Stem Length and Neck Resection on Fixation Strength of Press Fit Radial Head Prosthesis: An In-Vitro Model

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Introduction: Various radial head prosthesis designs are currently in use. There are very few studies that compare different prosthetic designs. We hypothesized that increasing a cementless implant stem’s length would reduce the stem-bone micromotion, with both 10 mm (which corresponds to a reasonable length of head resection following a radial head fracture) and 21 mm neck cuts (which simulates head and neck fracture). We also hypothesized that there might be a minimum requirement of stem length for the initial fixation strength of a press-fit implant.

Methods: In 16 fresh frozen cadaveric elbows (8 pairs), the radial head and neck were cut either 10 mm or 21 mm below the top of the had. Cementless stems were inserted, and sequentially lengthened in 5 mm increments (Fig. 1). Micromotion under eccentric loading was tested using a published technique (1) after each incremental change (Fig. 2). All data are reported as the mean ± standard error. The data were modeled with the use of 1-Factor Repeated Measures analysis and means contrast comparisons where appropriate, with a significance level of p ≤ 0.05.

Results: Resecting the radial head and neck had a significant effect on micromotion values as the stem was incrementally lengthened (10 mm resection: p = 0.0002; 21 mm resection: p = 0.04) (Fig. 3). In the 10 mm resection group, significant decreases in micromotion were only seen after the incremental addition of 10 mm or more to the initial 10 mm stem length (Fig. 3A). In the 21 mm resection group, the only significant differences in micromotion were observed after the 10 mm stem was lengthened to 25 mm (p = 0.006) and 30 mm (p = 0.009) (Fig. 3B). Statistical comparison of the matched stem lengths between the 10 mm and 21 mm resection groups demonstrated that there was no difference in their micromotion values (p-value range: 0.06 - 0.97). The longer stems had a tendency to tilt as they were inserted into the radial canal (Fig. 1).

Discussion: In this study, we investigated the differences in contribution to initial stability of a short stemmed versus a long stemmed radial head prosthesis. This study also investigated the effect of stem length on initial stability of radial head prosthesis in a model with a shortened radial neck, which simulated a revision situation or an extended radial head and neck fracture. The results showed that 25 mm or longer stems had significantly less micromotion than the stems that were less than 20 mm in length. In the 10mm resection group, the stem longer than 25mm had micromotion (108 μm) exceeded this threshold (2).

Significance: The longer stem achieved greater stability compared with shorter stem in simple and extended neck cutting. Stems 25 mm or longer achieved initial stability within the threshold for bone ingrowth, whereas those 20 mm or shorter did not. This suggests that prosthesis with shorter, textured, press-fit stems may not provide initial fixation that is conducive for bone ingrowth under the conditions tested in this study.

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Figure 1: Schematic representation of proximal radius with (A) 10 mm and (B) 21 mm cutting showing the placement/orientation of a radial head prosthesis with (i) 10 mm; (ii) 15 mm; (iii) 20 mm; (iv) 25 mm; and (v) 30 mm stems.
Figure 2: A) Schematic of the micromotion machine. The implanted stem was affixed to a 90 mm diameter plate and a geometric calculation was used to convert plate motion to stem micromotion. This tilt was assumed to occur at the center of the component. In a right triangle, the tilting angle (α) was calculated from the formula $\alpha = \arctan\left(\frac{l_{is}}{L}\right)$.
Figure 3: After 10 mm (A) and 21 mm (B) of head and neck resection, stem micromotion decreased as the stem was lengthened (p = 0.0002 and p = 0.04 respectively). Data shown are the means ± standard error of the means (error bars). Columns with letters in common in any one graph are not statistically different from one another (i.e. p > 0.05).