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Research Article

Morphological and Morphometric Examination of the Proximal and Distal Ends of the Radius

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Abstract

Aim: The radius, located on the lateral forearm, plays a key role in pronation and supination. Its proximal and distal ends contribute to the stability and motion of the elbow and wrist joints, making them susceptible to trauma, with fractures common, especially in the geriatric population. Understanding the morphological and morphometric features of these ends is crucial for surgical interventions, such as screwing techniques for complex fractures. This study aims to examine the morphological and morphometric characteristics of the proximal and distal ends of the human radius and provide clinically relevant data.
Material and Method: 70 radii (34 right and 36 left) from the collections of Necmettin Erbakan University and Acıbadem Mehmet Ali Aydınlar University were analyzed. Measurements were taken using digital calipers, an osteometric board, a tape measure, and the Image J program. Morphological classifications of the articular fovea and radial tuberosity were recorded. Morphometric analysis of the proximal and distal extremities was conducted, and data, analyzed using SPSS 21, were found to be normally distributed. Right-left comparisons were made using paired Student's t-tests, type differences with one-way ANOVA, and relationships with correlation tests.
Results: Among all radii, 97.1% of articular foveae were elliptical, while 54.3% of radial tuberosities were single roughened (Type b). No significant differences were found in the morphology of the articular fovea or radial tuberosity between the right and left sides ($p>0.05$). The medial thickness of the radial head (RH-mt) and the anterior lenght of the ulnar notch (UN-al) were significantly larger on the right side ($p<0.05$). Larger circumferences, diameters, and inclination angles were observed in double roughened (Type c) radial tuberosities ($p<0.05$). This was observed for the medial and lateral sides, as well as for the neck and head regions.
Conclusion: The data obtained from our study might be useful as a reference in post-traumatic reconstruction, prosthesis design and orthopaedic surgical procedures in adults.

Keywords: Radius, radial tuberosity, the articular fovea of the radius, inclination angle

INTRODUCTION

The radius is a long bone situated laterally to the forearm and plays a critical role in the rotation around the ulna during pronation and supination movements of the forearm. The proximal and distal ends of the radius join the elbow and wrist joints, thereby providing movement and stability to these joints (1,2). A disruption to any of the components of these joints can result in a considerable reduction in the range of supination-pronation movement, thus resulting in a notable impairment of limb functionality (3). The proximal and distal ends of the radius are particularly susceptible to trauma and fractures, with injuries occurring in these regions often resulting in significant functional losses and requiring surgical intervention (4).

Approximately 20% of all fractures are distal radius fractures, which are particularly common in active children and elderly individuals with osteoporosis (4,5). These fractures typically impact the kinematics of the wrist, potentially leading to limitations in wrist movement and chronic pain (6). Approximately 70% of forearm fractures are proximal radius fractures, which typically result from a fall or direct trauma (7). These fractures can result in instability and limitation of movement in the elbow joint (8). Therefore, a comprehensive examination of the anatomical and morphometric characteristics of the radius bone is crucial for the management of such fractures and surgical procedures.

CITATION
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A detailed examination of the proximal and distal ends of the radius is essential for the successful reconstruction and prosthesis design procedures that must be performed following iatrogenic injuries and trauma. Determining accurate morphometric parameters of the proximal and distal ends of the radius as well as its morphological appearance was the aim of our investigation.

MATERIAL AND METHOD

The study was conducted on 70 radii (34 right and 36 left) from an unknown sex in the bone collection of Necmettin Erbakan University and Acıbadem Mehmet Ali Aydınlar University, Faculty of Medicine Anatomy Laboratories. The Acıbadem University Medical Research Ethics Committee has reviewed and approved the research project numbered ATADEK/2024-18/696, focusing on the morphological and morphometric analysis of the radius bone, ensuring its compliance with ethical, scientific, and legal standards. In the present study, two groups were subjected to comprehensive morphological and morphometric assessments. In the morphological evaluations of the articular fovea of the radius, the classification proposed by Captier et al. was revised and used (9). Accordingly, Type 1 was classified as round, Type 2 as elliptical, and Type 3 as irregular (Figure 1). The radial tuberosity was evaluated using the classification described by Mazzocca et al. (10) as Type a: smooth, Type b: single roughened, and Type c: double roughened (10) (Figure 2).

