MORPHOMETRIC AND MORPHOLOGICAL STUDY OF FORAMEN MAGNUM IN DRIED HUMAN SKULL BONES

Sampada P K ¹, Poornima B ^{*2}, Mallikarjun M ³, Santosh B Sakri ⁴.

^{*1,2} Assistant professor, Department of Anatomy, Vijayanagar Institute of Medical Sciences, Ballari, Karnataka, India.

³ Professor and HOD, Department of Anatomy, Vijayanagar Institute of Medical Sciences, Ballari, Karnataka, India.

⁴ Professor, Department of public health Dentistry, SAIDS, Calicut, Kerala, India.

ABSTRACT

Background: The foramen magnum is the large opening located in the occipital bone of skull. The morphometric evaluation of foramen magnum is clinically interesting because of its relation with its contents. The vital structures passing through it may endure compression such as in cases of foramen magnum herniation, foramen magnum meningiomas and foramen magnum achondroplasia. The knowledge of foramen magnum diameters is needed to determine some malformations such as Arnold Chiari syndrome, which shows expansion of transverse diameter.

Objective: To measure the anteroposterior diameter, transverse diameter and to calculate the area of foramen magnum. The shape of the foramen was noted and were classified as oval, round, egg, tetragonal, pentagonal, hexagonal, irregular.

Materials and Methods: Completely ossified 100 dried human skull bones of unknown age and gender were taken from the Department of Anatomy, V.I.M.S., Ballari, Karnataka, India.

Results: The mean antero-posterior diameter was 34.84 ± 2.32 mm. The mean transverse diameter was 29.39 ± 1.73 mm. The mean area of foramen magnum was 803.8 ± 83.42 mm². The foramen magnum shapes were determined as an Oval 58%, Round 9(9%), Egg 11(11%), Tetragonal 8(8%), Pentagonal 1(1%), Hexagonal(3%), irregular(10%).

Conclusion: This study will be useful for the anatomist, neurosurgeon, radiologist and orthopaedic surgeon.

KEYWORDS: Foramen Magnum, Occipital Bone, Herniations, Meningiomas, Achondroplasia.

Address for Correspondence: Dr. Poornima B, Assistant professor, Department of Anatomy, Vijayanagar Institute of Medical Sciences, Ballari, Karnataka, India.

E-Mail: pnima73@gmail.com

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INTRODUCTION

Foramen magnum is a latin word meaning largest aperture in the skull. Foramen magnum is an important landmark of the skull base and is of particular interest for anthropology, anatomy, forensic medicine, and other medical fields [1]. It is surrounded by squamous part posteriorly,

basilar part anteriorly, and two condyles on right and left lateral sides [2,3]. Foramen magnum is situated in an anteromedian position, and is oval, being wider behind with its greatest diameter being anteroposterior [4]. The major structures passing through this large foramen are medulla oblongata with the meninges,

vertebral arteries, anterior and posterior spinal arteries and accessory nerves [4].

The dimensions of the foramen magnum are very important in dealing with compression during achondroplasia of foramen magnum [5], brain herniation [6,7] and in neurosurgical approach to access the lesions located anterior to the brainstem [8] and in malformations like Arnold Chiari syndrome, which shows expansion of transverse diameter [9]. The shape of foramen magnum varies. The importance of variations in shape is due to its effects on the vital structures passing through it and also plays an important role in various surgical approaches. Dimensions of the foramen magnum have clinical importance because the vital structures that pass through it may suffer compression. It has also been noted that longer anteroposterior dimension of foramen magnum permitted greater contralateral surgical exposure for condylar resection [10].

MATERIALS AND METHODS

The study was conducted on completely ossified 100 dried human skull bones of unknown age and gender. These bones were taken from the Department of Anatomy, Vijayanagar Institute of Medical Sciences, Ballari, Karnataka, India. Skull bones with damaged and deformed foramen magnum were excluded from the study.

The parameters measured included the following:

1. Anteroposterior diameter: It is the distance between basion (the midpoint of the anterior margin of the foramen magnum) and opisthion (the midpoint of the posterior margin of the foramen magnum).

2. Transverse diameter: It is the distance between the lateral margins of the foramen magnum at the point of greatest lateral curvature. Measurements of the foramen magnum were taken by using vernier calipers. All measurements were recorded to an accuracy of 0.1 mm. Measurements were taken twice and average of two values was taken as final measurement.

Area of the foramen magnum - It is calculated by the following formula¹¹.

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

w = Width, transverse diameter

h = Height, longitudinal diameter

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

The different shapes of the foramen magnum were macroscopically noted and classified as oval, round, egg, tetragonal, pentagonal, hexagonal and irregular.

