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Original Article

Analysis of morphology of foramen magnum in Indian population

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ARTICLE INFO

Article history:
Received 20 July 2015
Accepted 26 October 2015
Available online 19 November 2015

Keywords:
Foramen magnum
Antero-posterior diameter
Skull base
Anatomical variations

ABSTRACT

Introduction: The foramen magnum is a unique and complex neuroanatomical structure. This is an important landmark of the skull base for neurosurgical procedures. The aim of this study is to analyze the morphometry pertaining to variations of the shapes and sizes of foramen magnum separately for males and females of Indian population along with comparing antero-posterior and transverse diameters available in literature and to bring out associated clinical implications.

Methods: Thirty-five dry skulls (13 females and 22 males) have been examined for morphometric variations of foramen magnum. The surface area of foramen magnum was calculated manually using graphical method. The importance of morphometry and clinical significance of foramen magnum has been established by available literature.

Results: Mean antero-posterior diameter and transverse diameter of foramen magnum are 33.8 ± 02.5 mm and 28.2 ± 02.6 mm, respectively. The minimum, maximum and mean areas of foramen magnum in assorted skulls are 434 mm^2, 902 mm^2 and 648.5 ± 112.2 mm^2, respectively. Foramen magnum index in assorted skulls vary from 1 to 1.45.

Discussion: The dimensions of foramen magnum, separately for males and females in the Indian population, have been analyzed for the first time. This analysis will be of paramount importance for clinicians in surgical procedures around this region.

1. Introduction

The foramen magnum (FM) is mainly an oval-shaped, unique and complex anatomical structure/opening at the skull base surrounded by the basillar, squamous and two lateral parts of the occipital bone.[1–3] It is situated at the junction of atlanto-occipital joint and is responsible for lateral and dextral complex rotational movements of skull and cervical spine. It transmits the weight of skull to cervical spine too. This enhances the importance of FM. Apart from this, a number of vital neuroanatomic structures pass through the FM.[1,4–6] The neural structures include the cerebellar tonsils, inferior vermis, fourth ventricle, caudal aspect of the medulla, lower

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http://dx.doi.org/10.1016/j.jasi.2015.10.005

cranial nerves (9th–12th), rostral aspect of the spinal cord and upper cervical nerves (C-1 and C-2). The 9th through 11th cranial nerves arise as a series of rootlets along the anterior medulla, with the spinal component of the 11th cranial nerve arising midway between the anterior and posterior spinal rootlets of the spinal cord. The spinal accessory rootlets coalesce and ascend rostral to join the 9th, 10th, and the cranial portion of the 11th nerve. Major arterial structures located within the FM include the vertebral artery, posterior inferior cerebellar artery, anterior and posterior spinal arteries and the meningeal branches of the vertebral arteries.[7] This further adds greater importance to the FM. Furthermore, intradural and extradural tumours,[8] common congenital anomalies, such as FM syndrome caused by atlanto-occipital assimilation and basilar invagination,[8,9] and cerebellar tissue herniations, which invaginated into the FM, may lead to neural compression and even death and are the frequently encountered pathological conditions in this region.[6,10]

The studies related to morphometric analysis of antero-posterior diameter (APD) and transverse diameter (TD) of FM showed differences[11–13] and have extremely important neuroanatomic implications, particularly while dealing with congenital and acquired anomalies of cranio-vertebral junction.[1,8,14] This too necessitates the study in geographically diversified area and review of literature.

Anomalies of FM size effects (symptoms of small FM) vary from producing no symptoms to being associated with weakness of all limbs and body, apneic spells, hyperreflexia, hydrocephalus and abnormal somatosensory potentials and/or polysomnograms.[15] These data may also be used as a morphometric database for description of ''normal'' variants of FM morphology. Further consideration of possible factors influencing the variability of human FM size shall be explored in larger and geographically more diverse samples. Because of these issues, it still remains necessary to report geographically diversified morphometric measurements of FM. Dimensions of FM are very important not only to establish the most suitable surgical techniques, but also to obtain useful data for pathology associated with the multidirectional biomechanical movements of skull in relation to cervical spine.[16] Additionally, though a few studies have been carried out to demarcate FM by CT[7,16] for various surgical interventions in this bony region yet more real, geographically diversified dry bone/cadaveric studies are required to clarify and establish exact anatomical definition of FM and its anomalies by morphometric analysis. Therefore, to elucidate the importance of anatomic variations in morphology of FM extending geographical region and associated clinical implications, a study has been carried out in Indian dry bones and available literature has been reviewed to bring out the importance of FM.

2. Material and methods

The dry bone study of FM was carried out on the subjects consisting of 13 Female and 22 Male, totalling to 35 Indian skulls. The skulls were classified into male and female based on standard criteria for differentiating dry skulls. The APD and TD (Fig. 1) were measured by Vernier callipers.

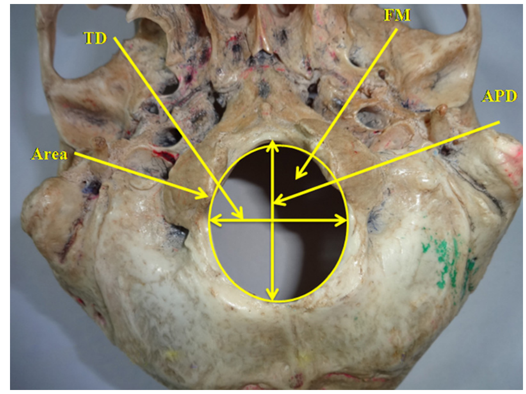

Fig. 1 – Various observed parameters. APD – antero-posterior diameter; TD – transverse diameter; FM – foramen magnum.

The FM index (FMI) was calculated based on the formula, FMI = APD/TD.[17] The surface area (SA) of FM was calculated manually using graphical method. The shapes of FM were sketched on a paper, which was placed below transparent centimetre/millimetre graph paper, and millimetre squares were counted manually by two observers separately to nullify errors in counting. Different shapes of FM were observed. Statistical analysis was also carried out.

3. Results

Mean APD and TD are 33.8 ± 02.5 and 28.2 ± 02.6, respectively. The morphometry consisting of APD, TD, Magnum Index, Area computed by graphical method and statistical analysis of these parameters of FM of assorted sex, male and female have been displayed in Table 1A, 1B, and 1C, respectively.

The minimum, maximum and mean SAs in assorted skull are 434, 902 and 648.5 ± 112.2, respectively. Range and mean of SA in males are 569–902 and 701.6 ± 100.7 and these values in females are 434–687 and 558.7 ± 63.4, respectively. Ranges of FMI in assorted, male and female skulls are 1–1.45, 1–1.44 and 1.15–1.45, respectively. The most frequent FMs are oval shaped, 30 numbers, constituting 85.7% (Fig. 3). 3FMs (8.5%) have circular shape (Fig. 2) and the rest, 2 FMs (5.8%), are found irregular.

Table 1A – The statistics and measurement of FM of Indian males and females combined.

Statistics/ Parameters	APD (mm)	TD (mm)	MI	SA-G (mm^2)
Range	30–40	22–33	1–1.45	434–902
Mean	33.8	28.2	1.21	648.5
Standard deviation	2.5	2.6	0.11	112.2
Mode	34	30	1	569
Median	35	28	1.21	633