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ORIGINAL RESEARCH

MORPHOLOGYAND MORPHOMETRY OF THE HEAD OF DRY ADULT HUMAN RADIUS IN NORTH INDIAN POPULATION

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Abstract

Introduction: Radius is the lateral bone of the forearm. The greater clinical importance of the proximal end of radius lies in the fact that it takes part in the formation of two important joints viz. humeroradial and proximal radioulnar joint. Numerous pathologies like subluxations, dislocations, fractures, degenerative diseases, osteochondromas, heterotopic ossification etc. can affect the proximal end of the radius.

Materials and Methods: A total of 60 North Indian unpaired dry adult human radii (Right-30, Left-30) of unknown sex were studied. Shape of the radial head was observed. Diameter, height and circumference of head of radius were measured. Depth, Diameter and thickness of curves of proximal articular surface of head of radius were also measured. All measurements were taken with digital vernier caliper and recorded in millimeters. The raw data obtained was statistically analyzed.

Results: The shape of the head was circular in 60% bones and ovalin 40% bones. The anteroposterior and transverse diameters, heights at the medial, lateral, ventral, dorsal ends and circumference of the radial head were20.61±1.78mm, 20.02±1.79 mm, 9.39±1.64mm, 6.82±1.08mm, 8.2±1.3 mm,7.67±1.23 mm and 67.18±5.93 mm respectively. The diameter of fovea radialis, depth of the proximal articular surface and thickness of the ventral, dorsal and lateral curves were 12.2±1.59 mm, 1.73±0.06 mm, 4.53±0.83 mm,3.61±1 mm and 3.86±0.68 mm respectively.

Conclusion: Since the morphometric parameters of the proximal end of radius are useful in the designing of a biomechanically correct prosthesis of head, our study will be helpful to the orthopaedic surgeons for reconstructive surgeries.

Key Words: radius,radial head, morphometry

INTRODUCTION

Radius is the lateral bone of the forearm. It has proximal and distal ends and a shaft. The proximal end includes head, neck and a tuberosity. The greater clinical importance of the proximal end of radius lies in the fact that it takes part in the formation of two important joints viz. humeroradial and proximal radioulnar joint.[1] Numerous pathologies can affect the proximal end of the radius. These pathologies include subluxations, dislocations, fractures, degenerative diseases and other conditions that may result in alternation of joint mechanics including osteochondromas and heterotopic ossification.[2]The head of the radius is a fundamental element responsible for the physiological or prosthetic stability of the elbow and superior radioulnar joints. It participates with fovea radialis in elbow flexion and with the radial head circumference in pronation and supination.[3] It plays a very important role in the elbow and wrist mechanics and any fracture or resection of the radial head leads to the instability of these joints.[4] Radial head instability is checked in all the three planes. In the coronal plane, it works with medial collateral ligament to prevent valgus instability. In the saggital plane, it works with the posterolateral ligamentous structures, the coronoid process and medial collateral ligament to prevent posterior dislocation. In the axial plane, it works with the interosseous membrane to prevent the shaft of the radius riding up.[5]In subluxation of the radial head, the head slips out partially from the annular ligament resulting in pulled elbow in children. The fractures of the head and neck of the radius occur from the falls on the outstretched hand.

