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Morphometric Study of the Proximal End of the Adult Human Dried Radii

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Abstract

Introduction: Knowledge of size and shape of proximal end of radius *i.e.* radial head is necessary for creation of anatomically and biomechanically correct radial head prosthesis. This difference in biome-chanics of circular shape and the elliptical shape of radial head must be taken in consideration in design of radial head prosthesis.[2] Further understanding of dimensions of bicipital tuberosity and its angular relationship to radial head is important in pathophysiology of bicepstendon rup-ture as well as to facilitate surgical procedures like reconstruction of biceps tendon, radial head prosthesis and implantation and reconstruction of proximal head trauma.[3] Several studies have been published on anatomy using different technical approaches however, most of these studies were conducted with special focus on parameters relevant to radi-al prosthetic design. The purpose of this study was to explore the complex geometry of the prox-imal radius with regard to fracture implant design.[4] *Methods:* Randomly selected 100 right and 100 left dried radii of Adult Human (20 years and above) of unknown gender were studied. The data obtained was analyzed statistically to find out mean, range, SD, standard error and 95% confidence intervals of observations. Box and whisker's plot are showing the pictorial forms of the observation sat a glance. *Results:* The mean height, anteroposterior and transverse diameter of head, length of radial neck, length of radial tuberosity, Neck shaft angle of radius, circumference at radial tuberosity of radius were 10.39 mm, 20.21 mm, 19.65 mm 11.62 mm, 19.40 mm, 169.29 degree and 4.78 cm respectively.

Keywords: Radial Head; Neck; Angle; Prosthesis.

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Introduction

Restoration of the anatomical situation can only be achieved when the implant is placed in the correct position, even with a perfectly created anatomical prosthesis.[1] Knowledge of size and shape of radial head is necessary for creation of radial head prosthesis that is anatomically and biomechanically correct. The biomechanics of the circular shape and the elliptical shape are different involving an adaptation of the angle between the neck and the radial diaphysis.This difference must be taken in consideration in the design of a radial head Prosthesis.[2] Further understanding of the dimensions of bicipital tuberosity and its angular relationship to radial head is important in pathophysiology of bicepstendon rupture as well as to facilitate surgical procedures like reconstruction of biceps tendon, radial head prosthesis and implantation and reconstruction of proximal head trauma.[3] The proximal radius features a complex anatomy. Several studies have been published on the anatomy using different technical approaches however, most of these studies were conducted with a special focus on parameters relevant to radial prosthetic design. The purpose of this study was to explore the complex geometry of the proximal radius with regard to fracture implant design.[4]

The morphological study of the proximal radius can be used to reconstruct the geometry of the

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injured radial head based on the obtained geometric features of the contra-lateral side.[6] Exact anatomical description of the proximal radius is imperative for the development of radial head prostheses.[7]

Morphometric radius study may also help in anthropometric, forensic, and archaeological investigation for the estimation of the stature of the remains of unknown bodies using regression equations and could serve as the basis of comparison for future studies.[10]

Materials and Methods

Randomly selected 100 right and 100 left dried radii of Adult Human (*20 years* and above) of unknown gender were studied from bone library of MCI recognized medical institutions.The data obtained was analyzed statistically to find out mean, range, D, standard error and 95% confidence intervals of the observations. The Box and Whisker's plot are showing the pictorial forms of the observation sat a glance. The various measurement are taken as described below:

1. Height of radial head: 5, 6, 9, 10, 13, 14.

   - Distance between the radial lips (superior border) to the head neckborder (Fig. 1).

Fig. 1:

2. *Anteroposterior diameter of radial head*: 2, 4, 5, 6, 7, 9, 12, 13, 14.

   - Distance between maximum convexity of its anterior and posteriorends (Fig. 2).

Fig. 2:

3. *Transverse diameter of radial head*: 2, 4, 9, 12, 14.

   - Distance between the maximum convexity of its lateral and medial ends (Fig. 3).

Fig. 3:

4. *Length of radial neck*:1,8,12.

   - Distance between upper margin of head neck border to upper most end of radial tuberosity (Fig. 4).

Fig. 4:

5. *Length of radial tuberosity*: 3, 12, 14.

   - Distance between the upper most and lower most ends of radial tuberosity (Fig. 5).

Fig. 5:

6. *Neck shaft angle*: 1, 2, 3, 8.

   -Angle between long axis of neck and long axis of shaft of radius (Figs. 6 and 7).

