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Morphological And Morphometrical Study Of Foramen Magnum

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Abstract

Background: The foramen magnum (FM) is the most conspicuous feature of the cranial base. It lies in an anteromedian position and leads into the posterior cranial fossa. The core structures passing through this foramen are the spinal cord, meninges, vertebral arteries, anterior and posterior spinal arteries and spinal accessory nerve. The morphometric knowledge of the FM is necessary to rule out chiari malformation, FM stenosis, achondroplasia, herniation and any compressions to the vital structures passing through this craniovertebral junction.

Objectives: To study the morphological and morphometric analysis of FM in dried adult human skull bones.

Materials and methods: The study was conducted on 31 dried adult human skulls of unknown gender, age and race available at the Department of Anatomy, RIMS, Imphal, Manipur. The shapes of the foramen magnum of all the skulls were observed at their base from the external side with naked eyes. The Anteroposterior and Transverse diameters were measured in millimeters using a digital vernier caliper.

Result: The shape of the FM in the study were oval (38.71%), circular (25.81%), tetragonal (19.36%), pentagonal (9.68%), hexagonal (3.22%) and irregular (3.22%). The average anteroposterior diameter was 33.12 ± 3.79 mm, transverse diameter was 28.35 ± 3.44 mm, mean index was 85.96 ± 8.21 and area was 743.63 ± 179.76 mm^2.

Conclusion: This study will be useful for the anatomists, radiologists, neurosurgeons and surgeons as it gives a detailed morphometric analysis of the foramen magnum to rule out proper diagnosis and in planning surgical interventions.

Keywords: Foramen magnum, achondroplasia, herniation

Introduction

The most prominent feature in the floor of the posterior cranial fossa is the foramen magnum in the occipital bone.[1] It occupies the central area of the floor.[2] It is oval and wider behind, with its greatest diameter being anteroposterior. It contains the lower end of the medulla oblongata, meninges, cerebrospinal fluid, vertebral arteries and veins, and the accessory nerves; the apical ligament of the dens and the tectorial membrane pass through it to attach to the internal basi occiput.[1] On the lateral parts of the occipital bone are two large protuberances, the occipital condyles, by which the cranium articulates with the vertebral column of the first cervical vertebra.[3] One-third of the foramen magnum lies in front and two-thirds behind a line joining the tips of the mastoid processes.[4] The medulla oblongata exits the cranial cavity through the foramen magnum to continue as the spinal cord. The cerebellum is fully contained within the posterior fossa. When the lower part of the cerebellum, the tonsils, descend abnormally through the foramen magnum, they may cause compression of the medulla

at the level of the foramen magnum, a condition called tonsillar herniation or Chiari malformation.[1]

The foramen magnum plays a central role in the formation of the craniocervical junction and facilitates the transmission of vital neuro vascular structures including the neural tissues to and from the brain. Structural configurations are known to vary racially and regionally. Understanding these ethno-regional differences enables personalized surgical approaches, improved preoperative planning, and encourages further research into region-specific neurological conditions.[5]

Moreover, FM morphometry seems to be affected by several factors including various ethnical group or different population, sample size, sexual dimorphism and types of population, genetic, environment and socio-economic factors.[6]

Gender determination in missing or damaged skeletal remains is a major problem in forensic medicine. To this end, numerous anatomic parameters, such as shape and dimensions of the FM, should be taken into consideration to solve this problem.[7]

Many authors have classified the shapes of the foramen magnum such as oval, circular, tetragonal, pentagonal, hexagonal and irregular. Variations in the shape of foramen magnum are important because of its effects on the vital structures which passes through it, can compress these structures.[8,9]

In regard to the diameters of the foramen magnum, the reported values that are highly concordant with previous results. Of the two diameters, the anteroposterior diameter was to be significantly greater in length. [10,11,12]

These variations have become significant because of newer imaging techniques such as computed tomography and magnetic resonance imaging in the field of diagnostic medicine.[8] The study may provide additional information on morphometric features of FM and may guide investigators dealing with neurosurgery, forensic medicine, radiology, anatomy, and anthropology in their practice.[13]

Thus, in the present study, morphological and morphometric analysis of foramen magnum in human skull bones will be studied which will be helpful not only in diagnosis, but also in planning of better operative procedures and to avoid complications of surgeries involving the skull base.

