






## Morphometric analysis of proximal ulna: An anatomical study

### *Proksimal ulnanın morfometrik analizi: Anatomik bir çalışma*

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### ABSTRACT

**Aim:** To investigate proximal ulna morphometry through a detailed analysis of 107 dry ulnae and to assert its possible clinical relevance.

**Materials and Methods:** A total of 107 (52 left, 55 right) dry ulnae were evaluated. The ulna lengths, olecranon, and trochlear measurements were performed. All measurements were carried on with a 0.01 mm sensitive digital caliper.

**Results:** The mean ulna length and ulna length excluding trochlear notch were 261.17±43.07 mm and, 232.37±43.17 mm, respectively. The mean posterior olecranon height, middle olecranon height, and anterior olecranon height were obtained as 24.05±2.36 mm, 17.80±1.70 mm, and 35.15±3.60 mm, respectively. The mean olecranon width was 23.20±2.79 mm. Moreover, the mean trochlear notch width, radial trochlear notch width, and ulnar trochlear notch width were 22.79±2.81 mm, 24.80±2.69 mm, and 30.14±3.05 mm, respectively. The mean radial trochlear height, ulnar trochlear height were 13.45±2.26 mm and 14.69±2.23 mm, respectively. Lastly, the mean radial notch height, radial notch width, radial notch-olecranon posterior, and radial notch-olecranon anterior were measured as 11.15±1.94 mm, 18.02±2.60 mm, 12.91±2.92 mm, and 30.94±4.62 mm, respectively.

**Conclusion:** The findings of current study may be useful in the application of dorsal plates, intramedullary screw fixation and anatomically pre-shaped plates for the management of proximal ulna fractures.

**Keywords:** Anatomy, ulna, morphometry, olecranon

### ÖZ

**Amaç:** Yüz yedi kuru ulnanın detaylı analizi ile proksimal ulna morfometrisinin araştırılması ve olası klinik öneminin ortaya konulması.

**Gereç ve Yöntem:** Toplam 107 (52 sol, 55 sağ) kuru ulna değerlendirildi. Ulna uzunlukları, olecranon ve troklear ölçümleri yapıldı. Tüm ölçümler 0,01 mm hassasiyetli dijital kumpas ile gerçekleştirildi.

**Bulgular:** Ortalama ulna uzunluğu ve troklear çentik hariç ulna uzunluğu sırasıyla 261,17±43,07 mm ve 232,37±43,17 mm idi. Ortalama posterior olecranon yüksekliği, orta olecranon yüksekliği ve anterior

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olecranon yüksekliği sırasıyla  $24,05\pm 2,36$  mm,  $17,80\pm 1,70$  mm ve  $35,15\pm 3,60$  mm olarak elde edildi. Ortalama olecranon genişliği  $23,20\pm 2,79$  mm idi. Ayrıca, ortalama troklear çentik genişliği, radyal troklear çentik genişliği ve ulnar troklear çentik genişliği sırasıyla  $22,79\pm 2,81$  mm,  $24,80\pm 2,69$  mm ve  $30,14\pm 3,05$  mm idi. Ortalama radial troklear yükseklik  $13,45\pm 2,26$  mm, ulnar troklear yükseklik ise  $14,69\pm 2,23$  mm idi. Son olarak, ortalama radyal çentik yüksekliği, radyal çentik genişliği, radyal çentik-olecranon posterior ve radyal çentik-olecranon anterior sırasıyla  $11,15\pm 1,94$  mm,  $18,02\pm 2,60$  mm,  $12,91\pm 2,92$  mm ve  $30,94\pm 4,62$  mm olarak ölçüldü.

**Sonuçlar:** Çalışmamızın bulguları proksimal ulna kırıklarının tedavisinde dorsal plakların, intramedüller vida fiksasyonunun ve anatomik olarak önceden şekillendirilmiş plakların uygulanmasında yararlı olabilir.

**Anahtar Kelimeler:** Anatomi, ulna, morfometri, olecranon

## INTRODUCTION

The elbow joint, which includes the proximal ulna as well, represents a complex anatomical structure that is integral to the mechanical linkage of the upper extremity, connecting the hand, wrist, and shoulder. It plays a critical role in hand positioning for fine motor tasks, strong grasping, and functioning as a fulcrum for the forearm. Any loss of elbow functionality can severely impact an individual's ability to perform daily tasks. Therefore, understanding the unique anatomy of the proximal ulna is essential for proper assessment and surgical management (1, 2).

