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The Distal Row Carpal Bones - A Morphometric Treatise

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ABSTRACT

Introduction: A comprehension of customized geometry of carpals is essential for preoperative planning and creation of implants and fixators. The present morphometric treatise on distal carpal bones has an anatomical, anthropological and clinical significance.

Objective: To assess the gross morphological features with special emphasis on the dimensions and configurations of the articular facets.

Methods: The study was done on 480 distal carpal bones.120 bones (60 right and 60 left) of each type (hamate, capitate, trapezoid and trapezium) were selected from the bone museum at Government Medical College, Amritsar. The morphometry and morphology of each distal carpal bone were studied.

Results: The mean values as measured for right and left-sided bones when compared were found to be statistically insignificant ('p' value >0.01) for most parameters. A statistical significance was observed for the width of capitate at its base ('p' value <0.001), length of the distal surface of a trapezoid for articulation with the base of 2nd metacarpal (p-value <0.01) and width of groove on the palmar surface of the trapezium (p-value <0.01). No vascular foramina were observable on the bend of the hook of hamate in the present study. This pioneering study on distal row carpals provides important data on the incidence of merging and discontinuity of articular facets.

Conclusions: The study provides pioneer results and addresses the paucity of a baseline 'morphometric criterion' for distal carpals. The normative data is invaluable for comprehension of wrist pathologic conditions like Kienbock's disease, post-traumatic arthritis and outcome of surgical procedures such as a proximal row corpectomy.

Key Words: Distal carpals, Morphometry, Morphology

INTRODUCTION

A comprehension of the customized geometry of distal carpals is essential for preoperative planning and creation of implants and fixators.[1] The distal carpals are prone to fractures and avascular necrosis. The distal morphology and morphometry influence the development or progression of various wrist pathologic conditions, such as kienbock's disease and post-traumatic arthritis and the outcome of certain surgical procedures. The fracture of the hook of hamate is quite common in athletes, especially baseball players, golfers and tennis players.[1,2] Trapezoid fractures occur in 0. 4% of all carpal injuries.[3] The bend of the hamate hook could be its weakest part and is prone to avascular necrosis.[4] The capitate is another bone prone to avascular necrosis.[5]The size of the trapezium must be taken into consideration when implanting a trapeziometacarpal prosthesis.[6]

The distal level of carpal tunnel tends to have an elevated pressure[7], and it is structurally stiffer than proximal level.[8] The distal row is considered to be tightly bound with little intercarpal motion during wrist movement[9-11] especially at the trapezium-trapezoid and trapezoid-capitate joints.[10,11] The carpal arch width is the distance between the hook of hamate and the ridge of the trapezium. Narrowing and widening of carpal arch width can occur during wrist motion[12], after carpal tunnel release[12-15], or during cadaveric experimentation.[16-18]

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Anthropometric studies of the hand bones also have forensic significance in postmortem identification of the human remains.[19, 20] The present morphometric treatise of distal carpal bones has an anatomical, anthropological and clinical significance.

MATERIALS AND METHODS

The study was done on 480 distal carpal bones.120 bones(60 right and 60 left) of each type (hamate, capitate, trapezoid and trapezium) were selected from the bone museum at Government Medical College, Amritsar. The morphometry and morphology of each distal carpal bone were studied (Figures 1-6).

Written permission was taken from the Institutional Ethical Committee, Government Medical College, Amritsar, Punjab, India to conduct the study. It was ensured that all distal carpals included in the study were dry, macerated and complete in all respects.

General morphometric measurements

The length and width of each distal carpal bone and its articular facets was measured. The bones were placed in anatomical position and outline was marked on graph paper. The measurements were done using vernier callipers. The length and width of facets were measured directly using vernier callipers.

The number of vascular foramina was noted using a magnifying lens.

Morphometric features specific to particular bones

Height of hook of hamate: It was measured by directly using digital vernier from base to tip.

Circumference of the hamate hook: It was measured by winding around a thread around the hook of hamate bone at the base. A point was marked on the thread using a permanent marker, this thread was then placed stretched on a plain paper and the dimension measured with a vernier calliper.

Length of distal palmar angle on the lateral surface: The distal palmar angle on the lateral surface was identified and its length was measured using vernier callipers.

Width of capitate in middle: Each bone was placed on graph paper in anatomical position and its outline was traced onto the graph paper. The most prominent points on the medial side and lateral side of the narrow constricted part of capitate were marked. The width was then measured using the digital vernier calliper.

Width of capitate at base: Each bone was placed on graph paper in anatomical position and its outline was traced onto the graph paper. The most prominent point on the medial side and the most prominent point on the lateral side of the most proximal part of the bone were marked. Then the width at the base was measured using the digital vernier calliper.

