

## MORPHOMETRIC EVALUATION OF THE FORAMEN MAGNUM AND VARIATION IN ITS SHAPE AND SIZE: A STUDY ON HUMAN DRIED SKULL

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### ABSTRACT

The foramen magnum is an important landmark located in the posterior part of the cranial base formed by the occipital bone. The purpose of this study was to evaluate the measurements of the foramen magnum in human dried skull and to note the variations in the shape and size of the foramen magnum. Additionally area and index of the foramen magnum were also calculated. Fifty human dried skulls of unknown age and sex were obtained from the department of CMCH Bhopal and FHMC Tundla. Foramen magnum were examined macroscopically for their different shapes. Anteroposterior and transverse diameters, foramen magnum area & foramen magnum index were measured.

The foramen magnum shapes were determined as round shaped in 22%, oval shaped in 16%, egg shaped in 16%, and irregular in 18%, tetragonal in 12% penta and hexagonal 8% each.

The mean A-P and transverse diameters of the foramen magnum was determined 38.75mm and 33.44mm respectively. In 4% of skull, the occipital condyle was observed to protrude in to the foramen magnum. The mean foramen index and foramen magnum area were 87.68 & 970.57mm<sup>2</sup>. The data obtained may be useful to the neurosurgeon in analysing the morphological anatomy of craniovertebral junction in trans condylar approach for brain stem lesion.

**KEY WORDS:** Evaluation Morphometry, Foramen magnum variations, skull.

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DOI: 10.16965/ijar.2015.246

**Web site:** International Journal of Anatomy and Research  
ISSN 2321-4287  
[www.ijmhr.org/ijar.htm](http://www.ijmhr.org/ijar.htm)

Received: 17 Aug 2015      Accepted: 09 Sep 2015  
Peer Review: 17 Aug 2015    Published (O): 30 Sep 2015  
Revised: None                Published (P): 30 Sep 2015

### INTRODUCTION

The complexity of the base of the skull makes this study interesting and useful to the neuro- surgeon orthopedicians and radiologist. Foramen magnum provides a wide communication between the posterior cranial fossa and the vertebral canal. The lower end of the medulla

oblongata, the vertebral artery and the spinal accessory nerve pass through it [1]. The dimensions of the FM become clinically as well as surgically important because these vital structures may compress in cases of FM herniation, FM meningiomas and FM achondroplasia [2]. The expansion of transverse

diameter is seen in Arnold Chiari syndrome thus the knowledge of FM diameter is needed to be determined [3,4]. The diameters of the FM are greater in male than female hence the study about FM dimensions can be used in the field of forensic medicine to determine sex in the medicolegal conditions as in aircrafts injuries and war fare injuries [5]. The FM dimensions can be used in forensic medicine and anthropology for determination of the gender of the human skulls [6,7,8]. It has been noted that the cranial base remain intact in cases where the rest of the cranium has been compromised, thus the researchers have made use of that fact by analysing sexually significant dimorphic trait for this anatomic region [9,10]. The diameters and area of the foramen magnum are generally more in males than females. Further foramen magnum index and cranial index along with other parameters are utilized in craniometry for making comparisons among races [11]. The shape of FM shows correlation with ancestry of an individual hence variations in its shape have got clinical, radiological and diagnostic importance [12,2]. In neurosurgery the transcondylar approach is commonly used to access the lesions near the brain stem & cervicomedullary junction [13].

## MATERIALS AND METHODS

Fifty dried human skulls of unknown age and sex were collected from the different medical colleges and examined for the present study. The different shapes of the foramen magnum were noted macroscopically and classified as round, oval, egg, tetragonal, pentagonal, hexagonal and irregular. The antero-posterior and transeverse diameters were measured by using manual vernier calliper with least count of 0.1mm. The antero-posterior diameter was measured from the end of the anterior border (basion) to the end of the posterior border (opisthion), while the transeverse diameter was measured from the point of maximum concavity on the right margin to the maximum concavity on the left margin. Area of foramen magnum was calculated by using Radinsky [14] formula:  $1/4 \times 3.14 \times FML \times FMW$

where FML= Foramen magnum length and FMW=Foramen magnum width.

Foramen magnum index was calculated by  $\text{Foramen magnum width} \times 100 / \text{Foramen magnum length}$ .

