STUDY OF MORPHOMETRIC ANALYSIS OF FORAMEN MAGNUM IN DRY HUMAN SKULL AT SMS MEDICAL COLLEGE, JAIPUR, RAJASTHAN

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Abstract

Background: The present study was conducted for analysis of the morphometry shape and determination of sex by foramen Magnum.

Methods: After applying inclusion and exclusion criteria 30 dried human skull of unknown age and sex were selected for present study from the Department of anatomy, S.M.S. Medical College, Jaipur, Rajasthan. In case of skull bones, all 30 cranial bases were visually assessed for FM shape classification. Each FM shape was classified into one of the 8 types: oval, egg, round, tetragonal, pentagonal, hexagonal, combination of 2 different semicircles and irregular.

Results: The mean anteroposterior diameter of foramen magnum male and female skull bones were found to be 37.17 ± 1.76 mm and 33.92 ± 3.50 mm respectively. The mean transverse diameter of foramen magnum in male and female skull bones were found to be 29.49 ± 2.68 mm and 29.38 ± 2.47 mm respectively. The mean area of foramen magnum male and female skull bones were found to be 818.05 ± 119.66 mm² and 847.57 ± 105.85 mm² respectively. The mean index of foramen magnum in male and female skull bones were found to be 84.00 ± 5.41 and 80.27 ± 5.79 respectively. Overall skull bones showed a medium type of foramen magnum index.

Conclusion: We concluded that the several anatomic parameters such as shape and dimensions of foramen magnum should be taken into consideration during surgery involving the craniovertebral junction. Also these can be used during forensic and anthropological investigation of unknown individuals for determining gender, ethnicity, etc

Keywords: Skull, foramen magnum, skull.

Introduction

The anatomy of cranium is of great importance for clinicians as some vital structures pass through the foramen magnum. Foramen magnum is situated in the cranial base and formed by occipital bone mainly and when we see the floor of skull it is situated in the the posterior cranial fossa. It is oval in shape, wide posteriorly and narrow anteriorly and in its superior & inferior relations there are posterior cranial fossa & vertebral canal respectively. It is situated at the level of mastoid process side by side. Just outside of foramen magnum there is presence of tubercle of occipital condyles attached to alar ligament of the dens.¹

Morphology of foramen Magnum is used in forensic identification determination of gender as well as applied anatomy in severe injuries and roadside accidents. In the compression of spinal cord and other structures related to foramen Magnum there is chances of respiratory complications cranial nerve paralysis and paralysis of upper and lower limbs.²

Morphology of foramen Magnum can also be used in surgery is related to the the posterior cranial fossa in which the approach is by foramen in Magnum. In the cases of archaeological and forensic studies foramen Magnum can be used as a identification of sex when human skeletal remains found.³

The present study was conducted for analysis of the morphometry shape and determination of sex by foramen Magnum.

Material and methods

Study place: Department of Anatomy, S.M.S. Medical College and Attached Hospitals, Jaipur, Rajasthan.

Study duration: probable duration of study will be about 1 month from approval for institutional ethics committee.

Study design: Cross- sectional study

Study type: Descriptive type of observational study.

Sample size:- Sample size was calculated at 95% confidence level and α -error of assuming standard deviation of Antero-posterior and Transverse diameter of foramen magnum as per result of seed article : Anil kumar , Mitesh Dave, Sanam Anwar ; Morphometric Evaluation of foramen magnum in dry human skull IJAR 2015 : 10:16965.

Method

After applying inclusion and exclusion criteria 30 dried human skull of unknown age and sex were selected for present study from the Department of anatomy, S.M.S. Medical College, Jaipur, Rajasthan. In case of skull bones, all 30 cranial bases were visually assessed for FM shape classification. Each FM shape was classified into one of the 8 types: oval, egg, round, tetragonal, pentagonal, hexagonal, combination of 2 different semicircles and irregular.

The maximum anteroposterior diameter (APD) was measured from the basion (the midpoint of the anterior margin of the FM) to the opisthion (the midpoint of the posterior margin of the FM). The maximum transverse diameter (TD) was measured between the lateral margins of the FM at the point of greatest lateral curvature. The APD and TD were measured with vernier sliding calipers. The circumference (C) was measured by pressing a narrow strip of paper along the inner margin of the FM; the paper strip was then unrolled and measured with sliding calipers. All measurements were recorded to an accuracy of 0.1 mm.

