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Morphometric Study of Foramen Magnum and Variation in Its Shape

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Abstract
Introduction: *Foramen magnum plays an important role as a landmark in the region of skull and spine because it transmits key structures like the lower end of the medulla oblongata, meninges, vertebral arteries and the spinal accessory nerve.*
Aims and objectives*: Our aim was to provide basic osteometric data of anteroposterior and transverse diameters of foramen magnum and to observe its different shapes.*
Materials and methods*: Thirty Four (34) adult human skulls of unknown sex were obtained from Department of Anatomy, RIMS, Ranchi. Foramen magnum diameters were calculated using sliding vernier calipers and shapes were visually assessed.*
Observations and results: *Maximum anteroposterior diameter of foramen magnum was found to be 41.5mm and minimum was 28.5mm with the mean of 34.06mm whereas Maximum transverse diameter was 35mm and minimum was 22mm with the mean of 27.83mm. Percentage of foramen magnum shapes were as follows: oval 58.8%, Tetragonal 17.6%, hexagonal 11.8%, circular 8.82% and irregular 2.94% cases.*
Conclusion: *Knowledge of dimensions of foramen magnum is important for radiologist, orthopaedicians and neurosurgeons, while planning and performing cranio-vertebral junction surgeries.*
Key words*: Foramen magnum, skull, morphometry, shape , variation.*

I. Introduction

Foramen magnum is the large opening at the lower part of the occipital bone and transmits key structures like the lower end of the medulla oblongata, meninges, vertebral arteries and the spinal accessory nerve[1]. The foramen magnum in apes and in humans is formed by the fusion of the four individual parts of the occipital bone (pars squama, left and right pars lateralis, and pars basilaris) [2]. Studies comparing the shape of human foramen magnum with other primates have been done earlier[3].The position of the foramen magnum in humans is unique compared to other mammals. In humans it has migrated well forward in the occipital bone from the back of the skull, to a position beneath the center mass of the skull and brain [4]. It is of particular interest for anthropology, anatomy, forensic medicine and other medical fields. The knowledge of foramen magnum diameters is needed to determine some malformations such as Arnold Chiari syndrome, which shows expansion of transverse diameter[5]. The dimensions of the foramen magnum are important prior to the cutting off of the foramen magnum lesions or posterior cranial fossa lesions, because more the antero-posterior diameter, greater is the contralateral exposure[6]. The diameters and area of the foramen magnum are greater in males than in females, hence its dimensions can be used to determine sex in the medicolegal conditions, especially in the following circumstances, such as explosions, aircraft accidents and war fare injuries[5,7]

II. Aims And Objectives

Our aim was to provide basic osteometric data of anteroposterior and transverse diameters of foramen magnum and to observe its different shapes

III. Materials And Methods

- Thirty Four (34) adult human skulls of unknown age and sex were obtained from Department of Anatomy, RIMS, Ranchi and studied. Deformed samples were excluded.
- The samples were visually assessed for shape of foramen magnum and were photographed(Fig.no.2) Foramen magnum was classified into five shapes – oval, round, irregular, tetragonal and hexagonal.
- Two bony land marks were determined. Basion i.e. the median point of the anterior margin of foramen magnum & Opisthion i.e. median point of posterior margin of foramen magnum.
- Anteroposterior diameter (APD) was calculated as distance between these two points.
- Transverse diameter (TD) was measured as a length of line drawn perpendicular to the previous line at the site of maximum curvature of the lateral margins.(Fig.No.1)
- Measurements were taken using the Vernier caliper and measured to the nearest millimeter.

- All the observations were taken by two observers, using the predetermined methodology to minimize, inter observer & intra observer error.

