Original Research Article

Morphometry of upper end of the ulna in north west Indian population and its implications

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Abstract: Introduction: Fractures in the upper end of the ulna, including its olecranon and coronoid processes, are common. Poor replacement of a dislocated or fractured bone can result in complications such as joint instability, stiffness, and functional deformity. This study aimed to determine the morphometry of the upper end, length, weight, and volume of the ulna bone on both sides in a cross-sectional study.
Materials and Methods: Eighty-four dry ossified ulna bones (42 right, 42 left) were used in this study. The length of the ulna (L) was measured using a digital vernier caliper, while the weight of the ulna (W) was measured using an electronic weight balance. Alginate cast material was used to measure the volume of the upper end of the ulna (V). Longitudinal dimensional parameters, such as the distance between the highest point of the olecranon and that of the coronoid process (OCD) and the mid-olecranon thickness in the mediolateral (T1) and anteroposterior orientation (T2), were measured using a digital vernier caliper. Paired t-tests were used to compare the parameters between the right and left ulnas, with a statistically significant p-value <0.05.
Results: There was a statistically significant variation (p<0.05) in T1, length, weight, and volume between the right and left ulna. However, there was no statistically significant variation in OCD and T2 between the right and left ulna. The average value of T1, T2, length, weight, and volume in the right ulna was higher than that of the left ulna, while the OCD of the left ulna was higher than that of its counterpart.
Conclusion: The findings of this study can be useful for engineers and medical professionals in designing implants for conditions such as fractures and dislocations. Parameters of the olecranon and coronoid processes can also be helpful in determining an individual's sex.

Keywords: Morphometry; Olecranon; Ulna; Digital Vernier caliper.

1. Introduction

The ulna is one of the two bones located in the forearm, lying on the medial side of the radius, and is essential in forming the elbow joint at its proximal end and the wrist joint at its distal end. The upper end of the ulna is made up of two notches, the Radial and Trochlear notch, and two processes, the Olecranon and Coronoid process. The Trochlear notch, also known as the greater sigmoid notch, is a C-shaped structure that articulates with the humerus trochlea to form the humero-ulnar joint. The Radial notch, located on the lateral side of the Trochlear notch, articulates with the medial side of the radius head to form the radio-ulnar joint [1]. The Coronoid Process is a projection from the front of the upper end of the ulna below the Olecranon process that looks like a bracket. The Olecranon Process is a beak-like projection at the upper end of the ulna [1,2].

Fractures can be diagnosed from the patient's medical history to assess the injury, as the commonest symptom is pain, but it can vary with the site and instability of the fracture. Loss of function in the injured area can occur, which may result in the patient being unable to move the limb at all or using it with difficulty. There may also be a loss of sensation or motor power due to nerve or vascular complications [3]. Bone stability

helps promote bone healing. Some studies have found that the olecranon coronoid angle differs between males and females [4].

Therefore, any variation in the morphology of the upper end of the ulna is of medicolegal importance for determining sex and for orthopedic surgeons in performing different surgeries around the elbow joint.

2. Materials and Methods

This study involved 91 dry ossified ulna bones obtained from the Department of Anatomy, Teerthanker Mahaveer Medical College, TMU Moradabad. Ethics approval was obtained from TMMC & RC, Moradabad Institutional Ethics Committee (TMC & RC/IEC/18-19/093). The main objective of this study was to determine the morphometry of the upper end of ulna. The materials used in this study were a Digital Vernier caliper, an electronic weight balance, and Alginate cast material.

The Digital Vernier caliper [5] was used to measure four longitudinal parameters, which were as follows:

a) The distance between the tip of the olecranon process and the tip of the coronoid process (OCD).
b) The thickness in the mid-region of the olecranon process between the highest point of the olecranon process and the coronoid process in the mediolateral orientation (T1).
c) The thickness in the mid-region of the olecranon process between the olecranon and coronoid processes in the anterior-posterior direction (T2).
d) The length of the ulna from the tip of the olecranon process to the tip of the styloid process of ulna (L).

All measurements were recorded in millimeters (mm).

Alginate cast material [6] was used to calculate the volume of the articular surfaces of the upper end of ulna, which was determined in cubic centimeters (cc) using Archimedes principle of buoyancy and fluid displacement. The electronic weight balance was used to measure the bone weight, which was recorded in grams. The Alginate cast material is shown in Figure 1, while the electronic weight balance is shown in Figure 2.

Figure 1. Alginate cast material

Figure 2. Electronic weight balance

3. Statistical analysis

All data were recorded in Microsoft Excel spreadsheet version 2016 and later on data analysis using SPSS (Statistical Package for the Social Sciences) for Windows (version 23.0). Categorical variables were described

as frequency (percentage), and mean $\pm$ standard deviation was used for continuous parameters. Mean $\pm$ SD were calculated for all the parameters and data was statistically analyzed.

