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MORPHOMETRIC STUDY OF DISTAL END OF ULNA AND ITS CLINICAL IMPLICATIONS RELATED TO DISTAL RADIO-ULNAR JOINTS INJURIES

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Abstract: The anatomical arrangement and articulation between the lower end of ulna and radius and the carpus bones are very specific and exact. This type of arrangement of bones in wrist region is unique and found in human beings where it involved in various movements of hand. The present study was conducted on fully ossified 118 dry adult ulna bones (58 right-sided ulna and 60 left-sided ulna) irrespective of age, sex and race. The parameters were studied in the present study were maximum height of seat, maximum width of fovea and pole, length and shape of styloid process, shape of pole, presence or absence of vascular foramina in fovea, and groove for ECU. All the morphometric parameters i.e. maximum height of seat, length of styloid process, maximum width of pole and maximum with of fovea of distal end of ulna were found to be statistically significant. The most common shape of pole was semicircular and absence of groove for ECU in 10.16% bones observed. For the proper treatment and diagnose, the knowledge in the variations in the size and shape of lower end of ulna is necessary for the orthopedic surgeons, anatomist and forensic experts.

Keywords: Anatomist, Pole, Seat, Significant.

Introduction: The ulna is the bone of the medial side of the forearm and is a long bone, consists of an expanded proximal end, a shaft and a head at the distal end. The distal end of the ulna has great anatomical and physiological importance for normal functioning of hand.[1] The distal end of ulna has articular head (pole), styloid process and fovea. The head consists of 2 parts: pole and seat which are used for explain the structure and function of bones and joints of wrist and hand in the context of kinesiology. The pole articulates with the triangular fibrocartilaginous complex (TFCC) which separates it from triquetral. The apex of a triangular fibrocartilaginous complex (TFCC) fits in the fovea. The seat of head of ulna articulates with the ulnar notch of radius forming distal radio-ulnar joint. The seat occupies more than 2/3rd of the perimeter of the head of ulna and is covered by articular cartilage. The distal end of ulna is having two structures – the lateral, larger, round articular head of the ulna and the medial, narrower, non-articular styloid process.[2]

The styloid process attaches to the ulnar collateral ligament of the wrist joint. The head is separated from the styloid process by a depression (Fovea) for the attachment of the apex of the TFCC, contains vascular foramina and bounded posteriorly by a shallow groove for the tendon of the extension carpi ulnaris.[2,3]

The distal end of ulna is most fixed part of wrist joint and important for load transfer from the hand to the forearm. Galeazzi fracture dislocation can occur in relation with the fracture of styloid process of ulna. The morphometric parameters of distal end of ulna are very useful in the prosthetic replacement as well as for the diagnosis of inferior radio-ulnar joint injury. Some common conditions like traumatic arthritis, arthrosis, rheumatoid arthritis, colles' fracture, tenosynovitis of extensor carpi ulnaris and injury to triangular fibrocartilage complex responsible for the replacement of ulnar head.[3]

The present study was examined the anatomical configurations of ulna which would be useful for designing prosthesis of distal end of ulna in case of distal radio-ulnar joint injuries.

Aim and objectives: The aim of present study was to examine the morphology and morphometric parameters of distal end of ulna in the population of Haryana.

Materials ad methods: The present study was done on fully ossified 120 dry adult ulna (60 right-sided ulna and 60 left-sided ulna) irrespective of age, sex and race. The present research was carried out in the department of Anatomy, Pt. B. D. Sharma PGIMS, Rohtak, Haryana. The study included intact and fully ossified ulnar bones and free from any pathological and congenital anomalies. Damaged bones showing any pathological deformity were excluded from the study. Statistical SPSS software version 21.0 was used to carry out data analysis.

