



Morphological Types of Foramen Magnum

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Authors' contributions

This work was carried out in collaboration between all authors. Author JAA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors ROP and RZCM managed the analyses of the study. Author FPR co-designed the study, managed the literature search and proof read the first draft manuscript. All authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

Introduction: The foramen magnum (FM) is a unique and complex anatomical area located in the central basal region of the occipital bone. It is a three-dimensional opening through which vital structures pass, such as the medulla oblongata and its membranes, the spinal accessory nerve, the vertebral arteries, the anterior and posterior spinal arteries, the tectorial membrane and the alar ligaments. Because of this vital relationship between the FM and its content, it is of great importance to study the morphological types of FM. Findings from such evaluations have essential applications in clinical practice and in surgery.

Objective: To determine the incidence of different morphological types of FM.

Materials and Methods: 110 FM from dry human crania of known sex and age were analyzed. The specimens belong to the anatomical collections of Tiradentes University (UNIT) and the Metropolitan University of Education and Culture (UNIME). Among these, 66 were male, 44 were female and their ages ranged from 11 to 91 years (mean: 58.01

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years). FM morphology was studied using photographic images and with the aid of Corel Draw Photo-Paint X5.

Results: Among the 110 FM analyzed, nine morphological types were found: pear-shaped 37.27%, rounded 15.45%, tetragonal 10.91%, biconvex 10.91%, hexagonal 9.09%, oval 5.45%, pentagonal 2.73% and heptagonal 1.82%. In the remaining 6.36% of the FM, it was not possible to define a regular and specific form.

Conclusions: Pear-shaped FM predominated, followed by rounded FM. In relation to sex, the tetragonal and biconvex forms occurred five times more frequently in males than in females, while the hexagonal form occurred twice as frequently in females than in males.

Keywords: Human anatomy; foramen magnum; morphology.

1. INTRODUCTION

The foramen magnum (FM) belongs to a unique and complex anatomical area of the occipital bone that is also one of the primary sites of ossification of the base of the cranium during growth and development [1]. It is a three-dimensional opening in the central region of the base of the occipital bone through which the medulla oblongata and its membranes, the spinal accessory nerve, the vertebral artery and the anterior and posterior spinal arteries pass [2].

The relationship between the FM and its content is of great importance both for clinical practice and for surgery, because of the possibility that compression of the vital structures that pass through the FM might occur. Exposure of this region in cases of intra or extradural lesions that involve the FM and brain stem is a veritable challenge for neurosurgeons, because of the vascular and nerve components that pass through it. 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 [3-7].

The frequencies of different morphological types of FM reported in the literature have been very divergent, with variations reaching 21.8 to 64%. The oval form has been the one most frequently found [1,6-10].

In view of the great discordance in the literature regarding the classification of different morphological types of FM, the present study had the aim of determining the incidence of different morphological types of FM in dry crania from human.

2. MATERIALS AND METHODS

One hundred and ten FM from dry human crania belonging to the anatomical collections of Tiradentes University (UNIT), Aracaju, Sergipe, Brazil and the Metropolitan University of Education and Culture (UNIME), Salvador, Brazil, were analyzed. Among these, 66 were male and 44 were female, and their ages ranged from 11 to 91 years (mean: 58.01 years). Only crania with a complete occipital region that were of known sex and age were included in the sampling process.

The FM were photographed using a digital camera (Sony DSLR-A100K) that was attached to a static support and was positioned at a standardized distance of 20 cm from the object that was to be photographed. The images were digitized and saved in JPEG format (Joint Photographic Experts Group). With the aid of the Corel Photo-Paint X5 software, was then draw the profile of each of the foramen and then determined its classification (Fig.1). The present study was approved by the Research Ethics Committee of the Federal University of Sergipe, under protocol number 0357.0.107.000-11.