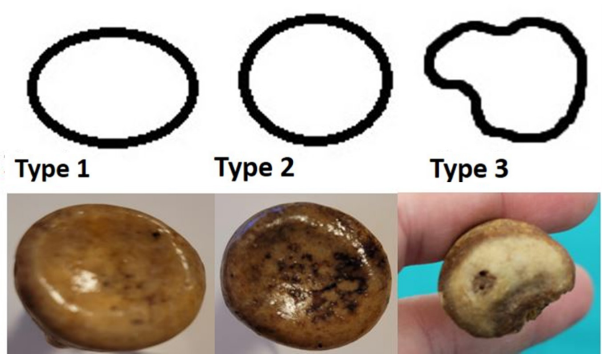

Figure 1. Morphological classification of the articular fovea of the radius (Type 1: Round, Type 2: Elliptical, Type 3: Irregular)

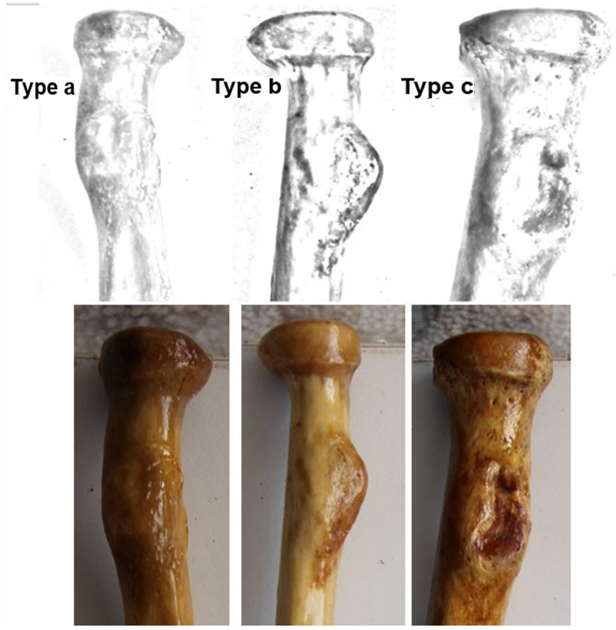

Figure 2. Morphometric classification of the radial tuberosity (Type a: Smooth, Type b: Single roughened, Type c: Double roughened)

All morphometric measurements were taken three times by an experienced anatomist using a digital caliper (INCA, DCLA-0605, 0.6-150 mm, USA), osteometric board, tape measure and Image J (NIH's National Institute of Mental Health, USA) software and the mean values were included in the study. All measurements were reported in millimetres (mm), while angle measurements were reported in degrees (°). Radii were photographed by placing them on an osteometric board with millimeter paper on them. The photographs of the radii were scanned into Image J software and were calibrated for the measurements. Morphometric measurements of the proximal and distal parts of the radius were then performed. The measurements were re-evaluated by three experienced anatomists at separate times. In case of differences between the measurements, the researchers met to discuss the matter and come to a consensus.

Lateral length of the radius (LLR): The length of the radius in the lateral direction.

Medial length of the radius (MLR): The length of the radius in the medial direction (Figure 3).

Figure 3. Morphometric measurements of the radius (1: measurement calibration with Image J, 2: medial length of the radius (yellow arrow), lateral length of the radius (red arrow))

Measurements of Proximal Radius

- ***Circumference of the articular surface of the radial neck (RN-CA):*** The circumference length of the articular surface at the neck of the radius.
- ***Circumference of the articular surface of the radial head (RH-CA):*** The circumference length of the articular surface at the radial head.
- ***Antero-posterior diameter of the radial head (RH-ap):*** The diameter of the radial head measured in the front-to-back (antero-posterior) direction.
- ***Medio-lateral diameter of the radial head (RH-ml):*** The diameter of the radial head measured in the side-to-side (medio-lateral) direction.
- ***Medial thickness of the radial head (RH-mt):*** Thickness of the radial head measured in the medial direction.
- ***Lateral thickness of the radial head (RH-lt):*** Thickness of the radial head measured in the lateral direction.
- ***Length of the radial tuberosity (RT-l):*** Measurement along the longest axis of the radial tuberosity.
- ***Width of the radial tuberosity (RT-w):*** Measurement along the widest axis of the radial tuberosity.
- ***Distance between the radial head and the radial tuberosity (RH-RT-d):*** The linear distance between the radial head and the radial tuberosity (Figure 4).

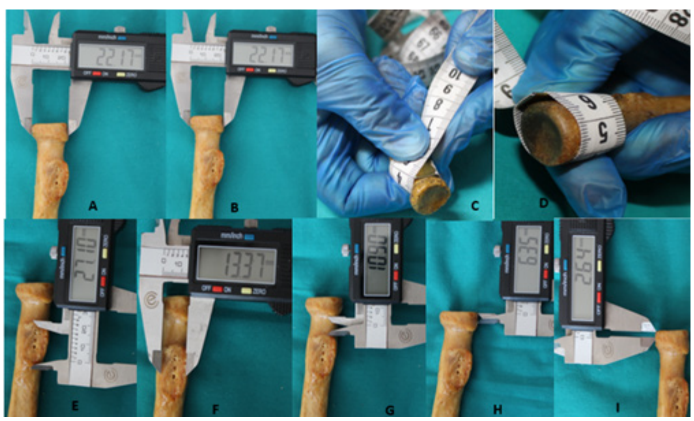

Figure 4. Morphometric measurements of the proximal radius; **A.** antero-posterior diameter of the radial head, **B.** medio-lateral diameter of radial head, **C.** medial thickness of the radial head, **D.** lateral thickness of the radial head, **E:** circumference of the articular surface of the radial neck, **F.** length of radial tuberosity, **G.** width of radial tuberosity, **H.** medial thickness of the radial head, I: lateral thickness of radial head

