

STUDY ON THE MORPHOMETRIC ANALYSIS OF THE FORAMEN MAGNUM AS AN INDICATOR FOR SEX DETERMINATION

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ABSTRACT

Introduction: Foramen Magnum is the largest foramen in the base of the skull which gives passage to vital structures such as medulla oblongata continues as spinal cord along with meninges, spinal arteries, vertebral arteries and spinal accessory nerve. The present study was carried out to determine the sex of the skull based on the morphometric analysis of foramen magnum.

Materials and Methods: The present study was carried out on 100 dry adult human skulls of which 57 were male and 43 female. The anteroposterior diameter and the transverse diameters of foramen magnum were measured with a vernier caliper and the readings were recorded for all male and female skulls separately. The index of the foramen magnum, the circumference of the foramen magnum & surface area of the foramen magnum were calculated.

Results: The incidence of oval, round, tetragonal and pentagonal shapes of foramen magnum was 45%, 29%, 14%, and 12% respectively. The average anteroposterior diameter was 36.7mm in males and 32.1mm in females. The average transverse diameter was 29.7mm in males and 26.1mm in females. Statistically, a significant difference was observed between male and female skulls.

Conclusion: With the results of the present study the Foramen Magnum can also be considered along with the other parameters of the skull for sex determination of the human skulls in forensic analysis of medico-legal cases or in anthropological studies.

KEY WORDS: Morphometry, Skull Base, Foramen Magnum, Sex Determination, Forensic Analysis.

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INTRODUCTION

The foramen magnum is the largest opening in the base of the skull. It gives passage to the lower end of the medulla oblongata which continues down as spinal cord along with the

meninges, the vertebral arteries, and spinal accessory nerves [1]. The morphometric analysis of the foramen magnum is clinically important as the vital structures are passing through it. Meningioma, Arnold-Chiari syndrome,

herniation of foramen magnum, achondroplasia may lead to the compression of the structures passing through it and requires surgical corrections [2-4]. Increase the intracranial pressure forces the brain stem through the foramen magnum leads to compress the nerves and vessels. Ischemia of the medulla oblongata causes anoxia of vital centers resulting in sudden cause of death [5].

The morphometry of neurocranium and viscerocranium were most often used for the estimation of age, stature, ethnicity as it plays an important role in the forensic investigation and anthropological examinations of unidentified individuals [6,7]. The skull is the second best choice of the skeleton for sex determination [8].

Mostly the craniofacial skeletal structures are injured or damaged after air accidents, mass disasters, fire, explosion, or injuries resulting from violence making it difficult to determine the gender and the identification of the individual [9]. When there was a fire, explosion, severe destruction, severe trauma to the other parts of the skull, the morphometric analysis of foramen magnum could be used to assist in determining the gender as the skull base is covered by a large mass of soft tissues which preserves the region of the foramen magnum [10]. The determination of sex in human skulls is based on morphological differences is mainly influenced by genetic factors rather than nutrition, hormones, or muscles [11]. The present study was carried out to determine the sexual dimorphism in foramen magnum by morphometric analysis which would be of great value to the forensic and anthropological investigators and also helpful while performing surgical procedures through the foramen magnum.

MATERIALS AND METHODS

The present study was a cross-sectional study consisting of 100 adult human skulls. Among that 57 were male and 43 were female skulls. The shapes of the foramen magnum were observed and recorded. The observed shapes were oval, round, Tetragonal, Pentagonal, Hexagonal, irregular A and irregular B. the incidence of each shape was recorded and photographs were taken. The anteroposterior and transverse diameters of the foramen magnum were measured

by using vernier calipers. The anteroposterior diameter of foramen magnum was measured from anterior border (basion) through the centre of foramen magnum to the posterior end of the border. The transverse diameter was measured from maximum concavity on right & left margins of the foramen magnum. The circumferences were measured by placing a thread around inner margin of the foramen magnum and transferred the thread to a measuring scale to take the readings.

Fig. 1: Showing the anteroposterior diameter of foramen magnum measuring with vernier calipers.



Fig. 2: Showing the transverse diameter of foramen magnum.



RESULTS

The shape of the foramen magnum was observed in all the 100 skulls and recorded. The most common shape was oval and the least common was the pentagonal shape. The incidence of oval, round, tetragonal and pentagonal was 45%, 29%, 14%, and 12% respectively (Figure 3 & 4). The incidence of each shape gender wise

was tabulated in Table 1.

