THREE VERSUS FOUR PEGGED GLENOID COMPONENTS: A BIOMECHANICAL EVALUATION OF FIXATION STABILITY WITH CYCLICAL LOADING

[1] David Wellman, [1]Paul Weinhold, [2]Carly Kreps, [1]Matthew Raynor, and [3]Spero Karas
[1]University of North Carolina-Chapel Hill, Department of Orthopaedics, [2]University of Virginia School of Medicine, [3]Emory University Department of Orthopaedics; email: weinhold@med.unc.edu

INTRODUCTION

The most common complication in total shoulder arthroplasty is glenoid loosening [6, 2, 4]. Past studies analyzing loosening have concluded that some glenoid designs are superior to others. Rough-backed is better than smooth-backed [1, 2], curve-backed superior to flat-backed [1,2], all polyethylene better than metal-mesh backed [5, 1, 3], and pegs preferred over a keeled design [1]. To date, no studies have investigated the difference between a 4 peg and 3 peg glenoid design. The objective of this study was to characterize the loosening performance of a commonly used 3-peg design (Encore Foundation Total Shoulder Glenoid) versus a 4-peg design (Zimmer Anatomical Total Shoulder Glenoid).

METHODS

Fourteen glenoid components were cemented into bone stock (Model 1522-12, Pacific Research Labs) using standard surgical methods. Loosening of the components was evaluated by a previously established dynamic testing method (ASTM F2028-02) with slight modification. Four of the samples were used to determine the 90% subluxation distance to be utilized in the dynamic testing method. This distance was found to be 4mm. The remaining ten samples were subjected to dynamic testing (n=5 per design).

A linear pneumatic cylinder aligned normal to the glenoid plane was used to compress the humeral head horizontally into the glenoid component at 112 lbs (+/- 11 lbs). The actuator of a servohydraulic materials testing system was used to displace the humeral head sinusoidally to 90% of the subluxation distance in the superior and inferior directions. Samples were subjected to 100,000 cycles at 2 Hz.

Loosening was measured by two eddy current sensors (Model 4U, Kaman Inc.) aligned normal to the glenoid plane that detected the rocking motion of aluminum targets attached to the superior and inferior edges of the glenoid component . A 21 point calibration of the sensors was completed using a non-rotating micrometer with 0.001'' resolution. Dynamic tests were paused at the following load cycles so that static edge displacements could be recorded after the humeral head was displaced to 90% of the subluxation distance: 1K-10K(in 1K increments), 20K, 30K, 40K, 60K, 80K, 100K.

Superior and inferior edge displacements were compared between the glenoid designs at equivalent cycle numbers by a student's T-test. In addition, a two-way ANOVA was used to compare displacements as a function of glenoid design and cycle number. Edge displacements were also plotted as a function of cycle number. Logarithmic regressions of these plots were compared for each design using a dummy variables statistical approach.

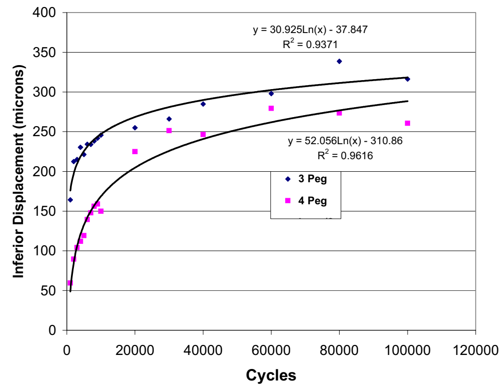

Figure 1: Mean inferior edge displacement of glenoid as a function of cycle number for the 3 and 4 peg designs.

RESULTS AND DISCUSSION

Both inferior and superior edge displacements were found to increase significantly with cycle number (Figure 1). While statistical analyses revealed the regressions of displacement versus cycle number differed with design, comparisons of displacements at specific cycle numbers revealed no difference with design except in the inferior displacement at 1000 cycles. Thus, while the 4 peg design displayed a slightly more stable fixation early, this did not prove to be significant over extended cycles. It is important to recognize that while the two designs did differ in peg number, they also differed in threading pattern of peg and in the width of the articular surface at the inferior pole. A limitation of this study is that inclination and cement mantle thickness were not controlled for.

CONCLUSIONS

Both the 3 and 4 peg design displayed similar loosening over extended cycles. Clinically, the difference over time between the two is unlikely to be detected by the patient. However, further clinical studies involving patient surveys and radiographic analyses are needed to confirm these *in vitro* results.

REFERENCES

1. Anglin, et al. *Clin Biomech* **16**(2): 144-50, 2001.
2. Anglin, et al. *J Shoulder Elbow Surg* **9**(4): 323-31, 2000.
3. Boileau, P., et al. *J Shoulder Elbow Surg* **11**(4): 351-9, 2002.
4. Lacroix, D., et al. *J Biomech Eng* **122**(4): 430-6, 2000.
5. Stone, K. D., et al. *J Shoulder Elbow Surg* **8**(2): 151-8, 1999.
6. Wirth, M. A. and C. A. Rockwood, Jr. *J Bone Joint Surg Am* **78**(4): 603-16, 1996.