Measurement of Distal Radius

- ***Anterior length of the ulnar notch (UN-al):*** Length of the anterior surface of the ulnar notch at the distal end of the radius, where it articulates with the ulna.
- ***Posterior length of the ulnar notch (UN-pl):*** Length of the posterior surface of the ulnar notch at the distal end of the radius, where it articulates with the ulna.
- ***Width of the ulnar notch (UN-w):*** Width of the ulnar notch at the distal end of the radius, where it articulates with the ulna.
- ***Length of the styloid process (SP-l):*** Length of the styloid process at the distal end of the radius.
- ***Radial inclination angle (RIA):*** Angle between the medial margin of the distal end of the radius and the axis of the styloid process (Figure 5).

Figure 5. Morphometric measurements of the distal extremities; **a.** anterior length of the ulnar notch, **b.** posterior length of the ulnar notch, **c.** width of the ulnar notch, **d.** radial inclination angle, **e.** length of the styloid process

Statistical Analysis

Version 21.0 of the Statistical Package for Social Sciences (SPSS) was used to analyze the data. All measurement data from the study were subjected to Skewness and Kurtosis tests. The skewness and kurtosis values between -3 and +3 indicated that the data exhibited a normal distribution (11) (Table 1).

The data were analyzed using both qualitative and quantitative methods. Qualitative methods included mean value, standard deviation (SD), maximum (max.) and minimum (min.) values, percentages (Chi-square), and quantitative methods included paired sample t-test to compare measurements between right and left bones, Pearson correlation, and One-Way ANOVA (with Post-Hoc Tukey test). Our results were evaluated according to a 95% confidence interval and a 0.05 margin of error, and differences at $p<0.05$ were considered statistically significant.

RESULTS

In the present study, comprehensive morphometric and morphological evaluations were conducted on a total of 70 radii (48.6% right; 51.4% left). The distribution of the morphological classifications of the articular fovea of the radius and radial tuberosity on the total, right, and left radius in the morphometric evaluations of our study are presented in Table 2.

The articular fovea of the radius was observed to be Type 2 in 97.1% of cases, Type 1 in 1.4% and Type 3 in 1.4% of all radii. The most common type was elliptical on the right and left sides, but the difference was not statistically significant between the left and right sides (χ^2: 2.003; p: 0.367). Radial tuberosity was most commonly seen as a single roughened type. Similarly, the difference was not statistically significant between the left and right sides (χ^2: 0.610; p: 0.737) (Table 2).

The minimum, maximum, mean, and SD values of the morphometric parameters of the right and left radius bones and the right and left comparison statistical values are presented in Table 3. In the present study, the RH-mt and the UN-al of the right radius were found to be larger and statistically significant ($p<0.05$) compared to the corresponding measurements of the left radius (Table 3).

The mean and SD values of the measurement data obtained according to tuberosity typing, as well as the observed differences between the study groups, are presented in Table 4. For several parameters, statistically significant differences between the groups were found. These include the MLR, the LLR, the RN-CA, the RH-CA, the RH-ml, the RH-ap, the UN-w, the RIA measurements of the radius, along with the Type c tuberosity ($p<0.05$). Furthermore, the MLR and the LLR of the radius were significantly reduced in Type b tuberosity cases compared to Type c tuberosity cases (Table 4). Additionally, a comparison of the the RH-ml and the RH-ap and the RIA across the three types of tuberosities revealed that these values were larger in the tuberosities with Type c, and this difference was statistically significant (Table 4).

The results of the correlation analysis between the morphometric measurements of the radius are presented in Table 5. The analysis demonstrates that there are strong positive correlations across the measurements. The highest correlation was found between the RML and RMA parameters (r=0.901) (Table 5).