Ii. Materials And Methods

Study Design: Cross-sectional study.

Study Location: The present study will be conducted at the Departments of Anatomy, Regional Institute of Medical Sciences (RIMS), Imphal, Manipur.

Duration of study: November 2025 to April 2026.

Sample size: 31 Dried adult human skull bones which was all available in the department during the period of study

Subjects & selection method: The study comprised of 31 dried adult human skull bones available at the department of Anatomy, RIMS. Purposive sampling method was done. The study variables were:

Independent variables: Age, Sex, Race.

Dependent variables : Shape, anteroposterior, transverse diameters, index and area

Study tools: Digital vernier caliper

Inclusion criteria: Normal dried adult human skull bones

Exclusion criteria: Skull with deformities, anomalies or any fractures

Procedure methodology:

31 Dried adult human skull bones were collected from the department of Anatomy, RIMS, Imphal, without any deformities, fractures and malformation for the study. The samples of the study were photographed to analyse the shapes of the foramen magnum. Then, measurements included the anteroposterior and transverse diameters of all the foramina were taken by using digital vernier caliper[14]. Based on the D.E. Ogolo et al[5] the following measurements will be taken.

Measurement of the antero-posterior diameter (APD) of the foramen magnum (optimally viewed on sagittal section) – a line drawn from the basion to the opisthion.

Measurement of the transverse diameter (TD) (optimally viewed on axial section) – a line drawn to connect both lateral margins of the foramen magnum at its greatest curvature.

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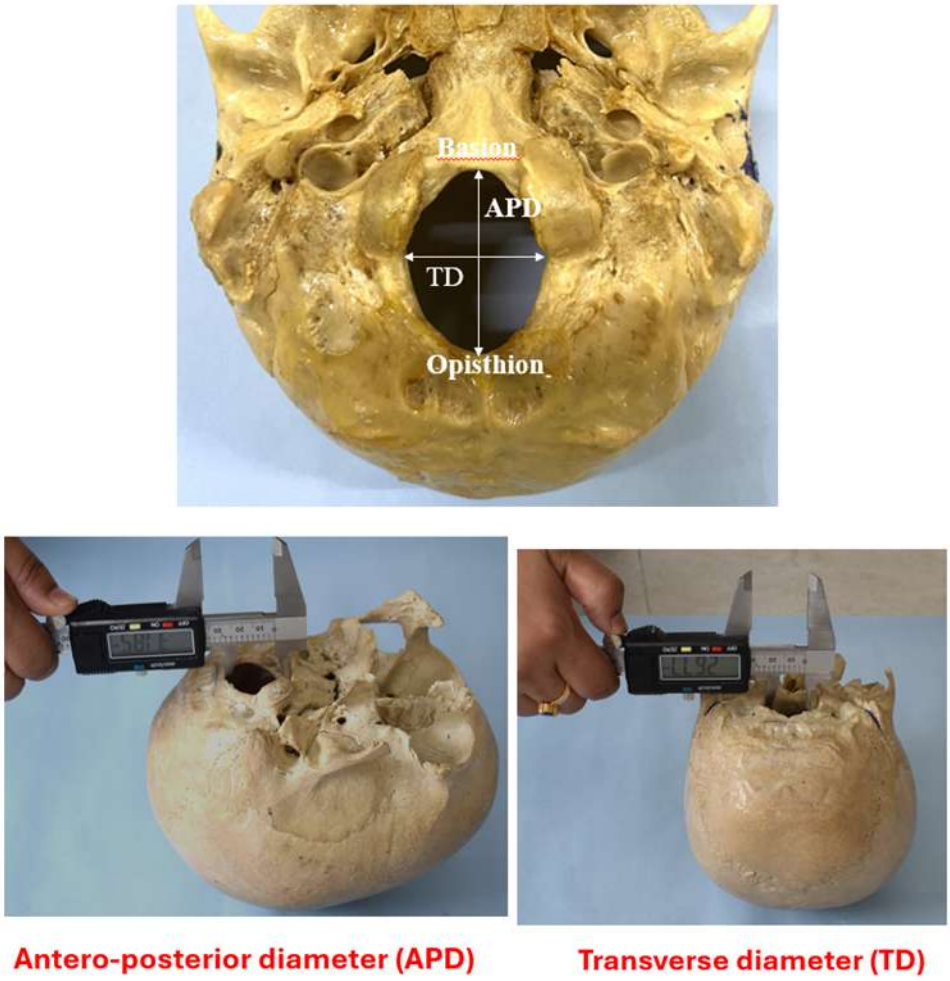
Foramen magnum area (FMA) was determined using the Routal formula: [π.APD.TD] / 4

