



**FORAMEN MAGNUM: IT'S MORPHOLOGY AND MORPHOMETRY IN DRY HUMAN SKULL BONES OF NORTHERN INDIA**

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**A B S T R A C T**

The foramen magnum, an important landmark of the skull base, is also known as Foramen Primum. It is the largest foramen of the skull. The morphometry of the foramen magnum is clinically important because the vital structures that pass through it may suffer compression in cases of achondroplasia, herniation of the hindbrain through the foramen magnum, and atlantooccipital fusion. In neurosurgical practice, the transcondylar approach is commonly used to access the lesions which are ventral to the brainstem.

**Aims and Objectives:** This study was done to analyze the morphology and to do morphometry of the foramen magnum in dry human skulls. The objective of the present study was to see the shape of the foramen magnum and to evaluate its anteroposterior and transverse diameter with the calculation of the foramen magnum index and its area.

**Materials and Methods:** One hundred thirty-four dry, adult human skulls of unknown age and sex were observed in the Department of Anatomy K.G.M.U. Lucknow and Muzaffarnagar Medical College, Muzaffarnagar Uttar Pradesh. Anteroposterior and transverse diameters of the foramen magnum were measured with the help of a Vernier caliper. The area of the foramen magnum and its index were also calculated

**Result:** The mean anteroposterior and transverse diameter of the foramen magnum was 34.47 mm and 28.46mm respectively. The average foramen magnum index was  $1.21 \pm 0.1$  and the average area of the foramen magnum was 770.79 mm<sup>2</sup>.

**Conclusion:** Detailed morphometric analysis will help in the planning of surgical intervention involving the skull base. This study will be useful for anatomists, neurosurgeons, radiologists, and orthopedic surgeons.

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**INTRODUCTION**

The foramen magnum is a Latin word meaning largest aperture in the skull. The foramen magnum, is also known as Foramen Primum<sup>1</sup>. The foramen magnum lies in an anteromedian position and leads into the posterior cranial fossa<sup>2</sup>. It is a transition zone between the spine and skull and plays an important role as a landmark because of its close relationship to key structures such as the brain and the spinal cord<sup>3</sup>. It is almost oval, wider behind with a greater anteroposterior diameter than the transverse diameter. It contains the lower end of the medulla oblongata, vertebral arteries, and spinal accessory nerves<sup>2</sup>. The occipital bone forms much of the back and base of the cranium. It is a trapezoid, internally concave, and encloses the foramen magnum. Occipital bone has four parts: basilar (basioccipital), which is the quadrilateral part in front of the foramen magnum; squamous, which is the expanded plate posterosuperior to the foramen magnum; and two lateral parts (condylar or exoccipital), one on each side of the foramen magnum. The middle point of the anterior margin of the foramen magnum is known as basion, while the middle

point of the posterior margin of the foramen magnum is known as opisthion. The margins of the foramen magnum are slightly overlapped by the occipital condyles<sup>2</sup>. The dimensions of the foramen magnum are clinically important because the medulla oblongata passing through it may compress in cases of herniation of the hindbrain through the foramen magnum. These parameters are also of clinical relevance in cases of foramen magnum meningiomas and foramen magnum achondroplasia<sup>4</sup>.

In neurosurgery, the lesions that are lying anterior to the brainstem are commonly approached by the transcondylar route. The ventral and ventrolateral region of the foramen magnum, brain stem, and the craniospinal junction is usually dealt with "far lateral transcondylar approach"<sup>5</sup>.

Arnold Chiari syndrome, showing the expansion of transverse diameter, and occipitocervical synostosis which shows a reduction in diameters, and before resection of lesions of the foramen magnum and posterior cranial fossa make it necessary to know morphometry of foramen magnum<sup>6</sup>.

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**Aims and Objectives**

This study was done to analyze the morphology and to do morphometry of the foramen magnum in dry human skulls. The objective of the present study was to see the shape of the foramen magnum and to evaluate its anteroposterior and transverse diameter with the calculation of the foramen magnum index and its area.

**MATERIAL AND METHOD**

134 dry adult human skulls of unknown sex (used for tutorial of undergraduate students) were taken for morphology and morphometry from the Department of anatomy, K.G.M.U. Lucknow, (U.P.) and Muzaffar Nagar medical college, Muzaffar Nagar, (U.P.). The skulls that have been broken and deformed were excluded from the study. The Anteroposterior diameter of the foramen was measured from basion to opisthion. Transverse diameter or Width is the maximum distance between the right and left lateral margins. The FM index was calculated by dividing the anteroposterior diameter by the transverse diameter. The data were analyzed and presented as mean ± SD. Both the anteroposterior and transverse diameters were measured using a Vernier caliper graded up to 0.01mm.

