



ASSESSMENT OF CEMENT AUGMENTATION, SCREW TRAJECTORY, AND PEDICLE CORTEX RETENTION ON PEDICLE SCREW FIXATION IN OSTEOPOROTIC VERTEBRAE

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Abstract

Internal fixation of osteoporotic spines for fracture or deformity is currently quite difficult, owing to failure at the bone-implant interface. Our previous work has shown a significant improvement in screw purchase using cement augmentation. This study aimed to ascertain whether pedicle screw angulation and pedicle entry-point cortical bone retention could independently improve fixation strength in osteoporotic vertebrae. Orienting the pedicle screw at 20° relative to the superior vertebral endplate independently, significantly increased load to failure ($p < 0.05$), as did retention of pedicle entry-point cortical bone.

Material and Methods

Twenty human osteoporotic cadaveric vertebrae (average bone mineral density 0.521 g/cm^3) were instrumented with solid core pedicle screws of similar geometric dimensions from a single vendor. Screws were placed according to usual surgical practice. In each vertebra, one screw was placed at 0° and the contralateral screw was placed at 20° relative to the superior vertebral endplate. A 20° insertion angle placed the tip of the screw against the superior endplate. Groups ($n=5$ each) of the pedicle screws were augmented with 1.5 mL Hydroset calcium phosphate bone cement. Other groups ($n=5$ each) had a 5 mm radius of pedicle cortical bone removed from around the insertion site prior to screw implantation. A pushrod-yoke fixture was used to apply toggle and pullout load similar to that experienced *in vivo* by vertebrae fixed with pedicle screws in the lower lumbar and upper thoracic spine. An optical tracking system was used to monitor 3D displacement of the screw with load application.

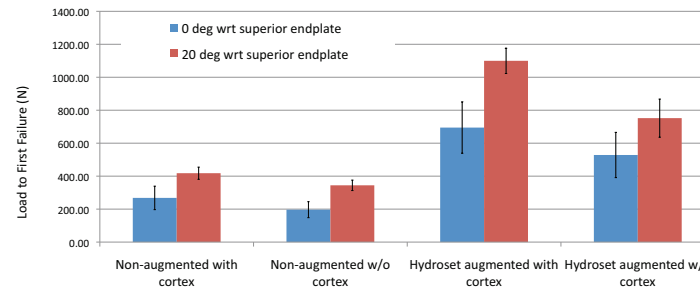
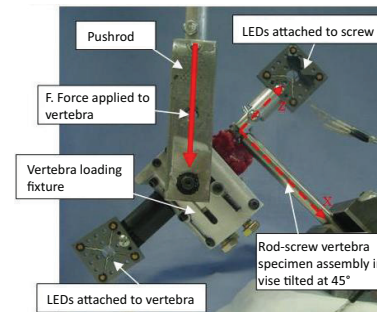


Figure 1: Effects of augmentation, pedicle cortex retention, and angulation on fixation of pedicle screws in cadaveric osteoporotic thoracolumbar vertebrae

	0 deg	20 deg
Non-augmented with dorsal cortex	268.17 (SD=71.36)	417.95 (SD=37.04)
Non-augmented w/o dorsal cortex	196.54 (SD=48.49)	344.45 (SD=31.81)
Hydroset augmented with dorsal cortex	694.71 (SD=155.69)	1099.78 (SD=77.01)



Radiograph displaying placement of two pedicle screws



Pushrod-yolk apparatus

Results

Failure load was observed to be dependent upon screw trajectory and augmentation as well as cortical bone retention. Failure load significantly ($p < 0.05$) increased with augmentation. It also increased independently ($p < 0.05$) with retention of the pedicle entry-site cortical bone. Load to failure was significantly ($p < 0.05$) higher for screws inserted at 20° relative to the superior vertebral endplate than for those inserted at 0°. Initial failure was a result of toggle, which was followed by pullout in all cases.

Discussion

Screws inserted at 0° relative to the superior endplate demonstrated a second loading and failure after initial failure. Initial failure occurred at the bone-screw interface, and the tip of the screw would then toggle until it contacted the superior endplate. The screw would then bear more load until the second failure. Screws with an initial trajectory of 20° exhibited no second load or failure. The mode of load application used produces toggle and pullout force similar to that seen in clinical situations, making our results good indicators of the clinically important criteria for pedicle screw insertion in osteoporotic thoracolumbar vertebrae. Retention of dorsal pedicle entry-site cortical bone, insertion of the screw so that the tip lies against the superior vertebral endplate, and augmentation can all improve fixation in osteoporotic vertebrae.

Acknowledgements

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