Foramen magnum index was measured using the Martin and Saller formula: [TD/APD].100 %

Figure 1: Measurement of foramen magnum parameters on dried adult skull bone. Antero-posterior diameter (APD) and Transverse diameter (TD).



Statistical Analysis:

Data collected were checked for consistency and completeness. The data were entered and analyzed using SPSS software, version 21.0 (IBM Inc., Armonk, NY, USA). Mean and standard deviation were used to summarize continuous variables such as anteroposterior, transverse diameters, index and area.

Iii. Result

In this study, Oval shape FM dominates, nearly half of all cases (38.71%) which is 12 in number out of 31 skulls. Circular shape is 8 in number (8%), then next comes to tetragonal 6 in number (19.36%). Pentagonal is found in 3 cases (9.68%). Hexagonal and irregular shapes are least common cases overall which is found in only one case each 3.22% (Table no 1, Figure no 2 & 3)

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Figure 2: Different shapes of Foramen Magnum

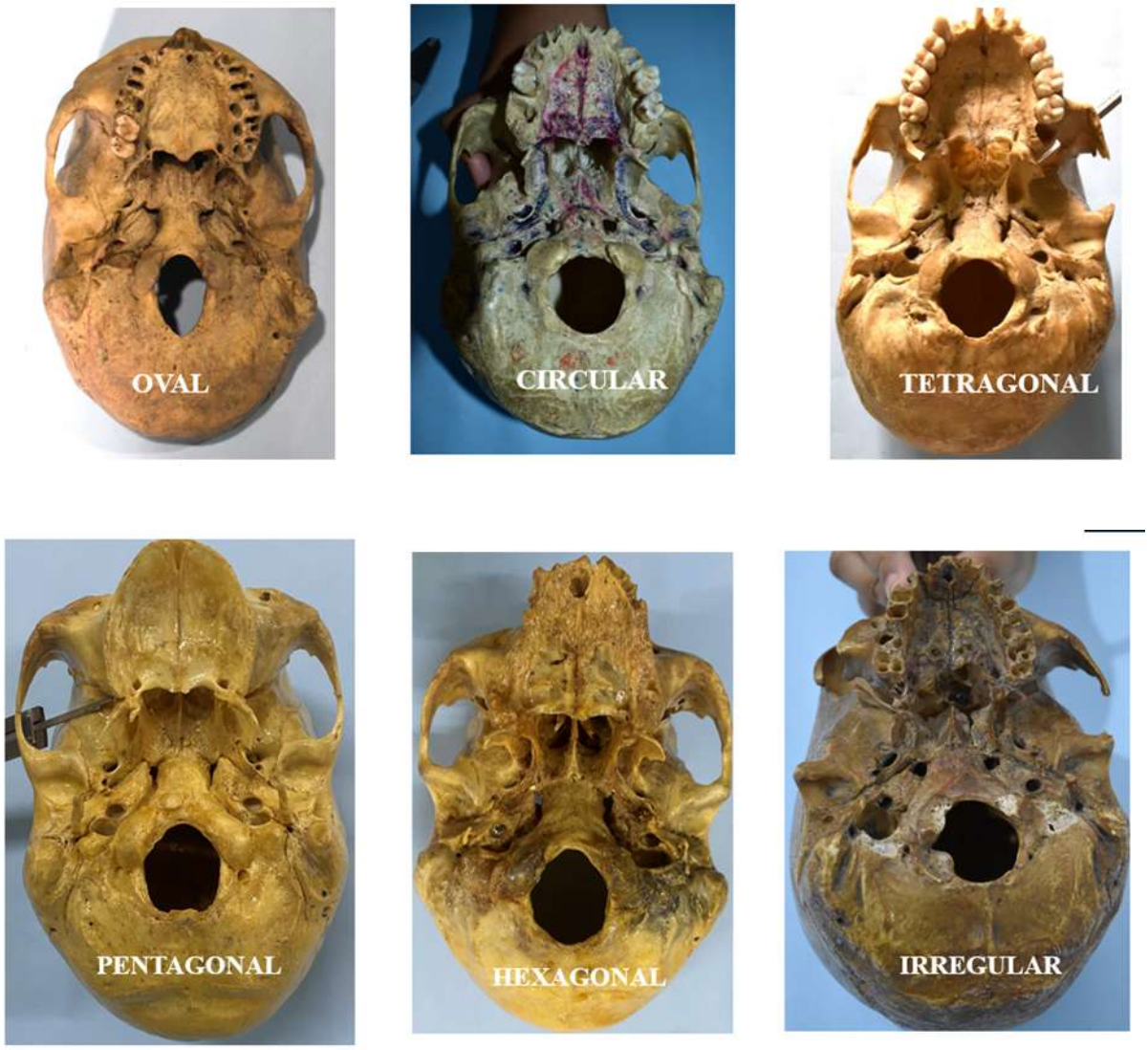

Table 1: The various shapes & its percentage:

FM Shape	Number	Percentage
1. Oval	12	38.71%
2. Circular	8	25.81%
3. Tetragonal	6	19.36%
4. Pentagonal	3	9.68%

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5. Hexagonal	1	3.22%
6. Irregular	1	3.22%