Fractures of the proximal ulna vary from uncomplicated transverse olecranon fractures to the more intricate Monteggia fractures. These fractures have an overall prevalence of 1.1% and represent about 21% of all proximal forearm fractures (3). While these fractures are common across all ages, an increase in incidence is noted in the seventh decade, with a maximum occurrence in the ninth decade (4). Achieving accurate anatomical restoration of the proximal ulna is recognized as a fundamental objective in patients with proximal ulna fractures. This restoration depends on a thorough understanding of anatomical characteristics of the proximal ulna (2, 5-9).

At present, proximal ulna fractures are managed using various techniques such as traditional tension band fixation, K-wire or screw-assisted tension band methods, intramedullary nail fixation, and open reduction with internal plate fixation (6, 7, 10, 11). However, the unique structure of the proximal ulna challenges both the surgeons and the radiologists, particularly in terms of the proper fitting of anatomically pre-shaped plates (7, 12-17). In this regard, in-depth knowledge of the proximal ulna anatomy and morphometric

variabilities is of critical importance for the precise reduction and stable fixation counting on implants that suit the fracture pattern (2, 6-8, 15, 16, 18, 19).

Although the anatomy of the proximal ulna has been studied in several anatomical, radiological, and cadaveric studies, there is still a need for a greater understanding of its morphometric properties (2, 14, 17, 20). Consequently, this study aimed to investigate proximal ulna morphometry through a detailed analysis of 107 dry ulnae and to assert its possible clinical relevance.

## MATERIALS and METHODS

A total of 107 (52 left, 55 right) well-preserved dry ulnae without age, sex, and race information were investigated at the Department of Anatomy in Istanbul University Faculty of Medicine. None of them had structural deformity or fracture that would likely affect morphometric measurements. The study was approved by the İstanbul University Faculty of Medicine Clinical Research Ethics Committee (Institutional Review Board: 2021/1104).

Sixteen measurements, as described below, were carefully taken from each ulna.

**1-Ulna Length (UL):** The shortest distance between the transverse lines passing through the most proximal and most distal tips of the ulna (Figure-1a).

**2-Ulna length excluding trochlear notch (UL-T):** The shortest distance between the transverse lines passing through the tips of the styloid and coracoid processes (Figure-1a).

**3-UL-small:** The shortest distance between the transverse lines passing through the tip of the coracoid process and the most proximal point of the ulna (The length of the proximal ulna located above the coronoid process level) (Figure-1a).

**4-Posterior Olecranon Height (POH):** The shortest distance between the upper end of the trochlear notch and the axis of the posterior cortex of the olecranon (Figure-1c).

**5-Middle Olecranon Height (MOH):** The shortest distance between the deepest point of the trochlear notch and the axis of the posterior cortex of the olecranon (Figure-1c).

**6-Anterior Olecranon Height (AOH):** The shortest distance between the lower end of the trochlear notch (the most anterior point of the coracoid process) and the axis of the posterior cortex of the olecranon (Figure-1c).

**7-Olecranon Width (OW):** The widest distance between the medial and lateral borders of the Olecranon in the sagittal plane (Figure-1d).

**8-Trochlear Notch Width (TW):** The distance between the closest proximal and distal ends of the trochlear notch in the sagittal plane (Figure-1b).

**9-Radial Trochlear Notch Width (RTW):** The widest distance between the proximal and distal ends of the trochlear notch on the radial side (Figure-1b).

**10-Ulnar Trochlear Notch Width (UTW):** The widest distance between the proximal and distal ends of the trochlear notch on the ulnar side (Figure-1b).

**11-Radial Trochlear Height (RTH):** The shortest distance between the most posterior point of the radial edge of the trochlear notch and the axis of the posterior cortex of the olecranon (Figure-1e).

**12-Ulnar Trochlear Height (UTH):** The shortest distance between the most posterior point of the ulnar edge of the trochlear notch and the axis of the posterior cortex of the olecranon (Figure-1f).

