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Original Research Article

Radius morphometry – A dry bone study

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ABSTRACT

Introduction: Normal values of morphometric parameters of frequently fractured bones of the population we live with is important. Radius is one such bone. In this study, less frequently studied features of radius are measured and compared to find a correlation between them. This is of surgical importance in reconstruction of radius and also in designing implants.

Materials and Methods & Results: 105 radius bones from the Anatomy department and students were studied, radial head diameter in two dimensions was measured and averaged. The radial bow length measured from radial tuberosity to proximal end of distal RadioUlnar joint facet. Maximum Bow is measured by the modified method of Schemitsch and Richards. Distal radial metaphysical thickness on either side of the Lister's tubercle and breadth of the distal end at the level of the distal radioulnar joint was measured using a digital Vernier caliper. Statistical analysis was performed using Minitab® 17.1.0., © 2013 Minitab Inc. All data distribution analysis was checked using the Shapiro-Wilk test. Correlation statistics were used to establish the relationship between two variables such as radial bow length with proximal and distal end parameters. The average diameter of the radial head was 20.11 mm SD 1.860. The mean Radial bow length was 19.52cm SD1.301. Mean maximum bow 9.105 SD 1.956 mm. The thickness of the distal end medially 17.80mm SD 1.593, lateral to Lister's tubercle was 15.39 SD1.417.

Conclusion: The correlation between different parameters is significant. Bow length and maximum bow are in constant relation. Different part of the radius is in proportion and is an important clinical feature to be appreciated.

1. Introduction

Supination and pronation movements at the radioulnar joints are part of many everyday functional activities of the upper limb. The radius and ulna are the important bones involved in these movements.

Radius and ulna are the two bones of the forearm. Radius is placed laterally. It forms a part of the elbow joint, radioulnar joint, and wrist joint. Anatomically the radial head is within the elbow joint cavity but is also a part of the proximal radioulnar joint. From the wrist joint, weight or force is transmitted through the radius to the ulna and humerus. In adults, radial head fractures are the most common fractures around the elbow.[1] Most of the displaced fractures undergo radial head excision and it does not affect the functional efficiency of the elbow. But the recent trend is prosthetic replacement reconstruction.

The radial head prosthesis is round irrespective of whether the bony head is round or elliptical. B Mahaisavariya et al in their study on proximal radius using computer tomography combined with the reverse engineering technique found radial head is more likely to be circular with an average diameter of 20.5 mm (SD = 1.9).[2] Morphometrically and functionally right and left radial head size difference is not significant. W Swieszkowski et al in a cadaveric bone study could conclude that right and left

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radial heads are equal in size.[3]

Rotational movements' supination and pronations take place around the axis passing through the center of the head of the radius and posterolateral part head of the ulna.[4] These movements take place at the proximal radio ulnar joint, interosseous membrane, and distal radioulnar joint. The distal end of the radius moves around the head of the ulna, while the proximally radial head rotates within the annular ligament.[5] The normal range of supination is 61°-66° and pronation is 70°-77°.[5] Both radius and ulna are curved in both coronal and sagittal planes.[6] But the ulnar curve is not obvious. Radial curvature is of importance in the normal range of rotation of the forearm. Radial curvature is apparent in the coronal plane. There are two curves in the coronal plane, a small curve proximally with medial convexity and a large curve with lateral convexity in between radial tuberosity and the distal end. This large curve is referred to as a radial bow.[7] Any alteration in this bowing can affect proximal and distal radioulnar articulations and hence the normal forearm rotations.[8,9] Radial bowing is a functionally important morphological feature.

Measurements of radial bow in radiograph were first described by Schemitsch and Richards in the year 1992. They used these measurements to determine the functional outcome of treatment to the restoration of anatomical bowing of the radius.[9] There are radiographic studies on the measurement and quantification of radial bowing. But not many studies on the measurement of the radial bow on dry bone.

The metaphysis of the radius is made of cancellous bone and is prone to senile /post-menopausal osteoporosis. Hence distal end radial fractures are common in elderly people. Distal end radius fracture forms about 15-18% of upper extremity fractures.[10] Now more and more distal end radial fractures are treated operatively. Often transverse part of the distal radial plates falls short of the breadth of the metaphysis and fixation may be difficult. Extensor tendon damages are one of the important post-operative complications, particularly the involvement of Extensor pollicis longus.[11,12] Dorsal screw prominence is one of the causes of tendon damage which could be avoided by correct sizing of screws. Breadth and thickness of distal metaphysis are useful knowledge in implant design and during surgical procedures. In this study, we are measuring the thickness of the distal end of the radius on either side of the Lister's tubercle and the breadth of the distal end.

