Original research article

Studying the foramen magnum morphometrically and morphologically

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Abstract

Background: The foramen magnum is an elliptical aperture located near the cranial base. The utilisation of the transcondylar technique is progressively growing in order to reach lesions located at the Craniovertebral junction. The objective of the current study was to analyse the morphology and morphometry of the foramen magnum.

Material and Methods: The Department of Anatomy, A.C.S.R. Government Medical College, Nellore and Government Medical College Ongole, Andhra Pradesh, India a collection of 50 adult human dry skulls, along with an additional 50 cranial specimens. The study utilised CT scans sourced from the archives of A.C.S.R. Government Medical College, Nellore. This study was done between January 2021 to December 2023.

Results: Forty percent of the skulls examined had an oval foramen magnum, according to the current study. According to cranial computerised tomography scans, the average anterior pulposus diameter in dry skulls was 35.03±0.95mm, while in dry skulls it was 35.12±2.65mm. In dry skulls, the average transverse diameter of the foramen magnum was 29.03±2.15mm, while in cranial CT, it was 28.79±1.17mm. The average measurement for the distance between the right occipital condyle's posterior margin and the intracranial edge of the right hypoglossal canal was 12.26±0.59mm, while the equivalent measurement for the left hypoglossal canal's posterior margin was 12.25±0.59mm.

Conclusion: In order to better plan and manage skull base surgeries, neurosurgeons will be able to use the acquired data to analyse the architecture of the craniovertebral junction. Radiologists, orthopaedists, anthropologists, morphologists, and clinical anatomists will all find something new and interesting in the results.

Keywords: Foramen magnum, morphometrically, morphologically

Introduction

The foramen magnum, situated in the central basal region of the occipital bone, is the largest osseous foramen. The craniovertebral junction's anterior aspect features the occipital bone, which is linked to both the foramen magnum and the occipital condyles. Symptoms may occur due to the compression of vital structures or the misalignment of bones caused by bony anomalies at the craniovertebral junction. Therefore, it is essential to measure the dimensions of the foramen magnum and occipital condyles [1-3].

The occipital bone comprises a significant portion of the posterior aspect of the cranial base. The foramen magnum is occluded by the inwardly concave trapezoid occipital bone. The structure consists of three distinct sections: the basilar or basioccipital, the squamous, and the two lateral or condylar. The quadrilateral basilar section is located in front of the foramen magnum. The squamous and condylar sections are located next to each other, opposite the foramen magnum. The exoccipital component is an expanded plate. The posterosuperior portion corresponds to the foramen magnum. The back and neck muscles are connected to the occipital bone. The atlanto-occipital joints are located at the point where it connects with the first cervical vertebra [4-6].

The foramen magnum is an unpaired structure that is oval in shape and angled. The anteroposterior diameter of the foramen magnum is greater than its transverse diameter. The occipital condyles exert downward pressure on both sides of the foramen magnum, establishing a connection with the superior articular facets of the atlas and encroaching towards the anterior limit. The anterior and posterior borders of the foramen magnum are the points where the anterior and posterior atlanto occipital membranes connect, respectively. The foramen magnum is surrounded by several structures, including the jugular foramina, bilateral occipital condyles, mastoid notches, hypoglossal canals (anterior condylar canal and posterior condylar canal), and the squamous parts of the occipital bone. The foramen magnum facilitates the exchange of information between the spinal canal and the posterior cerebral fossa [7-9].

The occipital condyles exhibit a reniform or oval morphology, with their elongated axes converging anteriorly and laterally. The medial side of each condyle is equipped with a tubercle that connects to the alar or check ligament. In order to access the basilar section of the bone, the front third of each condyle extends forward. The anterior condylar or hypoglossal canal indicates the point where the basilar and condylar sections meet. The hypoglossal canal serves as a conduit for a meningeal branch of the ascending pharyngeal artery and an emissary vein. The canal is oriented slightly forward and extends laterally. A fossa is located posterior to each condyle. In exceptional cases, the emissary vein might be conveyed through a posterior condylar canal. The third occipital condyle, which is an irregularly formed protuberance, forms a joint with the dens of the axis and protrudes from the anterior margin of the foramen magnum [10-12].

The basilar or basioccipital part, a bar of bone, extends upward and fires forward, connecting the basisphenoid near the foramen magnum. The inside surface of the object is concave, extending from one side to the other. The pons and medulla are upheld by it. The fibrous pharyngeal raphe is connected to the outside surface through the pharyngeal tubercle. The duramater situated in the foramen magnum is supplied with blood by both the anterior and posterior meningeal arteries, which arise from the vertebral artery. The mastoid branch of the occipital artery provides blood to the back part of the foramen magnum [13, 14].

