

Morphometry of Head of The Radius - a Prerequisite In Prosthesis of Radial Head; an Anatomical Study

Sarala HS¹, Jyothilakshmi GL², Vineesh PV³, Chandrakala C⁴, Padmalatha N⁵

¹Associate professor, Department of Anatomy, ACS Medical College and Hospital. Velappanchavadi, Chennai, TamilNadu

²Assistant professor, Department of Anatomy, Shri Atal Bihari Vajpayee Medical College and Hospital. Shivajinagar, Bengaluru, Karnataka

³Assistant professor, Department of Anatomy, Rajarajeswari medical College and hospital. Bengaluru, Karnataka

⁴Assistant professor, Department of Community Medicine, Rajarajeswari Medical College and Hospital. Bengaluru, Karnataka

⁵Assistant professor, Department of Anatomy, Rajarajeswari medical College and Hospital. Bengaluru, Karnataka

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ABSTRACT

Introduction: the head of the radius is articular and plays an important role in maintaining the stability of Elbow joint during flexion and extension and also in supination and pronation of the forearm. Fractures of the radial head and neck are one of the most common fractures of the elbow, comprising 33% of all elbow fractures and 1.5% to 4% of all fractures in adults. Operative treatment of displaced and comminuted radial head fractures involves open reduction and internal fixation with plates and screws in cases where reconstruction is possible and replacement with a radial head prosthesis when comminution renders the radial head unreconstructable.

Materials and Methods: this study was conducted on 128 dry adult undamaged human Radius bones of unknown age and gender using digital vernier caliper. The following measurements were taken on head of the Radius Anteroposterior diameter (APD), Transverse diameter (TD), Medial height (MH), Lateral height (LH). Thickness of ventral curve (TVC), Lateral curve (TLC), Dorsal curve (TDC). Depth of the superior articular facet (DH), Surface area (SA) and volume (V) were calculated using mathematical formulas and analysed statistically.

Formulas: $SA = \pi(h^2 + r^2)$ $V = 1/6\pi(3r^2 + h^2)$

Statistical tests - Student's t-test and Karl Pearson's coefficient of correlation.

Results: in our study the mean values \pm standard deviation were as follows, 19.63 \pm 1.75mm (APD), 19.18 \pm 1.73mm (TD), 10.33 \pm 1.05mm (MH), 7.34 \pm 1.30mm (LH), 2.61 \pm 0.63mm (DH), 3.45 \pm 0.77mm (TVC), 2.07 \pm 0.40mm (TDC), 2.41 \pm 0.64mm (TMC), 2.48 \pm 0.63mm (TLC), 2.61 \pm 0.63mm (DH), 314.21 \pm 57.10 mm² (SA), 396 \pm 142.18 mm³ (V).

Conclusions: the statistical correlations in our study based on Karl Pearson's correlation coefficient shows strong relation between the measured parameters like Depth, volume and surface area. The knowledge of the measurements of Head of the Radius is necessary for the creation of radial head prosthesis and also for the safe application of osteo-synthesis during reconstructive surgeries of upper end of Radius.

Keywords: Head of the Radius; Radial head prosthesis; superior articular facet of Radius; Elbow injuries.

Introduction

The radius is the lateral and shorter of the two forearm bones, its proximal end includes a short head, neck and medially directed radial tuberosity¹. The smooth superior aspect of the head is concave and articulates with the capitulum of the Humerus during flexion and extension of the Elbow joint. The articular circumference of the head of the radius articulates with the radial notch present on the Ulna and the Annular ligament forming proximal Radio-ulnar joint permitting pronation and supination of the forearm².

Fractures of the radial head and neck are one of the most common fractures of the elbow, comprising 33% of all elbow fractures and 1.5% to 4% of all fractures in adults³.

Operative treatment of displaced and comminuted radial head fractures involves open reduction and internal fixation with plates and screws in cases where

reconstruction is possible and replacement with a radial head prosthesis when comminution renders the radial head unreconstructed⁴. Gupta GG *et al.*, reported that currently available prosthetic implants are not anatomically correct and their designs are not derived from geometric dimensions of radial head⁵.

