Original Article

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Measurement of Bowing of Radius in Dry Bone

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Abstract

Radial architecture is unique with curvature or bowing, and is of importance in normal range of rotation of the forearm. Radial bow is two dimensional but is apparent in coronal plane. Any alteration in bowing will affect proximal and distal radio ulnar articulations and hence forearm rotations. Mild changes in bowing are difficult to recognize when compare to axial and translational changes. Changes in curvature can occur following fractures, traumatic bowing and green stick fracture in children. Maintenance of bow is of utmost importance in surgical management of fractures involving radius. In 1992 Schemitsch and Richards described a method to measure radial bowing on radiographs. A radiograph of anterior-posterior view of forearm in full supination was taken and radial bow was measured using three parameters. In the present study we tried to apply similar measurement on dry bone radius of Indian population. There are studies on measurement and quantification of radial bowing using radiographs of forearm,but no studies available on dry bones. The mean value of site of maximum bow was 46.668% (SD±3.219%) of length of entire bow. The mean value of magnitude of bow was 5.0472% (SD±0.6393%) of length of entire bow. The length of entire bow of the radius and the site of maximum bowing and magnitude of bow are strongly correlated. The magnitude of bow is within 7% of entire length of bow. This is the first study of bowing of radius on dry bones.

Keywords: Radial Bow; Site of Maximum Bow; Dry Bone Radius; Schemitsch EH; Richards RR.

Introduction

Supination and pronation movements of forearm takes place between radius and ulna. This rotational movement takes place around the axis passing through head of the radius and head of the ulna. Distal end of radius moves around the head of the ulna, while proximally head of the radius rotates within the annular ligament [1]. Radial architecture is unique with curvature and is of importance in normal range of rotation of forearm. Radial curvature is three dimensional but is apparent in coronal plane. There are two curves in coronal plane, a small proximal curve with medial convexity and large curve with lateral convexity in mid portion. This large curve is referred to as radial bow [2]. Any alteration in this bowing can affect proximal and distal radio ulnar articulations and hence the normal forearm rotations [3,4]. Mild changes in bowing are difficult to recognize when compared to axial and translational changes. Changes in curvature of radius can occur following fractures, traumatic bowing (also known as bow fractures or plastic deformation) and green stick fractures in children [2,3]. Radial bowing is of functionally important morphological feature. Normal range of supination 61^0-66^0 and pronation is 71^0-77^0 [1].

In 1992 Schemitsch and Richards developed a method to measure radial bowing using radiographs. For the assessment of radial bow an antero-posterior view of fore arm in neutral rotation was taken and three parameters were measured from the radial radiograph. They used the measurements to determine the relationship between restoration of function (movements) of forearm to restoration of normal amount and location of anatomical bowing of the radius after plate fixation of fractures of both bones of forearm [4]. Morphology of radius with respect to bowing is very important for its function. In the clinical practice this is assessed based on movement and radiologically. There are few

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radiological studies on radial bowing in relation to fracture treatment and functional outcome.

In the present study we tried to apply similar measurement on dry radius bones. Knowledge of dry bone measurement of bowing of radius is significant since maintenance of normal amount of bow is of utmost importance in surgical management of fractures involving radius to restore normal function. This is the first study on dry bone radius available on magnitude and site of bowing.

Radius has curvatures in coronal and sagittal planes. In 2012 a study by Shavantha L. Rupasinghe, has shown that there is a significant sagittal bow of the proximal shaft of the radius. The author described that plating this with contoured plates in the sagittal plane improves rotation when compared with straight plates [5].

But most of the studies including this study, the radial bow is measured in coronal plane. The kinematics of the forearm is complex and their study requires sophisticated techniques [6].