The objective of this study is to assess the occipital condyles and frontal lobes using morphometric and morphological analysis. Neurosurgeons, radiologists, and orthopaedicians ought to utilise the data to enhance the management and preparation of craniovertebral junction treatments prior to surgery.

Materials and Methods

The Department of Anatomy, A.C.S.R. Government Medical College, Nellore, and Government Medical College, Ongole, Andhra Pradesh, India a collection of 50 adult human dry skulls, along with an additional 50 cranial specimens. The study utilised CT scans sourced from the archives of A.C.S.R. Government Medical College, Nellore. This study was done between January 2021 to December 2023.

Inclusion criteria

- Adult human dry skull; no gender identified.
- The tooth of the third molar emerged.
- Clearly delineated cranial sutures.

Exclusion criteria

- Skull anomalies.
- Damaged skulls.

Results

A total of 50 mature desiccated human craniums were examined, and the findings were categorised based on morphological and morphometric characteristics.

Table 1: The percentage of several types of FM in dry cranium

Sr. No.	Myocardial foramen oval	Skulls (50)
1.	Oval	20
2.	Egg shape	11
3.	Round	8
4.	Pentagonal	2
5.	Hexagonal	4
6.	Others	5

Table 1 presents the distribution of different forms of FM in dry cranium, with oval accounting for 20, egg shape for 11 and round for 8, pentagonal for 2, hexagonal for 4, and others for 5.

Table 2: Dry skull FM anteroposterior diameter

Sr. No.	Statistical data	AP diameter of FM in dry skull (mm)
1.	skulls	50
2.	Min.	22.13
3.	Max.	38.24

Table 2 presents the anteroposterior diameter of the dry skull FM, with a minimum value of 22.13 and a maximum value of 38.24, reported as skull (50).

Table 3: Maximum dry skull foramen magnum (FM) transverse diameter

Sr. No.	Statistical data	FM transverse diameter in dry skulls (in mm)

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1.	skulls	50
2.	Min.	22.26
3.	Max.	34.74

Table 3 presents the range of transverse diameter measurements for the foramen magnum (FM) in dry skulls. The minimum measurement recorded was 22.26, while the largest measurement was 34.74.

Table 4: CT scan maximal foramen magnum anteroposterior diameter

Sr. No.	Statistical data	FM AP diameter in CT scan (mm)
1.	Skulls	50
2.	Min.	32.23
3.	Max.	35.66

The anteroposterior diameter of the foramen magnum, as measured by CT scan in Table 4, was reported as 50 for the skull. The minimum measurement was 32.23, while the maximum measurement was 35.66.

Table 5: CT scan maximum foramen magnum transverse diameter

Sr. No.	Statistical data	Transverse diameter of FM in CT scan (in mm)
1.	skulls	50
2.	Min.	26.33
3.	Max.	27.45

Table 5 presents the maximum transverse diameter of the foramen magnum as measured by a CT scan. The reported values for the skull range from a minimum of 26.33 to a high of 27.45.

Discussion

Similar investigations performed in various regions of India and abroad corroborated the results of the current investigation. A comparison was made with other research that demonstrated the FM's shape, and the results were tabulated. The oval form of the FM was the most prevalent. Additionally, 40% of the FM was oval and 22% was egg shaped, according to the current study. Surgical procedures and neuroimaging methods should account for the shape variability of FM. When operating on an oval-shaped FM, it may be challenging to expose the front part [15-17].

The purpose of this study was to use morphometric analysis to evaluate the foramen magnum, occipital condyles, and hypoglossal canals. Skull base procedures now have better surgical exposure thanks to advances in these approaches. Injuries to neurovascular systems or craniocervical instability caused by occipital condyle excision can complicate these manoeuvres. Therefore, it is imperative that neurosurgeons conducting this procedure are well-versed in both the typical anatomy and any variants pertaining to the foramen magnum area [18, 19].

Various studies found an average AP diameter of 34.5-36.6 mm for FM in both dry skulls and CT scans. Results showed that cranial CT had an average AP diameter of 35.03 mm and adult dry skulls had an average AP diameter of 35.12 mm. In craniovertebral junction disorders, the magnitude of FM is the important parameter for the emergence of clinical signs and symptoms. Craniovertebral canal stenosis can be a consequence of achondroplasia, a condition in which the base of the skull does not grow as it should. Surgical decompression and excision of the posterior side of the FM are necessary for this procedure [20-22].

