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The anatomic features of the radial head and their implication for prosthesis design

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Abstract

Objective. To establish the anatomical features of the radial head of an average normal human being and to verify the hypothesis that no significant difference exists between the geometry of the left and right normal radial heads.

Design. 17 proximal ends of the radius from the left and right forearms of fresh male (average age 50 and range 40–70) cadavers were measured.

Background. A reconstruction of anatomical features of the normal bone is important for prosthesis design.

Methods. A morphologic study of the radial head was performed using a co-ordinate measuring machine integrated with a computer aided design system. For comparative purposes, a statistical analysis including linear regression and correlation was performed.

Results. The maximum diameter (mean 23.36 mm (SD, 1.14 mm)) and height (mean 10.14 mm (SD, 1.38 mm)) of the radial head as well as the depth (mean 1.92 mm (SD, 0.32 mm)) and maximum radius (mean 20.27 mm (SD, 4.61 mm)) of the concave articulate surface are the most important anatomical features, which should be implicated in prosthesis design. The inclinations mean 2.50° (SD, 0.41°) and mean 9.50° (SD, 0.52°) and shift (mean 1.71 mm (SD, 0.35 mm)) of the radial head relative to its neck should also be taken into account in prosthetic design.

Conclusions. The results of the study showed that "left is equal to right" (no significant differences between sides were obtained, for probability value $P > 0.05$).

Relevance

This paper describes a morphological study of the proximal radius. The results can be used to reconstruct the geometry of the injured radial head based on the obtained geometric features of the contra-lateral side. These results can be also used to design radial head prosthesis.

Keywords: Radial head; Dimensions; Side differences; Prosthesis design

1. Introduction

The radial head (RH) plays a very important role in the function of the elbow joint [1,2]. The radial head is a secondary constraint to valgus stability. Due to its precise shape, the proximal radius can correctly articulate with the humerus and the ulna during the complex movements of the elbow joint. During these movements, a concave upper articulate surface of the radial head articulates correctly with the convex shape of the capitellum. The convex shape of the radial head articulates adequately with the concave radial notch of the ulna [1]. The main indication to perform the radial head replacement is a comminuted fracture of the radial head, especially when there is an complex injury of the elbow. Unfortunately, many complications after the radial head replacements have been reported [1]. We believe that one of the reasons is a difficulty to mimic the complicated shape of the radial head. We decided to evaluate precisely the real anatomic shape and dimensions of the radial head.

The studies of joint anatomic features have been known since Leonardo da Vinci [3]. He tried to describe human body geometry using several parameters. Since

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these times, the technical innovations, i.e., Roentgen X-ray beam etc., allowed us to have more precise recognition of the bone geometry in the human skeleton. The new techniques such as computerized tomography (CT), magnetic resonance imaging (MRI) and co-ordinate measurement machines (CMM) can be applied to measure the anatomic shapes and dimensions of the bones. CT and MRI techniques are usually used in medical imaging because of their in vivo applicability and non-invasive properties [4]. These techniques allow also us to measure the interior as well as the exterior bone geometry and structure with accuracy of approximately ±0.5 mm. CMM is the most accurate (±0.0025 mm) identification method [5], but due to its invasive character, it is not commonly used in bone measuring.

The techniques mentioned previously have also been used to measure the radial head. Numerous authors [1,6–9] have already presented morphometric studies regarding the radial head. Their work has initiated investigation of dimensional characteristics of the radius and its geometry in correlation with sex, age and side. Berrizbeitia [6] and Gupta et al. [8] found out that there is a possibility of sex determination for the radial head, but no significant differences existed between the geometry of the left and right side. Hiramoto [10] and MacIntyre et al. [11] had other opinions. Hiramoto [10] has already reported the mean differences between right and left radius. Mean differences of female bones are usually greater than those of males. Instead, MacIntyre et al. [11] have shown that the radial head of the dominant forearm is significantly greater than one from the non-dominant forearm.

The aim of this study was to determine the important anatomic features of the radial head, which could be implicated for prosthesis design. Our hypothesis is that there is no difference between the right and left side. The differences between the geometry of the radial head from the left and right limb were investigated. Another hypothesis is that it is possible to use regression equations to predict radial head shape.

There are some methods in the literature, regarding the regression analysis, e.g., in reconstruction of maximum bone length and living stature from fragmentary measurements of the ulna [12] or estimating femur and tibia length from fragmentary bones [13]. However, no information about using regression analysis in reconstruction of the radial head geometry has been found in the literature. Also no qualitative analyses of comparisons between radial heads from the left and right limbs are known.

