Foramen Magnum: A Morphological and Morphometric Study in Dried Human Skull Bones of Rajasthan Population and its Surgical Importance

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ABSTRACT

Introduction: The foramen magnum (FM) is a large opening in the base of the skull. The dimensions of FM are clinically important because many vital structure passing through it, viz., the lower end of medulla oblongata, the vertebral arteries, and spinal accessory nerves. It may endure compression such as in cases of FM herniation, FM meningiomas, and FM achondroplasia. The knowledge of FM diameter is needed to determine some malformations such as the Arnold–Chiari syndrome, which shows expansion of the transverse diameter.

Materials and methods: The present study was carried out on 75 dry human skulls of unknown age and sex belonging to Rajasthan population by the Department of Anatomy at Mahatma Gandhi Medical College and Hospital, Jaipur, Rajasthan. All the measurements were taken with the help of digital vernier calipers.

Results: The mean anteroposterior diameter was 35.11 ± 3.12 mm, the transverse diameter was 29.35 ± 3.48 mm, area was 813.94 ± 146.40 mm², and the FM index was 1.208 ± 0.150 . The FM shapes were determined as oval (22.67%), egg-shaped (12.00%), round (14.67%), tetragonal (14.67%), pentagonal (9.33%), hexagonal (16.00%), and irregular (10.67%).

Conclusion: This study will be useful for the anatomists, radiologists, neurosurgeons, and orthopedic surgeons.

Keywords: Achondroplasia, Arnold–Chiari syndrome, Foramen magnum.

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INTRODUCTION

The foramen magnum (FM) is a large opening (Latin: great hole) in the base of the skull (Fig. 1). It is an important landmark of the base of skull and is of particular interest for anthropologists, anatomists, forensic medicine, neurosurgeons, and radiologists.

The FM is surrounded by different parts of the occipital bone that has two condylar parts, the squamous part and the occipital part.

The squamous part lies behind and above, basilar part in front, and a condylar part on either side.¹

Border of Foramen Magnum

The anterior border of FM is formed by the basilar process of the occipital bone, the lateral border by left and right ex-occipitalis, and the posterior border is formed by the supraoccipital part of the occipital bone.²

The upper ends of anterior and posterior atlanto-occipital membranes are attached to the FM at its anterior and posterior margins, respectively, and their lower ends are attached to the superior surface of anterior and posterior arch of the atlas, respectively.³

Many authors have classified FM based on its shape, viz., oval, egg-shaped, round, tetragonal, pentagonal, hexagonal, and irregular.^{4–6}

The FM is a wide communication between the posterior cranial fossa and the vertebral canal.

The alar ligament of dens divides the foramen into anterior “Osseo-ligamentous compartment” and posterior “Neurovascular compartment.”

Both upper fasciculus of the cruciate ligament and membranatectoria are attached to the upper surface of basioccipital bone in front of the FM.

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Fig. 1: Norma basalis view showing foramen magnum and occipital condyles

Its wide posterior part contains the medulla oblongata and its meninges. In the subarachnoid space, spinal rami of the accessory nerve and vertebral arteries with their sympathetic plexus ascend into the cranium.

The posterior spinal arteries descend posterolateral to the brain stem, whereas the anterior spinal artery descends anteromedian to the brain stem. The cerebellar tonsils may project into the FM.⁷ The dimensions of the FM are clinically important because the abovementioned vital structures passing through it may endure compression such as in cases of FM herniation, FM meningiomas, and FM achondroplasia.

The transverse diameter of FM will be increased in the Arnold–Chiari syndrome.^{8–10}

The evaluation of morphometric of FM is helpful for forensic dentistry and medicine.¹¹

The progress in the neuroimaging techniques to diagnose craniovertebral abnormalities accurately has enhanced the field of craniovertebral surgery. Such surgeries are a challenging task for the neurosurgeons because of the close relation of vascular and neural structures within the FM. Advances in skull base surgeries such as the “far lateral transcondylar approach” have improved the better and wider access of surgical exposure leading to successful surgeries in this region. To perform such surgeries, prior analysis of the morphometric dimensions of FM is essential.¹²

The present study aims at collecting morphological and morphometric data on FM, which might help neurosurgeons to plan surgeries and add to the preexisting literature on FM.

MATERIALS AND METHODS

The study was conducted on 75 adult dry human skulls of unknown age and sex belonging to Rajasthan population by the Department

of Anatomy of Mahatma Gandhi Medical College, Jaipur, and Sawai Man Singh Medical College, Jaipur.

