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MORPHOMETRIC STUDY OF THE DISTAL END OF THE DRY ADULT HUMERUS AND ITS CLINICAL CORRELATION: AN INSTITUTIONAL STUDY

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Abstract

Background: The humerus is the largest and most powerful bone of the upper limb. Movement of the humerus is needed for daily activities like writing, lifting things and throwing, etc. Morphometry of the humerus is important for the identification of unknown bodies, 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:- The present study aims to determine the mean values of various parameters of the distal end of the humerus.

Methodology:-Eight morphometric parameters were evaluated from 70 dry adult humeri using measuring tape and vernier caliper. The average maximal length of the humerus in the present study on the right side is 306.55±16.45mm and on the left side is 303.20±11.12mm. The transverse distance between the medial and lateral epicondyle on the right side of the humerus is 59.47±2.53mm and on the left side 57.57±3.53mm respectively. The average transverse distance between the capitulum and medial flange of trochlea on the right side is 42.27±1.99mm and on the left side is 42.48±2.42mm respectively. The average maximum transverse distance from the medial epicondyle to the capitulum on the right side is 56.60±2.71mm and on the left side is 53.95±3.96 respectively. The average maximal horizontal diameter of trochlea on the right side is 23.27±1.79 and on the left side is 22.80±1.74 respectively. The anteroposterior diameter of the trochlea at the middle of the trochlea on the right side is 16.57 ±1.55 and on the left side is 16.30±1.24 respectively. The maximal length of the medial flange of the trochlea on the right side is 23.23±1.67 and on the left side is 22.67±1.70. The maximal length of the lateral flange of the trochlea on the right side is 18.17±1.72 and on the left side is 17.17±1.28respectively.

Conclusion: The morphometric analysis of the humerus can be useful for anatomists, forensic experts, and archeologists for the estimation of the stature, age, and sex of an individual. This information is also useful for surgeons in preparing implants and reconstruction of fractures of the distal end of the humerus.

Keywords:- Capitulum, distal end, trochlea, humerus, fracture, medial condyle, lateral condyle

Introduction

The humerus is the largest & strongest bone of the upper limb. It has a proximal end, distal end & shaft. The lower end has a 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 the remains of 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 an 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]. The lower end of Humerus ossifies from four secondary centers of ossification. Ossification center for medial epicondyle appears at the age of 5-6 years. Ossification center for capitulum appears at 1 year of age, for trochlea at the age of 9-10 years, and for lateral epicondyle appears at the age of 10-12 years. Secondary centers of ossification for the capitulum, trochlea, and lateral epicondyle fuse with each other at the age of 14 years, and unite with shaft at 15 years. Medial epicondyle unites at 16 years of age [4]. When the whole length of the long bone is not available but only a segment of the bone is available total humeral length by the fragments of the humerus can be determined[5].

The trochlea and capitulum of the 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 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. 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 implants [10]. Burkhart et al. reported that the postoperative mobilization was immediate in elderly patients who underwent total elbow arthroplasty and they could do routine activities [11].

AIM:-

The present study is aimed to determine the mean values of various parameters of the distal end of the humerus.

Material and methods

The present study is conducted on seventy (70) dry humerus of unknown age and sex obtained from the Department of Anatomy, Govt Medical College, Srinagar.

The morphometric 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 is the transverse distance between the medial and lateral epicondyle.
M3 is the transverse distance from the medial flange of the trochlea to the capitulum.
M4 is the horizontal distance from the medial epicondyle to the capitulum.
M5 is the maximal horizontal diameter of the trochlea.
M6 is the anterior-posterior diameter of the trochlea at the middle of the trochlea.
M7 is the maximum length of the medial flange of the trochlea.
M8 is the maximum length of the lateral flange of the trochlea.

