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Research Article

MORPHOMETRIC STUDY OF THE DISTAL END OF THE DRY ADULT HUMERUS AND IT'S CORRELATION WITH THE LENGTH OF THE HUMERUS: AN INSTITUTIONAL STUDY

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A R T I C L E I N F O

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A B S T R A C T

Background: The humerus is the largest bone of the upper limb. Morphometry of the humerus is important for the identification of unknown bodies,and the estimation of height, age, and gender in forensic science. Morphometry of the distal end of the humerus can assist in reconstructive surgeries through implants as orthopedic surgeons face difficulty in fixing complex fractures. **Aim and objectives:** The present study aims to provide morphometry of the distal end of the humerus and its length **Methodology:** Eight morphometric parameters were evaluated from 70 dry adult humeral bones using measuring tape and vernier caliper in units of mm. The length of the humerusis 306.55±16.45mm and 303.20±11.12mm on right and left side. The transverse distance between the medial and lateral epicondyle on the right side of the humerus was 59.47±2.53mmand 57.57±3.53mm on the right and left side. The average transverse distance between the capitulumand medial flange of trochlea was 42.27±1.99mm and 42.48±2.42mm on right and left side. Themaximum transverse distance from the medial epicondyle to the capitulumwas 56.60±2.71mm and 53.95±3.96mm on right and left side. The horizontal diameter of the trochlea was 23.27±1.79mm and 22.80±1.74mm on right and left side. The anteroposterior diameter of the trochlea at the middle was 16.57±1.55mm and 16.30±1.24mm on right and left side. The length of the medial flange of the trochlea was23.23±1.67mm and 22.67±1.70mm on right and left side. The length of the lateral flange of the trochlea18.17±1.72mm and 17.17±1.28mm on right and left side. **Conclusion**: When compared with the Turkish and Brazilian populations there wasa decrease in all parameters but when compared with the Indian population there was a little bit of difference or some measurements werethe same.

INTRODUCTION

The humerus is the largest &strongest bone of the upper limb. It has a proximal end, distal end & shaft. The lower end has lateral epicondyle, capitulum, trochlea & medial epicondyle. The medial & lateral epicondyle of the humerus gives attachment to the muscles for the flexor & extensor compartments of the forearm respectively.[1]Knowledge about the length, size & shape of the humerus is very important for anatomists &anthropologists. The estimation of stature from bones plays an important role in identifying unknown bodies, parts of bodies, or skeletal remains in forensic science.[2]

In anthropology & forensic science, morphometric analysis is carried out on remains on long bones of the individual in the absence of cranium &pelvis. In long bones, the femur & tibia collectively remain the best for assessment of the living stature of the individual. However, in the absence of long bones of the lower limb, estimation of living stature can also be assessed by long bones of the upper limb such as humerus, radius &ulna.[3] Lower end of humerus ossifies from four secondary centers of ossification. Ossification center for medial epicondyle appears at the age of 5-6 years of age. Ossification center for capitulum appears at 1 year of age, for trochlea at the age of 9-10 years of age, and for lateral epicondyle appears at the age of 10-12 years of age. Secondary centers of ossification for the capitulum, trochlea, and lateral epicondyle fuse with each other at the age of 14 years, and unite with the shaft at 15 years. Medial epicondyle unites at 16 years of age.[4]Whenthe whole length of the long bone is not available but only a segment of the bone is available, the total humeral length by the fragments of the humerus can be determined.[5]

The trochlea and capitulum of a distal end of the humerus join with the trochlear notch & radial head (ulna and radius) to form the elbow joint. The medial flange of the trochlea is sharp & at a lower level than the capitulum. This acts as a factor for the carrying angle at the elbow joint.[6]

Orthopedic surgeons face difficulty in fixing the complex fractures involving the distal end of the humerus with damage to the nerve & blood vessels. The availability of pre-contoured

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implants helps in fracture reduction.[7] Movements of the humerus help in essential activities like writing, lifting objects & throwing.[1]

The information on the morphometry of the distal end of the humerus can assist in reconstruction surgeries through implants.[8]Munoz et al.[10] used remains of humerus segments to estimate the total length of the humerus and gender.[9] The information on the morphometry of the distal end of the humerus can assist in reconstruction surgeries through elderly patients who underwent total elbow arthroplasty and they could do routine activities.[11]

Aims and Objectives

The present study is aimed to provide morphometry of the distal end of the humerus and its length. This will in turn help anatomists, forensic experts, and surgeons in improving their outcomes.

MATERIAL AND METHODS

The present study is conducted on seventy (70) dry adulthumeri of unknown age and sex obtained from the Department of Anatomy, Government Medical College, Srinagar. The morph metric measurements were done in all bones. Damaged bones were not considered for the study. The parameters of the humerus were measured by using measuring tape and vernier caliper**.** The following measurements were taken.

