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Original Article

A Morphometric Study of Variations in Cranial Foramen Ovale in Dry Human Skulls

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ABSTRACT

Background: The cranial foramina transmit critical neurovascular structures. The foramen ovale, which allows passage of the mandibular nerve and associated vessels, is of particular clinical importance during procedures such as trigeminal nerve block, percutaneous rhizotomy and other middle cranial fossa interventions. Variations in its morphometry may influence surgical access and radiological interpretation.
Aim: To evaluate the morphometric variations of cranial foramina with special emphasis on the foramen ovale in dry adult human skulls.
Materials and Methods: This descriptive observational study was conducted on 32 dry adult human skulls of unknown age and sex obtained from the Department of Anatomy, G.S. Medical College & Hospital and Rama Medical College & Hospital. The foramen ovale was examined bilaterally for shape, size, symmetry and presence of accessory foramina or unusual features. Shapes were categorized as oval, round, almond-shaped, or irregular. Observations were documented and analyzed using descriptive statistics.
Results: Considerable variation in the morphometry of the foramen ovale was observed. On the left side, oval shape was seen in 9 skulls (28.1%), round in 2 (6.25%), almond-shaped in 3(9.4%) and irregular in 2(6.25%).On the right side, oval shape was noted in7 skulls (21.9%), round in 3 (9.4%), almond-shaped in 5 (15.6%), and irregular in1 (3.1%). Bilateral asymmetry was present in 19 skulls (59.4%). Accessory foramen ovale was identified in 2 skulls (6.25%), and partial fusion with the foramen spinosum was observed in 1 skull (3.1%).
Conclusion: The foramen ovale demonstrates significant morphometric variability. Detailed anatomical knowledge of these variations is essential to enhance surgical precision and reduce procedural complications**.**

Keywords: *Foramen ovale, cranial foramina, skull variations, middle cranial fossa.*

INTRODUCTION

The middle cranial fossa has many openings (foramina). The sides of this area are mainly formed by the greater wing of the sphenoid bone. On the lower surface of the greater wing of the sphenoid, the foramen ovale is located in front of the foramen spinosum. The foramen spinosum lies slightly in front of and toward the middle of the pointed part of the greater wing, called the spine of the sphenoid bone.[1,2]. The foramen ovale transmits the mandibular nerve, accessory meningeal artery, lesser petrosal nerve and emissary veins.

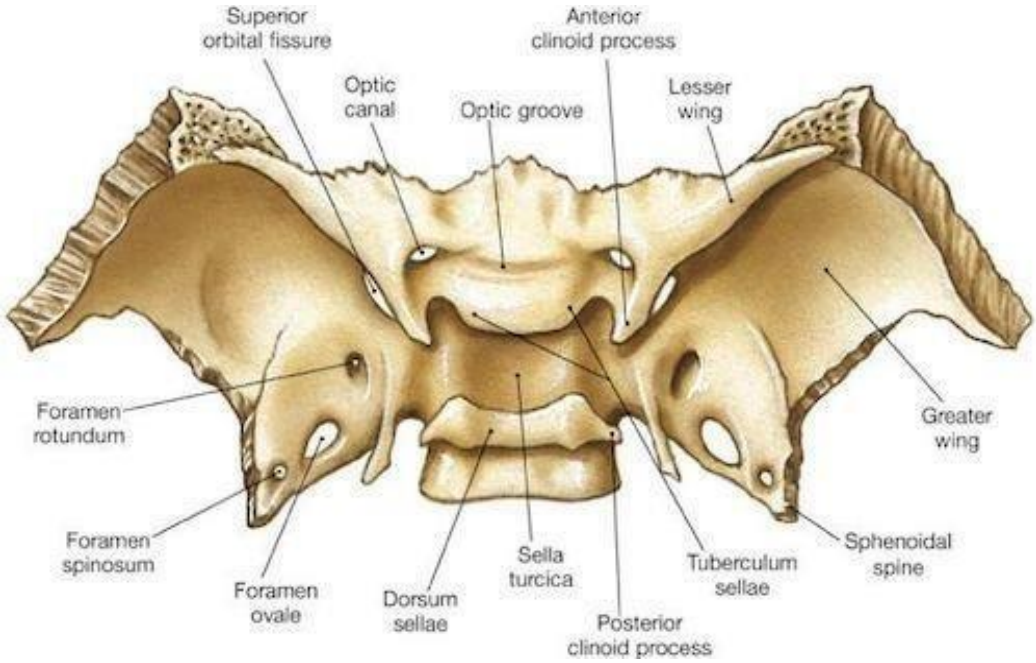

Fig.1Sphenoid Bone showing Foramen ovale.

Due to its functional importance, the foramen ovale is frequently accessed during neurosurgical procedures such as percutaneous trigeminal rhizotomy, balloon compression, and nerve block techniques for trigeminal neuralgia and skull base surgery.

The Morphometry of the foramen ovale is known to vary in shape, size, symmetry, and number. Developmental factors, ossification patterns of the sphenoid bone, and vascular influences may contribute to these variations. Such anatomical differences may pose challenges during surgical cannulation or radiological interpretation, potentially increasing the risk of procedural complications. The present study aims to observe and document the morphological variations of cranial foramina, with special emphasis on the foramen ovale, in 32 dry adult human skulls.

MATERIALS AND METHODS

Study Design

A descriptive observational study.

Study Material

The study was conducted on 32 dry adult human skulls obtained from the Department of Anatomy. G S Medical College & Hospital, Hapur and Rama Medical College & Hospital, Hapur. Skulls showing gross damage or deformity were excluded.