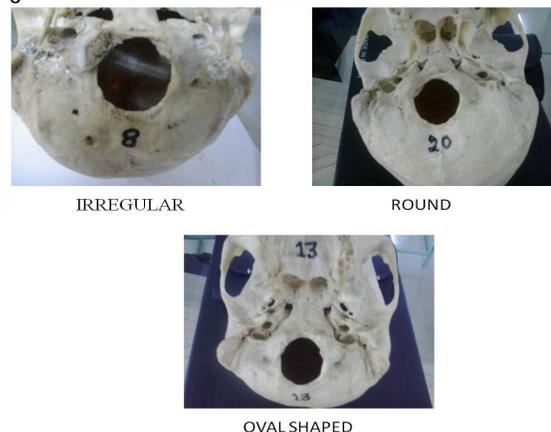
## RESULTS AND TABLES

The various shapes of foramen magnum observed in our study are shown in (Figure 1 - 2). Round shaped foramen was observed in 22% oval shaped in 16% egg shaped in 16%, irregular in 18%, tetragonal in 12%, pentagonal and hexagonal 8% each. The percentage and number of different shapes of the foramen magnum are shown in (Table 1). In 4% of the skull the occipital condyles were observed to protruded into the foramen magnum (Figure 3). The mean antero-posterior and transeverse diameters of the foramen magnum was recorded as 38.75mm and 33.44 mm in (Table 2). The mean of area of FM was observed 970.57mm<sup>2</sup>, and the mean of FM index was 87.68 (Table 3).

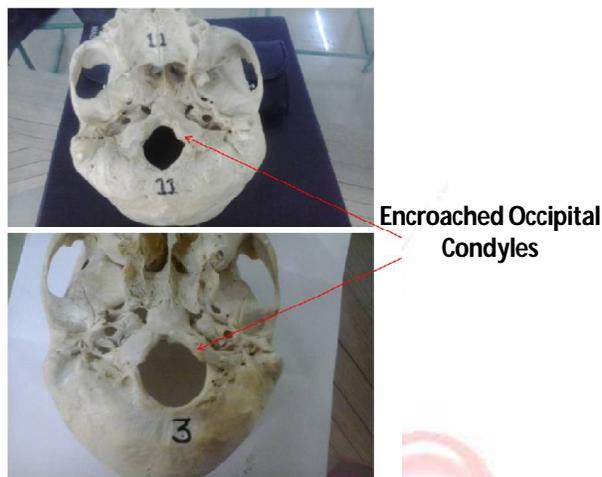
**Fig. 1:** Showing the various shapes of the foramen magnum.



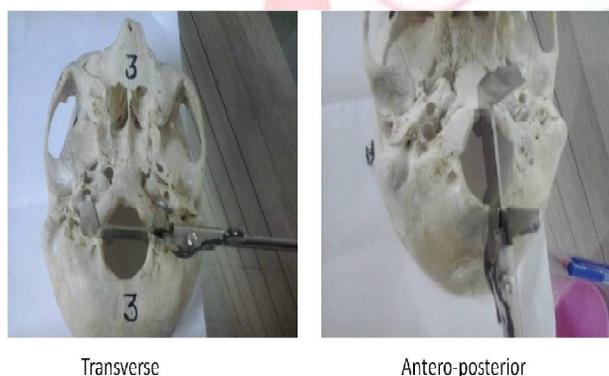
**Fig. 2:** Showing the various shapes of the foramen magnum.



**Fig. 3:** Showing encroached occipital condyles.



**Fig. 4:** Showing measurements undertaken in the foramen magnum.



**Table 1:** Showing the % and Different Shapes of Foramen Magnum (n=50).

	PRESENT STUDY	MURSHED et al.
Morphological variants of FM	Percentage and number	Percentage and number
Round shape	22 % (11)	21.8 % (24)
Irregular shape	18 % (9)	19.9 % (22)
Oval shape	16 % (8)	8.1 % (9)
Egg shape	16 % (8)	-
Tetragonal shape	12 % (6)	12.7 % (14)
Pentagonal shape	8 % (4)	-
Hexagonal shape	8 % (4)	17.2 % (19)

**Table 2:** Showing the comparison of Morphometric Data of FM with the previous reports.

AUTHORS	ANTEROPOSTERIOR OR DIAMETER	TRANVERSE DIAMETER
Schmeltzer et al 1971	35 mm	30 mm
Catalina – Herrera 1987	35.2 mm	30.3 mm
Wanebo and Chicine 2001	36±2 mm	32± 2 mm
Murshed et al 2003 [2]	35.9 ± 3.3 mm	30.4±2.6 mm
Tubs et al (16) 2010	31 mm	27 mm
Present study 2015	38.76 mm	33.44 mm
Burdan et al 2012 [20]	37.06 mm	32.98 mm

**Table 3:** Comparison of Area and Index of Foramen Magnum in various Studies.

AUTHORS AND YEARS	FORAMEN MAGNUM AREA (mm <sup>2</sup> )	FORAMEN MAGNUM INDEX
Teixeira 1983 [17]	963.73	-
Gunay and altinkok 2000 [5]	909.91	-
Burdan et al 2012 [20]	877.4	89.34
Jain et al 2014 [18]	-	86.69
Present study	970.57	87.68

## DISCUSSION

In this study the results were 47.70mm and 40.8 mm as maximum anteroposterior and transverse diameters respectively.