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As the force is transmitted along the radius, the head is driven sharply against the capitulum, causing the splintering of head.[6] Radial head and neck fractures constitute 1.7-5.4% of all fractures.[7] Radial head fractures alone constitute one-third of all elbow fractures and about 20% of all elbow trauma cases .[8]People in the age group of 30-40 years have 20% of the elbow injuries, especially radial head fracture and it is more common in women than in men.[9] However, concomitant injuries are also reported to occur with radial head fractures.[10] Radial head injuries occur on a spectrum, from isolated low-energy minimally displaced fractures to the high energy impacted, comminuted fracture with associated ligamentous and bone injury. Stiffness, the most common complication seen following the radial head injury, often contributes to functional deficits, even in injuries at the less severe end of the spectrum.[11]The treatment of radial head fractures includes immobilization, excision with or without prosthetic replacement and open reduction with internal fixation. Sometimes due to valgus forced injury to elbow, fracture of the proximal end of radius complicates with the fracture of ulna.[12]Internal fixation of the radial head is especially useful when radial head fractures are associated with other injuries, such as interosseous ligament tears, medial collateral ligament tears and coronoid fractures.[13]An appreciation of the role played by radial head in the overall stability of the elbow and forearm has motivated many investigators to recommend preservation of radial head, either by operative fixation or by prosthetic replacement.[14] The operative treatment for proximal radial fracture with minimal comminuted fractures includes anatomical reconstructions with stable fixation to achieve early recovery of function.[15] Treatment options for comminuted radial head fractures range from reconstruction of the radial head by several implants to simple resection of the radial head.[16] It is found that the long term results after resection of the radial head may lead to instability of the elbow and wrist joint.[17] Thus, in comminuted fractures, prosthetic radial head replacement is commonly recommended as an alternative to avoid complications like malunion, loosening and impingement of hardware in the proximal radioulnar joint.[15] The knowledge of the shape of the radial head may prove to be useful in the treatment of radial head fractures. Documenting and understanding the shape, position and orientation of the articular surface of the radial head, referable to its annular surface may be clinically important.[18] For ideal radial head prosthesis, the articular surface of the radial head prosthesis should be at the level or slightly proximal to the lateral edge of coronoid articular surface.[10]The mobility of the radial head could have adverse effects on the stability of the elbow joints if the pivoting joint of the radial head prosthesis is not aligned perfectly to the capitulum .[18] Therefore, an accurate knowledge of the size and the shape of the head of radius in a particular population is essential in construction of radial head prosthesis which is anatomically and biomechanically suitable for that population. Radial head prosthesis must restore maximum function of radial head within the elbow joint along with the correct positioning, load bearing and stability.[3] Gupta et al[14] reported that currently available prosthetic implants are not anatomically correct and their designs are not derived from geometric dimensions of radial head. Beredjiklian et al[19] measured various parameters of radial head by using magnetic resonant techniques and stated that currently available radial head prosthetic stem designs are overestimated the intramedullary dimensions of radial head. Some biomechanical studies have emphasized the importance of correctly sizing the radial head prosthesis at the time of implantation.[20]Since the morphometric parameters of the proximal end of radius are useful in the designing of a biomechanically correct prosthesis of head, our study will be helpful to the orthopaedic surgeons for reconstructive surgeries.

MATERIALS AND METHODS

The study was performed in the Department of Anatomy, Guru Gobind Singh Medical College, Faridkot, Punjab. A total of 60 unpaired human radius bones were studied from teaching collection of the Anatomy department. Of the 60 radii, 30were from the right side and 30 were from the left side. All the bones selected were dry, complete and showed normal anatomical features and were of unknown age and sex.

The following morphological and morphometric parameters of the head of the radius were studied:

1. Shape: The outline of the radial head was drawn on a tracing paper with the help of a lead pencil and the shape was observed. The shape was classified as circular, oval or irregular.

2. Diameter

a) Antero posterior**:** It is the distance between the most anterior and most posterior points on the radial head [Fig. 1(a)].

b) Transverse:It is the distance from the medial most point to the lateral most point on the radial head.[Fig. 1(b)].

The readings were measured using digital vernier caliper and were recorded in millimeters (mm)

3. Height: It is the distance between the radial lip and the junction of the head and neck at the medial, lateral, ventral and dorsal ends respectively. The readings were measured using digital vernier caliper and were recorded in millimeters (mm) [Fig. 1(c,d,e,f)].

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4. Circumference: The radial head was surrounded by an inelastic cotton thread and the end of the thread was marked with a sketch pen. The marked length of the thread was measured using the measuring scale. The reading was recorded in millimeters (mm) [Fig. 2(a)].

5. Proximal articular surface:

a) Depth: A measuring scale was placed over the radial head touching the most prominent anterior and posterior points on the rim of the head and the depth in the centre of the head was measured using digital vernier caliper. The reading was recorded in millimeters (mm) [Fig. 2(b)].

b) Diameter of fovea radialis: It is the distance between the ventral and dorsal curves on the proximal articular surface of the head. It was measured using digital vernier caliper and the reading was recorded in millimeters (mm) [Fig. 2(c)].

c) Thickness of curves: Thickness of ventral, lateral and dorsal curves was measured in ventral, lateral and dorsal parts of radial head on its articular surface using digital vernier calipers. The readings were recorded in millimeters (mm) [Fig. 2(d,e,f)].

