IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 20, Issue 9 Ser.13 (September. 2021), PP 48-52
www.iosrjournals.org

Morphometric Study of Foramen Magnum In Dry Human Skull And Its Clinical Importance

Binod Kumar[1], Pallavi Ranjan Anand[2], Md Jawed Akhtar[3], Sanjay Kumar[4], Rajiv Ranjan Sinha[5], Avanish Kumar[6]

1, 5. Additional Professor2. Senior Resident3,4. Assistant Professor 6. Professor & Head Department of Anatomy, Indira Gandhi Institute of Medical Sciences, Patna (Bihar).

Corresponding Author: Md. Jawed Akhtar
Assistant Professor,
Department of Anatomy,
Indira Gandhi Institute of Medical Sciences, Patna (Bihar)

Abstract:
Foramen magnum is a fundamental largest aperture of skull consisting of bony, ligamentous and soft tissue structures forming cranio-vertebral junction. Measurement of size and observation of shape has a critical importance clinically as it is helpful in surgical resection of skull and nearby structures like lower part of medulla oblongata, meninges, vertebral arteries, spinal nerves through transcondylar approach.
AIM:The aim of the study was to find out shape and size and their variationsin dry human skull.
MATERIALS&METHODS : Thestudy was done on 40 dried human skull, collected from department of Anatomy and Forensic Medicine of various medical collages. Anteroposterior and transverse diameters were calculated using sliding digital vernier caliper, while shape was observed visually.
RESULT:
In the present study various shapes of foramen magnum were observed. The most common shape we found was oval in 18 (36%) skulls; followed by tetragonal shape in 09 (18%) skulls. The mean of anteroposterior (AP) diameter was 35.67±3.61mm; transverse diameter 29.07±7.45 mm and foramen magnum index was 82.33± 22.77.
CONCLUSION:
Our study identified various shapes of foramen and diameter. In most of the cases antero-posterior diameter is greater than the transverse. The knowledge of dimension and shape of foramen magnum is important for neurosurgeons while planning cranio-vertebral junction approach while for posterior cranial fossa surgeries. Data of study are helpful to these surgeons, anthropologists and forensic persons, in calculating age, sex, blast injury and toknow malformations and complications related to them.
Key Words: Foramen magnum, Morphometry, Foramen magnum index, Skull, Surgery.

Date of Submission: 15-09-2021 Date of Acceptance: 30-09-2021

I. Introduction

Foramen magnum is a 3D large aperture in the central region of occipital bone i.e. in antero-median plane in posterior cranial fossa at the base of skull and is wider from behind. Its transverse diameter is less than 1/3rd of the distance between the two mastoid processes**.**Occipital bone is formed by fusion of 4 parts; pars squama, pars basalis, R & L pars lateralis. The anteriorborder of the foramen is formed by basilar process of occipital bone, lateral border by (R & L) ex-occipitalis & posterior border by supra-occipital part of occipital bone**.**[1]Embryologically the occipital bone is formed by the fusion of sclerotomes of first 4 somites. This fusion also leads to formation of posterior part of the foramen. Neural arch part of 4th sclerotome divides into ventrorostral &dorsocaudal part.Ventrorostral part forms the anterior margin & thedorsocaudal part posterior margin of the foramen. Occipital condyles overhang the anterior margin of the foramen and articulates with lateral mass of 1st cervical vertebra forming atlanto-occipital joint. All these 4 elements which form the occipital bone & posterior part of theforamen are connected by symmetrical posterior and anterior intra-occipital synchondroses. Fusion of posterior synchondroses takes place at 2-4 years of age and anterior synchondroses starts to fuse from 2 years of age tillthe age of 5-7 years.[2]The basilar part is connected to sphenoid bone by sphenooccipital synchondroses which disappear between the age of 16-22years (male), 11-19years (female). These fusion criteria are important to know age, deformities related to dental eruption & termination.[3]The morphological malformations and anomalies in the 4th sclerotome results in different shapes, types and forms of

foramen magnum i.e. there are developmental changes in intraoccipital synchondroses that connect them.The dimension of the foramen is important as it is employed with the purpose of identification of age, sex, species (as it is genetically driven), and a gateway for surgical approach. Due to variation in size & shape of the foramen, there may be many clinical conditions**.**But,very few data are available on morphometry of the foramen magnum of human skull in Bihar region hence the necessity of the present study arose. Objectives of the study were to obtain morphometric data of the foramen magnum belongs to population of Bihar and compare it to findings from other races of the world.

