

## A Morphometric Study to Define Anatomical Variations in Foramen Ovale: An Observational Study

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Conflict of interest: Nil

### Abstract

**Aim:** The aim of the present study was to define anatomical variations in foramen ovale.

**Method:** The study was carried out on 50 foramen ovale using 250 dry adult human skull bones of unknown sex and the bones were taken from the Department of Anatomy. Skulls which were fractured at the surrounding of foramen ovale were not included in the study.

**Results:** Out of 50 foramen ovale, minimum to maximum anteroposterior diameter on left side were 3.1 mm- 8.0 mm and on right side were 3.4 mm-8.4 mm. Average anteroposterior diameter on left side was  $5.6 \pm 1.412$  mm and on right side was  $5.5 \pm 1.375$  mm. Minimum transverse diameter on left side was 2.3 mm and on right side was 2.8 mm. Maximum transverse diameter was 6.5 mm and 5.6 mm on left and right sides respectively. Majority of the foramen were oval shaped and it was seen in 27 sides (left 12, right 15), almond shape was seen in 13 sides (7 left, 6 right), round shape was seen in 8 sides (4 left, 4 right), slit like foramen was seen in 2 sides (1 left, 1 right). Incidences of various shapes of the foramen ovale were oval 54%, almond 26%, round 16% and slit like 4%. Out of 50 foramina, bony spine was observed in 3 followed by 2 bony plate and 1 osseous lamina.

**Conclusion:** Morphometric and morphological anatomy of foramen ovale is very useful for medical practitioners while handling the cases of trigeminal neuralgia, tumour detection, bony outgrowths that leads to necrosis, ischaemia. The Foramen ovale is important foramina of the skull base.

**Keywords:** Foramen ovale, Middle Cranial Fossa, Mandibular Nerve, Trigeminal Neuralgia

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### Introduction

The foramen ovale is present in the infratemporal surface of the greater wing of sphenoid and it is an important foramen which transmits the mandibular division of the trigeminal nerve, lesser petrosal nerve, emissary veins, and accessory meningeal vessels. [1] The morphology and morphometry of foramen ovale are different among various subgroups of human population. [2-4] These morphometric details are lacking in the Indian population to the best of our knowledge. The mandibular nerve which traverses the foramen ovale and trigeminal ganglion that is situated in the Meckel's cave are targeted by neurosurgeons and pain physicians in patients with trigeminal neuralgia. Trigeminal rhizotomy procedures which are done for treating trigeminal neuralgia necessitate an in-depth knowledge about the foramen ovale.

The foramen ovale also differs in size and shape like other foramina. The earliest perfect ring shaped

formation of foramen ovale was observed in the 7th foetal month and latest in the 3 years after birth and seen as a discrete foramen at 22 weeks. The length of the foramen ovale was about 3.85 mm in the new born and 7.2 mm in adults and the width of foramen ovale was about 1.81 mm in the new born and 3.7 mm in adults. [5] The previous studies which indicates the different variations of foramen ovale such as the venous component of the foramen ovale may be separated from the other contents of the foramen by a bony spur located antero-medially resulting in double foramen ovale [6] or it can be covered by ossified ligaments extending between the lateral pterygoid process and the sphenoid spine or found to be divided into 2 to 3 components associated with irregularities. [7]

The foramen is found on the lateral side of the lacerum foramen and anterior side of the Eustachian tube, EoCC and spinous foramen of the skull. In

addition, the localization of the FO has an important place on the anterior side, due to its proximity with the PPF and the IOF. Knowledge of the foramen ovale morphometry and morphology is important in procedures involving Trigeminal neuralgia and administration of anaesthesia via mandibular nerve. [8] Through foramen ovale, percutaneous biopsy of cavernous sinus can be performed. [8-10]

The aim of the present study was to define anatomical variations in foramen ovale.

### Materials and Methods

The study was carried out on 50 foramen ovale using 250 dry adult human skull bones of unknown sex and the bones were taken from the Department of Anatomy, pmch, Patna, Bihar, India. Skulls which

were fractured at the surrounding of foramen ovale were not included in the study.

a) Maximum transverse diameter, anteroposterior diameters of the foramen were measured with the help of vernier calipers.

b) Any variations in the shape of foramen were noted.

c) Margins of foramen were carefully observed for any bony projections.

d) Duplication of foramen ovale was observed.

Independent sample 't' test was used for statistical analysis.

