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A MORPHOMETRIC STUDY OF THE ANGULAR RELATIONSHIP OF RADIAL TUBEROSITY

Acharya A[1], Singh J[2], Pahuja K[3]

[1]Senior Demonstrator, Department of Anatomy, Jaipur National University Institute for Medical Sciences and Research Centre, Jaipur, Rajasthan, India.
[2]Associate Professor, Department of Anatomy, Sardar Patel Medical College, Bikaner, Rajasthan, India.
[3]Professor, Department of Anatomy, Sardar Patel Medical College, Bikaner, Rajasthan, India.

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Corresponding Author:
Dr. Jaskaran Singh,
Email: jas.dev2006@gmail.com.

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Abstract

Background: The present study aims to find out morphometric measurements of radius bone with special emphasis on bicipital tuberosity. Various studies have been conducted on morphometric measurement of the radius but very few studies are available in the North Indian population that emphasize various angles of the radius bone concerning bicipital tuberosity. **Materials and Methods:** A Cross-sectional descriptive observational study A total of 110 dry adult human radii, 60 of the right side and 50 of the left side (of the North Indian population) of unknown sex and age, were measured for 7 liner and 3 angular parameters with the help of a Vernier caliper, Linear metal scale, Wooden stick, Digital Camera, Tripod Camera stand, and Bone Stand, and angular measurements were taken on photographs. **Results and Conclusion:** It was found that small ridge and medium ridge were seen most commonly in 32.70% and 43.60% of specimens respectively. Whereas a bifid ridge was seen in 10% of specimens. The mean radial neck shaft angle was found 10.26°±1.89. The mean of the styloid angle was found 19.4°±4.02. The mean torsion angle of bicipital tuberosity was found 40.34°±5.6. All the angular measurements of radius show a significant side difference, which can be due to the hand preference of the individual as the torsion angle of the right side is more than the left side.

INTRODUCTION

The knowledge of morphometric parameters of the radius is of great importance for better management of various clinical conditions and can be utilized by forensic experts for the determination of the sex and height of the individual. Morphometry of radius has been studied by various authors and the stress has given to the fact that the upper end and lower end show different geometrical variations and their importance it has also been postulated that upper and lower end radial injury requires in-depth knowledge of radial anatomy and its measurable linear and angular parameters.

According to previous studies, it is evident that the width of bicipital tuberosity shows racial and geographical variations. In a study conducted on foreign populations by Mazzocca1 et al the mean distance between the proximal radial head to the beginning of bicipital tuberosity was 25±3mm and the width of bicipital tuberosity was15±2mm; whereas Anjali Shastry,[2] et al found a mean of the width of bicipital tuberosity in Indian population was 11.52±0.58mm. In the Indian population, the mean length of bicipital tuberosity was 25.11±0.43mm. The mean length of bicipital tuberosity was 22±3mm in Chicago population1. According to B Mahaisavariya3 the length of the radius was 24mm. The diameter of the radial head was 20.5mm. Moumita Saha4 also found a mean diameter of radial head which was 16.22±2.91mm.

Radial neck-shaft angle is the angle made by the neck with the shaft of the radius bone. It indicates the amount of bending of the shaft concerning proximal radius which in turn determines wrist biomechanics. It limits movements at the proximal radioulnar joint during pronation and supination. Neck shaft angle is an important morphometric measurement for stem design of radial head prosthesis in head and neck fractures to enable adequate movements of the forearm following post-operative management.

The torsion of a long bone is the twist along its longitudinal axis; the torsion of the radius is defined by the angle between the proximal end and distal metaphysis in the transverse plane. Pathological or traumatic processes that cause rotational changes to the forearm bones, particularly the radius, may result in persistent pain, limitation of motion, and instability at the distal radioulnar joint. This occurs with malunited fractures that usually result in limited forearm rotation and can lead to degeneration and arthrosis of the wrist and elbow as well as articular dislocations and subluxations. Precise measurement of radial torsion angle may assist in the proper treatment of fractures and when performing a precise surgical correction for a possible malunion. Measurement of radial torsion angle provides a means of detection and quantification of malrotation after a fracture. By the study of R P Van,[5] a torsion angle was 54^0.

