THE USE OF A FENESTRATED SCREW SYSTEM WITH PMMA AUGMENTATION IN OSTEOPOROTIC BONE

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Introduction

Pedicle screw fixation is a standard procedure with indications spanning from degenerative spondylolisthesis to post-traumatic deformity to infection. This common form of internal surgical stabilization is inevitably critically dependent on the integrity of the bone-screw construct. As screw systems and materials become more advanced, the structural factor limiting rigid fixation and ultimately fusion becomes the bone itself. This is most evident in the osteoporotic patient where low bone mineral density results in a significant decrease in pedicle screw pull-out strength.\textsuperscript{1-6} For this reason, osteoporosis has become a relative contra-indication to posterior instrumented fusion.

Techniques influencing the purchase strength of pedicle screws have been described and include screw angle, depth, diameter, and screw tapping.\textsuperscript{7-9} When these variables cannot be sufficiently manipulated, the rigid instrumentation construct must be extended to include more vertebral segments for load sharing. Cement augmentation of pedicle screws using polymethylmethacrylate (PMMA) has also been shown to significantly increase pull-out strength of osteoporotic cadaveric human vertebrae.\textsuperscript{10-13} This synthetic polymer, commonly used for vertebroplasty, can be used in an off-label fashion to strengthen the bone-screw interface. To its detriment, however, routine use for pedicle screw augmentation is not performed due to associated complications including pulmonary embolism, thermal tissue injury, foreign body reaction, and difficulty imposed if hardware removal is needed.\textsuperscript{12,14,15}
Materials & Methods

The current technique for pedicle screw augmentation using PMMA requires injection of PMMA into a tapped hole and then placement of the pedicle screw into the filled tract, thus securing the screw in a hardening coat of PMMA. The risk inherent to this method of augmentation is cortical breach during placement of the pedicle screw. This can result in extrapedicular or extravertebral leakage of PMMA and consequent neurologic deficit.

Recently a fenestrated screw system (tangoRS™, Ulrich, Germany) has been developed to which has a hollow axis and screw tip fenestrations.\(^{16}\) (Figure 1) This system allows injection of PMMA after the screw has been placed.

This is the first published report of a U.S. case of a fenestrated screw injected with PMMA used for fusion in an osteoporotic patient. This 74 year-old male incurred an L1 burst fracture initially treated with a lumbar brace. After four months of external immobilization, he had persistent pain and a non-healing fracture (Figure 2 see page 5). Due to his significantly decreased BMD (0.892 g/cm\(^2\) AP L1-4; 0.347 g/cm\(^2\) Lat L2-3), he underwent fusion of T11-L3 with PMMA augmentation through a fenestrated screw system.

![Figure 1: TangoRS™ fenestrated system - fenestrations at the tip allow PMMA to pass into the vertebral body](image-url)
Results

The procedure was well tolerated. One cubic centimeter of PMMA was injected per screw (in addition to the volume of the screw cavity) and was observed under fluoroscopy to diffuse into the vertebral body in a controlled fashion (Figure. 3, Figure 4a,b,c).

The T11 screw on the right side was noted to have compromised the medial pedicle wall and thus was not injected. Post operative CT verified no extravasation of PMMA beyond the vertebral margins and good diffusion of PMMA into the vertebral body (Figure 5).

Figure 3: Intra-operative injection of PMMA through the fenestrated pedicle screws

Figure 4A: The L3 pedicle screw has been injected. L2 is pre-injected.

Figure 4b: L2 after partial injection

Figure 4c: L2 injection is complete
Figure 2: Pre-Operative L1 burst fracture

Figure 5: Post-Operative sagittal CT – the intravertebral PMMA is evident surrounding the screw tips
Discussion

The use of PMMA for pedicle screw augmentation can complicate fusion revisions and result in extravasation related complications.\textsuperscript{12,14,15} Previously, augmentation has been performed into tapped holes or through needle injections into the vertebral body. This method, however, carries the risk of extravertebral PMMA extravasation if the bony margins are disrupted by screw placement. A fenestrated screw conceptually decreases this risk in two ways. First, the fenestrated screw is always placed in an unfilled, tapped hole. This is in contrast to a typical screw system where a PMMA filled cavity can result in forceful cement extrusion upon screw insertion. Second, final screw position can be evaluated before injection and therefore avoided if it is not considered ideal.

When using the fenestrated screw, several technical points should be made regarding the injection of PMMA. Before placement of the lumbar screw, thorough testing of the tapped wall must be performed to evaluate for cortical breach. We do not recommend injection of PMMA if there is any uncertainty of the integrity of the vertebral body or pedicle cortex. Also, there is a cavity within the screw which first needs to fill before cement will diffuse through the vertebral body. The screw cavity volume should be noted to gauge the volume of intravertebral PMMA. Regarding the PMMA itself, it must be of an appropriate consistency for injection - neither too thin resulting in increased risk for extravertebral diffusion or too viscous resulting in inability to inject. We were able to perform injection of the four left sided screws with PMMA but required a new batch for injection into the right side (see Figure 3). For fluoroscopic tracking, the PMMA must be mixed with a radio-opaque compound. The PMMA we used was a pre-mixed barium/PMMA (Kyphon, Sunnyvale, CA).
Conclusions

In osteoporotic patients, the poor bone quality can preclude instrumentation altogether. With safer techniques, augmentation of pedicle screws may play a larger role in fusing this difficult patient population. The potential complications remain, but the possibility of decreasing fusion failure rates and fusing fewer segments is compelling. Future studies will hopefully elucidate the post-operative success of augmented fusion in patients with decreased bone density.
References


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