II. Material & Methods:

This is a crosssectional study which is carried out on 50 dried human skull collected from the department of Anatomy &Forensic medicine of different medical colleges of Bihar including IGIMS, Patna. It is a multivariant function analysis as it includes many parameters to calculate the morphometry of the skull.

Parameters: Foramen magnum length, width and foramen magnum index.

Landmark:

Basion: Median point on the anterior margin of foramen magnum.

Opisthion: Median point on the posterior margin of foramen magnum of the skull.

All dimensions of foramen magnum in dry human skulls were measured with anElectronic Digital Vernier Calipers with an accuracy of 0.01 mm.The two prongs of vernier caliper were put over the described landmarks & prongs were fixed manually with the screw then the displayed readings (length and width) over LCD display were recorded.Diameters were calculated using the landmarks in all 50 dry human skulls, their % of occurrence were calculated and a chart was prepared. On the basis of these parameters shape was observed. Their mean were calculated. Statistical analysiswasdone, data were collected, tabulated and statistically analyzed using SPSS software. It was found that the most common shape was oval followed by hexagonal & round.The dimensions measured include the following**:**it is a multivariant morphological analysis as it includes many criteria for morphometry

- **Antero-posterior diameter/Foramen magnum length(FML)**: Anteroposterior diameter was measured by taking a point on the middle of anterior margin to the point on the middle of posterior margin of the foramen (from point A to B).(Figure 1)
- **Transverse diameter/Foramen magnum width (FMW)**:
- The width of foramen magnum was taken by measuring most prominent parts of the lateral curvature as straight transverse diameter (from point C to D). (Figure 1)
- **Foramen Magnum Index (FMI)**:

On the basis of this calculation of diameter, Foramen magnum Index was calculated which describes different shape of the foramen.

FMI=APD/TD

STATISTICAL ANALYSIS: The data was analysedbygraph pad software, maximum and minimum values along with standard deviation were obtained.

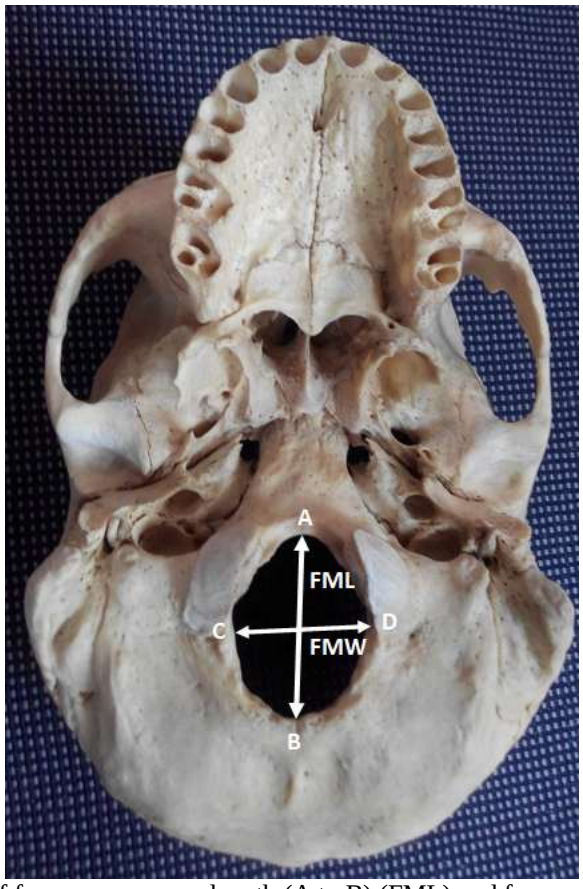

Figure 1: Measurement of foramen magnum length (A to B) (FML) and foramen magnum width (C to D) (FMW)

