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Foramen Magnum: An Osteological Study in Adult Indian Population

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Abstract

Background: The morphology of foramen magnum has a critical role in posterior cranial fossa pathologies and craniovertebral junction disorders. Foramen magnum is of considerable clinical interest as the vital structures traversing it are compromised in several pathologies affecting the posterior cranial fossa.

Aim: The objective of the study is to assess the morphometry of foramen magnum and to determine the antero-posterior diameter, transverse diameter of the foramen magnum and the foramen magnum index.

Material and Methods: The study was conducted on the foramen magna of 200 dry human skulls that were obtained from the Department of Anatomy of a private medical institutions.Skulls with intact foramen magnum were included in the study. The skulls which had partially missing or broken foramen magnum were excluded from the study. The antero-posterior and transverse diameters of foramen magnum were measured with a vernier calipers. The foramen magnum index was calculated. The shape of the foramen magnum was also noted.

Results: The mean antero-posterior and transverse diameter of the foramen magnum was recorded as 33.27 ± 2.1 mm and 27.13 ± 2.4 mm respectively. The average foramen magnum index was observed as 1.2 ± 0.14.The sagittal diameter ranges from the minimum value of 31 mm to maximum value of 38 mm. The transverse diameter ranges from the minimum value of 26 mm to the maximum of 34 mm. The most common shape of foramen magnum observed in our study is oval(30%), followed by egg shaped (21%), round (19%), irregular (13%) and hexagonal (11%).

Conclusion: The present study provides the mean dimensions of foramen magnum in South Indian population which may be used as reference in analyzing the morphological anatomy of posterior cranial fossa.

Keywords: Foramen magnum; Skull; Morphology; Osteology; Foramen magnum Index.

Introduction

The morphology of foramen magnum has a critical role in posterior cranial fossa pathologies and craniovertebral junction disorders. Foramen magnumis of considerable clinical interest as the vital structures traversing it are compromised in several pathologies affecting the posterior cranial fossa.[1, 2]

During radiological assessment, landmarks such as basion which is the midpoint of anterior margin of foramen magnum and opisthion which is the midpoint of posterior margin of foramen magnum are required to assess craniovertebral junction relationships. These landmarks are used to perform basic craniometric measurements while assessing craniovertebral junction anomalies. [2]This study was undertaken to determine the morphometry of foramen magnum in the skulls belonging to south Indian population.

Objectives

1. To study the antero-posterior (sagittal) and transverse diameter of foramen magnum.
2. To determine the foramen magnum index.
3. To study the different shapes of foramen magnum.

Material and Methods

The study was conducted on 200 dry human skulls that were obtained from the Department of Anatomy of a private medical institutions. Skulls with intact foramen magnum were included in the study. The skulls with broken foramen magnum were excluded from the study. The antero-posterior and transverse diameters of foramen magnum were measured with a vernier calipers. The average of the two measurements were taken by the observer to reduce inter-observer bias.

a. The antero-posterior diameter was measured from the midpoint of anterior border (basion) to the midpoint of posterior border (opisthion).
b. The transverse diameter was measured from the point of maximum concavity on the right margin to the maximum concavity on the left margin.
c. The Foramen magnum index was calculated by dividing the anteroposterior diameter by the transverse diameter of the Foramen Magnum.

The different shapes of the foramen magnum are noted. The results were statistically analyzed and P-value< 0.05 is considered significant.

Results

Table 1: Dimensions of Foramen Magnum observed in the study.

Dimensions of Foramen Magnum	Mean	S.D
Anteroposterior Diameter	33.27	2.1
Transverse Diameter	27.13	2.41
Foramen Magnum Index	1.21	0.14

The mean antero-posterior and transverse diameter of the foramen magnum was recorded as 33.27 ± 2.1mm and 27.13 ± 2.4 mm respectively. The average foramen magnum index was calculated as 1.2 ± 0.14. The sagittal diameter ranges from the minimum value of 31 mm to maximum value of 38 mm. The transverse diameter ranges from the minimum value of 26 mm to the maximum of 34 mm.

