Anatomical study of the distal end of cadaveric human ulnae: a clinical consideration for the management of distal radioulnar joint injuries

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ABSTRACT

Introduction: Detailed anatomical knowledge of the distal end of the ulna plays a pivotal role in understanding post-injury instability and painful conditions at the distal radioulnar joint (DRUJ), which can be due to avulsion of the ulnar styloid process or ulnar styloid triquetral impaction syndrome. With this in mind, data on the morphological features of distal ulnae in the Indian population was collected.

Methods: The distal end of 100 human ulnae (50 right-sided and 50-left sided) of unknown gender from the anatomy department's bone bank were studied with regard to the seat (articular circumference of the head of ulna), ulnar styloid process, fovea and pole (articular surface for articulation of triangular fibrocartilaginous complex of the wrist on the head of ulna).

Results: The average length of the styloid process was 5.2 mm in the right-sided ulnae and 5 mm in the left. The mean maximum height of the seat was noted to be 5.9 mm and 6.9 mm on the right- and left-sided ulnae, respectively. The maximum width of the pole was calculated to be 5.4 mm (right-sided ulnae) and 6.1 mm (left-sided ulnae). The shapes of the pole and styloid process were also noted. Extensor carpi ulnaris groove was more commonly found on the left-sided ulnae.

Conclusion: The study provides an anatomical database of the morphometry of parts of the distal end of the ulna in the Indian context, which will aid in the early management of DRUJ injuries.

Keywords: distal end of ulna, distal radioulnar joint, head of ulna, styloid process of ulna

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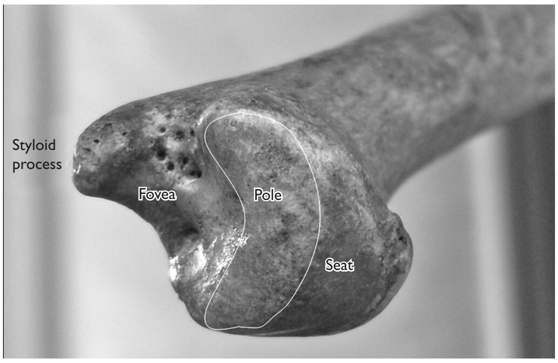

Fig. 1 Photograph shows the various parts of the distal end of the ulna.

INTRODUCTION

The whole upper limb works as a jointed lever. The human hand is a grasping tool that is exquisitely adaptable for performing various complex functions. The lower end of the ulna is of great anatomical and physiological significance for normal hand functioning. The distal end of the ulna consists of the head, ulnar styloid process and fovea (Fig.1). When describing the structure and function of the bones and joints of the wrist and hand in the context of kinesiology, the terms 'pole' and 'seat' are mainly used in relation to the head of the ulna. The 'pole' articulates with the triangular fibrocartilaginous complex (TFCC) of the wrist. More than two-thirds of the convex lateral articular surface of the distal part of the head of ulna is known as the 'seat', which is covered by cartilage.[1] This surface forms a gliding articulation with the concave semi-cylindrical sigmoid notch of the radius. The flat distal-most end of the ulna is also partially covered by cartilage and abuts the undersurface of the TFCC.

A non-articular recess separates the articular surface of the distal-most end of the ulna from the attachment of the TFCC at the fovea of the ulnar styloid process.[2] The proximal and distal radioulnar joints (DRUJs) move in synchronous rotation during pronation and supination.[3] The pronation-supination axis is fixed in relation to the ulna, serving as a centre about which the distal part of the

Table I. Quantitative analysis of various parameters of the distal end of the ulnae.

Component	Measurement	Mean ± SD (mm)	
		Right-sided ulna	Left-sided ulna
Pole	Maximum width	5.40 ± 0.99	6.10 ± 0.67
Seat	Maximum height	5.90 ± 0.69	6.90 ± 0.87
Fovea	Maximum width	4.50 ± 0.47	4.90 ± 1.10
Styloid process	Length	5.20 ± 0.82	5.00 ± 0.67

SD: standard deviation

radius rotates through a 150° arc; further lateral movement of the radius of around 30° in the direction of rotation enables this movement to go through approximately 180° for hand rotation.[4] At the extremes of the movement of pronation and supination, the ulnar head has little contact with the articulating sigmoid notch, making the joint vulnerable. Since the distal part of the ulna is a stable anatomical point of reference for rotation of the forearm, the distal part of the radius dislocates volarly or dorsally with respect to the ulna.

