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Original Research Article

A study on the morphology and morphometry of foramen ovale in dry human skulls

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ABSTRACT

Background: An oval shape foramen is present in the greater wing of sphenoid through which passes the many vital structures. It is located at the transitional area between intracranial and extracranial structures. It is important for diagnostic and surgical procedures.

Materials and Methods: A total 100 skulls were used for the study. 82 skulls were studied and 18 skulls were excluded from the study. The skulls were collected from Phase I MBBS students from different medical colleges in south India. Skulls in poor conditions or skulls with partly damaged surroundings of the foramen ovale were not considered. Maximum length and width of foramen ovale was measured using digital Vernier calliper. Also, the distance from the anterior root of zygoma and the distance from the articular tubercle on zygomatic arch to foramen ovale were measured. Variation in right and left side were calculated, the variations in shape also recorded.

Results: The mean length of foramen ovale was 6.8 ±1 and the mean breath of foramen ovale was 3.65±1. Two-sample independent t test showed significant difference between the right and left breadths of foramen ovale (p 0.0126), while the right and left lengths of foramen ovale were not significant (p 0.245). The mean distance of foramen ovale from articular tubercle on Zygomatic arch was 33±2 mm. The mean distance from anterior root of Zygomatic arch was 21.5 ± 2.1 mm.

Conclusion: The present study concludes that there is significant difference between sizes of right and left side foramen ovale. Foramen ovale has practical significance to both neurosurgical and functional cranial neuroanatomy as it provides transcutaneous approaches to the skull base especially in cases of trigeminal neuralgia, as the Gasserion ganglion can be approached through it.

1. Introduction

An oval shape foramen located in the base of skull is called as foramen ovale. The following structures passes through this oval foramen: the nerve supplying the derivative of first branchial arch-the mandibular nerve, an extra artery supplying the meninges of the middle cranial fossa-accessory meningeal artery, a vein connecting pterygoid venous plexus to cavernous sinus-emissary vein and a parasympathetic nerve which is going to relay in the otic ganglion-lesser petrosal nerve. This oval foramen is located just lateral and posterior to the round foramen called foramen rotundum and it is also lateral to the carotid groove-posterior end. The foramen ovale is located at the junction

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between extracranial structures and intracranial structures. It is therefore important for various diagnostic procedures and for a better surgical outcome.[1]

The sphenoid bone has 4 parts: body, lesser wing, greater wing and pterygoid processes. They are developed as follows: The cephalic mesoderm give rise to orbitosphenoid and basi-post sphenoid. Cephalic neural crest give rise to alisphenoid and basi-presphenoid. The following are the contribution:- Orbitosphenoid: lesser wing of sphenoid; basi-post sphenoid: Body of sphenoid; Alisphenoid : greater wing of sphenoid; basi-presphenoid: Pterygoid processes.

A unique ring like opening is present at the unossified area of the cartilage at 22^{nd} week of intrauterine life which transmits a thick nerve-which is mandibular nerve. By the age of three years the foramen ovale becomes distinct following ossification of the greater wing of sphenoid bone.[2]

The mean length of the foramen ovale is about 3.85 mm in the newborn and about 7.2 mm in adults and its width extends from 1.81 mm in the newborn to 3.7 mm in case of adults.[3]

2. Materials and Methods

A total of hundred dry skulls were collected from Shridevi Institute of Medical Sciences and Research Institute, Tumkur and ESIC Medical College & PGIMSR, Rajajinagar, Bengaluru.

Two varieties of parameters were studied: The various shapes of the foramen ovale and presence of any accessory bony structure were the non-metric parameter studied. The metric parameter studied were Breadth of foramen ovale and length of foramen ovale. The long and short axes of this oval foramen were measured using a digital Vernier calliper of 1mm precision. Also, the distance of foramen ovale from the two bony landmarks: 1) anterior root of zygoma and 2) articular tubercle on zygomatic arch.

Total of 100 dry skulls were obtained. 82 skulls without any damage to foramen ovale were studied and the 18 skulls were excluded from the present study.

Skulls which were damaged near to the foramen ovale were excluded from the present study. All the measurement was done using a digital Vernier calliper. Length and breadth were documented and any variations in the right and left side were calculated. The mean and standard deviation, P values of the length and breadth were calculated. The variations in shape were photographed and recorded.

3. Results

Mean, standard deviation and standard error of right and left side foramen ovale is tabulated in Table 1.

Two-sample independent t test statistical analysis was done and it showed significant difference between the right and left breadths of foramen ovale (p 0.0126), while the right and left lengths of foramen ovale were not statistically significant (p 0.245). 33±2 mm was the mean distance of foramen ovale from articular tubercle on zygomatic arch, whereas 21.5 ± 2.1 mm was the mean distance from anterior root of zygomatic arch. (Tables 2 and 3).