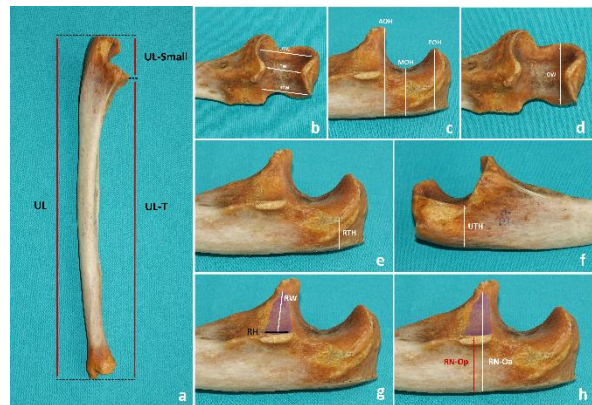
**13-Radial Notch Height (RH):** The shortest distance between the sagittal lines passing through the proximal and distal ends of the radial notch (Figure-1g).

**14-Radial Notch Width (RW):** The shortest distance between vertical lines passing through the anterior and posterior ends of the radial notch (Figure-1g).

**15-Radial notch - Olecranon Posterior (RN-Op):** The shortest distance between the most posterior point of the radial notch and the axis of the posterior cortex of the olecranon (Figure-1h).

**16-Radial notch - Olecranon Anterior (RN-Oa):** The shortest distance between the most anterior point of the radial notch and the axis of the posterior cortex of the olecranon (Figure-1h).

Width and length measurements were performed with a 0.01 mm sensitive digital caliper (INSIZE Co., Ltd., Taiwan). The measurements were performed separately by two experienced researchers, and the average of the two measurements was considered as the final value. If a measurement difference exceeding 10% was detected between the two researchers, the respective measurement was repeated to ensure consistency.



**Figure-1.** Demonstration of the proximal ulna morphometric measurements (left)

**a** UL: Ulna length; the shortest distance between the transverse lines passing through the most proximal and most distal tips of the ulna. UL-small: the length of the proximal ulna located above the coronoid process level; UL-T: the shortest distance between the transverse lines passing through the tips of the styloid and coracoid processes, medial view, left. The dotted black lines at the upper and lower ends of the ulna describe the level passing horizontally through these ends. The dotted black line between said lines defines the level passing horizontally through coronoid process.

**b** UTW: Ulnar trochlear notch width; the widest distance between the proximal and distal ends of the trochlear notch on the ulnar side; TW: Trochlear notch width; the distance between the closest proximal and distal ends of the trochlear notch in the sagittal plane; RTW: Radial trochlear notch width; the widest distance between the proximal and distal ends of the trochlear notch on the radial side, superior view, left.

**c** POH: Posterior olecranon height; the shortest distance between the upper end of the trochlear notch and the axis of the posterior cortex of the olecranon; MOH: Middle olecranon height; the shortest distance

between the deepest point of the trochlear notch and the axis of the posterior cortex of the olecranon; AOH: Anterior olecranon height; the shortest distance between the lower end of the trochlear notch (the most anterior point of the coracoid process) and the axis of the posterior cortex of the olecranon, lateral view, left.

**d** OW: Olecranon width; the widest distance between the medial and lateral borders of the olecranon in the sagittal plane, superior view, left.

**e** RTH: Radial trochlear height; the shortest distance between the most posterior point of the radial edge of the trochlear notch and the axis of the posterior cortex of the olecranon, lateral view, left.

**f** UTH: Ulnar trochlear height; the shortest distance between the most posterior point of the ulnar edge of the trochlear notch and the axis of the posterior cortex of the olecranon, medial view, left.

**g** RH: Radial notch height; the shortest distance between the sagittal lines passing through the proximal and distal ends of the radial notch, RW: Radial notch width; the shortest distance between vertical lines passing through the anterior and posterior ends of the radial notch, lateral view, left.

**h** RN-Op: Radial notch-olecranon posterior; the shortest distance between the most posterior point of the radial notch and the axis of the posterior cortex of the olecranon; RN-Oa: Radial notch - olecranon anterior; the shortest distance between the most anterior point of the radial notch and the axis of the posterior cortex of the olecranon, lateral view, left. The white double-headed arrow indicates RN-Oa, and the red double-headed arrow shows RN-Op.

