International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 23s,2025
https://theaspd.com/index.php

Morphometric Study Of Ulna&It's Proximal Angulations

Dr. Shubhangi R. Mutyal[1*], Dr. Nagaraja V. Pai[2], Dr. Mrinalini P. Wakchaure[3]
[1,3]- Assistant Professors, Department of Anatomy, Topiwala National Medical College, Mumbai
[2]Associate Professor, Department of Anatomy, Topiwala National Medical College, Mumbai
Corresponding author email- shubh.mutyal@gmail.com

Abstract:
Introduction: *The ulna is medial to the radius in the supinated forearm.The ulna in its whole length is slightly convex posteriorly making an anterior angle in the sagittal plane. The proximal ulna shows angulations in the coronal plane on the dorsal surface known as varus angulation. The angle between the posterior and superior surface of olecranon is olecranon angle. The aim of the present study is to provide osteometric data of proximal ulnar angulations and dimensions which will help in designing ulnar plates for reconstruction of proximal ulnar fractures.*
Methods: *Present study was conducted on 23 right and 25 left side dried ulna bones. Angles were measured with a goniometer and other linear parameters with vernier callipers.*
Results: *The mean length of ulna was recorded as 25.9 ± 1.63 cm (right) and 26.07 ± 1.67 cm (left). The mean maximum varus angle was observed as 11.91 ± 2.35^0(right)& 10.21±1.99^0(left)sides. The mean maximum anterior angle was observed as 8.13 ± 2.89^0 and on the left 6.87 ±3.02^0. The mean olecranon angle was 105.95 ± 4.99^0 (right) and 105± 5.98^0 (left). Mean mid shaft thickness was1.33 ± 0.20 cm (right) and 1.46± 0.18cm(left).*
Conclusion: *Considerable variations were found in the parameters measured for the proximal ulna so it is concluded that the data collected in the present study would be of importance in catering the ulnar plates according to the angles and dimensions of ulna.*
Key words: *Morphometry; Proximal ulna; Varus angulation.*

INTRODUCTION:

The ulna is medial to the radius in the supinated forearm. Its proximal end is a massive hook which is concave forwards. In its whole length it is slightly convex posteriorly. Mediolaterally, its profile is sinuous. The proximal half has a slight laterally concave curvature, and the distal half a medially concave curvature [1].

Fractures of proximal ulna are more complex and anatomical reduction is necessary. Surgical management has long been considered the gold standard in the management of displaced fractures with non-surgical management being considered only for non-displaced fractures with an intact extensor mechanism [3].If the fragments are not displaced, a simple splint immobilizing the forearm and preventing the elbow joint movements is adequate for rehabilitation.The proximal and upper thirds of the ulnar fractures are surgically treated with open reduction and internal fixation. The displaced proximal ulnar and the olecranon fractures are mostly stabilized by dorsal plates [2]. Commercially manufactured implants are mostly compatible with the dorsal surface of the proximal ulna. However, the unique structure of the proximal ulna challenges both the surgeons and the radiologists. Anatomically curve-shaped architecture of proximal ulna affects the functional recovery due to use of pre-curved dorsal plates. Another important issue is the diameter of the ulnar cavity and the thickness of the cortical bone at proximal ulnar angulations [4,5]. Having detailed knowledge of the wall thickness and diameter of the cavity at angulations, present Proximal ulnar measurements play a key role in implant design and surgical interventions [5].

MATERIALS & METHOD:

Study design: Descriptive cross-sectional observational study.
Place of study The Present study was conducted in the Department of Anatomy, Topiwala National Medical College, Mumbai.
Sample size: A total of 48 dry ulna bones (23 right, 25 left) were analysed, irrespective of age &gender.
Inclusion Criteria:

- Adult human right and left ulnae with intact articular surfaces.
- Specimens without visible deformities, fractures, or pathological changes.

Exclusion Criteria:

- Ulnae with congenital anomalies or malformations.
- Bones with fractures, erosion, or degenerative changes.

- Incomplete or damaged specimens unsuitable for accurate measurement.

Following parameters were measured on ulna-

1. Total length (UL)
2. Maximum varus angulation (MVA)
3. Maximum anterior angle (MAA)
4. Distance between MVA & Mid-point of Ulna (MB)
5. Distance between MAA to MB
6. Thickness of bone at midpoint (MPBT)
7. Olecranon length (OL)
8. Olecranon thickness at trochlea (OT)
9. Olecranon angle (OA)

For calculation of MVA (Fig.1)- Initially, the imaginary point of maximum varus angulation (iPMVA) of ulna on its dorsal surface was observed and marked. Then the four points were located on the dorsal surface of the proximal ulna. Out of four points, two points proximal to the imaginary point and two distal to it.