Fig. 6:

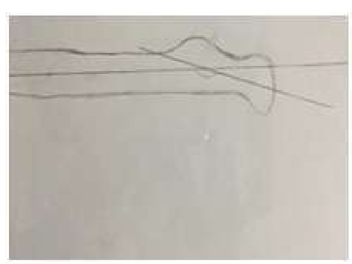


Fig. 7:

7. *Circumference at radial tuberosity of radius*: 10–11.

   - Circumference at maximum convexity of radial tuberosity (Fig. 8) taken at radial tuberosity by the help of suture thread is calculated with measuring scale.

Fig. 8:

Results

The mean, range, SD, standard error and 95% confidence intervals of all parameters for right and left radius shown in tables.

Box and Whisker's plot are showing the pictorial forms of observations of all parameters for right and left radius.

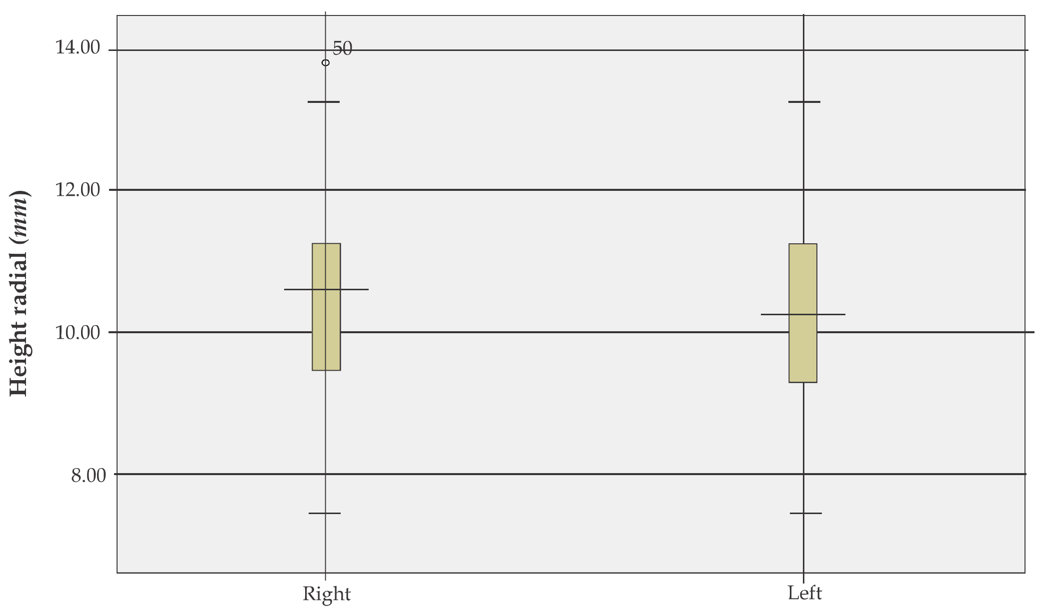
All the results depicted at the end of this article in the tables 1–7 and also in Box and Whisker's plot 1–7.

Table 1: Values of Height of Radial Head *(mm)*.

Height of Radial Head (*mm*)	*N*	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		*Min.*	*Max.*	Normal Range	
					Lower Bound	Upper Bound			*LL*	*UL*
Right	100	10.41	1.19	0.12	10.17	10.65	7.76	13.87	8.07	12.75
Left	100	10.38	1.24	0.12	10.13	10.62	7.48	13.48	7.95	12.81
Total	**200**	**10.39**	**1.21**	**0.09**	**10.22**	**10.56**	**7.48**	**13.87**	**8.01**	**12.77**

Abbreviation used: N-Number; LL-Lower Limit; UL-Upper Limit.

Box and Whisker's plot **1**



Box Plot 1: Comparing Median and quartiles values for Height of radial head of right and left sides.