M1- the maximum length of the humerus was measured from the tip of the head humerus to the transverse line passing at the apex of the trochlea
M2- the transverse distance between the medial and lateral epicondyle
M3- the transverse distance from the medial flange of the trochlea to the capitulum
M4- the horizontal distance from the medial epicondyle to the capitulum
M5- the maximal horizontal diameter of the trochlea
M6- the anteroposterior diameter of the trochlea at the middle of the trochlea
M7- the maximum length of the medial flange of the trochlea
M8- the maximum length of the lateral flange of the trochlea

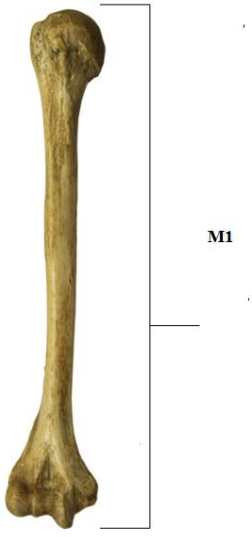

Figure 1: image shows how the measurement M1is taken

Figure 2 M3: The transverse distance from the medial flange of the trochlea to the capitulum. M4: The transverse distance from the medial epicondyle to the capitulum. M5: The maximal horizontal diameter of the trochlea.

Figure 3: How measurement M7 was measured.

Data analysis

Data were analyzed using Statistical Package for Social Science (SPSS) version 25.0.The mean, standard deviation, and student t methods were used to analyze the data, and a p-value< 0.05 was considered statistically significant.

RESULT

Seventy bones are used in this study which includes 30 right and 40 left humeral bones. Each bone was measured for eight parameters as described in the material and methods. The average value of the maximal length of 30 right humerus bones (M1) was 303±11.12mm and 40 left humerus bones (M1) was 306±16.45mmThe average transverse distance between the medial epicondyle and lateral epicondyle (M2) on the right side was 59.47±2.52mm and on the left side was 57.57±3.53mm.The average transverse distance from the

medial flange of the trochlea to the capitulum (M3) on the right side was 42.27±1.99mm and on the left side was 42.47±2.41mm.The average transverse distance from the medial epicondyle to the capitulum (M4) on the right side was 56.60±2.71mm and on the left side was 53.95±3.96mm.The mean horizontal diameter of the trochlea (M5) on the right side was 23.27±1.79mm and on the left side was 22.8±1.74mm.The average anteroposterior diameter of the trochlea (M6) on the right side was 16.57±1.54mm and on the left side 16.30±1.24mm.The average length of the medial flange of the trochlea(M7) on the right side was 23.23±1.67mm and on the left side 22.67±1.70mm.The average length of the lateral flange (M8) on the right side was 18.17±1.72mm and on the left side 17.17±1.27mm.The average values and standard deviation for the measurements obtained from the eight parameters were categorized under right and left humerus and the values are depicted in table 1.The p-value was obtained from the independent samples t-test to show the statistics.

DISCUSSION

Multiple parameters of the humerus help orthopedic surgeons, anthropological scientists, forensic experts, and morphologists. Distal humerus hemiarthroplasty is the most appropriate treatment of choice for old patients with unreconstructable intra-articular distal humerus fractures. Distal humeral hemiarthroplasty may also be used as a treatment of choice in rheumatoid arthritis, orthopedic tumors with significant bone loss, malunion, and osteomyelitis. [12]The regression equations are formulated for the estimation of the total length of the humerus from proximal segment measurements on 150 humeral bones by Lakshmi kanth[8] BM et al. These can be used for estimating the height of an individual, age, gender, and race.[8]The above measurements can also help orthopedic surgeons in the formation of prosthetic implants for reconstructive surgeries and arthroplasty.[9]

Table 1 Data analysis of the parameters used Morphometry of the distal end of the humerus in millimeters

Parameters	mean ± SD		P value
	Right (n=30)	left (n=40)	
M1: the maximal length of the humerus	306.55±16.45	303.20±11.11	0.340
M2: The transverse distance between medial Epicondyle and lateral epicondyle	59.47±2.53	57.57±3.53	0.015
M3: The transverse distance from medial flange of the trochlea to the capitulum	42.27±1.99	42.47±2.41	0.015
M4: The transverse distance from the medial Epicondyle to capitulum	56.60±2.71	53.95±3.96	0.002
M5: The maximum horizontal diameter of the Trochlea	23.27±1.79	22.80±1.74	0.28
M6: Anteroposterior diameter of trochlea at the middle part of the trochlea	16.57±1.55	16.30±1.24	0.43
M7: Maximal length of medial flange of trochlea	23.23±1.67	22.67±1.70	0.18
M8:Maximal length of lateral flange of trochlea	18.17±1.72	17.17±1.28	0.007

*P<0.05 to be statically significant. SD: Standard deviation.