The collected data was compiled in MS Excel and the statistical analysis was done using SPSS software.

Fig. 1: Showing measurement of: (a) Anteroposterior diameter of the radialhead
(b) Transverse diameter of the radial head (c) Height of radial head at the medial end
(d) Height of radial head at the lateral end (e) Height of radial head at the ventral end
(f) Height of radial head at the dorsal end.

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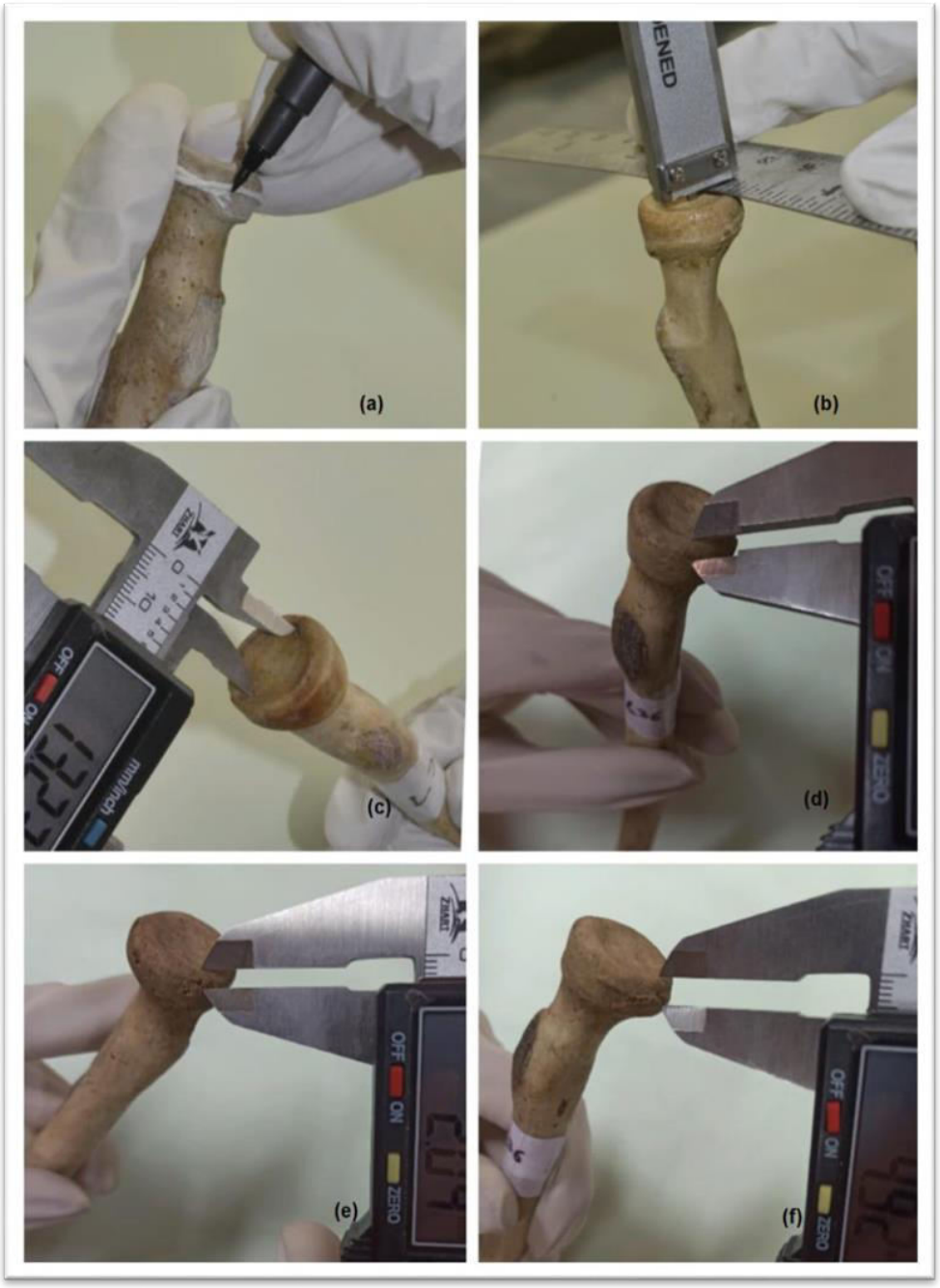

Fig 2: Showing measurement of: (a) Circumference of radial head(b) Depth of proximal articular surface (c) Diameter of fovea radialis (d) Thickness of ventral curve, (e) Thickness of lateral curve (f) Thickness of dorsal curve.

