine 2007;32:1077–83.

[16] Cook SD, Salkeld SL, Stanley T, et al. Biomechanical study of pedicle screw fixation in severely osteoporotic bone. Spine J 2004;4:402–8.

[17] Coe JD, Warden KE, Herzig MA, McAfee PC. Influence of bone mineral density on the fixation of thoracolumbar implants. A comparative study of transpedicular screws, laminar hooks, and spinous process wires. Spine (Phila Pa 1976) 1990;15:902–7.

[18] Gilbert SG, Johns PC, Chow DC, Black RC. Relation of vertebral bone screw axial pullout strength to quantitative computed tomographic trabecular bone mineral content. J Spinal Disord 1993;6:513–21.

[19] Chou D, Lu DC, Weinstein P, Ames CP. Adjacent-level vertebral body fractures after expandable cage reconstruction. J Neurosurg Spine 2008;8:584–8.