### Statistical analysis

Data analysis was performed using IBM SPSS Statistics version 21.0. Due to the unknown sex of

the ulnae and the uncertainty regarding whether paired bones originated from the same individual, comparative analysis based on sex or side was not feasible. The Shapiro-Wilk test was applied to assess the normality of variable distributions. Descriptive statistics, including means and standard deviations, were calculated for continuous variables. These variables were presented as both mean  $\pm$  standard deviation and median (minimum–maximum) values, depending on distribution characteristics. Categorical variables were summarized using frequencies (n) and percentages (%).

### RESULTS

For the ulna measurements, the mean UL, UL-T, and UL-small were 261.17 $\pm$ 43.07 mm, 232.37 $\pm$ 43.17 mm, and 28.81 $\pm$ 3.51 mm, respectively. Similarly, for the olecranon measurements, the mean POH, MOH, and AOH were obtained as 24.05 $\pm$ 2.36 mm, 17.80 $\pm$ 1.70 mm, and 35.15 $\pm$ 3.60 mm, respectively. Also, the mean OW was 23.20 $\pm$ 2.79 mm.

For the trochlear notch, the mean TW, RTW, and UTW were 22.79 $\pm$ 2.81 mm, 24.80 $\pm$ 2.69 mm, and 30.14 $\pm$ 3.05 mm, respectively. Additionally, the mean RTH, UTH were 13.45 $\pm$ 2.26 mm and 14.69 $\pm$ 2.23 mm, respectively. Lastly, for the radial notch, the mean RH, RW, RN-Op, and RN-Oa were measured as 11.15 $\pm$ 1.94 mm, 18.02 $\pm$ 2.60 mm, 12.91 $\pm$ 2.92 mm, and 30.94 $\pm$ 4.62 mm, respectively. Table-1 shows the detailed results for each evaluated parameter in terms of sides.

**Table-1.** Morphometric data of the proximal ulna in terms of side.

<b>General ulna measurements</b>		
	<b>Left (n=52)</b>	<b>Right (n=55)</b>
<b>Parameters (mm)</b>	<b>Mean<math>\pm</math>SD (mm)</b>	<b>Mean<math>\pm</math>SD (mm)</b>
<b>UL</b>	262.88 $\pm$ 41.31	259.56 $\pm$ 44.98
<b>UL-T</b>	234 $\pm$ 41.75	230.82 $\pm$ 44.8
<b>UL-small</b>	28.88 $\pm$ 3.96	28.74 $\pm$ 3.06
<b>Olecranon measurements</b>		
	<b>Left (n=52)</b>	<b>Right (n=55)</b>
<b>Parameters (mm)</b>	<b>Mean<math>\pm</math>SD (mm)</b>	<b>Mean<math>\pm</math>SD (mm)</b>
<b>POH</b>	23.7 $\pm$ 2.15	24.38 $\pm$ 2.52
<b>MOH</b>	17.99 $\pm$ 1.72	17.63 $\pm$ 1.69

AOH	35.40±3.77	34.9±3.44
OW	23.29±3.06	23.12±2.54

#### **Trochlear notch measurements**

	Left (n=52)	Right (n=55)
Parameters (mm)	Mean±SD (mm)	Mean±SD (mm)
TW	22.5±2.79	23.06±2.82
RTW	24.76±2.62	24.85±2.78
UTW	30±2.84	30.27±3.25
RTH	13.66±2.37	13.25±2.16
UTH	14.40±1.93	14.97±2.47

#### **Radial notch measurements**

Parameters (mm)	Mean±SD (mm)	Mean±SD (mm)
RH	11.41±1.95	10.9±1.9
RW	18.37±3	17.69±2.14
RN-Op	12.91±2.75	12.91±3.09
RN-Oa	31.29±4.97	30.6±4.28

UL: Ulna length; UL-T: Ulna length excluding trochlear notch; UL-small: The length of the proximal ulna located above the coronoid process level; SD: Standard deviation; POH: Posterior olecranon height; MOH: Middle olecranon height; AOH: Anterior olecranon height; OW: Olecranon width; TW: Trochlear notch width; RTW: Radial trochlear notch width; UTW: Ulnar trochlear notch width; RTH: Radial trochlear height; UTH: Ulnar trochlear height; RH: Radial notch height; RW: Radial notch width; RN-Op: Radial notch - olecranon posterior; RN-Oa: Radial notch - olecranon anterior; mm: millimeter.