III. Results:

In the present study various shapes of foramen magnum were observed. The most common shape we found was oval in 18 (36%) skulls; followed by tetragonal shape in 09 (18%) skulls and third commonest were hexagonal and pentagonal in 07 (14%) skulls. Round shaped foramen magnum was found in 06 (12%) skulls and pear shaped was present in 3 (6%) skulls [Table-1].The mean of anteroposterior (AP) diameter was 35.67±3.61mm; transverse diameter 29.07±7.45mm and foramen magnum index was 82.33± 22.77[Table -2]. The mean AP diameter, transverse diameter and foramen magnum index values for each shape of Foramen Magnum is shown in table 3.

Shape	**Number N (%)**	Percentage (%)
Oval	18	36
Tetragonal	09	18
Hexagonal	07	14
Pentagonal	07	14
Round	06	12
Pear	03	6
Irregular	0	0
Total	50	100

Table 1: Shape of foramen magnum and its incidence

Total Number (N) = 50	**Antero posterior diameter (mm)**	**Transverse diameter (mm)**	**Foramen Magnum Index (FMI)**
Mean ± SD	35.67±3.61	29.07±7.45	82.33± 22.77
Minimum	31.05	25.25	70.82
Maximum	41.03	34.32	96.94

Table 2: Dimension of foramen magnum in dry human skull in present study

Shape	**Number N (%)**	**Antero posterior diameter (mm)**	**Transverse diameter (mm)**	**Foramen Magnum Index (FMI)**
Oval	18 (36%)	34.61±2.63	33.62±3.61	34.62±2.68

Tetragonal	09 (18%)	32.74±2.06	34.74±1.09	32.71±2.08
Hexagonal	07 (14%)	34.93±1.89	35.72±1.86	32.91±1.91
Pentagonal	07 (14%)	28.66±2.32	29.44±1.31	30.41±1.31
Round	06 (12%)	36.21±1.38	32.21±1.32	32.24±1.38
Pear	03 (6%)	29.22±1.01	29.25±0.07	32.24±0.07

Table 3: Mean dimension of foramen magnum according to shape

IV. Discussion-

Data obtained from present study was compared with reports from different authors. Mushed et al[4], Chethan et al[5], Radhakrishan et al[6] reported round shapewas commonest in their study but in our study oval type was commonest, which is supported by Radhika et al.[7].

Shape of foramen Magnum	Murshed *et al.* [4]	Chethan *et al.* [5]	Radhakrishna *et al.* [6]	Radhika *et al.* [7]	Present Study
Oval	9(8.1%)	8(15.1%)	39(39%)	60(40%)	18(36%)
Round	24(21.8%)	12(22.6%)	28(28%)	30(20%)	6(12%)
Tetragonal	14(12.7%)	10(18.9%)	19(19%)	9(6%)	9(18%)
Hexagonal	19(17.2%)	3(5.6%)	-	9(6%)	7(14%)
Irregular	22(19.9%)	8(15.1%)	-	24(16%)	-
Pentagonal	-	-	-	-	7(14%)
Pear	-	-	-	-	3(6%)

Table 4: Comparison of distribution of morphological types of shapes in foramen magnum with previous studies.

