The Importance of Screw Design in Scaphoid Fracture Fixation

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SUMMARY
The purpose of this study was to determine the influence of gender, screw design, and the approach on maximal screw length in scaphoid fracture fixation. Measurements were performed on 3D reconstructions of 20 CT scans of normal scaphoids. A comparison was made between 15 different available screw designs and between volar and dorsal screw placement. The length of the scaphoid along its central axis is significantly longer in men. Screws with a trailing thread diameter > 3.9 mm and a leading thread diameter > 3.0 mm are significantly shorter. When using a volar approach, maximum screw length is significantly longer regardless of the screw design. Our data suggest that fixation of scaphoid fractures in men and through a volar approach will allow the surgeon to use longer screws. We recommend using a differential pitch screw with a thread diameter of 3.9 mm or less.

INTRODUCTION
Displaced or comminuted scaphoid fractures are treated routinely with reduction and internal fixation. Internal fixation also has been advocated in young and active individuals with nondisplaced scaphoid fractures. Scaphoid fracture stabilization with a single screw has been promoted and the past decade has seen the introduction of several different screw designs from various manufacturers.

McCallister et al [1] demonstrated that an eccentrically placed screw offers less biomechanical stability. A study by Dodds et al [2] showed that a short and centrally placed screw does not take advantage of the holding power of the cancellous bone throughout the scaphoid length as a long screw that ends just under the chondral surface can. Therefore a long, centrally placed screw provides better fixation.

As the scaphoid is narrowest at the proximal pole and contemporary screw designs have a trailing thread diameter that is greater than the leading thread diameter, the approach could have an influence on the maximum screw length that can be used.

The goals of this study were to determine the influence of gender and the approach on maximum screw length and to compare the maximum screw length of the different screw designs that can be used in the treatment scaphoid fractures to optimize biomechanical strength of the fixation.

METHODS
Twenty digital scaphoid models (10 men, 10 women) were used. Bone surface models were created from CT scans of the wrists in a neutral position. A coordinate system for each scaphoid was computed using its inertial properties and assuming a normalized, homogenous composition. Length of the scaphoid along the longitudinal axis and the width at the midwaist were determined. The outline of the 15 different screw designs was projected along the longitudinal axis of inertia and the maximum screw length according to the volar and dorsal approach was calculated.

Statistical analyses were performed using a paired t test for the comparison of two groups (male vs female, volar vs dorsal) and a repeated measures ANOVA with a post hoc Bonferroni’s multiple comparison test for the comparison of several groups (screw design).

RESULTS AND DISCUSSION
The mean length of the scaphoid in men was 27.15 mm ± 0.96 and 23.86 mm ± 0.38 in women. Scaphoid length was significantly longer in men (p=0.013). The mean width of the scaphoid at the midwaist in the coronal plane was 14.57 mm ± 0.65 and 11.34 mm ± 0.49 in women. The mean width of the scaphoid at the midwaist in the sagittal plane was 10.91 mm ± 0.18 and 9.88 mm ± 0.28 in women. Statistical analysis demonstrated that the width of the scaphoid at the midwaist was significantly more in men than in women in both the coronal and sagittal plane (p=0.004 and 0.014 respectively) (Figure 1).

Figure 1: A bar chart showing the mean values for the different dimensions of the scaphoid in men and women. Whiskers indicate standard error of the mean.
For screws with a conical design, screws with a relative narrow leading thread diameter were significantly longer than conical screws with a relative parallel design (p<0.01). For screws with a double-threaded or “Herbert-type” design, screws with a leading thread diameter > 3.0 mm and a trailing thread diameter > 3.9 mm were significantly shorter (p<0.0001). Screws with a leading thread diameter ≤ 2.5 mm and a trailing thread diameter ≤ 3.3 mm were the longest (p<0.05) (Figure 2).

There was no significant difference between the theoretically maximum screw length (up to 0.01 mm available) and the length of the actual screw when using screws with 1 mm increments. Screws with increments of 2 or 2.5 mm are significantly shorter than the theoretically maximum screw or screws with only 1 mm increments (p<0.01 and p<0.0001 respectively) (Figure 3).

The mean screw length when screws were placed according to the volar approach was 23.72 mm ± 0.19 compared to 23.31 mm ± 0.19 when using the dorsal approach (95% confidence interval 23.34 mm - 24.09 mm and 22.94 mm - 23.67 mm respectively). Statistical analysis demonstrated a significant difference with the maximum screw length being longer when using a volar approach compared to a dorsal approach regardless of the screw design (p<0.0001) (Figure 4).

When looking at the effect of screw design on maximum screw length we found that i) “Herbert-type” screws with a leading thread diameter > 3.0 mm and a trailing thread diameter > 3.9 mm and screws with a conical and relative parallel design were significantly shorter, ii) screws with 2 or 2.5 mm increments were also significantly shorter compared to screws with 1 mm increments, and iii) the maximum screw length was 30 mm. Our data suggest that a screw should comply with these criteria so that the surgeon can optimize scaphoid fracture fixation.

Using the same central long axis of the scaphoid, our data demonstrate that screws placed through a volar approach are significantly longer (p<0.0001) because of the narrower leading thread diameter and proximal pole. This leads to better purchase of the screw in the densest cancellous bone that is located at the poles. It has been previously demonstrated that a screw buried 2 mm under the chondral surface of the proximal and distal pole of the scaphoid offers more biomechanical stability.

**CONCLUSIONS**
Our data demonstrate a significant difference in scaphoid morphometry between men and women, but screws with a good design can be placed ≤ 2 mm of the articular surface. The maximum screw length offering maximum biomechanical stability is significantly different when comparing different screw designs. The surgeon must be well aware of the screw properties to optimize scaphoid fracture fixation. We recommend using a screw with a diameter ≤ 3.9 mm with 1 mm increments and available in length up to 30 mm to minimize the risk of screw prominence without compromising screw length and fixation strength. Screws placed through a dorsal approach are significantly shorter, but when the screw complies with the aforementioned criteria, screw prominence will be avoided and the approach only depends on the surgeon’s preference.

**REFERENCES**