Original Article

Morphological and Morphometric Study of Scaphoid Bone in South Indian Population

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Abstract

Introduction: Scaphoid fractures are the most common of the carpal bone injuries. Scaphoid fractures heal slowly due to the limited blood circulation of the bone. To avoid malunion, the scaphoid fracture has to be recognized in time and treated either by immobilization or by surgical fixation. The present study was carried out to observe the morphological variations of scaphoid and measure its dimensions and also to observe the position and number of nutrient foramen in the scaphoid bone. **Material and Methods:** A total of 100 dried adult human scaphoid bones were studied from the Department of Anatomy, VMKV Medical College and Hospital, to identify the possible morphological variations. The morphometry of scaphoid was measured using vernier caliper. The number of foramina was observed using a magnifying lens. The shape of tubercle, dorsal sulcus, and foramina on the dorsal sulcus were also observed and noted. The morphometric parameters were compared by Student's *t*-test on both the sides. **Results:** Of the 100 scaphoid bones studied, the tubercles were present in all the bones. Most of the scaphoid tubercles were conical and some were pyramidal in shape. All the scaphoid had main dorsal sulcus (54 scaphoids) and 46 scaphoids had two dorsal sulci. All the scaphoids had more than three foramina on the dorsal sulcus. **Discussion and Conclusions:** The morphological and morphometric data obtained from the scaphoid bone were compared with the previous studies, and the data may help the orthopedicians and radiologists for surgical reduction with internal fixation and to follow-up the reunion of fractured scaphoid bones.

Keywords: *Fracture, morphological variations, morphometry, scaphoid*

Introduction

The scaphoid is one of the important carpal bones that take part in the wrist joint along with lunate. It is situated in the proximal row of carpal bones on the radial side of the wrist.[1] Scaphoid articulates with other carpal bones, namely, lunate, trapezium, and capitate. It is connected with lunate bone by means of the scapholunate ligament. Scapholunate instability can occur when scapholunate ligament gets disrupted. Scaphoid heals slowly due to the limited blood supply and thus any fracture of this bone should be attended immediately in order to prevent malunion. Sometimes, nonunion may result in posttraumatic osteoarthritis.[2] Radial artery is the major blood supply to the scaphoid bone. There is excellent collateral circulation through the dorsal and volar branches of the anterior interosseous artery.[3] The middle and distal portions of the scaphoid bone are supplied by the lateral and distal branches of the radial artery through its palmar and dorsal branches, whereas the proximal portion of the bone has poor blood supply.[4] The medial surface has two facets, a flattened semi-lunar facet articulating with the lunate bone and an inferior concave facet articulating with the head of the capitate bone. Occasionally, abductor pollicis brevis may take its origin from the scaphoid tubercle.[5] The position of scaphoid bone is similar to the position of the navicular bone in the foot, hence scaphoid bone was referred as navicular bone of the hand.[6] Scaphoid injury is most common among the other carpal bones.[7] The incidence of malunion after surgical fixation treatment has been >12%, particularly in young men.[8] The waist has several ligamentous attachments.[9] Fracture may take place at any age, even in children. In males, it may occur between age group of 20 and 30 years of age.[10] Surgeons performing operative fixation of scaphoid fractures using a headless compression screw such as the Herbert screw and corticocancellous

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bone grafting for nonunion need to be familiar with these morphological and morphometric variations of the scaphoid bone.[11] The aim is to study the morphological variations and morphometric dimensions of scaphoid bone and also to observe the position and number of the nutrient foramen present in the scaphoid bone.

