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ORIGINAL ARTICLE

Cartilage thickness of distal humerus and its relationships with bone dimensions: magnetic resonance imaging bilateral study in healthy elbows

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Background: Little is known about the cartilage thickness of the distal humerus and how it affects the shape of the articular surface. Our aims were to assess cartilage thickness and to determine the extent to which it affects the true profile of the distal humerus.

Methods: We assessed 78 healthy elbows (39 subjects, 19 women and 20 men) with a mean age of 28 years (range, 21-32 years). Cartilage thickness was measured by use of high-definition magnetic resonance imaging scans at 19 different points of the articular surface, 13 on the trochlea and 6 on the capitellum, on the axial and coronal views. Bone diameters at the medial and lateral trochlear ridges, trochlear groove, and capitellum, as well as the articular surface width, were measured. Subject height was used as an indirect measurement of humerus length. Pearson correlation coefficients and the Student *t* test were used.

Results: Cartilage thickness showed a significant variation (range, 0.4-1.8 mm) independent of sex and side. It appeared thinner at the medial and lateral edges, whereas it increased at the level of the trochleocapitellar and trochlear grooves, the lateral trochlear ridges, and the center of the capitellum. The mean bone diameters of the medial ridge, lateral ridge, trochlear groove, and capitellum measured 25.1 mm, 21 mm, 16.9 mm, and 19.6 mm, respectively. The mean width of the articular surface was 42.9 mm (range, 35.8-50.2 mm). No significant correlation was found between cartilage thickness and bone dimensions.

Conclusion: Cartilage thickness is not uniform and modifies the morphologic shape and diameters of the humeral articular surface. These findings may be relevant to anatomic prosthesis design.

Level of evidence: Anatomy Study; Imaging

Keywords: Cartilage; thickness; humerus; elbow; hemiarthroplasty; humeral trochlea; capitellum; ulnohumeral joint

Few studies have examined the anatomy of the distal humerus. Only 5 of these studies have investigated the morphologic characteristics of the articular surface of the distal humerus, focusing mainly on bone dimensions.[4,8,10,17,18] These studies showed that several morphometric parameters in this

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anatomic region of the elbow may vary, including the capitellum and trochlear diameters, articular width, articular offsets, trochlear notch angle, and anatomic bow.[7] These anatomic studies did not, however, take into account the effect of the cartilage layer on the morphology of the distal humerus because the measurements were mainly performed by means of computed tomography (CT) or radiography. The information currently available on the humeral cartilaginous layer is scanty; the only 2 studies that focused on cartilage thickness observed values ranging from 0.8 to 1.4 mm.[10,18] However, neither of these studies examined the extent to which the cartilage layer varies along the different regions of the articular surface or investigated whether it affects the shape of the underlying bone morphology. Furthermore, it is not yet known whether the cartilage thickness correlates with the humeral bone dimensions.

For these reasons, we performed this anatomic study whose aims were (1) to determine the cartilage thickness of the humeral articular surface, (2) to assess the extent to which any variations depend on the underlying bone size, and (3) to determine whether the cartilage layer modifies the shape of the distal humerus. In view of the results reported for other joints,[1] we hypothesized that the cartilage surface is not uniform and significantly modifies the morphology of the articular distal humerus.

Materials and methods

Informed consent was obtained from each subject. Thirty-nine skeletally mature healthy volunteers were recruited for this study, comprising 19 women and 20 men, with a mean age of 28 years (range, 21-32 years). Subjects with a clinical history of elbow disorders were excluded. High-definition magnetic resonance images were acquired on a high-field scanner (1.5-T Espree; Siemens, Erlangen, Germany) for the right and left elbows by use of a knee-dedicated coil (8 channels), with the elbow positioned in full extension and the forearm in complete supination.

Three-dimensional (3D) balanced steady-state free precession images were acquired in the axial, sagittal, and coronal planes. The sections passing through the axis of flexion-extension of the elbow were selected for all measurements. The technical parameters were as follows: repetition time of 11.89 milliseconds, echo time of 5.3 milliseconds, 1.5-mm section thickness, 160- to 180-mm field of view, 384 base resolution, and 95% phase resolution. Data underwent postprocessing and analyses by use of OsiriX (version 3.6, 64 bit; Pixmeo, Geneva, Switzerland) on a workstation with a high-resolution monitor, which allowed the direct measurement of cartilage thickness and bone size.