Morphometry of the distal end of radius is important in various clinical orthopedic procedures such as reduction of distal radius fractures, design of distal radius prosthesis, and kinematics of the wrist joint. Distal radius fracture is one of the most common types of fractures, constituting 25% of fractures in the pediatric population and around 18% of all fractures in elderly people. Decreased length of radius, increased angle of radial inclination, and dorsal angulation cause significant alterations in the kinematics of the wrist joint and grip strength. Even pronation and supination depend on the initial length of radius and dorsal angulation. According to the P Voche,[6] study, the radial styloid angle was 5^0. Similarly, a study was done on the styloid angle by Chan CYW et al,[7] and found a mean which was 25.1 ± 3.42^0. Many other studies,[8-11] reported the styloid angle as 21.8 ± 2.5^0, 23.27 ± 7.42^0, $23.62,^0$ and 25.77 ± 2.91^0 respectively.

Understanding the bicipital tuberosity angular relationship to the radial head is important in the pathophysiology of biceps tendon rupture as well as to facilitate surgical procedures like reconstruction of biceps tendon, radial head prosthesis, and implantation and reconstruction of proximal head trauma. This will also help in making precise prosthetic designs.

Various studies have been conducted on morphometric measurement of radius but very few studies are available in the North Indian population; so, the present study is aimed to find out morphometric measurements of radius bone with special emphasis on bicipital tuberosity. The present study aims to find out the morphometric measurements of radius bone and determine various angles of radius bone about bicipital tuberosity.

MATERIALS AND METHODS

A Cross-sectional descriptive observational study was conducted in the Department of Anatomy, S.P. Medical College Bikaner. Necessary permission was taken before the study from the Ethical Committee of the Institute.

Inclusion criteria: The dry adult radii with clear and intact normal anatomical features were included in the present study.

Exclusion criteria: The Inappropriate and damaged specimens of radii (Broken or defective radii), showing obvious pathology, degenerative changes, osteoarthritic changes, and evidence of any previous trauma or skeletal disorders were excluded from the study.

A total of 110 dry adult human radii, 60 of the right side and 50 of the left side (of the North Indian population) of unknown sex and age, were collected from the Department of Anatomy. Measurements were taken with the help of a Vernier caliper, Linear metal scale, Wooden stick, Suitable Statistical Software, Digital Camera, Tripod Camera stand, and Bone Stand.

Methodology

The following Morphometric parameters of the Radius were measured by using a digital Vernier Calliper in millimetres with an accuracy of 0.01mm.in mm (Fig. 1)

- Distance between proximal radial head to beginning of bicipital or radial tuberosity
- Width of bicipital tuberosity right angle to the long axis of radius.
- Length of bicipital tuberosity in line with the long axis of radius.
- Diameter of radial shaft distal to radial tuberosity
- Width of the radial shaft at the level of the bicipital tuberosity.
- Diameter of radial head (average of maximum and minimum diameters)
- Length of radius (superior surface of the head of the radius to the tip of the styloid process)

Morphology of the Radial tuberosity: The shape of the radial tuberosity was noted as 1. smooth (with no ridge), 2. Ridged. Ridged tuberosity was classified under two headings based on the presenting number of ridges; a) Single Ridged (further classified into three categories small medium and large). b) Bifid Ridged.

Angular measurements were measured using suitable image editing software. Photographs were taken by fixing the radius on a flat surface and fixing the camera at a fixed distance measured between the camera lens and the radial shaft.

