Coracoid and Acromion Dimensions as Predictors of Extra-Articular Impingement in Reverse Shoulder Arthroplasty

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INTRODUCTION: Clinical and biomechanical studies have shown the benefits of Reverse Shoulder Arthroplasty (RSA) in pain relief and functional recovery, but concerns remain regarding range of motion (ROM) and impingement. There are numerous studies investigating how to minimize intra-articular impingement (contact of the cup with the glenoid) and avoid scapular notching. However, it is shown that ROM in RSA can also be restricted by extra-articular impingement, which is defined as the contact of the humerus to the acromion or the coracoid. To date it is not well understood how extra-articular impingement affects ROM and Activities of Daily Living (ADLs) and how it is affected by the scapula morphology. The objective of this study was to explore how acromion and coracoid size and shape correlate with ROM and risk of extra-articular impingement in common ADLs and how glenoid lateralization and humeral stem version can reduce the problem.

METHODS: This study utilized 3D-CT scans from 40 non-OA cadaveric shoulders. A 3D model of a commercial RSA design was used (Zimmer Biomet, Comprehensive Reverse Shoulder System) to perform a virtual RSA. A fellow trained shoulder surgeon assisted with the placement of the glenoid baseplate with neutral version and tilt and with the glenoid sphere having a 3mm overhang from the inferior glenoid border and the humeral stem was placed at 20°of humeral version as per surgical recommendations. A computerized shoulder biomechanical model was used to calculate intra and extra-articular impingement for a set of 6 activities of daily living (ADLs) (Tasks: 1. Reach opposite axilla, 2. Reach opposite side of neck, 3. Combing hair, 4. Reach back of head, 5. Place object on shelf at head height). All motions included scapulothoracic motion and recorded from healthy population. The study focused on extra-articular impingement, and it separated the results into contact between the humerus and the acromion or coracoid. The most lateral acromion point (LA), the angulus acromialis (AA) and the most lateral tip of the coracoid (CT) were identified and distances (lateral and superior offset) from the center of the glenoid were measured. The Pearson Correlation Coefficient (PCC) and R2 values were calculated to represent the risk of impingement between the coracoid/acromion and impingement, where a Welch's independent t-test was used to investigate significant differences.

RESULTS: The specimen's native humeral head version ranged from 53° to 12°. Extra-articular impingement data showed great variability within the subjects. Coracoid impingement was detected heavily in the task of 'reach opposite side of neck' (all 40 subjects) and less frequently in the other 2 tasks (Task1: 13 subjects, Task 3: 16 subjects). The lateral extension of the coracoid was the most reliable measurement to correlate with impingement (PCC: 0.776, $p<0.001$). The subjects that did not show coracoid impingement in Tasks 1 and 3 had an average lateral extension that was shorter than the subjects that had impingement (14.3±2.1mm vs 19.1±2.3mm, $p<0.001$). Acromion impingement detected in the tasks of 'reach back of head' (12 subjects) and 'place object on shelf' (22 subjects), but the location of the impingement sites was variable with impingement detected on both the angulus acromialis and acromion tip. The superior offset of both sites was the best indicator for impingement, however the correlation was weak (PCC:-0.600 and -0.265, $p=0.04$ with R2:0.360 and 0.365 respectively).

DISCUSSION: This study reveals that extra-articular impingement is a common occurrence during activities of daily living following reverse shoulder arthroplasty. Specifically, the humerus frequently makes contact with the acromion during arm elevation and with the coracoid when reaching across to the contralateral side. The dynamics of this impingement are complex, particularly in relation to the acromion and coracoid. The lateral offset of the coracoid tip relative to the glenoid center appears as a significant predictor of extra-articular impingement. In contrast, acromion impingement is influenced by multiple factors, with the superior offset of both the acromion angle and acromion tip contributing to increased impingement. It is crucial to recognize that these findings are specific to a particular RSA design, and outcomes may vary with different designs. Nonetheless, the methodology employed in this study holds the potential to be expanded to encompass a broader range of activities and prosthetic designs, offering valuable guidelines for mitigating extra-articular impingement.

