A BIOMECHANICAL STUDY OF THE PULLOUT STRENGTH OF THE SELF-TAPPING BONE SCREWS IN OSTEOPORTIC BONE MATERIAL INSERTED TO DIFFERENT DEPTHS

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INTRODUCTION

Bone screws are commonly used implants for fixation of fractures and are also for stabilizing bone transplants [1,2]. The failure of osteosynthesis is determined by the maximum load that can be transferred between a screw and the bone [3]. This maximum load is referred to as the pullout strength (PS) and can be assessed by axial pullout tests. PS becomes a crucial factor in osteoporotic bone. It is a common practice in orthopaedic surgery to insert the self-tapping bone screws (STS) 2mm past the far cortex to prevent the cutting flutes from remaining in the far cortex.

The purpose of this study was to determine PS of the screws inserted to different depths in the osteoporotic bone material and to evaluate if there is a significant difference in the PS of the STS of different manufacturers.

METHODS

Ninety Stainless Steel (SS) self-tapping cortical bone screws (40mm length, 3.9mm cutting flute length and 3.5mm diameter) from three manufacturers, Zimmer (Warsaw, IN), Synthes (Monument, CO) and Stryker (Mahwah, NJ), were evaluated. These screws were inserted into bone coupons representing osteoporotic bone material. The bone coupons were bicortical with polyurethane foam (density of 0.24 grams/cc and tensile modulus of 143 Mpa) for cancellous bone and E-Glass-filled epoxy sheets (1.7 grams/cc density and tensile modulus of 12.4 GPa) for cortical bone.

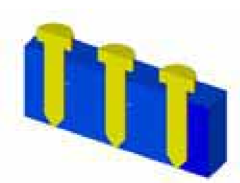

Figure 1: Layout of the bone coupons and the screws.

The screws were subdivided into five groups of six screws per depth per manufacturer. They were inserted -1mm, 0mm, 1mm, 2mm and 3mm relative to the far cortex. Three screws were inserted per coupon (Fig 1) based on the St. Venant's principle.

The axial pullout was performed in agreement with the *ASTM F 543-02* specifications for the metallic medical bone screws. Uniaxial load to failure was applied under displacement control at a rate of 0.1 mm/s using an Instron 8511 materials testing machine.

RESULTS AND DISCUSSION

Fig. 2 shows comparison of the PS of the screws of different manufacturers at different depths of insertion. It may be observed that the PS of the screws inserted 1, 2 and 3mm past the far cortex were significantly higher than the other groups.

Loading energy (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 manufacturers. Two-factor ANOVA and SNK tests were performed to determine the effect of the depth of insertion and manufacturer on the PS.

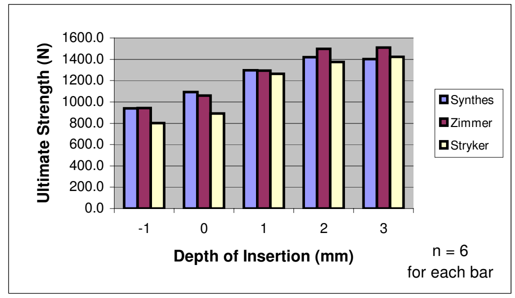

Figure 2: Pullout Strength of Bones screws from different manufacturers inserted to different depths

The statistical results indicate that the PS of the screw when inserted to 2 and 3mm past the far cortex is significantly different ($P<0.05$) from the other depths of insertion. The results failed to indicate any significant difference between the PS of the screws manufactured by different companies.

Table 1: Means ± standard deviation of the Loading energies (N-mm) of the screw pullouts at different depths.

DOI (mm)	Manufacturer		
	Synthes	Zimmer	Stryker
-1	294 ± 60.6	271 ± 83.4	211 ± 31.1
0	344 ± 83.6	337 ± 74.4	251 ± 35.5
1	416 ± 99.9	441 ± 109.3	421 ± 104.4
2	561 ± 87.2	636 ± 83.6	535 ± 51.5
3	560 ± 101.1	616 ± 50.1	628 ± 44.4

CONCLUSIONS

It has been confirmed with the help of biomechanical testing that the optimum depth of insertion for a bone screw in osteoporotic bone material is 2mm past the far cortex. It can also be concluded that the PS of the self-tapping bone screws made by different manufacturers are not statistically different from each other.

REFERENCES

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