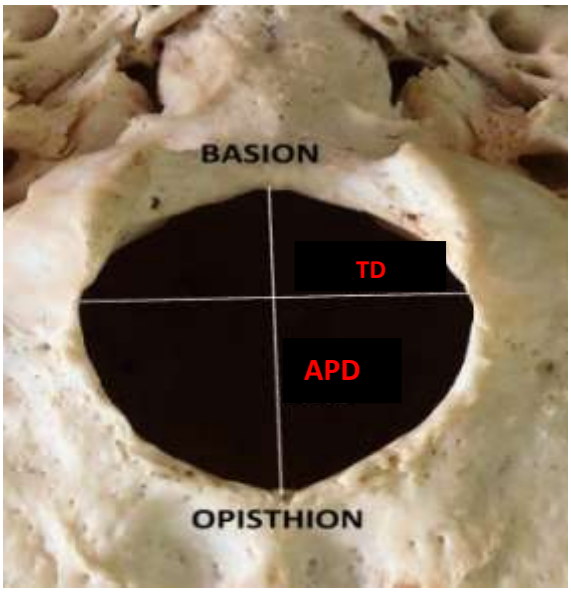

Fig.No. 1: Showing Measurements of Foramen Magnum

II. Statistical Analysis

- All the observations were tabulated in the MS-Excel, (MS Office-2007) format.
- The mean, Median, Mode & Standard Deviation (SD) for the anteroposterior diameter (APD)and transverse diameter(TD) of foramen magnum were calculated and tabulated – Table no. 1.
- Foramen magnum index (FMI) was calculated using the formula: FMI = APD /TD

III. Observations And Results

- The various parameters of foramen magnum recorded in dry skulls are represented in Table no.1
- Range of APD ---------- 28.5mm to 41.5mm.
- Range of TD---------- 22mm to 35mm.
- Mean of APD----------34.06mm.
- Mean of TD----------27.83mm.
- Range of FMI----------1.01 to 1.47
- Specimens having, FMI ≥ 1.2 were considered to have an oval shape.Their frequencies are shown in Table 2.
- The percentage of different shapes of Foramen magnum is tabulated in Table 3

Table 1: The antero-posterior and transverse diameter of foramen magnum in present study

Mean	**34.06**	**27.83**
Median	**33.75**	**27.75**
Mode	**33**	**27.5**
Standard Deviation	**2.53**	**2.6**
Minimum	**28.5**	**22**
Maximum	**41.5**	**35**

Table2: Frequency and percentage of foramen magnum index

<1.20	**14**	**41.17**
>=1.20	**20**	**58.82**
Total	**34**	**100**

Table 3: Various shapes of foramen magnum as seen in present study

Oval	**20 (58.8%)**
Tetragonal	**6(17.6%)**
Hexagonal	**4 (11.8%)**
Circular	**3 (8.82%)**
Irregular	**1 (2.94%)**

