

Foramen Ovale: Morphometry & its Surgical Importance

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Abstract

Aims: The study of foramen Ovale is of great surgical importance in procedures like percutaneous trigeminal rhizotomy for trigeminal neuralgia, electroencephalographic analysis for seizure and diagnostic transfacial fine needle aspiration technique in perineural spread of tumour. Localization of the foramen ovale can be difficult due to imaging quality (improved by biplanar radiology systems), operator inexperience and anatomical variations. **Methods and Material:** The present study was conducted on 38 dry adult, human skulls of unknown sex obtained from Bone Bank of the Department of Anatomy, IIMSR, Warudi, Jalna. In this study, presence of anatomic variations in shape of foramen ovale was noted. The length and width of foramen were measured. Comparison between right and left was done. **Results:** Mean length of foramen ovale was 7.27mm and mean width was 3.18mm. There was no statistical significant difference between means of the length and width of the right and left sided. Its shape was typically oval in 19, almond in 10, round in 6 and slit like in 3 skulls. **Conclusions:** These anatomical variations in size and shape of foramen ovale should be borne in mind during the surgical and diagnostic importance around the foramen ovale.

Keywords: Foramen Ovale; Foramina of Skull; Anatomical Variation.

Introduction

The foramen ovale (FO) lies medial to the foramen spinosum and lateral to the foramen lacerum on the infratemporal surface of the greater wing of the sphenoid bone. It transmits the mandibular division of the trigeminal nerve, the lesser petrosal nerve, the accessory meningeal branch of the maxillary artery and an emissary vein which connects the cavernous venous sinus to the pterygoid venous plexus in the infratemporal fossa. It passes through the greater wing of the sphenoid posterior to the lingula and posterior end of carotid groove [1].

Foramen ovale is an important constituent of cranial anatomy with high significance in

neurosurgery as it enables access to the trigeminal nerve. Thus knowledge of its position is clinically important in the event of anaesthesia of the mandibular nerve as well as in cases of assessment of skull base asymmetries where these foramina measurements become important [2].

Several studies have shown that right side foramen ovale is narrower than left side. It has been hypothesized that entrapment of mandibular nerve when it cross FO is a primary cause of Trigeminal neuralgia (TN) and accounts for the higher incidence of TN on the right side [3]. Anatomical knowledge of the foramen ovale is important for neurosurgical procedures involving the Trigeminal neuralgia and administration of anaesthesia via mandibular nerve [4]. Moreover percutaneous biopsy of cavernous sinus is also performed through FO [4,5].

The present study was undertaken to define anatomical variations in FO and review the literature regarding the same. Prior knowledge of variations in FO may be important for academic, anthropological, forensic and clinical purpose, hence this study aims to highlight such variations [4].

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Material and Methods

The materials for the present study include 38 dry adult human skulls of unknown sex obtained from Bone Bank of the Department of Anatomy, IIMSR, Warudi, Jalna. The posterior part of greater wing of sphenoid was carefully examined for the existence of FO and its patency was confirmed by inserting a probe through. Skulls in poor conditions or skulls with partly damaged surroundings of the FO were omitted from the study. Maximum length (Anteroposterior diameter) and width (transverse diameter) of foramen ovale were measured with help of compass aesthesiometer as shown in Fig.1. Variations in right and left side in length and width were calculated and the variations in shape also recorded as oval, almond, round and slit like.

Observation

In the present study, the mean length of FO was 7.27 ± 1.184 mm on right side and 7.46 ± 1.13 mm on left side. Whereas the observed maximum and minimum length was 9.0 mm and 3.0 mm on right side while 9.5 mm and 4 mm on left side. However, the difference between the length of right and left side, was statistically not significant. The Maximum width of FO was 5 mm on both sides, while the minimum width of right and left side was 2.0 mm and 2.5 mm respectively, (Table 1), and the mean width on right side was 3.18 ± 0.62 mm and 3.244 ± 0.75 mm on left side which is statistically insignificant. Shape of foramen ovale was also observed. It was typically oval in 36 sides (19 right & 17 left), almond in 22 sides (10 right & 12 left), round in 12 sides (6 right & 6 left) and slit like in 6 (3 right & 3 left) (Table-2).