Point 1-marked at the tip of the olecranon process

Point 2- at the mid distance from tip (Point 1) to the imaginary point

Point 3- marked at the midpoint of length of ulna

Point 4- at the mid distance between Point 3 and the imaginary point

The two long axes of ulna were drawn, first passing through the proximal two points of iPMVA and the second one passing through the distal two points of iPMVA. The angle thus obtained at the intersection was measured as MVA & the point obtained was marked as dPMVA.

For calculation of MAA (Fig.2)- The point of anterior angle (PAA) was located by seeing the bone from its lateral aspect and finding the maximum dorsal curve of ulna. The maximum anterior angle (MAA) was measured keeping the two arms of the goniometer parallel to the surfaces proximal and distal to the PAA.

Olecranon length (OL)- The olecranon length was measured as distance between most proximal point on the dorsal surface of ulna & most anterior point of the superior rough surface of olecranon.

The distances from the mid-point of ulna (MB) to the dPMVA and PAA points were measured respectively.

The olecranon angle (OA)(Fig.2)- was measured between dorsal and superior surfaces of the olecranon process by keeping the one arm of the goniometer parallel to the superior surface of olecranon and the other arm was placed parallel to the dorsal surface.

The thickness of the bone(Fig.3) was measured anterio-posteriorly (in sagittal plane) at right angle to the long axis of the bone at following points-

1.at the **trochlear notch (OT)** level where the distance was minimum and

2.at the **mid-point of the ulna(MPBT)**.

The above distances were measured thrice and the mean of that was recorded for statistical analysis. Mean, SD were calculated for all the parameters and tabulated.

The angles were measured using manual goniometer & linear parameters were measured with digital Vernier calliper with 0.01mm accuracy.

Fig. 1. Measurement of Ulnar length (UL) & Maximum varus angulation (MVA)

Fig. 2. Measurements of Maximum anterior angulation (MAA) & Olecranon angle (OA)

Fig. 3. Measurements of Olecranon thickness at trochlea (OT) & Thickness of bone at midpoint (MPBT)

RESULTS:

Parameter	Right side Mean ± SD	Left side Mean ± SD
Total length (UL)	25.9±1.63	26.07± 1.67
MVA	11.91±2.35	10.21±1.99
MAA	8.13±2.89	6.87±3.02
Distance between dPMVA & MB	4.49±0.50	4.29±0.50
Distance between PAA & MB	3.47±0.85	3.22±0.88
MPBT	1.33±0.20	1.46±0.18
Olecranon length (OL)	1.89± 0.38	1.87 ±0.42
Olecranon thickness at trochlea (OT)	1.94± 0.38	1.91±0.36
Olecranon angle (OA)	105.95±4.99	105±5.98

Table no.1. Measurements of Proximal ulna distances & angulations, SD = Standard Deviation

Linear parameters were in centimetres & angles were measured in degrees

A total of 48 dry adult human ulnae (23 right, 25 left) were examined for morphometric analysis. The mean UL was nearly identical on both sides: 25.9 ± 1.63 cm (right) and 26.07 ± 1.67 cm (left). The overall UL ranged from 23cm to 29 cm.

Angular measurements showed a mean MVA of 11.91 ± 2.35° on right & 10.21±1.99^0 on left side, indicating that the angle is slightly higher on the right side. The MAA averaged 8.13 ± 2.89° (right) and 6.87 ±3.02^0(left). The OA was consistent across sides, with a mean of 105 ± 4.99° (right) and 105± 5.98 (left).

Key anatomical distances showed slight side-to-side variation. Distances between dPMVA & MBwere 4.49± 0.50cm (right) and 4.29± 0.05cm (left) and those of PAA &MB were 3.47 ± 0.85cm (right) and 3.22 ± 0.88cm(left) respectively.
Olecranon measurements revealed a mean OLas 1.89 ± 0.38cm (right) and 1.87± 0.42cm (left). Mean OTwas observed as 1.94 ± 0.38cm(right) and 1.91 ± 0.36 cm (left)respectively. MPBT was 1.33 ± 0.20 cm (right) and 1.46± 0.18cm(left).

