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ANALYSIS OF MORPHOMETRIC SEGMENTS OF HUMERUS WITH CLINICAL RELEVANCE IN RAJASTHAN REGION

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ABSTRACT

Background: Long bones have long been used to determine the stature and identification of an individual. There are studies to determine the variation in anatomical segments focusing on ethnicities and with the need for required implant design for an individual. The aim of this is to contribute to the data on morphometric segments of the humerus of the Rajasthan region. **Materials and Methods:** A total of 100 (R-50 & L-50) humeri were used in this study. A total of eight morphometric segments were measured in each of these bones and their mean+SD were derived and compared with others. All measurements are in millimeters. **Results:** The results were 1. MH: mean maximum humeral length (R-290.16, L-288.48); 2. H1: mean distance between the most proximal point of the articular segment of the humeral head to the most proximal point of the greater tuberosity (R-5.3,L-5.16); H2: mean distance between the most proximal point of the caput humeri and most distal point of the anatomical neck (R-34.91,L-35.78); H3: mean distance between the most proximal point to the most distal point along the edges of the olecranon fossa (R-18.77,L-19.15); H4: The distance between the most distal point of the olecranon fossa and trochlea of the humerus (R-20.84, L-19.79); H5: The distance between along the proximal edge of the olecranon fossa and the most proximal point of the trochlea (R-36.04, L-34.90); WOF: Width of olecranon fossa (R-24.53,L-24.13); DOF: Depth of olecranon fossa (R-10.79, L-11.39). **Conclusion:** Analysis of data revealed that our results were in correlation with Indian studies but most of the foreign studies showed higher values of the segments studied. This difference is either be due to ethnic, genetic, nutritional or stature differences among different populations. We believe that data obtained herein can contribute to anthropologists and orthopedic surgeons.

Keywords: humerus, morphometry, arthrometry, tubercle, olecranon

INTRODUCTION

The humerus is the longest and largest bone of the upper limb and has significance in post-mortem anthropology and archaeology. **(1)** In these fields, long bones and their anatomical segments are used to estimate especially stature **(2, 3, 4)** and additionally age and gender **(5)**; height has shown proven correlation pertaining to bone size. **(6)** The knowledge of morphometric segments of humerus helps anthropologists and anatomists help in the identification of a person from skeleton remains.**(7)** There have been studies to determine the length of the humerus from morphometric segments and one regression equation cannot meet the expectation of racial variation.**(8)**

Clinically the fracture/s of either proximal or distal humerus is a common osteoporotic fracture occurring in the elderly. **(9)** Some of these patients require complex surgeries arthroplasty, operative fixation. **(10)**

Additionally, distal humerus fractures are on the rise in young males and osteoporotic elderly females and its management is often challenging due to the complexity of the regional anatomy. **(11)** It is often challenging, in a case of multiple distal humerus fractures, to restore the humerus to premorbid state as there is a need to design prosthesis/ implants based on ethnic, regional and stature variation of the patient. **(12)** In the cases of small-statured patients, suffering from osteoporotic humerus fracture, the screws and implants are often suboptimal and mismatched according to the size of the humerus. This leads to impingement and reduction in joint motion. Hence if any ethnic or regional significant differences occur in humerus bone shape and morphometrics then it must be ascertained which will help surgeons in providing a better design for a group of patients.

The study aims to measure different morphometric segments of the humerus of the Rajasthan region thereby will add to the knowledge founded in the disciplines of anthropology, bone morphometrics, and implant engineering. The results may suggest anthropologists in cataloging the humerus based on ethic, genetic variations as well as design engineers to consider these anatomical differences and designing implants for the patients of the Rajasthan region.

MATERIALS AND METHODS

For this anatomical study a total of one hundred humeri (Right-50 & Left-50) were used from the anatomy department of Govt. medical college, Kota and Jhalawar medical college, Jhalawar of Rajasthan state. All these humeri were dry, intact, adult and of unknown sex. A total of eight anatomical measurements were taken from each of these.