Statistical Analysis

Statistical analysis was performed with the SPSS, version for windows statistical software package (SPSS inc., Chicago, IL, USA). The quantitative data was presented as mean and standard deviation and were compared by student t-test. The student t- test was used to determine wheather there was a statistical difference between left and right side in the parameter measured. The categorical data was presented as(numbers and percentage) and were compared among groups using Chi-square test. In all entire above test the “ P ” value of less than 0.05 was accepted as indicating statistical significant

Observation and Result

The total of 30 dry human skulls used for present study. The statistical analysis was carried out and the obtained

results of various parameters have been comapared in tables and histograms accordingly. Following results were obtained –

Table 1: Morphological types of foramen magnum

Types of foramen magnum	Present Study
Oval	10 (33.33%)
Round	7 (3.33%)
Tetragonal	9 (30%)
Hexagonal	3 (10%)
Irregular	1 (3.33%)

The 5 different shape of foramen magnum were studied in 30 skull bones. They are: oval, round, tetragonal, hexagonal and irregular. Oval shape (33.33%) was the most common type and irregular (3.33%) was the least common type.

The mean anteroposterior diameter of foramen magnum in male skull bone was found to be 37.17 ± 1.76 mm, where as in case of female skull bones, it was 33.92 ± 3.50 mm.

The mean transverse diameter of foramen magnum in male skull bones was found to be 29.49 ± 2.68 , where as in case of female skull bones, it was 29.38 ± 2.47 mm.

The mean area of foramen magnum in male skull bones was found to be $818.05 \pm 119.66 \text{mm}^2$, where as in case of female skull bones, it was $847.57 \pm 105.85 \text{mm}^2$.

The mean index of foramen magnum in male skull bones was found to be 84.00 ± 5.41 , where as in case of female skull bones, it was 80.27 ± 5.79 .

Table 2: Descriptive statistics: Dimensions, Area and index of the foramen magnum.

Parameter	Males			Females		
	Range		Mean $\pm$ S.D	Range		Mean $\pm$ S.D
	minimum	maximum		Minimum	Maximum	
Transverse Diameter (mm)	22.62	35.06	29.49 ± 2.68	25.23	34.11	29.38 ± 2.47
Anteroposterior diameter (mm)	34.24	40.40	37.17 ± 1.76	27.51	37.98	33.92 ± 3.50
Foramen magnum Area (mm ²)	488.93	982.33	818.05 ± 119.66	667.82	1000.56	847.57 ± 105.85
Foramen magnum index	74.62	98.31	84.00 ± 5.41	70.18	90.91	80.27 ± 5.79

Table 3: Mean difference in dimensions, area and index of foramen magnum across gender.

Parameter	Male (N=16)		Female (N=14)		P value
	Mean	S.E.	Mean	S.E.	
Transverse diameter (mm)	29.49	2.68	29.38	2.47	0.905 (NS)
Anteroposterior diameter (mm)	37.17	1.76	33.92	3.50	0.002 (S)
Foramen magnum Area (mm ²)	818.05	119.66	847.57	105.85	0.482 (NS)
Foramen magnum index	84.00	5.41	80.27	5.79	0.079 (NS)

S = Significant; NS = Non significant

Discussion

Foramen magnum is one of the primary centres of ossification on the cranial base during growth and development and is located inferior to the sagittal suture on the cranial base. Characteristics of foramen magnum and cranial base have identifying features for sexing.⁴

Sex determination is one of the important components of biological profile One of the common ways to determine sex is by using the size of the bones; males tend to have larger bones than females. Males also tend to have larger areas for muscle attachment. The cranium or skull is a useful bone for sex determination. Sex determination is

possible only with adolescent or adult skeletons because there is not much sexual dimorphism in preadolescent children. There is little difference between the skulls of male and female until puberty. Sex is mainly influenced by the hormones where by sexual differences manifest in many tissues, including bone. It is the tissue, which is responsible to dictate the basis of sex difference. It reflects in the development of male and female skeletons.⁵

The gender differences in the human cranium are unique to each population and may be influenced by genetic, environmental and socio-economic factors. Sexual dimorphism is population specific and discriminant

functions applied to cases other than source population used to develop these functions has shown incorrect classification percentages between 32% and 48%. It is therefore necessary to study its expression in as many geographically and temporally diverse populations as possible.⁶

Many authors have reported the usefulness of the FM in gender estimation. But the data compiled for a certain population cannot be employed for determining sex in another population.⁷

Population differences are important in defining the sexual differences in the cranium. Therefore, it is necessary to know the source population of any unidentified skull and choose a method based on data from the population or a population with similar expression of sexual dimorphism.⁶

The base of the cranium is very interesting to study the diameters of the foramen magnum, from a descriptive and topographic point of view due to the important relation of the foramen magnum with its contents. The radiologic and anatomic values of the foramen magnum have been the objective of several studies. While the anatomic values obtained by different authors are almost the same, this does not happen with radiologic values.¹

Foramen magnum is of specific interest to many fields of medicine. Variations of the shape of the foramen magnum have got clinical, diagnostic, and radiological importance. The dimensions of foramen magnum have clinical importance because the vital structures passing through it may suffer compression as in cases of achondroplasia.⁷

Table 4: comparison of morphological types of foramen magnum and frequency of occurrence with previous studies.