Morphological parameters were included: (Figure 1)

1. Presence or absence of vascular foramina in the fovea
2. Shape of styloid process
3. Shape of pole
4. Presence or absence of groove for extensor carpi ulnaris (ECU)

Morphometric parameters were included: The following morphometric parameters were taken:

1. Maximum height of seat (SHmax)[3]: The distance between the lateral most points in the upper margin to the lateral most point in the lower margin of the seat. The convex lateral articular surface (more than 2/3) of the distal part of the head of ulna is known as seat. (Shown in figure 2)

2. Maximum width of fovea (FW) [3]: It is the distance between the points where transverse axis meets the lateral most point on the lateral margin of fovea and the lateral end of base of styloid process. (Shown in figure 2)

3. Maximum width of pole (PW) [3]: It is the distance between the points where the transverse axis meets the margin of the pole. (Shown in figure 2)

4. Length of styloid process (LSP) [3]: It is the distance between the tip of styloid process to the base of the styloid process. (Shown in figure 2)

All the measurements were taken in millimeter (mm). All the measurements were taken directly on the dry ulnae by using digital vernier caliper (accurate to 0.1mm).

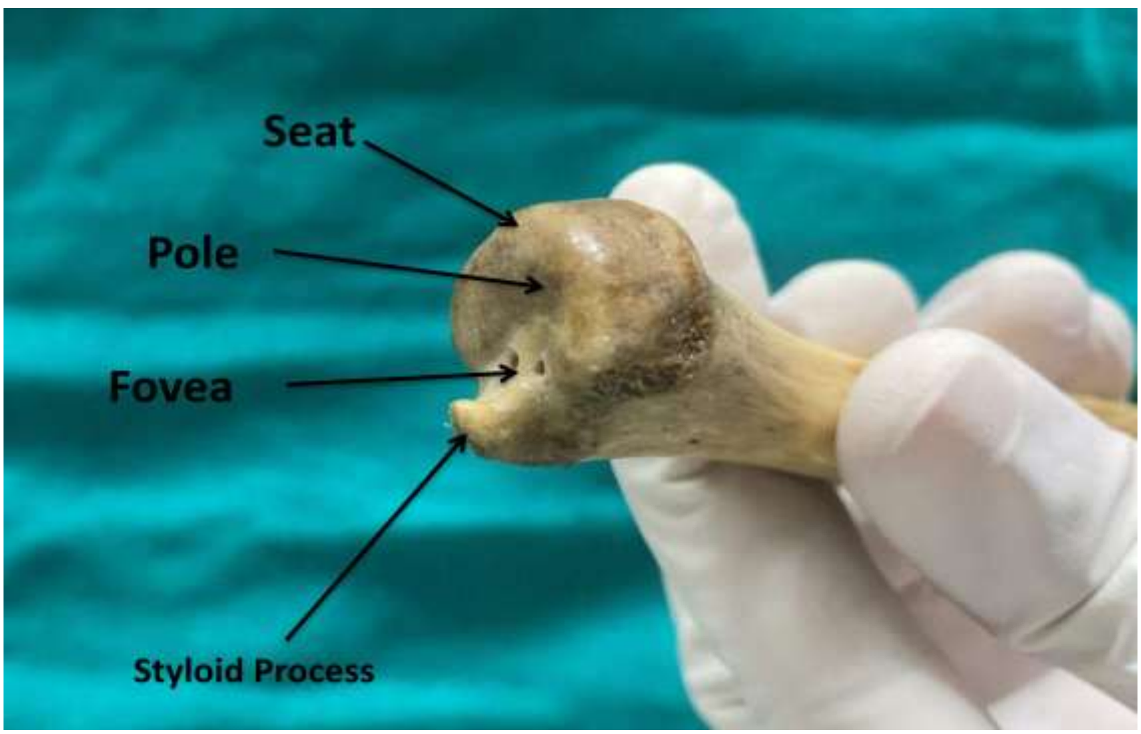

Figure 1: Showing various parts of distal end of ulna

Figure 2: Measurements of various morphometric parameters of distal end of ulna (where a: indicates length of styloid process, b: indicates maximum width of fovea, c: indicates maximum with of pole and d: shows maximum height of seat)

Results:

All the measurements of pole, seat, styloid process and fovea of both right and left sided ulna were taken and tabulated. The mean and SD of each parameter were calculated and various shapes of the poles and styloid processes were noted. The ulna seat, presence or absence of vascular foramina of the fovea and presence or absence of ECU groove were also noted.

Table 1: Showing measurements of morphometric parameters of distal end of Ulna (in mm).

