A NOVEL OSTEOTOMY TECHNIQUE IMPROVES RESTORATION OF HUMERAL HEAD GEOMETRY IN SHOULDER ARTHROPLASTY

**Gerber, A;** Harrold, F; **Apreleva M;** Warner, Jon J P
**Upper Extremity Unit, Clinic for Trauma and Reconstructive Surgery, Humboldt University, Berlin, Germany**
**Orthopaedic Biomechanics Laboratory, BIDMC and MGH, Harvard Medical School, Boston, MA, USA**

Introduction: Third generation prosthetic components are believed to allow restoration of the individual’s proximal humeral anatomy during arthroplasty, provided, a precise osteotomy of the humeral head at the level of the anatomical neck is performed (1). The osteotomy and reconstruction of the humeral head is based on the assumption that the resected articular segment corresponds to a segment of a sphere oriented, identically, in inclination and retroversion to the original humeral head (2,3). A previous report has suggested that the humeral head is not a perfect segment of a sphere and that the traditional osteotomy technique performed along the antero-superior part of the anatomical neck does not accurately replicate inclination and retroversion of the humeral head (4).

We hypothesize that a simulated osteotomy performed along the antero-inferior anatomical neck resects a portion of the humeral head similarly oriented to the original head in terms of inclination and retroversion, and, more closely matches head diameter and radius of curvature when compared to the traditional osteotomy approach.

Materials and Methods: Twenty-eight fresh frozen human cadaveric full arms (13 male, 15 female, age range 53-89 years) without bony deformities, previous fracture or surgical intervention were dissected free of soft tissue to expose the proximal humerus. The humeral insertion of the pectoralis tendon (PT) was preserved. The distal end of the humeral shaft was potted in PMMA and fixed rigidly in a custom-built jig. The following lines, points and surface s were identified and marked on each specimen (Figures 1a & 1b): (1) the circumference of the anatomical neck; (2) H as the highest point of the articular surface at the insertion of the supraspinatus tendon; L as the corresponding lowest point of the articular surface at the cartilage/calcific interface, and (HL) as a straight line between (H) and (L); (3) (AP) as a line perpendicular to (HL) passing through the centroid of the area (SA) formed by the articular circumference; (4) (G) as a point on the articular edge, adjacent to the superior glenoid ligament; (5) the circumference of the humeral shaft at the upper (UB) and lower (LB) borders of the insertion of the pectoralis major tendon; (6) the medial (MC) and lateral (LC) humeral condyles identified radiographically and marked with k-wires.

A Microscribe 3DX digitizer (Immersion Corp., San Jose, CA) was used to digitize the points and lines described above. The data was imported into Rhinoceros NURBS modeling software (McNeal and Assoc., Seattle, WA) and graphically modeled.

The following parameters, calculated from the model, were used to describe the humeral head geometry: the centroids of the areas delineated by each humeral shaft circumference (UB, LB) were used to construct the humeral shaft axis (s); the longitudinal and axial radii of curvature (RoC) defined as the radii of curvature of the articular surface in the planes formed by (HL) and (AP), respectively, and perpendicular to (SA); the inclination angle (α) and retroversion angle (β) were used to define the orientation of the humeral head. The inclination angle (α) was calculated as the angle between the humeral shaft axis (s) and (CB), where (CB) was defined as the line from a point at the centroid (C) of (SA), to the articular surface and perpendicular to the surface (SA). The retroversion angle (β) was calculated as the angle between the trans-epicondylar line (ML) and (CB).

To simulate the traditional osteotomy, a plane was constructed using the points (H), (L) and the digitized data points of the anterior portion of the anatomical neck between (H) and (L) (Figure 1c.). The new osteotomy plane was formed using the points (P), (L), (G) and the digitized data points of the anatomical neck between (P) and (G).

The distribution of continuous variables was tested for normality using a Shapiro-Wilk’s W test. Paired Student’s t-test was used to compare the geometry of the resected segments for the new and traditional osteotomy techniques with the geometry of the original humeral head. To account for multiple comparisons, a priori, a two-tailed value of p <0.1 was chosen to declare a statistically significant result.

Results: No differences were found between the axial RoC of the resected segment for the new technique (22.5±2.2mm) when compared to the original head (22.5±2.1mm); a difference was found for the old osteotomy technique (23.0±2.3mm) (p<0.01). In the coronal plane, no differences were found for the RoC of both the new and traditional techniques when compared to the original head. The axial and coronal diameters of the osteotomized surface were significantly different for both techniques. However, the mean difference between the axial and coronal diameters for the new technique was 2.4±0.8mm and, for the traditional technique, 3.2±0.8mm. Significant differences (p<0.01) in retroversion of the resected surface were found when the new osteotomy technique (24.5°±10.2°) and traditional technique (40.5°±12.2°) were compared to the original head (29.0°±10.3°). Further, significant differences (p<0.01) in inclination were found, when the new osteotomy technique (129.5°±4.4°) and traditional technique (132.1°±5.0°) were compared to the original head inclination (136.9°±4.7°).

Discussion: Previous studies have found that the humeral head is not a perfect segment of a sphere. However, by varying the osteotomy approach, this study found that an osteotomy performed along the antero-inferior part of the anatomical neck removes an articular segment that is more spherical than a segment removed by the traditional osteotomy approach. Although significantly different from the original head, the retroversion associated with the new technique more closely matches the anatomy when compared to the traditional technique. The new osteotomy decreased the inclination angle significantly (p<0.01) by 7 degrees. This finding is unlikely to be clinically relevant.

The results suggest that, with the novel osteotomy technique, a more accurate replication of anatomy is possible and, theoretically, complications that have been implicated with non-anatomical reconstructions might be reduced. Application of the technique on cadaveric specimens will reveal the accuracy of an anatomical reconstruction using the novel osteotomy approach and will form the basis for further investigation.


**49th Annual Meeting of the Orthopaedic Research Society**
**Poster #1179**