Materials and Methods

For this study, we used 105 dry radii which were available in our department and from our students. Deformed, mal united bones were excluded from the study. Digital vernier caliper and a metal scale are used for the measurements. We adopted Schemitsch and Richards's method on dry bone in our study. The bones are numbered and three points marked (Figure 1a), as

1. Distal point- which is on the proximal articular margin of distal radio -ulnar joint facet. (Figure 1b),
2. Medial highest point over the radial tuberosity.
3. Point of maximum bowing over medial margin of radius.

Then radius is placed on a horizontal platform/ surface with the dorsal aspect facing upwards (pronated position). Metal scale is placed as a line between distal point (point 1) to radialtuberosity (point 2).

Following measurements are taken

- Length of entire bow (y) – is the distance between point 1 and point 2.
- Maximum radial bow (b) – is the perpendicular distance from point 3 to scale.
- Distance to site of maximum bow (x) from radial tuberosity – is the distance between point 2 and point 3.

To compare bones of different length the values are expressed as percentage of length of entire bow. The distance to site of maximum bow(x) is expressed as % of length of entire bow(y) = (x/y) * 100. This is termed as site of maximum radial bow. The maximum radial bow (b) is also expressed as % of length of entire bow(y) = (b/y) *100. This is termed as magnitude of bow. The measurements were statistically analysed using 'Minitab® 17.1.0, © 2013 Minitab Inc. The data were checked for its distribution analysis using Anderson's Darling test. All the data were presented as Mean and standard deviation (SD) or median with Interquartile ranges (IQR). A Pearson's correlation tests were attempted to find out the association between the numerical variables of radius. A probability, P of <0.05 was considered as statistically significant.

Results

The comprehensive lists of statistical averages of radius bone are detailed in Table 1.

The mean value of length of entire bow of the radius (y) is 195.15 mm (SD ±13.01mm). The mean value of site of maximum bow was 46.668% (SD ±3.219%) of length of entire bow. The mean value of magnitude of bow was 5.0472 % (SD ±0.6393%) of length of entire bow. The data was analysed using Anderson Darling test. The results showed the data as non normal distribution (Figure 4).

Table 1: The anatomical details of the radial bone. The data are in mm of statistical averages or in percentages (N=105, SD= Standard deviation, IQR= Interquartile range)

Variable	Mean	SD	Minimum	Maximum	Median	IQR
Length of entire bow Y(mm)	195.15	13.01	160	228	197	19
Distance to site of maximum bow x (mm)	91.105	8.984	70	109	90	13
Maximum radial bow b(mm)	9.844	1.372	7.2	13.34	9.56	1.78
Site of max bow (%)	46.668	3.219	40	53.846	46.429	4.35
Magnitude of bow (%)	5.047	0.639	3.990	6.67	4.9514	0.952

Table 2: Values of radial bow from the different age groups and by different methods

Study	M.Firl&L.Wunsch (radiographic study)	Schemitsch&Richards (radiographic study)	Present Study (dry bone study)
Number	100	55	105
Site of Max. Bow (Mean, SD%)	60.39 (3.74)	59.9 (0.7)	46.67(3.219)
Max. Bow (Mean, SD, %)	7.21 (1.03)		5.047(0.639)
Age Group	paediatric	adult	adult

