Introduction  Although there is considerable clinical experience with reconstructing the elbow joint with total elbow replacement and with radial head replacement, reconstruction of the radiocapitellar joint (or lateral compartment) is a relatively new concept. There are several traumatic and degenerative disorders that can lead to isolated degeneration at the radiocapitellar joint, leaving the ulnohumeral joint relatively spared. Interest in capitellar arthroplasty with or without radial head replacement is increasing [1-3] as it is a less-invasive option for patients with pathology limited to the radiocapitellar joint. Although two designs of capitellar arthroplasties have recently become commercially available, a detailed morphological assessment of the capitellum has not been reported. Often assumed to have a spherical shape, McDonald et al [4] suggested that the capitellum has a more complex shape than generally appreciated. An understanding of the morphology of the capitellar articular surface is of utmost importance in ensuring optimal joint biomechanics when undertaking arthroplasty reconstruction of one or both sides of the radiocapitellar joint. The purpose of this study is to provide a detailed description of the morphology of the humeral capitellum with an interest in optimizing capitellar implant design.

Methods  Fifty human cadaveric elbows (33 L, 9 R, 8 unknown) underwent a CT scan (GE LightSpeed Ultra, 64 slice, axial thickness of 0.625 mm). A 3D bone model of the distal humerus was segmented from CT image using the Visualization ToolKit (Figure 1A). A coordinate system was developed for each humerus. The center of the capitellum was determined using a sphere-fit. The center of the trochlea was determined using a circle-fit through the trochlear groove (Figure 1B). A line drawn between these two points represented the flexion-extension axis.

![Figure 1: Establishment of a coordinate system of the distal humerus. A. Distal humerus. B. Flexion-extension axis through center of capitellum and trochlea. C. Schematic of 1 mm sagittal slices through capitellum.](image1)

For each 3D bone model, 1 mm sagittal cuts perpendicular to the flexion-extension axis were made along the surface of the capitellum (Figure 1C). Circle fit values and radii of curvature were calculated from the center of the capitellum to the surface at 60° of flexion. The sagittal cut with the largest radius of curvature was defined as central. The width of the capitellum was defined as being the distance between the most medial and most lateral cuts on the CT scan that still contained capitellum as determined by direct inspection. The height of the capitellum was defined as twice the 0° radius of curvature (Figure 2A).

![Figure 2: The four parameters of the capitellum. A. Height and width of the footprint. B. Humeral axis, and the height and sagittal radius in relation to it.](image2)

The base, or footprint, of the capitellum was defined as a plane passing through the center of the capitellum and angled anterior to the long axis of the humerus by 30° (Figure 2B). The axis of the capitellum was defined as a line passing through the center of the capitellum and perpendicular to this plane. The transverse radius of curvature of the capitellum was then calculated as the circle-fit radius of a circle including the center point and the apex point on the capitellar axis. Height and width, and the sagittal and transverse radii of curvature were compared using a paired t-test (n = 50, α = 0.05). Correlations of height and width, sagittal and transverse radii, and height and sagittal radius were obtained. All statistical testing was performed using SPSS 18.0 (SPSS Inc., Chicago, IL).

Results  Table 1 shows the four parameters used to characterize the capitellum.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean</th>
<th>Range</th>
<th>t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>24.1±3.0 mm</td>
<td>19.8-29.5 mm</td>
<td>P&lt;0.0001</td>
</tr>
<tr>
<td>Width</td>
<td>15.4±1.9 mm</td>
<td>13.1-19 mm</td>
<td></td>
</tr>
<tr>
<td>Sagittal radius</td>
<td>12.0±1.4 mm</td>
<td>9.9-14.8 mm</td>
<td>P&lt;0.0001</td>
</tr>
<tr>
<td>Transverse radius</td>
<td>14.9±3.2 mm</td>
<td>10.1-20.9 mm</td>
<td></td>
</tr>
</tbody>
</table>

The height and width were poorly correlated 0.547 (p < 0.01) (Figure 3A). The Pearson coefficient for the transverse and sagittal radii was 0.705 (p < 0.01) (Figure 3B), while R for height and sagittal radius of curvature was 0.991 (p < 0.01).

![Figure 3: Correlation between height and width (A) and sagittal and transverse radii of curvature (B) for the 50 specimens examined.](image3)

Discussion  The importance of reproducing the surface morphology of the native capitellum in implant systems is greater in a situation where the implant is intended to articulate with the native radial head. We have shown that the capitellum is not spherical, but rather ellipsoid, with a greater radius of curvature in the medial-lateral direction.

The morphology of the capitellum has several important implications for implant design. The first is that the shape is not predictable ellipsoid[4], although there is reasonable correlation between R$_h$ and R$_s$ in this study. The second implication is that a spherical capitellar implant, although conceptually simple and easy to manufacture, will not, in all likelihood, articulate with a native radial head in the same way as the native capitellum. The spherical surface will underestimate the R$_s$ increasing contact stresses. The third issue relates to correct sizing of the height and width of an implant footprint. The correlation between height and width was less robust than for the surface radii. Overhang of implants may change the resting tension of the lateral collateral ligaments, but undersized implants could lead to malposition and/or maltracking.

Conclusion  The capitellum has an ellipsoid surface and elliptical footprint. Future work is needed to assess the viability of anatomical implant designs through kinematic testing and assessment of contact area with both the native and reconstructed radial head prior to their utilization in patients.