The surface area of the foramen magnum was calculated by the following formula<sup>7</sup>.

$$\text{AREA (A)} = \frac{1}{4} \times \pi \times w \times h$$

w = Width, transverse diameter

h = Height, longitudinal diameter

$\pi = 22/7$ , mathematical constant.

**RESULTS**

The mean anteroposterior diameter of the foramen magnum was  $34.47 \pm 2.56$  (range 30-42.05mm) and the mean transverse diameter was  $28.46 \pm 2.56$  (range 19.9-32.09 mm). The average foramen magnum index was  $1.21 \pm 0.1$ . The mean surface area was calculated as 770.79 mm ranging from 597 mm. to 1043.97 mm.

Different shapes of the foramen magnum were observed as oval, round, tetragonal, pentagonal, hexagonal, and irregular shapes.

Types and percentages of the foramen magnum are given in the following table:

Type of foramen magnum	Percentage
Round	42.5 % (57)
Oval	28.3 % (38)
Irregular	12 % (16)
Tetragonal	8.2 % (11)
Hexagonal	6.7 % (09)
Pentagonal	2.2 % (03)

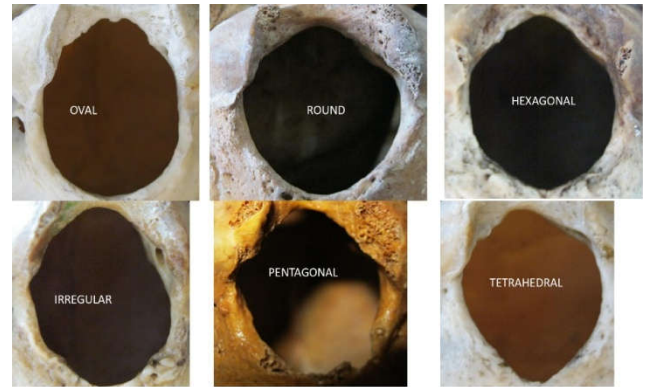


Fig 1 Different shapes of the foramen magnum



Fig 2 Skull and verniercaliper



Fig 3 Transverse diameter of the foramen magnum



Fig 4 Anteroposterior diameter of the foramen magnum

## DISCUSSION

The foramen magnum is an important communicator between the cranium and vertebral column and helps in interlinking bones, ligaments, and muscles that constitute the craniovertebral junction. As cranial vessels, the lower part of the brain stem is in close association with the foramen magnum, its morphology and morphometry act as an important parameter in managing the patients with craniovertebral abnormalities<sup>8</sup>.

As important structures pass through the foramen magnum, morphometric analysis plays an important role. In our study anteroposterior diameter of the foramen, magnum was 34.47mm ranging from 30 – 42.5 mm, and the mean transverse diameter in our study was 28.46 mm ranging from 19.9 - 32.09 mm, both the values were quite similar to the observations made by Sayee R<sup>9</sup>, Berge and Bergmann<sup>10</sup>, Murlidhar P Sherpur (Karnataka)<sup>11</sup>, Arpan Dubey (Madhyapradesh)<sup>12</sup> and Vidya H K, Nagashree M V (Tumkur)<sup>13</sup> in their study done on foramen magnum. Tubbs RS in their study on 72 dry skulls observed the mean anteroposterior diameter as 3.1cm, and the mean horizontal diameter was 2.7 cm, which was slightly less than the mean values observed in our study<sup>14</sup>. In his study done on the dry skull from western Europe Philipp Gruber observed the mean anteroposterior diameter of 36.6 mm (range 30 mm to 43 mm), and mean transverse diameter of 31.1 mm (range 25 mm to 39mm)<sup>15</sup>. Both the parameters were more than what we observed in our study.

Morphometry helps in planning surgeries for the base of the skull and in the diagnosis of certain diseases like Arnold Chiari I & II, where parameters are larger in comparison to normal human beings<sup>16</sup>. Narrowing of the foramen magnum seen in individuals with Achondroplasia occurs because of defective growth of cartilaginous bones & early fusion of bones, which leads to decreased growth of bones at the base of the skull<sup>4, 17</sup>.