Types of foramen magnum	Mueshad et al ⁸	Radhakrishna et al ⁹	p.chethan et al ¹⁰	Present study
Oval	9 (8.1%)	39 (39%)	8 (15.1%)	10 (33.33%)
Round	24 (21.8%)	28 (28%)	12 (22.6%)	7 (3.3%)
Tetragonal	14 (12.7%)	19 (19%)	10 (18.9%)	9 (30%)
Hexagonal	19 (17.2%)	-	3 (5.6%)	3 (10%)
Irregular	22 (19.9%)	-	8 (15.1%)	1 (3.33%)

Development of a particular shape of the foramen magnum is explained on the basis of the embryological data. It may be caused by ossification of primordial cranial residues, which join the endochondral ossification points in different locations, resulting in various shapes. Irregular shape of foramen magnum is intensify by the developmental anomalies of the bone and soft tissues at the craniovertebral junction.⁶

In ovoid type, the ability of the surgeon to suitably expose the anterior portion of the foramen magnum might be difficult. Protrusion of the occipital condyle into foramen magnum may indicate more ample bony removal during

surgery.⁴ Several anatomical parameters such as , size, shape and orientation of the foramen magnum should be taken into consideration during surgery involving the lateral and posterior craniovertebral junction. The quantitative data may be useful in planning the degree of bone work required for optimum exposure and minimization of the risks of morbidity.⁷

Generally, the anteroposterior diameter is greater than the transverse diameter. This is consistent with the normal oval shape of the FM. The authors concluded that the approach becomes easier in case of round, oval and hexagonal shapes, because the working space will be more for surgical approaches in these shapes. It becomes difficult in case of tetragonal, pentagonal and egg shape FM, with narrow posterior margin.

In head and neck head posture is essential in understanding features of the cervical vertebrae and the function of the cranial base. Flexion is a result of the expansion of the cranial base, which is directly responsible for the expansion of the foramen magnum. The expansion of the foramen magnum causes the first two cervical vertebrae to prolonging and allow for increased flexion. All side of the cranial base and cervical vertebrae work together to allow for greater upright head posture. The increased nutritional quantity and quality, over the last hundred years perhaps

contributed to the increase in the cranial vault size, thus resulting in the lengthening of the foramen magnum.¹¹

In the following section, the anteroposterior and transverse diameter of FM in the present study is compared with that of other studies and the results are tabulated and also represented as bar diagrams when required.

Table 5: comparison of foramen magnum dimensions in various studies.

Authors and years	Anteroposterior diameter (mm)	Transverse diameter (mm)
Murshed et al [2003]	35.9	30.45
Chetan et al [2011]	31	25.2
Radhakrishna et al [2012]	34.04	28.63
Present study	37.17	29.49

In the present study, mean anteroposterior diameter of foramen magnum in 30 skull was found to be 37.17 mm, range being 34 – 40 mm and the standard deviation of 1.76. the mean transverse diameter of foramen magnum was 29.49mm, with the range being 22-35mm and standard deviation of 2.68.

In the present study, the result coincide with the above mentioned studies. From the above data, it can be stated that there is significant difference between anteroposterior and transverse diameters, the anteroposterior diameter is generally larger than transverse diameter. Narrowing as well as widening of foramen magnum is important. The stenosis of the craniovertebral canal may result from

congenital underdevelopment or deformity of the skull base. Foramen magnum is small in all individuals with achondroplasia.⁵⁴ This is because markedly diminished growth as a result of abnormal endochondral bone growth and premature fusion of the synchondroses.

The area of foramen magnum of the present study will be compared with that of other studies and the results are tabulated.

In this study, the mean area of foramen magnum in females than males. findings showed statistically significant differences exist between the areas estimated using formula derived by radinsky.

In present study mean foramen magnum area was found to be 818.05mm², with range being minimum 488.93 to maximum 982.33 with standard deviation of 119.66.

Table 6: comparison of area of foramen magnum in various studies.

Authors and years	Foramen magnum area (mm ²)
Murshad et al [2003]	931.7
Raghavendra et al [2012]	811.67
Present study	818.05

Anil kumar et al. Calculated foramen magnum index by dividing anteroposterior length of foramen magnum with the width.

In present study mean foramen index was found to be 84.00 mm with range being minimum 74.62 to maximum being 98.31 with standard deviation of 5.41.

The morphological variations and shape of foramen magnum are important in neurological interpretation. In an ovoid type of foramen magnum, the capability of the surgeon to appropriately expose the anterior portion of the foramen magnum might be difficult.

Conclusion

We concluded that the several anatomic parameters such as shape and dimensions of foramen magnum should be taken into consideration during surgery involving the craniovertebral junction. Also these can be used during forensic and anthropological investigation of unknown individuals for determining gender, ethnicity, etc.

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