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

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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±2.32mm. The mean transverse diameter was 29.39±1.73mm. The mean area of foramen magnum was 803.8±83.42mm². 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.

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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 formula:\[ A = \frac{1}{4} \pi w h \]

\( w \) = Width, transverse diameter
\( h \) = Height, longitudinal diameter
\( \pi = \frac{22}{7} \), 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±2.32mm. The maximum antero-posterior diameter was 40.11mm and minimum anteroposterior diameter was 30.14mm. The mean transverse diameter was 29.39±1.73mm. The maximum transverse diameter was 32.39mm and minimum transverse diameter was 25.04mm. The mean area of foramen magnum was 803.8±83.42cmm. 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.
Sampada P K, Poornima B, Mallikarjun M, Santosh B Sakri. MORPHOMETRIC AND MORPHOLOGICAL STUDY OF FORAMEN MAGNUM IN DRIED HUMAN SKULL BONES.

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

Fig. 4: Showing various shapes of foramen magnum.

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±2.32mm and the mean transverse diameter was 29.39±1.73mm. 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±83.42mm². 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 820.53mm². A study done by Shika et al [23] on 50 dried skulls, the mean area of foramen magnum was 970.57mm². 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.

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<tr>
<td>Oval</td>
<td>90 (9.1%)</td>
<td>93 (9.3%)</td>
<td>91 (9.1%)</td>
<td>80 (8.0%)</td>
<td>130 (10.0%)</td>
<td>158 (15.8%)</td>
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<tr>
<td>Round</td>
<td>76 (7.3%)</td>
<td>---</td>
<td>103 (10.3%)</td>
<td>120 (12.0%)</td>
<td>70 (7.0%)</td>
<td>99 (9.9%)</td>
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<tr>
<td>Egg</td>
<td>242 (23.8%)</td>
<td>260 (26.0%)</td>
<td>222 (22.2%)</td>
<td>302 (30.2%)</td>
<td>---</td>
<td>122 (11.1%)</td>
</tr>
<tr>
<td>Tetragonal</td>
<td>14 (1.2%)</td>
<td>15 (1.5%)</td>
<td>10 (1.0%)</td>
<td>9 (0.9%)</td>
<td>---</td>
<td>8 (0.8%)</td>
</tr>
<tr>
<td>Pentagonal</td>
<td>19 (1.8%)</td>
<td>14 (1.4%)</td>
<td>23 (2.3%)</td>
<td>32 (3.2%)</td>
<td>---</td>
<td>11 (1.1%)</td>
</tr>
<tr>
<td>Hexagonal</td>
<td>19 (1.7%)</td>
<td>---</td>
<td>35 (3.5%)</td>
<td>96 (9.6%)</td>
<td>38 (3.8%)</td>
<td>35 (3.5%)</td>
</tr>
<tr>
<td>Irregular</td>
<td>22 (2.1%)</td>
<td>---</td>
<td>15 (1.5%)</td>
<td>24 (2.4%)</td>
<td>62 (5.2%)</td>
<td>109 (10.9%)</td>
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</table>

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

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