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Failure of Cement-Augmented Pedicle Screws in the Osteoporotic Spine: A Case Report

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Abstract

The treatment of patients with osteoporosis and spinal abnormalities that require surgical intervention is difficult because of the challenge of achieving fixation in osteoporotic bone. As the population ages, this challenge is becoming a common problem in the field of spinal surgery. Although numerous publications exist about the biomechanical benefits of various fixation devices and techniques, no standard of care has emerged that offers a clear method for accomplishing spinal stabilization in such patients. This case presents the failure mode of cement-augmented pedicle screws in a patient with severe osteoporosis, a description of the methods used to attain fixation and spinal stability during the revision surgery, and the outcome achieved for the patient 1 year after surgery. An 82-year-old female with a T9 burst fracture and a history of osteoporosis underwent minimally invasive instrumentation from T5 to T12, fusion from T7 to T11, and decompression from T8 to T10. Four weeks after surgery, the patient returned to the hospital because of back pain. Imaging studies showed that the pedicle screws at T11 and T12, which were augmented with polymethylmethacrylate (PMMA), had pulled out of the vertebral bodies. The pedicle screws failed by disengaging from the PMMA and displacing posteriorly and inferiorly. The PMMA did not appear to move during this process. A revision surgery was performed, in which the posterior construct was extended caudally and cephalad, the pedicle screws were augmented with PMMA, and a titanium hook and woven polyester band were used to increase the points of fixation. At 1-year follow-up after revision, our patient showed radiographic evidence of fusion, and the construct continued to maintain stability in the osteoporotic spine.

Keywords

osteoporosis, bone cement, polymethylmethacrylate, cement augmentation, pedicle screw, failure

Introduction

Osteoporosis, which is primarily a disease of aging, affects 10 million people in the United States and causes bone to lose structural integrity because of decreases in bone mineral density.[1] The decline in bone mineral density is associated with an imbalance in bone formation and resorption. This imbalance causes a reduction in bone mass, resulting in an increased susceptability to fractures. Osteoporosis-related fractures occur in 1.5 million people annually in the United States and comprise fractures of the hip, wrist, and vertebra (14.8%, 14.9%, and 22.2%, respectively).[2] Unfortunately, many of these fractures require surgical intervention and fixation with hardware. Recently, Ponnusamy et al[3] reviewed and provided a comprehensive discussion of the devices and methods used to achieve fixation in the osteoporotic spine. However, a new technique has emerged that uses bone cement to anchor pedicle screws within the osteoporotic vertebral bodies. We report a case of a patient with an osteoporotic spine who experienced failure of cement-augmented pedicle screws and underwent successful revision surgery. Our goal was to detail our experience with the failure of a cement-augmented pedicle screw construct and how we approached fixation in this severely osteoporotic spine. Because of the increasing prevalence of osteoporosis, finding strategies to aid surgical fixation within the aging spine is an important topic within geriatric medicine.

Case Report

Institutional review board approval was not required for this study. An 82-year-old female with a medical history of Parkinson