Ibeabuchi Nwachukwu Mike et al estimated the maximum length of the radius from a single fragment of the bone, whether at its proximal, middle, or distal end using values of regression coefficient and intercept for known measurement of a significant marker.[13] This shows that the relationship between different parts is in proportion to the length.

In the present study measurements from the proximal and distal end of the radius are correlated with the radial bow length. It may provide useful knowledge in Implant design and also intraoperative in maintaining the normal bone architecture during repair and reconstruction surgeries.

2. Materials and Methods

We used 105 dry radii which were available in our department and from the students. Deformed, malunited bones were excluded from the study. A Digital Vernier caliper and a metal scale are used for the measurements. Measurements are done on the radial bone as follows:

1. Radial head diameter is measured in anteroposterior and transverse diameters using a digital Vernier caliper. The average is taken as radial head diameter because the radial head prosthesis is round.
2. To measure the bow length and maximum depth of the bow, we used Schemitsch and Richards's radiographic method on dry bone in our study. Medial most point over the radial tuberosity, Point of maximum bowing over the medial margin of radius, and the proximal end of the distal radioulnar joint facet (Figure 2) are marked as points 1, 2, and 3 respectively. The radius is placed in a prone position over the flat surface of the table. A metal scale is placed as a line between point 1 and points 3 (Figure 1). The length of the bow(y) – is the distance between point 1 and point 3. Maximum radial bow (b) – is the perpendicular distance from point 2 to scale.
3. Distal end thickness measurements were taken on both sides of Lister's tubercle and an average is taken. (Figure 3). The breadth of the distal end of radius is measured from the medial to the lateral side of bone.

Parameters measured during the study were:

1. Radial head diameter (HD)
2. Radial bow length (Y)
3. Maximum bow —(BW)
4. Thickness of distal end of radius on either side of Lister's tubercle as DT1 (medial) and DT2 (lateral)
5. Breadth of the distal end of radius at the level of ulnar notch (B).

The mean and the standard deviation of the morphometric parameters were assessed. Statistical analysis was performed using Minitab® 17.1.0., © 2013 Minitab Inc. All data distribution analysis was checked using the Shapiro-Wilk test. After testing normality, an appropriate parametric or non-parametric test was considered. Mean, standard deviation (SD) and 95% confidence intervals (CI) or median (range) were considered for all continuous data. Correlation statistics were used to establish the relationship between two variables such as radial bow

length with proximal and distal end parameters. A correlation coefficient measures the extent to which two variables tend to change together and we derived this using 'Pearson product-moment correlation analysis. The relationship between variables was represented with a scatterplot. All primary and secondary outcomes were compared using a conventional α level of 0.05

3. Results

The results of the study are presented as descriptive statistics (mean ± SD), with their respective standard errors of estimate (SE) for the five different anthropometric parameters of radius in Table 1.

The mean value of the length of the entire bow of the radius (y) is 19.52cm (SD ±1.301cm). A correlation was attempted between the length of the radial bow(y) and maximum bow, radial head diameter and distal metaphysical breadth. A 'Pearson correlation' test revealed the strong relation of dimensions to each other. (Figures 4, 5, 6 and 7). The radial Bow length has a significant correlation even with Distal Metaphysial thickness both medial and lateral to the Lister's tubercle.

Strong correlation was also seen between radial head and distal metaphysial breadth.

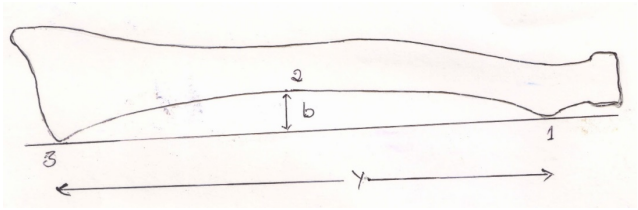

Figure 1: Markings for measuring the radial bow length and radial bow .