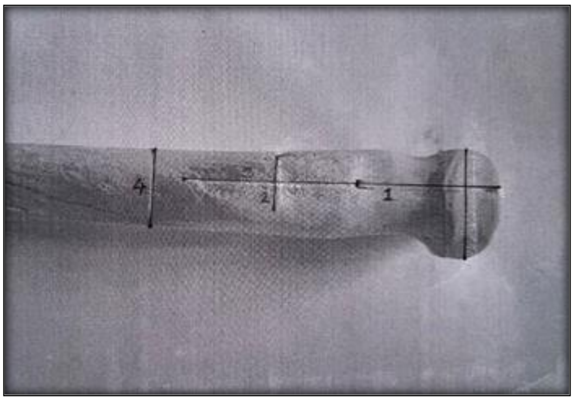

Figure 1: Showing measurements as 1-Distance between proximal radial head to beginning of bicipital or radial tuberosity, 2-Width of bicipital tuberosity right angle to the long axis of radius, 3-Length of bicipital tuberosity in line with the long axis of radius and 4-Diameter of radial shaft distal to radial tuberosity.

Radial Neck Shaft angle: It was measured as the angle between line AB drawn along the long axis of the neck of radius and another line is drawn along the long axis of the radial shaft between the line EF and AB as shown in Figure 2. Photographs were taken by fixing the radius.

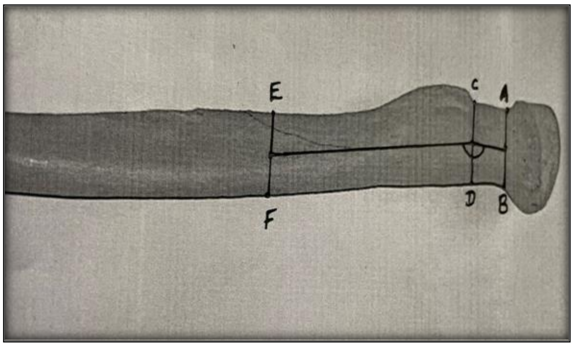

Figure 2: Showing measurement of Radial Neck Shaft angle.

The styloid angle of radius: It was measured as the angle between line AB drawn along the long axis of the shaft of radius another line CE is drawn parallel to the lower end of the radius and a CD line passes through the tip of the styloid process as shown in Figure 3. Photographs were taken by fixing the radius.

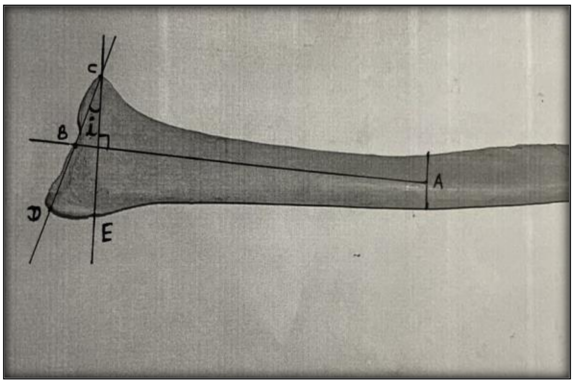

Figure 3: Showing measurement of the styloid angle of radius (i)

The torsion angle of radial tuberosity: - It was measured from the photographs. Two wooden thin sticks (the size of a toothpick) were used for the angular demarcation. One stick was pasted on (pasted with the help of white clay) the superior surface of the radial head with one end passing through the center of the head and another end pointing in the direction of maximum protrusion of the radial tuberosity as shown in Figure. 4. The second stick was pasted onto to anterior surface of the lower end of the radius right angle to the long axis of the radial shaft; the angle formed between the two sticks represents 'A' as shown in Figure-4. For angular measurements, Photographs were taken by fixing each radius on a stand keeping the long axis of the radius in line with the central focal axis of the camera lens, stabilizing the camera at a certain distance and the photograph was taken. The angles were measured from the photographs.

Statistical Analysis

All the observations were done by a single observer; readings were obtained for each parameter to avoid errors and the average was recorded. The measurements were tabulated and the data was analyzed statistically by using Microsoft Excel software. Range, mean, standard deviation, and p-value were determined for each parameter. The values of the right and left sides were analyzed and compared by using a t-test. The p-value ≤0.05 was taken as statistically significant.