There are not many studies on Morphometry of Head of the Radius, which can limit the bio mechanical knowledge during prosthesis preparation.

Thus this study has been conducted to supplement the available literature.

Materials and Methods

This study was conducted for a period of 6 months from April 2021 to September 2021 in the Department of Anatomy, Rajarajeswari medical college and hospital, Bengaluru, Karnataka. The study was conducted on 128 dry adult undamaged human Radius bones of unknown

age and gender using digital vernier caliper. Following parameters are measured on the Head of the Radius as shown in Figure 1 e 2.

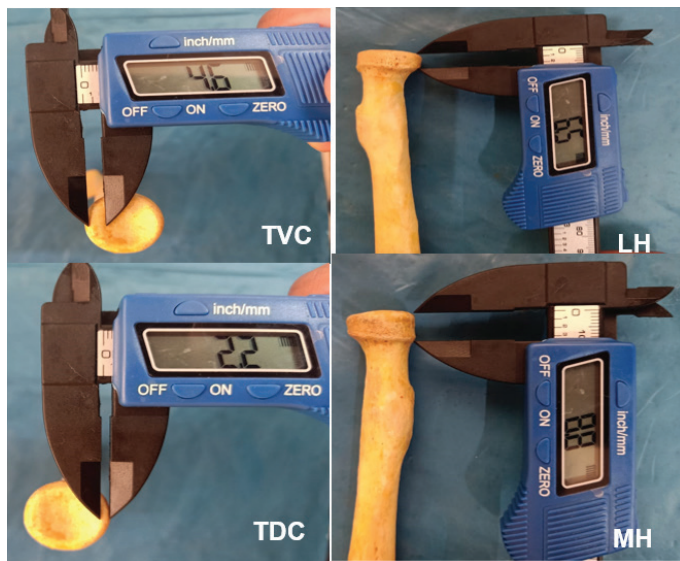


Figure1. Photographs showing the measurements on Head of the Radius.

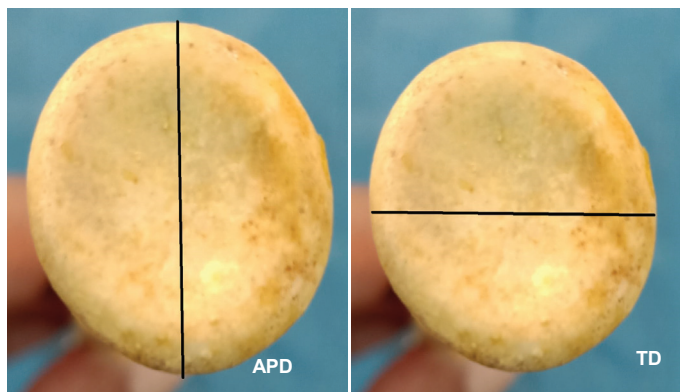


Figure 2. Photographs showing the measurements on Head of the Radius.

Anteroposterior diameter (APD): Distance from most anterior point on the head of the radius to most posterior point.

Transverse Diameter of radial head (TD): Distance from medial point on radial head to most lateral point.

Medial Height of radial head (MH): Distance between radial lip and head and neck junction on medial side. (Height of circumference of radial head at medial side).

Lateral Height of radial head (LH): distance between the radial lip and head & neck junction on lateral side. (Height of circumference of radial head at lateral side)

Thickness of Ventral Curve (TVC), Thickness of Lateral Curve (TLC), Thickness of the Medial curve (TMC) and Thickness of Dorsal Curve (TDC): Thickness of curve on superior articular surface of head on ventral, lateral, Medial and dorsal aspects respectively.

Depth of Superior Articular Facet (DH): Scale

put over the radial head touching most prominent anterior and posterior rim of radial head and depth in centre was measured by digital Vernier caliper.