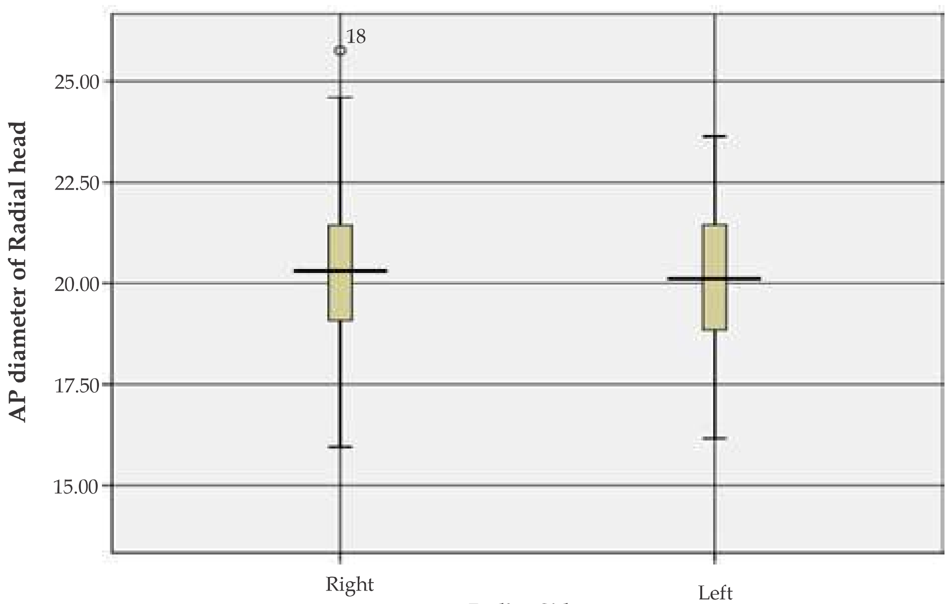
Box Plot 1 shows that the data for height of radial head for right and left radius. It is negatively skewed, where sample number 50 is outlier which is not considered in the study.

Table 2: Values of AP diameter of Radial Head (*mm*).

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min.	Max.	Normal range	
						Lower Bound	Upper Bound			LL	UL
AP diameter of Radial Head (*mm*)	Right	100	20.32	1.92	0.19	19.94	20.70	15.95	25.76	16.56	24.09
	Left	100	20.09	1.81	0.18	19.73	20.45	16.16	23.64	16.55	23.63
	Total	**200**	**20.21**	**1.86**	**0.13**	**19.95**	**20.47**	**15.95**	**25.76**	**16.55**	**23.86**

Abbreviation used: N-Number; LL-Lower Limit; UL-Upper Limit.w

Box and Whisker's plot 2



Box Plot 2: Comparing Median and quartiles values for anteroposterior diameter of Right and Left Radial Head.

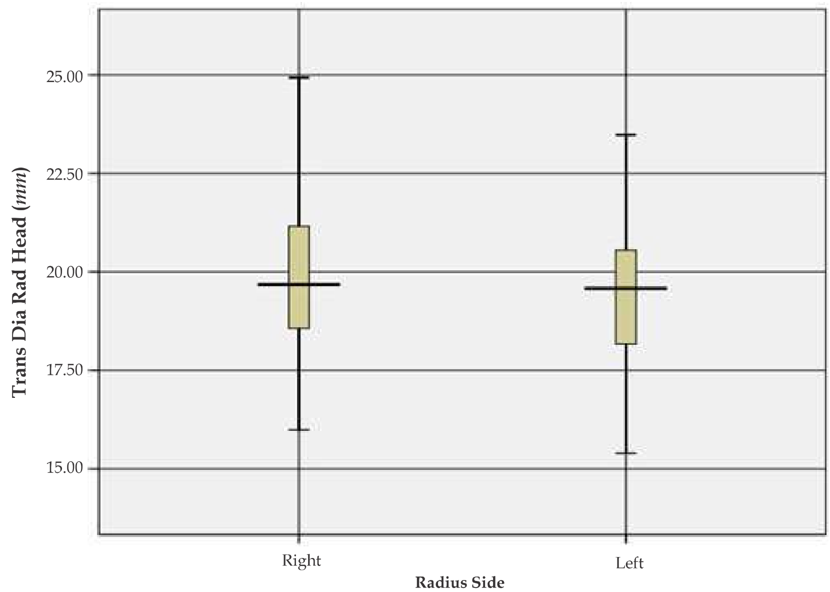
Box Plot 2: shows that the data for AP diameter of radial head of right and left radius. It is positively skewed, where sample 18 is outlier.

Table 3: Values of Transverse Diameter of Radial Head (*mm*).

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		*Min.*	*Max.*	Normal range	
						Lower Bound	Upper Bound			*LL*	*UL*
Trans Dia Rad Head (*mm*)	Right	100	19.85	1.86	0.19	19.48	20.22	15.99	24.93	16.21	23.49
	Left	100	19.45	1.77	0.18	19.10	19.80	15.40	23.48	15.98	22.92
	Total	**200**	**19.65**	**1.82**	**0.13**	19.40	19.90	15.40	24.93	16.08	23.22

Abbreviation used: N-Number; LL-Lower Limi; UL-Upper Limit.

