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ORIGINAL ARTICLE

Does prosthetic humeral articular surface positioning associate with outcome after total shoulder arthroplasty?

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Background: The purpose of this study was to determine the effect of humeral articular component positioning on changes in patient-reported outcomes after anatomic total shoulder arthroplasty.
Methods: This was a retrospective series of consecutive patients at 2 high-volume referral centers. The study included patients with (1) a preoperative and postoperative radiograph demonstrating a perfect or nearly perfect profile of the humerus and implant and (2) Simple Shoulder Test, visual analog scale for pain, and American Society of Shoulder and Elbow Surgeons (ASES) Standardized Shoulder Assessment scores preoperatively and at greater than 2 years postoperatively. Head height, head diameter, tuberosity-to-head height distance, inclination, and medial offset of the center of rotation (COR) were measured preoperatively and postoperatively. Distance and direction from the ideal COR to the reconstructed center of rotation was measured. Measurements were correlated with improvement in functional outcomes.
Results: The study included 95 patients, aged 66 ± 9 years, with a mean follow-up of 4.3 ± 1.7 years. An a priori power analysis suggested that a sample size of 95 patients provided 80% power to detect correlations of $R^2 = 0.07$. The COR shift was >2 mm in 62% of patients and >4 mm 15%. Thirty-two percent had a change of ASES of <21 points. On multivariate analysis, there were no significant associations between any change in measured prosthetic radiographic parameters and changes in the visual analog scale, Simple Shoulder Test, or ASES scores ($P > .05$).
Conclusion: In this retrospective analysis of total shoulder arthroplasty in which most components were well positioned, humeral component positioning did not associate with change in postoperative outcomes. These findings should be prospectively confirmed.
Level of evidence: Level IV; Case Series; Treatment Study

Keywords: Total shoulder arthroplasty; humeral component; shoulder arthroplasty; shoulder replacement; patient-reported outcomes; humeral anatomy

This study was approved by the Institutional Review Boards of the University of Utah (protocol #65636) and Washington University in St. Louis Medical Center (protocol #201707043).

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Shoulder replacement frequency is increasing.[28] For instance, during 2011 and 2012 in the United States, more than 100,000 shoulder replacements were performed compared with just over 46,000 between 2001 and 2002.[28,43] The expansion is partly due to an increase in the use of total shoulder arthroplasty (TSA).[28] Clinical outcomes after TSA are predictably very good.[11,36,46] However, not all patients achieve optimal postoperative function and range of motion. For instance, an analysis of a recently published data set[12] found up to 8% of patients will not regain active forward elevation of >120° and up to 32% of patients will not regain an American Shoulder and Elbow Surgeons (ASES) score of >80 points, which is considered to be a "fair" outcome, but not a "good" or "excellent" outcome.[12] Not all patients are able to return to their preinjury activities.[9] In addition, implant longevity is suboptimal. Within 13 years after TSA, there are signs of rotator cuff dysfunction in 70% of patients and glenoid component loosening in 50%.[37] Possible reasons for poorer outcomes may be patient-related but also may be related to how well the arthroplasty was technically performed.

Humeral component design and positioning has long been considered to correlate with TSA outcome.[1,5,7,14-16,18-20,23,31-33,45,48] Humeral anatomy is highly variable[6,21,22,32,40,41] and can be technically challenging to accurately reconstruct.[1,32-35] This has prompted many prosthetic implant design changes since the advent of modern shoulder arthroplasty,[30] including modularity at the head/neck junction,[17] eccentricity within the humeral head replacement,[6,32] humeral heads of variable sizes and thicknesses,[20] and variable inclination implants.[6,32]

Multiple biomechanical studies have demonstrated that the biomechanics of the glenohumeral articulation is sensitive to even very small deviations in anatomy.[2,20,25,27,31,48] For instance, a change of 2.5 to 4 mm in the humeral center of rotation (COR) between the anatomic and the prosthetic heads increases glenoid edge loading, stiffness, and impingement.[14,17,32] These biomechanical data would suggest that shoulder function after anatomic shoulder arthroplasty should be very sensitive to humeral component position.

Very little evidence exists examining the relationship between accuracy of the humeral articular surface reconstruction and clinical outcome. For instance, failure to restore the COR of the humeral head has been demonstrated to be common after TSA.[1] Retrospective clinical comparisons have not demonstrated any difference in patient-reported outcome between second- and third-generation components[39] or between standard and eccentric humeral heads.[42] In addition, stemless components, which theoretically should offer the best anatomic restoration because they are not constrained by diaphyseal or metaphyseal anatomy,[10,26] have not demonstrated improved outcomes over more traditional stemmed components.[4]

Traditionally, many surgeons have suggested that TSA is a "soft tissue surgery" and that the outcome may thus be less dependent on implant selection and positioning.[17] However, analysis of failed anatomic arthroplasties has demonstrated a high proportion of malpositioned and malaligned humeral components, suggesting that accuracy of humeral reconstruction may play a role.[19] To date, only a single article has attempted to correlate humeral component position with postoperative outcome, and this study had >50% loss to follow-up and did not include radiographic quality criteria,[1] clouding the conclusions.[18]

The purpose of this study was to determine the effect of humeral component positioning on postoperative outcomes after anatomic TSA. We hypothesized that improved humeral component positioning would be associated with a greater improvement in postoperative patient-reported outcomes.

Materials and methods

This was a retrospective study. We included patients who underwent primary anatomic TSA for a diagnosis of primary glenohumeral osteoarthritis at the University of Utah or Washington University of St. Louis Medical Center after 2007 with a minimum of 2 years of follow-up, including preoperative and postoperative American Shoulder and Elbow Surgeons (ASES) Standardized Shoulder Assessment, Simple Shoulder Test (SST), and visual analog for pain (VAS) scores. We excluded patients with less than 2 years of follow-up available, patients without complete preoperative shoulder functional scores, patients without adequate quality radiographs as defined below, revision shoulder arthroplasty, history of a rotator cuff repair in the involved shoulder, patients with known postsurgical subscapularis insufficiency, and patients who underwent revision of their shoulder arthroplasty during the follow-up period. Postsurgical subscapularis insufficiency was determined based on migration of the lesser tuberosity fragment on the postoperative radiographs because all included patients underwent a lesser tuberosity osteotomy. Our goal was to exclude patients with known potential causes of lower postoperative outcome scores.

This cohort was part of a previous study of the minimal clinically important difference for the ASES score, SST, and VAS after shoulder arthroplasty.[44] Within this cohort and during the period studied, the surgeons who performed these procedures shared a very similar surgical technique with regards to exposure, subscapularis management, and implant positioning. During the study period, the surgeons aimed to place all humeral implants in 20° to 40° of retroversion and used corrective reaming to within 10° of neutral version for the management of glenoid deformity and retroversion. No augmented glenoid components or glenoid bone grafts were used. Because this is a retrospective study, case-to-case variation exists.

Data collection

Once the cohort was determined, the following information was collected for each patient: age, sex, body mass index, medical comorbidities sufficient for calculation of the Elixhauser score,[13] duration of follow-up, and preoperative and postoperative ASES, SST, and VAS scores. Preoperative radiographs were used to judge the pattern of glenoid erosion as described by Walch et al.[47]

Radiographic measurement protocol

Preoperative and postoperative true anterior-posterior radiographs obtained in the outpatient clinic were evaluated. Preoperative