Table 1. Test of normality with Skewness and Kurtosis

Parameters	Min.	Max.	Mean	SD	Skewness	Kurtosis
MLR	17.35	25.65	21.69	2.14	0.8	-0.181
LLR	16.6	26.6	22.410	2.0674	.085	-.281
RN-CA	5.3	9.2	7.283	.7721	.272	.148
RH-CA	4.3	7.4	5.754	.5564	.300	.810
RH-ml	13.52	29.59	21.0254	3.25583	.027	-.114
RH-ap	10.81	25.46	19.6828	2.84789	-.387	.469
RH-mt	3.02	14.84	8.3696	2.58945	.220	-.053
RH-lt	1.79	12.01	6.2452	2.22677	.629	.255
RT-l	10.88	28.85	20.7381	3.79875	-.041	-.103
RT-w	5.47	19.03	12.5723	2.64334	-.085	.335
RH-RT-d	5.65	17.39	11.3113	2.36340	.018	.167
UN-al	2.05	12.26	7.3368	1.64224	.139	1.399
UN-pl	4.80	14.70	9.4493	1.92289	.305	.311
UN-w	7.14	19.72	14.5562	2.79631	-.815	.703
SP-l	2.57	9.09	5.1200	2.52816	1.089	1.096
RIA	15.32	39.45	22.4000	4.00000	-.810	.700

Morphometric data of the radius for the right and left sides included medial length of the radius (MLR), lateral length of the radius (LLR), the circumference of the articular surface of the radial neck (RN-CA), the circumference of the articular surface of the radial head (RH-CA), the antero-posterior diameter of the radial head (RH-ap), the medio-lateral diameter of the radial head (RH-ml), the medial thickness of the radial head (RH-mt), the lateral thickness of the radial head (RH-lt), the length of the radial tuberosity (RT-l), the width of the radial tuberosity (RT-w), the distance between the radial head and the radial tuberosity (RH-RT-d), the anterior length of the ulnar notch (UN-al), the posterior length of the ulnar notch (UN-pl), the width of the ulnar notch (UN-w), the length of the styloid process (SP-l), the radial inclination angle (RIA)

Table 2. Distribution of the articular fovea of the radius and the radial tuberosity in total, right and left radius

		Total (n=70)		Right (n=34)		Left (n=36)			
		n	%	n	%	n	%	χ^2	p
Articular fovea of the radius	Type 1	1	1.4	0	0.0	1	2.8	2.003	0.367
	Type 2	68	97.1	33	97.1	35	97.2		
	Type 3	1	1.4	1	2.9	0	0.0		
Radial tuberosity	Type a	6	8.6	2	5.9	4	11.1	0.61	0.737
	Type b	38	54.3	19	55.9	19	52.8		
	Type c	26	37.1	13	38.2	13	36.1		

n: number of individuals, χ^2: chi-square test, Type 1: round, Type 2: elliptical, Type 3: irregular, Type a: smooth, Type b: single roughened, Type c: double roughened, p: significance value

Table 3. Minimum, maximum, mean, standard deviation values of morphometric data of radius according to right and left sides

Parameters		Right (n=34)		Left (n=36)		
		Min.-Max.	Mean±SD	Min.-Max.	Mean±SD	p
	MLR	17.35-25.65	21.69±2.14	18.8-26.79	21.4±1.85	0.543
	LLR	19-26.6	22.8±2.09	19.5-26.1	22.29±1.86	0.293
Proximal radius	RH-ml	14.29-29.59	21.27±3.53	13.52--26.99	20.81±3.01	0.564
	RH-ap	13.88-25.09	20.01±3.01	10.81-25.46	19.38±2.7	0.366
	RN-CA	68.9	7.38±0.8	5.3-9.2	7.2±0.74	0.343
	RH-CA	4.3-7.4	5.82±0.63	4.4-6.9	5.7±0.48	0.389
	RT-l	10.88-28.85	20.87±3.77	13.52-28.54	20.62±3.87	0.787
	RT-w	7-19.03	12.7±3.12	5.47-16.93	12.46±2.15	0.713
	RH-RT-d	5.65-16.58	11.45±2.6	6.66-17.39	11.19±2.15	0.651
	RH-mt	3.02-14.84	9.27±2.96	3.33-10.8	7.54±1.89	0.006*
	RH-lt	1.79-12.01	6.12±2.82	3.56-9.5	6.36±1.52	0.664
Distal radius	UN-al	4.45-12.26	8.12±1.62	2.05-8.96	6.62±1.32	0.000*
	UN-pl	5.75-14.7	9.89±1.97	4.8-12.57	9.04±1.81	0.069
	UN-w	7.14-19.72	14.85±3.14	7.87-19.11	14.29±2.46	0.413
	SP-l	2.57-11.9	8.25±2.17	3-10.8	7.87±1.69	0.424
	RIA	15.57-39.45	22.01±4.6	15.32--31.32	23.37±3.58	0.174