Previous studies (Year)	Antero-posterior diameter (mm)	Transverse Diameter (mm)
Murshed et al. [4]	35.9	30.45
Chethan et al.[5]	31	25.2
Radhakrishna et al.[6]	34.04	28.63
Kanchan et al.[8]	34.51	28.98
Radhika et al. [7]	35.3	29.4
Kumar et al.[9]	36.78	30.05
Present study (2021)	35.67	29.07

Table 5: Comparison of morphological parameters of foramen magnum in various studies

Foramen magnum is a passage between thevertebral canal and cranial cavity, which is formed by the combination of bony ligaments as well as muscular structures which forms the complex craniovertebral junction. For transcondylar approach of base of skull surgeries, knowledge of different morphometric measurements of foramen magnum is needed. Different morphometric measurements of foramen magnum also have a significance rolein various intracranial surgical approaches, in the herniation of cerebellar tonsil. It also play a significant role inidentification of fire victims in forensic science.

In our study of foramen magnum, the mean antero-posterior and transverse diameters in 50 skulls were 35.67±3.61mm and 29.07±7.45mm similar to study on Brazilian skulls, which also shows that the mean antero-posterior diameter was 35.22±3.3 mm and the mean transverse diameter was 30.3±2.0 mm [10]. Ukokha U et al conducted a study on 100 Nigerian skulls in 2011, which showed a mean Antero-posterior diameter of 36.2±2.3 mm and a transverse diameter of 30.0±2.5 mm [11]. These differences in observations are may be due to different racial composition of study population. Nevell L et al explained how different osteological features of foramen magnum undergoes various evolutionary changes[12].The morphological shapes of foramen magnumshows different variations in different population. The morphological variations of the foramen magnum found in our study were oval (36%), rounded (12%), hexagonal (14%), pentagonal (14%) andpear (6%) shapes. Radhika et al. [7] also observed oval as main type 64% while it is tetragonal in other studies.For surgeons as it is difficult to explore anterior portion of foramen magnum in ovoid type. So knowledge of these types of morphological variations is very important[13].Different researchers reported round shape is commonly observed like Mushed et al. [4], Chetan et al. [5] andRadhakrishan et al[6]. A study done on CT images by Edril et al.[13] showed CT images parameters are higher in males as compared to females similar to our findings. These multivariant studies deals with amorphometricreferences to various types of foramen magnum in Indian

population, as there is a great variations regarding literature available on the morphological dimensions of foramen magnum.The clinical observation by this study deals mainly with the surgical and neuronal malformations. As it is important to know the neurological disturbances in which cranial nerves, vertebral artery, spinal cord, parts of brain passes through this foramen. it. This study is aimed to describe the morphometry of the foramen and near by structures to deal with many clinical problems like syringomyelia in which there is destruction of central portion of spinal cord due to widening of central canal which begins usually in cervical region. Narrow cranial fossa due to thick occipital bone (>30mm) leads to chiary malformation. Besides this, measurement is also helpful in determination of sex as there is significant difference of value of the diameter. Our study provide data for forensic examination for estimation of sex of fragmented, incomplete or damaged dry human skulls. It varies in size in different individuals. The foramen magnum may be too large or small, or of variable shapes. A small foramen may lead to neurological conditions. Reduced circulation of CSF may cause hydrocephalus. The average value of foramen magnum index obtained in our study was 82.33±22.77. Chaturvedi RP et al.[14] and Howale DS et al.[15] reported the average value of foramen magnum index as 83.81 and 84.85±4.77 respectively after study on skull of Indian origin, which was very much near to our observation. Different radiological morphometrical studies onthis foramen were also conducted. Bello SS et al.[16]observed that meanantero posterior diameter as 34.3±4.1 mm and mean transverse diameter 30.1±3.1 mm after radiological study offoramen magnum by CT scan.Kanodia G et al.[17]studied the different dimensions of foramen magnum in dry skull as well as in living one with the help of CT scan and observedthatanteroposterior diameter as 34.1±2.9 mm and transverse diameter as 27.5±2.5 mm in dry skull andstated that there was no significant difference between the CT scan group and morphometric values of dry skull in transverse diameter and surface area but anteroposterior diameter of dry skull was larger than CT scan group. The difficulties of bony resection during neurosurgery around skull base is directly related to the size of foramen magnum [18].