DISCUSSION:

	Young WJ et al [7]	**Totlis T et al [10]**		**Puchwein P et al [8]**	**Jaskaran Singh et al [6]**		**Present study**	
Parameter	-	Right side mean ± SD	Left side mean ± SD	-	Right side mean ± SD	Left side mean ± SD	Right side mean ± SD	Left side mean ± SD
UL	-	-	-	-	26.10± 1.75	26.12±1.65	25.9±1.63	26.07± 1.67
MVA	10.78	8.51± 2.21	8.48±2.60	14.38	11.68±2.44	9.88±2.27	11.91±2.35	10.21±1.99
MAA	4.38	8.63± 2.57	8.36±2.81	6.28	8.44±2.27	7.68±3.08	8.13±2.89	6.87±3.02
Distance between dPMVA & MB	-	-	-	-	5.05±0.54	4.76±0.83	4.49±0.50	4.29±0.50
Distance between PAA & MB	-	-	-	-	3.87±0.99	3.50±0.91	3.47±0.85	3.22±0.88
MPBT	-	-	-	-	1.23±0.18	1.40±0.25	1.33±0.20	1.46±0.18
OL	-	1.60± 0.16	1.57±0.18	-	1.40±0.27	1.36±1.21	1.89± 0.38	1.87 ±0.42
OT	1.97 cm	-	-	1.88 cm	1.76±0.32	1.72±0.32	1.94± 0.38	1.91±0.36
OA	-	110.85±6.37	109.83±6.38	95.38	103.78±5.69	102.32±4.61	105.95±4.99	105±5.98

Table. 2. Comparative measurements of proximal ulna in different studies

Linear parameters are mentioned in centimetres & angles in degrees.
Total 48 ulna bones were studied, in which 23 were right and 25 were left sided. The mean UL was observed as 25.9 ± 1.63 cm (right) and 26.07 ± 1.67 cm (left). The mean UL is similar to study conducted by Jaskaran Singh et al [6].
In the present study the mean MVA was found as 11.91 ± 2.35^0 (right) and 10.21 ± 1.99^0 (left). Similar findings have been reported by Jaskaran et al [6] on dry bones and Yong WJ et al [7] on CT study of 20 cadavers. Few previous studies reported a higher MVA as in the case of Puchwein P et al [8]. Windisch G et al [9] reported mean MVA as 14.38^0 (right) and 17.78^0 (left). Grechenig W et al [4] also supports the findings of Windisch G et al [9] with the mean MVA of 17.58^0 in 54 cadaveric samples.
MAA of the proximal ulna in the present study was found as 8.13 ± 2.89^0 (right) and 6.87 ± 3.02^0 (left), which is higher than the other studies. According to Yong WJ et al [7], mean MAAwas 4.38^0 which is very

less as compared to present study. In this series only the finding of the Puchwein P et al [8] which was 6.28^0 and that of Jaskaran Singh et al [6] which was 8.44 ± 2.27^0 (right) and 6.87 ± 3.02^0 (left) were found close to the mean value of the present study.
In present study the mean OA was observed as 105.95 ± 4.99^0 (right) and 105 ± 5.98^0 (left). The OA reported by Puchwein P et al [8] was 95.38^0. A study by Totilis T et al [10] reported the mean OA was 110.380^0.
The mean OL was observed as 1.89± 0.38cm (right) and 1.87 ±0.42cm (left) in the present study which is slightly higher as compared to the study reported by Totilis T et al [10] which was 1.58 cm.
In the present study the distance betweenPMVA&MB was found as 4.49±0.50(right) and4.29±0.50 (Left) & distance between PAA & MB was found 3.47±0.85cm (right) and 3.22±0.88cm (left) respectively, which would be useful in deciding the length of the part of the ulnar plate which is parallel to the ulnar shaft.
The OT was 1.94 ± 0.38cm(right) and 1.91 ± 0.36 cm (left) respectively. MPBT was 1.33 ± 0.20 cm (right) and 1.46± 0.18cm(left) respectively. These values may be less due to variation in the deciding the point of measurement.
There are considerable variations in the parameters measured for the proximal ulna, especially the angulations. The present study is one of the few studies conducted on Indian samples. Thus,the data collected in the present study would be of importance in catering the ulnar plates according to the angles and dimensions of ulna found in Indian population.

CONCLUSION:

During intraoperative procedures for fractured proximal ulna the prosthetic plates are used which may need bending to suit patients' needs. But these plates cannot bend unlimitedly. The anatomical preshaped plates should follow the averages of normal ulna to reduce the amount of intraoperative bending. The absence of side-to-side difference allows surgeons to preoperatively estimate the degree and the point of intraoperative bending of a plate, if required, using a radiograph of the unaffected elbow, in case of fracture reduction. The great range of ulnar angulation values imply that anatomical preshaped olecranon plates should have a less rigid design, easier to bend in both planes. Present study would be of importance in catering the ulnar plates according to the angles and dimensions of ulna.
The proximal ulnar morphometry may help in designing and modifying prosthesis and preshaped ulnar implants and also can contribute to the knowledge of surgeons, radiologists, anthropologists and the anatomists. Although considerable variations in proximal ulnar measurements makes it necessary to conduct more studies on large numbers of samples in different geographical areas.

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