S. No.	Parameters	Mean ±SD (mm)	p-value
1.	Maximum height of seat (SH)	6.87±1.29	0.001^{S}
2.	Length of styloid process (LSP)	5.93±1.19	0.001^{S}
3.	Max. width of pole (PW)	5.96±1.32	0.001^{S}
4.	Max. width of fovea(FW)	4.26±1.17	0.001^{S}

**S indicates statistically significant*

All the morphometric parameters i.e. maximum height of seat, length of styloid process, maximum width of pole and maximum with of fovea of distal end of ulna were found to be statistically significant ($p<0.001$). (Shown in table 1)

Table 2: Showing measurements of morphometric parameters of right-sided and left- sided in distal end of Ulna (in mm).

S. No.	Parameter	Right (n=58)	Left (n=60)	p-value
1.	Maximum height of seat (SH)	6.06±1.34	5.84±1.01	0.318
2.	Length of styloid process (LSP)	7.33±1.26	6.41±1.65	0.001^{S}
3.	Max. width of pole (PW)	5.94±1.29	5.98±1.36	0.878
4.	Max. width of fovea (FW)	4.24±1.18	4.31±1.18	0.706

*S indicates statistically significant

In the lower end of the end, more than 2/3rd of the circumference was articular in which mean value of maximum height of seat (SH) 6.06mm and length of styloid process (LSP) 7.33mm were observed higher on right side than left side (SH-5.84mm, LSP-6.41mm) and there was statistically significant difference observed in length of styloid process. (Shown in table 2)

The mean values of maximum width of pole (PW) 5.98±1.36 and maximum width of fovea (FW) 4.31±1.18 were observed higher in left sided ulna than right-sided ulna. (Shown in table 2)

Morphological parameters:

Table 3: Showing shape of pole in distal end of both-sided Ulna.

Parameter	Right (n=58)	Left (n=60)	Total (n=118)
Comma	8 (13.79%)	9 (15%)	17 (14.40)
Semilunar	5 (8.62%)	9 (15)	14 (11.86)
Kidney-shaped	12 (20.68%)	14 (23.33)	26 (22.03)
Semicircular	33 (56.89%)	28 (46.66)	61 (51.69)

Shape of pole: In right ulna, the most predominant shape of pole was semicircular (56.89%) followed by kidney shaped (20.68%), comma (13.79%) and semilunar (8.62%) while in left-sided ulna, the most predominant shape of pole was semicircular (46.66%) followed by kidney shaped (23.33%), comma (15%) and semilunar (15%). (Shown in table 3 & Figure 3)

Figure 3: Showing the different shapes of pole in distal end of Ulna.

Table 4: Showing presence or absence of vascular foramina in fovea of distal end of Ulna .

Parameter	Right (n=58)	Left (n=60)	Total (n=118)
Present	47 (81.03%)	51 (85%)	98 (83.08%)
Absent	11 (18.96%)	9 (15%)	20 (16.94%)

In the present study, vascular foramina in fovea were present in 83.08% in distal end of ulna and vascular foramina in fovea were absent in 16.94% in distal end of ulna. On comparison, the vascular foramina were found to be absent in more in right-sided ulna than left-sided ulna. (Shown in table 4)

Table 5: Showing presence or absence of ECU groove in distal end of Ulna.

Parameter	Right (n=58)	Left (n=60)	Total (n=118)
Present	54 (93.10%)	52 (86.66%)	106 (89.83%)
Absent	4 (6.89%)	8 (13.33%)	12 (10.16%)

In the present study, ECU groove were present in 89.83% in distal end of ulna and ECU groove were absent in 10.16% in distal end of ulna. (Shown in table 5)

Table 6: Showing shapes of styloid process in distal end of Ulna.

