International Journal of Anatomy and Research,
Int J Anat Res 2019, Vol 7(2.1):6361-69. ISSN 2321-4287
DOI: https://dx.doi.org/10.16965/ijar.2019.119

MORPHOLOGICAL AND MORPHOMETRIC STUDY OF DRY SCAPHOID BONE IN THE NORTH INDIAN POPULATION

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ABSTRACT

Background: A review of the relevant literature showed that previous descriptions of scaphoid were not detailed enough to match our present clinical knowledge or the requirements of modern imaging especially in the North Indian population. With this in mind a study was conducted on 50 dry cadaveric scaphoids of North Indian origin.

Material and Methods: The study was performed on 50 dry human scaphoid bones of the North Indian population. Various morphological and morphometric parameters were observed and measured using vernier callipers, a non-stretchable thread, centimetre scales and a protractor.

Results: All the morphological parameters studied were present in all the 50 bones except the sulcus for flexor carpi radialis that was absent in 12 and the ridge for the scapho-capitate interosseous ligament that was absent in 13 bones. The tubercle was conical in 36, pyramidal in 13 and round in the remaining 1 bone. The maximal length of scaphoid and the thickness of waist were significantly higher on the right side. 30 bones had equally developed, 10 bones had under developed proximal while the remaining 10 bones had under developed distal pole. The average value of anteroposterior intra scaphoid angle of 50 scaphoid was found to be 39.20 ± 6.42^0.

Clinical significance: The data obtained in the present study will be helpful for the hand surgeons, radiologists, morphologists and clinical anatomists.

KEY WORDS: scaphoid, morphology, morphometry, sulcus for flexor carpi radialis, ridge for scapho-capitate interosseous ligament.

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Access this Article online	Journal Information	
Quick Response code	**International Journal of Anatomy and Research**	
	ICV for 2016 90.30	ISSN (E) 2321-4287 | ISSN (P) 2321-8967 **https://www.ijmhr.org/ijar.htm** **DOI-Prefix:** https://dx.doi.org/10.16965/ijar
	Article Information	
DOI: 10.16965/ijar.2019.119	Received: 23 Jan 2019 Peer Review: 24 Jan 2019 Revised: None	Accepted: 07 Mar 2019 Published (O): 05 Apr 2019 Published (P): 05 Apr 2019

INTRODUCTION

Scaphoid (Os Scaphoideum) is the largest and most lateral of the proximal row of carpals [1]. It has a unique three dimensional orientation and forms an important link between the proximal and distal rows of carpal bones on the radial aspect of the wrist [2]. Since it articulates with several other bones in the hand and wrist, it plays an important role in wrist dynamics [3].

It is roughly cuboidal in shape, presenting six surfaces, dorsal, palmar, proximal, distal, medial and lateral. The palmar surface is proximally flat and faces anteriorly. On the distolateral part of the palmar surface there is a projection known as tubercle (Tuberculum ossis scaphoidei) [1]. It is located at the base of the thenar eminence and is in line with the radial border of the long finger [4]. One of its three sides faces medially and slightly palmarwards and sometimes has a groove for flexor carpi radialis. Occasionally its base is marked with a small ridge where the scapho-capitate interosseous ligament inserts [1].

The body of the scaphoid is defined as the part of the scaphoid which is not the tubercle and waist refers to the narrowest part of the body [5]. The waist subdivides the scaphoid into proximal and distal segments. It serves as an anchoring point for several ligamentous attachments [6,7,8].

Scaphoid has two poles, proximal and distal, where proximal pole refers to the area proximal to the waist and the distal pole as the area distal to the waist [9,10]. The proximal pole is solely articular. The radial aspect of the proximal pole contributes to the radio-scaphoid articulation, while the ulnar aspect of the pole contributes to the scapho-lunate articulation [10,11]. The distal pole is largely articular; the remainder constituting the tubercle. This pole articulates with the trapezium radially and trapezoid ulnarly to form the scaphotrapeziotrapezoidal joint [12].