The minimum values of anteroposterior and transverse diameters are 31.50 mm and 27.40 mm. The irregular shape of the foramen is seen with the developmental anomalies of the bones and the soft tissues at the craniovertebral junction [4]. The foramen magnum is described as oval in shape [2]. The shape and morphological variations of foramen magnum are important in neurological interpretation. In ovoid type, the surgeon may find it difficult to explore the anterior portion of foramen magnum. Zaidi and Dayal [15] observed the oval shaped foramen magnum in 64% of the skull, Sindel et al [16] observed oval foramen in only 18.9% of the skull and 81.1% of the cases the shapes were different. According to Murshed et al [2] the foramen magnum was found to be oval in 8.1%, egg shaped in 6.3%, round in 21.8%, irregular in 10.9% pentagonal in 13.6% and hexagonal in 13.6%. Their study was based on examination of computer tomogram films in the healthy individuals.

Zaidi and Dayal 1988 [15] reported the hexagonal shape in 24.5%, pentagonal in 7.5%, irregular in 3.5% and round in 0.5%. In the present study the foramen magnum was observed:

Round shaped in 22%, oval in 16%, egg in 16%, irregular in 18% and tetragonal in 12%, Penta and hexagonal 8% each. This variability in different shapes indicative of racial variation among the morphology.

The present study agrees with Murshed et al 2003 as in both these studies the round shape was the most common type.

In 4% of the cases the occipital condyle were protruded in to the foramen magnum. This type of morphology can lead to compression of the vital structures passing through the FM. The mean area of the FM was 970.5mm<sup>2</sup> in our study which was similar to the observations made by Teixeira WR [17] while the mean of FM index was 87.68 similar to the Jain et al [18].

It is of keen interest to study the morphometry of the FM, from a descriptive and topographical point of view (2). The anatomic diameter have been reported to be about 47.70mm for the A-P diameter and 40.80mm for the transeverse diameter. These values are similar to Richard GD, & Jabbar RS [19] for the antero posterior diameter & Burden et al [20] for the transverse diameter Uthman et al [21] reported that the foramen magnum area is the best discriminant that could be used to study sexual dimorphism.

The data obtained from the present study was compared with the data reported by other authors as shown in (Table 2 & 3). After the comparison, we observed that our findings are almost similar to that of Burdan et al [20]. Data obtained for area of FM and FM index was also compared with data obtained by other authors as shown in (Table 3). Our findings are almost similar to Burdan et al [20] and Jain D et al [18].

The FM is taken as the anatomical landmark in transcondylar approach for a safe occipital condyle resection [22]. The present study illustrates the morphometric data and the variations in the morphology of the FM with emphasis on their clinical implications. This study is also helpful in medicolegal cases for the identification of unknown individuals. With the advancement of the CT and MRI scans as investigation the anatomy of the FM becomes interesting in the field of medicine .

## CONCLUSION

The mean anteroposterior diameter of FM was 38.75 mm and the mean transeverse diameter was 33.44 mm. These parameter should be taken during craniocervical and cervical spine surgical procedures. Morphometric analysis of the foramen magnum can be used as supportive findings in estimation of sex of fragmented incomplete or damaged dry human skulls. The knowledge of dimensions of the FM also help

ful in determination of malformation (Arnold Chiari Syndrome) and in transcondylar approach to make a safe occipital condyle resection. Though the present study has a limitations as the age and sexes of the skull were not determined, this study may provide an important reference and the measurement may be used as a data for the description of morphological variant of FM.

## ACKNOWLEDGEMENTS

We are thankful to Mr. Ramesh and MR. Mukesh of department of anatomy of FHMC for their technical support in taking photographs and to Ms. Shilpi for her support in drafting the text.

**Conflicts of Interests: None**

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#### How to cite this article:

Shikha Sharma, Anil Kumar Sharma, Bhawani Shankar Modi, Mohd. Arshad. MORPHOMETRIC EVALUATION OF THE 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