Figure 1: image shows how the measurement 1 is taken

Figure 2:-The measurements(M3-M5) used for measuring the distal end of the humerus.M3 is 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 was 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±11.12 and 40 left humerus bones (M1) was 306±16.45 The average transverse distance between the medial epicondyle and lateral epicondyle (M2) on the right side was 59.47±2.52 and on the left side was 57.57±3.53.The average transverse distance from the medial flange of the trochlea to the capitulum (M3) on the right side was 42.27±1.99 and on the left side was 42.47±2.41. The average transverse distance from the medial epicondyle to the capitulum (M4) on the right side was 56.60± 2.71 and on the left side was 53.95±3.96. The mean horizontal diameter of the trochlea (M5) on the right side was 23.27±1.79 and on the left side was 22.8±1.74. The average anteroposterior diameter of the trochlea (M6) on the right side was 16.57±1.54 and on the left side 16.30±1.24. Trochleas´s medial flange average length (M7) on the right side was 23.23±1.67 and on the left side 22.67±1.70. The average length of the lateral flange (M8) on the right side was 18.17±1.72 and on the left side 17.17±1.27. 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 is obtained from the independent samples t-test to show the statistics.

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

Parameters	mean± SD mm		P
	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 the medial Epicondyle and lateral epicondyle	59.47±2.53	57.57±3.53	0.015
M3: The transverse distance from the medial flange of the trochlea to the capitulum	42.27±1.99	42.47±2.41	0.70
M4: The transverse distance from the medial Epicondyle to the 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 the medial flange of the trochlea	23.23±1.67	22.67±1.70	0.18
M8: Maximal length of the lateral flange of the trochlea	18.17±1.72	17.17±1.28	0.007

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

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 un reconstructable intra-articular distal humerus fractures. Distal humeral hemiarthoplasty 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 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].

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 in Turkish and Brazilian populations[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 contralateral 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 M2 to M6 associated with 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[1].

Distal humerus fractures are challenging to treat 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 extraarticular to communicated fractures. The communicated 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 humural fractures.[18] The hemi/total elbow plasty 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 limitations of this study are unequal (right & left) sample size when compared to the actual population in the area and gender inequality. 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. Morphometric measurements obtained by this study when compared with the Turkish and Brazilian populations measurements, but when compared with the Indian population measurements are almost the same or there is a little difference.

Conclusion

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 change in the mode of living of a human being. The Morphometry of the distal end of the humerus can help improve the design of prosthetic implants which are used for reconstruction of complex fractures either by partial or total elbow arthroplasty other than helping in the estimation of height and age of an individual.

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

Author	population	N	Maximal length of arm bone(mm)	
			Right humerus	Left humerus
Akman et al;2006 [13]	Turkish	120 (Right-64, Left-56)	307±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)	303.2±16.6	303.2±15.8
Vinay et al;2020[1]	South Indian	200(Right-93,Left-107)	306.32±21.98	301.13±22.44
Present et al;2024	Indian (Kashmir)	70(Right-30.Left-40)	306.55±16.45	303.20±11.12

Table 3: Comparision of measurements between the different authors

Measurement (mm)	Groups	Siva Narayan & Himabindu [10]	Salles et al [14]	Ashiyani et al [8]	Vinay et al [1]	Present study
		100 humeri	40 humeri	100 humeri	200 humeri	70 humeri
P2	Right	58.8±4.0	58.0±6.0	56.6±3.6	57.4±3.6	59.47±2.53
	Left	57.0±4.6	57.0±4.0	55.8±4.2	56.02±4.77	57.57±3.53
P3	Right	40.7±6.3	40.0±4.0	38.7±2.5	39.61±3.45	42.27±1.99
	Left	41.0±6.8	39.0±4.0	39.0±3.0	39.55±4.33	42.47±2.41
P4	Right	56.3±3.7	58.0±5.0	54.2±3.3	54.56±4.9	56.6±2.71
	Left	56.0±4.5	56.0±4.0	53.9±4.1	52.68±6.63	53.95±3.96
P5	Right	22.4±2.2	24.0±3.0	22.4±1.8	24.43±2.69	23.27±1.79
	Left	22.4±2.2	24.0±2.0	22.4±2.0	23.57±2.61	22.8±1.74
P6	Right	15.6±1.8	16.0±2.0	14.5±1.5	17.05±3.96	16.57±1.55
	Left	15.6±1.8	16.0±1.0	14.5±1.7	16.35±3.77	16.30±1.24

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Conflict of interest

There are no conflicts of interest

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