There is general agreement that the mechanism of injury in an ulnar dorsal dislocation of the DRUJ is hyperpronation, while the mechanism of injury in ulnar volar dislocation is hypersupination. Galeazzi-fracture dislocations can also be associated with fracture of the ulnar shaft and styloid process in high-energy trauma. During sporting activities, forceful impact loading on the thenar side of the hand causes the wrist to be progressively levered into hyperextension, with ulnar deviation and intercarpal supination.[5]

Many reports on the diagnosis and treatment of injuries of the DRUJ under-emphasised the role of the lower end of the ulna. Many of these irreducible dislocations commonly have displaced fracture of the ulnar styloid process as an associated feature.[6] Although instability of the DRUJ after radius end fracture did not receive much attention, the residual symptoms related to DRUJ instability are common. Our anatomical studies revealed the detailed structural anatomy of the lower end of the ulna. This study is one of the few to present the morphometric data of configurations of the lower end of the ulna. The detailed morphometric data on regular anatomy in this study would be helpful to the design of ulnar head prosthesis. Irreparable fracture dislocation of the ulnar head with concomitant fracture of the radius (Galeazzi lesion) had been treated by implantation of a Herbert Ulnar Head Prosthesis, which had yielded good results.[7]

METHODS

The present study, which was conducted over a period of one year, involved 50 right- and 50 left-sided dry adult human ulnae of unknown gender belonging to an Indian population. Approval for the study was obtained from the institutional ethics committee. A selected number of specimens were collected from the bone bank of the anatomy department at our institution, depending on the availability and time planned to conduct the study. Only bones that were intact and free from any pathological or congenital anomalies were selected. Anatomic measurements were taken using a vernier caliper (accurate to 0.1 mm). Appropriate statistical analysis was done wherever applicable. Each ulna was studied for different features, such as the shape of the pole (articular surface for articulation with TFCC), maximum width of the pole along the transverse axis (mm), slope of the seat (articular surface on the head of ulna for articulation with radius), maximum vertical height of the seat (mm), maximum width of the fovea (roughened depression at the base of the styloid process) along the transverse axis (mm) (Fig. 1). Also noted were the presence or absence of vascular foramina in the fovea, the presence or absence of styloid process, the shape and length (base to apex) of the styloid process, if any, and the presence or absence of grooves for extensor carpi ulnaris (ECU).

RESULTS

All quantitative measurements of the pole, seat, fovea and styloid process of the 50 right- and 50 left-sided ulnae were taken and tabulated. The mean and standard deviation of each parameter was calculated (Table I), and the various shapes of the poles and styloid processes were noted. The ulna seat (sloping or non-sloping surfaces), the presence or absence of vascular foramina of the fovea and that of ECU groove were also observed and their percentages tabulated (Table II).

DISCUSSION

DRUJ injury can occur in association with fracture of the forearm or as an isolated phenomenon. A dislocation of this joint may be simple or complex. The possibility of DRUJ injury should be kept in mind when treating wrist, forearm and elbow injuries. The distal end of the

Table II. Measurements of various parts of the distal end of the ulna.

Component	No. (%)	
	Right (n = 50)	Left (n = 50)
Pole		
Comma	5 (10)	15 (30)
Semilunar	30 (60)	20 (40)
Semicircular	10 (20)	10 (20)
Kidney-shaped	5 (10)	5 (10)
Seat		
Sloping	30 (60)	30 (60)
Non-sloping	20 (40)	20 (40)
Styloid process		
Present	50 (100)	50 (100)
Absent	-	-
Overall shape		
Curved	5 (10)	-
Straight	45 (90)	50 (100)
Shape of tip		
Blunt	30 (60)	35 (70)
Pointed	20 (40)	15 (30)
Fovea (vascular foramina)		
Present	40 (80)	40 (80)
Absent	10 (20)	10 (20)
ECU groove		
Present	40 (80)	50 (100)
Absent	10 (20)	-

ECU: extensor carpi ulnaris

ulna comprises the head, fovea and styloid process. The ulnar head is the fixed point of the distal arm and wrist, around which the forearm, carpus and hand rotate. It is also an integral part of the ulnar-carpal wrist joint, which plays an important role in load transfer from hand to forearm. The kinematics and biomechanics of this region is unique and is found only in humans. The ulnar head consists of two parts, the dome (pole) and seat. The dome faces the carpus, while the seat faces the radius laterally. Radially, the slightly convex and triangular-shaped part is covered by the cartilage to articulate with the underside of the TFCC. Centrally, there is a roughened depression (fovea) for attachment of the apex of the TFCC. On the dorsal side, opposite to the fovea, a longitudinal sulcus is located for the ECU tendon and its sheath. Traumatic derangements around the ulnar head usually affect both the joint compartments, the distal radioulnar and ulnar-carpal joints. Therefore, the aim must be to restore normal anatomy in acute situations whenever possible.[8]

Besides this, the anatomical relationships of the distal ulna with the distal radius and ulnar carpus are precise. These relationships are important from the functional point of view, e.g. minor modifications in these lead to significant load changes and resultant pain syndromes (ulnar-carpal abutment, ulnar styloid triquetral impaction syndromes and ulnar styloid impaction). These functional correlations as well as the treatment modalities of the region require detailed anatomical knowledge and morphometric data collection. The literature is replete with studies of the anatomy of bony configurations on dry bones, forming the wrist joint, which can aid in surgical interventions in the region of the wrist. Studies conducted by Berger et al[8] and Joshi et al[9] have targeted these relevant points. Keeping this relevance in mind, we compared our findings with their observations.

