ORIGINAL ARTICLE

Morphometry of the radiocapitellar joint: is humeral condyle diameter a reliable predictor of the size of the radial head prosthesis?

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Background and hypothesis: Radial head arthroplasty (RHA) is a reliable procedure to manage complex injuries of the elbow, but complications due to inadequate sizing have been observed. Radiocapitellar morphometry has been studied widely, but RHA preoperative planning is not yet well defined. We hypothesized that specific morphologic parameters of the radiocapitellar joint measured with simple clinical software for radiographic analysis could be useful tools for clinical practice to predict RHA size preoperatively.
Methods: Radiologic radiocapitellar joint dimensions (humeral condyle diameter [HCDi], radial head diameter [RHDi], and radial head height) were analyzed on true anteroposterior and lateral radiographs, using commercial picture archiving and communication system software, in 43 patients with non-osseous pathology of the elbow and 24 patients with RHA. Interobserver concordance was studied, and a regression model to relate different parameters was developed.
Results: Interobserver concordance was greater than 0.8 for HCDi and RHDi on the lateral view and RHDi on the anteroposterior view for the general population. The parameter with the best correlation with the radial head arthroplasty diameter (RHADi) size was HCDi on the lateral view. A regression model was calculated and defined as follows: RHADi = 6.99 + 0.733 × HCDi on lateral view. This model allows prediction of RHADi in 67% of cases.
Conclusion: Radiologic radiocapitellar parameters show good interobserver reliability. RHADi can be calculated preoperatively from HCDi on the lateral view in 67% of cases.
Level of evidence: Anatomy Study; Imaging
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Keywords: Radial head; arthroplasty; preoperative; template; planning; radiologic measures; humeral condyle diameter

Radial head arthroplasty (RHA) has become a reliable procedure for treating radial head fractures when stable osteosynthesis is not feasible.[6,11] The proximal radial head anatomy is difficult to replicate with a prosthesis, and different designs regarding head and neck parameters, materials, and stems have been proposed.[7,18,20,22]

The radiocapitellar compartment of the elbow has a particular morphometry. It is a condylar-type joint (radiohumeral joint) allowing for flexion-extension of the elbow and pronation-supination of the forearm. In addition, it should

have enough congruity and precise articular contact to enable force transmission while being sufficiently stable during the entire range of motion.[4,16] Radiocapitellar parameters should be considered during an RHA implantation to avoid complications related to altered load transmission and elbow biomechanics.[21] Prosthetic size and height are two of the most relevant factors determining a precise surgical technique. Overstuffing and overlengthening may lead to a failed surgical procedure, with a painful joint with alteration in proximal radioulnar joint biomechanics and overload of the radiocapitellar joint.[1,3,21] Undersizing the prosthesis with the use of a decreased-diameter head will increase the peak load force transmission through the articular cartilage of the capitellum.[13]

Although the size of the RHA should always be assessed intraoperatively, few studies have focused their attention on the preoperative planning of implant size.[5,8] These studies are based on cadaveric computed tomography (CT) scans[17] and usually use sophisticated and complicated software for rendering images[8] that limit their clinical use.

In our study, we aimed to describe the radial head and capitellum dimensions on simple radiographs with simple clinical software for radiographic analysis and to determine whether there was a correlation between them in the general population. After that, we tried to confirm that this measured correlation is useful for accurately predicting RHA size preoperatively.

Materials and methods

First, we designed a study focused on defining the radiologic dimensions of the radiocapitellar compartment of the elbow and tried to establish a correlation between different parameters. Fifty biplanar simple radiographic studies were randomly selected from the general population of patients who attended our emergency department for non-osseous pathology of the elbow. A correct anteroposterior (AP) view should match the following criteria: (1) the articular edges of the radius, humerus, and medial cubitus were not superposed; and (2) the bicipital tuberosity was visible on the medial surface of the proximal radius, reflecting complete supination. A correct lateral view was defined when (1) the articular edges of the proximal radius and distal humerus were not superposed; (2) an about 90° relationship between the humerus and cubitus was present; and (3) the articular surface of the capitellum, trochlea, and epicondyle matched concentric circles.[14,15,19] According to these criteria, 7 studies from the initial sample were discarded.

In the second phase, we selected postoperative radiographs of patients in whom a circumferential RHA (Evolve; Wright Medical Technology, Memphis, TN, USA) had been implanted for those who had sustained an isolated radial head fracture that could not be fixed. The studies of patients who had concomitant condylar or distal humeral fractures, who had injuries that could alter the radiocapitellar compartment, or who received an RHA for other reasons were discarded.

The same radial head and capitellar dimensions were measured on appropriate images, and we attempted to establish a correlation. Afterward, we aimed to develop a prediction model of RHA size using the correlation between the analyzed parameters.

We selected all the patients with an RHA implanted in our unit between 2009-2013. We initially selected 32 patients, but only 24 matched the correct radiologic criteria for the study.

Image analysis and parameters

In both phases of the study, pure lateral and AP views were used. The image was amplified 4 times before being measured.

In the first group (nonoperative group), the analyzed parameters were as follows:

- On the lateral view, the humeral condyle diameter, radial head height, and radial head diameter were measured (Fig. 1, A).
- On the AP view, the humeral condyle diameter, radial head height, and radial head diameter were measured (Fig. 1, B).

In the operative group, the analyzed parameters were as follows:

- On the lateral view, the humeral condyle diameter (oHCDiL), radial head height, and radial head diameter were measured (Fig. 1, A).
- On the AP view, the humeral condyle diameter, radial head height, and radial head diameter were measured (Fig. 1, B).

Image analysis was done with a commercial software pack for clinical use (AGFA RIS-PACS; Agfa HealthCare, Mortsel, Belgium). Each parameter was measured 3 times independently by 3 orthopedic surgeons (2 senior trainees in orthopedics and 1 senior surgeon focused on elbow surgery). The average value of each measure was used for statistical analysis. For cases after an RHA, measurements done by investigators were compared with the real size of the prosthesis recorded from clinical records to calculate radiographic image magnification accurately.

Statistical analysis

Statistical analysis was done with SPSS software (version 16; SPSS, Chicago, IL, USA). A descriptive study was done. Interobserver reliability was measured with intraclass correlation coefficients with Bonferroni adjustment. A correlation coefficient greater than 0.80 was considered good. The level of significance was set at 5% ($P < .05$). Regression analysis and analysis of variance (ANOVA) between different dimensions of the RHA and distal humerus were performed.

Results

In the first phase of the study, 43 radiographs from the general population were analyzed, comprising 22 male and 21 female patients. There were 25 right and 18 left elbows. The mean age was 48.7 ± 18.05 years (range, 17-84 years).

Morphometric results and interobserver concordance on the AP and lateral views are shown in Tables I and II. Measures on the lateral view were observed to be more accurate. Radial head diameter was the most reliable parameter on both the lateral and AP views. Interobserver concordance greater than 0.8 with a confidence interval of 95% was found for radial head diameter on the AP view, radial head diameter on the lateral view, and humeral condyle diameter on the lateral view.