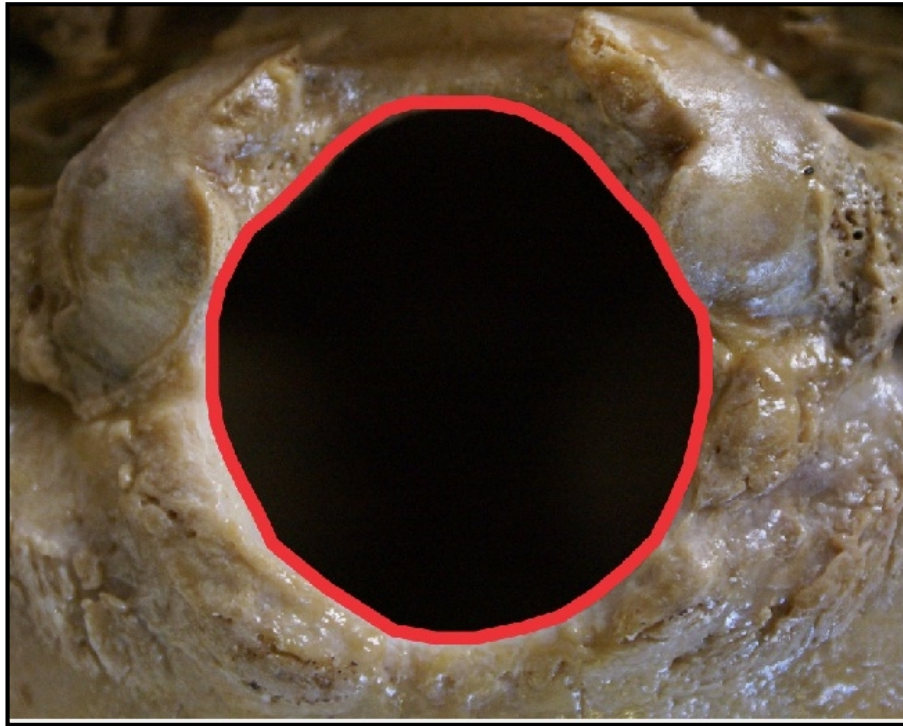


Fig. 1. Image of the outline of the FM, displayed through Corel Photo-Paint X5

3. RESULTS

The morphological types of FM found in the present study are demonstrated in Fig. 2. The incidence of these types had the following frequency of distribution: pear-shaped 37%, rounded 15.45%, tetragonal 10.91%, biconvex 10.91%, hexagonal 9.09%, oval 5.45%, pentagonal 2.73% and heptagonal 1.82%. In the remaining 6.36% of the FM, it was not possible to define a regular and specific shape. The frequency distribution of the different morphological types of FM in relation to sex is presented in Table 1.