Morphometric data of the radius for the right and left sides included medial length of the radius (MLR), lateral length of the radius (LLR), the circumference of the articular surface of the radial neck (RN-CA), the circumference of the articular surface of the radial head (RH-CA), the antero-posterior diameter of the radial head (RH-ap), the medio-lateral diameter of the radial head (RH-ml), the medial thickness of the radial head (RH-mt), the lateral thickness of the radial head (RH-lt), the length of the radial tuberosity (RT-l), the width of the radial tuberosity (RT-w), the distance between the radial head and the radial tuberosity (RH-RT-d), the anterior length of the ulnar notch (UN-al), the posterior length of the ulnar notch (UN-pl), the width of the ulnar notch (UN-w), the length of the styloid process (SP-l), the radial inclination angle (RIA), p<0.05 was considered statistically significant; Min.: minimum, Max.: maximum, SD: standard deviation

Table 4. Comparison of morphometric data of the radius of the right and left sides

		Type a (n=6)	Type b (n=38)	Type c (n=26)	p	GA
	MLR	20.9±1.20	20.80±1.04	22.30±1.80	0.010*	bc
	LLR	21.98±2.17	21.84±2.04	23.34±1.81	0.013*	bc
Proximal radius	RN-CA	6.68±0.43	7.21±0.77	7.52±0.75	0.037*	ac
	RH-CA	5.07±0.66	5.81±0.57	5.84±0.4	0.005*	ab.ac
	RH-ml	17.35±2.42	20.54±2.53	22.56±3.52	0.000*	ab,bc,ac
	RH-ap	17.49±3.01	19.71±2.72	21.15±2.87	0.0.17*	ab,bc,ac
	RH-mt	7.77±3.52	8.2±2.59	8.74±2.42	0.607	
	RH-lt	5.81±2.87	6.65±2.22	5.77±2.06	0.276	
	RT-l	18.77±6.64	20.53±3.42	21.48±3.46	0.791	
	RT-w	10.78±2.66	12.68±2.87	12.83±2.2	0.260	
	RH-RT-d	11.9±1.85	11.32±2.39	11.16±2.49	0.219	
Distal radius	UN-al	6.43±0.56	7.42±1.7	7.43±1.7	0.370	
	UN-pl	9.25±1.71	9.17±1.78	9.89±2.14	0.332	
	UN-w	12.04±3.59	15.05±2.07	14.44±3.26	0.046*	ab
	SP-l	3.57±1.41	5.83±0	6.32±3.92	0.681	
	RIA	20.01±4.00	21.09±1.02	22.50±1.20	0.030*	ab,bc,ac

Morphometric data of the radius for the right and left sides included medial length of the radius (MLr), lateral length of the radius (LLr), the circumference of the articular surface of the radial neck (RN-CA), the circumference of the articular surface of the radial head (RH-CA), the antero-posterior diameter of the radial head (RH-ap), the medio-lateral diameter of the radial head (RH-ml), the medial thickness of the radial head (RH-mt), the lateral thickness of the radial head (RH-lt), the length of the radial tuberosity (RT-l), the width of the radial tuberosity (RT-w), the distance between the radial head and the radial tuberosity (RH-RT-d), the anterior length of the ulnar notch (UN-al), the posterior length of the ulnar notch (UN-pl), the width of the ulnar notch (UN-w), the length of the styloid process (SP-l), the radial inclination angle (RIA), Types of the articular fovea of the radius Type a: smooth, Type b: single roughened, Type c: double roughened GA refers to intergroup comparisons. p: significance value

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Table 5. Pearson correlation coefficients (r) and statistical significance levels (p) between various morphometric measurements of radius bones