Figure 3: Chart showing various shapes of FM

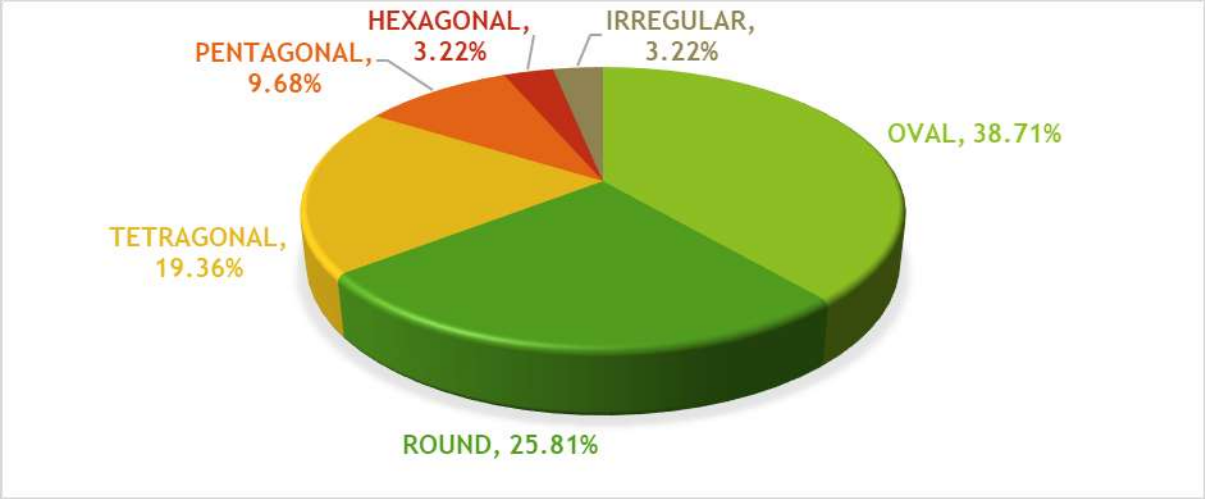

Table 2: Morphometric measurements of FM

Parameters	Minimum	Maximum	Mean±SD
1. Anteroposterior Diameter (mm)	26.77	38.88	33.12± 3.79
2. Transverse Diameter (mm)	21.48	36.06	28.35 ± 3.44
3. Index	63.44	99.64	85.96 ± 8.21
4. Area (mm^2)	456.45	1090.39	743.63 ± 179.76

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Table 2. summarizes the different parameters of the FM. In the total sample, the minimum and maximum anteroposterior diameter (APD) of the FM were found to be 26.77 mm and 38.88 mm with an overall mean of 33.12± 3.79. Similarly, the transverse diameter (TD) minimum and maximum diameters were 21.48mm and 36.06 mm with an overall mean of 28.35 ± 3.44. In the present study, the mean APD had higher than the mean TD.

The FM index showed significant variation across different shapes. The minimum and maximum index were found to be 63.44 and 99.64 with an overall mean of 85.96 ± 8.21. FM area was markedly varied across different shapes. The minimum and maximum areas were 456.45 mm^2 and 1090.39 mm^2 with an overall mean of 743.63 ± 179.76.

Iv. Discussion

In the present study, oval-shaped FM was the commonest shape which was found in 12 cases (38.71%), which is similar to findings of other researchers[2,3,4,6,7] as shown in Table no 3. However, circular shape was found to be the commonest in the studies of Murshed et al[6] and Chetan P et al[8]. In the present study, the lowest seen shape were the hexagonal and irregular shape which were observed in 1(3.22%), which is similar to finding of Krishna K et al[10]. In contrast, most authors observed pentagonal shape to be the least found shape. [2,3,4,6]