As there is limited documentation of normal, variant morphological and morphometric parameters of scaphoid in the North Indian population so this study was undertaken. We believe that the data obtained from the present study will be helpful for the hand surgeons, radiologists, morphologists and clinical anatomists.

MATERIALS AND METHODS

The material for the present study comprised of 50 dry scaphoid bones (25 right and 25 left) of unknown sex, obtained from the Department of Anatomy, Guru Gobind Singh Medical College, Faridkot. The bones were labelled from 1-50 with the suffix R for Right or L for Left. Apparently pathological and bones with previous signs of fracture were excluded.

Following instruments were used for the study:

Vernier callipers with a least count of 0.02 mm for measuring the lengths, breadths and thickness of various parts of scaphoid.

A non-stretchable thread for measuring circumference.

Two centimetre scales with a least count of 1 mm each, a blank white paper and a protractor for measuring the anteroposterior intrascaphoid angle.

Following morphological and morphometric parameters of scaphoid were observed and recorded:

<u>Of scaphoid as a whole:</u>

1. Maximal length - Measured as the distance between the most prominent point on its proximal articular surface and that on the tubercle.

2. Axis length - For this, the bone was placed on a flat surface. Two lines were drawn, one perpendicular to the most prominent point on the proximal pole and the other on the distal pole. The linear distance between these two lines was recorded with a centimetre scale.

3. Maximum width - Measured at its two poles separately.

4. Minimum thickness

5. The two poles (proximal and distal) were compared with each other and assessed as equally developed, underdeveloped proximal or underdeveloped distal.

6. Anteroposterior intra scaphoid angle - For measuring this angle, the bone was placed on a blank white paper. Two centimetre scales were placed, one along the long axis of the body and the other along the long axis of the tubercle. Then a protractor was placed at the point of intersection of these two scales and the angle between them was recorded.

<u>Of waist:</u>

1. It was observed whether the waist was present or absent.

2. Width

3. Thickness

4. Circumference - Measured by placing a non-stretchable thread around the waist. Then the thread was taken off the scaphoid and its length was measured using a centimetre scale.

<u>Of tubercle:</u>

1. It was observed whether the tubercle was

present or absent.

2. Shape was examined as conical or pyramidal.

3. Primary height - Measured as the distance between the most prominent point on the tubercle and the point of intersection of the anterior and superior ridges of the scaphocapitate articular surface.

4. Secondary height - Measured as the distance between the most prominent point on the tubercle and the deepest point of the waist.

5. Circumference - Measured by placing a non-stretchable thread around its base. Then the thread was taken off the scaphoid and its length was measured using a centimetre scale.

6. Sulcus for flexor carpi radialis – Presence or absence of the sulcus was observed.

7. Ridge for scaphocapitate interosseous ligament - Presence or absence of the ridge was observed.

The observations and measurements thus made were recorded on specially designed proforma and were analyzed statistically. Each variable was investigated and correlated individually with reference to the side. Any gross variations in the morphological and morphometric observations were considered and an attempt was made to explain them as per accessible literature.

Fig.1: Showing equally developed proximal (P) and distal (D) poles.

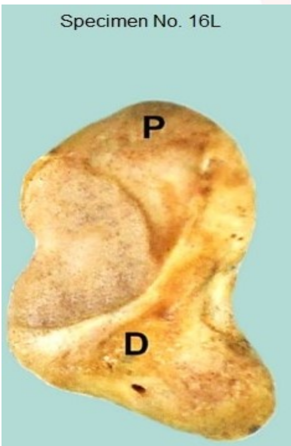


Fig.2: Showing underdeveloped proximal pole (P).

Fig.3: Showing underdeveloped distal pole (D).

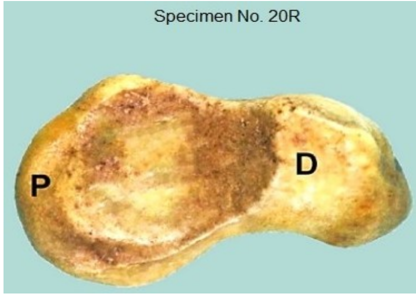


Fig.4: Showing sulcus for flexor carpi radialis muscle on the base of the tubercle.