		RIA	SP-l	UN-w	UN-pl	RN-CA	RH-CA	RH-mt	RH-ap	RH-ml	RH-lt	RH-mt	RT-l	RT-w	UN-al	UN-pl	UN-w
UN-w	r	.098	.452**	-.085	.125	.446**	.273*	.516**	.592**	.469**	.320**	.169	.214	.484**	.359**	.364**	1
	p	.424	.000	.488	.306	.000	.023	.000	.000	.000	.007	.164	.078	.000	.002	.002	
UN-pl	r	.152	.347**	.023	.216	.329**	.286*	.303*	.373**	.333**	.337**	-.136	.376**	.293*	.471**	1	
	p	.213	.003	.855	.075	.006	.017	.012	.002	.005	.005	.265	.001	.015	.000		
UN-al	r	.272*	.293*	-.173	.244*	.342**	.230	.225	.408**	.364**	.348**	.170	.259*	.313**	1		
	p	.024	.015	.158	.044	.004	.058	.063	.001	.002	.003	.164	.032	.009			
RT-w	r	.225	.373**	-.070	.258*	.561**	.561**	.507**	.613**	.506**	.491**	.133	.580**	1			
	p	.063	.002	.571	.032	.000	.000	.000	.000	.000	.000	.276	.000				
RT-l	r	.315**	.362**	.190	.388**	.567**	.520**	.464**	.492**	.342**	.298*	.003	1				
	p	.008	.002	.121	.001	.000	.000	.000	.000	.004	.013	.977					
RH-mt	r	.568**	.079	-.161	.535**	.208	-.078	.165	.329**	.338**	.190	1					
	p	.000	.521	.191	.000	.086	.523	.176	.006	.004	.118						
RH-lt	r	.123	.297*	-.039	.128	.272*	.299*	.102	.441**	.569**	1						
	p	.314	.013	.754	.296	.024	.013	.403	.000	.000							
RH-ml	r	.263*	.365**	-.066	.298*	.450**	.292*	.357**	.586**	1							
	p	.029	.002	.596	.013	.000	.015	.003	.000								
RH-ap	r	.522**	.429**	-.075	.519**	.789**	.468**	.783**	1								
	p	.000	.000	.542	.000	.000	.000	.000									
RH-mt	r	.449**	.360**	-.028	.460**	.781**	.449**	1									
	p	.000	.002	.823	.000	.000	.000										
RH-CA	r	.272*	.177	-.019	.285*	.578**	1										
	p	.024	.145	.875	.018	.000											
RN-CA	r	.598**	.337**	-.025	.597**	1											
	p	.000	.005	.839	.000												
UN-pl	r	.901**	.163	-.138	1												
	p	.000	.178	.258													
UN-w	r	-.205	.389**	1													
	p	.092	.001														
SP-l	r	.084	1														
	p	.488															
RIA	r	1															
	p																

**correlation is significant at p <0.01, *correlation is significant at p <0.05. r: direction and magnitude of correlation, p: statistical significance of correlations, the circumference of the articular surface of the radial neck (RN-CA), the circumference of the articular surface of the radial head (RH-CA), the antero-posterior diameter of the radial head (RH-ap), the medio-lateral diameter of the radial head (RH-ml), the medial thickness of the radial head (RH-mt), the lateral thickness of the radial head (RH-lt), the length of the radial tuberosity (RT-l), the width of the radial tuberosity (RT-w), the distance between the radial head and the radial tuberosity (RH-RT-d), the anterior length of the ulnar notch (UN-al), the posterior length of the ulnar notch (UN-pl), the width of the ulnar notch (UN-w), the length of the styloid process (SP-l), the radial inclination angle (RIA)

DISCUSSION

In this study, morphometric analysis of the proximal and distal ends of 70 radius bones was performed and several important correlations between different anatomical parameters were revealed (Table 5). The data obtained should provide important clinical information that can be used in the management of injuries occurring in these regions. These findings may provide important data for the development of prosthetic design and surgical techniques, especially in the fields of orthopedic and reconstructive surgery.

The results of our study are consistent with similar studies in literature. For example, Samokhina et al. stated that proximal and distal radius measurements are important for the design of implants to be used in these regions (12). Another study emphasized the need for morphometric data for plate and screw placement in the treatment of distal radius fractures (13). These findings highlight the importance of the morphometric characteristics of the radial bone in post-traumatic reconstruction and prosthesis design.

When comparing the circumference of the RN-CA measurements with literature, we observed both similarities and differences. In one study, the RN-CA was reported as 4.64 cm on the right side and 4.62 cm on the left side, which is close to our findings (14). Another study reported 50.04 mm on the right side and 50.32 mm on the left side (15). In our study, we measured 7.38 cm was found on the right side and 7.20 mm on the left side.

In our study, we measured 5.82 cm on the right and 5.70 cm on the left, whereas Rayna et al. reported values of 6.3 cm on the right and 6.1 cm on the left for the RH-CA (14). We believe that measurements of RN-CA and RH-CA can be used to determine the methods to be used in the treatment of radial head and neck fractures.

The RH-ap and the RH-ml measurements of radial head obtained in our study were found to be consistent with other studies in literature. Captier et al. reported the mean of RH-ap as 21.6 mm (9), Kadel & Thapa, reported it as 2.09 cm (16), Puchwein et al. as 22.44 mm (17), Singh & Singh, as 20.50 mm (18), King et al., as 23.4 (19), and Gupta et al. as 1.91 cm on the right side (20). The result was determined to be 20.01 mm for the right radius and 19.38 mm for the left radius in our study. These differences may be due to biological variation between studied populations and the measurement methods used. For RH-ml, similar consistency with literature was observed. Captier et al. reported 21.0 mm (9), Ajit Singh et al. reported 19.53 mm (21), Puchwein et al. reported 23.15 mm (17), King et al., reported 23.6 mm (19), Gupta et al. reported 1.85 cm, and 23 mm (20), and Mazzocca et al. reported 23.0 mm (22). In our study, RH-ml was measured as 21.27 mm for the right radius and 20.81 mm for the left radius. The RH-ap and RH-ml measurements are important anatomical parameters for overall radial head stability and prosthetic fit. The RH-ap and RH-ml measurement provides guidance for proper sizing and placement of radial head prostheses (23). Consideration of this parameter in prosthetic surgery contributes to improved postoperative outcomes. They are also essential for fracture management (24) and overall assessment of elbow joint stability and function (25).