2. Methods

A morphologic study was performed using co-ordinate measuring machine measurement techniques integrated with a computer aided design (CAD) system.

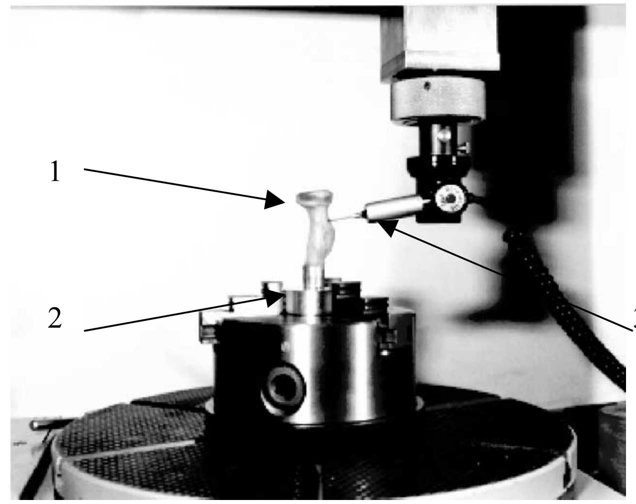

Fig. 1. Radial head measuring using CMM; where 1– radial head specimen, 2 – holder, 3 – contact probe.

Seventeen proximal ends of the radius bone from the left and right forearms of a fresh male (average age 50 and range 40–70) cadavers were measured using a CMM Poli SKY II Machine (Varallo Sesia, Italy). The upper articulate surface of the radial head, lateral surface, and the neck were measured. During measurements, the bones were fixed in a special holder on the CMM table (Fig. 1).

In the course of CMM measurements, the spatial co-ordinates x, y and z of points lying on the external surfaces of the measured bones were determined by means of dynamic scanning of the bone surface using a Renishaw contact probe. The displacements of the probe center were recorded and the data were corrected to obtain the xyz co-ordiantes of measured bone points. The data was then formatted and written to files containing co-ordinates of the measured surface. The co-ordinates of the bone surface have been measured to a high accuracy (of the order ±0.01 mm). The co-ordinates were used in the geometric modelling process, which was the next stage in the geometry reconstruction of the radius bone.

The geometric model, i.e., a geometric computer model to reconstruct the shape of the examined bone, was made using the computer aided design system ProENGINEER® (Parametric Technology Corporation, Waltham, USA) using own procedures. It is worth noting that the very complicated shape of the radial head (there are no such complicated shapes to be found in the engineering practice) requires more sophisticated methods of 3D surface description. The non-uniform rational B-spline (NURBS) [14] method was used for the mathematical representation of the 3D surface geometry of the examined bone in the geometric modelling stage.

Using generated points (Fig. 2(a)) a curve net (Fig. 2(b)) was fitted, in which the primary curves formed

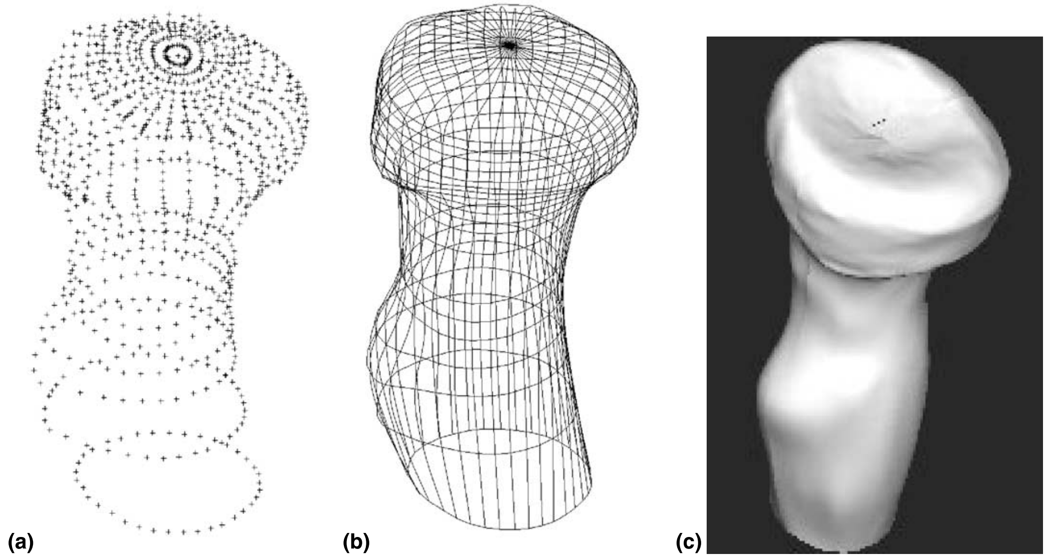

Fig. 2. Radial head models: (a) points, (b) curves and (c) solid representation.