RESULTS

In our study the mean antero-posterior diameter was 34.84 ± 2.32 mm. The maximum antero-posterior diameter was 40.11 mm and minimum anteroposterior diameter was 30.14 mm. The mean transverse diameter was 29.39 ± 1.73 mm. The maximum transverse diameter was 32.39 mm and minimum transverse diameter was 25.04 mm. The mean area of foramen magnum was 803.8 ± 83.42 cm². The incidence of the morphological types of foramen magnum had the following frequency of distribution: Oval 58%, Round 9(9%), Egg 11(11%), Tetragonal 8(8%), Pentagonal(1(1%)), Hexagonal(3%), irregular(10%).

Fig. 1: Showing 100 dried adult human skull bones.

Fig. 2: Showing measurement of anteroposterior diameter of foramen magnum

Fig. 3: Showing measurement of transverse diameter of foramen magnum.

Fig. 4: Showing various shapes of foramen magnum.

DISCUSSION

Table 1: Comparison of foramen magnum dimensions in various studies.

Authors and years	Anteroosterior diameter (mm)	Transverse diameter (mm)
Patel and Mehta (2014) [13]	33.7	28.29
Howale et al (2014) [14]	31.2	26.9
Osunwoke E.A (2012) [15]	36.1	29.5
Muralidhar et al (2014) [16]	33.4	28.5
Mahajhan D et al (2013) [17]	32.83	27.47
Santhosh et al (2013) [18]	34.37	28.98
Anil kumar et al (2015) [19]	36.78	30.05
Ganapathy et al (2014) [20]	33.9	28.7
Radhakrishna et al (2012) [21]	34.04	28.63
Present study (2016)	34.84	29.39

Foramen magnum is a transition zone between spine and skull. It is a morphologically variable osteological feature in the skull which has undergone evolutionary changes [12]. It plays an important role as a landmark because of its close relationship to key structures such as brain,

spinal cord and vertebral arteries. In the present study, mean anteroposterior diameter of foramen magnum in 100 skulls was found to be 34.84 ± 2.32 mm and the mean transverse diameter was 29.39 ± 1.73 mm. The comparison of the morphometric analysis obtained in this study with the result of other studies has been tabulated (Table 1).

In the present study, the mean area of foramen magnum was 803.8 ± 83.42 mm². In a study conducted by Rohini devi M et al [22] on 35 dried skulls of unknown sex, they found that the mean area of foramen magnum was 820.53cm². A study done by Shika et al [23] on 50 dried skulls, the mean area of foramen magnum was 970.57cm². The variations obtained in the mean values of area of foramen magnum in the above mentioned studies may be due to sexual dimorphism.

There is great variation in the morphological types of foramen magnum. The shape and morphological variations of foramen magnum are important in neurological interpretation. In the present study, oval shaped foramen magnum were found more frequently, which was similar to the results obtained by study done by Radhakrishna S [21].

Table 2: Comparison of foramen shapes with previous studies.

Shapes of foramen magnum	Murshed et al 2003 [10]	Radhakrishna et al 2012 [21]	Chethan P et al 2012 [24]	Radhika PM et al 2012 [21]	Anil kumar et al 2015 [19]	Present study
Oval	9(8.1%)	39(39%)	8(15.1%)	60(40%)	18(50%)	58(58%)
Round	7(6.3%)	-----	10(18.9%)	15(10%)	7(20%)	9(9%)
Egg	24(21.8%)	28(28%)	12(22.6%)	30(20%)	-----	11(11%)
Tetragonal	14(12.7%)	19(19%)	10(18.9%)	9(6%)	2(6%)	8(8%)
Pentagonal	15(13.6%)	14(14%)	2(3.8%)	3(2%)	-----	1(1%)
Hexagonal	19(17.2%)	-----	3(5.6%)	9(6%)	3(8%)	3(3%)
Irregular	22(19.9%)	-----	8(15.1%)	24(16%)	6(16%)	10(10%)

In the study done by Murshed et.al and Chethan P et al, the round shaped foramen magnums were more frequent [10,24]. These variations might have been attributed by the factors such as sexual dimorphism [25], types of population [24], and ethnic groups [26]. Therefore the variation in the foramen magnum shape should be taken into consideration during clinical and radiological diagnostic procedures and the surgical approach [24].

Development of a particular shape of the FM is explained on the basis of the embryologic data.

It may be caused by ossification of primordial cranial residues, which join the endochondral ossification points in different locations, resulting in various shapes [27]. Irregular shape of foramen magnum is accentuated by the developmental anomalies of the bone and soft tissues at the craniovertebral junction [24].

CONCLUSION

Morphological and morphometric analysis of foramen magnum is important for anatomists, anaesthetists, radiologists and neurosurgeons. The knowledge about the diameters is necessary while performing surgeries for foramen magnum meningiomas or posterior cranial fossa lesions and also in determining Arnold Chiari Syndrome.