## **DISCUSSION**

In this detailed morphometric study, a total of 16 parameters were measured in 107 ulnae (55 right, 52 left). These measurements included ulna length (UL, UL-T, and UL-small), olecranon measurements (POH, MOH, AOH, and OW), trochlear notch width (TW, RTW, and UTW), trochlear height (RTH and UTH), and radial notch measurements (RH, RW, RN-Op, and RN-Oa).

### **General ulna measurements**

A brief literature review of proximal ulna measurements conducted over the last twenty years is presented in Table-2 (6, 7, 15, 21-29). According to this table, it is seen that the average UL varies between 230.1±15 mm and 261±19 mm, and the average UL-T varies between 217.8±18.5 mm and 223.49±15.52 mm in different studies. On the other hand, no study specifically measuring the UL-small could be identified. In the current paper, the mean UL, UL-T, and UL-small were measured as 261.17±43.07 mm, 232.37±43.17 mm, and 28.81±3.51 mm, respectively. Our UL is almost the same as the results of some previous

studies (23-25); however, UL-T and UL-T are not consistent with the previous reports (6, 26, 29). The difference in sample size may be the reason for this inconsistency.

### **Olecranon measurements**

In our study, the mean POH, MOH, and AOH were calculated as 24.05±2.36 mm, 17.80±1.70 mm, and 35.15±3.60 mm, respectively. Similarly, the mean OW was obtained as 23.20±2.79 mm. Some researchers have defined the POH value as 'olecranon height' (Table-2) (15, 21, 28). The lowest mean POH was reported in a radiological study by Hopf et al. (23.6±3.2 mm), while the highest was stated in their radiological study by Wadia et al. (26.2±2.01 mm) (15, 21). In the study of Beşer et al., this value was noted as 24.6±2.6 mm, which is almost the same as the results of our study (6).

The only study reporting the MOH value in the literature review was conducted by Beşer et al., and in that study, the mean MOH was 17.3±1.3 mm (6). Our result is consistent with the result of that research.

It is seen that researchers report different values for mean AOH (Table-2). They also characterized this parameter with different names, such as 'coronoid height' and 'height of the tip of the coronoid' (15, 25, 27). Monum et al. reported that the mean AOH was  $35.32 \pm 1.90$  mm for the left side and  $35.31 \pm 2.02$  mm for the right side in males. Similarly, they recorded the value  $31.59 \pm 1.82$  mm for the left side,  $31.63 \pm 1.82$  mm for the right side in females (27). The AOH value in this study is very similar to the result for males in the study of Monum et al. (27). However, as the gender of the specimens used in this study remains unknown, any association of this fit with a specific gender cannot be established.

The OW has been reported in several studies, however, no consensus exists among the researchers (6, 22, 27-29). The study by Beşer et al. calculated this value as  $23.1 \pm 2$  mm, and the OW in the study is compatible with this result (6).

#### **Trochlear notch measurements**

Regarding the trochlear notch measurements, there is very limited research in the literature (Table-2).

The mean TW, RTW, and UTW were reported as  $22.3 \pm 1.9$  mm,  $24.4 \pm 2.4$  mm, and  $29.4 \pm 2.7$  mm, respectively, in the study of Beşer et al. (6). Additionally, the mean RTH and UTH were  $16.2 \pm 1.8$  mm and  $15.8 \pm 1.7$  mm, respectively (6). Aydın Kabakçı et al. measured only the mean TW, RTW, and UTW and calculated these parameters as  $22.57 \pm 2.43$  mm,  $25.35 \pm 2.72$  mm, and  $22.36 \pm 2.05$  mm, respectively (29). In the present study, the mean TW, RTW, and UTW were  $22.79 \pm 2.81$  mm,  $24.80 \pm 2.69$  mm, and  $30.14 \pm 3.05$  mm, respectively. Similarly, the mean RTH and UTH were  $13.45 \pm 2.26$  mm and  $14.69 \pm 2.23$  mm, respectively. The vast majority of our trochlear notch measurements are consistent with the results of two previous studies. Nevertheless, the RTH is not constant to the result reported by Beşer et al. (6). This discrepancy may be caused by different sample sizes.