All the measurements were taken with the help of digital vernier calipers (Fig. 2).

Following metric parameters were noted:

- Shapes of FM: The different shapes of the FM were macroscopically noted and classified according to Zaidi et al. as oval, egg-shaped, round, tetragonal, pentagonal, hexagonal, and irregular (Fig. 3).
- Anteroposterior diameter (APD): It is the distance between basion (midpoint of the anterior margin of the FM) and opisthion (midpoint of the posterior margin of the FM) (Fig. 4).
- Transverse diameter (TD): It is the distance between the lateral margins of the FM at the point of greatest lateral curvature (Fig. 5).
- Foramen magnum index (FMI): It is calculated by dividing the anteroposterior diameter by the transverse diameter (APD/TD).
- Area of FM by Radinsky's formula: $A = \frac{1}{4} \times \pi \times W \times L$

$$\pi = \text{pi (22/7 or 3.14)}$$

W = width (transverse diameter)

L = length (anteroposterior diameter)

Hence, area will be calculated as follows:

Area of FM = $\frac{1}{4} \times \pi \times \text{transverse diameter} \times \text{anteroposterior diameter}$

RESULTS

The morphological and morphometric observations of the FM in 75 dried human skulls belonging to Rajasthan population are as follows (Table 1):

The most common shape was oval (22.67%) and the least common shape was pentagonal (9.33%) (Fig. 6).

The mean anteroposterior diameter was 35.11 ± 3.12 mm. The maximum anteroposterior diameter was 43.14 mm and the minimum anteroposterior diameter was 27.01 mm observed in the present study (Table 2).

The mean transverse diameter was observed to be 29.35 ± 3.46 mm. The maximum transverse diameter was 38.11 mm, and the minimum transverse diameter was 25.49 mm.

The mean values of APD and TD are represented in the form of bar diagrams (Fig. 7).

In the present study, the mean value of FM index was found to be 1.208, with minimum value of 0.969 and maximum being 1.740 with standard deviation of 0.150 mm for 75 specimens (Table 3).

When the FMI is greater than 1.2, the foramen is found to be ovoid (Radhika et al.) (Table 4).

Around 45.33% of skulls studied exhibited an ovoid FM.

The mean value of area of FM was calculated to be 813.94 ± 146.40 mm². The maximum area was 1105.70 mm², and the minimum area was 559.54 mm² (Table 5).

Fig. 2: Digital vernier calipers

Fig. 3: Shapes of foramen magnum

Fig. 4: Anteroposterior diameter

Fig. 5: Transverse diameter

Fig. 6: Percentage of various shapes of the foramen magnum

Table 1: Number and percentages of various shapes of the FM

Shapes of FM	No. of specimens (n = 75)	Percentage
Oval	17	22.67
Egg-shaped	9	12.00
Round	11	14.67
Tetragonal	11	14.67
Pentagonal	7	9.33
Hexagonal	12	16.00
Irregular	8	10.67

Table 2: Anteroposterior diameter and transverse diameter

Parameter	APD (mm)	TD (mm)
Minimum	27.01	25.49
Maximum	43.14	38.11
Mean	35.11	29.35
Standard deviation	3.12	3.48

DISCUSSION

In the present study, oval-shaped FM was the commonest shape, which is comparable to findings of researchers of ethnic groups, Kumar et al., Piras et al., and Pelinlihan et al. (Table 6).

Fig. 7: Mean value of anteroposterior diameter and transverse diameter

Table 3: Foramen magnum index

Parameters	FMI
Minimum	0.969
Maximum	1.740
Range	0.969–1.740
Mean	1.208
Standard deviation	0.150

Table 4: Frequency and percentage of FMI

Foramen magnum index (FMI)	Frequency	Percentage
<1.20	41	54.67
≥1.20	34	45.33
Total	75	100

Table 5: Area of FM

Parameter	Area (mm ²)
Minimum	559.54
Maximum	1105.70
Mean	813.94
Standard deviation	146.40