Conflicts of Interests: None

REFERENCES

- [1]. Ferreira, F. V.; Rosenberg, B. & da Luz, H. P. The Foramen Magnum index in brazilians. Rev. Fac. Odontol. SaoPaulo, 1967;5(4):297-302.
- [2]. Krogman WM, Iscan MY. Skeletal Age: Cranium, Skeletal Age: Post Cranium and Determination of Sex and Parturition. In: The Human Skeleton in Forensic Medicine. 2nd ed. USA: Charles C Thomas Publishers, 1986:103-267.
- [3]. Luiz AS and Marco S. Sexing the human skull through the mastoid process. Rev. hosp. Clin. Fac. Med. S Paulo, 2003;58(1):15-20.
- [4]. Standring S, Gray's Anatomy: The Anatomical Basis of Clinical practice. 39th edition. Edinburg: Elsevier Churchill Livingstone, 2005;463-465.
- [5]. Hecht TJ, Horton WA, Reid CS, et al. Growth of the foramen magnum in achondroplasia. American Journal of Medical Genetics.1989;32:528-35.
- [6]. Reich JB, Sierra J, Camp W, et al. Magnetic resonance imaging measurements and clinical changes accompanying transtentorial and foramen magnum brain herniation. Annals of Neurology.1993;33:159-70.
- [7]. Ropper AH. MRI demonstration of the major features of herniation. J Neurol Neurosurg Psychiatry.1993;56:932-5.
- [8]. Muthukumar N, Swaminathan R, Venkatesh G, Bhanumathy SP: A morphometric analysis of the foramen magnum region as it relates to the transcondylar approach. Acta Neurochir (Wien.) 2005;147:889-895.
- [9]. Sgouros S, Goldin HJ, Hockely AD, Wake MJ, et al. Intracranial volume change in childhood. J Neurosurg; 1999;91:610-616.
- [10]. Murshed KA, Cicekcibasi AE, and Tuncer I. Morphometric Evaluation of the Foramen Magnum Variations in its Shape: A Study on Computerized Tomographic Images of Normal Adults. Turkish Journal of Medical Sciences.2003;33(1):301-306.
- [11]. Radinsky L. Relative brain size: anew measure. Science 1967;155:836-38.
- [12]. Nevell L,Wood B. Cranial base evolutionwithin the hominin clade. J Anat., 2008;212: 455-468.
- [13]. Roma Patel, C. D.Mehta. Morph metric study of Foramen Magnum at the base of human skull in South Gujarat. Journal of Dental and Medical Sciences. 2014;13(6):23-25.
- [14]. Deepak S. Howale, Anil Bathija, Sudarshan Gupta, D P Pandit. Correlation between cranial index and foramen magnum index in human dried skulls. GJRA. 2014;3(1):3-6.
- [15]. 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.
- [16]. 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):249-55.
- [17]. Divya Mahajan, Gaurav Agnihotri, Abha Sheth, Rahat Brar. An anatomical perspective of human occipital condyles and foramen magnum with neurosurgical correlates. International journal of clinical and experimental anatomy. 2013;6(7):29-33.
- [18]. Santhosh CS, Vishwanathan KG, Ashok Gupta, Siddesh RC, and Tejas J. Morphometry of the Foramen Magnum: An Important Tool in Sex Determination. Research and Reviews: Journal of Medical and Health Sciences. 2013;4(2):88-91.
- [19]. Anil Kumar, Mitesh Dave, Sanam Anwar. morphometric evaluation of foramen magnum in dry human skulls. Int J Anat Res 2015;3(2):1015-1023.
- [20]. Arthi Ganapathy, Sadeesh T., Sudha Rao. Morphometric analysis of foramen magnum in adult human skulls and ct images. Int J Cur Res Rev., 2014;6(20):11-15.
- [21]. Radhakrishna S, Shivarama C, Ramakrishna A, Bhagya B. Morphometric analysis of foramen magnum for sex determination in south Indian population. Nite university journal of health science. 2012;2(1):20-22.
- [22]. Rohinidevi M, Vimala V. Morphometric analysis of foramen magnum and variations in its shape in dried human adult skulls: an original article. Int J Anat Res 2016;4(3):2670-2673.
- [23]. Shika S, Anil Kumar S, Bhawani S M, Arshad M. Morphometric Evaluation of the Foramen Magnum and Variation in its Shape and Size: A Study on Human Dried Skull. International Journal of Anatomy and Research. 2015;3(3):1399-03.
- [24]. 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.
- [25]. Ukoha U, Egwu O, Okafor I, Anyabolu A,Ndukwe G,

- Okpala I. Sexual Dimorphism in the Foramen Magnum of Nigerian Adult. *Int J Biol Med Res.*, 2011;2(4): 878-881.
- [26]. Espinoza E, Ayala C, Ortega L, Collipal E, Silva H, Morfometría tomográfica del foramen magno y su relación con el sexo y la etnia mapuche. *Rev. ANACEM (Impresa)*. 2011;5(1):28-31.
- [27]. Govsa F, Ozer MA, Celik S, Ozmutaf NM. Three-Dimensional Anatomic Landmarks of the Foramen Magnum for the Craniovertebral Junction. *The Journal of Craniofacial Surgery*. 2011;22(3):1073-1076.

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