Circumference of capitate head: It was measured by winding a thread around the head of the capitate bone. A point was marked on the thread using the permanent marker, this thread was then placed on plain paper and circumference was measured using a digital vernier calliper.

Tubercle circumference of trapezium: It was measured by winding around a thread around the tubercle of trapezium bone. A point was marked on the thread using the permanent marker, this thread was then placed on plain paper and circumference was measured using a digital vernier calliper.

Width of groove on the palmar surface of trapezium: On the palmar surface lies a deep groove on the medial side of tubercle. The width of this groove was measured by directly placing the vernier calliper over the bone.

Statistical analysis

The measures for the right and left sides were compared utilizing the unpaired ‘t ‘test. This is the independent t-test. The predictive ‘p’ value was determined. A ‘p’ value of <0.05 was considered to be statistically significant.

RESULTS

From table 1 (depicting dimensions of hamate bone), It is clear that no statistically significant differences in the average values of right and left hamates($p>0.01$)was observed. The same was true for all but one parameter measured for right and left capitate Table 2), Trapezoid and trapezium bones. The width of the capitate at its base, the length of the distal surface of a trapezoid for articulation with the base of second metacarpal and width of groove on the palmar surface of trapezium as measured for right and left sides when compared came to be significant ($p <0.01$).

The vascular foramina were found on all hamate hooks predominantly on the radial base and ulnar tip of the hook of the hamate. The incidence of these vascular foramina at the radial base and ulnar tip came out to be 90% and 66% respectively.No, vascular foramen was observed at the end of the hook of the hamate.

DISCUSSION

The present study on 480 human carpal bones of the distal row assessed the gross morphological features with special emphasis on the dimensions and configurations of the articular facets. The results so obtained were compared with the

results of a very limited number of earlier studies available to provide a database of the normal values for future comparative studies. The height of the hamate hook was measured previously by Kumar 'et al'[4] (right side-9.5±1.35 and left side 10.14±1.03) and our values agree with them. The articular facet for capitate was observed to be oblong and continuous in shape in the majority of bones but exhibited discontinuity in36 specimens (24 right sides and 12 left sides).

All hamate hooks had vascular foramen on them. These foramina were found predominantly on the radial base and ulnar tip of the hook of the hamate. The incidence of these vascular foramina at the radial base and ulnar tip came out to be 90% and 66% respectively. No vascular foramina were observed at the end of the hook, in accordance to study of by Kumar 'et al'.[4] Hence, we can conclude that the bend of the hook is an area prone to avascular necrosis. It was observed that the lateral surface presents a grooved region known as neck which provided attachment to the ligaments.[21] In our study, this neck was seen extending up to the palmar surface in eight specimens (incidence 6.6%). Similarly, the articular facet for hamate on a medial surface in capitate (oblong shape in the majority) exhibited a detached smooth facet in its distal part in thirty-six specimens. No data was available for comparison of study, so the present study is a pioneer study which provides references for further similar types of studies.[19,20]

In trapezoid bone, the smooth articular surface for capitate on the medial surface was observed to present a groove at its lower end in thirty-six specimens(incidence30%). The trapezium dimensions determined in the present study were on lower side vis-a-vis the study by Loisel F et al[6] and this could be attributable to the impact of ethnicity on bone morphometry.[22] The two portions of the medial surface of the trapezium are proximal(larger and for trapezoid) and distal(for the base of the second metacarpal) facets. These were seen to have merged within the absence of the distinct ridge separating them in sixteen specimens (incidence 13.33%).

CONCLUSION

In human anatomy, the main role of the wrist is to facilitate the effective positioning of the hand. The proximal row bones are more mobile at interosseous joints compared to the more distal row bones. The hallmark of the distal row bones is their geometric complexity. The quantified characterization of distal carpals has been overlooked in research. The present study is a pioneer morphometric treatise on distal carpals and the results and observations have anatomical, anthropological, forensic and clinical implications.

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Conflict of interest: Nil

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Table 1: Dimensions for hamate bone

Parameters	Right (n=60)		Left (n=60)		Total		'p' value
	Mean (mm)	SD	Mean (mm)	SD	Mean (mm)	SD	
Length	18.12	2.51	18.00	2.76	18.06	0.18	0.90
Width	14.22	1.65	14.17	2.24	14.20	0.42	0.94
Height of Hamate hook	10.28	0.27	10.56	0.54	10.42	0.19	0.09
Circumference hamate hook (at the base)	24.73	1.89	26.24	2.26	25.49	0.26	0.06
Length of distal palmar angle on lateral surface	5.31	0.31	5.33	0.32	5.32	0.01	0.86
Width of facet on proximal surface	4.43	0.29	4.52	0.38	4.48	0.06	0.48
Length of facet on proximal surface	5.08	0.44	5.22	0.57	5.15	0.09	0.46

