



Original Article

Morphological and Morphometric study of the foramina of the middle cranial fossa in dried human skulls

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ABSTRACT

Background: The foramina of the middle cranial fossa—specifically the foramen ovale, foramen rotundum, foramen spinosum, and foramen lacerum—serve as channels for important neurovascular structures. Understanding their morphological variations and morphometric measurements is crucial for neurosurgeons, radiologists, and anatomists during diagnostic and surgical procedures.

Aim and Objectives: To evaluate the morphology and morphometry of the foramina of the middle cranial fossa in dry human skulls and to analyze their variations.

Methods: The present osteological study was conducted on 50 dried adult human skulls obtained from the Department of Anatomy Integral University Lucknow. The anteroposterior diameter (APD) and mediolateral diameter (MLD) of the foramen ovale, rotundum, spinosum, and lacerum were measured using a digital vernier caliper. The shapes of the foramina were also recorded. Statistical analysis was performed to compare right and left side measurements.

Results: The foramen ovale most commonly exhibited an oval shape, followed by round and almond shapes. The mean APD of the foramen ovale was approximately 6.62 ± 1.11 mm on the right side and 6.72 ± 1.08 mm on the left, while the mean width was 3.78 ± 0.89 mm on the right and 3.89 ± 0.73 mm on the left. The foramen spinosum predominantly showed a round shape, whereas the foramen rotundum was mainly round or oval. The foramen lacerum commonly displayed an irregular shape. No statistically significant difference was observed between the right and left sides for most parameters.

Conclusion: The present study highlights the morphologic and morphometric variations of the foramina of the middle cranial fossa. Such anatomical information is essential for neurosurgical planning and radiological interpretation, particularly in procedures involving the trigeminal nerve and middle cranial fossa structures.

Keywords: Foramen ovale, rotundum, spinosum, lacerum.

INTRODUCTION

The skull's interior is divided into three cranial fossae—anterior, middle, and posterior—which together support and protect the Brain. The middle cranial fossa (MCF) is a depression within the skull base, primarily situated in the temporal region, lying between the petrous part of the temporal bone and the lesser wing of the sphenoid bone. [1, 2] Anteriorly, it is bounded by the posterior margin of the lesser wing of the sphenoid, the anterior clinoid processes, and the anterior border of the

sulcus chiasmatis. Posteriorly, its limits are defined by the superior border of the petrous portion of the temporal bone, the posterior clinoid processes, and the dorsum sellae. Laterally, the middle cranial fossa is enclosed by the greater wing of the sphenoid, and the floor of the fossa is formed centrally by the body of the sphenoid bone and laterally by its greater wings. Several foramina are present in the middle cranial fossa, which may be irregular or regular in shape. The main foramina include the foramen rotundum, ovale, spinosum, and lacerum, all of which are located in the greater wing of the sphenoid bone. These openings serve as important passageways for vital neurovascular structures entering and leaving the middle cranial fossa. In addition, this fossa houses key anatomical structures such as the cavernous sinus, hypophysis cerebri (pituitary gland), temporal lobes of the cerebrum, middle meningeal artery, and the trigeminal ganglion. [1, 2]

In the greater wing of the sphenoid bone, anteromedial part, find the foramen rotundum, which is situated between the mandibular and ophthalmic divisions of the trigeminal nerve. It serves as a passage through which the maxillary nerve passes through it and arises from the anterior convex surface of the trigeminal ganglion. In the lateral wall of the cavernous sinus, the maxillary nerve runs forward, neighbouring the oculomotor and trochlear nerves, as well as the ophthalmic division of the trigeminal nerve. After passing the foramen rotundum, the maxillary nerve exits the middle cranial fossa and enters the upper part of the pterygopalatine fossa. The foramen rotundum runs downward and opens into the pterygopalatine fossa, providing a direct pathway between the middle cranial fossa and this space. [4, 5, 6]

The foramen ovale lies just posterior to the foramen rotundum and lateral to the posterior end of the carotid groove. It is an oval opening at the base of the skull that serves as an important passageway for several vital structures. These include the mandibular nerve, which supplies derivatives of the first branchial arch; the lesser petrosal nerve, a parasympathetic nerve that passes to the otic ganglion; an emissary vein connecting the pterygoid venous plexus with the cavernous sinus; and the accessory meningeal artery, which supplies the dura mater of the middle cranial fossa. Owing to the critical neurovascular structures it transmits, the foramen ovale holds considerable clinical importance in diagnostic and surgical procedures and contributes significantly to improved surgical outcomes. [8, 9]

The foramen spinosum is located in front and towards the midline of the sphenoid bone's spine, and behind and to the side of the foramen ovale. It is one of the main Openings on the infratemporal face of the greater wing of the sphenoid bone. This opening allows the passage of the meningeal branch of the mandibular nerve, the middle meningeal artery, and the middle meningeal vein. [11, 12] The foramen spinosum also serves as an important anatomical landmark in cases of skull base trauma, especially when the middle cranial and infratemporal fossae are involved.