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Among the various shapes of foramen ovale, the oval shape was the most common shape accounting for 73% on right side and 68% on the left side, other shapes were almond, round and irregular shapes (Table 5) and (Figure 1).

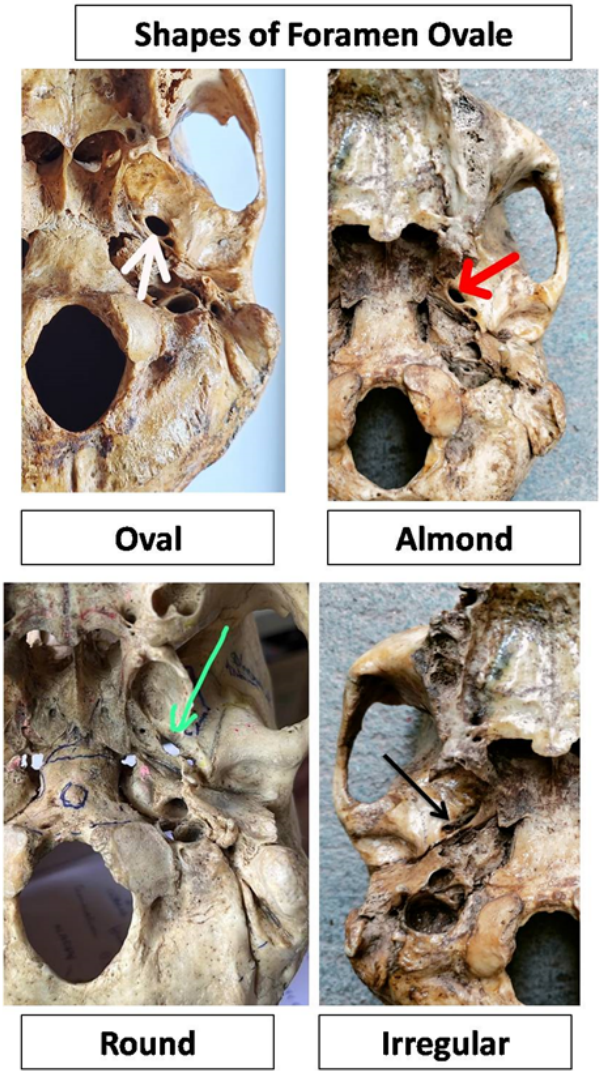

Fig. 1: Shapes of foramen ovale

The foramen ovale is one of the vital foramina which is present at the junction between the interior and exterior of skull, connecting the middle cranial fossa to the

Table 1: Length and breadth of foramen ovale

	Right (mm)		Left (mm)	
	Length	**Breadth**	**Length**	**Breadth**
Mean	6.9	3.5	6.7	3.8
Standard deviation	1.07	0.81	0.94	0.62
Standard error	0.11	0.09	0.10	0.06

Table 2: Right length versus left length of foramen ovale. (Two-sample independent t test)

Length foramen Ovale	**Right (mm)**	**Left (mm)**
Mean	6.98	6.97
Standard deviation	1.07	0.94
T test/ P value	0.245 (Not significant)	

Table 3: Right breadth versus left breadth of foramen ovale. (Two-sample independent t test)

Breadth foramen Ovale	**Right (mm)**	**Left (mm)**
Mean	3.58	3.8
Standard deviation	0.82	0.62
T test/ P value	0.0126 (Significant)	

Table 4: Distance of foramen ovale from landmarks on zygomatic process

Distance from anterior root of zygoma	**Right (mm)**	**Left (mm)**
Range	13.1-24.3	17.1-27.2
Mean±SD	21±2.1	22±2.1
T test/ P value	P>0.05 (Not significant)	
Distance from articular tubercle	**Right (mm)**	**Left (mm)**
Range	28.5-37.1	28.5-38.1
Mean±SD	33 ± 2.1	33 ± 2.2
T test/ P value	P>0.05 (Not significant)	

Table 5: Shapes of foramen ovale

Shape offoramen Ovale (82)	**Right side**	**Left side**
Oval	60 (73%)	55 (68%)
Almond	15 (18%)	17 (20%)
Round	5 (6%)	6 (7%)
Irregular	2 (2%)	4 (4%)

infratemporal fossa. It transmits mandibular nerve, a branch of trigeminal nerve to the exterior and allows the accessory meningeal artery to enter into the skull, also transmits the emissary vein which connects the pterygoid venous plexus to cavernous sinus and helps in the transmission of lesser petrosal nerve towards the otic ganglion, the foramen ovale is used for various diagnostic and therapeutic usage. Therefore, it is vital for the neurosurgeons to know the exact size, shape and topographical location of foramen ovale, in order to minimise surgical complications.[4]