Table 2: Dimensions for capitate bone

Parameters	Right (n=60)		Left (n=60)		Total		'p' value
	Mean (mm)	S.D.	Mean (mm)	S.D.	Mean (mm)	S.D.	
Length	24.55	2.26	24.03	2.08	24.29	0.13	0.52
Width in the middle	13.25	2.44	13.34	1.80	13.30	2.12	0.91
Width at base	7.63	1.63	13.34	1.80	10.49	0.12	0.001
Circumference of head	39.46	9.13	41.54	1.13	40.50	5.66	0.42
Width of facet on medial surface	6.34	0.37	6.53	0.40	6.44	0.02	0.18
Length of facet on medial surface	17.12	1.32	17.00	1.06	17.06	0.18	0.79
Length of facet on dorso-medial surface	4.13	0.38	3.96	0.33	4.05	0.04	0.20
Width of facet on dorso-medial surface	4.29	0.48	4.13	0.30	4.21	0.13	0.30

Table 3: Dimensions for trapezoid bone

Parameters	Right (n=60)		Left (n=60)		Total		'p'value
	Mean (mm)	SD	Mean (mm)	SD	Mean (mm)	SD	
Length	12.82	2.24	11.66	1.89	12.24	0.25	0.13
Width	11.60	2.13	11.24	2.08	11.42	0.04	0.64
Length of concave facet on medial surface	8.68	1.83	8.34	1.01	8.51	0.58	0.53
Width of concave facet on medial surface	5.76	0.91	5.65	0.77	5.71	0.10	0.72
Length of distal surface for articulation with base of second metacarpal	13.16	1.26	12.26	1.56	12.71	0.21	0.09
Width of distal surface for articulation with base of second metacarpal	5.88	0.91	5.58	0.93	5.73	0.01	0.37

Table 4: Dimensions for trapezium

Parameters	Right (n=60)		Left (n=60)		Total		'p'value
	Mean (mm)	SD	Mean (mm)	SD	Mean (mm)	SD	
Length	15.35	2.38	16.02	1.84	15.69	0.38	0.39
Width	14.86	2.44	14.00	3.18	14.43	0.52	0.41
Tubercle circumference	25.96	1.36	27.00	2.02	26.48	0.47	0.10
Width of groove on palmar surface	3.62	0.69	3.15	0.62	3.39	0.05	0.05
Width of ridge on proximal surface for articulation with scaphoid	4.34	0.24	4.40	0.40	4.37	0.11	0.62

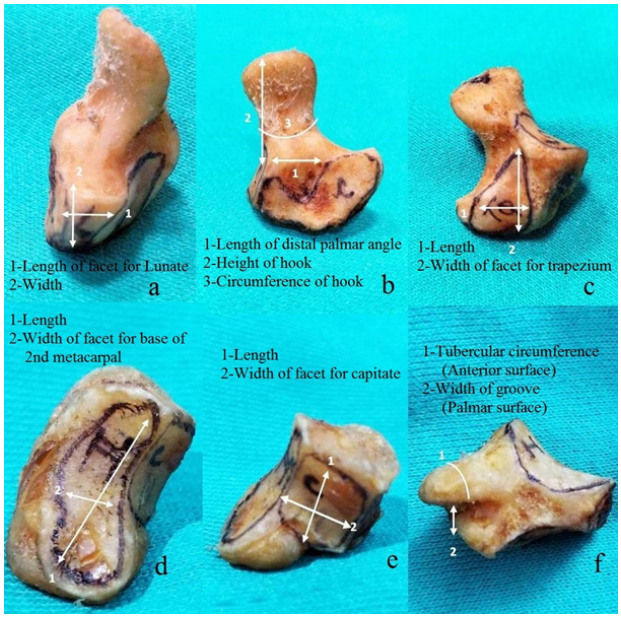

Figure 1: Showing some measurements on distal carpals (a- Proximal surface of hamate; b- Lateral surface of hamate; c- medial surface of hamate; d- distal surface of trapezoid; e- medial surface of trapezoid; f- anterior and palmar surface of trapezium).

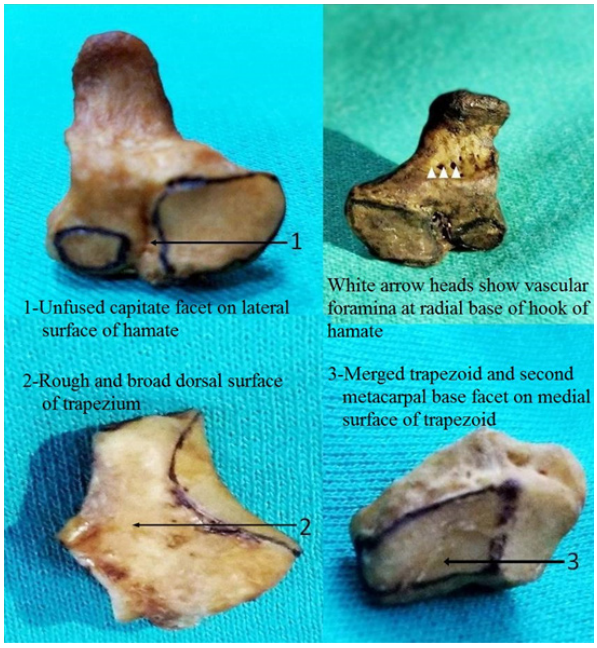

Figure 2: Showing some morphological characteristics of distal carpals.