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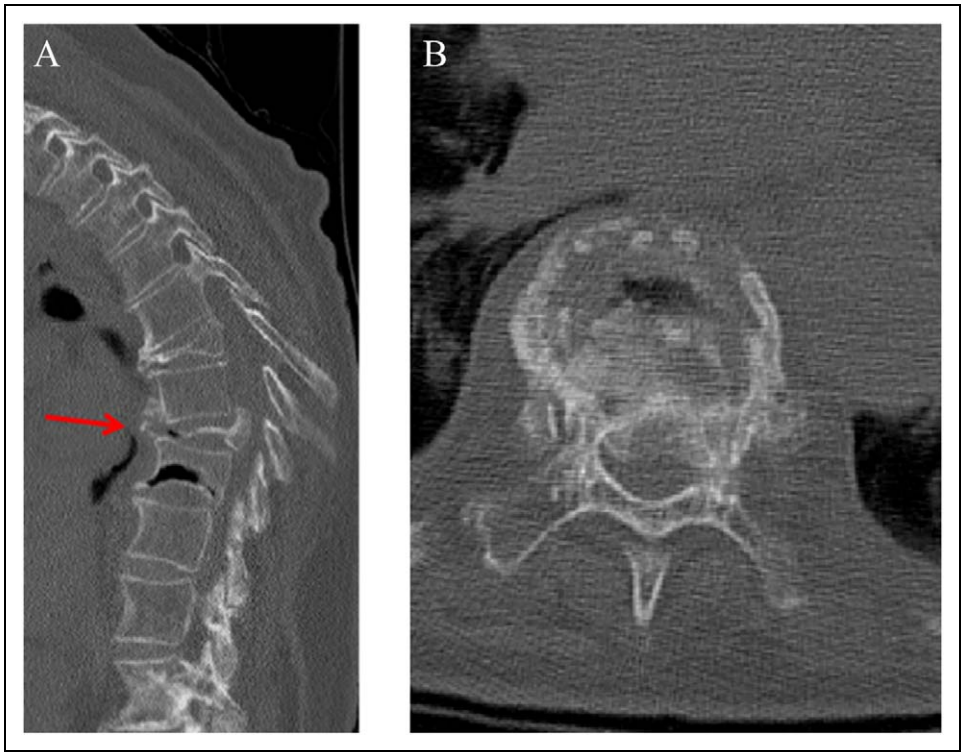

Figure 1. Computed tomography images of the T9 burst fracture with retropulsion into the spinal canal and cord compression. A, This sagittal computed tomography image shows a T9 burst fracture (arrow) with retropulsion into the spinal canal. B, Axial computed tomography image showing the retropulsion into the spinal canal.

disease and osteoporosis was referred to our office for evaluation of persistent back pain and difficulty with ambulation. She had decreased sensation in the T9 and T10 distribution and symptoms consistent with T9 and T10 radiculopathy. Imaging studies showed a T9 burst fracture with cord compression (Figure 1). She underwent minimally invasive instrumentation via pedicle screws from T5 to T12, fusion from T7 to T11, and decompression from T8 to T10 (Viper system; DePuy Spine, Raynham, Massachusetts). During this procedure, the pedicle screws at T5, T6, T11, and T12 were augmented with polymethylmethacrylate (PMMA). The construct was extended to T5 because of a compression fracture at T7 and to avoid proximal junction kyphosis. The patient tolerated the procedure well and had no immediate postoperative complications.

At 4 weeks, the patient complained of right-side thoracic back pain. Imaging studies indicated that the pedicle screws on the right side at T11 and T12 had failed at the cement–screw interface and displaced posteriorly and inferiorly (Figure 2).

At 7 weeks after the index surgery, open surgery was performed to remove the failed construct and to stabilize the spine. On visual inspection and probing, the pedicle at T11 appeared structurally intact despite the failure of the pedicle screw. Therefore, a larger diameter screw was inserted. The right pedicle of T12 was compromised by the failure of the pedicle screw, and a screw was not inserted.

The construct was extended caudally to L4 with PMMA-augmented pedicle screws at L1 and L4. Because of previous vertebroplasty, PMMA was present at L2 and L3, preventing the use of cement augmentation. However, we were able to place short pedicle screws, which created additional points of fixation. The number of points of fixation was further increased using the following methods. First, a woven polyester band (Universal Clamp; Zimmer, Warsaw, Indiana) was used to connect the right transverse process and lamina of L2 to the rod between L1 and L2. The construct was extended proximally to T4 with transverse process hooks on the right transverse process. The left transverse process fractured during an attempted hook placement and was left uninstrumented. After the surgery, the patient had an uneventful postoperative course and was discharged to an inpatient rehabilitation facility.

Twelve months after the revision surgery, the patient was able to ambulate without difficulty, her motor strength was 4+/5 in all extremity muscle groups, and light touch sensation was intact throughout the extremities. She was pain free, and her incisions were well healed with no evidence of prominent instrumentation. Radiographs showed that her instrumentation was intact and well aligned from T4 to L4 (Figure 3).