MHL (maximum humeral length): It is the distance between the most proximal point of the caput humeri to the most distal point of the trochlea. **(1)**

DISCUSSION

The literature indicates that sex; racial size and shape variation occurs in the humerus bone but to what extent ethnicities have different humeral size and shape is yet to be determined. Present work was aimed to study morphometric segments of the humerus in the Rajasthan region and to contribute to the available literature. A

H1: The distance between the most proximal point of the articular segment of the humeral head to the most proximal point of the greater tuberosity. **(1)**

H2: The distance between the most proximal point of the caput humeri to the most distal point of the anatomical neck. **(1)**

H3: The distance between the most proximal point to the most distal point along the edges of the olecranon fossa. **(1)**

H4: The distance between the most distal point of the olecranon fossa and trochlea of the humerus. **(1)**

H5: The distance between along the proximal edge of the olecranon fossa and the most proximal point of the trochlea. **(1)**

WOF: Width of olecranon fossa

DOF: Depth of olecranon fossa

The measurements were taken with an electronic digital caliper, osteometric board and measuring scale and measuring tape. The values were recorded separately for humeri of right and left side respectively. Mean, SD were calculated, and unpaired ‘t’ test was used to compare the data of right and left humeri for any statistically significant difference.

RESULTS

A total of 100 humeri (R-50, L-50) were used for this study and eight anatomical measurements were taken from each of these. Table 1 shows the mean of eight morphometric segments measured in 100 humeri. All parameters were measured in millimeters. The anatomical segments MHL, H1, H4, H5, and WOF were slightly higher on the right side and rest were more on the left side respectively but no statistically significant difference ($p>0.05$) was observed in right and left humerus, in any of the parameters.

total one hundred (R-50, L-50) dry, intact, adult humeri were used and eight morphometric measurements were taken from each bone. Evaluation of measurements revealed that the mean value of maximum humeral length, in 100 humeri, was found to be 289.32mm.

Mean maximum humeral length was found to be on Right-290.16±17.71mm and Left-288.48±18.51mm. Our results are close to study in Karnataka population

study by Desai et al(21) (R-292, L-289mm) as well as Premchand et al(22) (R-303.78, L-293.71mm) and another west Indian study Kishve et al(20) (R- 299, L-294.9mm). But it was found to be lower than the observation by Somesh et al of 309.6 on right and 299.6 on the left side as well as Turkish study by Akman et al where mean length was 307.1 on right & 304 on left side respectively. Analysis of results shows that our MHL results are lesser than most other foreign population studies of Turkish(1), Athenian(13), Brazilian(14), and Istanbul(15); but comparable to other Indian studies. This indicates that difference could be due to different anthropological characteristics among ethnic populations of the world. One reason for the difference in results with Derya et al **(15)** is that their study is using radiographic measurement and it is known that dry bone is shorter than fresh cadaveric bones.

The difference between the highest point on the articular segment of the humeral head (H1) has been reported to be 6 to 8 mm higher than the most proximal point of the greater tuberosity. This relative distance of greater tubercle is important functionally in the abduction of arm, and clinically in cases of subluxation of the shoulder joint. The incidence of proximal humerus fractures is increasing and it is commonly an osteoporotic fracture. **(10)** Needless to say, the importance of H1 lies in isolated fracture of the greater tuberosity.**(23)** In this study, we found this distance (H1) on the right and left humerus to be Right-5.3 and Left-5.16 mm respectively. Our results are in correlation with Indian studies by Premchand et al **(22)** (R-5.76, left-5.12 mm); Somesh et al **(18)** (R-5.9, L-5.8 mm) but values are lesser than other foreign anatomical studies.

In our results, the distance from the most proximal point on the articular surface of the head of the humerus to the distal point on surgical neck of humerus (H2) in the humerus of Rajasthan region was right-34.9 and on left-35.78mm respectively. Similar to the observation in H1, the H2 results are comparable with Premchand et al **(22)** (R-32.88, L-32.15 mm) and Somesh et al **(18)** (R-37.1, L-37.2mm) but are lesser than Turkish study **(1)** (R-41, L-40.9 mm). Lesser results are reported by Kishve at el**(20)** (R-29, L-28.7 mm). These H1 and H2 morphometric segments proximal humeral become important in cases of displacement fracture/s in this region.