Figure 1: Acromion impingement showed

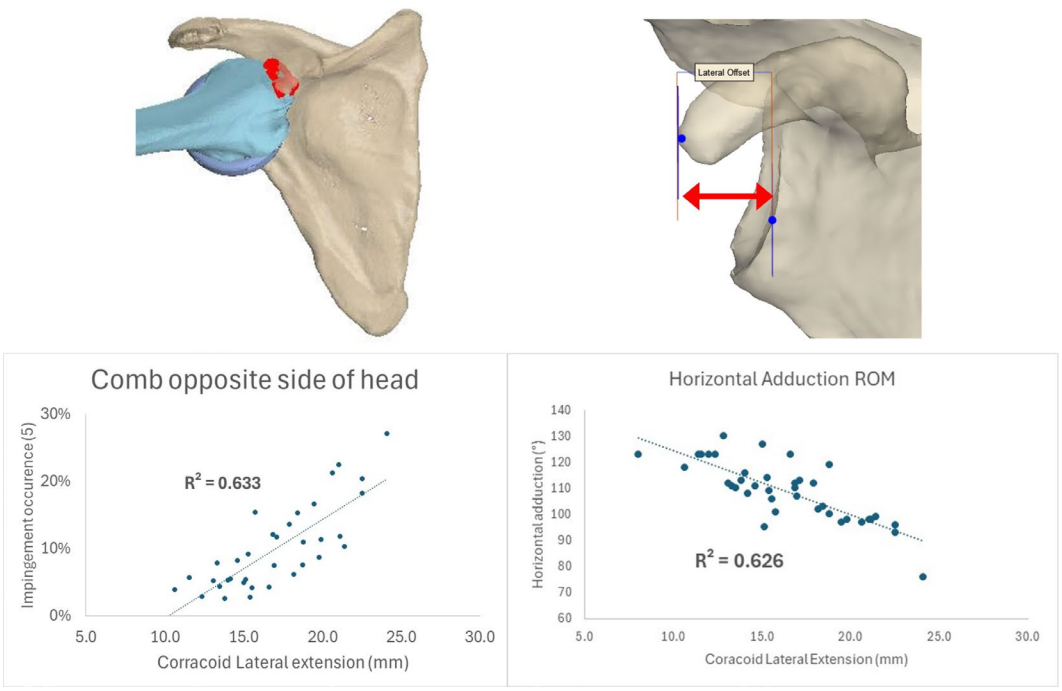

Figure 1: Coracoid lateral extension showed high correlation with impingement risk in ADLs and Rang of Motion

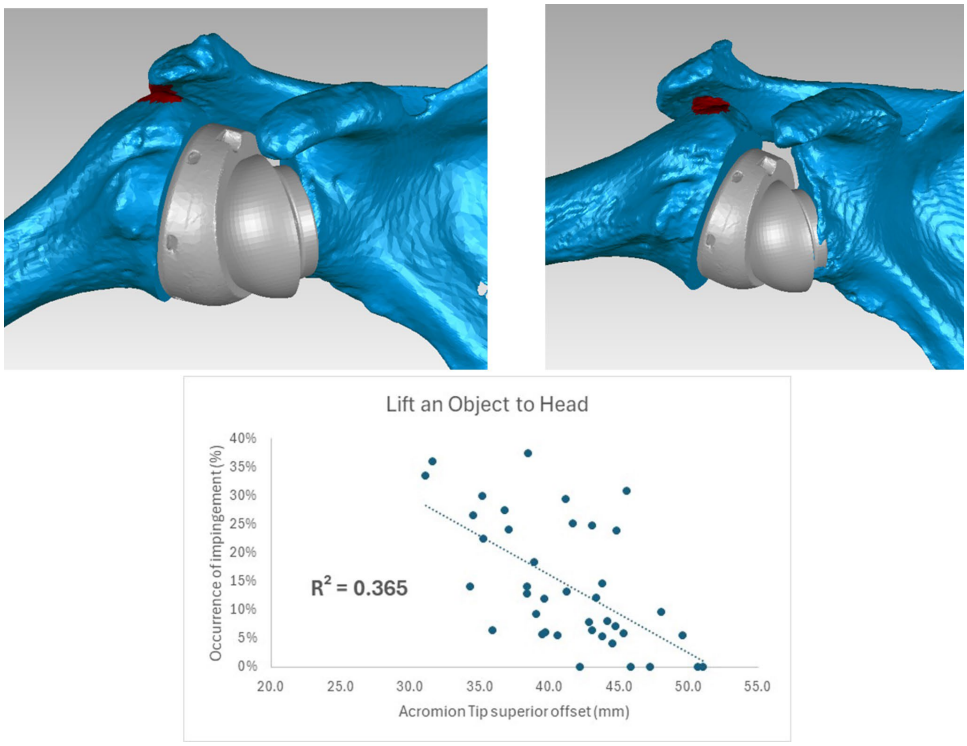

Figure 2: Acromion showed multiple sites of impingement (under the acromion or on the acromion tip) and none of the measurement showed strong correlation with risk of impingement during ADLs