Authors, numbers of skulls observed						
TYPES	Murshed <sup>6</sup> (110)	Radhakrishna S K <sup>18</sup> (100)	P. Chetan <sup>19</sup> (53)	Radhika PM <sup>20</sup> (150)	Zaidi & Dayal <sup>21</sup>	Present Study (134)
Round	24 (21.8%)	28 (28%)	12 (22.6%)	30 (20%)	0.5%	57 (42.5%)
Oval	9 (8.1%)	39 (39%)	8 (15.1%)	60 (40%)	64%	38 (28.3%)
Tetragonal	14 (12.7%)	19 (19%)	10 (18.9%)	9 (6%)	-	11 (8.2%)
Pentagonal	15 (13.6%)	14 (14%)	2 (3.8%)	3 (2%)	7.5%	03 (2.2%)
Hexagonal	19 (17.2%)	-	3 (5.6%)	9 (6%)	24.5%	09 (6.7%)
Irregular	22 (19.9%)	-	8 (15.1%)	24 (16%)	3.5%	16 (12%)

In the study done by Sayed & Zaidi, an oval-shaped foramen magnum was observed in 64 % of skulls, which was very different from other authors.

Comparison of foramen magnum index and area of the foramen magnum

AUTHORS	FM Index	Area (mm <sup>2</sup> )
Zdilla <i>et al</i> <sup>22</sup>	1.16 ± 0.08	864.1 ± 149.5
Radhika.P.M <sup>20</sup>	1.20 ± 0.10	-
Kizilana <sup>23</sup>	1.20	-
Shifan K <sup>1</sup>	-	576.0
P. Chetan <sup>19</sup>	1.2 ± 0.1	-
Roma Patel <sup>24</sup>	-	755.37
<b>Present study</b>	<b>1.21 ± 0.1</b>	<b>770.79</b>

According to Testut and Latarjet's value of foramen, the index acts as a good guide while doing surgeries around the base of the skull, as substantial resection of bone is to be done when the value of the foramen index was calculated more than 1.20.<sup>25</sup>

Muthukumar *et al.* used the foramen index in determining the foramen magnum shape. According to him skulls in their index were calculated to be equal to or greater than 1.20 and were categorized as oval-shaped foramen magnum<sup>5</sup>.

In a retrospective study done by Kina *et al.* on 16 patients who were diagnosed with anterolateral FM meningiomas on MRI, it was observed that the oval-shaped foramen magnum was accompanied by multiple intra operated and postoperative complications in the form of post-operative hydrocephalous, injury to the brain stem, inadequate resection of the tumor, longer hospital stay<sup>26</sup>.

As the foramen, magnum provides passage to vital neuroanatomical components, injury to this area will need immediate intervention by neurosurgeons in deciding the most commander approach depending upon the morphology and morphometry of the foramen magnum to prevent any neurological disability<sup>27, 28</sup>.

## CONCLUSION

Knowledge of morphology and morphometry of the foramen magnum is essential for orthopedics, and neurosurgeons while performing craniovertebral surgeries for malignancies arising in the craniovertebral region. Morphometry is also beneficial for forensic scientists in determining the sex of the skull. Appropriate knowledge of variable shapes of the foramen magnum is also helpful in choosing and implementing better surgical procedures.

**Conflicts of Interests:** None

## Reference

- Shifan K, Pranu C. Morphology and Morphometry of foramen magnum, International Journal of Current Research. 2016;8(03), 27765 - 27767.
- Standarding S. Gray's anatomy. The anatomical basis of clinical practice. 39th ed. London: Elsevier Churchill Livingstone. 2005, 460
- Gruber P, Henneberg M, Böni T, Rühli FJ. Variability of human foramen magnum size. Anat Rec (Hoboken). 2009 Nov; 292(11):1713-1719.
- Hecht TJ, Horton WA, Reid CS, *et al.* Growth of the foramen magnum in achondroplasia. American Journal of Medical Genetics. 1989; 32: 528-535.
- Muthukumar N, Swaminathan R, Venkatesh G, Bhamumathi SP. A morphometric analysis of the foramen magnum region as it relates to transcondylar approach. Actaneurochir (Wien). 2005; 147(8): 889-885.
- Murshed K A, Cicekeibasi A E, Tuncer I. Morphometric evaluation of the foramen magnum and variations in its shape. A study of computerized tomographic images of normal adults. Tur J Med Sci. 2003; 33:301-306.
- Radinsky I. Relative brain size : a new measure. Science 1967;155:836-38.
- Kanodia G, Parihar V, Yadav YR, Bhatlele PR, Sharma D. Morphometric analysis of posterior fossa and foramen magnum. J Neurosci Rural Pract. 2012; 3(3):261-266.
- Sayee R, Jankiram S, Thomas IM. Foramen magnum measurements of crania from Karnataka. J Anat Soc India. 1987; 36(2):87-89.