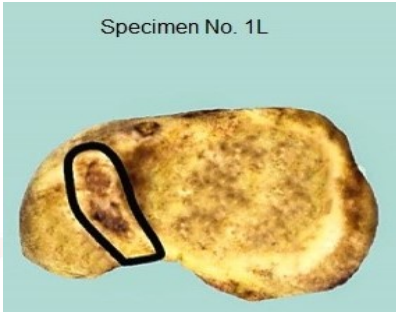


Fig.5: Showing absence of the sulcus for flexor carpi radialis muscle on the base of the tubercle.

Fig.6: Showing triangular sulcus for flexor carpi radialis muscle on the base of the tubercle.

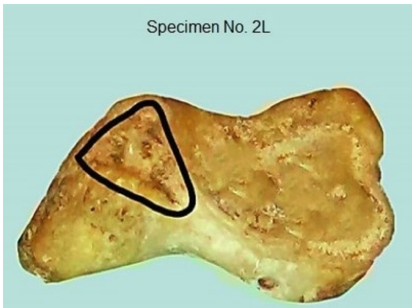


Fig.7: Showing the ridge for the Scaphocapitate interosseous ligament on the base of the tubercle.

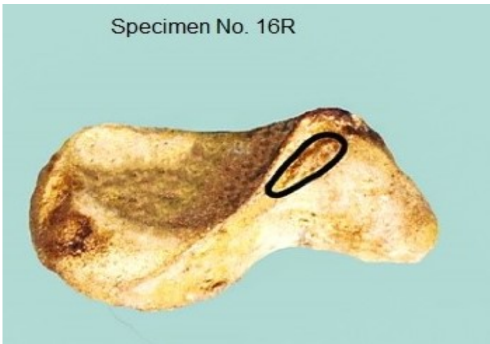


Fig.8: Showing the absence of the ridge for Scapho capitate interosseous ligament on the base of the tubercle.

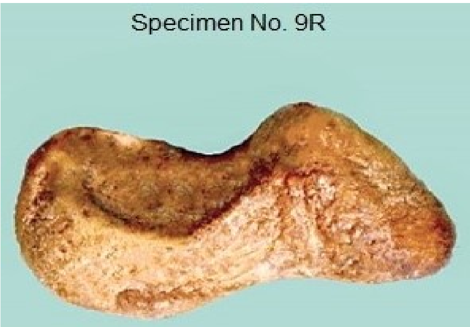


Fig.9: Showing conical tubercle (C).

Fig.10: Showing pyramidal tubercle (P).

Fig.11: Showing round tubercle (R).

Fig.12: Showing anteroposterior intrascaphoid angle ($\angle$ AOB= 30^o).

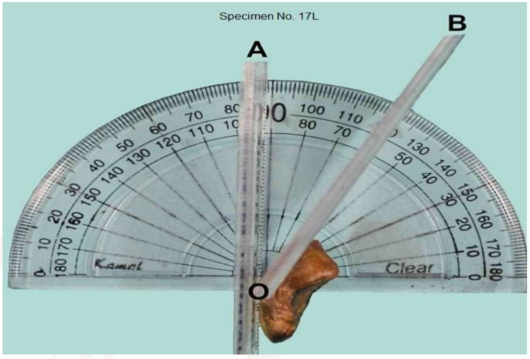
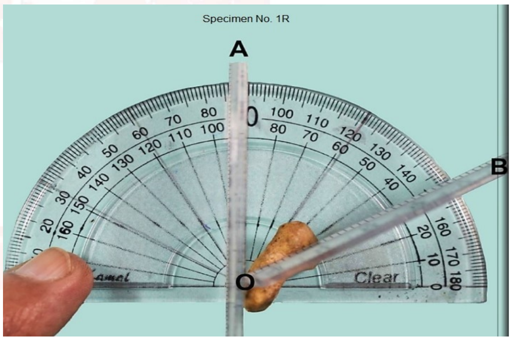


Fig.13: Showing anteroposterior intrascaphoid angle (“ AOB= 60^o).



