

Effect Of Implant Positioning And Resection Plane Selection On Available Fixation Depth For Stemless Shoulder Arthroplasty

Gregory Spangenberg^{1,2}, Fares Uddin², Kenneth J. Faber^{1,2}, G. Daniel Langohr^{1,2}

¹The University of Western Ontario, London, ON, ²Roth|McFarlane Hand and Upper Limb Clinic, London, ON

Disclosures: Gregory Spangenberg (N), Fares Uddin² (N) Kenneth J. Faber (1:Exactech, 3B:Exactech), G. Daniel G. Langohr (N)

INTRODUCTION: Stemless implants have been developed to preserve bone stock and avoid stem-related complications. The lack of stem also aids in the reconstruction of the shoulder anatomy closer to the original native state. In contrast to stemmed implants, stemless humeral implants rely on cement-less metaphyseal fixation. The amount of metaphyseal fixation available is partly determined by the space available from the resection plane to the inner cortex, however the effect of implant positioning and resection plane selection has not been thoroughly explored.

METHODS: 35 computed tomography scans of non-diseased cadaveric humeri were segmented to create three dimensional models. A shoulder surgeon digitized the location of the anatomic neck of the humerus. Humeral retroversion for this population ranged from 27.6° to 68.9° and the anatomic neck-shaft angle ranged between 125.4° and 141.7°. Patient specific coordinate systems were automatically constructed from the humeral head axis and the canal axis by *shoulder* [3]. A plane was fit to the anatomic neck and served as the initial resection plane before further variation. Resection location was translated $\pm 5\text{mm}$ along the normal vector of the anatomic neck plane starting from the centroid of the anatomic neck. This translation is analogous to a translation in the centre of rotation. The neck shaft angle of the resection cut was varied $\pm 10^\circ$ from the anatomic neck-shaft angle and the version was also varied $\pm 10^\circ$ from anatomic. The location of the stemless implant was translated $\pm 5\text{mm}$ along the anterior-posterior axis, and $\pm 5\text{mm}$ along the medial-lateral axis. All variations were done in 1° or 1mm increments resulting in 586,971 unique combinations of implant and resection location for just one bone. For each combination a ray emanating from the centre of the top of the stemless implant was cast along the normal of the resection and the distance until collision with the inner cortex. The magnitude of the ray is the depth of the humerus available for fixation for that combination. Multivariate regression analysis was used to evaluate the effect of the dependent variables neck-shaft angle, version angle, anterior-posterior translation, and medial-lateral translation on the independent variable available fixation depth. A generalized linear model using Generalized Estimating Equations (GEE) with exchangeable dependence was fit using the python package statsmodels, to account for within subject correlations.

RESULTS: Correlating to an increase in available fixation depth was lateral translation of the implant from the centroid of the resection 0.527 [CI 0.490 – 0.564], a reduction in neck-shaft angle of the resection plane 0.336 (CI 0.307 – 0.366), and posterior translation of the implant from the centre of the resection 0.218 (CI 0.108 – 0.32). Increasing resection version angle had a small correlation 0.086 (CI 0.044 – 0.129) to increased fixation depth. All coefficients were statistically significant as the null hypothesis, that the effect of the variables is 0, was rejected for each coefficient ($p < 0.001$).

DISCUSSION: Reeves et al. investigated resection depths from the anatomic neck and found it to be correlated to resection plane diameter, gender, and patient height [1]. These are factors that can limit the amount of available fixation depth. If depth is limited for the metaphyseal fixation of the implant a reduced neck-shaft angle resection cut could suffice, and lateral or posterior translation of the implant after resection. The variations in implant positioning that we explored encompassed a range of clinically relevant adjustments or deviations from the anatomic position used in stemless total shoulder arthroplasty [2]. However, a limitation of this study was that variations were conducted starting from an anatomic resection and not the higher neck-shaft angle resection done for reverse shoulder arthroplasty.

SIGNIFICANCE/CLINICAL RELEVANCE: The analysis suggests that small lateral and posterior offsets of the implant from the centroid of the resection can increase the amount of available fixation depth for the stemless implant. Conversely, increasing the neck-shaft angle from the anatomic position can reduce available fixation depth.

REFERENCES & ACKNOWLEDGEMENTS: [1] J. M. Reeves et al., JSES, vol. 27, no. 4, pp. 650–658, Apr. 2018. [2] B. Kadum et al., International Orthopaedics, vol. 40, no. 4, pp. 751–758, Apr. 2016. [3] Shoulder 1.1.0, PYPI, June 2023.