Figure 2: Proximal end of the distalradioulnar joint facet marked as point 3

4. Discussion

The present study was done on dry bones of the Indian population in the southwest coastal region to determine the normal values of radial head size, radial bow, thickness, and

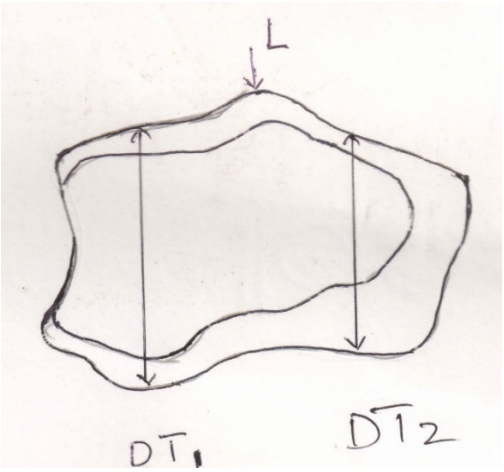

Figure 3: Points on the distal end of radius to measure the distal end thickness, L-Lister's tubercle, DT1 –thickness medial to the tubercle, DT2- thickness lateral to the tubercle

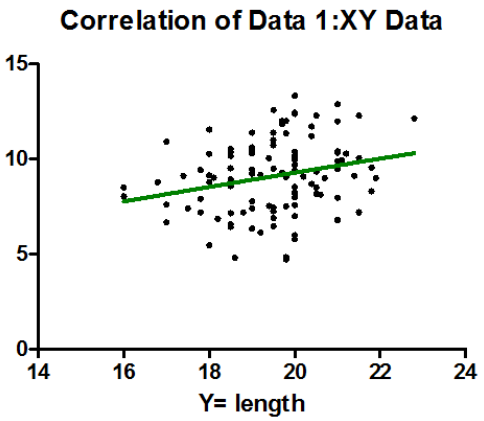

Figure 4: Scatter plot showing the correlation between the Radial bow length (Y) to Maximum bow(BW). (Correlation: Y-cm versus BW-mm, Pearson correlation= 0.2476, P-value =0.0109)

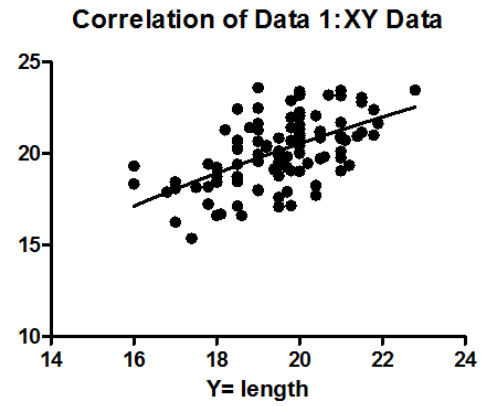

Figure 5: Scatter plot showing the correlation between the Radial Bow length(Y) to Radial head size (HD). (Correlation: Y-cm versus HD-mm, Pearson correlation= 0.5580, P-value < 0.0001)

Table 1: Descriptive statistics of anthropometric parameters of radius bone

	Y= length(cm)	BW(mm)	HD(mm)	B(mm)	DT1(mm)	DT2(mm)
Number of values	105	105	105	105	105	105
Minimum	16.00	4.720	15.35	19.49	14.34	11.08
25% Percentile	18.50	7.560	18.77	23.48	16.39	14.40
Median	19.70	9.120	20.20	24.41	18.00	15.22
75% Percentile	20.40	10.39	21.36	26.25	18.96	16.12
Maximum	22.80	13.34	23.58	29.21	21.66	18.78
Mean	19.52	9.105	20.11	24.73	17.80	15.29
Std. Deviation(SD)	1.301	1.956	1.860	1.993	1.593	1.417
Std. Error(SE)	0.1270	0.1908	0.1815	0.1945	0.1554	0.1383
Lower 95% CI of mean	19.26	8.727	19.75	24.35	17.49	15.01
Upper 95% CI of mean	19.77	9.484	20.47	25.12	18.11	15.56

Y= bow length in cm, BW= maximum bow in mm, HD= radial head diameter in mm, B= distal metaphysis breadth in mm, DT1= thickness on the medial side, in mm, DT2= thickness on the lateral side, in mm. CI= confidence intervals

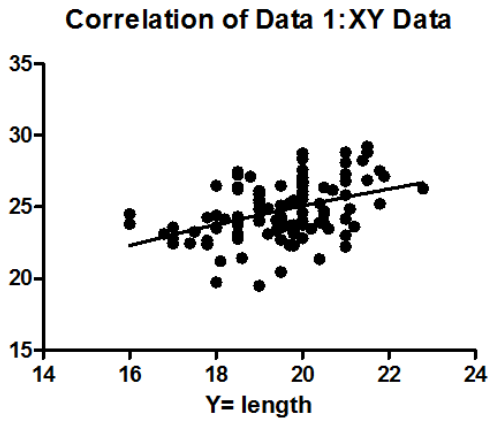

Figure 6: Scatter plot showing the correlation between the Radial Bow length (Y) to Distal Metaphysial Breadth (B). (Correlation:Y-cm versus B-mm, Pearson correlation= 0.4276, P-value =< 0.0001)