In the present study, the distance between the proximal and distal edge of olecranon fossa (H3) was 18.77mm & 19.15mm on right & left side respectively. These values were comparable to Premchand et al **(22)** (R-17.62, L-18.26); higher than western Indian study Kishve et al**(20)** (R-16.2, L-15.9 mm); but are noticeably lesser than Akman et al(1) (R-24.2, L-23.9 mm), Desai(21) (R-38.3, L-39.7 mm) & Rai **(24)** (R-27.4, L-27.5 mm) studies. Our results are similar to an archaeological study by Churchill & Smith (2000) **(26)** where the distance between the proximal and distal edge of olecranon fossa was 20.2 mm for females and for males as 20.3 mm respectively.

Thus, it is implied that there occurs wide variation in shape and size of olecranon fossa in the humerus of different ethnic and racial origin. The distal humerus is involved in a wide variety of fractures involving olecranon fossa, some may require fixation. Hence, the knowledge of ethnic variation in this region is essential for surgeons in fracture reconstruction and the designing of implants.

The distance between the distal margin of the olecranon fossa and trochlea (H4) in our study was 20.84+1.47 & 19.79+2.34 mm on right & left side respectively. These values were comparable to the South Indian study by Desai SD et al(21) (R-21.2, L-20.7 mm) and Turkish study by Akman et al(1) (R-20.0, L-19.7 mm). Although previous segments were in correlation with Premchand et al **(22)** here they reported lesser values (R-14.02, L-14.44 mm). Similar to previous segments, our values are lesser than by Rai and Chawla **(24)** (R-26.1, L-22.1 mm). This difference indicates the racial morphometric variation in humerus bone. Another foreign study by Wright & Vásquez **(27)** on 100 Maya skeletons, of Central America, reported a much lesser value of H4 segment in males 14.2+1.8mm. The distal part of the humerus articulates with both radius and ulna and the compound fractures involving distal segments may pose a challenge to reconstruction to a premorbid state by orthopedic surgeons. **(12)**

In our assessment of the anatomical segment from the proximal margin of the olecranon fossa to the proximal trochlea (H5) was R-36.02, L-34.90 mm respectively.

These values were again found to be similar to Premchand et al **(22)** and lesser than the Turkish population study of Akman et al **(1)** (R- 40.6, L-39.7mm). Additionally, it is comparable to the Uttar Pradesh population study by Rai & Chawla (R-34.5, L-32.6 mm). But much lesser values are reported by Karnataka population study Desai SD et al **(21)** (R-25.72, L-22.56 mm). Thus, the distal segment of the humerus has shown variation in anatomical segments among different ethnicities.

As seen in Table 4 the width of olecranon (WOF) fossa in our study (R-24.53, L-24.13 mm) closely resembles by Turkish study by Kabakci et al(28) (R-24.72, L-25.16 mm) but the depth of olecranon fossa (DOF) varies with their result and they have reported a higher depth of olecranon fossa. This again substantiates the fact that wide racial change exists in humerus bone.

This research highlights the variation of humeral anatomical segments among various populations of the world and the need to design the implants based on stature and ethnicity of the patient. Our results add to the anthropometric data of humerus bone of the Rajasthan region.

CONCLUSION

Comparing the morphometric segments data of humerus with other studies revealed that there occurred a noticeable difference in data among different ethnicities. Our results were in correlation with many Indian studies but most of the foreign studies showed higher values of the segments studied. This difference can either be due to ethnic, genetic, nutritional or stature differences among different populations. We believe that data obtained herein will contribute to anthropologists and orthopedic surgeons.

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Table 1: Eight anatomical segments in this study (mean ±SD in millimeters)

	Parameter	Right (N=50)	Left (N=50)	Total (N=100)
1.	**MHL**	290.16±17.71	288.48±18.51	289.32±18.04
2.	**H1**	5.3±1.22	5.16 ±0.97	5.23±1.10
3.	**H2**	34.91±2.15	35.78 ±3.39	35.34±2.87
4.	**H3**	18.77±2.29	19.15 ±1.79	18.96±2.05
5.	**H4**	20.84±1.47	19.79 ±2.34	20.31±2.01
6.	**H5**	36.04±1.47	34.90 ±3.23	35.47±3.08
7.	**WOF**	24.53±1.01	24.13 ±2.79	24.33±2.40
8.	**DOF**	10.79±1.93	11.39 ±1.12	11.09±1.57

Table2: Comparison of Mean of maximum humeral length with other studies.