Discussion

Osteoporosis causes a decrease in bone mineral density. As bone mineral density decreases, the force required for pedicle screw pullout decreases.[4-6] In 2 studies, the presence of osteoporosis was shown to decrease the fixation strength of pedicle screws by 40% to 80%.[5,7] To overcome the decrease in fixation strength, a variety of techniques and devices have been

Figure 2. The patient underwent pedicle screw fixation, and the lateral radiograph immediately after index surgery showed an intact construct. A, The patient presented 4 weeks later with severe pain, and imaging examination showed failure of the pedicle screws at T11 and T12. B, Lateral radiograph showing posterior and inferior displacement of the right T12 pedicle screw (bottom arrows) and less severe displacement of the right T11 pedicle screw (top arrows). C, Anteroposterior radiograph showing successful cement augmentation in the right T11 pedicle (top arrow) and right T12 pedicle (bottom arrow). D, Anteroposterior radiograph showing the failed T12 pedicle screw (bottom arrow) in the intervertebral foramen immediately distal to T12 and the moderately displaced T11 pedicle screw (top arrow).

developed, including exandable pedicle screws,[8] cement augmentation of pedicle screws,[9] cannulated pedicle screws,[10] hooks,[11] clamps,[12] and pedicle screws with increased diameters.[13] These techniques have been recently reviewed by Ponnusamy et al.[3] However, it remains unclear as to which techniques or combinations thereof are optimal.

Biomechanical testing shows that augmenting pedicle screws with PMMA increases the force required for pedicle screw pull-out.[14] However, there is limited evidence indicating the failure mode of cement-augmented pedicle screws. This failure mode must be considered to analyze the risk of using cement augmentation. In the current report, we address the failure of cement-

Figure 3. The patient underwent revision surgery as treatment for the failure cement-augmented pedicle screws. A, Anteroposterior and (B) lateral radiographs showing the stable construct and biologic fusion 1 year after revision surgery.

augmented pedicle screws in osteoporotic bone, the methods used in the revision surgery, and the outcome achieved for the patient 1 year after surgery.

Concern exists that cement-augmented pedicle screws may fail by posterior displacement while still bound to PMMA.[15] In contrast to this hypothesis, we observed a different mechanism of failure, which was characterized by the detachment of the pedicle screw from PMMA followed by posterior and inferior displacement. Thus, this case provides an example that cement-augmented pedicle screws may fail because of detachment from the bone cement, rather than from the posterior displacement of the intact screw–cement mantle construct. This failure mode carries substantially less risk than the posterior displacement of the intact construct and has important implications for the future use of cement augmentation in the osteoporotic spine. If additional examples and research indicate that cement-augmented pedicle screws fail by detaching from the bone cement, the use of this technique may become an optimal solution for fixation in the aging spine.

The failure mechanism highlighted in this case report is important because it warns the surgeon against being overreliant on PMMA-augmented pedicle screws. The type of pedicle screw used (nonfenestrated) may contribute to the failure mechanism. Choma et al[16] recently performed a biomechanical analysis of PMMA-augmented, partially cannulated fenestrated, fully cannulated fenestrated, and nonfenestrated screws in osteoporotic vertebrae. They found that the partially fenestrated PMMA-augmented screws provided the greatest fixation. The increased fixation of the fenestrated screws may be the result of a higher cement concentration at the distal tip of the screw or within the vertebral body compared with that of the nonfenestrated screw, where the cement is distributed throughout the pedicle.[16] However, with the fenestrated screws, there is a risk of PMMA leakage and neurological complications if the screw is too short and the fenestrated portion of the screw is close to the foramen.[17]

In our case, successful management of the construct failure by the extension of the fusion proximally and caudally and the

addition of a Universal Clamp (Zimmer Spine) and proximal laminar hook was possible. At 1-year follow-up, our patient showed radiographic evidence of fusion and was clinically symptom free. In conclusion, the aging, osteoporotic spine represents a challenge for achieving fixation and stability. However, new techniques are emerging that may offer optimal fixation. Balancing the strength of fixation with the construct's risk profile will remain an essential consideration for these patients.