Table 6: Various shapes of FM studied by various authors

Authors	Year	Population	N	Sex	Shapes of foramen magnum						
					Oval (%)	Egg-shaped (%)	Round (%)	Tetragonal (%)	Pentagonal (%)	Hexagonal (%)	Irregular (%)
Zaidi et al. ¹³	1998	Kanpur	200	–	64	–	0.5	–	7.5	24.5	3.5
Murshed et al. ⁵	2003	Turkish	110	–	8.1	6.3	21.8	12.7	13.6	17.2	A:10.9, B:9.09
Chethan et al. ⁶	2012	Mangaluru	53	–	15	18.9	22.6	18.9	3.8	5.6	15.1
Radhakrishna et al. ⁴	2012	Mangaluru	100	–	39	–	28	19	14	–	–
Sumana et al. ¹⁴	2014	Kerala	100	Male	10.7	17.86	39.29	7.14	3.57	10.7	0.0
				Female	14.29	14.29	28.57	0.0	28.57	14.29	0.0
Radhika et al. ¹⁵	2014	Bengaluru	150	–	40	10	20	6	2	6	16
Rathva et al. ¹⁶	2015	Gujarat	210	–	28.75	11.90	16.66	10.47	2.38	4.76	11.71
Kumar et al. ¹⁷	2015	USA	36	–	50	–	20	6	–	8	16
Riyaz et al. ¹⁸	2015	Maharashtra	61	–	31.14	–	29.50	18.03	1.63	8.19	11.47
Gopalakrishna et al. ¹⁹	2015	Kerala	55	–	41	–	25	14	–	–	20
Sharma et al. ²⁰	2015	Tundla	50	–	16.0	16	22	12	8	8	18
Vinutha et al. ²¹	2016	Karnataka	200	Male	32	11	10	12	5	11	10
				Female	35	5	13	12	5	12	8
Pires et al. ²²	2016	Brazil	77	–	53.24	2.36	24.67	16.88	1.29	1.29	–
Rohinidevi et al. ²³	2016	Tamil Nadu	35	–	18	4	26	11	6	6	22
Fathima et al. ²⁴	2016	Chennai	53	–	26	36	13	–	4	21	–
Devadas et al. ²⁵	2017	Telangana	100	–	45	–	29	14	12	–	–
Rajkumar et al. ²⁶	2017	Rajasthan	298	–	66	–	24.83	3.35	2.68	4.02	–
Remya et al. ²⁷	2017	Mangaluru	50	–	46	14	16	20	–	2	2
Singh et al. ²⁸	2017	Varanasi	50	–	34	–	20	16	4	18	8
Arora et al. ²⁹	2017	Bareilly	40	–	60	–	40	–	–	–	–
Sampada et al. ³⁰	2017	Karnataka	100	–	58	11	9	8	1	3	10
Pelinllhan et al. ³¹	2018	Turkish	100	–	10	12	6	24	2	21	22
Raikaar et al. ³²	2018	Karnataka	150	–	10.45	28	26	3.67	14.1	2.33	15.45
Mishra et al. ³³	2018	Lucknow	71	–	37.8	–	30.9	7.04	7.04	11.2	9.85
Veeramani et al. ³⁴	2018	Puducherry	100	–	6	12	15	11	3	21	32
Present study	2019	Rajasthan	75	–	22.67	12	14.67	14.67	9.33	16	10.67

N = no. of skulls studied

Other ethnic groups—italic

Indian population—regular

Present study—bold

In the present study, oval-shaped FM was the commonest shape, which is comparable to findings of Indian researchers, Zaidi et al., Radhakrishna et al., Radhika et al., Rathva et al., Riyaz et al., Gopalakrishna et al., Vinutha et al., Devadas et al., Rajkumar et al., Remya et al., Singh et al., Arora et al., Sampada et al., and Mishra et al.

In the present study, the oval-shape was observed in 22.67% of dry skull specimens in contrast to highest 64% reported by Zaidi et al. and lowest 6% reported by Veeramani et al. (Tables 7 and 8).

The mean anteroposterior diameter observed in the present study was 35.11 mm, which is comparable to findings of ethnic researchers, Olivier et al., Mursed et al., Suazo et al., Monoel et al., and Lyrtizis et al. They observed the mean values of the anteroposterior diameter as 35.7 mm, 35.6 mm, 35.9 mm, 35.6 mm

(in female), 35.7 mm (in male) and 35.1 mm (in female), and 35.05 mm, respectively.

The mean transverse diameter reported in the present study was 29.35 mm, which is similar to findings of ethnic researchers, Suazo et al., Monoel et al., Kumar et al., Lyrtizis et al., Pires et al., and Pelimllhan et al., i.e., 29.5 mm, 29.5 mm (in female), 29.4 mm, 29 mm, 29.49 mm (in female), 30.19 mm, 28.62 mm, and 29.73 mm, respectively.