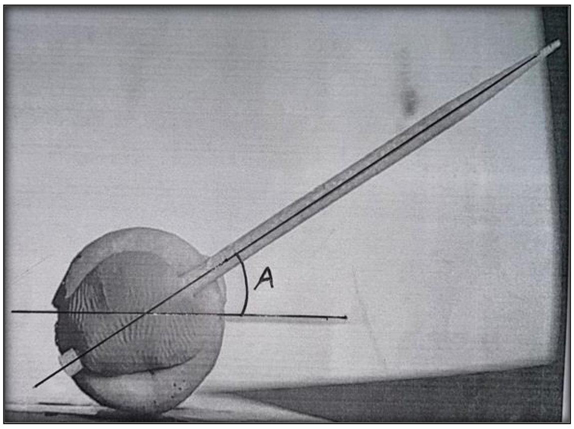

Figure 4: Showing measurement of the torsion angle of radial tuberosity (A)

RESULTS

The present study was conducted at the Department of Anatomy, Sardar Patel Medical College, Bikaner, Rajasthan after obtaining permission from the institutional ethical committee. The study incorporated a total of 110 bones, which included 60 right side and 50 left side. The angles were measured with the help of a protractor. The study was related to the morphometric of the radius with special emphasis on Bicipital tuberosity (BT) or Radial tuberosity.

The following observations were recorded

Table 1 shows the frequency and percentage of ridges i.e., the smooth ridge is the least common which is seen in 4.5% of specimens, small ridge, and medium ridge appeared most common type and are seen in 32.7% and 43,6% of specimens, large ridges seen in 9.1%, and bifid ridge seen in 10% specimens. The association of the morphological type of BT to the Side of Bone is significant. The bifid ridge and smooth ridge are associated on the right side.

Among all the linear measurements only the Width of BT, the Diameter of the radius distal to the tuberosity, and the Width of the radius at the level of BT were found to be significant (Table 2). For all the angular measurements p-value was less than 0.05 which was significant. In the comparison of the torsion angle of BT and the styloid angle on the right and left sides, the mean angle on the right side

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is more whereas the Radial neck-shaft angle is less on the right side.

Table 1: Association of morphological type of bicipital tuberosity (BT) to the Side of the Bone

Morphological type of BT	Right Radius		Left Radius		X2	df	p-value
	Count	%	Count	%			
Smooth No Ridge	5	4.5%	0	0.0%	8.478	4	.076
Small Ridge	20	18.2%	16	14.5%			
Medium Ridge	24	21.8%	24	21.8%			
Large Ridge	3	2.7%	7	6.4%			
Bifid Ridge	8	7.3%	3	2.7%			
Total	60	54.5%	50	45.5%			

Table 2: Descriptive Statistics and mean comparison of various morphometric parameters

Parameters	Side of Bone	Minimum	Maximum	Mean	Std. Deviation	p-value
Distance between proximal radial head to beginning of BT (mm)	Right Radius	16.76	28.00	22.5297	2.38379	0.682
	Left Radius	18.50	26.03	22.3584	1.89171	
	Total	16.76	28.00	22.4518	2.16607	
Width of BT (mm)	Right Radius	10.64	17.19	13.7087	1.34578	0.174
	Left Radius	10.39	17.95	14.1200	1.80311	
	Total	10.39	17.95	13.8956	1.57614	
Length of BT (mm)	Right Radius	18.36	27.75	22.9867	1.79820	0.829
	Left Radius	18.97	27.22	23.0748	2.47422	
	Total	18.36	27.75	23.0267	2.12231	
Diameter of radius distal to tuberosity (mm)	Right Radius	10.09	15.00	12.2780	.98956	0.005
	Left Radius	10.00	16.66	12.9178	1.35451	
	Total	10.00	16.66	12.5688	1.20716	
Width of radius at level of BT (mm)	Right Radius	11.16	18.60	15.0222	1.43114	0.164
	Left Radius	11.86	18.41	15.4122	1.47736	
	Total	11.16	18.60	15.1995	1.45872	
Radial head diameter (mm)	Right Radius	12.65	24.90	20.1232	2.35680	0.692
	Left Radius	14.05	26.10	20.3016	2.33747	
	Total	12.65	26.10	20.2043	2.33896	
Length of radius (cm)	Right Radius	19.0	27.0	23.888	1.6607	0.818
	Left Radius	20.0	28.0	23.960	1.5760	
	Total	19.0	28.0	23.921	1.6158	
Radial neck shaft angle°	Right Radius	7.0	15.0	9.643	1.6623	0.000
	Left Radius	6.0	15.0	11.020	1.9005	
	Total	6.0	15.0	10.269	1.8957	
Styloid angle°	Right Radius	10.0	30.0	20.817	3.8023	0.000
	Left Radius	8.0	28.0	17.700	3.6422	
	Total	8.0	30.0	19.400	4.0273	
Torsion angle of BT°	Right Radius	30.0	65.0	42.083	5.7144	0.000
	Left Radius	30.0	50.0	38.260	4.9076	
	Total	30.0	65.0	40.345	5.6709	