### Results

**Table 1: Anteroposterior and transverse diameters of foramen ovale on both sides (Right and Left)**

Values	Anteroposterior diameter(mm)		Transverse diameter(mm)	
	Right	Left	Right	Left
Maximum	8.4	8.0	5.6	6.5
Minimum	3.4	3.1	2.8	2.3
Mean	5.5	5.6	3.43	3.52
Standard Deviation	1.375	1.412	0.554	0.812
p-value	0.650		0.855	

Out of 50 foramen ovale, minimum to maximum anteroposterior diameter on left side were 3.1 mm- 8.0 mm and on right side were 3.4 mm-8.4 mm. Average anteroposterior diameter on left side was  $5.6 \pm 1.412$  mm and on right side was  $5.5 \pm 1.375$  mm. Minimum transverse diameter on left side was 2.3 mm and on right side was 2.8 mm. Maximum transverse diameter was 6.5 mm and 5.6 mm on left and right sides respectively.

**Table 2: Variations in the shape of foramen ovale**

Foramen ovale shapes	Right	Left	Total
Oval	15	12	27
Almond	6	7	13
Round	4	4	8
Slit	1	1	2

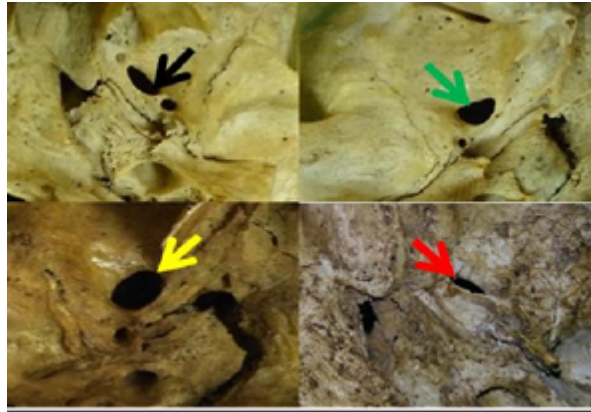
Majority of the foramen were oval shaped and it was seen in 27 sides (left 12, right 15), almond shape was seen in 13 sides (7 left, 6 right), round shape was seen in 8 sides (4 left, 4 right), slit like foramen was

seen in 2 sides (1 left, 1 right). Incidences of various shapes of the foramen ovale were oval 54%, almond 26%, round 16% and slit like 4%.

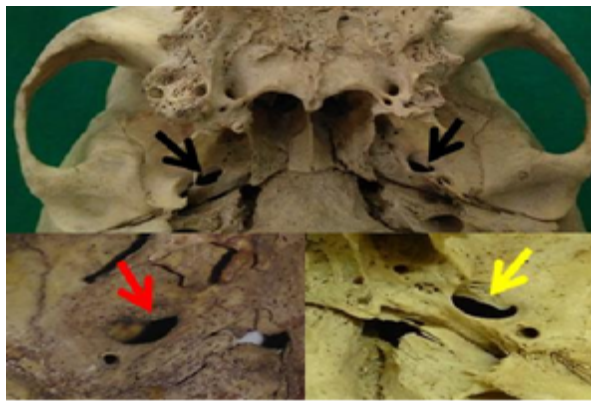
**Table 3: Incidence of Accessory bony structures in Foramen Ovale**

Accessory bony structures	RIGHT SIDE	LEFT SIDE
Spine	2 (4%)	1 (2%)
Bony plate	1 (2%)	1 (2%)
Osseous lamina	0	1 (2%)

Out of 50 foramina, bony spine was observed in 3 followed by 2 bony plate and 1 osseous lamina.



**Figure 1: Variations in the shape of foramen ovale: oval shape (black arrow), almond shape (green arrow), round shape (yellow arrow), slit like (red arrow)**



**Figure 2: Margins of the foramen ovale exhibiting variable projections: bilateral presence of spine (black arrow), tubercle (red arrow), bony plate (yellow arrow)**



**Figure 3: Showing duplication of foramen ovale (yellow arrow)**

### Discussion

There are several foramina piercing the greater wing of the human sphenoid bone and one amongst them is the foramen ovale. Foramen ovale is present medial to the foramen spinosum and foramen lacerum is located medial to the foramen ovale. It transmits the mandibular division of the trigeminal nerve, accessory meningeal branch of the maxillary artery, lesser petrosal nerve and an emissary vein which connects the pterygoid venous plexus in the infratemporal fossa to the cavernous sinus. [1,11] Foramen ovale is situated at the transition zone

between the extra cranial and the intracranial structures. [12] Thus, it is one of the important foramina of the skull. Hence, it is used for diagnostic and surgical procedures. The foramen ovale which is present in the posterior part of the greater wing of sphenoid bone is of great diagnostic & surgical importance. It is used for various procedures like microvascular decompression by percutaneous trigeminal rhizotomy for trigeminal neuralgia, and permits biopsy of deep seated lesions which would otherwise require a craniotomy or a biopsy through open surgical procedure. [13] This would help to

decrease patient morbidity & also reduce the cost significantly.