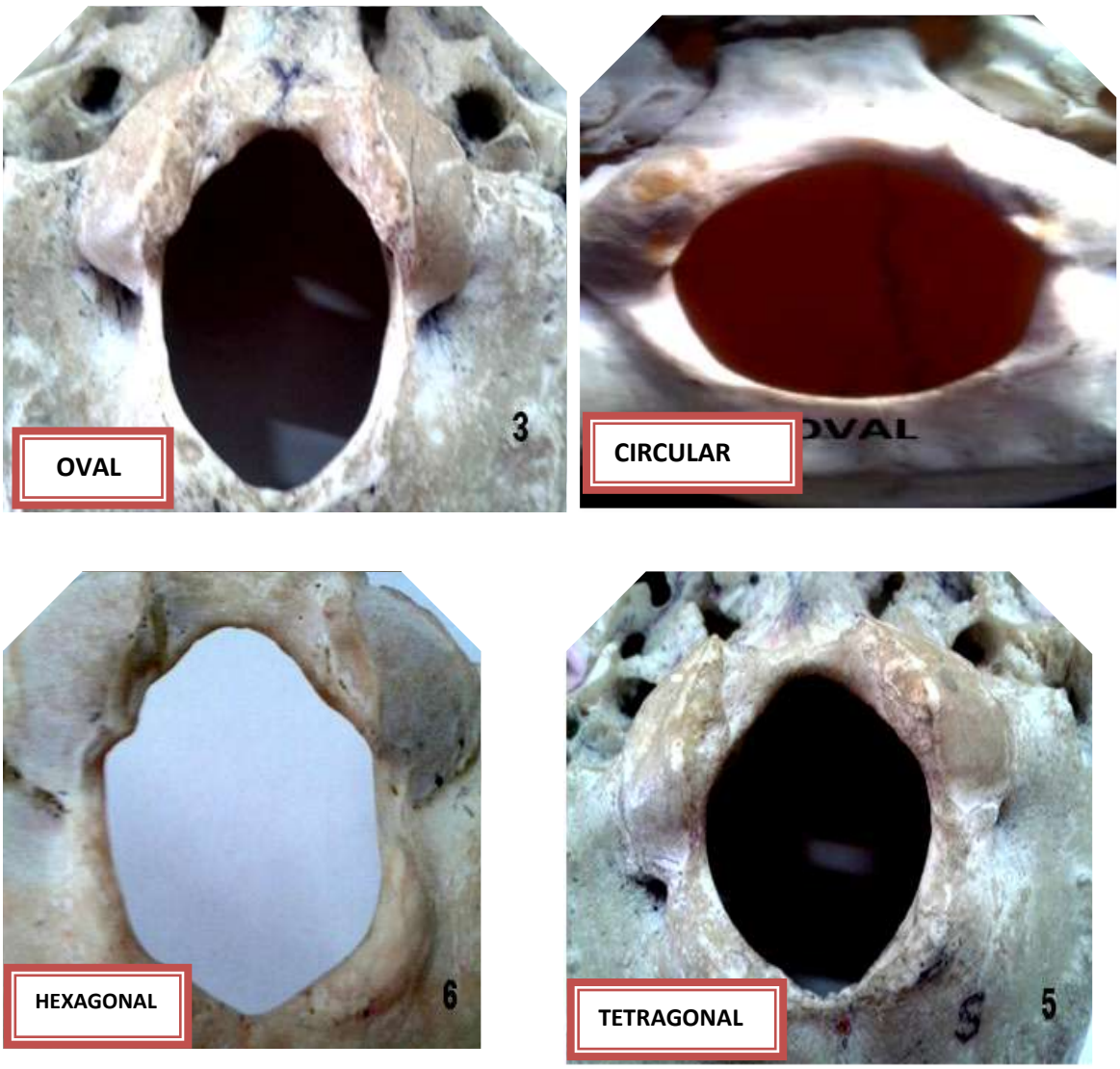

Fig.no.2: Showing various shapes of foramen magnum.

V. Discussion

The shape of foramen magnum is considered oval, when FMI ≥ 1.2 . In the present study, the oval shape was most commonly found, as in studies by many other authors. Some authors found round shape as most common. The proportion of different shapes in various studies has been compared in Table 4. Oval shape is associated with difficult surgical approach to the anterior part of foramen magnum. Anteroposterior and transverse diameter of foramen magnum in the present study is compared with those of various authors in Table 5.Abnormal foramen magnum morphometry and shape is associated with various clinical problems. Cerebellar tonsillar herniation is associated with larger anteroposterior diameter [8]. Arnold-Chiari malformation is a condition where anomalous development of occiput causes decreased posterior cranial fossa volume. Basilar invagination is seen. Enlargement of skull base & cervical canal may develop secondarily [9].

Table 4 : Comparison of morphological types of foramen magnum and frequency of occurrence with previous studies

Types of foramen magnum	Mursh-ed et al	Radha-krishanan et al	P.Chethan et al	Radhika P.M	Anil Kumar et al	Present Study
Oval	**8.1%**	**39%**	**15.1%**	**40%**	**50%**	**58.8 %**
Round	**21.8%**	**28%**	**22.6%**	**20%**	**20%**	**8.82%**
Tetragonal	**12.7%**	**19%**	**18.2%**	**6%**	**6%**	**17.6%**
Hexagonal	**17.2%**	**_**	**5.6%**	**6%**	**8%**	**11.8%**
Irregular	**19.9%**	**_**	**15.1%**	**16%**	**16%**	**2.94%**

Table 5: Comparison of Antero-posterior Diameter & Transverse Diameter of various studies

Authors and Year	Antero-posterior diameter (mm)	Transverse diameter (mm)
Murshed et al (2003)	**35.9**	**30.45 (Max.)**
Muthukumar et al (2005)	**33.3**	**27.9**
Kizilkant et al (2006)	**34.8**	**29.6**
Manoel et al (2009)	**35.4**	**29.85**
Suazo, G.et.at (2009)	**36.05**	**30.05**
Avci et al (2010)	**34.5**	**29**
Tubbs et al (2010)	**31 (Min.)**	**27 (Min.)**
Osun woke et al (2012)	**36.1 (Max.)**	**29.5**
Radhika.P.M et al (2014)	**35.3**	**29.4**
Present study (2016)	**34.06**	**27.83**

As per anteroposterior diameter of foramen magnum is considered the finding of present study i.e.34.6mm is close to that of Avci et al(2010),34.5mm and Kizilkant et al(2006) which was 34.8mm. The transverse diameter of present study 27.83mm is close to Tubbs et al(2010) 27mm and Muthukumar et al(2005) which was 27.9.

VI. Conclusion

The present study gives an insight into the variations in morphology and morphometry of foramen magnum & may be used as a database. Knowledge of its dimensions and variations in its shape are important for radiologist, orthopaedicians and neurosurgeons, while planning and performing cranio-vertebral junction (CVJ) surgeries, to avoid damage to important structures passing through it & to avert atlanto - occipital instability and hemorrhage[10].

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