RESULTS AND DISCUSSION

Table 1: Showing comparison of the percentage incidence of the waist in the present study with the previous studies.

Workers	Year	No. of scaphoids studied (n)	No. of scaphoids in which waist was present n (%)	No. of scaphoids in which waist was absent n (%)
Compson et al [13]	1994	50	50 (100%)	0 (0%)
Ceri et al [14]	2004	200	195 (97.5%)	5 (2.5%)
Purushothama et al [15]	2011	100	99 (99%)	1 (1%)
Philip et al [2]	2014	30	30 (100%)	0 (0%)
Present study	2018	50	50 (100%)	0 (0%)

Table 2: Showing comparison of the percentage incidence of the tubercle in the present study with the previous studies.

Workers	Year	No. of scaphoids studied (n)	No. of scaphoids in which tubercle was present n (%)	No. of scaphoids in which tubercle was absent n (%)
Compson et al [13]	1994	50	50 (100%)	0 (0%)
Ceri et al [14]	2004	200	200 (100%)	0 (0%)
Purushothama et al [15]	2011	100	100 (100%)	0 (0%)
Philip et al [2]	2014	30	30 (100%)	0 (0%)
Present study	2018	50	50 (100%)	0 (0%)

Table 3: Showing comparison of the percentage incidence of sulcus for flexor carpi radialis (FCR) in the present study with the previous studies.

Workers	Year	No. of scaphoids studied (n)	No. of scaphoids in which sulcus for FCR was present n (%)	No. of scaphoids in which sulcus for FCR was absent n (%)
Ceri et al [14]	2004	200	158 (79%)	42 (21%)
Purushothama et al [15]	2011	100	80 (80%)	20 (20%)
Philip et al [2]	2014	30	21 (70%)	9 (30%)
Present study	2018	50	38 (76%)	12 (24%)

Table 4: Showing comparison of the percentage incidence of the ridge for scaphocapitate interosseous ligament (SCIL) in the present study with the previous studies.

Workers	Year	No. of scaphoids studied (n)	No. of scaphoids in which ridge for SCIL was present n (%)	No. of scaphoids in which ridge for SCIL was absent n (%)
Ceri et al [14]	2004	200	163 (81.5%)	37 (18.5%)
Purushothama et al [15]	2011	100	81 (81%)	19 (19%)
Philip et al [2]	2014	30	22 (73.3%)	8 (26.6%)
Present study	2018	50	37 (74%)	13 (26%)

Table 5: Showing comparison of the percentage incidence of the varied shapes of the tubercle in the present study with the previous studies.

Workers	Year	No. of scaphoids studied (n)	No. of scaphoids with conical tubercle n (%)	No. of scaphoids with pyramidal tubercle n (%)	No. of scaphoids with round tubercle n (%)
Ceri et al [14]	2004	200	142 (71%)	55 (27.5%)	0 (0%)
Purushothama et al [15]	2011	100	58 (58%)	42 (42%)	0 (0%)
Philip et al [2]	2014	30	16 (53.3%)	14 (46.6%)	0 (0%)
Present study	2018	50	36 (72%)	13 (26%)	1 (2%)

Table 6: Showing the gross anatomical dimensions of the various parts of scaphoid.