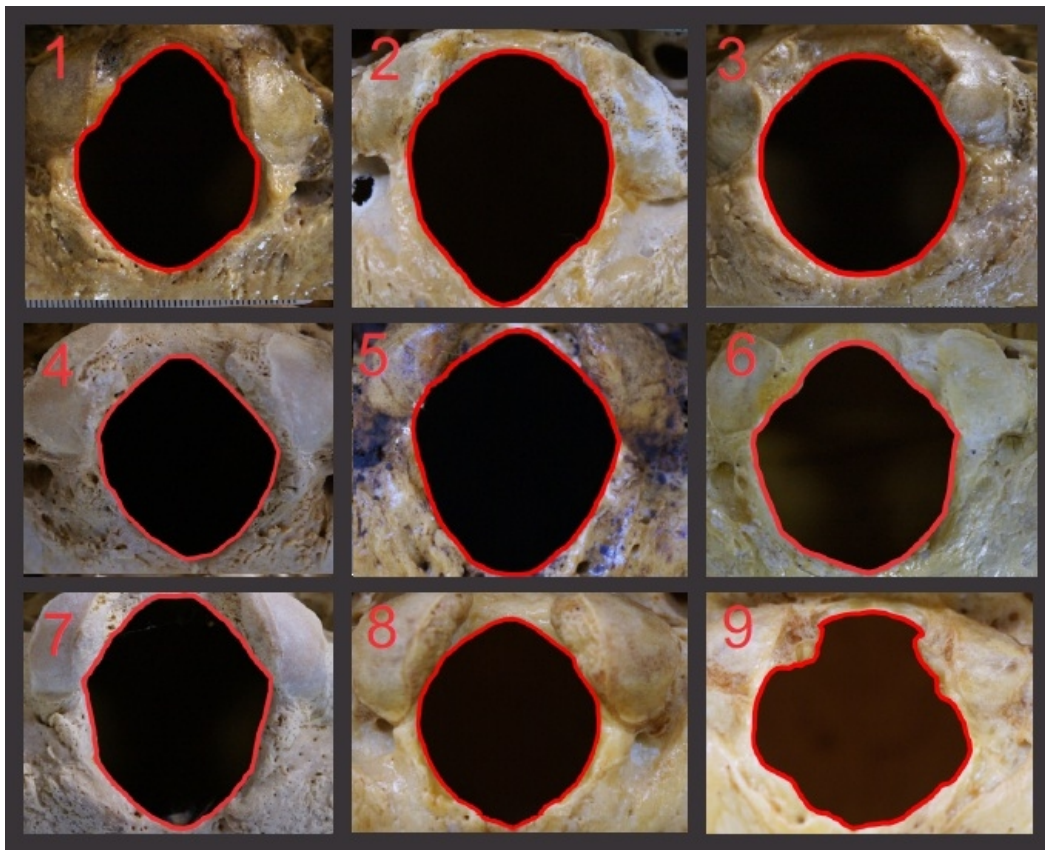


Fig. 2. Morphological types of FM

1) Pear, 2) Oval, 3) Rounded, 4) Tetragonal, 5) Pentagonal, 6) Hexagonal, 7) Heptagonal, 8) Biconvex, 9) Irregular.

Table 1. Frequencies of the different morphological types of FM in relation to sex

Shapes of foramen magnum	Sex					
	Male		Female		Total	
	n	%	n	%	n	%
Pear	20	18.2	21	19.1	41	37.3
Rounded	11	10.0	6	5.5	17	15.5
Tetragonal	10	9.1	2	1.8	12	10.9
Biconvex	10	9.1	2	1.8	12	10.9
Hexagonal	3	2.7	7	6.4	10	9.1
Oval	3	2.7	3	2.7	6	5.5
Pentagonal	3	2.7	0	0	3	2.7
Heptagonal	1	0.9	1	0.9	2	1.8
Irregular	5	4.5	2	1.8	7	6.4
Total	66	60	44	40	110	100

4. DISCUSSION

In both sexes, the visual classification showed that the most frequent morphological types of FM were the pear-shaped, rounded, tetragonal, biconvex and hexagonal shapes. In the literature, there is great discordance regarding the predominant morphological type of FM. Among some authors, the oval shape is considered to be the main type [8,10]. According to Murshed et al. [6], Chethan et al. [11] and Radhakrishna et al. [1], the rounded shape is the main type, while it is the tetragonal shape according to Sindel et al. [9] and the pear shape for Natsis et al. [12].

In the present study, the pear-shaped was the morphological type of FM most frequently found. Natsis et al. [12] reported similar findings from a study on individuals from the Greek population. The Table 2 shows that there is great variation in the morphological types of FM. These variations has been attributed, among some authors, the factors such as sexual dimorphism [2], types of population [11], ethnic groups [10]. Although the oval and rounded morphological types of FM are the ones most frequently found, other types with their respective frequencies of occurrence have been described by some authors [1,6,10-12] in Table 3.

Table 2. Most frequent morphological types of FM in different studies

Studies	Morphological type	Population	%
Zaidi and Dayal [8]	Oval	Indian	64
Sindel et al. [9]	Tetragonal	Turkish	49.42
Murshed et al. [6]	Rounded	Turkish	21.8
Espinoza et al. [10]	Oval	Chilean	45
Chethan et al. [11]	Rounded	Indian	22.6
Avcı et al. [12]	Oval	Turkish	58
Radhakrishna et al. [1]	Oval	Indian	39
Present Study	Pear	Brazilian	37.3

