

Morphometric and Topographic Assessment of Foramen Ovale in Skulls of Jharkhand Population

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ABSTRACT

BACKGROUND

Foramen ovale, situated in the greater wing of sphenoid, posterolateral to the foramen rotundum, transmits the sensory and motor root of mandibular nerve, accessory meningeal artery, emissary vein and lesser petrosal nerve to the infratemporal fossa. The normal shape of the foramen is oval, but its shape and size is quite variable. It plays an important role in the diagnostic and surgical procedures related to the middle cranial fossa. So, knowledge of the variations, dimensions and the topographic location is of importance to the neurosurgeons while dealing with surgeries in this region. Our study aims at finding the morphological variations in shape, dimensions of foramen ovale and its location in relation to the zygomatic arch.

METHODS

A cross-sectional observational study was carried out over a period of one year from 1/6/2018 to 31/5/2019, on 46 adult human skulls, taken from the department of Anatomy, RIMS, Ranchi. Fully dried, intact, adult human skulls were included in the study. Foramen ovale was observed for variation in shape, size and location. The presence of any accessory bony structure like bony plate, spine or septa was looked for and prevalence noted. The maximum antero-posterior length and width of foramen ovale and its distance from articular tubercle and the anterior root of zygomatic arch were measured using Vernier callipers. Pathologically malformed and damaged skulls were excluded from the study.

RESULTS

Four types of shapes were observed – oval (76.08%) , almond (5.43%) , semilunar (8.69%) and triangular (9.78%). The mean anteroposterior dimension of foramen ovale was 6.96 ± 1.17 mm (6.89 ± 1.28 mm on the right side & 7.02 ± 1.05 mm on the left side) and the mean transverse dimension was 3.35 ± 0.66 mm (3.25 ± 0.57 mm on the right side, 3.45 ± 0.73 mm on the left side) . The mean distance of foramen ovale from articular tubercle on zygomatic arch was 32.58 ± 1.29 mm (32.41 ± 1.10 mm on the right side, 32.74 ± 1.45 mm on the left side) and from anterior root of zygomatic arch was 24.75 ± 1.70 (23.91 ± 0.85 mm on the right side, 25.59 ± 1.92 mm on the left side).

CONCLUSIONS

There is no significant average difference between FO_AP_RT – FO_AP_LT. There is no significant average difference between FO Width_RT - FO_Width_LT. There is a significant average difference between FO to Art. Tubercle Right - FO to Art Tubercle left. There is a significant average difference FO to ant. root Right - FO to ant. root left.

KEY WORDS

Foramen Ovale, Middle Cranial Fossa, Mandibular Nerve, Zygomatic Arch, Morphological Variations, Double Foramen Ovale, Partial Septation, Neurosurgeons

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BACKGROUND

The foramina of skull have attracted the attention of anatomists, forensic experts, clinicians and anthropologists mainly because of the variations in their size, shape, location, in most instances being asymmetrical. Foramen ovale is located in the middle cranial fossa in greater wing of the sphenoid bone, posterolateral to the foramen rotundum and anteromedial to foramen spinosum, thereby connecting it to the infratemporal fossa. Motor and sensory root of mandibular nerve, accessory meningeal artery, lesser petrosal nerve and an emissary vein passes through the foramen ovale.¹⁻³ An interesting feature that can be observed is that the foramen ovale, foramen lacerum and line of fusion of body of sphenoid with basilar part of occipital bone lie in the same transverse line. The foramen ovale is not present in the class Reptilia and was acquired in Mammalia during the process of evolution. The foramen is absent in some living mammals including the mammalian embryo, where the semilunar ganglion develops outside the skull and its intracranial position is secondary in ontogeny. So, it was concluded that a separate exit of mandibular nerve through foramen ovale is an advanced character acquired during the evolutionary process.⁴

The sphenoid bone develops from both intramembranous and endochondral ossification centers. The first ossification centre appears for the greater wing of sphenoid by membranous ossification. The mandibular nerve becomes surrounded by cartilage to form the foramen ovale. At 22 weeks of foetal age, the foramen ovale is seen as a distinct ring shaped opening in the area of unossified cartilage which is well recognised by 3 years after birth.^{5,6} Ossification of the ligaments stretching between the lateral pterygoid plate and the spine of sphenoid results in the morphological variation in the form of a double foramen ovale.^{7,8}

Foramen ovale plays an important role in many neurosurgical and diagnostic procedures related to middle cranial fossa. Electroencephalographic analysis of seizure by placing electrode at foramen ovale provided good neurophysiological information in candidates for selective amygdalohippocampectomy.⁹ 100% success rate was achieved in the treatment of trigeminal neuralgia when foramen ovale was punctured with the help of radiofrequency ablation under the guidance of X-ray real time imaging.¹⁰ Foramen ovale permits biopsy of deep lesions of middle cranial fossa such as biopsy of cavernous tumours, percutaneous trigeminal rhizotomy for trigeminal neuralgia due to easy access of the Gasserian ganglion through CT guided fine needle aspiration technique which is better than the open surgical biopsy or craniotomy, thus decreasing cost and patient morbidity.¹¹⁻¹⁴ The present study was carried out to provide proper knowledge of the location, dimensions and variations of foramen ovale in Jharkhand population, which would be of valuable guidance to neurosurgeons while performing various procedures through foramen ovale.