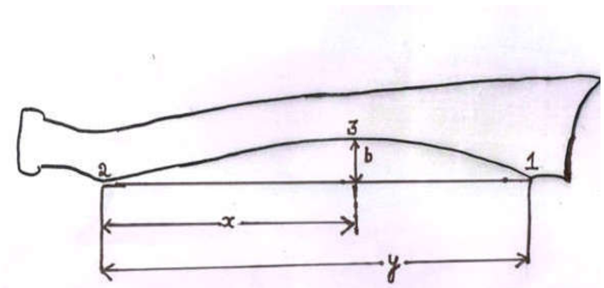

Fig. 1a: Points of markings and measurements of radial bow

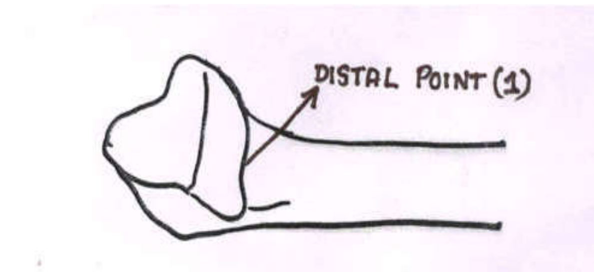

Fig. 1b: Distal end of radius showing distal radioulnar articular facet

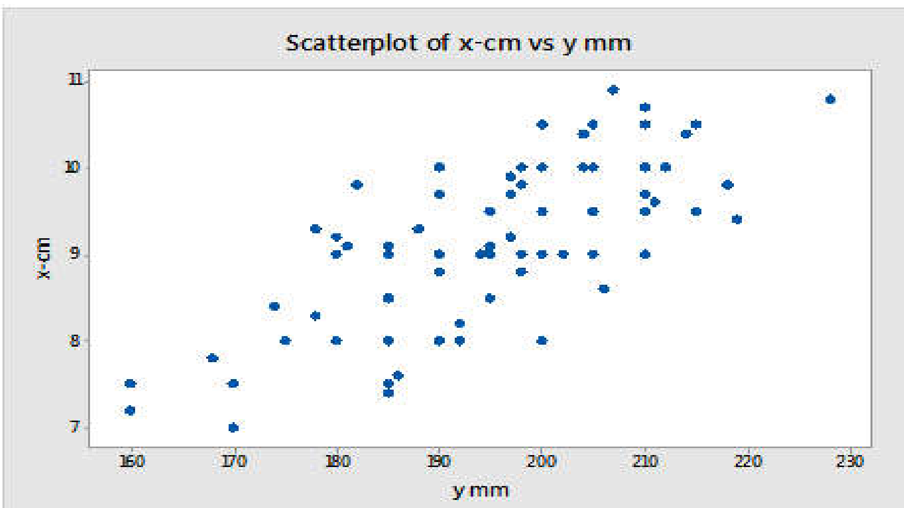

Fig. 2: Scatter plot showing the correlation between the the length of the entire bow(y) to the distance to site of maximum bowing (x)

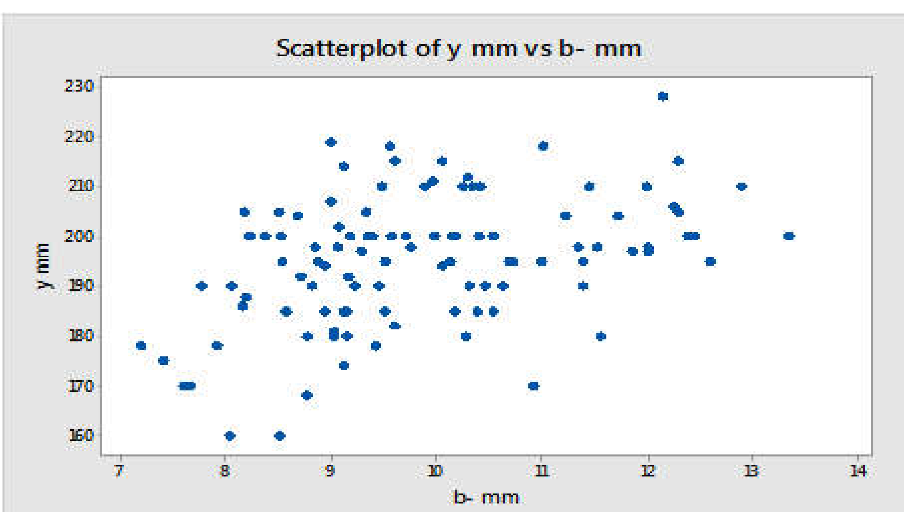

Fig. 3: Scatter plot showing the correlation between the lengths of the entire bow(y) to magnitude of bow (b).