Table 3: Comparison of different shapes of foramen magnum

Authors	Place	No. of skull	Oval No. (%)	Circular No. (%)	Tetragonal No. (%)	Pentagonal No. (%)	Hexagonal No. (%)	Irregular No. (%)
1. Murshed et al.[15]	Turkey	100	9(8.1)	24(21.8)	14(12.7)	15(13.6)	19(17.2)	12(10.9)
2.Radhika PM et al.[8]	Bangalore	150	60(40)	30(20)	9(6)	3(2)	9(6)	24(16)
3. Mishra AK et al. [14]	Lucknow	71	24(37.8)	22(30.9)	5(7.04)	5(7.04)	8(11.2)	7(9.85)
4. Sharma DK et al.[11]	Rajasthan	75	(22.67)	(14.67)	(14.67)	(9.33)	(16.00)	(10.67)
5. Chetan P et al. [16]	Mangalore	53	8(15.1)	12(22.6)	10(18.9)	2(3.8)	3(5.6)	8(15.1)
6.Hashmi IC et al.[17]	Karnataka	154	52(33.76)	26(16.88)	31(20.12)	13(8.44)	18(11.68)	14(9.12)
7. Krishna K et al.[18]	Ranchi	34	20 (58.8)	3 (8.82)	6(17.6)	-	4 (11.8)	1 (2.94)
8. Present study	Manipur	31	12(38.71)	8(25.81)	6(19.36)	3(9.68)	1(3.22)	1(3.22)

Table 4: Comparison of the APD and TD of various studies

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Authors and Year	APD ± SD (mm)	TD ± SD (mm)
1. Murshed et al.[15] (2003)	35.9 ± 3.29	30.45± 2.59
2. Tubbs et al.[19] (2010)	31 (min)	27 (min)
3. Radhika.P.M et al.[8] (2014)	35.3	29.4
4. Krishna K et al.[18](2016)	34.06	27.83
5. Sharma DK et al.[11] (2019)	35.11 ± 3.12	29.35 ± 3.46
6. Mishra AK et al.[14](2018)	34.09 ± 2.33	28.22 ± 2.19
7. Cirpan et al.[13] (2016)	34.38 2.38	28.95 2.19
8. Hashmi IC et al.[17] (2024)	36.84±4.62 (max)	30.45±2.82(max)
9. Present study (2026)	33.12± 3.79	28.35 ± 3.44

