

EFFECT OF PILOT HOLE SIZE ON THE INSERTION TORQUE AND PULLOUT STRENGTH OF SELF-TAPPING CORTICAL BONE SCREWS IN OSTEOPOROTIC BONE

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INTRODUCTION

Screws are the most commonly used implants for osteosynthesis. All the surgical screws can experience failure if the torsional, tensile and flexion loads are considerably high. The use of self-tapping screws results in higher insertion torques, i.e. higher torsional loads, as these screws cut their own threads in the pilot hole drilled in the bone sample. The insertion torques (IT) and axial forces vary with respect to size of the pilot hole. Gantous et al. suggested that one way to decrease the IT was to increase the pilot hole size. Their results suggested that the pilot hole size (PHS) could be increased to 80% of the outer diameter (OD) of the screws without compromising on the pullout strength (PS) of the screws. They tested their theory using blocks of Delcron that simulated bone but what remains unknown is the validity of their theory in the presence of a cortical shell and also for osteoporotic bone.

In this study, the torque for inserting the STS into an osteoporotic bone block for different PHS was measured and the PS for extraction of the screws was determined for different depths of insertion.

METHODS

Bone blocks simulating the osteoporotic bones were acquired from Pacific Research Laboratories (Vashon, WA). The bone blocks had a bi-cortical layer made from e-glass-filled epoxy sheets and cancellous

bone mimicked by polyurethane foam with densities 1.7 & 0.24 gms/cc and tensile moduli 12.4 GPa & 143 MPa respectively. Seventy-two Synthes stainless steel (SS) self-tapping cortical bone screws (40mm length & 3.5mm diameter) were inserted into the pilot holes, drilled into the blocks, of sizes 2.55 (A: 73% of OD), 2.50 (B: 71.5%), 2.45 (C: 70%) or 2.8mm (D: 80%). Using a digital torque screwdriver, as shown in Fig 1, screws were inserted to 0, 1 or 2 mm past the far cortex.

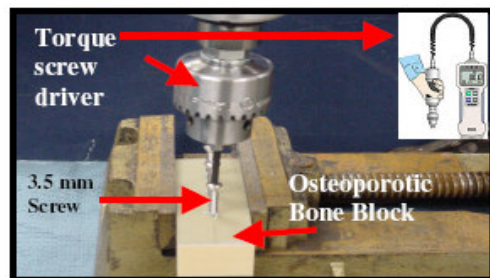


Figure 1: Insertion of the screws into the osteoporotic bone block using the digital torque screwdriver.

All the pullout tests were performed using a servo-hydraulic material testing system (Instron 8511). The holding fixture for the axial pullout was designed according to the *ASTM F 543-02* specifications for the metallic medical bone screws. The screws were extracted axially from the blocks under displacement control at 0.1 mm/s. The force-displacement data was digitally recorded for each of the pullout tests and the maximum value of the applied tensile force was determined as the PS of the screw. ANOVA

and SNK tests were performed to determine the effect of the depth of insertion and PHS on the loading energy (LE), PS and IT.

RESULTS AND DISCUSSION

Fig. 2 shows comparison of the mean IT (\pm Std Dev) values of the screws for different PHS. It may be observed that IT of the screws inserted into pilot holes A, B & C were higher than those inserted into D. It was observed during screw insertion that the peak IT value was reached when it penetrated the far cortex and didn't change for 0,1 or 2mm penetration past the far cortex.

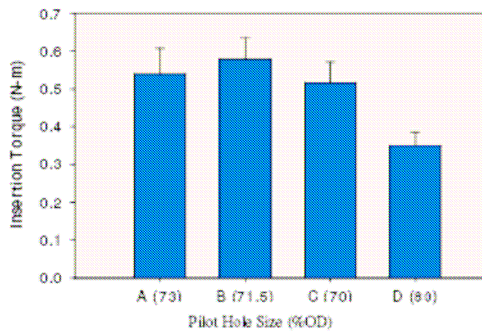


Figure 2: Insertion torque of the self-tapping screws inserted into 4 PHS.

Mean PS (\pm Std Dev) values for all the PHS at different insertion depths are illustrated in Fig 3. It may be observed that PS for 1 & 2 mm penetration past the far cortex are higher than that for 0mm regardless of the PHS. It may also be observed that the PS for the screws at all the depths was lower for pilot hole D when compared to the others.

LE was computed as the area under the load displacement curve up to maximum load (PS). Table.1 summarizes the results of the LE at different depths and also for all PHS.

The statistical analysis indicated that the IT for the screws inserted into A, B & C was significantly different from that of the D size pilot hole. The PS at 1 & 2mm past the far cortex was significantly different ($P < 0.05$)

from 0mm depth of insertion. The results also indicated a significant difference between LE for A,B & C pilot holes to be significantly different from that of D for all depths of insertion.

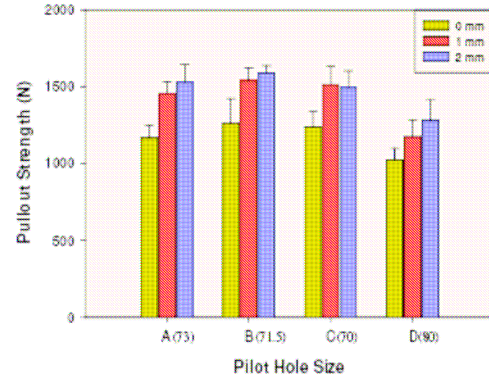


Figure 3: Pullout Strength of the screws inserted to different depths for 4 PHS.

Table 1: LE to peak force for screws inserted to different depths for 4 PHS.

	A (N-mm)	B (N-mm)	C (N-mm)	D (N-mm)
0 mm	348.1	403.0	381.9	286.9
1 mm	555.5	563.8	570.0	358.0
2 mm	657.9	693.9	648.5	430.4

SUMMARY/CONCLUSIONS

It has been confirmed with the help of biomechanical testing that the PHS has an influence on the IT, PS and LE for cortical bone screws inserted in osteoporotic bone. It can be concluded that the recommendations made by Gantous et al. do not apply to osteoporotic bone and bones with cortical - cancellous interface. This study illustrated that an increase in the PHS to 2.8mm (80% OD) will reduce the IT but will also reduce the PS of the bone-screw construct relative to that of PHS of 2.5mm (71.5% OD), which is currently used as optimal for 3.5mm cortical screws.

REFERENCES

- Gantous.A, Phillips. J. (1995). *Plastic and reconstructive surgery*, 1165-69.
- Heidemann W, Gerlach K.L., et al. (1998). *J Craniomaxillofac Surg*. 26(1):50-5.