Surface Area (SA) and Volume (V) of articular surface of head of radius:Mathematical Method of measurement was used to calculate the above parameters by using the formulas as shown in the table.

Formulas: $SA = \pi(h^2+r^2)$ $V = 1/6\pi(3r^2+h^2)$

Karl Pearson’s correlation test was used to know the correlation between the study parameters. The p- values less than 0.05 were considered as significant.

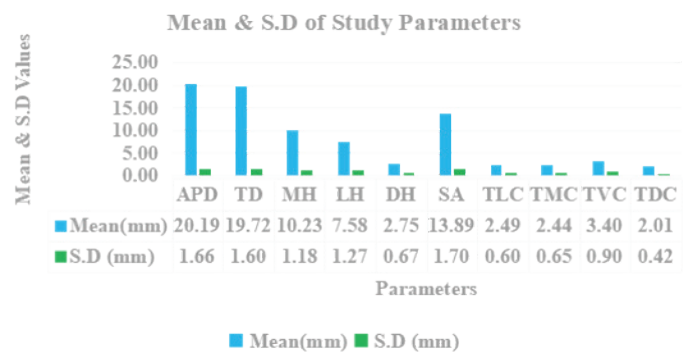
Aims and Objectives

The purpose of this study were to evaluate the morphometry of the radial head. The knowledge of these dimensions may be an add on for the clinical and surgical skills of the Orthopedic surgeons during reconstructive surgeries of the Elbow joint.

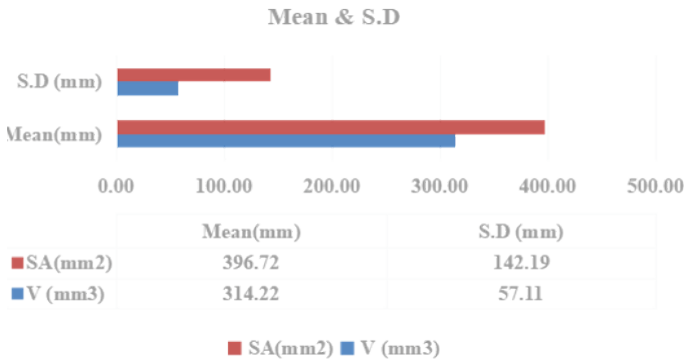
Results

In the present study the mean values ± standard deviation were as follows, 19.63 ± 1.75mm (APD), 19.18 ± 1.73mm (TD), 10.33 ± 1.05mm (MH), 7.34 ± 1.30mm (LH), 2.61 ± 0.63mm (DH), 3.45 ± 0.77mm (TVC), 2.07 ± 0.40mm (TDC), 2.41 ± 0.64mm (TMC), 2.48 ± 0.63mm (TLC), 2.61 ± 0.63mm (DH), 314.21 ± 57.10mm² (SA), 396 ± 142.18mm³ (V).

Mean ±SD values of morphometric parameters of radii bones are shown in the Graphs 1 e 2. Comparison between the parameters of right (n=70) and left (n=58) radius bones was done as shown in table 1 e 2, t-values and p- values are shown in table 3. Statistical analysis using Karl Pearson’s correlation test proved a strong correlation between depth vs.surface area, depth vs. volume and surface area vs.volume. The p values which were obtained found to be less than 0.00001, that shows strong positive correlation for the measured parameters.



Graph 1. Showing the Mean and standard deviation of study parameters.



Graph 2. Showing the Mean and standard deviation of Surface area & Volume.

Table 1. Showing the Mean and standard deviation of study parameters on right Radii bones.

Parameter	Mean	Standard Deviation
APD(mm)	20.19	1.66
TD (d=r/2)	19.72	1.60
MH	10.23	1.18
LH	7.58	1.27
DH(h)	2.75	0.67
SA	13.89	1.70
TLC	2.49	0.60
TMC	2.44	0.65
TVC	3.40	0.90
TDC	2.01	0.42

Table 2. Showing the Mean and standard deviation of study parameters on Left Radii bones.