The cartilage thickness of the anterior and posterior articular surfaces was measured by use of axial cuts, whereas that of the inferior articular surface was measured on coronal images. The points identified for the measurements are shown in Figure 1A and B. In particular, 11 points (from point A to point K) were measured in the axial plane and 8 (from point a to point h) in the coronal plane. The following points were selected: (1) at the apex of the trochlear medial ridge (point A and point a); (2) at the midpoint between the trochlear medial ridge and the trochlear groove (point B and point b), with the midpoint being defined as the point that lies halfway between the 2 straight lines that are perpendicular to the axis of flexion and extension and that transect the medial ridge (MR) and trochlear groove (TG), respectively; (3) at the deepest point of the trochlear groove (point C and point c); (4) at the midpoint between the trochlear groove and the lateral ridge (point D and point d), with the midpoint being defined as the point that lies halfway between the 2 straight lines that are perpendicular to the axis of flexion and extension and that transect the TG and lateral ridge (LR), respectively; (5) at the apex of the trochlear lateral ridge (point E and point e); (6) at the deepest point of the trochleocapitellar groove (point F and point f); (7) at the point of greatest convexity of the capitellum (point G and point g); and (8) at the lateral extremity of the articular surface of the capitellum (point H and point h); (9) at the posterior trochlear groove (point I), (10) at the level of the posterior trochlear lateral ridge (point J), and (11) at the level of the posterior trochlear medial ridge (point K).

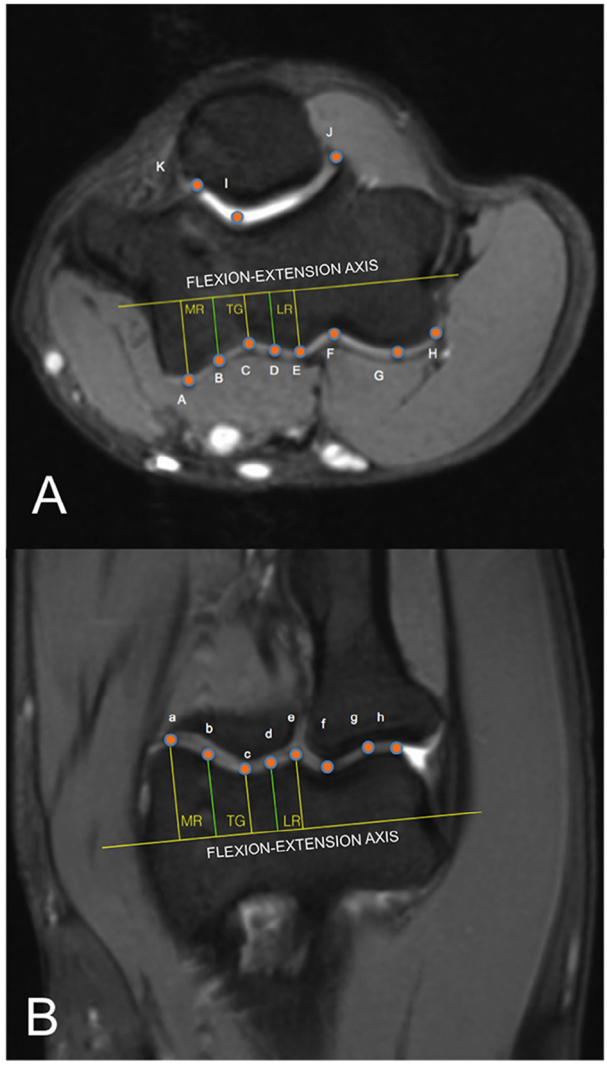

Figure 1 Points of the articular surface where the cartilage thickness was measured in the axial plane (**A**) and coronal plane (**B**). LR, lateral ridge; MR, medial ridge; TG, trochlear groove.

The following bone parameters were also measured: (1) in the axial plane, the width of the articular distal humerus was measured as the distance between the 2 lines passing through the medial