meridians, while crossing ones represented the parallels. Based on the generated curves, the surface representing the bone shape was created directly. After the surface model, the solid model was created automatically in the system. An example of the solid model is presented in Fig. 2(c). During curves and surface creating, 3-degree approximating polynomials were chosen. If a too high degree function was chosen, strong oscillations and surface folding appeared. 3D models reconstructing real shapes of the examined bones have been obtained using the geometric modelling procedures described previously.

The models obtained, as well as CAD system capabilities, allowed the geometric identification of examined bones to be completed. Because the models cannot be represented by basic geometric shapes (spheres, cones), a dimensional characterization of them was very difficult. However, this performance was necessary to determine the anatomic features of the radial head. Before the parameters were established, the co-ordinate system, which was connected to the bones, was determined [15]. The co-ordinate system xyz is presented in Fig. 3. The plane Π, which is parallel to the upper surface of the radial head, determines the xy-plane of the system. The z-axis is the axis perpendicular to the xy-plane going through the point of the concave articular surface which has the greatest distance to the Π plane. The direction of the x-axis is determined by the tuberosity's point which has the greatest distance to the z-axis. Parameters of such a co-ordinate system implicitly determine geometric characteristics of the radius.

In the defined co-ordinate system, based on results obtained by King et al. [7] and Beredjiklian et al. [9], the following dimensional parametrization of the radial head was proposed:

- $D1_{max}$ and $D1_{min}$ – maximum and minimum diameters of the radial head at the level of the radial head concavity (Fig. 3(c));

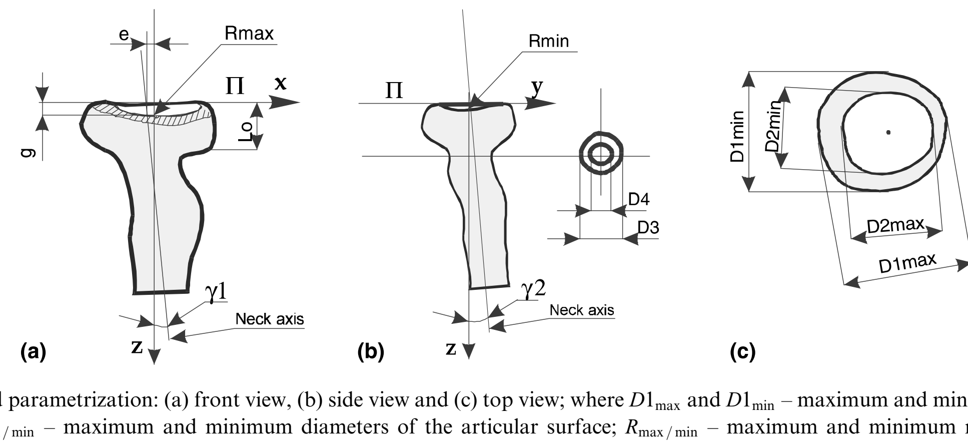

Fig. 3. Radial head parametrization: (a) front view, (b) side view and (c) top view; where $D1_{max}$ and $D1_{min}$ – maximum and minimum diameters of the radial head; $D2_{max/min}$ – maximum and minimum diameters of the articular surface; $R_{max/min}$ – maximum and minimum radius of the articular surface; g – maximum depth of the articular surface; L_0 – maximum height of the radial head; $\gamma 1$ and $\gamma 2$ – angles at which the head is inclined relative to the neck; e – shift of the neck in relation to the head; $D3$ – minimum diameter of the neck; $D4$ – minimum diameter of the marrow cavity.