Fig. 1: Measurement of foramen ovale with the help of Compass Aesthesiometer

Table 1: Dimensions (in mm) of foramen ovale in right and left side

Values	Length(right)	Length(left)	Width(Right)	Width(left)
Maximum	9	9.5	5	5
Minimum	3	4	2	2.5
Mean	7.27	7.46	3.18	3.21

Table 2: Variations in appearance of foramen ovale

Shape	Right (n=38)	Left (n=38)	Total (n=76)
Ovale	19 (50.00%)	17 (44.73%)	36 (47.36%)
Almond	10 (26.31%)	12 (31.57%)	22 (28.94%)
Round	6 (15.78%)	6 (15.78%)	12 (15.78%)
Slit like	3 (5.26%)	3 (7.89%)	6 (6.57%)

Discussion

Foramen ovale (FO) is one of the important foramina used for various invasive surgical as well as diagnostic procedures. Knowing the anatomic variations of foramen ovale is important because surgical treatment of trigeminal neuralgia is most commonly accomplished by microvascular decompression by percutaneous trigeminal rhizotomy done through FO [6]. In a study conducted in India, forty patients of trigeminal neuralgia were treated with percutaneous trigeminal ganglion balloon compression. In all patients except one, the needle could be introduced easily. The only exception was the patient with foramen ovale stenosis, in whom, the needle just fitted in the foramen. The accuracy of percutaneous biopsy of cavernous sinus tumours through the foramen ovale is 84% [7] and it is important before making any decision to indicate open surgical, radiosurgical or radiotherapeutic treatment. Nasopharyngeal carcinoma (NPC) frequently spreads intracranially and most common route of spread is through the foramen ovale (34%) [8]. The CT-guided transfacial fine needle aspiration technique through FO to diagnose squamous cell carcinoma, meningioma, Meckel cave's lesions allows biopsy of deep lesions that would otherwise require open surgical biopsy or craniotomy. This results in decreased patient morbidity and significant cost reduction. Electroencephalographic analysis of seizure by electrode placed at FO is done. FO electrode technique provided good neurophysiological information in candidates for selective amygdalohippocampectomy. So knowledge of the exact topography and morphometry of the FO electrodes is required for a more precise anatomic-electro-clinical correlation of seizures [9].

In the present study mean length of FO was 9mm on right side and 9.5mm on left side. On comparing length of foramen ovale on right and left side the later was found to be longer than the former but the difference between the two was statistically insignificant ($p > 0.01$).

In a study conducted by N. Gupta an average mean length of foramen ovale was 7 mm on right side and average length was 7.46 mm on left side and difference between right and left side was observed which is similar to present study [10]. In a developmental study conducted in Japan by Yanagi, 1987, an average maximal length of foramen ovale was 7.48 mm and average minimal length was 4.17 mm and significant difference between right and left side was not observed which is similar to present study [11]. Fluoroscopically-assisted laser targeting

of the FO conducted in New York by Landl MK, 2005, showed length 6.9mm on right side and 6.8 mm on left side with range length 5.0-10.0mm; left, 6.0-9.0mm; right [12].

According to present study mean width on right side was 3.18 mm and 3.21mm on left side. Maximum width was 5.0 mm on both right and left sides. Minimum width on right side was 2 mm and 2.5 mm on left side. Difference between the width of right and left side was statistically not significant ($p > 0.01$).

In a study conducted by N. Gupta maximum width of foramen ovale was 5.0mm on both right and left sides while minimum width was 1.0mm on right side and 2.2mm on left side. Mean width on right side was 3.21 ± 1.02 mm and 3.29 ± 0.85 mm on left side. Difference between the width of right and left side was statistically not significant ($p > 0.01$) [10]. Similar findings were observed by a German study where average width was 3.7mm in adult skull [13]. Average width on right side was 3.4mm and 3.8mm on left side was reported in a study conducted by fluoroscopically-assisted laser targeting of foramen ovale in New York [14]. Arun Kumar found in his study that maximum length of foramen ovale was 9.8 mm and minimum length was 2.9 mm. Mean length on left side was 6.56 mm, on the right side was 5.08 mm; Mean width on left side was 3.60 mm and on the right side 3.64 mm [15].