The mean anteroposterior diameter observed in the present study was 35.11 mm, which is comparable to findings of Indian researchers, Kanchan et al., Radhika et al., Sahoo et al., Rohinidevi et al., Arora et al., Sampada et al., Veeramani et al., and Feridoz et al. They observed the mean values of the anteroposterior diameter as

Table 7: Anteroposterior and transverse diameter of FM of ethnic groups

Authors	Year	Population	N	Sex	APD $\pm$ SD (mm)	TD $\pm$ SD (mm)
Olivier et al. ¹	1975	French	125	–	35.7 $\pm$ 2.72	30.34 $\pm$ 2.15
Mursed et al. ⁵	2003	Turkish	110	–	35.9 $\pm$ 3.29	30.4 $\pm$ 2.59
Suazo et al. ³⁵	2009	Brazil	211	Male	36.5 $\pm$ 2.6	30.6 $\pm$ 2.5
				Female	35.6 $\pm$ 2.5	29.5 $\pm$ 1.9
Monoel et al. ¹¹	2009	Brazil	215	Male	35.7 $\pm$ 0.29	30.3 $\pm$ 0.20
				Female	35.1 $\pm$ 0.33	29.4 $\pm$ 0.23
Gruber et al. ³⁶	2009	Europe	348	–	36.6 $\pm$ 2.8	31.1 $\pm$ 2.7
Tubbs et al. ¹²	2011	Spanish	13	–	31	27
Kumar et al. ¹⁷	2015	USA	36	Male	36.78 $\pm$ 0.0.35	30.05 $\pm$ 0.54
				Female	33.22 $\pm$ 0.49	29.49 $\pm$ 0.4
Lyrtizis et al. ³⁷	2016	Greek	141	–	35.05 $\pm$ 2.57	30.19 $\pm$ 2.69
Pires et al. ²²	2017	Brazil	77	–	34.23 $\pm$ 2.54	28.62 $\pm$ 2.83
Chovalopoulou et al. ³⁸	2017	Greece	154	Male	36.69 $\pm$ 2.47	32.48 $\pm$ 2.70
				Female	34.87 $\pm$ 2.41	30.62 $\pm$ 2.18
Farid et al. ³⁹	2018	Egyptian	75		47.1 $\pm$ 03.4	43.6 $\pm$ 2.5
Pelinllhan et al. ³¹	2018	Turkish	100		35.18 $\pm$ 2.94	29.73 $\pm$ 2.54
Present study	2019	Rajasthan	75	–	35.11 $\pm$ 3.12	29.35 $\pm$ 3.46

N = no. of skulls studied

Indian population—regular

Present study—bold

Table 8: Anteroposterior and transverse diameter of FM of Indian population

Authors	Year	Population	N	Sex	APD $\pm$ SD (mm)	TD $\pm$ SD (mm)
Mahajan et al. ⁴⁰	2011	Chandigarh	126	–	32.83 $\pm$ 2.62	27.47 $\pm$ 2.25
Radhakrishna et al. ⁴	2012	Mangaluru	100	–	34.04 $\pm$ 2.36	28.63 $\pm$ 1.89
Chethan et al. ⁶	2012	Mangaluru	53	–	31 $\pm$ 2.4	25.2 $\pm$ 2.4
Jain et al. ⁴¹	2013	Moradabad (North Indian)	68	Male	36.9 $\pm$ 0.2	31.5 $\pm$ 0.27
				Female	32.9 $\pm$ 0.3	29.5 $\pm$ 0.28
Kanchan et al. ⁴²	2013	Mangaluru	118	Male	34.51 $\pm$ 2.77	33.60 $\pm$ 2.63
				Female	27.36 $\pm$ 2.09	26.74 $\pm$ 2.36
Patel et al. ⁴³	2014	Surat	100	–	42.2	28.29
Shepur et al. ⁴⁴	2014	Karnataka	150	Male	33.40 $\pm$ 2.60	28.50 $\pm$ 2.20
				Female	33.10 $\pm$ 2.70	27.30 $\pm$ 2.00
Radhika et al. ¹⁵	2014	Bengaluru	150	–	35.30 $\pm$ 2.7	29.49 $\pm$ 2.6
Ganapathy et al. ⁴⁵	2014	Puducherry	100		33.9	28.7
Vedanayagam et al. ⁴⁶	2015	Chennai	420	Male	18.4 $\pm$ 0.7	28.2 $\pm$ 0.6
				Female	17.6 $\pm$ 1.0	21.8 $\pm$ 0.7
Rathva et al. ¹⁶	2015	Gujarat	210	Male	33.5 $\pm$ 0.45	22.5 $\pm$ 0.20