When comparing the measurements of the RH-mt with literature, varying results were found. Singh & Singh reported the RH-mt of 8.65 mm (18) whereas, Akshaya reported 0.92 mm on the right side and 0.82 mm on the left side (26). Ethiraj et al. found the RH-mt to be 0.86 cm on the right side and 0.95 cm on the left side (27). In our study, RH-mt was measured as 9.27 mm on the right side and 7.54 mm on the left side. For the RH-lt, Singh & Singh reported a measurement of 6.28 mm (18). Akshaya found it to be 0.84 mm on the right and 0.73 mm on the left (26), while Ethiraj et al. reported 0.73 cm on the right and 0.71 cm on the left (27). In our study, the RH-lt, was measured as 6.12 mm on the right side and 6.36 mm on the left side. These differences may be attributed to biological variations among populations and differences in measurement methods. The RH-mt and RH-lt are important considerations in surgical planning for procedures such as radial head arthroplasty, fracture reduction, fixation, and joint reconstruction. Precise measurements of these dimensions help to select appropriate implants and ensure optimal surgical outcomes (27,28).

The RT-l and the RT-w measurements in our study were found to be consistent with data reported in literature. RT-l, a prominent anatomical feature of the radius, has been the subject of several studies investigating its morphology, morphometry, and clinical implications. RT-l and RT-w are important parameters to be used in surgical procedures such as bicipital tendon reconstruction. In previous studies, Gupta et al. reported the RT-l as 2.02 cm on the right and 1.92 cm on the left (20), while Ethiraj et al. recorded it as 2.29 cm (27). Rayna et al. measured it at 3.36 cm on the right and 3.34 cm on the left (14), and Mazzocca et al. found it to be 22.3 mm (22). In our study, the RT-l was measured as 20.87 mm on the right side and 20.62 mm on the left side. These parameters are critical considerations for surgical planning and reconstruction involving the bicipital tendon. The RT-w was also measured in our study, and the findings were compared with literature. Mazzocca et al. reported the RT-w as 15.2 mm (22). Gupta et al. reported this length as 1.25 cm on the right and 1.21 cm on the left (20). In our study, the RT-w was measured as 12.7 mm on the right side and 12.46 mm on the left side. These measurements provide valuable insight into the structural features of the radial tuberosity and its relationship with reconstructive surgical procedures, elbow joint function and bone diseases. Additionally, we analyzed the types of radial tuberosity in our study. Mazzocca et al. classified these as smooth, single roughened and double roughened and reported the prevalence rates as 6%, 88% and 6%, respectively (22). When the single ridges were classified according to their size, reporting large, medium and small sizes in 12%, 47% and 41% cases, respectively. In the study conducted by Gupta et al. 36% of radial tuberosity was classified as flat, 60% as single prominence, and 4% as double prominence (20). In our study, the classifications were as follows: Type a (5.9% on the right, 11% on the left), Type b (55.9% on the right, 52.8% on the left), Type c (38.2% on the right, 36.1% on the left). We also compared the shapes of the articular fovea, classifying them as Type 1, Type 2 and Type 3. Type 2 was observed in 97% of cases on both the right and left sides, while Type 1 on the right side and Type 3 on the left side were not observed. However, Captier et al. reported 57% of shapes as elliptical and 43% as flat (9). The high proportion of circular shapes in our study may indicate anatomical variations that differ from previous studies. This may require further investigation of population-specific characteristics or measurement methods.

Distance between the RH-RT-d is a critical anatomical measurement that plays an important role in orthopaedic practice. Studies have focused on the morphology and morphometry of the proximal end of the dry radius bones. Understanding this distance is essential for surgical planning, fracture management, and overall assessment of elbow joint function and stability, including radial head prosthesis implantation, biceps tendon reconstruction, and proximal radial trauma reconstruction (27).

In addition, research has also demonstrated that a larger radial tuberosity size is associated with an increased risk of distal biceps tendon rupture, highlighting the clinical importance of this anatomical feature (29). One study reported this measurement as 25 mm (22) whereas in our study, it was measured as 11.45 mm on the right side and 11.19 mm on the left side. In conclusion, the differences observed between studies may be due to methodological differences, population-specific anatomical variations, and the inherent complexity of human anatomy. Further studies that standardize measurement techniques and control for demographic factors are needed to clarify these discrepancies.