Biswabina Ray did a study of foramen ovale in which the mean length of foramen ovale on the right and left side was 6.86 ±1.26 mm and 6.84 ± 1.3 mm respectively. In a study done by Bekov the mean length of foramen ovale was 7.46 ±1.41 mm on the right side and 7.01±1.41 mm on left side. The maximum and minimum length of foramen ovale on the right and left side was 10 mm, 4.4mm and 9.8 mm, 3.4 mm respectively. A study by Arun in Nepal, in which the minimum length was 2.9 mm and maximum length of foramen ovale was 9.8 mm.[5]

In another study by Ambica Wadhwa, mean value of width of left and right foramen ovale was 3.51±0.58 mm and 3.53±0.59 mm respectively. The minimum width on right side was 2.5 mm and on left side was 2.7 mm and maximum width on right side was 5 mm and on left side was 4.9 mm. They reported the mean width was 3.21±1.02 mm and 3.29±0.85 mm on the right and left side respectively, minimum width was 1 mm on right side and 2.2 mm on left side and the maximum width of foramen ovale was 5 mm on both right and left side, while In Lang J study the average width was 3.7 mm.[3,6]

Binod Kumar study, the most common shape of foramen ovale was oval shape accounting for 60%, followed by almond and round shaped, which were 28.75% and 10%

respectively. Least common shape of foramen ovale was D-shaped, 1.25%. These results are in agreement with the study done by Biswabina ray at al the reported that oval shape in 61.4%, almond shaped in 34.3% and round in 2.9% and slit like in 1.4% of foramen ovale.[7]

There is strong association between the cranial morphology and the neurovascular anatomy of the skull. The sphenoid bone, is unique bone at the base of the skull in its embryology as well as its ossification. Foramen ovale is important for various diagnostic and therapeutic surgeries such as the following:

1. In seizure patients by doing electroencephalogram followed by the therapeutic surgery called selective amygdalohippocampectomy.[8]
2. In trigeminal neuralgia patient, by doing microvascular decompression and the procedure is percutaneous trigeminal rhizotomy.[9]
3. In cavernous sinus tumor patient, by doing the percutaneous biopsythrough skull base.[10]

Diagnostic measure of the following: squamous cell carcinoma, meningioma, meckel tumor, a CT-guided transfacial fine needle aspiration procedure is done through the skull base via the foramen ovale. Such a deep seated lesions that usually require craniotomy or open surgical biopsy, can be performed with this unique technique.[11,12]

The present study is helpful to determine the various diameters such as length and breadth of foramen ovale and its shape, the knowledge obtained may help in surgeries of neurological diseases. An accurate knowledge of the surgical anatomy of the infratemporal fossa housing the foramen ovale plays a pivotal role for the surgical interventions. The most consistent lowest point of the middle cranial fossa is the foramen ovale.[13,14]

Two bony landmarks on zygomatic arch have to be considered to know the exact topographic location of foramen ovale in the patient. That is the distance of foramen ovale from the: 1) anterior root of zygoma and 2) articular tubercle on zygomatic arch.

This topographic location of foramen ovale helps in surgical approach through transjugal-transoval route as described by Hartel in 1912, through the pterygomaxillary fossa up to the Foramen Ovale. In this approach, the anatomical region crossed by the biopsy needle is an inverted three-sided pyramid, with its apex directed towards the skin, 3cm lateral to the labial commissure on cheek. The base of this pyramid is located at the base of skull demarcated by three surface landmarks: cutaneous point on the orbito-meatal line, 3cm in front of the tragus along the lower border of the zygomatic arch and another point correspond to the papilla and the last point is the deep-seated one and it is the foramen ovale.[15]

The vital structures are internal jugular vein, internal carotid artery, membranous part of auditory tube and optic nerve which are located at the base of this pyramid, which is at the skull base. They are at very high risk of getting injured during the surgical procedure and therefore caution is a must while operating in this area.

4. Conclusion

The variations in the morphometry and morphology of foramen ovale have various anatomical, clinical and surgical importances.

Morphometric measurements will be useful in neurosurgical procedures like administration of anaesthesia involving the mandibular nerve. It helps in diagnostic detection of tumors.

Neurosurgical procedures like administration of anaesthesia involving the mandibular nerve in the treatment of trigeminal neuraglia and also while doing surgical procedures with tumours of the cavernous sinus.

The present study shows variations in shape may be due to developmental reason. There was no statistical difference in length, whereas significant difference between the right and left breadths of foramen ovale was obtained. The knowledge of present study helps the neurosurgeons and oncologists in diagnosis and treatment.

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None.

6. Conflict of Interest

None.

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