Dimension	Mean±S.D. (mm/^{0})			p-value
	Total (n=50)	Left (n=25)	Right (n=25)	
Maximal length of scaphoid	26.20±1.24	25.76±1.00	26.65±1.32	0.018
Axis length of scaphoid	26.15±1.07	26.06±1.31	26.23±0.77	0.56
Maximum proximal width of scaphoid	14.39±1.22	14.29±1.17	14.50±1.29	0.557
Maximum distal width of scaphoid	10.20±0.86	10.08±0.89	10.33±0.83	0.301
Minimum thickness of scaphoid	2.84±0.80	2.63±0.74	3.05±0.82	0.066
Anteroposterior intra scaphoid angle	39.20±6.42	39.80±4.20	38.60±8.10	0.283
Length of body	14.97±0.94	14.74±0.65	15.20±1.13	0.204
Maximum thickness of body	7.06±0.78	7.01±0.90	7.11±0.67	0.574
Width of waist	10.46±1.24	10.55±1.2	10.37±1.2	0.614
Thickness of waist	9.95±0.75	9.72±0.62	10.18± 0.80	0.022
Circumference of waist	33.52±2.29	33.1±2.50	33.93±2.03	0.202
Primary height of tubercle	14.06±1.46	13.99±1.50	14.11±1.44	0.741
Secondary height of tubercle	9.66±1.21	9.32±1.09	9.99±1.25	0.051
Circumference of tubercle	36.19±2.88	35.6±2.58	36.7±3.09	0.105

Table 7: Showing comparison of the various morphometric parameters in the present study with the previous studies.

	Workers	Year	No. of scaphoids studied (n)	Mean (mm)	Range (mm)	S.D.
Maximal length of scaphoid	Ceri et al [14]	2004	200	25.8	-------	2.4
	Kong et al [18]	2009	48	27.42	--------	--------
	Purushothama et al [15]	2011	100	22.49	--------	2.24
	Philip et al [2]	2014	30	22.19	--------	1.31
	Present study	2018	50	26.2	24.56 – 29.00	1.24
Axis length of scaphoid	Kong et al [18]	2009	48	25.68	--------	--------
	Present study	2018	50	26.15	23.65-29.1	1.07
Maximal proximal width of scaphoid	Ceri et al [14]	2004	200	15.3	-------	1.6
	Purushothama et al [15]	2011	100	11.76	--------	1.58
	Philip et a [2]	2014	30	11.38	--------	0.68
	Present study	2018	50	14.39	12.22-16.21	1.22
Maximal distal width of scaphoid	Ceri et al [14]	2004	200	14.9	-------	1.8
	Purushothama et al [15]	2011	100	10.8	--------	1.51
	Philip et al [2]	2014	30	10.61	--------	0.56
	Present study	2018	50	10.2	8.56-12	0.86
Length of body	Kong et al [18]	2009	48	16.36	--------	1.84
	Present study	2018	50	14.97	13.56-18.00	0.93
Width of waist	Ceri et al [14]	2004	200	10.9	-------	1.6
	Kong et al [18]	2009	48	10.59	--------	1.11
	Purushothama et al [15]	2011	100	6.97	--------	1.51
	Philip et al [2]	2014	30	6.94	--------	0.4
	Present study	2018	50	10.46	9.02-13.47	1.24
Thickness of waist	Kong et al [18]	2009	48	12.02	--------	1.9
	Present study	2018	50	9.95	9.00-12.30	0.75
Circumference of waist	Ceri et al [14]	2004	200	34.5	-------	3.8
	Purushothama et al [15]	2011	100	30.7	--------	3.06
	Philip et al [2]	2014	30	30.52	--------	0.55
	Present study	2018	50	33.52	29.19-36.22	2.29
Primary height of tubercle	Ceri et a [14]	2004	200	12.4	-------	1.4
	Purushothama et al [15]	2011	100	9.29	--------	1.34
	Philip et al [2]	2014	30	9.34	--------	0.41
	Present study	2018	50	14.06	11.02-16.00	1.46
Secondary height of tubercle	Ceri et al [14]	2004	200	9.1	-------	1.4
	Kong et al [18]	2009	48	11.28	--------	0.94
	Purushothama et al [15]	2011	100	6.2	--------	1.2
	Philip et al [2]	2014	30	6.41	--------	0.52
	Present study	2018	50	9.66	6.74-12.60	1.21
Circumference of tubercle	Ceri et al [14]	2004	200	35.3	-------	3
	Purushothama et al [15]	2011	100	25.9	--------	3.73
	Philip et al [2]	2014	30	25.27	--------	0.79
	Present study	2018	50	36.19	30.41-41.00	2.88

Table 8: Showing comparison of the anteroposterior intrascaphoid angle of scaphoid in the present study with the previous studies.