- $D2_{max}$ and $D2_{min}$ – maximum and minimum diameters of the concave articulate surface (Fig. 3(c));
- R_{max} and R_{min} – maximum (Fig. 3(a)) and minimum (Fig. 3(b)) curvatures of the concave articulate surface. The curvatures were determined from the mean square approximation of the arc-represented cross-section of the concave surface;
- g – maximum depth of the concave articular surface, measured from the plane Π (coincides with the plane xy) (Fig. 3(a));
- L_0 – maximum height of the radial head measured from the plane Π (Fig. 3(a)) to the edge of the radial notch of the ulna;
- $\gamma 1$ and $\gamma 2$ – angles at which the head is inclined relative to the neck, (Figs. 3(a) and (b), respectively). The neck axis and the radial head axis (coinciding with the axis z) were determined from the mean square approximation of the centre of gravities of all obtained cross-sections of the neck and the radial head respectively;
- e – shift of the neck axis relative to the radial head axis;
- $D3$ – minimum diameter of the neck;
- $D4$ – minimum diameter of the marrow cavity, measured from the point of the minimum diameter of the neck.

The values of the geometrical parameters have been determined from the dimensional analysis of the obtained radial head models of 17 bones using the CAD system.

A statistical analysis was performed for these bone parameters. Taking into account the character of the variables i.e., bone parameters in such a sample, the paired t-test was used to test the differences between the parameters of the radius in the right and left elbow joints. To assess the similarity of the bone geometry in the left and right side, the statistical parallel t-test of differences between regression coefficients of the same bone parameters in the left and right joint was performed. Moreover, linear correlation and regression analysis were performed to study the relationships which exist between a few of the parameters of the radial head.

3. Results

The values of the geometric parameters of all examined radial heads, are presented in Table 1.

During the statistical analysis, the bone sample was limited to 16 bones, i.e., 8 left and 8 right specimens. It is worth mentioning that the 17th specimen (k17) was included only to assess the assumed regression models presented in Table 4.

The mean values of the geometric parameters of the radial head are presented in Table 2 for the first 16 specimens. The analysed bone sample was restricted to 8 pairs of measurements of 2D random variables (X and Y). Next, the paired t-test [16] was used to assess a significance of the differences between the means of the geometric parameters of the right and left radial heads (see Table 3). The obtained results demonstrated that the means of the parameters were not significantly different ($P > 0.05$). Thus, the hypothesis that left is equal to right cannot be rejected. To test a power of the hypothesis, the 95% confidence intervals (CI) for the differences were also studied. However, it could not be concluded that the two sides (left and right limbs) were equivalent because of the quite wide intervals CI in Table 3.

Table 1
The values of the geometric parameters of the left and right radial heads, where k1, k2, etc. – specimen number, l – left limb, p – right limb

No./specimen		Parameters $D1_{max}$ (mm)	$D1_{min}$	$D2_{max}$	$D2_{min}$	R_{max}	R_{min}	g	L_0	e	$D3$	$\gamma 1$ (°)	$\gamma 2$
1	k1l	22.93	21.50	16.28	14.32	19.76	15.63	1.74	9.33	1.70	10.80	2.50	10.00
2	k1p	23.91	23.77	15.23	13.94	21.00	19.00	2.01	10.65	1.59	9.73	3.00	10.50
3	k2l	23.83	22.32	16.54	14.87	24.25	16.36	2.28	9.79	1.78	12.25	2.50	9.50
4	k2p	23.71	22.81	15.95	14.18	19.88	16.42	2.31	8.83	1.88	11.52	3.00	10.00
5	k3l	22.80	21.34	16.75	14.80	30.36	13.85	1.93	9.50	1.90	12.40	2.00	9.00
6	k3p	23.73	23.34	17.70	15.25	21.95	14.08	2.08	10.75	1.90	12.73	2.50	9.00
7	k4l	23.95	22.80	17.70	16.85	17.00	16.00	1.85	10.80	1.80	13.22	2.50	9.50
8	k4p	24.80	23.00	17.50	15.00	15.00	14.00	1.85	10.70	1.80	13.03	2.00	9.00
9	k6l	20.94	19.46	16.21	13.79	17.44	13.84	1.23	8.20	1.35	9.83	2.00	9.00
10	k6p	21.33	20.69	16.56	14.22	17.28	14.92	1.49	8.45	1.25	9.67	2.50	9.00
11	k7l	25.22	21.93	15.76	15.07	26.33	18.00	2.08	10.25	1.57	13.20	2.50	10.00
12	k7p	23.31	21.28	15.50	14.04	27.45	18.48	1.43	9.83	2.50	13.03	3.00	10.00
13	k8l	24.05	23.80	18.05	16.95	16.50	15.00	1.90	13.00	2.00	13.07	2.00	9.00
14	k8p	24.00	23.30	17.85	15.75	16.00	14.50	2.20	13.10	1.90	13.43	2.00	9.00
15	k9l	22.96	22.66	14.61	14.20	16.34	15.83	2.05	9.45	1.01	13.02	3.00	9.50
16	k9p	22.25	22.20	16.25	15.94	17.78	15.74	2.37	9.58	1.40	12.00	3.00	10.00
17	k17	24.20	23.30	17.00	15.30	24.00	18.00	2.00	10.40	1.50	12.35	2.50	10.00