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Authors	Year	Population	N	Sex	APD $\pm$ SD (mm)	TD $\pm$ SD (mm)
				Female	31.0 $\pm$ 0.30	20.4 $\pm$ 0.15
Sahoo et al. ⁴⁷	2015	Orissa	150		35.30 $\pm$ 2.709	29.49 $\pm$ 2.572
Riyaz et al. ¹⁸	2015	Maharashtra	61		33.4 $\pm$ 2.5	28.5 $\pm$ 2.2
Khanday et al. ⁴⁸	2016	Chennai	60		36.8	30.9
Jasuja et al. ⁴⁹	2016	Mumbai	100		34.13 $\pm$ 2.73	27.82 $\pm$ 3.32
Fathima et al. ²⁴	2016	Chennai	53		38.22	35.15
Rohinidevi et al. ²³	2016	Tamil Nadu	35		34.80	28.5
Naqshi et al. ⁵⁰	2017	Srinagar	25		31.6 $\pm$ 0.21	26.5 $\pm$ 0.21
Singh et al. ²⁸	2017	Varanasi	50		33.76 $\pm$ 2.18	28.09 $\pm$ 1.92
Rajkumar et al. ²⁶	2017	Rajasthan	298		33.98 $\pm$ 2.75	28.16 $\pm$ 2.15
Remya et al. ²⁷	2017	Mangaluru	50		33.64 $\pm$ 0.228	27.04 $\pm$ 0.214
Arora et al. ²⁹	2017	Bareilly	40		35.42 $\pm$ 3.22	27.90 $\pm$ 2.58
Sampada et al. ³⁰	2017	Karnataka	100		34.84 $\pm$ 2.32	29.39 $\pm$ 1.73
Veeramani et al. ³⁴	2018	Puducherry	100	Male	37.03 $\pm$ 0.3	33 $\pm$ 0.23
				Female	35.23 $\pm$ 0.23	32 $\pm$ 0.43
Ashwini et al. ⁵¹	2018	Karnataka	162		33 $\pm$ 1.4	27 $\pm$ 1.6
Mishra et al. ³³	2018	Lucknow	71		34.09 $\pm$ 2.33	28.22 $\pm$ 2.19
Raikar et al. ³²	2018	Bengaluru	150		34.19 $\pm$ 3.57	31.77 $\pm$ 3.59
Feridoz et al. ⁵²	2018	Chennai	50		35 $\pm$ 2.8	29.4 $\pm$ 2.9
Present study	2019	Rajasthan	75	–	35.11 $\pm$ 3.12	29.35 $\pm$ 3.46

N = no. of skulls studied

Indian population—regular

Present study—bold

Table 9: Foramen magnum index

Authors	Year	Population	N	Sex	FMI
Chethan et al. ⁶	2012	Mangaluru	53	–	1.2 $\pm$ 0.1
Radhika et al. ¹⁵	2014	Bengaluru	150	–	1.20 $\pm$ 0.1075
Sahoo et al. ⁴⁷	2015	Orissa	150	–	1.2028 $\pm$ 0.1075
Dubey et al. ⁵⁵	2017	Sagar and Jabalpur	80	Male	1.18 $\pm$ 0.11
				Female	1.16 $\pm$ 0.07
Pelinllhan et al. ³¹	2018	Turkish	100	–	1.19 $\pm$ 0.09
Veeramani et al. ³⁴	2018	Puducherry	100	Male	1.13 $\pm$ 0.11
				Female	1.09 $\pm$ 0.15
Present study	2019	Rajasthan	75	–	1.208 $\pm$ 0.15

N = no. of skulls studied

Other ethnic groups—italic

Indian population—regular

Present study—bold

34.51 mm, 35.30 mm, 35.30 mm, 34.80 mm, 35.42 mm, 34.84 mm, 35.23 mm (in female), and 35 mm, respectively.