Parameter	Right (n=58)	Left (n=60)	Total (n=118)
Blunt	36 (62.06%)	24 (40%)	60 (50.84%)
Pointed	22 (37.93%)	36 (60%)	58 (49.15%)

In the present study, the blunt shape of styloid process was observed in 50.84% of distal end of total ulna bones and the pointed shape of styloid process was observed in 49.15% of distal end of total ulna bones. On comparison of both side of ulna, blunt shape of styloid process was found to be higher in right sided ulna (62.06%) than left sided ulna (37.93%) while pointed shape of styloid process was found to be higher in left sided ulna (60%) than right sided ulna (37.93%). (Shown in table 6)

Discussion:

The anatomical arrangement and articular between the lower end of ulna and radius and the carpal bones are exact and specific. Presence of minor modifications in the arrangements of above bones lead to pain syndromes i.e. ulnar styloid impaction, ulnar styloid impaction syndromes etc. the lower end of the ulna is very significant part of ulnar-carpal wrist joint, which makes a contribution in transfer of load from hand to forearm. This type of unique arrangement of bones of wrist joint is found only in human which is involved in various movements and biomechanics of joint. For the proper treatment and diagnosis of the pain syndromes wrist joint, it is necessary to have complete knowledge of functional anatomy and configurations of bones in wrist joint. Hence, result of the present study was compared with the previous studies which can be used in surgical interventions.

1. Presence or absence of Vascular foramina in Fovea: In the present study, the vascular foramina in fovea absent in 16.94% of total ulna (18.96% in right-sided ulna and 15% in left sided ulna). This result was found to be similar to the findings of Joshi et al[4] (15.61%) and Sharma A et al[2] (20%). Vascular foramina were found absent in 18.96% of right sided ulna which was not similar to the finding of Nagari S et al (2017)[5], Ashiyani ZA et al[6] (2014), Gupta C et al (2021)[10].

In left sided ulna, vascular foramina was absent in 15% bones which was similar to the findings of Nagari S et al[5] (2017), Gupta C et al[7] (2021) while Ashiyani ZA et al[6] (2014) observed absence of vascular foramina in only 5% left ulna.

2. Shape of pole: In present study, the most common shape of pole in right sided ulna semicircular (56.89) followed by kidney shaped, coma and semilunar and in left sided ulna, the most common shape was semicircular, followed by kidney shaped, comma shaped and semilunar of cases each whereas in previous studies of Ashiyani ZA et al[6] (2014), Sharma et al[2], Joshi et al[4], the most common shape of the pole was semilunar (55%, 60%, 63.76%), followed by comma shaped (25%, 10% & 23.18%), semicircular (15%, 20%, 13.04%) and kidney (5%) shaped.

Gupta C et al (2021)[7] observed the most common pattern of the pole was kidney shaped (34.6%) followed by semicircular (26.9%), semilunar (19.2%) and coma-shaped (19.2%) on the right side and on the left side, most common shape was kidney shaped (62.5%), followed by comma shaped (45.4%), semicircular (20.8%) and semilunar shaped 4%.

These variations in the shape of the pole may affect the angulation between the seat and pole of the ulnar head. Oommen SS et al (2015)[8] observed most common shape of pole as kidney shape in both right and left sided ulna which was followed by semicircular, semilunar and comma shaped.

3. Groove for ECU: In present study, the absence for ECU was observed in 6.89% in right sided ulna and 13.33% in left ulna which was similar to the findings of Oommen SS et al[8] (2015) while findings of Gupta C et al[7] (2019), Sharma A et al[2] (2011), Joshi SD et al[4] (2009) and Ashiyani ZA et al[6] (2014) were not similar to the present study.

4. Shape of styloid process:

In the present study, the tip of styloid process was blunt in 62.06% right ulna and 40% in left ulna and pointed in 37.93% in right ulna and 60% in left ulna. Oommen SS[8] (2015) also observed pointed styloid process in 56% of left ulna similar to present study while 52% right sided ulna had pointed styloid process.

Sharma A et al[2] (2011) also observed similar finding in right side ulna while left sided ulnae not had similar findings. Findings of studies of Nagari S et al[5] (2017), Joshi SD et al[4], Gupta C et al[7] (2019) et al were not similar to the present study.