The mean APD in the present study was 33.12± 3.79 mm, which is comparable to findings of Krishna K et al[10] (34.06 mm) and Mishra et al[4] (34.09 ± 2.33 mm) as shown in Table no 4. Whereas the minimum APD was seen in Tubbs et al[11] (31 mm) and the maximum in Hashmi IC et al[9] (36.84±4.62 mm).

The mean TD in the present study was 28.35 ± 3.44 mm which is close to the findings of Mishra et al[4] (28.22 ± 2.19 mm) and Cirpan et al[12] (28.95 2.19 mm). While, the minimum TD was seen in Tubbs et al[11] (27 mm) and maximum in Hashmi IC et al[9] (30.45±2.82 mm).

Table 5: Comparison of the mean Area & Index of FM

Authors	Year	Mean Area± SD (mm^2)	Mean Index± SD
1. Sharma S et al.[20]	2015	970.57(max)	87.68(max)
2. Mehta and Kalra.[21]	2024	739.93 ± 94.85(min)	82.92±5.63
3. Sharma DK et al.[3]	2019	813.94 ± 146.40	-
4. Rajkumar et al.[22]	2017	754.32±105.6	83.14±6.33
5. Cirpan et al.[13]	2016	783.66±99.34	-
6. Nagwani M et al.[23]	2016	757.09 ±115.82	78.71± 5.94(min)
7. Present study	2026	743.63 ± 179.76	85.96 ± 8.21

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In the present study, the area was calculated as 743.63 ± 179.76 mm^2 which is close to the study of Mehta and Kalra[14] (739.93 ± 94.85 mm^2) as shown in Table no 5. The highest area was reported by Sharma S et al[13] (970.57 mm^2) and the least was reported by Mehta and Kalra[14] (739.93 ± 94.85 mm^2).

The foramen magnum index of the present study was 85.96 ± 8.21 which is close to the study of Rajkumar et al[15] (83.14±6.33) as shown in Table no 5. The highest index was reported by Sharma S et al[13] (87.68) and the least was reported by Nagwani M et al[16] (78.71± 5.94).

V. Conclusion

The structural significance of FM arises from its variable sizes, shapes and surrounding bony structures which affect in accessing during surgical procedures regarding the skull base. By knowing the variations of its different shapes, diameters, areas and index, it will be quite useful for the anatomists, radiologists and neurosurgeons as it gives a detailed morphometric analysis of the FM to rule out proper diagnosis and in planning surgical interventions. Moreover, the study of this largest foramen of the skull may provide additional information and may guide investigators dealing with forensic medicine and anthropology in their practices.