The foramen lacerum is a triangular-shaped opening situated at the junction of three bones. The pterygoid process and the greater wing of the sphenoid bone, the posterolateral border by the apex of the petrous part of the temporal bone, and the posteromedial border by the basilar part of the occipital bone form its anterior border. [7, 12]

Several important structures

pass over the superior surface of the foramen lacerum, rather than through it. These include the internal carotid artery as it courses horizontally, the accompanying sympathetic plexus, the greater petrosal nerve, an emissary vein connecting the pterygoid venous plexus to the cavernous sinus, and small branches of the ascending pharyngeal artery. [21]

MATERIALS & METHODOLOGY

The present descriptive osteological study was carried out in the Department of Anatomy at the Integral Institute of Medical Sciences and Research, Lucknow, to examine the morphology and morphometry of the foramina in the middle cranial fossa. A total of 50 adult dry human skulls of unknown sex were included in the study. Only well-preserved, intact skulls with clearly identifiable middle cranial fossa foramina were selected, while damaged skulls and those exhibiting pathological deformities or fractures at the cranial base were excluded to ensure Accuracy of observations. Before starting the work, a clearance certificate from the institutional ethical committee was obtained.

Measurements

All measurements were taken using a digital Vernier caliper, divider, and measuring scale. The valuate parameters for each foramen—namely the foramen, rotundum, ovale, spinosum, and lacerum, which included the, mediolateral diameter, anteroposterior diameter and overall shape, providing a comprehensive assessment of their anatomical variations.



RESULTS

Foramen ovale

The mean Anteroposterior diameter was 6.62 ± 1.11 mm on the right side and 6.72 ± 1.08 mm on the left side, while the mean width was 3.78 ± 0.89 mm on the right and 3.89 ± 0.73 mm on the left.

Foramen Rotundum

The mean Anteroposterior diameter was 4.42 ± 0.66 mm on the right side and 4.41 ± 0.59 mm on the left side the mean Transverse diameter was 3.78 ± 0.89 mm on the right and 3.89 ± 0.73 mm on the left

Foramen Spinosum

The mean Anteroposterior diameter was 3.21 ± 0.32 mm on the right side and 3.10 ± 0.50 mm on the left side, the mean mediolateral diameter was 2.53 ± 0.61 mm on the right and 2.47 ± 0.54 mm on the left.

Foramen Lacerum

The mean Anteroposterior diameter was 6.77 ± 0.74 mm on the right side and 6.73 ± 0.64 mm on the left side, the mean mediolateral diameter was 4.93 ± 0.64 mm on the right and 4.95 ± 0.80 mm on the left.

Table 1: Mean value of APD and MLD of all the foramina calculated by the use of Student t- test. ($p < 0.01$)

Foramen	Dimension	Right Side(mm)	Mean \pm SD	Left Side(mm)	Mean \pm SD	p-value
Foramen Ovale	APD	6.13 – 6.61	6.37 ± 0.86	6.09–6.49.	6.29 ± 0.72	0.62
	MLD	4.15–4.49	4.32 ± 0.61	4.10–4.4	4.25 ± 0.54	0.54
Foramen Rotundum	APD	4.23–4.61	4.42 ± 0.66	4.24–4.5	4.41 ± 0.59	0.78
	MLD	3.82–4.13	3.97 ± 0.55	3.76–4.0	3.91 ± 0.53	0.58
Foramen Spinosum	APD	3.12–3.30	3.21 ± 0.32	2.96–3.24	3.10 ± 0.50	0.19
	MLD	2.36–2.70	2.53 ± 0.61	2.32–2.62	2.47 ± 0.54	0.63
Foramen Lacerum	APD	6.56–6.98	6.77 ± 0.74	6.55–6.92	6.73 ± 0.64	0.77
	MLD	4.75–5.11	4.93 ± 0.64	4.72–5.17	4.95 ± 0.80	0.89

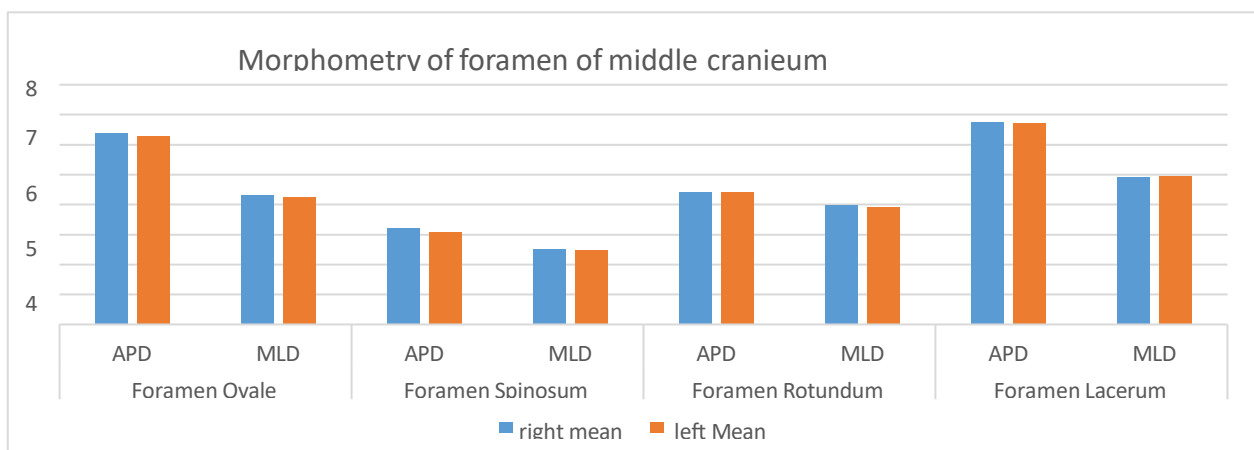


Figure 1: The comparison of anteroposterior and mediolateral dimensions of all foramina