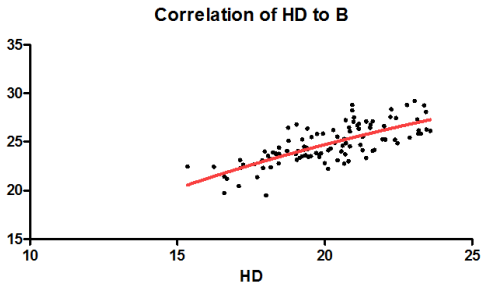

Figure 7: Scatter plot showing the correlation between the Radial Head (HD) to Distal Metaphysial Breadth (B) (Correlation: HD-mm versus B-mm, Pearson correlation= 0.7367, P-value < 0.0001)

breadth of distal metaphysis. We tried to correlate the radial bow length with these parameters.

The radial head articulates with the radial notch of the ulna, though the articulation is within the elbow joint capsule. Weight transmission from radial head to capitulum is not established. Radial head fractures which are displaced or communited are treated with excision, except where it is associated with coronoid process fracture of ulna which leads to instability at the elbow. In such cases, the radial head prosthesis is preferred. The radial head is ovoid with minimal difference between Antero posterior and transverse diameters. The prosthesis is round. We have taken the average of the two diameters as the size of the head in our present study. The average size was 20.11mm with SD ±0.1815 and the median being 20.20mm. Valentin Rausch et al had the mean largest and smallest radial head diameters were 24.2 mm (± 2.2, range 19.9–30.3; ICC=0.992) and 22.5 mm (±2.0, range 18.9–27.5; ICC=0.985). In a radiological study wherein they calculated the two diameters separately.[14] Muna Kadel and Trilok pati Thapa had the radial head with mean anteroposterior and transverse diameters of 2.09 cm and 2.02 cm respectively. The most common shape of the radial head was circular in 40 (59%) radii and elliptical in 23 (34%).[15] W Swieszkowski et al in a cadaveric bone study had a maximum diameter radial head (mean 23.36 mm (SD, 1.14 mm)) and no significant differences between the two sides.[3]

Puchwein et al. found the mean AP diameter of the radial head at its widest part as 23mm, and in the transverse plane as 22.4mm.[16] Chandni Gupta et al got the values as 1.91cm and 1.85 cm, respectively.[17]

Rotatory movement Supination and pronation take place between radius and ulna bones. The radius rotates around the axis passing through the head of the radius and styloid process of the ulna. The kinematics of this movement is complex. Any alteration in the bowing of the radius

will affect the alignment of articulation with the ulna and the rotatory movements between them. In the anatomical position mediolateral, the bowing radius bow is significant. There are no studies on the quantification of the radial bow on dry bone.

In 1992, Schemitsch and Richards developed a method to measure the amount of radial bow from an anteroposterior radiograph of forearms. They were the first authors to describe the normal values of radial bow in adults. They found functional outcome following forearm fractures is directly related to restoration of the anatomical bow of radius. They also found that the location of the maximum radial bow was of greater functional significance than the depth of the bow.[7]

In 2004, Firl and L.Wunsch modified Schemitsch and Richard's method in pediatric study. From their study they found that radial bow length and the maximum radial bow increase with age. The maximum bowing did not exceed 10% of the entire bow length. Their study result was similar to that of Schemitsch and Richards. The mean Maximum bow they had was 7.21 (SD1.03). Measurement of radial bowing in children can be of diagnostic and therapeutic value.[8]

Morgan B Weber et al had the mean depth of bow of 1.3cm in their cadaveric radiologic study.[18] In the present study mean maximum bow is 9.105 mm with SD 1.956, ranging from 13.34 to 4.72mm. The average bow length is 19.52cm with SD 1.301.

The average distal breadth of metaphysis is 24.73 with SD ±1.993. Ibeabuchi Nwachukwu Mikeet al had the distal radial breadth of 32.586mm SD 0.32044 on the left side and 33.242mm SD 0.518 on the right side.[13] Mean distal end thickness (DT1) medial to Lister's tubercle is 17.80mm SD ± 1.593, (DT2) lateral to tubercle is 15.29 with SD ± 1.417. Knowledge of metaphysial breadth and thickness are useful in implant design and manufacturing.

Limitations of the study: In the present study parameters like sex, age, right or left side are not considered.

5. Conclusion

The knowledge of normal values of Morphometry of bones is important for any population or racial group. Different part of the radius is in proportion to the bow length of the radius and is an important clinical feature to be appreciated.

6. Source of Funding

None.

7. Conflict of Interest

None.

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