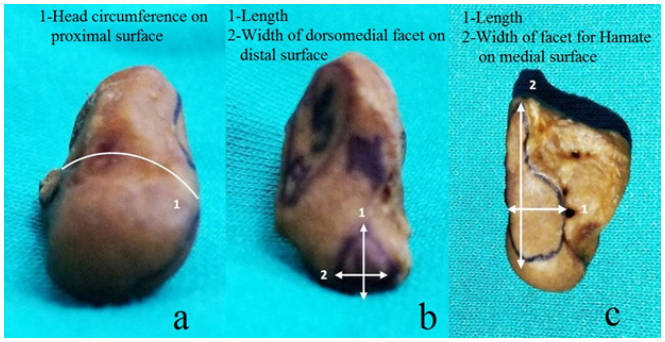

Figure 3: Showing Mmeasurements on capitate bone.

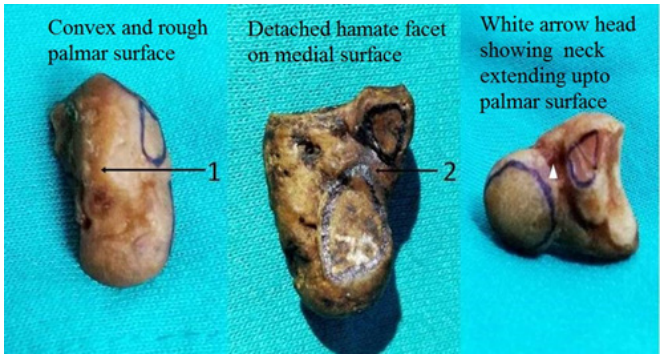

Figure 4: Showing morphological characteristics of capitate bone.

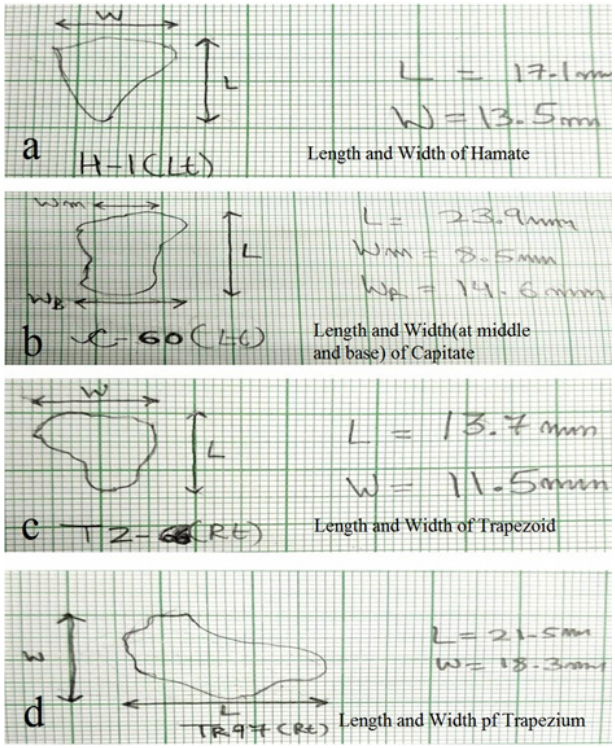

Figure 5: Showing measurements of dimensions of distal carpals on graph paper.

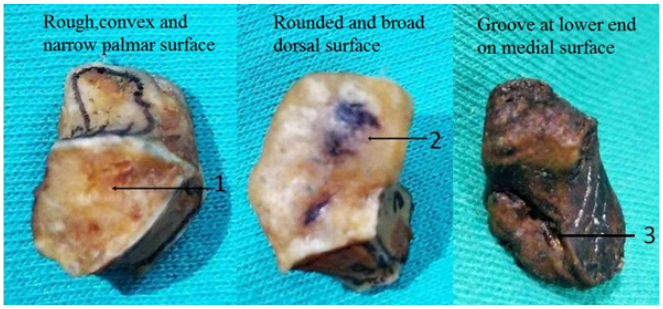

Figure 6: Showing morphological characteristics of trapezoid bone.