Workers	Year	No. of scaphoids studied (n)	Mean (^{0})	Range (^{0})	S.D.
Amadio et al [19]	1989	45	40	--------	4
Giessen et al [20]	2010	50	46	--------	8.3
Present study	2018	50	39.2	30-60	6.42

Morphological parameters: Included the comparison of the poles of scaphoid, presence or absence of waist, tubercle, sulcus for flexor carpi radialis and ridge for scapho-capitate interosseous ligament, shape of the tubercle.

Scaphoid pleomorphism: Compson et al classified the poles of scaphoid into three morphological types i.e. Equally developed, Underdeveloped proximal and Underdeveloped distal pole [13].

In our study, out of the total 50(100%) [Rt.- 25(50%), Lt.- 25(50%)] bones studied, 30(60%) [Rt.- 15(30%), Lt.- 15(30%)] bones had equally developed (Fig.1), 10(20%) [Rt.- 5(10%), Lt- 5(10%] bones had under developed proximal (Fig.2) while the remaining 10(20%) [Rt.- 5(10%), Lt.- 5(10%)] bones had under developed distal pole (Fig.3). On comparison with the previous studies it was seen that the percentage incidence of the varied shapes of the poles of the scaphoids were in consonance with those of Ceri et al who in their study on 200 scaphoids recorded equally developed, underdeveloped proximal and underdeveloped distal poles in 116(58%), 38(19%) and 46(23%) bones respectively [14].

Waist was present in all the 50(100%) [(Rt.- 25(50%), Lt.- 25(50%)] bones. Its incidence has been compared with the previous studies in Table 1.

The findings of the present study stand equivalent to the works of Philip et al and Compson et al [2,13]. On the contrary, waist was absent in 5(2.5%) and 1(1%) bones in the studies by Ceri et al and Purushothama et al respectively [14,15]. The waist serves as an important anchoring point for several ligamentous attachments [16]. In its absence the attachments would be weak and this may explain the fact that its absence is accompanied with more ligamentous injuries [2,13,14].

Tubercle was present in all the 50(100%) [(Rt.- 25(50%), Lt.- 25(50%)] bones. This has been compared with the previous studies in Table 2.

Sulcus for flexor carpi radialis (FCR) was present in 38(76%) [Rt.- 19(38%), Lt.- 19(38%)] scaphoid bones (Fig.4). Out of these, it was well defined in 18(36%) [Rt.- 8(16%), Lt.- 10(20%)] and ill defined in the remaining 20(40%) [Rt.- 11(22%), Lt.- 9(18%)] bones. There is no mention of such a demarcation in the previous studies. The absence of the sulcus in the remaining 12(24%) bones in the present study may be related to the greater carpal instabilities in such cases (Fig.5).

In 1(2%) of the bones in the present study i.e. Specimen no. 2 of left side, the sulcus for flexor carpi radialis was found to be characteristically triangular in shape (Fig.6). There is no mention of such a sulcus in the available literature.

The percentage incidence of this sulcus in the present study has been compared with the studies of other workers in Table 3.

Ridge for scaphocapitate interosseous ligament (SCIL) was present in 37(74%) [Rt.- 17(34%), Lt.- 20(40%)] bones (Fig.7). Out of these, it was well defined in 8(16%) [Rt.- 2(4%), Lt.- 6(12%)] bones and ill defined in the remaining 29(58%) [Rt.- 15(30%), Lt.- 14(28%)] bones. On the contrary Philip et.al, Ceri et al and Purushothama et al are silent as far as this aspect of the observed parameter is concerned [2,14,15]. The absence of this ridge recorded in the remaining 13(26%) [Rt.- 8(16%), Lt.- 5(10%)] bones of the present study could indicate the weak attachment of SCIL further making the scaphocapitate joint weak (Fig.8).