DISCUSSION

Bicipital tuberosity or radial tuberosity is divided into two areas: posterior rough area and anterior smooth area; the biceps tendon is inserted on the posterior rough area and the bursa is attached to the anterior smooth area. A total of 10 linear and angular parameters of radius were selected in this study.

Measurements of bicipital tuberosity and its angular relationship are significant in various surgical interventions such as reconstruction of biceps tendon, and reconstructions of proximal end trauma. This will also help in making precise prosthetic designs. Various studies have been conducted on morphometric measurement of radius but very few studies are available in this region; So, the present study aimed to correlate the morphometric study of radius with special emphasis on bicipital tuberosity in the north Indian population.

In the present study, the mean length of radius was 23.92±1.61mm. Similar results were obtained in the study of B Mahaisawariya,[3] et al the length of the radius was 24mm. Similarly, in a study conducted by Augustus D. Mazzocca1 et al, the mean length of radius was 24±2mm.

The mean width of BT was found 13.89±1.57mm. Similarly, in a study of Mazzocca1 the mean width of bicipital tuberosity was 15±2mm. In accordance to Chandni Gupta,[12] width of tuberosity was 11.97cm. In the present study, both side's mean distance between the proximal radial to the beginning of BT was 22.45±2.16mm. By Mazzocca1, the distance between the proximal radial head to the beginning of BT was 25±3mm. In the present study, the length of the BT mean was 23.02±2.12mm. Similarly, Mazzocca1 found a mean which was 22±3mm. In accordance to, Chandni Gupta,[12] the length of BT was 4.54cm. In the present study, the mean diameter of the radius distal to the tuberosity of both sides was 12.56±1.20mm. dissimilar to this Mazzocca1 et. al. found the diameter of radius distal to BT was 17±2mm.

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The mean difference in both sides of the diameter of the radius distal to tuberosity was found significant. In the present study, the width of the radius at the level of BT mean was 15.19±1.45mm. Similarly, Mazzocca1 found the minimum width of radius at the level of BT was 12mm, the maximum was 23mm and the mean was 17±2mm. the present study indicates the difference in the width of the radius at the level of BT between both sides was not significant.

The radial head diameter of both sides mean was 20.2±2.33mm. In accordance to, B Mahaisavariya,[3] et al diameter of the radial head was 20.5mm. whereas Mazzocca1 et. al. also found a radial head diameter; of 23±2mm. Similarly, Anjali Shastry,[2] et al found that the anteroposterior radial head diameter was 19.81mm and the transverse diameter was 18.92mm. Similarly, Archana Singh,[13] also found that the anteroposterior diameter was 20.5±2.32mm and the transverse diameter was 19.52±mm2.26mm. Similarly, according to, Moumita Saha,[4] et. al. mean anteroposterior diameter was 16.86±2.92mm and the transverse diameter was 16.22±2.91mm.

In the present study, the mean of both side's radial neck shaft angle was found to be 10.26±1.89^0. By, Mazzoca,[1] the mean radial neck shaft angle was 7±3^0 which is slightly less. Ashwani Ummat,[14] et al also found the mean value on the right side was 165.7±2.5^0 and on the left side was 165.9±2.8^0. Anjali Shastry et al,[2] also found the mean value of radial neck-shaft angle on the right side was 165.67±4.44^0 and on the left side was 168.01±3.65^0. A similar study was done by Utoon Ekene et al,[15] their measurement for radial neck shaft angle was 169.49±2.79^0. According to the present study, the mean radial neck shaft angle is more on the left side as compared to the right side. The p-value is less than 0.005 which is significant.