The ISP-l was also measured in our study with values of 8.25 mm on the right side and 7.87 mm on the left side. This result is in accordance with several studies that have investigated the dimensions of the styloid process and its clinical implications. For example, Rayna et al. reported a SP-l of 1.01 cm on the right and 1.0 cm on the left (14), while Prithishkumar et al. recorded lengths of 10.8 mm on the right and 11.0 mm on the left (30). Captier et al. found an SP-l measurement of 12.8 mm (9). Additionally, the clinical implications of styloid process length are significant noting that elongation can lead to complications such as Eagle syndrome (31). These studies highlight the importance of understanding variations in styloid process length, as they may have important implications for diagnosis and treatment in clinical practice.

In our study, anterior length of the UN-al was measured as 8.12 mm on the right side and 6.62 mm on the left side. This measurement is significant for understanding anatomy of the distal radius and its impact on joint stability and function. Literature on this topic is limited; however, one study reported UN-al measurements ranging from 4 to 7 mm (32).

Additionally, we measured the posterior length of the UN-pl and the UN-w in our study. These measurements ranged from 9.89 to 14.85 mm on the right side and 9.04 to 14.29 mm on the left side, respectively. The stability of the distal radioulnar joint is mainly provided by both the bony structure of the ulnar notch of the radial head and the surrounding soft tissues (33). In conclusion, the measurements of the UN-w in our study reveal the variations in the distal radius anatomy and its potential effects on joint stability. Given that soft tissues and bone structures provide joint stability, these results are somewhat compatible with previous studies. These measurements may contribute to a better understanding of joint function.

The length of the radius is crucial in the context of distal radius fractures and their treatment as it plays a key role in maintaining wrist stability and function. In our study, the LLR and the MLR were measured as 22.8 cm and 22.29 cm on the right side and 21.69 cm and 21.4 cm on the left side, respectively. Similarly, Rayna et al.reported these measurements as 23.7 cm on the right side and 22.5 cm on the left side (14). In other studies, the radius length was reported as 29.4 cm (9) and 23.39 cm in another study (34). It has been noted that loss of radial length, especially following distal radius fractures, is common in patient-reported complaints, indicating that proper alignment and length preservation are critical for optimal healing (35). Furthermore, the need for accurate measurements during surgical procedures has been emphasized, as any reduction in radial length can lead to complications such as malunion, impaired wrist function, and significant limitations in forearm rotation, affecting both pronation and supination (36,37).

The RIA was also measured in our study. RIA indicates the angle of inclination at the distal end of the radius and is important for wrist kinematics and distal radius prosthesis design (38). In our study, the RIA was measured as 22.01° on the right side and 23.37° on the left side. This measurement is important for understanding the anatomy of the distal radius and its effect on wrist stability and function. A review of relevant studies in literature revealed similar measurements. Prithishkumar et al. reported an RIA of 22.1°±2.9° on the right and 21.8°±2.5° on the left side (30). A study of distal radius morphometry found radial tilt angle of 21.85°±2.76° (39), while Ajit Singh et al.reported it as 25.1°±3.42° (21). In addition, Bilgin reported a mean radial tilt of 26.7°, highlighting variations across populations (40). Collectively, these studies underscore the clinical importance of measuring radial inclination as it plays a critical role in assessing wrist mechanics, guiding surgical intervention, and predicting functional outcomes after distal radius fractures. Accurate measurements of radial tilt are essential to optimize treatment strategies and improve patient care. Furthermore, the combined data on radial length and radial tilt angle contribute valuable insights for ensuring normal anatomical alignment and optimizing surgical procedures.

Our study has several limitations that should be acknowledged. First, the sample size of radius bones was limited, which may affect the generalizability of the results. Additionally, all the bones used in the study were only obtained from Türkiye, potentially limiting the applicability of the findings to other populations. Another significant limitation is that the gender of the bones is unknown. This factor could have considerable effects on the findings of the study. To address this, future studies should aim to include larger and more diverse sample sizes from different populations and ensure that the gender of the bones is identified.

CONCLUSION

The results of this study provide detailed morphometric analyses of the proximal and distal ends of the dry human radius, providing important information that can be used in clinical applications. The data demonstrates that various anatomical features of the radial bone play a critical role in post-traumatic reconstruction, prosthetic design, and orthopedic surgical planning. Comparisons with other studies in literature revealed differences in the morphometric measurements of the radius in the Turkish population, highlighting the impact of ethnic and biological diversity on bone structure. It is believed that these findings suggest that this dataset may serve as a valuable resource for understanding the effects of different ethnic and biological diversity on bone structures and may provide important contributions to future research and clinical applications.

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