Table 2: Variants in the shape of the Foramen Magnum.

Variants in shape of the Foramen Magnum	Frequency [Number]
Oval	30%[60]
Egg shaped	21%[42]
Round	19%[38]
Pentagonal	6%[12]
Irregular	13%[26]
Hexagonal	11%[22]

The pictures of different shapes of Foramen Magnum observed in the study are shown below.

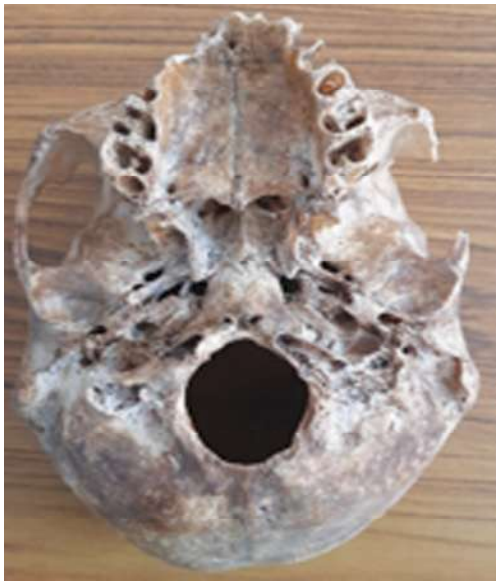

Fig. 1: Round Foramen MagnumFigure.

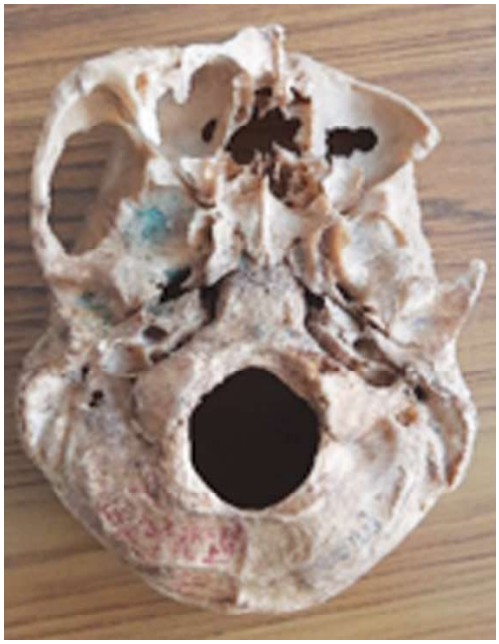

Fig. 2: Hexagonal Foramen MagnumFigure.

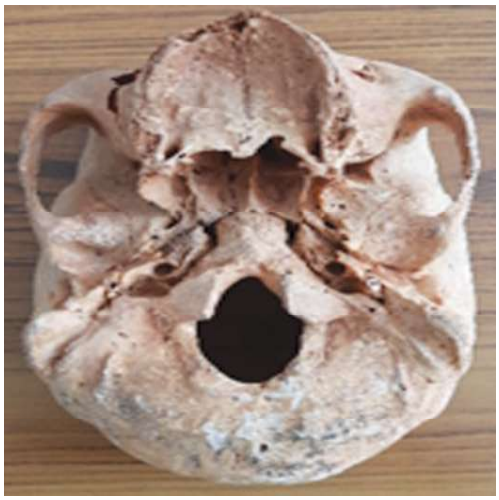

Fig. 3: Oval Foramen Magnum.

Discussion

The values of sagittal diameter in the study is similar to the findings of Muthukumar et al, Archana Singh et al, while the results of Chethan et al was slightly lower than our study.[3,4,5] Table 3 shows the comparision of results of our study with previous studies. The sagittal diameter of the foramen magnum is significantly greater than the transverse diameter (P<0.05). This finding agrees with observation that oval foramen magnum is more common than other shapes.

Table 3: Comparision of morphometric data of our study with previous studies.