***Box and Whisker's plot* 3**



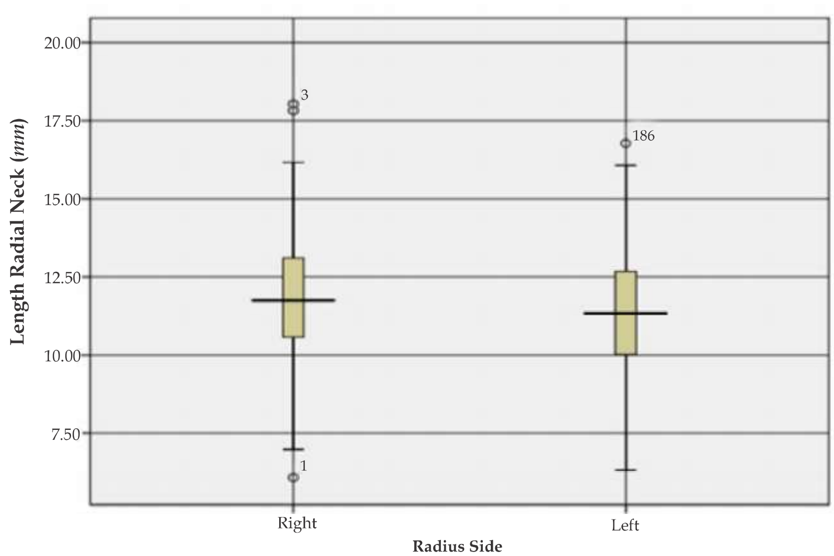
Box Plot 3: Comparing Median and Quartiles values for Transverse diameter of Radial head between Right and Left Sides.

Box Plot 3 shows that the data for transverse diameter of radial head of right and left radius. It is positively skewed.

Table 4: Values of Length Radial Neck (*mm*).

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min.	*Max.*	Normal range	
						Lower Bound	Upper Bound			*LL*	*UL*
Length Radial Neck (*mm*)	Right	100	11.80	2.07	0.21	11.39	12.21	6.08	18.04	7.74	15.85
	Left	100	11.45	1.97	0.20	11.06	11.84	6.32	16.78	7.59	15.31
	Total	**200**	**11.62**	2.02	0.14	11.34	11.91	6.08	18.04	7.66	15.59

***Box and Whisker's plot* 4**



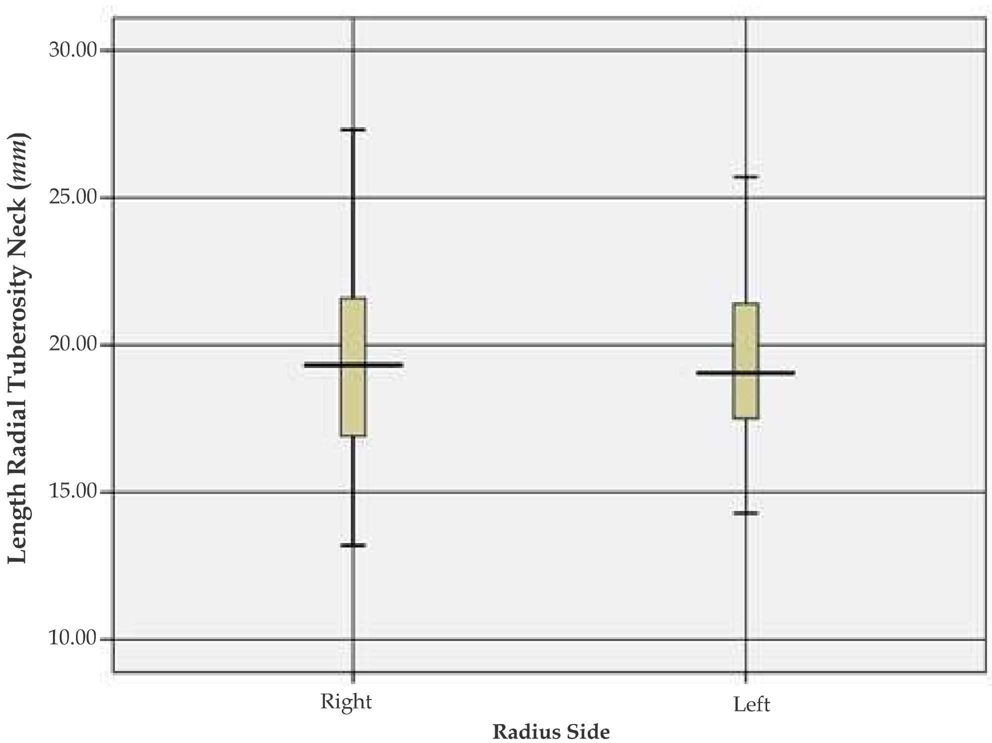
Box Plot 4: Comparing Median and Quartiles values for Length Radial Neck between Right and Left Sides.