References

1. Collins P, Jawaheer G, Sharpe RM. Development of the urogenital system. In: Standring S, Collins P, Jawaheer G, Anand N, Tubbs RS, Birch R, et al, editors. Gray's anatomy: the anatomical basis of clinical practice. 41st ed. London: Elsevier; 2016. p. 567-8.
2. Snell R.S. Clinical Anatomy for Medical Student. 4th edition. Boston; Little, Brown and Company: 1992:808-812.
3. Moore KL, Dalley AF, Agur AMR. Clinically oriented anatomy. 6th ed. Philadelphia: Lippincott Williams & Wilkins; 2010.
4. Sinnatamby CS. Last's anatomy: regional and applied. 12th ed. Philadelphia: Churchill Livingstone; 2011.
5. D.E. Ogolo et al. Morphometric evaluation of the foramen magnum in the West African population: Implications for neurosurgical interventions. Brain Disorders. 2024;14:1-6. DOI: https://doi.org/10.1016/j.dscb.2024.100140
6. Öksüzler et al. Harmony of the foramen magnum and cranium: An anatomical and radiological study. Cukurova Med J. 2022;47(2):876-885. DOI: 10.17826/cumj.1102142.
7. de Lucena et al. Morphometric analysis of the foramen magnum in dry human skulls in northeastern Brazil. J Morphol Sci. 2019;36:97-104.
8. Radhika PM, Shailaja S, Prathap KJ et al. Morpho metric study of the foramen magnum in adult human skulls in Indian population. Asian J Med and Clin Sc. 2014;3(2):62-72.
9. R. Kumar, M. Javia, D. Agrawal, P. Manik. Anatomical Observation of Different Shapes of Foramen Magnum and Its Clinical Implications: A Study in Dry Adult Human Skulls of Indian Population. Int J Anat Res 2022;10(3):8445-8451. DOI: 10.16965/ijar.2022.189
10. Diana M, Nuveen AK et al. Foramen magnum– A study on its morphometry among the south Indian population. Asian J Pharm Clin Res. 2024;17(6): 91-93.
11. Sharma DK, Mehra S. Foramen Magnum: A Morphological and Morphometric Study in Dried Hu man Skull Bones of Rajasthan Population and its Surgical Importance. J Mahatma Gandhi University of Med Sc and Tech. 2018 May;3(2):41-9.
12. Samara OA, Amarin JZ, Badran DH, Al-Khayat OW, Suradi HH, Shatarat AT et al. Morphometric analysis of the foramen magnum. Int J Morphol. 2017;35:1270-5.
13. Cirpan S, Yonguc GN, Mas NG, Aksu F, Orhan Magden A. Morphological and Morphometric Analysis of Foramen Magnum: An Anatomical Aspect. J Craniofac Surg. 2016;Sep;27(6):1576-8. doi: 10.1097/SCS.0000000000002822. PMID: 27607122.
14. Mishra AK, Pandey SB, et al. Morphometric study of foramen magnum of skull in population of Uttar Pradesh. Int J Anat Res 2018;6(2.2): 5186–5190. DOI:10.16965/ijar.2018.150.
15. Murshed AK, Cicekcibasi AE, Tuncer I. Morphometric evaluation of the foramen magnum and variations in its shape: A study on computerized Tomographic images of normal adults. Turk J Med Sci. 2003; 33: 301-306.

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16. Chethan P et al. Morphological Analysis and Morphometry of the Foramen Magnum. Turk Neurosurg. 2012:22(4):416-9.
17. Hashmi IC, Shaikh SA, Hakim AHA, Saheb SH. Morphological and morphometric study on foramen magnum and its Clinical importance. Euro j cardio med. 2024:14(1):639-43.
18. Krishna K et al. Morphometric Study of Foramen Magnum and Variation In Its Shape. IOSR-JDMS. 2016:15(8):120-3.
19. Tubbs RS, Griessenauer CJ, Loukas M, Shoja MM, Cohen-Gadol AA. Morphometric analysis of the foramen magnum: An anatomic study. Neurosurg. 2010; 66:385-88.
20. Sharma S, Sharma AK, et al. Morphometric evolution of foramen magnum and variation in its shape and size: a study on Human dried skull. Int J Anat Res 2015;3(3):1399–1403. DOI: 10.16965/ijar. 2015.246.
21. Mehta A, Kalra S. Foramen magnum: Morphometric analysis in dry adult human skulls. Natl J Clin Anat 2024;13:143-8.
22. Rajkumar, Prabhakaran kattimuthu, Punita Manik Vikram Singh. MORPHOMETRIC ANALYSIS OF THE FORAMEN MAGNUM OF DRY HUMAN SKULLS IN NORTH INDIAN POPULATION. Int J Anat Res 2017;5(1):3480-3484. DOI: 10.16965/ijar.2016.495.
23. Nagwani M, Rani A, Rani A. A morphometric and comparative study of foramen magnum in North Indian population. J Anat Soc India. 2016;65(1):11-15. https://doi.org/10.1016/j.jasi.2015.11.001.

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