10. Berge JK, Bergmann RA. Variation in size and in symmetry of the foramina of the human skull. *Clin Anat.* 2001; 14: 406–413
11. Muralidhar P Shepur, Magi M, Nanjundappa B, Pavan P Havaladar, Premalatha Gogi, Shaik Hussain Saheb. Morphometric analysis of foramen magnum. *Int J Anat Res* 2014; 2(1):249-255.
12. Arpan Dubey, S K Verma. The anatomy of occipital condyles and foramen magnum and their surgical importance: A morphometric study. *Int J Anat Res* 2017; 5(2.1): 3780-3783.
13. Vidya H K, Nagashree M V, Morphometric evaluation of foramen magnum. *Medplus International Journal of Anatomy.* 2018 Oct; 8(1).
14. Tubbs RS, Griessenauer CJ, Loukas M, Shoja MM, Cohen-Gadol AA. Morphometric analysis of the foramen magnum: an anatomic study. *Neurosurgery.* 2010 Feb; 66(2):385-388.
15. Gruber, P., Henneberg, M., Böni, T., Rühli, F. J. Variability of Human Foramen Magnum Size. *Anat Rec.* 2009; 292:1713–19
16. Gardner WJ, Goodall RJ. The surgical management of Arnold-Chiari malformation in adults. An explanation of its mechanism and importance of encephalography in diagnosis. *J Neurosurg.* 1950; 7:199-206.
17. Osunwoke EA, Oladipo GS, Gwunireama IU, Ngaokere JO. Morphometric analysis of the foramen magnum and jugular foramen in adult skulls in southern Nigerian population. *Am. J. Sci. Ind. Res.,* 2012; 3(6): 446-448.
18. Radhakrishna SK, Shivarama CH, Ramakrishna A, Bhagya B. Morphometric analysis of foramen magnum for sex determination in South Indian population. *NUJHS,* March 2012; 2(1): 20-22.
19. Chethan P, Prakash KG, Murlimanju BV, Prashant KU, Prabhu LV, Saralaya VV et.al Morphological Analysis and Morphometry of the Foramen Magnum: An Anatomical Investigation. *Turkish Neurosurgery.* 2012; 22 (4): 416-419.
20. Radhika.P.M, Shailaja Shetty, Prathap K.J, C. Sheshgiri, Jyothi K.C. Morphometric Study Of The Foramen Magnum In Adult Human Skulls In Indian Population. *Asian J Med Clin Sci.* 2014 Aug; 3(2): 68 – 72.
21. Zaidi SH, Dayal SS: Variations in the shape of foramen magnum in Indian skulls. *AnatAnz Jena.* 1988; 167:338-340.
22. Zdilla MJ, Russell ML, Bliss KN, Mangus KR, Koons AW. The size and shape of the foramen magnum in man. *J Craniovert Jun Spine.* 2017; 8:205-221.
23. Kizilkanat Emine Dondu, Boyan Neslihan, et al. Morphometry of hypoglossal canal, occipital condyle and foramen magnum.: abstract, *Neurosurgery quarterly* 2006; 16(3): 121- 125.
24. Patel R., Mehta C.D., Morphometric study of Foramen Magnum at the base of human skull in South Gujarat. *IOSR Journal of Dental and Medical Sciences.* 2014; 13(6): 23 – 25.
25. Testut L, Latarjet A: *Tratado de Anatomia humana.* Barcelona: Salvat, 1977.
26. Kina H, Erginoglu U., Hanalioglu S., Ozaydin B., Baskaya MK., Ovoid Foramen Magnum Shape is Associated with Increased Complications and Decreased Extent of Resection for Anterolateral Foramen Magnum Meningiomas. *J Neurosurg B Skull Base.* 2021; 82:682– 688.
27. Ünal F, Kırýr T, Ýzgi N, Önal Ç, Tükel T. Mukopolisakkaridozlarýnnöroþirürjikkomplikasyonlarý. *Ýstanbul Týp Fakültesi Mecmuası.* 1998; 61:1.
28. Iwata A, Murata M, Nukina N, Kanazawa I. Foramen Magnum Syndrome Caused by Atlanto-occipital Assimilation. *J Neurol Sci.* 1998; 154: 229-231.

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