#### **Radial notch measurements**

For radial notch measurements, Beşer et al. measured the mean RH, RW, RN-Op, and RN-Oa, and they reported these values as  $9.9 \pm 1.1$  mm,  $14.8 \pm 1.7$  mm,  $17.3 \pm 1.7$  mm, and  $27.9 \pm 2.4$  mm, respectively (6). Öztürk et al. examined only RH and RW, and they found that the mean RH and RW were  $12.09 \pm 1.70$  mm and  $18.50 \pm 3.38$  mm,

respectively (26). Similarly, Aydın Kabakçı et al. stated that the mean RH and RW were  $9.69 \pm 1.64$  mm and  $15.22 \pm 2.18$  mm, respectively (29). In the current study, the mean RH, RW, RN-Op, and RN-Oa were  $11.15 \pm 1.94$  mm,  $18.02 \pm 2.60$  mm,  $12.91 \pm 2.92$  mm, and  $30.94 \pm 4.62$  mm, respectively. Our RH and RW are compatible with the result of Öztürk et al., whereas the RN-Op and RN-Oa are inconsistent with the result of Beşer et al. (26, 29). The different sample sizes between the two studies may explain the discrepancy.

#### **Clinical relevance**

Olecranon fractures, typically caused by either direct or indirect trauma, have consistently presented significant treatment challenges (30, 31). Displaced fractures of the proximal ulna require surgical intervention for proper stabilization. All anatomical features, including the shape and size of the proximal ulna, are key factors in determining the stability of fixation and the outcome of functional recovery (32). Therefore, a comprehensive understanding of the anatomical aspects of the proximal ulna is essential.

Proximal ulna fractures can be treated using several methods, including tension band wiring, K-wire or screw tension bands, intramedullary nailing, and plate fixation (6, 7, 10, 11, 32). The length of the dorsal plates and intramedullary screws is important for the reconstruction of the fracture (32). The mean values identified in this study may aid in guiding the appropriate sizing of dorsal plates and intramedullary screw fixation.

The effectiveness of a fixation device increases with its conformity to the bone's natural shape (32). Anatomically pre-shaped plates designed for the proximal ulna have been found to deviate significantly from the actual anatomical structure of the bone (2). From this standpoint, mean values related to the proximal ulna in this study could serve as a useful reference for designing plates that more accurately conform to the anatomy of the proximal ulna.

As the primary aim of surgical treatment is to achieve normal anatomical restoration of the ulna while preserving elbow joint function (5), the overall findings from this study on the proximal ulna may be considered useful in guiding reconstruction procedures.

**Limitations of the study:** This study has several significant limitations. First, the sample size was

relatively small, which may reduce the strength and applicability of the findings. Second, the gender of the bone samples was not available, and it was uncertain whether both bones came from the same person, making it impossible to compare measurements by gender or side. Lastly, the study did not include the reliability and validity of morphometric evaluations. This might limit the repeatability of our findings. However, the consistency of our findings with existing research adds strength to our conclusions.