Out of 50 foramen ovale, minimum to maximum anteroposterior diameter on left side were 3.1 mm-8.0 mm and on right side were 3.4 mm-8.4 mm. Average anteroposterior diameter on left side was  $5.6 \pm 1.412$  mm and on right side was  $5.5 \pm 1.375$  mm. Minimum transverse diameter on left side was 2.3 mm and on right side was 2.8 mm. Maximum transverse diameter was 6.5 mm and 5.6 mm on left and right sides respectively. The study of Gupta N was similar with the results of our study which was conducted on 35 dry adult skulls. Their study revealed that the mean length of foramen ovale was  $7.228 \pm 1.39$  mm on right side and  $6.48 \pm 1.131$  mm on left side. On left side, mean width was  $3.50 \pm 0.75$  mm and on right side was  $3.57 \pm 0.70$  mm. The difference between the mean values of the length and width of the right and left foramen ovale [14] was not that significant. Osunwoke E.A. study revealed that the mean of the lengths of the right and left foramen ovale was 7.01 mm and 6.89 mm with the range; 5.0-9.5 mm and 5.0-9.0 mm, on right and left sides respectively. The mean value for the widths of the right and left foramen ovale was 3.37 mm and 3.33 mm with range of 2.0-5 mm on both sides. Significant difference between the mean of the length and width of the right and left foramen ovale [15] was not observed.

Majority of the foramen were oval shaped and it was seen in 27 sides (left 12, right 15), almond shape was seen in 13 sides (7 left, 6 right), round shape was seen in 8 sides (4 left, 4 right), slit like foramen was seen in 2 sides (1 left, 1 right). Incidences of various shapes of the foramen ovale were oval 54%, almond 26%, round 16% and slit like 4%. Our results are in agreement with study of Gupta N and Rai AL, which followed in the same sequence of oval shaped 54.2%, almond shaped 35.7%, round shaped 8.5% and slit like 1.4%. [14] In a study conducted by Ray B et al, they observed the presence of a bony spur that divided the foramen ovale in two separate compartments. [13] Reymond et al, in their study found that in 4.5% of the cases the foramen was divided into two or three different compartments. [11] Since the proximity of FO to IOF and PPF poses a risk factor in refractory trigeminal neuralgia treatment. Out of 50 foramina, bony spine was observed in 3 followed by 2 bony plate and 1 osseous lamina. Nader A. et al. reported an other application via the PPF as an alternative that might reduce injury to the corneal reflex.<sup>16</sup> Taking this proximity issue into consideration the vertical distance between the anterior point of FO and IOF and the transverse distance between the anterior point of FO and PPF were measured and recorded.

In various diagnostic and surgical procedures, foramen ovale is used. It is used for electroencephalographic analysis of the seizure for

patients undergoing selective amygdalohippocampectomy, [17] percutaneous biopsy of cavernous sinus tumours and micro vascular decompression by percutaneous trigeminal rhizotomy for trigeminal neuralgia. [17,18] Through the foramen ovale the CT-guided transfacial fine needle aspiration technique is performed. It is done to diagnose meningioma, squamous cell carcinoma etc., and biopsy of the lesions which require open surgical biopsy or craniotomy. [19]

### Conclusion

Morphometric and morphological anatomy of foramen ovale is very useful for medical practitioners while handling the cases of trigeminal neuralgia, tumour detection, bony outgrowths that leads to necrosis, ischaemia. The Foramen ovale is important foramina of the skull base. Undoubtedly, taking a single bone or a point of a bone as a landmark is insufficient. Orientation waypoints are valuable information for physicians and surgeons. It is an incontestable fact that it can help easier access to the Foramen ovale, reducing the risk of mandibular nerve injury. The success rate of the operation mainly relies on the practitioners' and surgeons' knowledge of the landmarks of the Foramen ovale and gaining the right orientation in the skull base. The information maintained in this study along with the existing imaging can help surgeons provide a shorter surgery time and avoid complications.

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