A correlation was attempted between the length of entire bow(y) of radius and bowing dimensions. A 'Pearson correlation' test revealed the strong relation of dimensions to each other. Therefore, we observed as the length of entire bow(y) increases, the maximum radial bow (b) also increases. (Correlation: y-mm versus b-mm, Pearson correlation = 0.411, *P*-value = 0.000, Figure 3). Similarly, we also correlated the length of the entire bow(y) to the distance to site of maximum bowing (x). Here, too a similar correlation was found between the two variables (Correlation: y mm, x-cm, Pearson correlation, r= 0.721, *P*-value = 0.000, Figure 2).

Discussion

Radius is one of the two bones of the forearm, placed laterally to ulna. It has expanded proximal and distal ends. The shaft is convex laterally and concave anteriorly in its distal part. It is triangular in section with sharp interosseous border [1]. Anterior surface, between anterior and interosseous borders, is concave transversely and shows a distal forward curvature. It moves around ulna during supination, pronation around an axis running between head of the radius and head of the ulna. Distally radius articulates with carpal bones to form wrist joint [1]. In the forearm radius articulates with ulna at distal radio- ulnar joint, proximal radio ulnar joint and through interosseous membrane. Weight/force transmit through radius from wrist to elbow. Supination, pronation movement takes place between the two bones.This is possible because of architecture of radius, which has three dimensional curvatures along its long axis. Kinematics of this movement is complex. Any alteration of the bowing will affect its articulation with ulna and in turn the rotatory movements between them. In the anatomical position (in anterior posterior view) that is in coronal plane radial bow is more obvious. There are radiological studies on quantification of radial bow and its affect on forearm rotations.

In 1992, Schemitsch and Richards were the first authors to describe the normal values of radial bow in adults using the measurements from antero posterior radiograph of both forearms. They developed a technique to measure the amount of bow of radius and to determine the relationship between restoration of functions (movements) and restoration of anatomical bowing of the radius after plate fixation of fractures of both bones of forearm .They compared the bowing of normal forearm with the surgically corrected opposite forearm and observed that better results were found after plating if the degree of bowing approached normal. They suggested that location of maximum radial bow was of greater functional importance than the depth of the bow (magnitude of bow). Shape of the radius changes by both site of maximum bow and depth of bow [4].

In 2004, Firl and L.Wunsch modified the method used by Schemitsch and Richards and described values of radial bowing in the Antero posterior radiographs in children. From their study they found that radial length (length of entire bow) and the maximum radial bow increases with age. But the site of maximum bowing does not change. The median site of maximum radial bow was 60.39% (SD±3. 74%). The maximum bowing did not exceed 10% of entire bow length. Their study result was similar to that of Schemitsch and Richards. Measurement of radial bowing in children can be used for diagnostic and therapeutic purpose [3].

Our study was done on dry bones of Indian population to determine the normal values of radial bow. We found that the mean length of entire bow is 195mm (SD±13.01mm). The mean of magnitude of bow is 5.0472% of length entire bow**.** The site of maximum bow is 46.668% of length of entire bow. Site of maximum bow was within 54% of length of entire bow. Maximum bow is less than 7% of bow length. Our study gives similar inference as that of radiological studies (Table 2). But radiological measurement of bowing cannot be compared with dry bone measurement. There will be difference in the rotational position of radius in complete supination in living human being as compared to dry bone on horizontal plane.

Knowledge of dry bone measurements would be of importance for clinicians during surgical correction and plating of radial fractures since the functional outcome would depend on the near normal restoration of radial bow. Our observation during the study is that the site of maximum bow is at or close to the site of insertion of pronator teres. This shows that pronator pull act at the apex of the bow for maximum efficiency.

Conclusion

Site of maximum bow of radius is in constant relation to length of entire bow. Maximum bow is within 7% of length of entire bow of radius. More dry bone of studies of different population is required to standardize the results.

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