Reverse Shoulder Glenoid Loosening Test Method: an analysis of fixation between two different offset glenospheres

Recent successes achieved with reverse shoulder arthroplasty (RSA) have led to an expansion of its indications and an increase in the number of commercially available designs in the global marketplace. Despite these development efforts, little guidance exists regarding reverse shoulder test methods and little published data exists regarding reverse shoulder performance standards. At least one of the bench studies published using RSA was performed under idealized bone conditions (e.g., polyurethane bone substitutes and densities of 30 lb/ft³) or were based on physiologic-relevant loading conditions (2,3; such as, applying the ASTM 2028 glenoid rocking test which translates a convex humeral head against a concave glenoid to induce edge loading and facilitate the rocking horse mechanism).

Patients who receive a reverse shoulder commonly have some form of comorbidities accompanied by bone or soft-tissue changes of age, deformity, and/or pathology. Therefore, the authors contend that any reverse shoulder test method should utilize a low density polyurethane substitute (e.g., 15 lb/ft³) as a baseline. Additionally, each of the currently available reverse shoulder designs do not have a “radial mismatch” between the humeral liner/glenosphere articular surfaces, which conventionally occurs in traditional total shoulder arthroplasty between the convex humeral head and concave glenoid. Typically, reverse shoulders have congruent articular curvatures; and as such, translation and edge loading does not occur in RSA as it does in traditional total shoulder arthroplasty. Therefore, the authors contend that any reverse shoulder test method should simulate the primary loading conditions experienced by a reverse shoulder; that is, rotation of the congruent articular curvatures in abduction, as generated by the deltoid. The purpose of this study is to utilize this proposed reverse shoulder testing method to quantify the fixation associated with two different offset reverse shoulder glenosphere designs.

Methods

The two different offset 38mm reverse shoulder glenoid components (standard offset and +4mm laterally offset 38mm glenospheres; Equinox; Exactech Inc.) were assembled to a 15 lb/ft³ polyurethane bone substitute block, conforming to ASTM F 1839 (Pacific Research Laboratories; Vashon, WA: 76mm x 577mm x 48mm). These glenoid components were fixed to the bone blocks using four, 4.5mm compression screws (via a 3.2mm pilot hole) and subsequently locked with caps according to the manufacturers recommended technique. The tapered peg of each glenoid plate was press-fit using a 7.37mm drill.

Five samples of the standard offset 38mm glenosphere were tested and three samples of the +4mm laterally offset 38mm glenosphere were tested (n=8). Each mating 38mm humeral liner component was cyclically loaded for 50,000 cycles about a 5° arc along each offset glenosphere using a rotatory actuator at a rate of 0.5 Hz as a 750 N compression load was applied through the center of the glenosphere via a rotatory actuator (e.g. polyurethane bone substitute block). This cyclic loading simulated the clinical loading of reverse shoulders by using a rotatory actuator to simulate rotation (e.g. abduction) of a congruent articular joint typical of a reverse shoulder prosthesis rather than an edge-loading test which simulates translation of a non-congruent articular joint atypical of a reverse shoulder prosthesis (e.g. the radial mismatch between a traditional glenoid component and a humeral head). The primary limitation of this study is the small sample size, larger numbers of samples may be required to elucidate differences in the measured parameters.

Discussion and Conclusions

The results of this study demonstrate that the standard offset 38mm glenosphere and the +4mm laterally offset 38mm glenosphere are associated with similar fixation in the A/P and S/I directions before and after 50k cycles of 750 N loading in a low density bone substitute. While the use of this test method did not elucidate any statistical differences between the two designs, it did demonstrate that statistical differences could be resolved between loading conditions. The authors contend that the employed test method better simulates the clinical conditions of the older patient population who would typically receive a reverse shoulder prosthesis by using a lower density bone substitute (15 lb/ft³ vs. 30 lb/ft³). Further, the authors contend the employed test method better simulates the clinical loading of reverse shoulders by using a rotatory actuator to simulate rotation (e.g. abduction) of a congruent articular joint rather than an edge-loading test which simulates translation of a non-congruent articular joint atypical of a reverse shoulder prosthesis (e.g. the radial mismatch between a traditional glenoid component and a humeral head). The primary limitation of this study is the small sample size; larger numbers of samples may be required to elucidate differences in the measured parameters.

References