The Use of Constrained Liners in Reverse Shoulders

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Introduction
Reverse shoulder arthroplasty is an increasingly popular treatment option for cuff tear arthropathy, revision arthroplasty, and other degenerative conditions of the glenohumeral joint that have been previously treated with limited success. Despite these successes, joint instability and recurrent dislocations are clinical concerns for which there are few solutions. Currently, the only prothetic options are to increase humeral offset (which changes the angle of the remaining musculature) or use a constrained humeral liner (i.e., humeral liners with a greater degree of constraint, defined as the ratio between humeral liner depth and width at its face - for clarification, a constraint > 0.5 is a constrained joint). To better understand the implications of using a constrained humeral liner, a range of motion (ROM) assessment was conducted in internal/external rotation at varying levels of humeral abduction/adduction to quantify and compare the motion profile and impingement points associated with the standard and constrained reverse shoulder prosthesis.

Methods
The standard and constrained 38mm, 42mm, and 46mm Equinoxe reverse shoulder (Exactech, Inc.) were geometrically modeled using 3-D computer-aided design software (Unigraphics; UGS, Inc.). The standard and constrained 38mm Equinoxe has a 145° neck angle; a humeral liner constraint of 0.26 and 0.33, respectively; and a glenosphere geometry of 38x21mm. The standard and constrained 42mm Equinoxe has a 145° neck angle; a humeral liner constraint of 0.25 and 0.32, respectively; and a glenosphere geometry of 42x23mm. The standard and constrained 46mm Equinoxe has a 145° neck angle; a humeral liner constraint of 0.24 and 0.31, respectively; and a glenosphere geometry of 46x25mm. Additionally, a distal offset is built-in to each 38, 42, and 46mm design to provide 2.25mm, 2.45mm, and 6.25mm of inferior glenosphere offset, respectively. After modeling, each prosthesis was assembled to a 3-D digitized scapula (3-D male scapula; Zygo Inc., Inc.) to create a functional glenohumeral joint. Prior to assembly, <2mm of bone was removed from the glenoid of the digitized scapula to create a conforming surface for each implant; each glenoid component was implanted in the center of the glenoid. A geometric computer analysis was then conducted to quantify anterior/posterior scapular impingement as the humerus was internally/externally rotated at varying levels of abduction/adduction. The locations of prosthesis impingement on the scapular were plotted vs. motion; the total motion associated with each prosthesis was calculated from the enclosed area of each plot (note this measurement is unit-less).

Results
The motion profile associated with the standard and constrained 38mm, 42, and 46mm Equinoxe reverse shoulder during internal/external rotation at varying levels of humeral abduction is depicted in Figures 1, 2, and 3. The 38mm standard design is associated with 43% more motion than the 38mm constrained design (9449 and 5418, respectively). The 42mm standard design is associated with 32% more motion than the 42mm constrained design (11018 and 7524, respectively). The 46mm standard design is associated with 29% more motion than the 46mm constrained design (11909 and 8482, respectively). The linear relationship of total motion in abduction/adduction at zero rotation (y) and humeral liner constraint (x) for the standard and constrained humeral liners is y = -396x + 184 and y = -489x + 224, respectively.

Discussion and Conclusions
The results of this study demonstrate that at nearly every level of humeral abduction, the constrained liner impinges on the scapula prior to the standard liner; the only exception being at mid-levels of humeral abduction outside the physiologic range of external rotation. Of particular concern is the region of impingement at lower levels of abduction; this impingement could induce levering-out of the humeral liner, resulting in dislocation. Should the clinical need for additional stability arise, the authors recommend using larger glenospheres to minimize inferior impingement and incorporating additional techniques that have been previously demonstrated1 to minimize inferior scapular impingement, such as: inferior offsetting and/or inferiorly tilting the glenosphere.

References

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