V. Conclusion

In various surgical procedures of posterior cranial fossa, the morphometric knowledge regarding foramen magnum is very helpful to neurosurgeons. This type of morphometric study gives us significant parameters to determine feasibility of transcondylar approaches to prevent complications like hemorrhage and injury to vital structures passing through it.

References

[1]. Standring S. Gray's anatomy. The anatomical basis of clinical practice. 39th ed. London: Elsevier Churchill Livingstone; 2005: 460.
[2]. Burdan F, Szumilo J, Walocha J, Klepacz L et al Morphology of the foramen magnum in young Eastern European adults. Folia Morphol (Warsz). 2012 Nov;71(4):205-16.
[3]. Bogin B. Evolutionary Hypotheses for Human Childhood. Yearbook of Physical Anthropology. 1997;40:63–89.
[4]. Murshed KA, Emine A, Tuncer I. Morphometric evaluation of the foramen magnum and variations in its shape: a study of CT images of normal adults. Turk. J. Sci., 2003; 33: 301-06.
[5]. Chethan P, Prakash JA, Murlimanju BV, Prashanth KV. Morphological analysis and morphometry of the foramen magnum: an anatomical investigation. Turkish Neurosurg., 2012; 22(4): 416-19.
[6]. Radhakrishna SK, Shivarama CH, Ramakrishna A, Bhagya B. Morphometric analysis of foramen magnum for sex determination in south Indian population. Nitte Univ. J. Heal. Sci., 2012; 2(1): 20-22.
[7]. Radhika PM, Shetty S, Prathap KJ, Sheshgiri C, Jyothi KC. Morphometric study of the foramen magnum in adult human skulls in Indian population. Asian J. Med. Clin. Sci., 2014; 3 (2): 68-72.
[8]. Kanchan T, Gupta A, Krishan K. Craniometric analysis of foramen magnum for estimation of sex. Int. J. Med. Health, Biomed. Pharm. Eng., 2013; 7(7): 111-13.
[9]. Kumar A, Dave M, Anwar S. Morphometric evaluation of foramen magnum in dry human skulls. Int. J. Anat. Res., 2015, 3(2): 1015-23.
[10]. Manoel C, Prado FB, Caria PHF, Groppo FC. Morphometric analysis of the foramen magnum in human skulls of brazilian individuals. Its relation to gender. Braz. J. Morphol. Sci, 2009; 26(2): 104-08.
[11]. Ukoha U, Egwu O, Okafor I, AnyaboluA,Ndukwe G, et al. Sexual Dimorphism in the Foramen Magnum of Nigerian Adult. Int. J. Biol. Med. Res., 2011; 2(4): 878-81.
[12]. Nevell L, Wood B. Cranial base evolution within the hominin clade. J. Anat, 2008; 212; 455-68.
[13]. Edril FH, Saban V, Cimen M, Isik O. Morphometric Evaluation of the foramen magnum by CT. Ericyes Med. J., 2010; 32(3): 167-70.
[14]. Chaturvedi RP, Harneja NK. A craniometric study of human skull. Journal of Anatomical Society of India.1963;12:93-96.
[15]. Howar DS, Bathija D, Pandit DP. Correlation between cranial index and foramenmagnum index in human dried skulls. GJRA. 2014;3(1):3-6.
[16]. Bello SS, Zagga AD, Kalale SB, Usman JD, Bello A, Abdulhameed A, etal. Measurements of foramen magnum using computerised tomography inSokoto State, Nigeria. International Journal of Health and Medical Information.2013;2(2):29-35.
[17]. Kanodia G, Parihar V, Yadav YR, BhatelePR,Sharma D. Morphometric analysis ofposterior fossa and foramen magnum. J Neurosci Rural Pract. 2012;3(3):261-66.
[18]. Testut L, Latarjet A. Tratado de Anatomia Humana. Barcelona: Salvat; 1977.