Various investigations found mean transverse diameters of FM ranging from 34.5mm to 36.6mm in both dry skulls and CT scans. Results showed that cranial computed tomography (CT) detected a mean transverse diameter of 28.79 mm for FM in adult humans and dry skulls of the same species as 29 mm. In a few research, there were minor disagreements. In craniometaphyseal dysplasia and Marchesani's disease, the size of FM is decreased. In this investigation, it was discovered that 20% of adult dry skulls had occipital condyles that protruded into the FM. Previous research has shown that oval or egg-shaped FM are more likely to have OC protruding into them. Surgery involving the skull base may be necessary to remove more OC if it protrudes, which can lead to increased craniovertebral instability [23, 24].

In dry skulls, the average length of the ROC was 23.85 mm and the LOC was 23.77 mm, according to the current study. In cranial CT, the average length of the ROC was 23.11 mm and the LOC was 23.20 mm. On dry skulls, the mean ROC width was 13.29 mm and the mean LOC width was 13.44 mm. In cranial CTs, the mean width of the ROC was 12.92 mm while the mean width of the LOC was 12.88 mm [25]. Compared to cranial CT scans, OC measurements taken from dry skulls were higher. The FM's lateral boundary is formed by the OC. Surgery on the skull base could be impacted by OC's morphology and measures. The best way to remove lesions that are located beneath the FM is using the transcondylar technique. While a third of the OC removed had no effect on craniovertebral stability, the same amount of condylectomy in shorter OCs might lead to instability. More extensive excision may be necessary to achieve improved surgical exposure in cases of long OC. Because the occipital condyles converge

ventrally and laterally on the FM, the OCs are uniquely shaped on the inside and outside. Results from AICD and PICD were thus not same. In order to get the best possible view of the FM's ventral or ventrolateral side, a transcondylar approach necessitated a condylectomy [25, 26].
The present investigation indicated that 40 skulls had PCC while 60 skulls on the right side did not. Out of fifty-one skulls, 49 had it on the left side and 51 did not. Bilateral presence was found in around 33 skulls. The PCC is the conduit via which a nerve and an emissary vein travel to the posterior cerebral fossa duramater. Compression of tissues travelling through the PCC can occur at complete extension of the neck due to the posterior border of the atlas impinging into the condylar fossa. Various research' percentages of PCC were tabulated. The study's findings of higher values are noteworthy [26, 27].
The average distance between the right and left intracranial edges of the HGC and the anterior margins of the ROC and LOC were found to be 11.02±1.29mm and 10.93±1.30mm, respectively. The measurements for the average distance between the right and left intracranial edges of the HGC and the posterior margins of the ROC and LOC were 12.27±0.6mm and 12.26±0.59mm, respectively. Several investigations were used to compare and tabulate the measured value. Consistent with previous research, the current investigation found similar findings. For the sake of a risk-free removal of the occipital condyle, this is of clinical importance. According to our study, the OC can be securely drilled for 12mm from the posterior margin before it meets the HGC, and this distance was found to be 12.27 ±0.59mm. The current study compared and summarised HGC distance from anterior and posterior ROC and LOC with other investigations [26-28].

Conclusion

Foramen magnums were determined to be oval in 40% of patients in this investigation. When doing neuroimaging procedures or skull base surgery, it is important to account for this variance in configuration. In adult dry skulls, the average anterior-posterior diameter of the foramen magnum was 35.12±2.65mm, while in cranial CT scans, it was 35.03±0.95mm. When diagnosing craniovertebral junction pathology, the size of the foramen magnum is the most important factor in determining the presence of clinical symptoms. The foramen magnum's mean transverse diameter in adult dry skulls was 29.03±2.15mm, while in cranial CT it was 28.79±1.17mm. It plays a key role in the transcondylar method. Preoperative radiological evaluation is crucial for greater surgical success, as this study shown that there was no significant difference between radiological and anatomical measurements. The morphometry and different forms of FM were also uncovered in this investigation. Neurosurgeons may be able to use the acquired data to better plan and manage skull base surgeries by analyzing the craniovertebral junction's anatomy. Clinical anatomists, anthropologists, radiologists, orthopedists, and morphologists will all find something new to learn from the results.

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Conflict of Interest: None.

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