Table 2 Comparison between the different studies for the measurement of the maximal length of the humerus (M1)

Author	Population	Maximal length of Arm bone	Right humerus	Left humerus
Akman et al;2006[13]	Turkish	120 (right-64, left-56)	307.1±20.8	304.8±18.9
Salles et al;2009[14]	Brazilian	40 (right-20, left-20)	313±23	304.8±18.9
Ashiyani et al;2016[8]	Indian (gujrat)	100(right-50,left-50)	303.9±16.6	303.2±15.8
Vinay et al;2020[1]	South Indian	200 (right-93, left-107)	306.32±21.983	301.13±22.441
Present et al;2023	India (Kashmir)	70 (right-30,left-40)	306.55±16.45	303.20±11.12

Mean and SD in millimeters, SD-Standard deviation

Table 3 Comparison of measurements between the different authors

Measurements	Groups	Siva Narayana and Himabindu[10] (100 humerus)	Salles et al.[14] (40 umerus)	Ashiyani et al.[8] (100 humerus)	Vinay et al.[1] (200 humerus)	Present Study (70 humerus)
M2	Right	58.8±4.0	58.0±6	56.6±3.6	57.40±3.6	59.47±2.53
	Left	57.0±4.6	57.0±4	55.8±4.2	56.02±4.77	57.57±3.53
M3	Right	40.7±6.3	40.0±4	38.7±2.5	39.61±3.45	42.27±1.99
	Left	41.0±6.8	39.0±4	39.0±3	39.55±4.33	42.47±2.41
M4	Right	56.3±3.7	58.0±5	54.2±3.3	54.56±4.9	56.60±2.71
	Left	56.0±4.5	56.0±4	53.9±4.1	52.68±6.63	53.95±3.96
M5	Right	22.4±2.2	24.0±3	22.4±1.8	24.43±2.69	23.27±1.79
	Left	22.42±2.2	24.0±2	22.4±2.0	23.57±2.61	22.8±1.74
M6	Right	15.6±1.8	16.0±2	14.5±1.5	17.05±3.96	16.57±1.55
	Left	15.6±1.8	16.0±1	14.5±1.7	16.35±3.77	16.30±1.24

The average value of the maximal length of the humerus provides proof to reveal the typical features of a group of people.[14]The average maximal length of the arm bone of the present study is compared with different authors in Table 2.

The maximal length of the humerus in the present study is lower than the Turkish and Brazilianpopulations.[14,15] The difference between the populations can be recognized as heredity and acclimatization. The incidents of asymmetry of the right and left humerus are natural features. This is because of control of the contra lateral hemisphere of the brain, the left half cerebral hemisphere will be bigger than the right one and show dominance and shows prevalent effect on the right side.[16]Table 3 shows the comparison of the values acquired after measurement 2 to measurement 6 associated to the distal end of the humerus.

The length of the medial flange of the trochlea is more than the lateral flange of the trochlea which forms the angle, known as trochlear angle. The difference in length of the medial and lateral epicondyle of the trochlea results in the formation of a carrying angle during the extension of the elbow joint. Any variation related to the carrying angle can cause cubitus varus and cubitus valgus.

Distal humerus fractures are challenging to treatment and can result in long-term impairment. The overall occurrence of distal end fractures in adults has been reported 5.7 cases per 1,00,000 cases.[17] Distal end fractures of the humerus can range from extra-articular to comminuted fractures. The comminuted distal humeral fractures with a split in the trochlea and capitulum make fracture reduction and stabilization challenging. Complex fractures can be managed with the help of open reduction and internal fixation. Total elbow arthroplasty has the best success rates in patients with inflammatory arthritis, and aged patients with distal humeral fractures.[18]The hemi/total elbow arthroplasty has minimal after-effects on the strength of the upper limb. There were no consequences on Mayo's Elbow performance score following total elbow plasty.[19] The result of this study is important in the case of fractures of elder patients with considerable bone loss, osteoarthritis, and bone tumor where total/hemi arthroplasty is required. The purpose of the present study is to compare various measurements of the right and left humerus bones. The average values of different measurements of the distal end of the humerus are almost similar to different authors with little variations. The difference noticed in the distal end of humeral morphometry is due to genetic factors, age, sex, race, environment, and even continuous change in the mode of living of the population. The morphometry of the distal end of the humerus can help in designing prosthetic implants which are used for reconstruction of complex fractures either by partial or total elbow arthroplasty other than estimation of height and age of an individual.

CONCLUSION

Eight morphometric measurements of 70 humeri are taken. The average maximal length is 304.87mm average maximal length was 304.87±13.78mm,the average distance between the medial and lateral epicondyle was 58.52±0.36mm, and the average distance from the medial flange of trochlea to the capitulum was 42.37±2.2mm.Morphometric measurements obtained by this study when compared with the Turkish and Brazilian population, all measurements are less but when compared with the Indian population, measurements are almost the same or a little different. The measurements obtained by this study are more on the right side as compared to the left side. The various measurements in the distal humeral morphometry can be due to genetic factors, race, environment, and even continuous changes in the mode of living of a human being. The morphometry of the distal end of the humerus can help in improving the design of prosthetic implants which are used for the reconstruction of complex fractures either by partial or total elbow arthroplasty other than helping in the estimation of height and age of an individual.

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Conflict of interest

There are no conflicts of interest

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