5. Maximum Height of Seat (SH):

Seat is also one of the important factor for determining the gliding articulation and complexity of the movement at the distal radio-ulnar joint. In the present study, the mean value of maximum height of seat was found to be 6.06mm on right side and 5.84 mm on the left sided ulna respectively. In right-sided ulna, the findings are similar to the findings of Sharma A et al[2] (2011), Vijaykishan B et al[3] (2016), Zarana AA et al[9] (2014), while not similar to the Joshi SD et al[4] (2009), Chetan S et al[10] (2019), Nagari S et al[5] (2017), Gupta C et al[7] (2020), Oommen SS et al[8] (2015).

In left-sided ulna, the findings are similar to the Vijaykishan B et al[3] (2016), Nagari S et al[5] (2017) while not similar to the Sharma A et al[2] (2011), Joshi SD et al[4] (2009), Chetan S et al[10] (2019), Gupta C et al[7] (2020), Zarana AA et al[9] (2014), Oommen SS et al[8] (2015). (Table 7)

Table 7: Comparison of height of seat (SH) of present study with previous studies.

S. No.	Author	Population	No. of sample	Rt. Width of seat (SH) mm	Left width of seat (SH) mm
1.	Sharma A et al[2] (2011)	Indian	100	5.90±0.69	6.90±0.87
2.	Joshi SD et al[4] (2009)	Indian	129	6.39	5.26
3.	Vijaykishan B et al[3] (2016)	Indian	100	6.06±0.7	5.75±0.7
4.	Chetan S et al[10] (2019)	Indian	100	3.91±0.55	3.81±0.47
5.	Zarana AA et al[9] (2014)	Indian	100	6.01±0.98	6.46±0.93
6.	Gupta C et al[7] (2020)	Indian	50	6.90±0.19	7.50±0.18
7.	Oommen SS et al[8] (2015)	Indian	100	6.51±0.08	6.42±0.05
8.	Nagaris S et al[5] (2017)	Indian	50	6.66±1.12	5.98±0.87
9.	Present study (2023)	Indian	120	6.06±1.34	5.84±1.01

6. Maximum Width of pole (PW):

Table 8: Comparison of maximum width of pole (PW) of present study with previous studies.

S. No.	Author	Population	No. of sample	Rt. Width of Pole (PW) mm	Left width of Pole (PW) mm
1.	Sharma A et al[2] (2011)	Indian	100	5.40±0.99	6.10±0.67
2.	Joshi SD et al[4] (2009)	Indian	129	5.26	4.76
3.	Vijaykishan B et al[3] (2016)	Indian	100	4.92±0.7	4.93±0.90
4.	Chetan S et al[10] (2019)	Indian	100	4.19±0.60	4.07±0.52
5.	Zarana AA et al[9] (2014)	Indian	100	5.67±0.79	5.72±0.82
6.	Gupta C et al[7] (2020)	Indian	50	5.50±0.19	5.70±0.13

7.	Oommen SS et al[8] (2015)	Indian	100	5.04±1.45	5.00±1.43
8.	Nagaris S et al[5] (2017)	Indian	50	5.99±0.65	5.97±1.18
9.	Present study (2023)	Indian	120	5.94±1.29	5.98±1.18

The size of the pole may help in guiding the direction of transmission of forces through ulna. In the present study, the maximum width of pole were 5.96 mm (Rt. 5.94 mm & Lt. 5.98 mm) documented which was similar to the findings of Sharma A et al[2] (2011), Ashiyani ZA et al[6] (2014), Gupta C et al[7] (2020), Zarana A A et al[9] (2014), Nagaris S et al[5] (2017) while not similar to the studies of Joshi et al[4] (2009), Vijayishan B et al[3] (2016), Chetan S et al[10] (2019), Oommen SS et al[8] (2015). (Table- 8)

Width of the pole in the present study showed a small level of variation. These variations may be due to overall medium stature of the people in the North India. It seems that the inclination of the pole does not have much effect on the pathology of TFCC or the wrist as compared to the effect of positive ulnar variance.

7. Maximum Width of fovea (FW):

Table 9: Comparison of width of fovea (FW) of present study with previous studies (in mm).