Declaration of Conflicting Interests

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References

1. Kilbanski A, Adams-Campbell L, Bassford T, et al. Osteoporosis prevention, diagnosis, and therapy. *JAMA*. 2001;285(6):785-795.
2. Gabriel SE, Tosteson AN, Leibson CL, et al. Direct medical costs attributable to osteoporotic fractures. *Osteoporos Int*. 2002;13(4): 323-330.
3. Ponnusamy KE, Iyer S, Gupta G, Khanna AJ. Instrumentation of the osteoporotic spine: biomechanical and clinical considerations. *Spine J*. 2011;11(1):54-63.
4. Cook SD, Salkeld SL, Stanley T, Faciane A, Miller SD. Biomechanical study of pedicle screw fixation in severely osteoporotic bone. *Spine J*. 2004;4(4):402-408.
5. Halvorson TL, Kelley LA, Thomas KA, Whitecloud TS, III, Cook SD. Effects of bone mineral density on pedicle screw fixation. *Spine (Phila Pa 1976)*. 1994;19(21):2415-2420.
6. Hashemi A, Bednar D, Ziada S. Pullout strength of pedicle screws augmented with particulate calcium phosphate: an experimental study. *Spine J*. 2009;9(5):404-410.
7. Burval DJ, McLain RF, Milks R, Inceoglu S. Primary pedicle screw augmentation in osteoporotic lumbar vertebrae. Biomechanical analysis of pedicle fixation strength. *Spine (Phila Pa 1976)*. 2007; 32(10):1077-1083.
8. Cook SD, Salkeld SL, Whitecloud TS, III, Barbera J. Biomechanical evaluation and preliminary clinical experience with an expansive pedicle screw design. *J Spinal Disord*. 2000;13(3): 230-236.
9. Chang MC, Liu CL, Chen TH. Polymethylmethacrylate augmentation of pedicle screw for osteoporotic spinal surgery: a novel technique. *Spine (Phila Pa 1976)*. 2008;33(10):E317-E324.
10. Waits C, Burton D, McIff T. Cement augmentation of pedicle screw fixation using novel cannulated cement insertion device. *Spine (Phila Pa 1976)*. 2009;34(14):E478-E483.
11. Tan JS, Kwon BK, Dvorak MF, Fisher CG, Oxland TR. Pedicle screw motion in the osteoporotic spine after augmentation with laminar hooks, sublaminar wires, or calcium phosphate cement: a comparative analysis. *Spine (Phila Pa 1976)*. 2004;29(16): 1723-1730.
12. Hongo M, Ilharreborde B, Gay RE, et al. Biomechanical evaluation of a new fixation device for the thoracic spine. *Eur Spine J*. 2009;18(8):1213-1219.
13. Polly DW, Jr., Orchowski JR, Ellenbogen RG. Revision pedicle screws. Bigger, longer shims—what is best? *Spine (Phila Pa 1976)*. 1998;23(12):1374-1379.
14. Frankel BM, D'Agostino S, Wang C. A biomechanical cadaveric analysis of polymethylmethacrylate-augmented pedicle screw fixation. *J Neurosurg Spine*. 2007;7(1):47-53.
15. Bullmann V, Schmoelz W, Richter M, Grathwohl C, Schulte TL. Revision of cannulated and perforated cement-augmented pedicle screws: a biomechanical study in human cadavers. *Spine (Phila Pa 1976)*. 2010;35(19):E932-E939.
16. Choma TJ, Pfeiffer FM, Swope RW, Hirner JP. Pedicle screw design and cement augmentation in osteoporotic vertebrae: effects of fenestrations and cement viscosity on fixation and extraction. *Spine (Phila Pa 1976)*. 2012;37(26):E1628-E1632.
17. Amendola L, Gasbarrini A, Fosco M, et al. Fenestrated pedicle screws for cement-augmented purchase in patients with bone softening: a review of 21 cases. *J Orthop Traumatol*. 2011;12(4): 193-199.