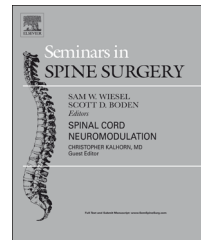


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Complex spinal surgery in patients with osteoporosis: Tips and tricks for achieving adequate constructs and avoiding complications

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ABSTRACT

Osteoporosis presents a unique set of challenges for instrumentation and correction of spinal deformity, both due to the unique pathology created by the disease and the technical considerations for obtaining spinal fixation. As a result, the spine surgeon is faced with the challenge of needing a robust reduction method to achieve stability in a relatively weak medium. Complications from fixation failure most frequently present as pedicle screw pullout and junctional failure. Many solutions have been offered to improve construct strength from preoperative therapeutics to intraoperative surgical adjuncts. From our experience, we review several promising strategies.

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1. Introduction

Osteoporosis is the leading cause of metabolic bone disease, affecting approximately 200 million people worldwide.^{1,2} It is primarily a disease of the elderly, characterized by an imbalance in bone remodeling that results in decreased bone mass and progressive loss of bone strength. These changes in bone infrastructure increase susceptibility to fracture and other forms of spinal deformity and listhesis. Given that the U.S. population of citizens age 65 and older is expected to double between 2005 and 2030, it is not surprising that reports of complex fusion cases for spinal deformity in elderly patients are increasing.^{3,4}

However, surgical fixation in the setting of osteoporosis is challenging, and associated with high rates of fracture, fixation failure, and junctional kyphosis. Prior studies have shown that decreased bone mineral density directly decreases the pullout strength, cutout torque, and maximum

insertion torque of pedicle screws, contributing to fixation failure.^{5,6} The spine surgeon is faced with the challenge of needing a robust reduction method to achieve stability in a relatively weak medium.

Junctional failure in the form of proximal junctional kyphosis (PJK) is a challenging complication. PJK is defined as a Cobb angle greater than 20°, measured between the upper instrumented vertebra (UIV) and two vertebrae above (Fig. 1).⁷ Patients with osteoporosis are particularly susceptible to the development of PJK, as their decreased bone strength increases vulnerability to failure at the proximal junction. Failure occurs secondary to the increased biomechanical stress between the rigid UIV and adjacent unfused vertebra. Although PJK is seen in up to 39% of adult deformity patients, Kwon et al.⁸ previously described a case series in which 85% of patients with proximal junctional failure had clinically documented osteopenia or osteoporosis.

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Fig. 1 – Thoracic AP and lateral radiographs of a 78-year-old female patient with previous posterior spinal fusion for correction of sagittal plane deformity. She subsequently developed proximal junctional kyphosis (PJK) resulting in significant pain and diminished quality of life.

As the societal burden of osteoporosis continues to grow, it is critical to understand the techniques that can optimize fixation of the osteoporotic spine and limit junctional failure.

2. Increasing construct strength

Cement augmentation of pedicle screws facilitates stronger fixation through stabilization of the screw–bone interface. Using polymethylmethacrylate (PMMA) cement, Pfeifer et al.⁹ showed a 149% increase in screw pullout strength relative to uncemented screws. Others have demonstrated higher fusion rates with preservation of deformity correction with use of PMMA cement.¹⁰ Cemented screws can be placed via a variety of techniques. Although the use of solid screws with retrograde cement pre-filling has been shown to have higher pullout strength relative to cannulated screws, it is thought that cannulated screws may more effectively alleviate concerns regarding extravasation of cement into the spinal canal.^{11,12}

PMMA cement can also be used to stabilize the proximal junction through vertebroplasty. In a biomechanical study using a cadaveric model, Kebaish et al.¹³ demonstrated that prophylactic vertebroplasty of the UIV and supra-adjacent vertebra decreased the risk of junctional fractures following long spinal instrumentation, relative to spines managed with UIV vertebroplasty or no vertebroplasty. In addition to reducing the risk of adjacent level complications, this strategy has been shown to be cost effective as it is associated with lower revision rates.¹⁴

Other techniques for increasing points of fixation include augmenting the construct with sublaminar wires or hooks to increase segmental fixation. Halvorsen et al.⁶ demonstrated that pedicle screws augmented with laminar hooks had higher pullout strength. This technique preserves cortical bone in the lamina, thereby improving pullout strength. Similarly, the use of supralaminar hooks is also an option at the top of the construct.¹⁵ While the use of crosslinks is generally felt to improve the rigidity and pullout strength of the instrumentation, some studies suggest this may not be the case in the osteoporotic spine.¹⁶

3. Teriparatide (Forteo)

Another promising strategy that can be used to improve outcomes is perioperative recombinant PTH, also known as teriparatide (Forteo). Although teriparatide has been shown to promote fracture healing among patients with osteoporosis, recent evidence suggests that it can play an important role in osteoporotic spine surgery.¹⁷ Ohtori et al.¹⁸ demonstrated that perioperative teriparatide reduced pedicle screw loosening compared to patients who received alendronate or placebo. This group also showed that teriparatide accelerates posterolateral fusion rates in women with osteoporosis when compared to bisphosphonates.¹⁹

In addition to improving fixation, perioperative teriparatide can decrease the incidence of PJK from bone failure in women with low bone density.²⁰ These authors demonstrated significant increases in volumetric bone mineral density, fine bone structure, and bone strength in the vertebra above the

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