4. Results

The mean value of the distance from the tip of the olecranon process to the tip of the coronoid process (OCD) in the right ulna was found to be 0.9 mm less than that in the left ulna. However, the calculated p-value of 0.09, which is greater than the significance level of 0.05 (p<0.05), indicates that this difference is statistically insignificant (Table 1 and Figure 3).

The mean value of the thickness of the mid-region of the olecranon process in the mediolateral orientation (T1) in the right ulna was found to be 0.3 mm more than that in the left ulna. The calculated p-value of 0.03, which is less than the significance level of 0.05, indicates that this difference is statistically significant (Table 1 and Figure 3).

The mean value of the thickness of the mid-region of the olecranon process in the anterior-posterior direction (T2) in the right ulna was found to be 0.1 mm more than that in the left ulna. The calculated p-value of 0.65, which is greater than the significance level of 0.05, indicates that this difference is statistically insignificant (Table 1 and Figure 3).

The mean value of the length of the ulna in the right arm was found to be 1.5 mm more than that in the left arm. The calculated p-value of 0.03, which is less than the significance level of 0.05, indicates that this difference is statistically significant (Table 2 and Figure 4).

The mean value of the weight of the ulna in the right arm was found to be 0.8 g more than that in the left arm. The calculated p-value of 0.04, which is less than the significance level of 0.05, indicates that this difference is statistically significant (Table 3 and Figure 5).

The mean value of the volume of the articular surfaces of the upper end of the ulna in the right arm was found to be 0.1 cc more than that in the left arm. However, the calculated p-value of 0.57, which is greater than the significance level of 0.05, indicates that this difference is statistically insignificant (Table 4 and Figure 6).

Table 1. Longitudinal Parameter of bone

Side	OCD	T1	T2
Right Ulna (Mean + S.D.)	20.35+2.41	19.93+2.57	17.79+2.28
Left Ulna (Mean + S.D.)	21.20+2.33	18.89+1.99	17.58+2.10
p-value	0.09	0.03	0.65
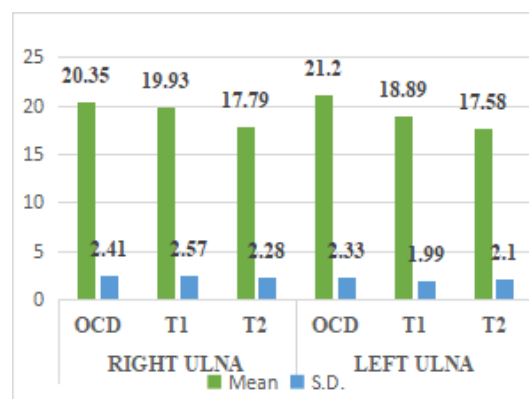
Figure 3. Showing the Mean value and S.D. value of both sided ulna

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Table 2. Length of bone

Side	Length	p-value
Right Ulna (Mean + S.D.)	252 .16 + 17.59	0.03
Left Ulna (Mean + S.D.)	243.92 + 18.87	
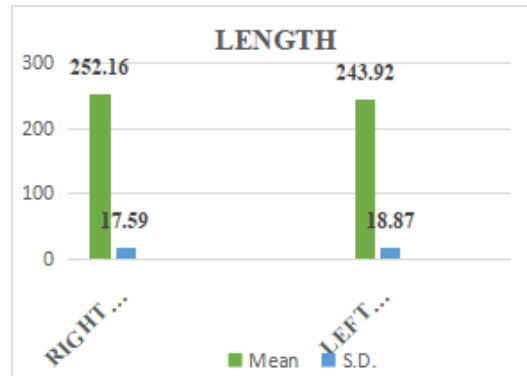
Figure 4. Graph 2: showing the mean and S.D. value of length of ulna

Table 3. Weight of bone

Side	Weight	p-value
Right Ulna (Mean + S.D.)	48.24 + 13.95	0.04
Left Ulna (Mean + S.D.)	42.73 + 12.17	
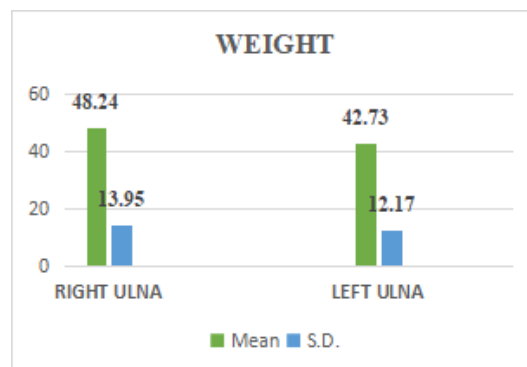
Figure 5. Showing the Mean and S.D. value of weight of ulna