Material and Methods

A total of 100 dried adult human scaphoid bones (50 right and 50 left) of unknown sex were studied from the Department of Anatomy, over a period of 7 years (2011–2018) to identify the possible morphological variations. The study was approved by the Institution Ethical Committee of Medical College, Reference no. VMKVMC/IEC/18/01. The morphometry of scaphoid was measured using the vernier caliper. The number of foramina was observed using a magnifying lens and noted. The shape of tubercle, dorsal sulcus, and foramina on the dorsal sulcus were also observed. Scaphoid with arthrosis, evidence of trauma, or other pathological changes was excluded from the study. Side determination of the bones was done by anatomical features.[11,12]

Morphological parameters

The scaphoid tubercle shape, dorsal sulcus, ridge for origin of scaphocapitate interosseous ligament (SCIL), and the sulcus for flexor carpi radialis (FCR) were observed and tabulated**.** The numbers of foramina on tubercle, dorsal sulcus [Figure 1], and other parts of scaphoid were observed using a magnifying lens. The shapes of the scapholunate joint surface were also noted.[11,12]

Morphometric parameters

Scaphoid bones were measured with vernier calipers of 0.02 mm accuracy. The length was measured by distance between the most prominent points of proximal articular surface and the tubercle. The circumferences were measured at three different regions (proximal, waist, and distal) by placing a thread around them.[12] The primary and secondary height of the tubercle and length and width of the dorsal sulcus were measured and tabulated. The primary height of the tubercle is defined as the distance between the most prominent point of the tubercle and the intersection of the anterior and superior ridges of the scaphalolunate articular surface. The secondary height of the tubercle is defined as the most prominent point of the tubercle and the deepest point of the waist. Circumference of the tubercle measured at its base.[11]

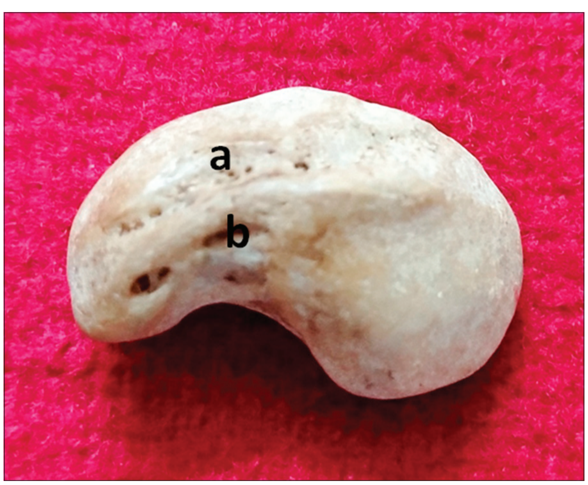

Figure 1: Nutrient foramen in the sulci of the scaphoid bone. (a) Nutrient foramen in main dorsal sulci, (b) Nutrient foramen in secondary dorsal sulci

Statistical analysis

The mean, standard deviation, standard error mean, and range were calculated. The data were analyzed by Student's *t*-test for comparison on the right and left side measurements. Statistical analysis was done using SPSS software 13.0, (SPSS, Chicago, IL, USA).

Results

Morphological features of scaphoid bone

Table 1 shows the presence of various morphological features of scaphoid such as tubercle, waist, dorsal sulcus, ridge for the attachment of SCIL, and sulcus for FCR tendon.

The shape of the scaphoid tubercle was observed. In the left scaphoid, 31 tubercles were conical in shape and 29 were pyramidal in shape, whereas in the right scaphoid, 24 tubercles were conical in shape and 26 were pyramidal in shape. Tubercle in the left side scaphoid showed a range of 2–8 foramina with minimum 2 foramina and right scaphoid showed 2–10 foramina with minimum 2 foramina. The dorsal sulcus of scaphoid bonewas observed for single or double sulcus and in 25 scaphoid dorsal sulcus were single and in 21 were double on the left side with foramina in the range of 2–10 present in it, whereas 29 sulcus were single and 25 were double on the right side scaphoid dorsal sulcus with foramina in the range of 2–11 present in it. The 54 scaphoids had single dorsal sulcus and 46 scaphoids had double dorsal sulcus irrespective of the sides.

Foramina in scaphoid other than in dorsal sulcus and tubercle was observed, and it was found that a minimum of

Table 1: Morphological features of the scaphoid bone

Morphological features present	Left (*n*=50)	Right (*n*=50)	Total (*n*=100)
Tubercle	50	50	100
Waist	50	50	100
Dorsal sulcus	50	50	100
Ridge for the origin of SCIL	46	49	95
Sulcus of FCR	40	46	86

SCIL=Scaphocapitate interosseous ligament, FCR=Flexor carpi radialis tendon single foramen to a maximum of 10 foraminawas found on the left side scaphoid bone, whereas a minimum of single foramen to a maximum of 11 foramina was found on right side scaphoid bone.