The percentage incidence of this ridge has been compared with the studies of other workers in Table 4.

Shape of the tubercle was conical in 36(72%) [Rt.- 18(36%), Lt.- 18(36%)] bones (Fig.9), pyramidal in 13(26%) [Rt.- 6(12%), Lt.- 7(14%)] bones (Fig.10) and round in the remaining 1(2%) bone of the right side (Fig.11). These observations have been compared with the previous studies in Table 5.

Above comparative analysis elucidates that the percentage incidence of the different shapes of the tubercle in the present study were comparable to those recorded by Ceri et al [14]. The only difference was the round tubercle seen in 1(2%) of the scaphoids in the present series which was not reported earlier by Ceri et al [14]. Also in the study by Ceri et al, the shape of the tubercle could not be defined in 3(1.5%) bones while this was not the case in the present study [14].

The tubercle gives attachment to the flexor retinaculum and a few fibres of abductor pollicis brevis [17]. The force exerted by this muscle may explain the varied shapes of the tubercle [14].

Morphometric parameters: Included maximal and axis lengths, maximum proximal and distal widths, minimum thickness and the anteroposterior intra scaphoid angle of scaphoid as a whole; length and maximum thickness of the body of scaphoid; width, thickness and circumference of the waist; primary and secondary heights, circumference of the tubercle.

The average values of these parameters recorded in the present study are given in Table 6.

From the above table it is evident that in the present study, there were no statistically significant differences in the average values of the various dimensions of the scaphoids of the two sides except for the maximal length of the bone as a whole and the thickness of the waist that were significantly higher on the right side. This difference may indicate greater force transmission on the dominant side as per the Wolfe's law [14].

The various morphometric parameters of scaphoid have been compared with the previous works in literature in Table 7. No comparative data pertaining to the minimum thickness of scaphoid and the maximum thickness of the body could be found in the available and accessible literature..

The differences observed between the parameters in our study and the previous studies may be due to the difference in the race, native place and living habits of the populations studied by them.

Anteroposterior intra scaphoid (APIS) angle Amadio et al defined this as the change in the angulation between the proximal and distal poles [19]. In the present study, the average value of anteroposterior intra scaphoid angle of 50 scaphoids was found to be 39.20 ± 6.42^0 (Rt.- 38.60 ± 8.10^0, Lt.- 39.80 ± 4.20^0) with a range of 30 to 60^0 (Fig.12,13). We could not find any study related to this angle conducted on dry cadaver bones in the past. The only studies pertaining to this angle reported previously in literature were carried out on the CT scans of healthy wrists and have been compared with the present study in Table 8.

The body of scaphoid bone is oval in cross-section and concave towards the capitate in two planes. The tubercle, arising from the distal end of the body, projects palmarwards and radially. Although the body has no intrinsic rotation in its long axis, the offset tubercle gives the complete bone a twisted appearance. Because of the variability in the angle that the tubercle subtends to the body, the amount of this apparent twist varies considerably [17]. Modgil et al further added that the acquaintance with the varied bone geometries would be helpful in the development of wrist prosthetics [21].

Clinical significance: The complexity in the shape and orientation of scaphoid makes it difficult to interpret its anatomy radiologically. Hence, a detailed knowledge and awareness of its anatomy, and variations in its morphological and morphometric features will allow a better understanding of injury patterns and carpal kinematics. This will ultimately improve the understanding of wrist function and promote enhancement of treatments for wrist dysfunction [22].

Conflicts of Interests: None

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How to cite this article:

Meenakshi Khullar, Priti Chaudhary, Satvir Singh. MORPHOLOGICAL AND MORPHOMETRIC STUDY OF DRY SCAPHOID BONE IN THE NORTH INDIAN POPULATION. Int J Anat Res 2019;7(2.1):6361-6369. **DOI:** 10.16965/ijar.2019.119