Table 4. Volume of bone

Side	Volume	p-value
Right Ulna (Mean + S.D.)	7.42 ± 2.81	0.57
Left Ulna (Mean + S.D.)	6.13 ± 2.42	
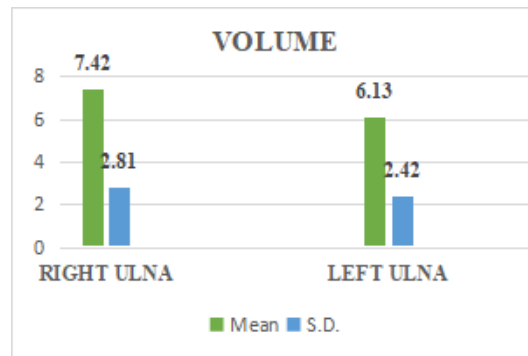
Figure 6. Showing the mean and S.D. value of volume of ulna

5. Discussion

The management of elbow dislocation and fracture requires a good knowledge of its anatomy, which is important for the stability of the elbow. Well-designed implants and appropriate medical techniques are required for the best outcome of fracture management.

The mean value of OCD in the right ulna was found to be less compared to the left ulna. The p-value calculated by t-test was 0.09, which is more than 0.05 (p<0.05) and shows that it is statistically insignificant (Table 1/ Figure 3). In contrast to our study, Al-Imam *et al.,* [5] found a statistically significant difference between the right and left ulna in the Iraqi population. The mean value of OCD of the right ulna was more compared to the left ulna.

The mean value of T1 in the right ulna was found to be more compared to the left ulna. The p-value calculated by t-test was 0.03, which is less than 0.05 (p<0.05), and shows that it is statistically significant (Table 1/ Figure 3). Likewise, the study conducted by Al-Imam *et al.,* [5] in the Iraqi population found that the mean value of T1 of the right ulna was 17.97 ±2.09, and in the left ulna, it was measured 17.71 ±1.37. Its p-value is 0.6, which is considered statistically insignificant.

The mean value of T2 in the right ulna was more compared to the left ulna. It indicates that there was a statistically insignificant difference between both sides of the ulna, as the p-value found to be 0.65, which is more than 0.05 (p<0.05) (Table 1/ Figure 3). In another study conducted by Al-Imam *et al.,* [5] in the Iraqi population, the mean value of T2 of the right ulna was more compared to the left ulna. Its p-value is 0.75, which shows that it is statistically insignificant. In the study conducted by Jaskaran Singh *et al.,* [7] in the north Indian population, the mean value of the right ulna was 17.6 mm, and the mean value of the left ulna was 17.2 mm. The findings of both studies support the findings of our study. The findings of this study will help in designing the implant for the fracture.

The mean value of length in the right ulna was found to be more than the left ulna. The p-value calculated was 0.03, which is less than 0.05 (p value<0.05) and shows that it is statistically significant (Table 2/ Figure 4). Likewise, the study conducted by Al-Imam *et al.,* [5] in the Iraqi population found that the mean value of length of the right ulna was 246.50 ± 18.44 (mm), and in the left ulna, it was measured 245.89 ±16.59 (mm). In the study conducted by Jaskaran Singh *et al.,* [7] in the north Indian population, the mean value of the right ulna was 261.06 mm, and the mean value of the left ulna was 261.06 mm and mean value of left ulna was 261.22 mm. In another study conducted by Humara Gul *et al.,* [8] mean ulna length of male students was more (274±21.3mm) in comparison to mean ulna length of female students (247±14.3mm). Its p value was <0.001 which is highly significant. These finding will help biomedical engineers for manufacturing of prosthetic so that they can make proper size of prosthetics which will be useful for fixation. If the implant will be short then there will be less stability and if size is large it causes damage to the surrounding tissues.

The mean value of weight in right ulna was found to be more in comparison to left ulna. P-value was 0.04 which is less than 0.05 showing that it is statistically significant (Table 3/ Figure 5). In another study conducted by Al Imam *et al.,* [5] in the Iraqi Population, the mean value of weight of right ulna was also more than left ulna. Its p value is 0.180 which shows that it is statistically in-significant. These finding will help biomedical engineers for manufacturing of prosthetic.

The mean value of volume in right ulna was more than left ulna. P-value as calculated by t-test was 0.57 which is more than 0.05 shows that it is statistically insignificant (Table 4/ Figure 6). In another study conducted by Al-Imam *et al.,* [5] in the Iraqi Population the mean value of volume of right ulna was less than left ulna. The p value of 0.67 confirms statistically insignificant result. Malone P S *et al.,* [9] had also conducted a similar type of study and they calculated bone volume using water displacement technique and the mean average of volume of ulna was found to be 28ml. Their difference was statistically significant. These findings are important as it will help in designing of prosthetic.

6. Conclusion

This study is similar to the study conducted by Ahmad-Al Imam on Iraqi population. Present study is conducted on the north west Indian population and same method was used as for Iraqi population. Present study was done on the articular surface of upper end of ulna. In this study statistically significant difference is found in relation to the T1, length, volume, weight between right and left ulna.

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Conflicts of Interest: "Authors declare that they do not have any conflict of interests."

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