Authors	Sagittal Diameter		Transverse Diameter	
	Mean	S.D	Mean	S.D
Muthukumar et al[3]	33.3	-	27.9	-
Chethan et al[5]	31.0	2.4	25.2	2.4
Archana S et al[4]	33.79	2.6	28.25	1.83
Suresh et al[6]	34.17	--	28.86	-
Sanjay KR et al[7]	34.36	3.13	28.48	3.97
Present study	33.27	2.10	27.13	2.41

Table 4: Comparision of Foramen Magnum Index of our study with previous studies.

Authors	Mean	S.D
Chetan et al[5]	1.2	0.1
Zdilla et al[8]	1.14	-
Sanjay KR et al[7]	1.23	0.18
Present study	1.21	0.14

The transverse diameter noted in our study is similar to the findings of Muthukumar et al, while the results of Archana et al, Suresh et al, Sanjay KR et al were higher than our findings.[3,4,6,7] The variations in dimensions of foramen magnum noted in the study can be attributed to ethnic variations. Gruber et al observed a positive correlation between the sagittal and transverse diameters of the foramen magnum which is important to estimate the size of foramen magnum in skeletal remains.[9] Also, both the diameters showed poor correlation with femur length indicating foramen magnum cannot be relied on to estimate stature.[9] Both the diameters were reported to show an interindividual variability and both are normally distributed.[9] The foramen magnum is reportedto exhibit sexual dimorphism.[10] Elevated Intracranial pressure may lead to compensation via cerebellar tonsil herniation through the foramen magnum. The anatomy of the foramen magnum may influence the displacement of the herniated tissues.[8] The dimensions of the foramen magnum are critical in the management of anomalies such as craniosynostosis, increased intracranial pressure in Chiari Malformations, etc.

The commonest shape of the foramen magnum in the study was ovoid and the least common type is pentagonal, as shown in Table 5. Muthukumar et al reported that foramen was found to be ovoid when the foramen magnum index was >1.2.[3] The comparision of Foramen Magnum Index obtained in our study with previous studies is shown in Table 4. Several morphological variants of basion tubercles have been described including the tubercular, clubbed, and cup-like type. Presence of basion tubercle may diminish the sagittal diameter of the foramen magnum.[8,11,12,13]

Table 5: Comparision of frequency of variants in Shape of Foramen Magnum of our study with previous studies.

Authors	Population	Number	Oval	Egg shaped	Round	Tetra hedral	Irregular	Penta gonal	Hexagonal
Chethan P et al[5]	Mangalore	53	15.1	18.9	22.6	18.9	15.1	3.8	5.6
Archana Singh et al[4]	Uttar Pradesh	120	33.3	-	13.3	16.6	-	13.3	16.6
Sanjay KR et al[7]	Mangalore	40	22.5	12.5	17.5	12.5	10	12.5	12.5
Suresh et al[14]	Jaipur	62	35.48	19.35	17.74	11.29	4.84	1.61	9.68
Amit Singh Bharti et al[15]	Telangana	40	35	-	32.5	25	-	-	7.5
Present study	Karnataka	200	30	21	19	-	13	6	11

In 20% of the skulls studied the occipital condyle protruded into the foramen magnum.[3] Wide and sagittally inclined occipital condyles, medially protruberant occipital condyles along with a foramen magnum index of more than 1.2 will require much more extensive bony resection to expose lesions ventral to the brainstem.[3]

Chiarimalformationtype I (CM-I) is the displacement of the cerebellar tonsils 5 mm or greater below the foramen magnum radiographically. The size and area of the foramen magnum were significantly smaller in patients with classical CM-I and CM-I occurring with craniosynostosis and significantly larger in patients with CM-II and CM-I occurring with Tethered Cord Syndrome.[16] The anatomic proximity of a foramen magnum mass to the cerebellar tonsils, caudal medulla, lower cranial nerves, rostral spinal cord, and upper cervical nerves results in highly variable symptomatology that is commonly misdiagnosed.[17]

Conclusion

This study attempts to establish a baseline data of morphometric measurements of Foramen magnum in dry skulls belonging to South Indian population which would be valuable to clinicians, neurosurgeons and radiologists.

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