

BIOMECHANICAL PERFORMANCE OF AN INJECTABLE SCREW FOR FIXATION IN SEVERELY OSTEOPOROTIC BONE: AN EXPERIMENTAL STUDY

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INTRODUCTION

Pedicle screw fixation in a severely osteoporotic spine remains a challenge for orthopaedic surgeons. Previous studies have demonstrated that pedicle screw fixation is highly correlated to the bone mineral density [1], and increasing the screw's pullout strength can be achieved using a variety of methods, these include the use of pedicle screws with various designs [2,3]. However, the literature on the effects of radial holes for cannulated screws with cement injection and pilot-hole tapping on the bone/screw interfacial strength is lacking. To increase the effectiveness of securing a pedicle screw on severe osteoporosis patient, this work examines how a self-designed cannulated pedicle screw with various numbers of radial holes injected with bone cement can increase the interfacial strength. The effect of pilot-hole tapping prior to screw insertion was also examined.

METHODS

Six groups of conical screw designs (Figure 1), with or without radial holes, are installed in tapped and untapped pilot holes and then injected with cement. The groups include Group S: Solid screw without holes; Group C0: Central hole only; Group C2: Central hole with two radial holes; Group C4: Central hole with four radial holes; Group C6: Central hole with six radial holes and Group C8: Central hole with eight radial holes. A uniform synthetic bone (test block) was used to simulate a cadaveric spinal bone with extreme osteoporosis and provide a platform for each screw design. Specimens with screw insertion were then tested for axial pullout failure.

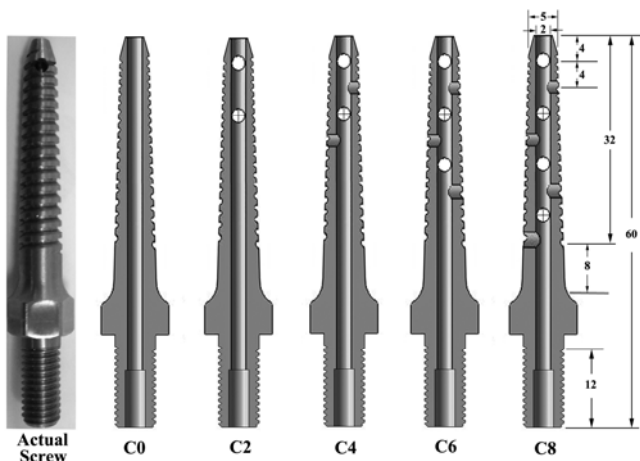


Figure 1: Actual and schematic cannulated screws with dimension presented. (Note: ⊕ represent radial hole in direction outward to the paper; .Unit: mm)

RESULTS AND DISCUSSION

The average ultimate pullout strength for various screw designs with or without tapping is shown in Figure 2. All cannulated screws with cement augmentation have a

significantly higher pullout strength as compared to solid screws ($p < 0.001$). The average pullout strength for cannulated screws with PMMA injection increases as the radial hole number increases; exceptions are that no statistical difference was found between groups C4 and C6 ($p > 0.05$) for untapped case; whereas no statistical difference were found between groups C2 and C4 ($p > 0.05$) as well as C4 and C6 ($p > 0.05$) for tapped case. Within a screw design, tapping the pilot holes significantly reduced the pullout strength for group C4 ($p < 0.05$) and group C6 ($p < 0.05$). However, no statistical difference in the pullout strength was found for the other groups with or without tapping the pilot holes ($p > 0.05$). Additionally, the pullout strength of cannulated screws without tapped pilot holes had a smaller standard deviation than the screws with tapped pilot holes.

Radiological examination indicates that the cement exudes from the most proximal holes on the very beginning through its flow path, whereas no cement exudation is found from the remained distal holes. Cement exudation from the holes of cannulated screws into the open cell of the test block leads to a composite (cement/bone) structure at the area that cement exudes. The observation of the failed specimens demonstrates that the failure occurs at composite/bone interface, while the composite is well bonded on the screws. This implies that the screw/composite interfacial strength is much higher than the composite/bone interfacial strength.

CONCLUSIONS

Distal radial holes combined with PMMA cement augmentation and without tapping may be a viable clinical option for achieving fixation in severely osteoporotic bone.

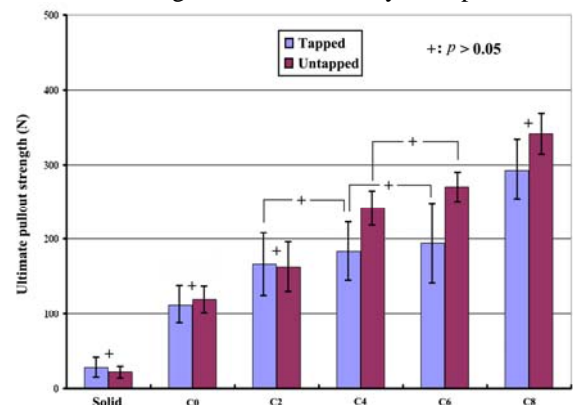


Figure 2: Average ultimate pullout strength for various screw designs with or without tapping. (+: not statistically different)

REFERENCES

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