Parameter	Mean	Standard Deviation
APD(mm)	18.97	1.64
TD (d=r/2)	18.54	1.69
MH	10.47	0.88
LH	7.06	1.31
DH(h)	2.45	0.55
SA	14.18	1.55
TLC	2.49	0.69
TMC	2.40	0.65
TVC	3.52	0.61
TDC	2.15	0.38

Table 3. showing the correlation, r value and p value of measured variables.

Variable	r value	p value	Significance
Depth Vs Surface Area	0.4544	<0.00001	Yes
Depth Vs Volume	0.8688	<0.00001	Yes
Surface Area Vs Volume	0.8218	<0.00001	Yes

Discussion

Fractures of the proximal end of Radius are approximately 1.7% - 5.4%of all the fractures and

about 1/5th of all the fractures at elbow⁶. Prosthetic replacement of radial head has been suggested after excision of comminuted fracture of radial head. Radial head prosthesis were first proposed by Speed in 1941⁷. If the orthopedicians are performing Hemiarthroplasty the main goal is restoring the normal anatomy as much as possible.

Some biomechanical studies have emphasized the importance of correctly sizing the radial head prosthesis can lead to valgus instability, whereas a long implant has the potential to over stuff the radiocapitellar joint. Some authors have suggested that a difference of no more than 2mm from the patient's native anatomy is tolerated⁸.

The height of the articular circumference is the same in the ventral and dorsal portions while that of the medial portion is greater and represents nearly all the height of the radial head. This height is very important from the bio mechanical point of view and must be conserved to avoid articular complications in both elbow and wrist⁹. An upward displacement of the radius occurs when medial height of circumference of head of radius decreases and it results in progressive laxity of the radioulnar ligaments and the interosseous membrane which increases the instability¹⁰.

Puchwein P et al., have found that the Mean of the widest AP diameter of the head of the Radius as 2.3cms, in the transverse Plane as 2.24 cms¹¹, Captier G et al., reported reported 2.16cm(AP diameter and in transverse plane it is 2.1cm)¹². The values reported by Archana singh & Arun singh were 2.05cm(APD)) & 1.95cm (TD)². The values in the present study are 2.19 (APD) & 1.97 cms (TD). The values reported by many of the Indian authors was less than values reported by King GJ et al, Puchwein P et al and Captier G et al.^{11,12,13,14}.

Medial height & lateral height of the radial was 11.7mm and 11.8mm respectively as reported by Puchewin P et al., 8.65mm and 6,28mm as reported by Archana singh and Arun singh, 10.23mm and 7.58mm in the present study^{11,2}. The values were more in Puchwein's study because the measurements were taken by CT scan, while other authors measured dry bones¹⁵.

Strong correlation was observed in the present study between depth vs surface area, depth vs volume and also surface area vs volume as shown in Table 3.

Conclusions

The morphometric measurements of the head of the Radius plays an important role in the preparation of Radial head prosthesis.

The statistical correlations in our study based on Karl Pearson's correlation coefficient shows strong relation between the measured parameters like Depth, volume and surface area.The data on Head of the Radius is necessary for the creation of radial head prosthesis and also provides precision and validity for

the biomedical engineering industry. knowledge of these measurements is of great importance in the safe application of osteo-synthesis during reconstructive surgeries of upper end of Radius.

List of Abbreviations

1. Anteroposterior diameter (APD)
2. Transverse Diameter of radial head (TD)
3. Medial Height of radial head (MH)
4. Lateral Height of radial head (LH)
5. Thickness of Ventral Curve (TVC)
6. Thickness of Lateral Curve (TLC)

7. Thickness of the Medial curve (TMC)
8. Thickness of Dorsal Curve (TDC)
9. Depth of Superior Articular Facet (DH)
10. Surface Area (SA)
11. Volume (V) of articular surface of head of radius

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Corresponding author
Sarala H. S.
E-mail: drsaralhs@yahoo.co.in