S. No.	Author	Population	No. of sample	Rt. Width of Fovea (FW) mm	Left width of Fovea (FW) mm
1.	Sharma A et al[2] (2011)	Indian	100	4.50±0.47	4.90±1.10
2.	Joshi SD et al[4] (2009)	Indian	129	5.26	5.18
3.	Vijaykishan B et al[3] (2016)	Indian	100	5.42±0.7	5.17±0.6
4.	Chetan S et al[10] (2019)	Indian	100	3.83±0.44	3.89±0.42
5.	Zarana AA et al[9] (2014)	Indian	100	4.76±0.64	4.10±0.76
6.	Gupta C et al[7] (2020)	Indian	50	4.60±0.15	4.80±0.13
7.	Oommen SS et al[8] (2015)	Indian	100	4.14±1.63	4.50±1.37
8.	Nagaris S et al[5] (2017)	Indian	50	2.56±0.78	2.29±0.70
9.	Present study (2023)	Indian	120	4.24±1.18	4.31±1.18

In the present study, the width of fovea was 4.24mm on right side and 4.31 mm on the left sided ulna respectively. In right-sided ulna, the findings are similar to the findings of Sharma A et al[2] (2011), Gupta C et al[7] (2020), Oommen SS et al[8] (2015) while not similar to the Joshi SD et al[4] (2009), Vijaykishan B et al[3] (2016), Chetan S et al[10] (2019), Zarana AA et al[9] (2014), Nagari S et al[5] (2017).

In left-sided ulna, the findings are similar to the Zarana AA et al[9] (2014), Oommen SS et al[8] (2015) while not similar to the Sharma A et al[2] (2011), Joshi SD et al[4] (2009), Vijaykishan B et al[3] (2016), Chetan S et al[10] (2019), Gupta C et al[7] (2020), Nagari S et al[5] (2017). (Table 9)

8. Length of styloid process (LSP):

Table10: Comparison of length of styloid process (SP) of present study with previous studies (in mm).

S. No.	Author	Population	No. of sample	Rt. Length of styloid process (SP)	Left Length of styloid process(SP)
1.	Sharma A et al[2] (2011)	Indian	100	5.20±0.80	5.00±0.67
2.	Vijaykishan B et al[3] (2016)	Indian	100	4.89±0.7	4.5±0.7
3.	Chetan S et al[10] (2019)	Indian	100	6.26±1.11	6.09±1.06
4.	Zarana AA et al[9] (2014)	Indian	100	4.25±0.53	5.28±0.80
5.	Gupta C et al[7] (2020)	Indian	50	5.60±0.11	5.50±0.09
6.	Oommen SS et al[8] (2015)	Indian	100	5.80±1.24	5.50±1.28
7.	Nagaris S et al[5] (2017)	Indian	50	4.18±0.67	4.69±0.90
8.	Present study (2023)	Indian	120	7.33±1.26	6.41±1.65

The length of styloid process in present study was 7.33±1.26mm and 6.41±1.65mm on the right and left side ulna respectively. On the right side, there was no previous which had similar findings while while not similar to the Sharma A et al[2] (2011), Vijaykishan B et al[3] (2016), Chetan S et al[10] (2019), Zarana AA et al[9] (2014), Gupta C et al[7] (2020), Oommen SS et al[8] (2015) and Nagari S et al[5] (2017). (Shown in Table 8)

In left-sided ulna, findings was similar to the findings of Chetan S et al[10] (2019) while not similar to the findings of Sharma A et al[2] (2011), Vijaykishan B et al[3] (2016), Zarana AA et al[9] (2014), Gupta C et al[7] (2020), Oommen SS et al[8] (2015) and Nagari S et al[5] (2017). (Shown in Table 8)

Conclusion: Minor modifications in the articular surfaces of distal end of ulna and radius leads to significant load changes and causes many pain syndromes i.e. ulnacarpal abutment, ulnar styloid impaction and ulnar styloid triquetral impaction syndrome etc. Changes or modification in the shape, size, inclination and various articular areas of lower end ulna and radius and ulna carpus will leads to deterring or manipulating skills and movements exhibited by the hand. The detailed knowledge of the distal end of ulna plays a significant role in understanding post-injury instability and painful conditions at the distal radio-ulnar joint (DRUJ). The result of the present study provides a data base on Indian population which can be useful for making suitable ulnar prosthesis and reconstruction surgeries of patients with fractures at the lower end of ulna.

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