OBSERVATION and RESULTS

The study was done on 60 radii, of which 30 were of right side and 30 of left side. In the present study the shape of head was circular in 36 (60%) bones [Rt.-19 (63.34%) and Lt.-17(56.67%)] and oval in 24 (40%) bones [Rt.-11 (36.67%) and Lt.-13(43.34%)]. None of the bones studied had irregular shape of the head. Antero-posterior and transverse diameters, heights at the medial, lateral, ventral and dorsal ends and the circumference of the radial head; depth, diameter of fovea radialis and thickness of ventral, dorsal and lateral curves of the proximal articular surface of the head were measured. The average values recorded in the present study are given in Table no.1. : In the present study, the average values of the anteroposterior (AP) and transverse diameters of the radial head were found to be 20.61 mm (Rt.-20.41 mm, Lt.-20.82 mm) and 20.02 mm (Rt.-19.75 mm, Lt.-20.30mm) respectively.

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Table no. 1: Morphometric parameters of the head of the radius

S. No.	Dimensions	Mean (mm)			p-value
		Total (n=60)	Left (n= 30)	Right (n=30)	
1	Anteroposterior diameter	20.61±1.78	20.82±1.78	20.41±1.79	0.496
2	Transverse diameter	20.02±1.79	20.30±1.75	19.75±1.82	0.412
3	Height at the medial end	9.39±1.64	9.54±1.23	9.23±1.97	0.122
4	Height at the lateral end	6.82±1.08	6.85±0.78	6.79±1.32	0.935
5	Height at the ventral end	8.20±1.30	7.85±0.90	8.55±1.53	0.054
6	Height at the dorsal end	7.67±1.23	7.82±1.00	7.52±1.42	0.311
7	Circumference	67.18±5.93	67.70±6.12	66.85±5.82	0.635
8	Diameter of fovea radialis	12.20±1.59	12.29±1.64	12.11±1.56	0.435
9	Depth of the proximal articular surface	1.73±0.06	1.62±0.07	1.85±0.08	0.043
10	Thickness of ventral curve	4.53±0.83	4.62±0.85	4.44±0.81	0.399
11	Thickness dorsal of curve	3.61±1	3.87±1.23	3.36±0.62	0.041
12	Thickness lateral of curve	3.86±0.68	4.01±0.67	3.72±0.66	0.105

DISCUSSION

The present study was conducted on 60 dry adult human radii (30 right and 30 left) of unknown sex in the Department of Anatomy, Guru Gobind Singh Medical College, Faridkot. The morphological and morphometric study of the head of radius was done. The results obtained were tabulated, statistically analyzed and compared with the accessible literature. Shape of the head of radius: In the present study, 60% of the bones had a circular radial head and 40% had oval shape. Captier et al[21] recorded 43% radii had circular head and 57% had oval shape head, whereas Gupta et al[14]reported 64% were circular,26% oval and 10% had irregular radial head shape. Mittal et al[10]studied 100 radii and they also concluded that 60% radii head were circular and 40% were oval in shape. Diameter of head of radius: In the present study, the average values of the anteroposterior (AP) and transverse diameters of the radial head were found to be 20.61 mm (Rt.-20.41 mm, Lt.-20.82 mm) and 20.02 mm (Rt.-19.75 mm, Lt.-20.30mm) respectively.Gupta et al[14] recorded mean AP diameter to be 19.1 mm and transverse diameter to be 18.5 mm. Rajasree et al[22] reported that the mean AP diameter of the radial head was 15.43 mm and mean transverse diameter was 13.44mm.Singh et al[3]studied 106 radii and noted that the mean AP diameter of head was 20.50mm and transverse diameter was 19.53 mm. The findings of the present study stand equivalent to those of the study done by Singh et al[3]. Height of head of radius: In the present study, mean height of the radial head at the medial, lateral, ventral and dorsal ends was 9.39±1.64 mm (Rt.- 9.23±1.97 mm, Lt.- 9.54±1.23 mm), 6.82±1.08 mm (Rt.-6.79±1.32 mm, Lt.- 6.85±0.78 mm), 8.20±1.30mm (Rt,-8.55±1.53 mm, Lt.- 7.85±0.9 mm) and 7.67±1.23 mm (Rt.-7.52±1.42 mm, Lt.-7.82±1 mm) respectively. Shastry et al[12]studied 142 radii and recorded mean radial head height of 9.795 mm on medial end and 7.735mm on lateral end. Ethiraj et al[23] recorded mean height of the radial head at the medial, lateral, ventral and dorsal ends to be 9.1mm,7.3mm, 8.6 mm, 7.8mm respectively. Singh et al[3] reported mean radial head height on medial end was 8.65+ 1.55 mm and on its lateral end was 6.28+1.09 mm. Circumference of head of radius: The mean circumference of the radial head recorded in our study was 67.17±5.93 mm (Rt.-66.85±5.82 mm and Lt.-67.50±6.12 mm). It was also noted that the mean value of the circumference of the radii of the left side was slightly higher than that of the bones of the right