Table 1: Showing the gender wise distribution of the shapes of the foramen magnum.

Gender	Shape				Total
	Oval	Round	Tetragonal	Pentagonal	
Males	26	16	8	7	57
Females	19	13	6	5	43
Total	45	29	14	12	100

Fig. 3: Pie chart showing the incidence of the shapes of the Foramen Magnum.

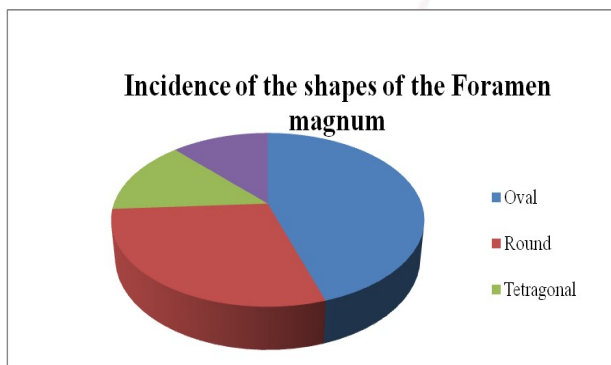
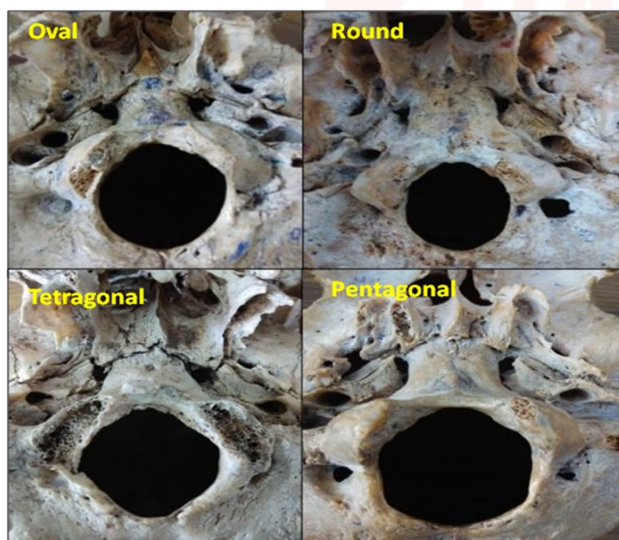


Fig. 4: Showing the shapes of the foramen magnum.



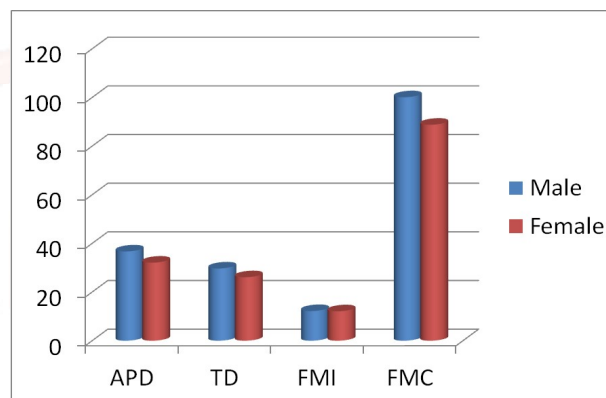
The average anteroposterior diameter was 36.7mm in males and 32.1mm in females. The average transverse diameter was 29.7mm in males and 26.1mm in females. The foramen magnum index was calculated from the anteroposterior and the transverse diameters and the average index was reported as 12.2mm in males and 12.1mm in females. The circumference was measured with a thread placing along the margins of the foramen and the average circumference of foramen magnum was reported as 100.1mm² in males and 88.01mm² in females. The surface area in male and female skulls was 1089.99mm² and 837.81mm² respectively. A

statistical tool “student test” was performed to know the level of significance at 95% confidence interval. Statistically, a significant difference was observed between male and female skulls as the p-value was less than 0.05 for all the parameters (Table 2, Figure 5).

Table 2: Showing the statistics of the morphometric analysis of the foramen magnum.

Parameter	t – value	P value
Anteroposterior diameter (APD)	13.6	0.0001
Transverse diameter (TD)	5.72	0.0001
Circumference of the foramen magnum (FMC)	5.75	0.0001
Index of the foramen magnum (FMI)	1.79	0.037
Surface area of the foramen magnum (FMSA)	9.38	0.0001

Fig. 5: Showing the gender difference in the morphometric values of the foramen magnum.



