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Contribution of cartilage to size and shape of radial head circumference: magnetic resonance imaging analysis of 78 elbows

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Background: The aims of our study were to quantify cartilage thickness at the minimum and maximum diameters of the radial head circumference and to investigate its influence on the size and shape of the proximal radius.
Methods: We analyzed high-definition magnetic resonance imaging scans of 78 healthy elbows in 19 men and 20 women, with a mean age of 28 (21-32) years. All measurements were estimated in the axial plane just distal to the fovea radialis. Maximum and minimum bone diameters, maximum and minimum total diameters (including cartilage thickness), and cartilage thickness were calculated. Cartilage thickness was measured at 4 different points: (1) at the articular side of the maximum diameter (point A), (2) at the nonarticular side of the maximum diameter (point B), (3) at the medial side of the minimum diameter (point C), and (4) at the lateral side of the minimum diameter (point D). Pearson correlation and *t* test were used for the statistical analysis.
Results: Mean maximum and minimum bone diameters and maximum and minimum total diameters were 22.2, 21.5, 24.0, and 23.2 mm, respectively. All differences between diameters were statistically significant. Mean cartilage thickness at points A, C, and D was 1.7, 0.8, and 0.8 mm, respectively. No measurable cartilage thickness was found at point B. No significant correlation was found between bone diameters and cartilage thickness.
Conclusions: Cartilage surface significantly increases and modifies the size and shape of the radial head. The observation that cartilage thickness varies between subjects and does not correlate with bone parameters suggests that the diameters of the radial head cannot be inferred from indirect measurements of dry bones or radiographs.
Level of evidence: Basic Science Study, Anatomy Study, Imaging.

Keywords: Radial head; cartilage thickness; size of radial head; shape of radial head; MRI study; elbow joint anatomy; proximal radius

The radial head features a complex anatomy that is due to its irregular shape. In recent decades, several authors have performed morphometric studies designed to analyze the shape and size of the proximal radius with a view to improving the design and biomechanics of radial head

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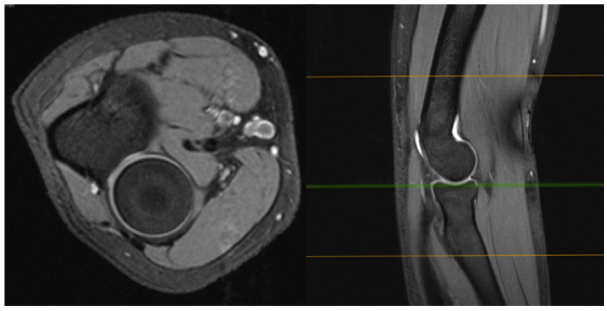

Figure 1 The MRI axial plane of the radial head circumference just below the fovea, which was the point selected for all the measurements.

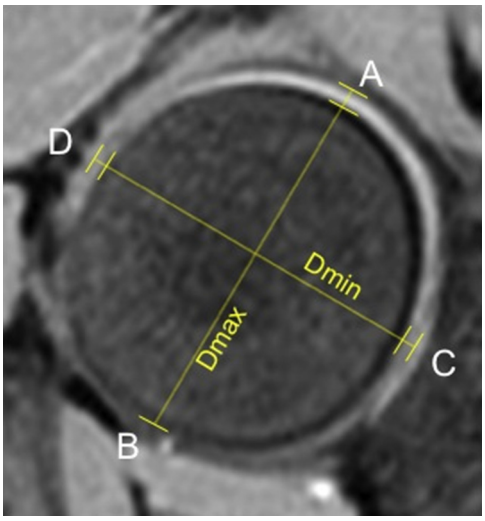

Figure 2 The method adopted to measure the maximum diameter (Dmax) and minimum diameter (Dmin) and the cartilage thickness at 4 different points: *A*, at the level of the articular surface of the maximum diameter; *B*, at the level of the nonarticular surface (safe zone) of the maximum diameter; *C*, at the level of the medial side of the minimum diameter; *D*, at the level of the lateral side of the minimum diameter.

implants.[1-4,6,9,12,14,16-18] These studies have assessed the morphometric parameters in cadaveric dry bones, cadaveric fresh bones, and healthy patients by a range of methods, including digital calipers, radiography, computed tomography (CT), magnetic resonance imaging (MRI), and coordinate measuring machines.[1-10,12-14,16-18,21,22] Nevertheless, the description of the exact geometry of the proximal radius, including its shape and size, is still a matter of debate, and the anatomy of the radial head has yet to be fully defined. One aspect that remains unclear is how much cartilage covers the articular surface of the proximal radius and how it affects the morphology of the radial head. The aims of our study were to quantify the cartilage thickness at the level of the minimum and maximum diameters and to investigate its influence on the size and shape of the radial head. We hypothesized that the cartilage surface significantly modifies the radial head morphology.

Table I Results of radial head diameters

Morphologic measurements	Minimum (mm)	Maximum (mm)	Mean (mm)	Standard deviation (mm)
Bone maximum diameter	18.0	26.4	22.2	1.7
Bone minimum diameter	17.7	25.3	21.5	1.7
Total maximum diameter	19.7	27.9	24.0	1.8
Total minimum diameter	19.0	27.3	23.2	1.7

Table II Results of cartilage thickness

Cartilage thickness	Minimum (mm)	Maximum (mm)	Mean (mm)	Standard deviation (mm)
Point A	0.5	3.5	1.7	0.6
Point B	—	—	—	—
Point C	0.2	1.8	0.8	0.3
Point D	0.2	1.8	0.8	0.3

Point A, at the level of the articular surface of the maximum diameter; point B, at the level of the nonarticular surface (safe zone) of the maximum diameter; point C, at the level of the medial side of the minimum diameter; point D, at the level of the lateral side of the minimum diameter.

Materials and methods

The study recruited 39 skeletally mature healthy subjects, 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. The subjects' height was recorded and used as an indirect parameter of the radius length.[11,19,20] High-definition MRI scans were performed on a high-field scanner (Espree 1.5T; Siemens, Erlangen, Germany) for the right and left elbows using a knee-dedicated coil (8 channels), with the elbow positioned in full extension and with the forearm in complete supination. Three-dimensional balanced steady-state free precession images were acquired in the axial, sagittal, and coronal planes. The technical parameters were 11.89/5.3 msec (repetition time/echo time), 1.5-mm section thickness, 160- to 180-mm field of view, 384 base resolution, 95% phase resolution. Data underwent postprocessing and analyses using OsiriX (version 3.6, 64 bit; Pixmeo, Geneva, Switzerland) on a workstation with a high-resolution monitor. All measurements were taken in the axial plane just distal to the fovea radialis at the level of the widest part of the radial head, as described in previous studies (Fig. 1).[5,18] The following parameters of the radial head were measured: (1) maximum and minimum bone diameters (excluding cartilage thickness), (2) maximum and minimum total diameters (including cartilage thickness), and (3) cartilage