Table 2
The mean values (SD) of the geometric parameters of the radial heads (confidence level $\alpha = 0.05$)

Parameter	Sample (mm)	Left limb	Right limb
$D1_{max}$	23.36 (1.14)	23.33 (1.25)	23.38 (1.10)
$D1_{min}$	22.26 (1.18)	21.98 (1.28)	22.54 (1.08)
$D2_{max}$	16.53 (1.01)	16.48 (1.08)	16.57 (1.01)
$D2_{min}$	14.95 (0.99)	15.11 (1.18)	14.79 (0.80)
R_{max}	20.27 (4.61)	20.99 (5.33)	19.54 (3.99)
R_{min}	15.73 (1.63)	15.43 (1.33)	15.52 (1.88)
L_0	10.14 (1.38)	10.04 (1.41)	10.23 (1.44)
g	1.92 (0.32)	1.88 (0.31)	1.96 (0.35)
e	1.71 (0.35)	1.64 (0.32)	1.78 (0.38)
$D3$	12.06 (1.34)	12.22 (1.26)	11.89 (1.48)
$\gamma1$	2.50° (0.41°)	2.37° (0.35°)	2.62° (0.44°)
$\gamma2$	9.50° (0.52°)	9.44° (0.42°)	9.56° (0.62°)

Table 3
Differences between mean values of the geometric parameters of radial heads in the left and right limb ($P > 0.05$) and 95% confidence interval (CI) for mean differences

Parameter	Mean difference	CI
$D1_{max}$	−0.045	−0.872 to 0.782
$D1_{min}$	−0.57	−1.844 to 0.699
$D2_{max}$	−0.09	−1.213 to 1.036
$D2_{min}$	0.32	−7.655 to 1.398
R_{max}	1.455	−3.597 to 6.507
R_{min}	−0.08	−1.619 to 1.447
L_0	−0.085	−0.442 to 0.272
g	−0.19	−1.728 to 1.336
e	−0.14	−0.518 to 0.241
$D3$	0.33	−1.444 to 1.801
$\gamma1$	−0.25°	−0.679° to 0.179°
$\gamma2$	−0.125°	−0.693° to 0.444°

To make the assumption, that the left and right limbs are geometrically similar, more valid, the differences of the relationships between some of the parameters of the radial head in the left and right side were tested. For this reason the relationships (linear regressions $y = \alpha x + \beta$) between the maximum dimension of the radial head neck ($D3$) and radial head height (L_0), the height (L_0) and maximum diameter of the radial head ($D1_{max}$), as well as the maximum diameter ($D1_{max}$) and maximum depth of the concave surface (g) were separately studied for the left and right sides. For each of the relationships the regression coefficients (slope – α, intercept – β) were calculated (Table 4). According to the parallel test [16], the hypothesis that the obtained regression coefficients are the same for both sides (left α_l and right α_p), was tested at a significance level of 0.05. Because the calculated values of statistics (t) are less than the critical value of statistic ($tcr = 1.782$) for degree of freedom 12 ($df = 12$), the hypotheses that two regression coefficients are equal cannot be rejected (Table 4). The regression lines, which represent the relations between the same parameters on the left and right side, are almost parallel. These results demonstrate that the differences of the relationships between the parameters of the left and right radial head are not significant ($P = 0.05$). Thus, these sides are geometrically similar.