The size and projection of the pole (articular surface for articulation of TFCC of the wrist on the head of ulna) may help in guiding the direction of transmission of forces through the ulna. We recorded the maximum width and various shapes of the pole. The average maximum widths of the pole from the radial to ulnar side on the right- and left-sided ulnae were documented as 5.4 ± 0.99 mm and 6.1 ± 0.67 mm, respectively (Table I). An earlier study that reported a dimension of 8.2 (range 5.1–13.2) mm, regardless of the side of the ulna,[8] is in line with the findings of our study. The widths recorded in the present study were varied, but they did not show such a wide range of variation. The confounding factor may be the overall medium stature of the people in the northern part of India. The variety of pole shapes may have affected the angulation between the seat and pole of the ulnar head. The most common shape observed on the right (60%) and left (40%) ulnae was semilunar. This observation concurs with Joshi et al's study, which found a semilunar shape to be the most common on both sides.[9] The distribution of the shapes was found to be varied on both sides. The 'comma', the next most common shape, was found on the left side in 30% of ulnae and on the right, in just 10% of ulnae (Table II).

More than two-thirds of the convex lateral articular surface of the distal part of the ulna, viz the seat, is the main determining factor for gliding articulation and complexity of movement at the DRUJ. In our study, the average maximum height of the seat was found to be 5.9 ± 0.69 mm on the right side and 6.1 ± 0.67 mm on the left side (Table I). However, another study had documented the maximum height of the seat as 9.3 (range 6.8–12.6) mm.[8] This could be attributed to the difference in the study population of the two studies. 60% sloping and 40% non-sloping surfaces on both the right and left sides were found in our study (Table II). The height and slope of the seat may be of great clinical significance in understanding any dysfunction of the site, as far as assessing the stability of the DRUJ is concerned.

The fovea is a roughened depression at the base of the styloid process. The mean recorded maximum widths of the fovea in right-sided and left-sided ulnae were 4.5 ± 0.47 mm and 4.9 ± 1.1 mm, respectively (Table I). 20% of both the right- and left-sided ulnae showed an absence of any vascular formina in the fovea. A previous study has recorded an absence of any foramina in 24.63% of the cases involving right-sided ulnae.[9] A substantial amount of nutrition reaches the TFCC of the wrist from the synovial fluid of the DRUJ (on the superior surface) and the wrist joint (on the inferior surface), as well as from the vasulature in the ligament at the medial end of the disc by the vascular foramina.

The mean length of the styloid process was 5.2 ± 0.82 mm and 5.0 ± 0.67 mm on the right- and left-sided ulnae, respectively (Table I). If the length of the styloid process was > 6 mm, it was considered a criterion of long ulnar styloid process.[10] The length of the styloid process may act as a causative factor in ulnar styloid triquetral impaction, causing ulnar-sided wrist pain.[11] The dorsal surface on the head of the ulna showed a groove for ECU tendon in all left-sided ulnae and in 80% of right-sided ulnae (Table II). Its anatomical position is of great importance in the treatment of dislocation of the DRUJ.

Over the last decade, there has been a greater appreciation of the anatomy and mechanics of the proximal radioulnar joint compared to the DRUJ. Morphometrical analysis of the DRUJ is still evolving. Traumatic derangements around the ulnar head usually affect the DRUJ. Most untreated injuries to the bony or stabilising ligamentous structures lead to arthrosis of the DRUJ. Therefore, the aim must be to restore normal anatomy in an acute situation, whenever possible, rather than delaying it until only excision or arthrodesis remains the treatment of choice. Also, in certain isolated intra-articular fractures of the head of ulna, open reduction and internal fixation with K-wires, screws or small plates is a common treatment. In all these cases, if the congruency of the joint is not restored, permanent functional impairment will ensue.[8] The dislocations of the ulnar head with concomitant fracture of the radius (Galeazzi lesion) had been treated by implantation of prosthesis such as the Herbert Ulnar Head instead of arthrodesis, as commonly found in the literature.[7] These metrical values of structural anatomy of the lower end of the ulna are valuable for reconstruction of the DRUJ with prosthesis. While the literature is replete with detailed anatomical descriptions of the distal end of the radius, the lower end of the ulna is a neglected area of research in the Indian population. Therefore, our study aimed at providing the morphometric database for configurations and kinematics of the distal end of the ulna, which is a less frequently researched area in the Indian context.

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