Validation of a Simple Overlay Device to Assess Radial Head Implant Overlengthening

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Introduction: Proper sizing of radial head implants is necessary for optimal joint function. Overlengthening of the implant can result in capitellar wear, loss of motion, and degenerative arthritis. Due to the need for a reliable system of measuring radial head and neck height, a simple overlay device (SOD) was created based on the idea of a ‘three-point fix’. In a review of 30 anteroposterior elbow radiographs(1), the SOD was reliably able to detect 2.5 mm of overstuffing, the critical threshold for radial head prostheses after which deleterious consequences can occur. This cadaveric study was done to validate the simple overlay device in the laboratory setting.

Methods: Five fresh frozen cadavers were implanted with sequentially longer implants, adjusted by collar size (0, 2, 4, and 8 mm). Fluoroscopic images were obtained in 4 forearm positions: flat supinated, flat neutral, supinated in 45 degrees of flexion, and neutral in 45 degrees of flexion. The SOD measurements were compared for each native radial head (control) to assess for implant overstuffing. First, using a simple line-drawing tool, a line was drawn that is tangential (T) to the top of the radial head. A perpendicular line (P) was then drawn using the software’s set-square tool. The overlay template, which was printed on a laminate, was manually held up to the computer display so that the vertical template lines (V) were parallel with line P, perpendicular to the radial head. The image was zoomed to a magnification that allowed the upper and lower sides of the triangle to contact the upper and lower edges of the bicipital tuberosity. The height of the radial head and neck were then measured by obtaining the distance from line T (radial head) to line H on the template (Fig. 1). Additionally, gapping of the ulnohumeral joint space was measured for comparison purposes. Interclass correlation coefficients (ICCs) were used for the analysis of measurement reliability between observers. The data were modeled with the use of 2-Factor Repeated Measures Analysis of Variance and statistical means contrast comparisons where appropriate with a significance level of $p \leq 0.05$.

Results: For the SOD, the mean errors for all 4 collar sizes were less than 2 mm, except in one measurement in which the bicipital tuberosity was exceedingly difficult to visualize. The ICC values for Observer 1 versus the Overlay were between 0.96 - 0.99. The ICC values between observers were between 0.94 - 0.95. For both observers, neither elbow position, collar height, nor the two variables combined significantly affected the SOD values ($p > 0.05$)(Fig. 1). Measurements of the ulnohumeral joint spaces had higher inter-observer variability though could reliably detect overstuffing of over 4 mm.

Discussion: The SOD measurements are consistent across multiple observers. This is evidenced by the excellent ICC in this study as well as in the study by Moon, et al (1), which demonstrated excellent correlation between two different observers, neither of which were involved in the present investigation. Thus, a total of 5 different observers evaluating this tool over two studies have demonstrated the instruments consistency and reliability. The data suggests that the accuracy of this overlay does not decrease with an increasing implant length, and is not dependent on how the elbow is positioned when the x-ray is obtained.

Significance: The simple overlay device is a reliable method of simply assessing radial head overstuffing using x-rays, and can accurately detect between 0 and 2 mm of overlengthening.

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Figure 1: The simple overlay device as used in A) the native, intact joint and B) measuring overlengthening with an 8 mm overstuffed joint.
Figure 2: Simple Overlay Device Measurement