Box Plot 4 shows that the data for length of radial neck of right and left radius. It is positively skewed, where sample 3 and 1 are outlier for right radius and sample 186 is outlier for left radius.

Table 5: Values of Length of Radial Tuberosity (*mm*).

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	*Min.*	*Max.*	Normal range *LL*	Normal range *UL*
Length Radial Tuberosity (*mm*)	Right	100	19.41	3.28	0.33	18.76	20.06	13.20	27.31	12.98	25.84
	Left	100	19.39	2.52	0.25	18.89	19.89	14.30	25.71	14.44	24.33
	Total	200	19.40	2.92	0.21	18.99	19.81	13.20	27.31	13.68	25.12

***Box and Whisker's plot* 5**



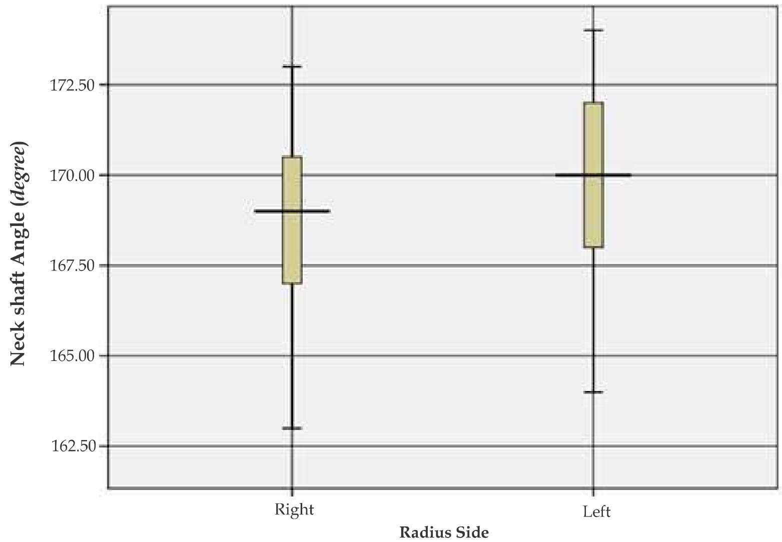
Box Plot 5: Comparing Median and quartiles values for Length of right and left radial tuberosity.

Box Plot 5 shows that the data for length of radial tuberosity of right and left radius. It is positively skewed.

Table 6: Values of Neck Shaft Angle (*degree*).

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	*Min.*	*Max.*	Normal range *LL*	Normal range *UL*
Neck Shaft Angle (*degree*)	Right	100	168.81	2.44	0.24	168.33	169.29	163.00	173.00	164.03	173.59
	Left	100	169.76	2.27	0.23	169.31	170.21	164.00	174.00	165.31	174.21
	Total	**200**	169.29	2.40	0.17	168.95	169.62	163.00	174.00	164.58	173.99

Box and Whisker's plot **6**



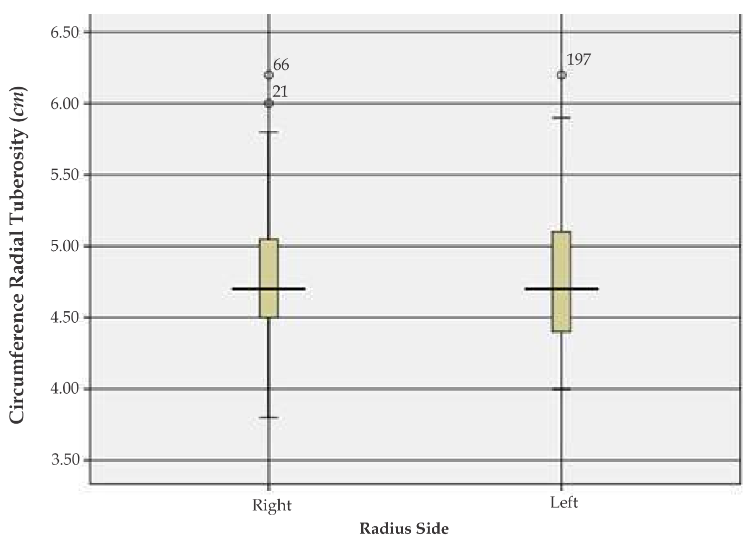
Box Plot 6: Comparing Median and Quartiles values for neck shaft angle of right and left radius.