In our study the shape of foramen ovale was oval in 47.36%; almond in 28.94%; round in 15.78% and slit like in 6.57% of skulls. Biswabina Ray [10] et al, reported that maximum number of foramen to be oval shaped 61.4% almond shaped 34.3%, round shaped 2.9% and slit like 2.9%. The similar results were observed in developmental studies conducted by Yanagi [11].

Roma Patel [16] et al mentioned variations in the shape of foramen ovale as oval 59.5%, round 27.5%, almond 12% and slit like 1%. A thorough understanding of fetal growth and development is the key to understanding both the completed normal anatomic structure and the abnormal variations. Most of the central skull base develops from endochondral ossification through an intermediary chondrocranium. The sphenoid bone consists of the body (formed by the presphenoid and postsphenoid centres, with a contribution from the medial crus of the orbitosphenoid). The lesser and greater wings from orbitosphenoids, alisphenoids respectively [17]. The ossification of the skull progresses in an orderly pattern from posterior to anterior. The postsphenoid (14 weeks) and then presphenoids (17 weeks) of the sphenoid bone ossify. Ossification is seen laterally in the orbitosphenoid (16 weeks) and the

alisphenoids (15 weeks). A CT scan study of fetal specimen with a gestational age of 22 weeks 3 days showed ossification of alisphenoid (that forms greater wings) and FO seen as large defect. Ossification around the large trunk of mandibular nerve takes place later. Hence the variations observed in shapes and margins of FO indicate bony outgrowth during developmental process. FO is of great surgical and diagnostic importance. Knowledge of the variations of its anatomy may help to better identify and preserve important neurovascular structures during approaches to the middle cranial fossa because surgical treatment of TN is most commonly done by microvascular decompression by percutaneous trigeminal rhizotomy done through FO [17,18]. In a study conducted in china, 100% success rate was achieved when FO was punctured in TN radiofrequency ablation under the guidance of X-ray real time imaging [19]. Moreover electroencephalographic analysis of seizure by electrode placed at FO provided good neurophysiological information in candidates for selective amygdalo-hippocampectomy [09]. Nasopharyngeal carcinoma frequently spreads intracranially via FO (34%) [08]. The CT guided fine needle aspiration technique through FO permits biopsy of deep lesions that otherwise require open surgical biopsy or craniotomy, thus decreasing cost and patient morbidity [20,21].

Conclusion

In the present study, the mean length of FO was 7.27 ± 1.184 mm on right side and 7.46 ± 1.13 mm on left side. Whereas the observed maximum and minimum length was 9.0 mm and 3.0 mm on right side while 9.5 mm and 4 mm on left side. However, the difference between the length of right and left side, was statistically not significant. The Maximum width of FO was 5 mm on both sides, while the minimum width of right and left side was 2.0 mm and 2.5 mm respectively, (Table 1), and the mean width on right side was 3.18 ± 0.62 mm and 3.244 ± 0.75 mm on left side statistically insignificant difference between the two sides. The various shapes of foramen ovale observed were typically oval in 36 (19 right & 17 left), almond in 22 (10 right & 12 left), round in 12 (6 right & 6 left) and slit like in 6 skulls (3 right & 3 left) (Table 2).

This study is of clinical, diagnostic and anatomical significance to medical practitioners in cases of trigeminal neuralgia, detection of tumours, bony outgrowth that may lead to ischaemia, necrosis and possible paralysis of the parts of the body being

supplied, drained or innervated by its contents. And it is of paramount importance in diagnosing any aneurysm or vascular lesions of the cranial cavity. This knowledge will be useful to neurosurgeons for the identification and preservation of the neurovascular structures when using approaches to the middle cranial fossa. Also it is of important for Anatomists & Anthropologists.

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