DISCUSSION

Gender determination in human skulls is based on morphological features especially the size, shape, and strength of certain structures which may also show ethnic variation in each population group which are influenced by certain factors like genes, environment and socioeconomic status.^{12, 13}

The oval shape of the foramen magnum was predominant in the present study which is similar to the other Indian studies by Radhakrishna S et al., and Sampada PK et al., Development of a particular shape of the foramen magnum is based on the ossification of primordial cranial residues, which later join the endochondral ossification points in different locations may result in various shapes.^{14,15,16}

In the present study all the parameters anteroposterior diameter, transverse diameter, circumference, surface area and index of the foramen magnum were showing sexual dimorphism with great significance, but in a Brazilian

study, the anteroposterior diameter was not showing any significant difference between male and female skulls.¹⁷ The average anteroposterior diameter of the foramen magnum of male skulls was higher than the other two Indian studies by Arpan et al., (Madhya Pradesh Population) and Routal Pal et al., (Gujarat Population), but the average anteroposterior diameter of female skulls of the present study was similar to these studies.^{18,19} The results of the present study were compared with other studies of different ethnicity (Table 3).

Table 3: Comparison of the anteroposterior and transverse diameters of the foramen magnum.

Author/ Ethnicity	Gender	Anteroposterior diameter	Transverse diameter
Manoel C et al., (2009) Brazilian [17]	Male	35.7 ± 0.29	30.3 ± 0.20
	Female	35.1 ± 0.33	29.4 ± 0.23
Murshed et al., (2003) Turkish [2]	Male	37.2 ± 3.43	31.6 ± 2.99
	Female	34.6 ± 3.16	29.3 ± 2.19
Herrera et al., (1987) Spanish [20]	Male	36.2 ± 0.3	31.1 ± 0.3
	Female	34.30 ± 0	29.6 ± 0.3
Gapert et al., (2008) British [10]	Male	35.91 ± 2.41	30.51 ± 1.77
	Female	34.71 ± 1.91	29.36 ± 1.96
Routal Pal, et al., (1984) Gujarat [19]	Male	35.5 ± 2.8	29.6 ± 1.9
	Female	32.0 ± 2.8	27.1 ± 1.6
Arpun Dubay et al., (2017) Madhya Pradesh [18]	Male	33.4 ± 2.6	28.5 ± 2.2
	Female	33.1 ± 2.7	27.3 ± 2.0
Present study Telangana	Male	36.7 ± 0.20	29.7 ± 0.27
	Female	32.1 ± 0.09	26.1 ± 0.22

The anteroposterior diameter of females was much lower than the all other ethnic groups. The anteroposterior diameter of males was higher than the Brazilian, Spanish, British, Gujarat region of India and Madhya Pradesh of India and lower than the Turkish population. The transverse diameter of males was similar with all the other ethnic population groups, but the females were little smaller than all the other studies [2,10,17-20].

The circumference of the foramen magnum in the present study in males and females was 100.1mm² and 88.8mm² respectively. The circumference of the male population of the present study was higher than the Iraq population Herrera reported as 99.3mm², whereas the female population of the present study shows much lower than the Iraq population which was 92.6mm² [21]. The studies done on the circumference of foramen magnum was very limited. So could not compare with other ethnic populations.

The surface area of the foramen magnum in the

present study was in males and females were 1089.99mm² and 837.81mm² respectively which were slightly higher than the Spanish and Turkish populations. In the Spanish population, the surface area of the males and females were 888.4mm² and 801.0mm² respectively whereas in Turkish population the males and females were 909.91mm² and 819.01mm² respectively.^{2,20} The surface area of the foramen magnum in the Iraq population it was much lower than the present study where it was 765.2mm² in males and 670.2mm² in females [21]. Thus, the morphometry of the foramen magnum shows sexual dimorphism and the ethnic variance.

CONCLUSION

In the present study anteroposterior diameter, transverse diameter, circumference, surface area and Index shows sexual dimorphism. With the results of the present study, the morphometric analysis could be considered for sex determination in forensic and or anthropological analysis where the other parts of the craniofacial skeleton are severely damaged as the foramen magnum is protected by rich soft tissue and could be available in most of the mass disasters.

Conflicts of Interests: None

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