In the last part of the statistical analysis, the correlation and regression analysis were also performed to study the relationships which exist between some of the parameters of radial head, given in Fig. 3. The main aim of this analysis was to find relations between the unreconstructed parameters such as maximum diameters ($D1_{max}$), the height (L_0) of the damaged radial head and the minimum diameter of the neck of this bone, which can be measured when a radial head is fractured. From Table 5 it can be concluded that the minimum diameter of the neck $D3$ and the maximum diameter $D1_{max}$ of the head, as well as its height L_0 were correlated. The height of the radial head L_0 and its diameters ($D1_{max}$, $D1_{min}$, and $D2_{min}$) were also significantly correlated. No significant correlation between the curvature radius of the articulate concave surface (R_{max}, R_{min}) and other dimensions of the radial head were found in the examined sample. There was a correlation ($R = 0.458$) between the

Table 4
The relationships (linear regression models) between the maximum height of the radial head (L_0), minimum diameter of the neck ($D3$), maximum diameter of the radial head ($D1_{max}$) and maximum depth of the concave articular surface (g) of the left and right radial heads, as well as the differences ($|t| - tcr$) between statistics in tested differences for the regression coefficients of the same parameters in left and right side, where l – left limb, p – right limb, R – correlation coefficient, P – probability value for the regression models, t – the calculated value of statistic, tcr – critical value of statistic ($tcr = 1.782$)

Parameter		R	Slope α	Intercept β	P	$\|t\| - tcr$
X	Y					
$D3_l$	L_{0_l}	0.668	0.750	0.875	0.03	1.293
$D3_p$	L_{0_p}	0.561	0.547	3.736	0.07	
L_{0_l}	$D1_{max_l}$	0.650	0.577	17.544	0.04	1.431
L_0p	$D1_{max_p}$	0.614	0.465	18.618	0.05	
$D1_{max_l}$	g_l	0.768	0.190	−2.553	0.01	1.373
$D1_{max_p}$	g_p	0.492	0.140	−1.379	0.09	

Table 5
The regression models of relation between radial head parameters and their validations errors: RMSE – root mean square error, ERROR – the difference between the predicted and measured parameters for specimen k17, where R – correlation coefficient, P – probability value of the regression analysis

Parameter		R	Slope	Intercept	RMSE	ERROR	P
X	Y						
$D3$	$D1_{max}$	0.650	0.552	16.699	3.34	0.60	0.006
$D3$	L_0	0.592	0.612	2.763	3.79	0.08	0.01
$D1_{max}$	g	0.557	0.145	−1.470	1.08	0.04	0.01
L_0	$D1_{max}$	0.631	0.518	18.103	3.41	0.71	0.008
L_0	$D1_{min}$	0.743	0.635	15.824	3.06	0.81	0.0009
L_0	$D2_{min}$	0.703	0.502	9.865	2.72	0.22	0.002
$\gamma 1$	$\gamma 2$	0.791	1.000	7.000	1.22	0.00	0.0002
$D1_{min}$	g	0.677	2.467	17.514	3.37	0.85	0.003
$D1_{max}$	$D1_{min}$	0.728	0.757	4.569	3.01	0.12	0.001
$D2_{max}$	$D2_{min}$	0.730	0.712	3.180	2.67	0.21	0.001

depth g of the concave articular surface and the minimum diameters $D1_{min}$ of the radial head. The maximum and minimum diameters of the radial head were also correlated to each other ($R = 0.530$ and $R = 0.533$).

The linear regression resulted in a root mean square error (RMSE) between the measured and predicted parameters of less than 3.79 mm (see Table 5). Moreover, the application of obtained regression models to predict geometry parameters of a new specimen resulted in an error (ERROR) of less than 0.85 mm. This error was the difference between the predicted and measured parameters of the new specimen (k17).

4. Discussion

The aim of this study was to establish the anatomical features of the radial head and to answer the question whether a significant difference in the shape and dimensions between the left and right sides exists. For this morphometric study, only 16 plus 1 bones were very accurately measured using CMM. MRI and CT have not been used because of the smaller accuracy, which does not allow to measure small dimensions, e.g., the depth of the concave articular surface. The measurement of $n = 17$ specimens of a small statistical sample was limited by experimental costs and time of experiment realization. However, the number of samples is sufficient to be used in a t-student statistical analysis (n should be no less than 8).

No general or international standards for measurement and parametrization of the complex bone geometry have been established yet. In the case of the radial head, there are few studies describing the geometry by 7 geometrical parameters [7]. In the present study, 12 parameters are selected to obtain a more accurate geometry description of the radial head (Table 1). The proposed parametrization takes into account characteristic dimensions of the radius, allowing the description of the shape of its proximal end. Due to parametrization, it is possible to formulate a relationship between the shape of the bone and age, sex and profession of the patient.