Table 3. Other morphological types of FM and frequencies of occurrence

Authors	n	FM shapes										
		1	2	3	4	5	6	7	8	9	10	11
		%										
Murshed et al. [6]	110	-	21.8	12.7	-	17.2	8.1	13.6	-	6.3	19.9	-
Espinoza et al. [10]	100	-	11	3	-	17	45	7	-	12	5	-
Chethan et al. [11]	53	-	22.6	18.9	-	5.6	15.1	3.8	-	18.9	15.1	-
Radhakrishna et al. [1]	100	-	28	19	-	-	39	14	-	-	-	-
Natsis et al. [12]	143	22.4	1.4	-	25.9	-	14.7	-	-	21	7	14
Present Study	110	37	15.45	10.91	10.91	9.09	5.45	2.73	1.82	-	6.36	-

1. Pear; 2. Rounded; 3. Tetragonal; 4. Biconvex; 5. Hexagonal; 6. Oval; 7. Pentagonal; 8. Heptagonal; 9. Egg; 10. Irregular; 11. Rhomboid

The relevance to clinical and surgical anatomy of the variation in form of FM was highlighted by authors such as Natsis et al. [12]. In this direction, we hope that the present findings might also contribute to the understanding of the meaning of the form of FM, especially in pathology at the level of the craniocervical junction that can lead to obstruction of the brainstem.

5. CONCLUSION

In the present study, the pear-shaped and rounded FM types predominated. Among males, the tetragonal and biconvex types occurred five times more frequently than among females, while the hexagonal type occurred twice as frequently among females than among males.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Radhakrishna S, Shivarama C, Ramakrishna A, Bhagya B. Morphometric analysis of foramen magnum for sex determination in south Indian population. *NUJHS*. 2012;2:20-22.
2. Ukoha U, Egwu O, Okafor I, Anyabolu A, Ndukwe G, Okpala I. Sexual Dimorphism in the Foramen Magnum of Nigerian Adult. *Int J Biol Med Res*. 2011;2(4):878-881.
3. Hecht JT, Horton WA, Reid CS, Pyeritz RE, Chakraborty R. Growth of the foramen magnum in achondroplasia. *Am J Med Genet*. 1989;32(4):528-35.
4. Reich JB, Sierra J, Camp W, Zanzonico P, Deck MD, Plum F. Magnetic resonance imaging measurements and clinical changes accompanying transtentorial and foramen magnum brain herniation. *Ann Neurol*. 1993;33(2):159-70.
5. Ropper AH. Magnetic resonance imaging measurements and clinical changes accompanying transtentorial and foramen magnum brain herniation. *Ann Neurol*. 1993;34(5):748-9.
6. Murshed K, Çiçekcibasi A, Tuncer I, Morphometric Evaluation of the Foramen Magnum and Variations in its Shape: A Study on Computerized Tomographic Images of Normal Adults. *Turk J Med Sci*. 2003;33:301-306.
7. Avci E, Dagtekin A, Ozturk AH, Kara E, Ozturk NC, Uluc K, Akture E, Baskaya MK. Anatomical variations of the foramen magnum, occipital condyle and jugular tubercle. *Turk Neurosurg*. 2011;21(2):181-90.
8. Zaidi SH, Dayal SS. Variations in the shape of foramen magnum in Indian skulls. *AnatAnz Jena*. 1988;167:338-340.
9. SindelM, Özkan O, Uçar Y, Demir S. Foramen Magnum'un Anatomik Varyasyonları. *Akdeniz Üniversitesi Týp Fakültesi Dergisi*. 1989;44(6):97-102.

10. Espinoza E, Ayala C, Ortega L, Collipal E, Silva H, Morfometría tomográfica del foramen magno y su relación con el sexo y la etnia mapuche. *Rev. ANACEM (Impresa)*. 2011;5(1):28-31.
11. Chethan P, Prakash KG, Murlimanju BV, Prashanth KU, Prabhu LV, Saralaya VV, Krishnamurthy A, Somesh MS, Kumar CG. Morphological Analysis and Morphometry of the Foramen Magnum: An Anatomical Investigation. *Turkish Neurosurgery*, 2012;22(4):416-419.
12. Natsis K, Piagkou M, Skotsimara G, Piagkos G, Skandalakis P. A morphometric anatomical and comparative study of the foramen magnum region in a Greek population. *Surg Radiol Anat*. 2013;26.

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