Exact localization of foramen ovale was done by measuring the distance between the foramina and the articular tubercle of zygomatic arch and also the foramina and anterior root of zygoma; since both palpable as surface landmark. These parameters are of immense help in localizing the foramen ovale for various neurological and therapeutic purposes.^{15,16}

METHODS

A prospective observational study was carried out over a period of one year from 1/6/2018 to 31/5/2019, on 46 adult human skulls, taken from the department of Anatomy, RIMS, Ranchi. Fully dried, intact, adult human skulls were included for the study. Pathologically malformed and damaged skulls were excluded from the study. Foramen ovale was observed for variation in shape, size and location on the right and left side of each skull. The morphological observations made were regarding - a) shape of foramen ovale b) the presence of any accessory bony structure like bony plate, spine or septa. The metric measurements were noted and tabulated regarding- a) length and width of foramen ovale measured along its long and short axes respectively, b) distance of foramen ovale from anterior root of zygoma c) distance of foramen ovale from the articular tubercle on zygomatic arch. All measurements were taken using digital Vernier calipers. The metric data of right and left side were analysed using paired samples t-test to look for any significant difference. Specimen showing variations were photographed.

RESULTS

Shape	Right	Left	Total
Oval	37	33	70 (76.08%)
Almond	02	03	05 (5.43%)
Semilunar/D-Shaped	03	05	08 (8.69%)
Triangular	05	04	09 (9.78%)

Table 1. Variations in Shapes of Foramen Ovale

Dimensions	Right Side	Left Side
Anteroposterior length	6.89 ± 1.28 mm	7.02 ± 1.05
Transverse dimension (Width)	3.25 ± 0.57 mm	3.45 ± 0.73 mm

Table 2. Mean and Standard Deviations of the Anteroposterior Length and Width of the Foramen Ovale

Measurement	Right Side	Left Side
Distance	32.41 ± 1.10 mm	32.74 ± 1.45 mm

Table 3. Distance of Foramen Ovale from Articular Tubercle of Zygomatic Arch




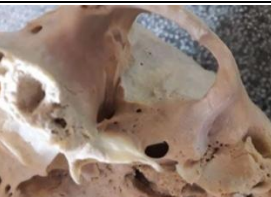

Measurement	Right Side	Left Side
Distance	23.91 ± 0.85 mm	25.59 ± 1.92 mm

Table 4. Distance of Foramen Ovale from Anterior Root of Zygoma

Paired Samples Test									
		Paired Differences							
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		T	Df	Sig. (2-Tailed)
					Lower	Upper			
					Pair 1	FO_Ap_RT- FO_AP_LT			
Pair 2	FO_Width_RT FO_Width_LT	-.19674	.75872	.11187	-.42205	.02857	-1.759	45	.085
Pair 3	FO to Art Tubercle Right FO to Art Tubercle Left	-.32543	1.05878	.15611	-.63985	-.01102	-2.085	45	.043
Pair 4	FO to Ant Root Right FO to Ant Root Left	-1.68891	1.98100	.29208	-2.27720	1.10063	-5.782	45	.000

Table 5. Statistical Analysis

Pair 1: comparison between anteroposterior dimension of foramen ovale of both side
 Pair 2: Comparison between transverse dimension of foramen ovale of both side
 Pair 3: comparison of the distance between foramen ovale and articular tubercle of zygomatic arch of both side
 Pair 4: comparison of the distance between foramen ovale and anterior root of zygoma of both side

	Figure 1. Bilateral Oval Shaped
	Figure 2. Right Side- Almond Shaped, Left Side-Triangular
	Figure 3. Bilateral Triangular Foramina
	Figure 4. Left Side Semilunar/ D-Shaped Foramina
	Figure 5. Ossified Ligament Creating Duplication of Foramen Ovale

There was no significant difference in the measurements of various metric parameters between right and left sides of foramen ovale ($p > 0.05$). However, dimensions of measurements between foramen ovale to articular tubercle and the distance between foramen ovale to anterior root of zygomatic arch of both sides shows significant difference. All the foramina were found located in the greater wing of sphenoid, posterolateral to foramen rotundum. Presence of complete bony septa creating double foramen ovale was seen in 04 skulls; presence of bony spicule/spine in 09 skulls.