Author	Population	Maximum length (mean ±SD) (in mm)
Akman et al**(1)**	Turkish	R-307.1 ± 20.8
		L-304.8 ± 18.9
Papaloucas M et al**(13)**	Athenian	In Male R-347.3±6.3, L-342.2±6.2
		In Female R-319.1±3.2, L-314.1±3.9
Salles AD et al**(14)**	Rio de Janeiro	R-31.3±2.3
		L-30.5±1.6 (in cm)
Derya Atamtürk et al**(15)**	Istanbul	324.16±32.21
Mall G**(16)**	Munich and Cologne	M-33.4, F-30.7
Anudeep S et al**(17)**	North Indian	305.42±1.4
Somesh MS et al**(18)**	Karnataka	R-309.6±20.6
		L-299.6±22.5
Sinha P et al**(19)**	Sikkim	286.69±20.78
Kishve P et al**(20)**	Western India	R-299.1±20.1
		L-294.9±19.9
Desai SD et al**(21)**	Karnataka	R-292.3±22.9
		L-289.45±21.8
Our study	Rajasthan	R-290.16±17.71
		L-288.48±18.51

Table 3: Comparison of five morphometric segments of the humerus

Parameter		Akman et al(1)	Somesh et al(18)	Desai SD et al(21)	Rai R & Chawla M(24)	Premchand SA et al(22)	Kishve P et al(20)	Prasad NC et al(25)	Our study
Year		2005	2011	2012	2014	2014	2015	2017	2018
Region		Turkish	Karnataka	Karnataka	Moradabad	Karnataka	Western india	Karnataka	Rajasthan
H1	R	6.5	5.9	6.9	6.4	5.76	6.8	6.7	5.3
		± 1.6	± 1.1	±1.2	±1.3	±1.43	±0.20	±1.5	±1.22
	L	6.6	5.8	7.1	6.5	5.12	6.3	7.5	5.16
		± 1.3	± 1.5	±1.1	±1.3	±1.45	±0.63	±1.6	±0.98
H2	R	41.0	37. 1	39.9	39.3	32.88	29.0	40.8	34.91
		± 5.1	± 4.8	±6.3	±5.4	±3.43	±0.34	±7.8	±2.15
	L	40.9	37.7	39.1	39.2	32.15	28.7	40.3	35.78
		± 3.9	± 4.4	±6.1	±4.8	±2.94	±0.31	±8.2	±3.39
H3	R	24.2	20.1	38.3	27.4	17.62	16.2	39.6	18.77
		± 2.0	± 3.4	±1.9	±2.4	±1.67	±0.31	±2.3	±2.29
	L	23.9	19.0	39.7	27.5	18.26	15.9	41.1	19.15
		± 2.6	± 2.9	±2.5	±2.6	±1.59	±0.35	±2.9	±1.79
H4	R	20.0	17.37	21.2	26.1	14.02	16.1	22.6	20.84
		± 2.2	± 3.36	±1.8	±2.9	±1.32	±0.24	±1.3	±1.47
	L	19.7	16.8	20.7	22.1	14.44	16.6	21.7	19.79
		± 2.5	± 2.2	±2.1	±2.3	±1.43	±0.33	±1.8	±2.34
H5	R	40.6	35.7	25.72	34.5	31.64	31.7	24.12	36.04
		± 3.3	± 4.3	±2.9	±3.6	±2.30	±0.32	±2.3	±1.47
	L	39.7	37.2	22.56	32.6	32.70	31.8	26.92	34.90
		± 3.4	± 4.7	±2.9	±3.5	±2.51	±0.28	±2.2	±3.23

Table 4: Comparison of morphometrics of olecranon fossa

Olecranon Fossa	Side	Kabakci A et al(28)	Our study
Width (WOF)	R	24.72±2.31	24.53±1.01
	L	25.16±2.45	24.13 ±2.79
Depth (DOF)	R	13.41±1.78	10.79±1.93
	L	14.60±1.44	11.39 ±1.12

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