Box Plot 6 shows that the data for neck shaft angle of right and left radius. It is negatively skewed.

Table 7: Values of Circumference at Radial Tuberosity (*cm*).

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		*Min.*	*Max.*	Normal range	
						Lower Bound	Upper Bound			*LL*	*UL*
Circumference at Radial Tuberosity (*cm*)	Right	100	4.79	0.48	0.05	4.70	4.89	3.80	6.20	3.86	5.73
	Left	100	4.78	0.47	0.05	4.68	4.87	4.00	6.20	3.86	5.70
	Total	**200**	**4.78**	**0.47**	**0.03**	**4.72**	**4.85**	**3.80**	**6.20**	**3.86**	**5.71**

Box and wWhisker's **7**



Box Plot 7: Comparing Median and Quartiles values for circumference at radial tuberosity of right and left radius.

Box Plot 7 shows that data for circumference at radial tuberosity of right and left radius. It is positively skewed. Where sample 21 and 66 are outlier for right radius. Sample 197 is outlier for left radius.

Discussion

Table 8: Comparison of Mean AP, Transverse Diameter and Height of Radial Head.

Study done by	Sample size	Mean AP diameter of radial head (*mm*)	Mean transverse diameter of radial head (*mm*)	Mean height of radial head (*mm*)
Berrizbeitia *et al.*(1989)[15]	1108	22	21	
Beredjiklian PK *et al.* (1999)[16]	46	23		12
Swieszkowski *et al.* (2001)[6]	17	23.36		10.14
Captier *et al.* (2002)[2]	96	21.6	21	
Mahaisavariya *et al.* (2004)[5]	40	20.5		12.9
Popovic *et al.* (2005)[4]	51	22.9	21.9	
Koslowsky *et al.* (2007)[7]	36	24.13		
Itamura *et al.* (2008)[13]	22	22.3		10.41
Puchwein *et al.* (2013)[9]	30	23	22.4	11.8
Mike *et al.* (2015)[10]	40			11.35
Gupta *et al.* (2015)[14]	50	19.15	18.55	9.05
Rajasree *et al.* (2016)[13]	100	15.43	13.43	
Present study	**200**	**20.21**	**19.65**	**10.39**

(*Abbreviation*: AP-Anteroposterior).

In present study, mean AP diameter of radial head is in close agreement with mean value obtained by Mahaisavariya *et al.* (2004).[5]

In present study mean transverse diameter of radial head is in close agreement with the study done by Gupta *et al.* (2015).[14]

In present study, mean height of radial head is in close agreement with the mean value obtained by Swieszkowski *et al.* (2001)[6] and Itamura *et al.* (2008).[13]

Table 9: Comparison of Mean Length, Length of Radial Tuberosity, Circumference at Radial Tuberosity and Neck Shaft Angle of Radius.

Study done by	Sample size	Mean length of radial neck (*mm*)	Mean length of radial tuberosity (*mm*)	Mean circumference at radial tuberosity (*cm*)	Mean of neck shaft angle of radius (*degree*)
Captier *et al.* (2002)[2]	96				168.62
Van Riet *et al.* (2004)[1]	27	13			165
Koslowsky *et al.* (2007)[8]	40	13.3			167.8
Gupta *et al.* (2015)	50	11.9	19.79		
Rajasree *et al.* (2016)[12]	100	13.57	12.20		
Mazzocca *et al.* (2007)[3]	178		22		173
Waghmare *et al.* (2012)[11]	198			5	
Mike *et al.* (2015)[10]	40			4.87	
Present study	**200**	**11.62**	**19.40**	4.78	169.29

In present study, mean length of radial neck and radial tuberosity are in close agreement with the study done by Gupta *et al.* (2015).[14]

In present study, mean circumference at radial tuberosity of radius is in close agreement with the mean values obtained by Waghmare *et al.* (2012)[11] and Mike *et al.* (2015).[10]

In present study, mean neck shaft angle of radius is in close agreement with the study done by Captier *et al.* (2002).[2]

Conclusion

The dimension and shape of the radii may be useful for construction and manufacturing of prosthesis of radius with accuracy. The morphometric data may be significant in surgical procedures like reconstruction of biceps tendon.

Conflict of interest: There is no conflict of interest.

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