Morphometric parameters of scaphoid bone

The morphometric comparison was done on both sides of the bone [Table 2]. The waist circumference and tubercle circumference was statistically significant ($P = 0.001$). The width of the waist ($P = 0.02$) were significant. The mean values and standard deviation for the Morphometric parameters are shown in Table 2.

Discussion

The scaphoid bone is a unique carpal bone in its shape as well as function. It has unique three dimensional orientations and connects the proximal and distal rows of carpal bones on the radial aspect of the wrist to perform various functions.[13] The scaphoid due to its complex shape and its orientation when compared with other carpal bones, it is so difficult to interpret its anatomy radiologically in X-rays when the bone gets fractured.[14,15] In acute scaphoid fractures, internal fixation is the only well-established line of treatment alternative to casting.[16] In healthy young individuals, the only carpal bone of the wrist to get fractured is scaphoid.[17]

Morphological features of scaphoid bone

In the present study, all the scaphoids have tubercles, waist, and dorsal sulcus. The scapholunate joint surface was also observed, and it was found that 31 scaphoids have crescent shape and 19 have half-moon shape on the left side, whereas 32 were crescent shape and 18 were half-moon shape on the right side. In a study done by Chandra *et al*., the waist was absent in one scaphoid of the right side, and other features were present in all the bones.[11] The waist gives attachments to several ligamentous.[9] As the waist provides several ligamentous attachments if it is absent, the attachments could become weaker; this is the reason for ligamentous injuries if the waist of scaphoid is absent.

Table 2: Morphometry of the scaphoid bone

Parameters	Mean±SD		T	P
	Left	Right		
Length	2.37±0.27	2.41±0.22	0.85	0.39#
Waist circumference	3.24±0.40	4.1±0.29	3.35	0.001***
Tubercle circumference	3.44±0.37	3.65±0.34	3.05	0.001***
Proximal width	1.04±0.9	1.02±0.13	0.60	0.55#
Waist width	0.62±0.19	0.74±0.15	2.49	0.02**
Distal width	1.13±0.16	1.11±0.10	0.59	0.66#
Primary height tubercle	1.31±0.19	1.31±0.17	0.06	0.96#
Secondary height tubercle	1.14±0.15	1.16±0.15	0.67	0.50#
Length of dorsal sulcus	0.64±0.04	0.69±0.32	0.96	0.34#
Width of dorsal sulcus	0.18±0.09	0.24±0.08	0.78	0.43#

Values are expressed as mean±SD, n=100, #Nonsignificant, *Significant, *P<0.05, **P<0.01, ***P<0.001. Statistical analysis – Students t-test. SD=Standard deviation

A study was done on 100 unknown human scaphoids in Sikkim of Northeastern Indian population. The morphometric parameters were measured and statistically analyzed. On the left side, scaphoid tubercles were conical in (44%) and pyramidal shape in 28 (56%). On the right side, scaphoid tubercles were conical in 36 (72%) and pyramidal shape in 14 (28%).[12] In another study, on the left side, 7 scaphoid tubercles were conical and 8 were pyramidal in shape. Similarly, on the right side, 9 scaphoid tubercles were conical and 6 were pyramidal in shape.[11] All the scaphoids had waist except one.[12] In the present study, the shape of the scaphoid tubercle was observed. In the left scaphoid, 31 tubercles were conical in shape and 29 were pyramidal in shape, whereas in the right scaphoid, 24 tubercles were conical in shape and 26 were pyramidal in shape. Tubercle in the left side scaphoid showed a range of 2–8 foramina with minimum 2 foramina and right scaphoid showed 2–10 foramina with minimum 2 foramina. The foramina in the scaphoid tubercle were observed in the present study, earlier studies have not reported any regarding the foramina in tubercles.

