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Original Research Article

MORPHOLOGICAL AND MORPHOMETRICAL ANALYSIS OF FORAMEN MAGNUM: AN ANATOMICAL STUDY

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ABSTRACT

Background: Foramen magnum (FM) is an important landmark of the skull base and is of particular interest for anthropology, anatomy, forensic medicine and other medical field. It is one of several oval or circular apertures in the base of the skull, through which medulla oblongata is transmitted. Variations of the shape of FM have got diagnostic clinical and radiological importance. The dimensions of FM have clinical importance because the vital structures that pass through it may suffer compression as in cases of FM achondroplasia and FM brain herniation, so this study aimed to access its diameter and determining its various shape.

Materials and Methods: Study sample consisted of 75 dry adult human skull of unknown sex, free from any pathology and collected from Department of Anatomy, P.D.U. Medical College, Rajkot, Gujarat and American international institute of medical sciences, Udaipur, Rajasthan, India.

Results: The FM was observed to have round shape in 8%, egg shape in 9.33% tetragonal in 25.33%, oval in 33.33%, irregular in 2.67%, hexagonal in 8% and pentagonal in13.33% of the cases. The mean antero-posterior and transverse diameter of the FM was recorded as 34.00+/- 2.38 mm and 28.68+/-1.88 mm respectively. The Maximum diameter of antero-posterior and transverse diameter was recorded 39.53mm and 32.14mm respectively. The Minimum diameter of antero-posterior and transverse diameter was recorded 28.72 mm and 23.54 mm respectively.

Conclusion: Though the present study has a limitation as the exact age and sexes of skull were not determined, this study may provide an important reference and the measurements may be used as a data for the description of normal morphological variants of FM. The present study will be of useful to the neurosurgeons and is also helpful to the anthropologists and clinical anatomists.

KEY WORD: Foramen magnum, Morphometry, Shape, Skull.

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INTRODUCTION

The foramen magnum (FM) is the oval shape opening, an important landmark, unique and complex anatomical area of occipital bone that

is also one of the primary sites for ossification of base of cranium during growth and development [1]. It contains the lower end of medulla oblongata, meninges, cerebrospinal fluid, vertebral arteries and veins, and the accessory nerves; the apical ligament of dens and tentorial membrane pass through it to attach to the internal basi-occiput [2]. Variations of the shape of FM have got diagnostic clinical and radiological importance [3].

The FM, as a transition zone between spine and skull, play a vital role as a landmark because of its close association to key structures such as the brain and the spinal cord [4]. The dimensions of FM have clinical importance because the vital structures that pass through it may suffer compression as in cases of FM achondroplasia and FM brain herniation [5]. In transcondylar approach, the anatomical landmarks of the FM should be well known in order to make a safe occipital condyle resection [6]. Studies on the anatomical and morphological characteristics of the FM, along with its variations have particularly contributed towards enabling surgeons to improve the surgical access conditions in cases of tumor resection, achondroplasia and cerebral herniation in the FM, which may make such procedures more successful [7-10], so this study aimed to access its diameter and determining its various shape.

MATERIALS AND METHODS

The present work was carried out at the Department of Anatomy, P.D.U. Medical College, Rajkot, Gujarat and American international institute of medical sciences, Udaipur, Rajasthan. Study sample consisted of 75 dry adult human skull of unknown sex, free from any pathology. The different shapes of FM were macroscopically noted and classified as oval, round, egg, tetragonal, pentagonal, hexagonal and irregular shapes. The antero-posterior and transverse diameters of the FM were measured using vernier calipers of 0.01mm accuracy. The antero-posterior diameter was measured from basion to opisthion along the mid-sagital plane. The transverse diameter was measured from the point of maximum concavity on the right margin to the maximum concavity on the left margin. The data were analyzed and presented as mean +/- SD.

RESULTS AND DISCUSSION

The FM was observed to have oval shape in 33.33%, Tetragonal in shape 25.33%, pentagonal in13.33%, egg in shape 9.33%, round and hexagonal in 8.0% and irregular in 2.67% (Table 1, Figure 1). The mean antero-posterior and transverse diameter of the FM was recorded as 34.0 +/-2.38mm and 28.68+/-1.88mm. The Maximum diameter of antero-posterior and transverse diameter was recorded 39.53mm and 32.14mm respectively. The Minimum diameter of antero-posterior and transverse diameter was recorded 28.72mm and 23.54mm respectively (Table 2).

Table 1: Frequency of shapes of FM.

Shape of foramen magnum	n	%
Oval	25	33.33
Round	6	8
Egg	7	9.33
Irregular	2	2.67
Tetragonal	19	25.33
Pentagonal	10	13.33
Hexagonal	6	8

Table 2: Measurements of FM.

Statistical value	Antero-posterior diameter(mm)	Transverse diameter(mm)
Mean	34.0 +/- 2.38	28.68 +/- 1.88
Maximum	39.53	32.14
Minimum	28.72	23.54

It was reported that some of the osteological features in skull like FM have undergone evolutionary changes [11, 12]. During the early fetal growth, the development of skull base begins as a cartilaginous mass with multiple centers of ossification and the FM is one such center [12].