Table 2: Distribution of shapes for Foramen Ovale, Rotundum, Spinosum, and Lacerum.

Foramen	Shape	Right Side (%)	Left Side (%)	Total (%)
Foramen Ovale	Oval	72	68	70
	Almond	10	16	13
	Irregular	00	02	01
	Round	18	14	16
Foramen Rotundum	Oval	22	24	23
	Round	78	76	77
Foramen Spinosum	Oval	14	10	12
	Irregular	08	08	16
	Round	78	82	80
Foramen Lacerum	Irregular	64	66	65
	Round	26	24	25
	Oval	10	10	10

DISCUSSION

The present study provides a comprehensive evaluation of the morphometry and morphology of the foramina of the middle cranial fossa, namely the foramen ovale, rotundum, spinosum, and lacerum. The findings consistently demonstrate a high degree of bilateral symmetry in both dimensions and shape, reflecting the stable anatomical configuration of these structures.

The present study found that the mean anteroposterior diameters were 6.37 ± 0.86 mm on the right side and 6.29 ± 0.72 mm on the left side. The mediolateral diameters were 4.32 ± 0.61 mm and 4.25 ± 0.54 mm, respectively, with no significant difference between the two sides. Alike findings were also reported by S. Santhosh et al. (2020) and Gowri Shankar et al., who reported similar symmetrical sizes. However, slightly higher values were reported by Supriya Garapati et al. and Shivamurthy K et al., suggesting minor differences across populations. The oval shape was most commonly seen at 70% dried skulls, which is consistent with studies by Agarwal et al. Sarbani Das et al. and Desai et al., all of which identified the oval shape as the most common. This consistency indicates that the oval shape is a stable anatomical characteristic, though the proportion of other shapes can differ between studies.

Foramen rotundum, the present study found that the mean Anteroposterior diameter was 4.42 ± 0.66 mm on the right side and 4.41 ± 0.59 mm on the left side. The mean transverse diameter was 3.78 ± 0.89 mm on the right and 3.89 ± 0.73 mm on the left no significant difference between the right and left sides for both APD and MLD. This finding contrasts with Reema Rao et al., who reported significant asymmetry in the mediolateral diameter. Nonetheless, these results align with those from Binita Purohit et al., who observed consistent dimensions. The round shape was predominant at 77%, consistent with many earlier studies, confirming the similar structure of this foramen.

Foramen spinosum, the present study found that the mean Anteroposterior diameter was 3.21 ± 0.32 mm on the right side and 3.10 ± 0.50 mm on the left side, the mean mediolateral diameter was 2.53 ± 0.61 mm on the right and 2.47 ± 0.54 mm on the left, with no significant side differences. These findings match those of Pallavi Sharma et al and Siddharth Tewari et al., who also noted no significant variation between sides. The round shape was the most common at 80%, which corresponds with the results from Shaik Hussain Saheb et al. and Camellia Chanda et al. However, the study also found minor variations, such as oval and irregular shapes, suggesting slight anatomical diversity.

Foramen lacerum, the present study showed the mean Anteroposterior diameter was 6.77 ± 0.74 mm on the right side and 6.73 ± 0.64 mm on the left side, the mean mediolateral diameter was 4.93 ± 0.64 mm on the right and 4.95 ± 0.80 mm on the left. With no significant bilateral difference. These measurements are lower than those reported by Abeer Fareed et al., who found larger sizes as compared to the present study; however, they were still insignificant. The irregular shape was the most common in this study, which aligns with traditional anatomical descriptions, though studies done by Sanghpriya Chaudhary et al. reported round shapes to be more common. These differences might stem from variations in sample makeup, sex Distribution, and measurement methods.

Overall, the present study is consistent with most of the literature reviewed, showing bilateral symmetry and common shapes. Nevertheless, the variations in morphometric values across different studies highlight the impact of regional, racial, and methodological factors.

CONCLUSION

The study demonstrates the morphology and morphometry of the foramina of the middle cranial fossa. The foramen ovale most commonly exhibited an oval shape, while the spinosum and rotundum were predominantly round. The lacerum typically showed an irregular shape.

Knowledge of these anatomical variations is essential for neurosurgeons, radiologists, and anatomists. Such information is particularly useful in surgical procedures involving the trigeminal nerve, middle meningeal artery, and skull base structures. Further studies with larger sample sizes and advanced imaging techniques are recommended to enhance understanding of these anatomical variations.

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