The dorsal sulcus contains numerous nutrient foramina,[18] the foramina in the dorsal sulcus are related to the vascular supply of scaphoid.[14] In a study, all the scaphoid had a minimum of one foramen in the main dorsal sulcus and 92% had more than one foramen. The scaphoids presented with secondary sulci had more than one foramen in it.[12] In the present study, the dorsal sulcus of scaphoid bonewas observed for single or double sulcus and in 25 scaphoid dorsal sulcus were single and in 21 were double on the left side with foramina in the range of 2–10 present in it, whereas 29 sulcus were single and 25 were double on the right side scaphoid dorsal sulcus with foramina in the range of 2–11 present in it. The 54 scaphoid has single dorsal sulcus and 46 scaphoids had double dorsal sulcus irrespective of the sides.

Foramina in scaphoid other than in dorsal sulcus and tubercle was observed in the present study, and it was found that a minimum of single foramen to a maximum of 10 foramina were found on the left side scaphoid bone, whereas a minimum of single foramen to a maximum of 11 foramina were found on the right side scaphoid bone. The foramina which were assessed at proximal region were present only in 15%, this may explain the occurrence of nonunion and avascular necrosis after proximal fracture.[11] Ceri *et al*.[14] in their study found at least one foramen in the main dorsal sulcus and 88% had more than five foramen, 18% had no foramen in the proximal region.

The ridges for origin of SCIL were present in 41 scaphoids of the left side and 40 of the right side.[12] Ceri *et al*.[14] observed SCIL ridge in 80 specimens of the right and 83 in the left side of a total of 200 scaphoids. In the present

Table 3: Comparison of morphometry of scaphoid from the previous studies with the present study

Parameters	Chandra *et al*.[11] 2014 (*n*=30)		Purushothama *et al*.[12] 2011 (*n*=100)		Present study 2018 (*n*=100)	
	Left (mm)	Right (mm)	Left (mm)	Right (mm)	Left (mm)	Right (mm)
Length	21.97	22.42	22.33	22.65	23.7	24.1
Waist circumference	30.57	30.47	30.06	31.35	32.4	41.2
Tubercle circumference	25.41	25.13	25.67	26.23	34.4	36.5
Proximal width	11.23	11.53	11.53	12	10.4	10.2
Waist width	6.97	6.91	6.88	7.06	6.2	7.4
Distal width	10.66	10.56	10.92	10.69	11.3	11.1
Primary height tubercle	9.34	9.34	9.41	9.18	13.1	13.1
Secondary height tubercle	6.52	6.31	6.45	5.96	6.4	6.9
Length of dorsal sulcus	16.46	16.50	16.12	17.92	19.4	19.9
Width of dorsal sulcus	1.82	1.79	1.83	2.56	1.82	2.43

study, the ridges were found on 46 on the left and 49 on the right. The absence of ridge indicates weak attachment of SCIL ligament or absence of this ligament, further making the scaphocapitate joint weak resulting in dislocation of scaphoid. Sulci of FCR were present in 38 scaphoids of the left side and 42 of the right side.[12] In the present study, the sulcus was found on 46 on the left and 49 on the right. Comparison of morphological features of both sides other than shape of tubercles were not significant.[11]

Morphometry of scaphoid bone

The present study morphometric measurement was compared with earlier studies done in 30 scaphoid from South Indian population and 100 scaphoid bones from the Northeast population of India [Table 3]. In the present study, it was observed that tubercles were present in all scaphoids and the height and circumference of base of the tubercle were strongly correlating with each other. This may explain the relatively low incidence of fractures of tubercles.[14] Most population are right dominant the mean length and circumference of waist of right scaphoids were found to be more than left in the present study.