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side. In a study done on 160 radii by Raynaet al[24]mean circumference of head of radius recorded was 63mm. Ethirajet al[23] reported the mean circumference to be 47.8mm in the 60 radii they studied. Diameter of fovea radialis: In present study, the mean diameter of fovea radialis was 12.20 mm (Rt.-12.11±1.64 mm, Lt.-12.29±1.56 mm) with a range of 7.93-14.75 mm. Swieszkowski et al[25], Captier et al[21], Koslowsky et al[16]reported mean diameter of fovea radialis to be 16.5mm, 12.1mm, 16.7mm respectively Depth of proximal articular surface of head of radius: In present study, the mean depth of the proximal articular surface was found to be 1.73±0.44 mm (Rt.-1.85±0.45 mm, Lt.-1.62±0.41 mm) with a range of 0.92-2.92 mm. The mean depth of this surface was significantly higher on the right side than the left.Mahasavariya et al[17], Imam et al[2], Shastry et al[12], Ethiraj et al[23], Singh et al[3] recorded the depth of proximal articular surface to be 1.5mm, 1.983mm, 1.735 mm, 2.9 mm, 1.96 mm respectively. Thickness of curves: In the present study, the mean values of the thickness of ventral, dorsal and lateral curves of the proximal articular surface of the radial head were found to be 4.53 mm (Rt.-4.44±0.81 mm, Lt.- 4.62±0.85 mm), 3.61 mm (Rt.-3.36±0.62 mm, Lt.-3.87±1.23 mm) and 3.86 mm (Rt.-3.72±0.66 mm, Lt.-4.01±0.67 mm) respectively.Captier et al[21] recorded mean values of the thickness of ventral, dorsal and lateral curves of the proximal articular surface of the radial head to be 5.5mm, 4.3mm,4.7mm respectively; whereas Shastry et al[12] reported them to be 5.05mm, 3.69mm, 3.64mm respectively. In a study done by Singh et al[3],the mean thickness of ventral, dorsal and lateral curves was 5.07$\pm$0.96mm,4.02$\pm$0.94mm,3.63$\pm$0.82 mm respectively. In the present study, it can be noted that the thickness of curves was highest in the ventral curve and least in the dorsal curve of the proximal articular surface of the radial head.On comparison between the average values of the two sides, it was seen that the depth and the thickness of dorsal curve of the proximal articular surface of the left-sided radii was significantly higher than the right sided radii.

CONCLUSION

The overall goal of this study was to generate information that would be helpful to the orthopaedic surgeons for reconstructive surgeries and will also provide a precision leverage and validity for the biomedical engineering to manufacture explicit radial head prosthesis. The study will also be useful to the radiologists as radiographic evaluation is essential to evaluate the position, location and the type of fracture or fracture dislocation; to the forensic experts in cases where the most reliable source of information i.e pelvis might not be available for analyses. However, it should be kept in mind, that the present study had a smaller number of radius bones, so it is worthwhile to perform similar study on more number of bones for its theoretical and practical importance in the coming years.

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