The styloid angle of both sides' mean values was found to be 19.4±4.02^0. In contrast, P Voche,[6] et al measured the styloid angle which was 5^0. By, Mazzocca1 et al found that the mean styloid angle was 127±10^0. Similarly, in the study done by Chan CYW7 et al their measurement of the radial inclination was 25.1 ± 3.42. Similarly, to our findings I. Prithish k et al8 mean styloid angle was 21.8±2.5^0 on the left side and 22.1±2.9^0. however, Pankaj Kumar Mishra et al,[9] found the mean value of styloid angle 23.27±7.42^0. According to Muna Kadel et al,[10] styloid angles were 23.62^0. Mudasir Ahmad Bhat et al11 found a slightly higher mean angle of 25.77±2.91^0. In the present study, the mean of the styloid angle is more on the left side as compared to the right side. The p-value is less than 0.005 which is significant.

In the present study, the minimum torsion angle of BT of both sides was found to be 30^0, the maximum was 65^0, and the mean was 40.34^0±5.67, whereas R P Van et al5 measured a higher torsion angle reported 54^0. Thus, according to the present study mean of the torsion angle of the right side is more than the left side. The p-value is less than 0.005 which is significant.

Table 3: Comparison of various parameters with previous studies

Parameters	Present study	A D Mazzocca et al[1] 2007	Anjali Shastry et al[2] (2017)	Chandni Gupta et al[12] (2015)	Muna Kadel et al[10] (2020)
Distance between proximal radial head to the beginning of bicipital tuberosity	22.45±2.16mm (Range: 16.76mm-28mm)	25±3mm (Range: 19mm-30mm)	Not reported	Not reported	Not reported
Width of BT	13.89±1.57mm (Range: 10.39mm-17.95mm)	15±2mm (Range: 10mm-19mm)	11.52±0.58mm	1.23cm	Not reported
Length of BT	23.02±2.12mm (Range: 18.36mm-27.75mm)	22±3mm (Range: 16mm-30mm)	25.11±0.43mm	1.97cm	Not reported
Diameter of radial shaft distal to radial tuberosity	12.56±1.20mm (Range: 10mm-16.66mm)	17±2mm (Range: 13mm-22mm)	Not reported	Not reported	Not reported
Width of radial shaft at level of bicipital tuberosity	15.19±1.45mm (Range: 11.16mm-18.60mm)	17±2mm (Range: 12mm-23mm)	Not reported	Not reported	Not reported
Diameter of radial head	20.20±2.33mm (Range: 12.65mm-26.10mm)	23±2mm (Range:18mm-28mm)	Not reported	1.91 and 1.85 cm	Not reported

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Length of radius	23.92±1.61mm (Range: 19mm-28mm)	24±2mm (Range: 20mm-27mm)	Not reported	23.5 cm	Not reported
Radial neck shaft angle	10.26±1.89° (Range: 6°-15°)	7±3° (Range: 0°-14°)	168.01±3.65°	Not reported	Not reported
Styloid angle	19.4±4.02° (Range: 8°-30°)	123±10° (Range: 98°-142°)	Not reported	Not reported	23.62° (Range: 17°-31°)
Torsion angle	40.34±5.6° (Range: 30°-65°)	Not Reported	Not reported	Not reported	Not reported

CONCLUSION

In the present study, we found that the morphology of BT is variable which was as per previous studies. The result of the present study on the variability of BT will be helpful for clinicians for surgical procedures such as the reconstruction of distal biceps tendon, radial head prosthesis implantation, and reconstruction of proximal radial trauma. The angular measurements of radius show there was a significant side difference which can be due to the handedness of the individual. it would be worthwhile measuring the BT and neck shaft angle for proper design of the stem of the radial prosthesis moreover side determination should also be considered while implanting the prosthesis on the affected side. The data of the present study on morphometry of distal radius may also be used as reference data for anatomical alignment during surgical corrections of the distal end of the radius. No grant was received to conduct this study.

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