The length and waist circumference of scaphoid when compared to other studies showed increase in morphometric measurements, whereas tubercle circumference showed a wide range of difference of 10 mm, length of dorsal sulcus and primary height tubercle showed a slight difference of 2 mm in morphometric measurements. The other morphometric measurements were within the same range and did not show much variation. The difference in morphometry may be due to age, gender, and ethnicity.[19] The morphometric comparison was done on both sides of the bone [Table 2]. The waist circumference and tubercle circumference was statistically significant (P = 0.001). The width of the waist (P = 0.02) were significant when compared on both sides

Conclusions

Scaphoid fracture preferred treatment is surgical reduction with internal fixation. Internal fixation has become a well-established alternative to casting for acute scaphoids fractures. Screw design has evolved, and several different types of screws of varying sizes are now available. An established nonunion or mal-union after fracture results in pain, loss of mobility, and ends up in osteoarthritis. The morphological and morphometric data obtained in the present study may help the orthopedicians, hand surgeons, morphologists, clinical anatomists, and radiologists for surgical reduction with internal fixation to follow-up the reunion of fractured scaphoid bones.

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Conflicts of interest

There are no conflicts of interest.

References

1. Drake R, Vogl AW, Mitchell AW. In: Gray's Anatomy for Students E-Book. 2nd ed. Philadelphia: Elsevier Health Sciences, Elsevier/Churchill Livingstone; 2009.
2. Glanze WD, Anderson K, Anderson LE. Mosby's Medical, Nursing, and Allied Health Dictionary. 4th ed. St. Louis: Mosby; 1990. p. 1396.
3. Gelberman RH, Menon J. The vascularity of the scaphoid bone. J Hand Surg Am 1980;5:508-13.
4. Tokyay A, Gunal I. Avascular necrosis of the distal pole of the scaphoid. Case Reports Plast Surg Hand Surg 2015;2:40-2.
5. Eathorne SW. The wrist: Clinical anatomy and physical examination – An update. Prim Care 2005;32:17-33.
6. Henry G. II. Osteology 6b. The hand – The carpus. Anatomy of the Human Body. Philadelphia: Lea and Febiger; 1918.
7. Mack GR, Bosse MJ, Gelberman RH, Yu E. The natural history of scaphoid non-union. J Bone Joint Surg Am 1984;66:504-9.
8. Leslie IJ, Dickson RA. The fractured carpal scaphoid. Natural history and factors influencing outcome. J Bone Joint Surg Br 1981;63:225-30.
9. Berger RA. The ligaments of the wrist. A current overview of anatomy with considerations of their potential functions. Hand Clin 1997;13:63-82.
10. Patterson R, Moritomo H, Yamaguchi S, Mitsuyasu H, Shah M, Buford WL, *et al*. Scaphoid anatomy and mechanism: Update and review. Oper Tech Orthop 2003;13:2-10.
11. Chandra Philip X, Prabhavathy G, Bilodi AK. Study of anatomical variations of scaphoid bone and its clinical

importance. J Evid Based Med Healthc 2014;1:270-8.

12. Purushothama C, Sarda RK, Konuri A, Tamang BK, Gupta C, Murlimanju BV. Morphological and morphometric features of scaphoid bone in North Eastern population, India. Nepal Med Coll J 2011;13:20-3.
13. Compson JP, Waterman JK, Heatley FW. The radiological anatomy of the scaphoid. Part 1: Osteology. J Hand Surg Br 1994;19:183-7.
14. Ceri N, Korman E, Gunal I, Tetik S. The morphological and morphometric features of the scaphoid. J Hand Surg Br 2004;29:393-8.
15. Heinzelmann AD, Archer G, Bindra RR. Anthropometry of the human scaphoid. J Hand Surg Am 2007;32:1005-8.
16. Bretlau T, Christensen OM, Edström P, Thomsen HS, Lausten GS. Diagnosis of scaphoid fracture and dedicated extremity MRI. Acta Orthop Scand 1999;70:504-8.
17. Megerle K, Harenberg PS, Germann G, Hellmich S. Scaphoid morphology and clinical outcomes in scaphoid reconstructions. Injury 2012;43:306-10.
18. Bongumill G. Anatomy of the wrist. In: Lichtman D, editor. The Wrist and its Disorders. Philadelphia: W. B. Saunders; 1988. p. 14-26.
19. Darmawan MF, Yusuf SM, Haron H, Kadir MR. Review on Techniques in Determination of Age and Gender of Bone Using Forensic Anthropology. In: Computational Intelligence, Modelling and Simulation (CIMSiM), 2012 Fourth International Conference on IEEE; 2012. p. 105-10.