Shapes of Foramen Ovale

1) Almond, 2) Semilunar, 3) Triangular shape besides the normal oval shape. The prevalence of different shapes is shown in Table 1.

Presence of Ossified Ligament

Four skulls (4.35%) showed ossification of ligament extending from upper end of lateral pterygoid plate to the spine of sphenoid, creating double foramen ovale (Figure 5).

Presence of Bony Spicules

Bony spicules were observed in 09 skulls (9.78%) which were partially dividing the foramen ovale.

Dimensions of Foramen Ovale

The mean anteroposterior dimension of foramen ovale was 6.89 ± 1.28 mm on Right side and 7.02 ± 1.05 mm on left side and the mean transverse dimension (width) was 3.25 ± 0.57 mm on Right side, 3.45 ± 0.73 mm on left side. There was no significant difference in the anteroposterior length and width of foramen ovale between the right and left sides ($p > 0.05$).

After application of paired t test for mean difference of following parameters of right and left side we found that-

1. There was no significant average difference between FO_AP_RT - FO_AP_LT as $t_{45} = -0.58$, $p = 0.563$.
2. There was no significant average difference between FO Width_RT - FO_Width_LT as $t_{45} = -1.76$, $p = 0.085$.
3. There was a significant average difference between FO to Art. Tubercle Right - FO to Art Tubercle left as $t_{45} = -2.08$, $p = 0.043$.
4. There was a significant average difference FO to Ant root Right - FO to ant root left as $t_{45} = -5.78$, $p = 0.000$.

DISCUSSION

Foramen ovale is one of the important foramina situated in the greater wing of sphenoid bone through which middle cranial fossa can be approached for micro neuro surgical and diagnostic procedures without performing craniotomy. So the knowledge of anatomical variations, location and dimensions of foramen ovale is essential for surgeons. In the present study, 14% of skulls showed accessory bony structures around foramen ovale; bony spicules/spines dividing the foramen partially were observed in 9.78% of cases and complete septum dividing the foramen into two parts was observed in 4.35% of cases. Presence of bony structures around the foramen ovale may complicate the anatomical organization of the nerves transmitted through the foramen namely mandibular and lesser petrosal nerves which often results in the lateral disposition of mandibular nerve resulting in the entrapment of its branches between bony structure and the neighbouring muscles which might lead to neuralgia.¹⁷

The size of the foramen ovale in the present study was determined by measuring maximum anteroposterior length and maximum transverse dimension i.e. width. The anteroposterior length ranged from 4.63 mm to 9.5 mm on the right, 4.17 mm to 9.5 mm on the left whereas width ranged from 2.0 mm to 4.58 mm on the right and 2.15 mm to 4.8 mm on the left. Narrow size of foramen ovale is a common manifestation in the clinical scenario of Paget's disease or Osteopetrosis.¹⁸ The average anteroposterior length and width of foramen ovale were 6.96 ± 1.17 mm and 3.35 ± 0.66 mm respectively. Our results coincided with the study of Suniti Raj Mishra et al., where the mean length was 7.5 mm and width was 4.2 mm.¹⁹ The anteroposterior length of the present study was lesser than the study by Magi Murugan et al., where it was 8.4mm. ⁵ Karishma Ravinthar et al. reported the mean length on right side as 6.7 mm and left side 5.7 mm

which were less when compared to the results of the present study whereas width was 3.56 mm on right side and 4.28 mm on left side, which were more compared to our results.²⁰ Also the results of the present study tally with the findings of B Sadananda Rao et al with mean length 7.17 ± 0.94 mm (7.24 ± 0.89 mm on the right side and 7.11 ± 1.00 mm on the left) and the mean width was 3.75 ± 0.69 mm (3.75 ± 0.71 mm on the right side 3.75 ± 0.67 mm on the left).

Pinpoint localization of foramen ovale was done by measuring its distance from the articular tubercle of zygomatic arch and also the anterior root of zygoma. These parameters are of immense help in penetrating procedures to reach the structures passing through it, as any failure in this may often lead to the injury to the structures nearby, including fatal haemorrhage in the temporal lobe of the brain.²¹ Hence with skin markers and image intensifiers techniques, these parameters will be helpful for above mentioned surgical invasive procedures.²¹⁻²³ However, one should always remember that these parameters are not similar in all individuals as the location of zygomatic point in Korean population and in population of certain western countries often varies.²⁴

CONCLUSIONS

There is no significant average difference between FO_AP_RT - FO_AP_LT. There is no significant average difference between FO Width_RT - FO_Width_LT. There is a significant average difference between FO to Art. Tubercle Right - FO to Art Tubercle left. There is a significant average difference FO to ant. root Right - FO to ant. root left. Knowledge of morphometric and morphological variations of foramen ovale is of importance to neurosurgeons while performing procedures like percutaneous trigeminal rhizotomy in trigeminal neuralgia.

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