The radial head is a solid structure with a very complicated irregular shape. Due to substantial differences between the maximum and minimum diameters, Beredjiklian et al. [9] and King et al. [7] determined the elliptical shape of the radial head. However, in the presented investigation, the obtained difference between diameters is rather small (averaged 1.10 mm) and the maximum and minimum diameters are correlated ($P = 0.001$). Average dimensions of female radial head diameters presented by Beredjiklian et al. [9] were equal (mean $D1_{max}$ = mean $D1_{min}$). For these reasons, it can be assumed that the articular surface of the radial head is more circular ($D_{min} \approx D_{max}$), with an average depth g 1.92 (SD, 0.32) mm. The differences of its curvatures show that the proximal radius can be moved relative to the capitellum during forearm rotation [1]. The height of the radial head, which was denoted by length L_0 of radio-ulnar articular surface, averaged 10.14 (SD, 1.38) mm. The value of the shift, e of the head relative to its neck is similar to the shift obtained by King et al. [7]. Moreover, the presented method of identification allows us to establish a new characteristic anatomic feature of the radial head – the radial head inclination relative to its neck. These angles have not been presented before and may be important in the process of prosthesis design and attempt to restore properly the biomechanics of the elbow joint. This finding should be verified in further studies.

In the examined radial heads there were bone specimens from two sides. We would like to answer the question “if left is equal to right”. Results of the study showed that there is no significant difference between the left and right radial heads ($P > 0.05$). This statement was substantiated by the performed statistical analysis. The similarity of the bone geometry on the left and right sides was also proved by no significant differences between regression coefficients of the same parameters of the left and right radial heads. However, 95% CI for the mean differences were quite large, so it cannot be concluded that the two sides are the same and so more specimens should be tested. In this study, the dominant and non-dominant arms were not distinguished. The aim of this study was to investigate the similarity of left and right, which was found.

It is possible, that the shapes of the radial head and its articulating joint surface strongly depend upon the side (dominating upper extremity or not), because of a high level of physical activity of the patients. For example, for a professional tennis player, the changes in the geometry of dominant humerus (in the playing arm) can occur as a result of geometric remodelling in response to exercise [20]. In such a patient, the unreconstructed parameters such as maximum diameters and the height of the damaged radial head can be reconstructed based on the measurement of the minimum diameter of the neck of this bone, using the regression models. The method of statistical analysis presented in this manuscript allowed us to establish relations between some of the geometrical parameters of the radial head. The obtained regression models allowed us to establish the unknown geometric parameters.

Because of the better functional outcome [9], the reconstruction of the geometrical shape and dimensions of bones are very important [8], [19] for prosthesis design. Although the prosthesis design process is beyond the scope of this study, the obtained results can be used to prepare assumptions for design and selecting the correct prosthesis for patient with a comminuted fracture of the radial head.

From the present morphologic study, the implant's head could be circular in shape. The maximum diameter ($D1_{\max}$) and height (L_0) of the radial head as well as the depth (g) and maximum radius ($R_{\max}$) of the concave articulate surface are very important anatomical features. They describe articulating surfaces of the radial head. They should be measured and implicated in prosthesis design. Shift and inclinations of the radial head are also important for prosthesis design. It is possible that a bipolar radial head prosthesis, with a mobile radial head is a good option [17–19].

The data in Tables 1 and 2 together with data presented by King et al. [7] and Beredjiklian et al. [9] can be used to establish a set of data for the parametrization of the radial head prosthesis.

Such design parameters are very often difficult to establish when the bone has been seriously damaged, e.g., Mason III fracture of radial head. Here, direct geometric identification of the damaged bone is virtually impossible. Because of the verified hypothesis that left is equal to right, the following solution of this problem is proposed. First, to take measurements of the undamaged bone using, for instance, the X-ray or computer tomography. Next, the identification of the anatomical characteristics of the undamaged radial head of the contralateral side can be carried out. The parameters of the healthy bone can be used to reconstruct the geometry of the injured radial head. The obtained geometrical parameters can then be used in the prosthesis design or selection.

5. Conclusions

A co-ordinate measuring machine measurement technique together with a computer aided design system allows one to precisely assess the characteristic dimensions of the radial bone. Correlation and regression analysis of the anatomic features can then be performed. This technique is useful in prosthesis design. It is possible to evaluate dimensions of the radial head based on the measurements of the collateral undamaged side which can be done by X-ray or CT.

In further investigations, an increased number of tested bones is recommended.

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