In the various studies, there is some dissimilarity regarding the predominant morphological types of FM. According to Zaidi and Dayal, Radhakrishna et al. and Radhakrishnan et al., the oval shape was the most frequent type [1,13,14], while the round shape is the main type according to Murshed et al. and Chethan et al [3, 5]. In present study the oval shape (33.33%) is the most frequent type followed by, Tetragonal (25.33%), pentagonal (13.33%), egg (9.33%), round and hexagonal (8.0%) and irregular

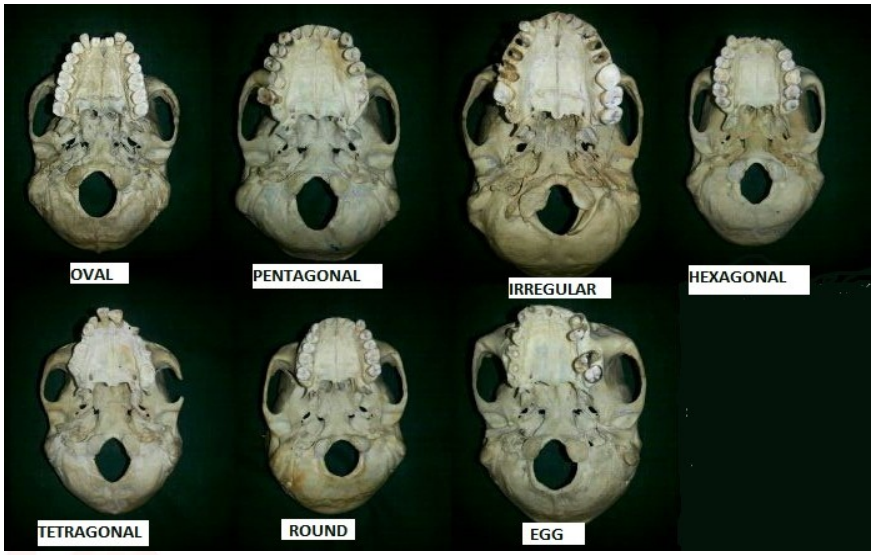

Fig. 1: Showing various morphological types of foramen magnum.

(2.67%) in shape. The difference in shapes of the FM from various studies indicates the racial variability among the morphology. The present study agrees with Zaidi and Dayal, Radhakrishna et al. and Radhakrishnan et al., as these all studies the oval shape is the most frequent type [1, 13, 14].

In 2 (2.67%) cases, the occipital condyles were protruded into the FM. This type of morphology can lead to compression of structures passing through the FM. So, the variation in the FM should be taken into the consideration during the clinical and radiological diagnostic procedure and the surgical approach.

Although the oval and round shape morphological types of FM are most common found, other types with their respective frequencies of occurrence have been described by some authors in Table 3.

The anatomic diameters have been reported to be about 35mm for sagittal diameter and 30mm for transverse diameter. The data obtained from present study was compared with other studies represented in Table 4. The radiologic values obtained by Murshed et al. were 35.9 +/- 3.3mm for sagittal diameter and 30.4+/-2.6mm for transverse diameter [3]. Similar data obtained by Radhakrishnan et al., which was 35.76+/-2.38mm for sagittal diameter and 29.79+/-2.85mm for transverse diameter [14]. The values of present study are almost similar with this both studies. The value reported by tubs et al. and chethan et al., 31mm and 31+/-2.4mm for sagittal diameter and 29.79+/-2.85mm and 25.2+/-2.4mm for transverse diameter respectively [5, 15], which were lesser than the present study. Testut and Laterjet stated that longer FM antero-posterior dimensions permitted greater contralateral surgical exposure for condylar resection [16].

Table 3: Other morphological type of FM and frequencies.

Shape of FM	Zaidi and Dayal 1988 [13]	Chethan et al. 2012 [5]	Radhakrishna et al. 2012 [1]	Radhakrishnan et al. 2012 [14]	Present study
Oval	64	15.10%	39	35.2	33.33
Round	0.5	22.60%	28	7.6	8
Egg	-	18.90%	-	-	9.33
Irregular	3.5	15.10%	-	11.6	2.67
Tetragonal	-	18.90%	19	6.8	25.33
Pentagonal	7.5	3.80%	14	12.4	13.33
Hexagonal	24.5	5.60%	-	24.8	8

Table 4: Comparison of morphometric values of FM with previous reports.

Authors	Antero-posterior diameter(mm)	Transverse diameter (mm)
Murshed et al. 2013 [3]	35.9+/-3.3	30.4+/-2.6
Tubbs et al. 2010 [15]	31	27
Chethan et al. 2012 [5]	31+/-2.4	25.2+/-2.4
Radhakrishnan et al. 2012 [1]	35.76+/-3.4	29.79+/-2.85

CONCLUSION

In the present study, the oval and tetragonal shaped of FM are predominated. The present study revealed the morphometric data and the

variations in the morphology of the FM. These morphological characteristics have medicolegal importance and helpful in the identification of unknown individuals. Though the present study has a limitation as the exact age and sexes of skull were not determined, this study may provide an important reference and the measurements may be used as a data for the description of normal morphological variants of FM. Since the anatomy of the FM is of interest to many fields of medicine due to increased application of CT and MRI scans, this investigation was undertaken. We believe that the data obtained from the present study will be of useful to the neurosurgeons and is also certainly helpful to the anthropologists, morphologists and clinical anatomists.

Conflicts of Interests: None

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