The mean transverse diameter was reported as 29.35 mm in the present study, which is similar to the findings of Indian researchers, Radharkrishna et al., Jain et al., Shepur et al., Radhika et al., Vedanayagam et al., Saini et al., Sahoo et al., Riyaz et al., Rohinidevi et al., Sampada et al., Mishra et al., and Feridoz et al., i.e., 28.63 mm, 29.5 mm (in female), 28.50 mm (in male), 29.49 mm, 28.5 mm, 29.39 mm, 28.22 mm, and 29.4 mm, respectively.

The foramen magnum index of 1.2 has been reported in Karnataka population (Chethan et al. and Radhika et al.) and Orissa population (Sahoo et al.) (Table 9).

In the present study in Rajasthan population, FMI was also 1.2.

The foramen magnum index was relatively lower in Madhya Pradesh population (Dubey et al.) and Puducherry population (Veeramani et al.). In ethnic group studies only, Pelinllhan et al. (Turkish population) have reported lower FMI.

In the present study (Jaipur region, Rajasthan), area was calculated as 813.94 mm², which is similar to the study of Jaitley et al. in female (812.22 mm²) in the Indore region of Madhya Pradesh (Table 10).

The highest area was reported by Faridoz et al., i.e., 1598 mm², and the least was reported by Khanday et al., i.e., 576 mm².

In another study by Rajkumar et al., the Udaipur region of Rajasthan has reported much lower area of FM (754.32 mm²).

Table 10: Area of FM

<i>Authors</i>	<i>Year</i>	<i>Population</i>	<i>N</i>	<i>Sex</i>	<i>Area</i>
<i>Murshed et al.⁵</i>	2003	<i>Turkish</i>	110	<i>Male</i>	931.7 ± 144.29
				<i>Female</i>	795.0 ± 99.32
Sing and Talwar ⁵⁴	2013	Chandigarh	50	Male	733.32 ± 9.40
				Female	692.64 ± 13.20
Patel et al. ⁴³	2014	Surat	100	–	756.37
Shepur et al. ⁴⁴	2014	Karnataka	150	Male	862.0 ± 119
				Female	758.0 ± 109
Sharma et al. ²⁰	2015	Tundla	50	–	970.57
Rathva et al. ¹⁶	2015	Gujarat	210	Male	853 ± 020
				Female	718 ± 015
<i>Kumar et al.¹⁷</i>	2015	<i>USA</i>	36	<i>Male</i>	876.88 ± 88.83
				<i>Female</i>	776.87 ± 68.51
Riyaz et al. ¹⁸	2015	Maharashtra	61	–	747.92
Jaitley et al. ⁵³	2016	Indore	280	Male	916 ± 145
				Female	812.22 ± 95.9
Khanday et al. ⁴⁸	2016	Chennai	60	–	576
<i>Lyrtzis Ch et al.³⁷</i>	2016	<i>Greek</i>	141	–	778.15 ± 125.11
Fatima et al. ²⁴	2016	Chennai	53	–	1102
Rohinidevi et al. ²³	2016	Tamil Nadu	35	–	820.53
Naqshi et al. ⁵⁰	2017	Srinagar	25	–	660 ± 090
Devadas et al. ²⁵	2017	Telangana	100	Male	1089.99
				Female	837.84
Singh et al. ²⁸	2017	Varanasi	50	–	834.45 ± 75.79
Rajkumar et al. ²⁶	2017	Rajasthan	298	–	754.32 ± 105.16
Remya et al. ²⁷	2017	Mangaluru	50	–	714.99 ± 0.844
<i>Chovalopoulou et al.³⁸</i>	2017	<i>Greek</i>	154	<i>Male</i>	938.12 ± 123.20
				<i>Female</i>	839.82 ± 99.91
Sampada et al. ³⁰	2017	Karnataka	100	–	803.8 ± 83.42
Raikar et al. ³²	2018	Bengaluru	150	–	800.72 ± 86.85
Faridoz et al. ⁵²	2018	Chennai	50	–	1598 ± 182
Present study	2019	Rajasthan	75	–	813.94 ± 146.40

N = no. of skulls studied

Other ethnic groups—italic

Indian population—regular

Present study—bold

CONCLUSION

The morphological and morphometric analysis of FM and its variations is important not only to anatomists but also to the neurosurgeons, anesthetists, orthopedicians, and radiologists. These variations have become significant because of newer imaging techniques such as computed tomography and magnetic resonance imaging in the field of diagnostic medicine.

This study will also be a help to forensic medicine experts since ethnic variations as seen and compared with research of other ethnic region population researchers may help in identification of different races.

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