**Table-2.** Previous studies and the current study regarding morphometric data of the proximal ulna.

Author	Country	Study design	n	UL (mm)	UL-T (mm)	UL-Small (mm)	POH (mm)	MOH (mm)	AOH (mm)	OW (mm)	TW (mm)	RTW (mm)	UTW (mm)	RTH (mm)	UTH (mm)	RH (mm)	RW (mm)	RN-Op (mm)	RN-Oa (mm)
Wadia et al. (21)	N/A	Radiographs	100 adults (33 males, 67 females)	-	-	-	*26.2±2.01	-	-	-	-	-	-	-	-	-	-	-	-
Keener et al. (22)	USA	Fresh frozen cadaver	36 elbows (13 males, 10 females)	-	-	-	-	-	-	26.9	-	-	-	-	-	-	-	-	-
Beşer et al. (6)	Türkiye	Dry ulna	50 (24 right, 26 left)	250.5 ±14.9	220.5 ±14.4	-	24.6 ±2.6	17.3±1.3	33.1±2.4	23.1±2	22.3±1.9	24.4±2.4	29.4±2.7	16.2±1.8	15.8 ±1.7	9.9±1.1	14.8 ±1.7	17.3 ±1.7	27.9 ±2.4
Singh et al. (23)	North India	Dry ulna	100 (50 right, 50 left)	261.1 ±16.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ndou and Schepartz (24)	South Africa	Dry ulna	1175 paired	261.01±18.77 in Blacks, 258.49±17.33 Whites, 249.23±20.07 in Mixed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Hopf et al. (15)	N/A	CT	100 individuals (60 males, 40 females)	253.6 ±19.9	-	-	*23.6±3.2	-	**36.1±3.9	-	-	-	-	-	-	-	-	-	-
Erdem (7)	Türkiye	Dry ulna	82 (39 right, 43 left)	250.6 ±17.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Walch et al. (25)	R/A	CT	80 cadaveric arms (from 54 males)	261±19	-	-	-	-	***36±4	-	-	-	-	-	-	-	-	-	-
Öztürk et al. (26)	Türkiye	Dry ulna	25 (14 right, 11 left)	251.0 ±16.23	223.49±15.52	-	-	-	-	-	-	-	-	-	-	12.09 ±1.70	18.50 ±3.38	-	-
Monum et al. (27)	Thailand	Dry ulna	200 paired ulnae (100 males, 100 females)	-	-	-	-	-	**For males 35.32±1.90 left, 35.31±2.02 right; for females 31.59±1.82 left, 31.63±1.82 right	For males 24.42±1.77 left, 24.99.2.16 right; for females 20.66 ±1.73 left, 20.62±1.52 right	-	-	-	-	-	-	-	-	-
Wegman et al. (28)	N/A	Preserved cadavers	41 (20 males, 21 females)	230.1 ±15	-	-	*26.7±2.3	-	-	25.3±2.4	-	-	-	-	-	-	-	-	-

Aydın Kabakçı et al. (29)	Türkiye	Dry ulna	62 (26 right, 36 left)	245.9 ±20 (n=50)	217.8 ±18.5 (n=50)	-	-	-	-	25.47±2.76	22.57 ± 2.43	25.35 ±2.72	22.36 ±2.05	-	-	9.69 ±1.64	15.2 ±2.18	-	-
Present study	Türkiye	Dry ulna	107 (55 right, 52 left)	261.17±43.07	232.37±43.17	28.81±3.51	24.05±2.36	17.80±1.70	35.15±3.60	23.20±2.79	22.79 ±2.81	24.80 ±2.69	30.14 ±3.05	13.45 ±2.26	14.69±2.23	11.15±1.94	18.02±2.60	12.91±2.92	30.94±4.62

\*Described as 'olecranon height'. \*\*Described as 'coronoid height'. \*\*\*Described as 'height of the tip of the coronoid'.

The values, except for those in the first four columns, are presented as mean ± standard deviation.

UL: Ulna length; UL-T: Ulna length excluding trochlear notch; UL-small: The length of the proximal ulna located above the coronoid process level; POH: Posterior olecranon height; MOH: Middle olecranon height; AOH: Anterior olecranon height; OW: Olecranon width; TW: Trochlear notch width; RTW: Radial trochlear notch width; UTW: Ulnar trochlear notch width; RTH: Radial trochlear height; UTH: Ulnar trochlear height; RH: Radial notch height; RW: Radial notch width; RN-Op: Radial notch - olecranon posterior; RN-Oa: Radial notch - olecranon anterior; mm: millimeter; N/A: Not applicable.

## CONCLUSION

It is essential to comprehend all anatomical aspects of the proximal ulna anatomy, which exhibits variations among different racial groups. In pursuit of this aim, the morphometry of the proximal ulna was analyzed in a sample of 107 ulnar bones. More detailed anatomical insights are documented in this study compared to earlier

investigations performed in different countries. The findings of this study may be useful in the application of dorsal plates, intramedullary screw fixation and anatomically pre-shaped plates for the management of proximal ulna fractures.

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