COMPARISON OF FIVE HEADLESS SCREWS FOR FIXATION OF SMALL BONES

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INTRODUCTION

Headless screws are favored for internal fixation in the treatment of displaced or unstable small bone (e.g., Scaphoid) fractures, because they are embedded below the articular surface of the bone, reducing tissue irritation and immobilization. Compression plays an important role in fracture stability, maintaining gap reduction and also accelerating the healing of cancellous bone [1]. There are several types of screws being used in practice and it is of clinical interest to know how different they are in generating and maintaining the compression force.

Several studies have investigated the compressive forces of headless screws [2,3]. However, little attention has been paid to the fastening torque and the effect of pre-drilling. This study compares the generated compression force and fastening torque and the effect of pre-drilling during the insertion of five frequently used headless compression screws that are typically used for scaphoid fixation.

MATERIAL AND METHODS

Five cannulated headless bone screws, Herbert-Whipple (Zimmer, Inc.), Mini-Acutrak 2 (Acumed®), Kompressor Mini (Kompressor™), HCS 3.00mm (Synthes) and 3.2mm Twinfix (Stryker®) with nominal size of 3x24 mm were used in this study. Previous studies have shown that the density and elastic modulus of the scaphoid cancellous bone are highly variable and affect the maximum achievable compression [3]. Therefore, in this study solid rigid polyurethane foam (Sawbones®, 0.16 g/cm³), commonly used as a cancellous bone surrogate material [2,3], was chosen to make 50 identical bone models. To simulate a 30mm scaphoid with a transverse fracture in the middle, the bone models were cut into two 15mm-thick pieces. The setup was made such that both bone models could freely move along four rods which transferred the fastening torque to a torque cell (QWFK-8M, Sensotec®) (Fig. 1). A washer load cell (LC8200, Omegadyne, Inc.) was placed between the two Sawbones parts to measure the generated compression force. All the screws were applied according to their technical instruction. However, in order to study the risk of loss of compression due to over-fastening, the fastening continued until compression did not change any more. Since all the screws in this study are self-cutting, in order to study the effect of pre-drilling, the screws were tested once with the suggested pre-drilling method and once without pre-drilling.

For each screw, the maximum generated compression, the stage at which it was generated and the fastening torque at that stage were compared using the Student’s t Test in JMP software (SAS Institute Inc.). Two-way ANOVA was used to compare the maximum compression between screw types and the effect of pre-drilling method on its magnitude. p < 0.05 was considered significant.

RESULTS

Mini-Acutrak 2 (Acumed) - The compression generated by Mini-Acutrak 2 and the fastening torque gradually increased with each turn until the compression reached 4.63 kgf (Fig. 2). The generated force did not change by over-fastening. The achieved compression without pre-drilling was higher (5.00 kgf) but was not significantly different. However, the fastening torque at the same stage increased by 87%.

Twinfix (Stryker) - Unlike the Mini-Acutrak, the maximum achievable compression was generated immediately after a quarter to half a turn after unlocking the second stage of screwdriver and it reached 3.13 kgf. There was a high risk of loss of compression up to 42% by advancing a quarter of turn more. Without pre-drilling there was no significant increase in the maximum generated force, but the fastening torque increased by 73%.

Figure 1: Experimental setup
**Kompressor Mini** - Although the generated compression trend was similar to Twinfix, the compression gradually reached the maximum level of 2.12 kgf one turn after compression stage started, and the compression loss due to more turns was 24%. The fastening torque increased with decreasing of compression due to over-fastening (Fig. 3). Without pre-drilling the maximum compression was 17% higher and there was no significant increase in the fastening torque.

**HCS 3mm (Synthes)** - The maximum achievable compression using Synthes screw was 1.76 kgf which was not significantly different from the without pre-drilling method (1.8 kgf). There was 67% increase in fastening torque without pre-drilling. Over-fastening of the screw did not change the generated compression in both methods.

**Herbert-Whipple** - This screw generated the least compression force equal to 1.37 kgf and it did not change significantly without pre-drilling (1.03 kgf). Unlike the other screws, the self-cutting did not work well without pre-drilling and it was needed to apply extra 2 kgf axial load on the screw to make more advance, which caused 129% increase in fastening torque.

**DISCUSSION**

In this study solid rigid polyurethane foam was used as substitution to human cancellous bone to achieve more consistent statistical results. Pre-drilling did not have a significant effect on the average maximum generated compression, although it significantly increased the fastening torque for all the screws except Kompressor Mini. Mini-Acutrak 2 generated the maximum compression and showed the most reliability and sustainability of the generated compression and no risk of losing compression due to over-fastening was observed. This is because of its conical and variable pitch design. Twinfix and Kompressor Mini, contrary to other screws, have a rotating head which generates most of the compression. Twinfix had the second highest generated compression, 31% more than Kompressor Mini which might be the result of its larger thread size. However, since the head of Twinfix is axially fixed, it showed a higher risk of losing compression (Fig. 3). The maximum generated compression by Mini-Acutrak 2 (Acumed), Herbert-Whipple (Zimmer) and HCS 3mm (Synthes) presented in this study are in agreement with results reported in other studies [2,3] and there was no report in the literature on Kompressor Mini and the fastening torques of either screws.

**REFERENCES**

1. Aro HT, Chao EY. “Bone healing patterns affected by loading, fracture fragment stability, fracture type and fracture site compression” *Clin Orthop*, 1993