Methodology

- Each skull was carefully examined in the middle cranial fossa.
- The foramen ovale was observed on both sides for:
  - Shape and Size.
  - Symmetry.
  - Presence of accessory foramina.
  - Duplication or fusion with adjacent foramina.
  - Two measurements of each foramen size were taken and average of that has been taken with the help of digital caliper.
  - We have also measured the distance of foramen ovale from medial pterygoid plate.
- Findings were recorded and tabulated**.**

RESULTS

Foramen Ovale Variations

Out of 32 skulls examined:

Table.1Different shapes of the 32skulls observed with their percentage.

Shape of Foramen Ovale	Number of Skulls (%)	
	Left side	Right side
Oval	9 (28.1%)	7 (21.9%)
Round	2 (6.25%)	3 (9.4%)
Almond-shaped	3 (9.4%)	5 (15.6%)
Irregular	2(6.25%)	1 (3.1%)

- Asymmetry between right and left sides was observed in19 skulls (59.4%).
- Accessory foramen ovale was noted in 2 skulls (6.25%).
- Partial fusion with foramen spinosum was observed in 1skull (3.1%).

Table.2 Different size of Foramen ovale (Left and Right) with distance from medial pterygoid plate (MPP).

S. No	Foramen Ovale				Distance from MPP (mm)	
	Length(mm)		Breadth(mm)			
	Left	Right	Left	Right	Left	Right
1	8	8.2	3.23	3.5	3.68	3.7
2	7.94	7.44	3.57	3.79	4.61	4.94
3	7.37	7.29	5.82	5.92	3.79	3.9
4	7.9	7.95	3.28	3.62	5.98	5.8
5	4.58	4.87	2.71	4,89	5.44	6.10
6	5.80	6.14	3.51	6.1	5.85	6.15
7	5.97	7.70	3.96	3.99	9.15	6.7
8	7.47	7.46	4.63	4.69	7.47	7.03
9	9.25	8.46	5.18	5.48	7.19	6.50
10	8.08	7.49	5.03	5.54	6.8	4.95
11	6.7	6.95	5.3	5.83	8.24	7.85
12	7.2	7.03	4.55	4.98	7	6.78
13	7.65	8.07	3	3.45	5.63	5.97
14	7.05	8.90	3.96	4.73	6.2	6.4
15	7.70	7.75	5.41	5.45	7.7	7.82
16	8.64	8.03	6.65	5.08	6.54	5.97
17	6.4	6.45	6.24	6.26	6.5	6.65
18	7.2	6.56	6.54	6.78	6.8	6.67
19	6.56	6.92	6.8	6.9	5.9	5.79
20	7.1	6.89	6.9	6.26	6.35	6.45
21	6.7	7	6.72	6.54	6.4	6.54
22	8.1	8.3	4.9	4.56	6.8	6.68
23	4.02	5.52	3.94	3.95	6.14	7.3
24	5.83	5.97	4.2	4.23	6.7	6.8
25	6.35	6.43	3.98	3.96	6.5	6.48
26	7	6.9	4.18	4.29	6.85	6.72
27	7.4	7.68	4.86	5.28	7.24	7.02
28	7.93	5.53	4.96	3.78	6.34	6.86
29	9.3	7.14	4.46	4.70	6.90	4.57
30	6.91	7.36	3.68	3.84	7.44	7.62
31	9.68	8.66	5.15	7.65	7.98	7.69
32	6.90	7.26	3.9	3.88	6.85	6.9

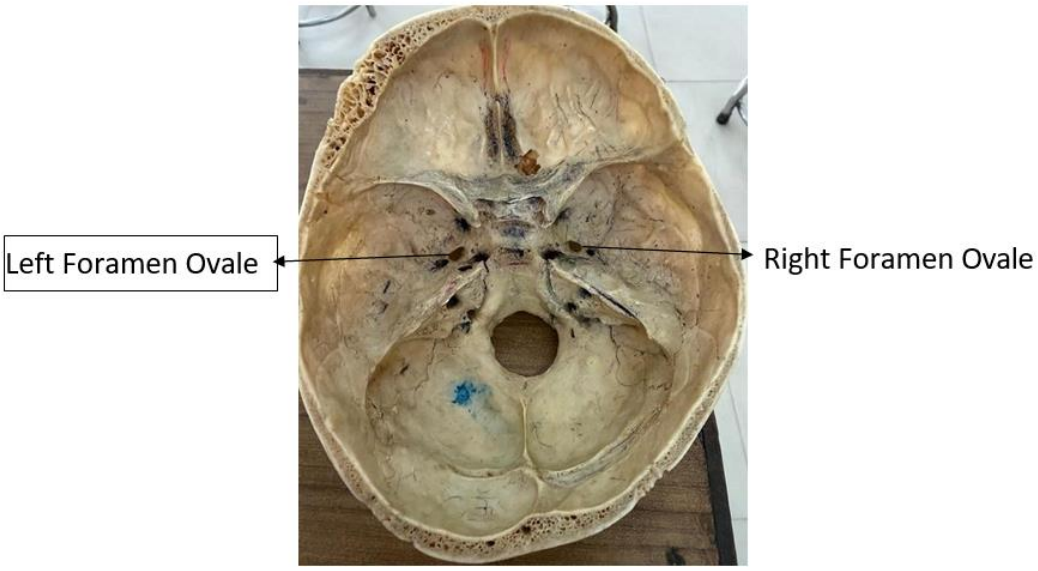

Fig.2 Foramen ovale showing oval shapes.

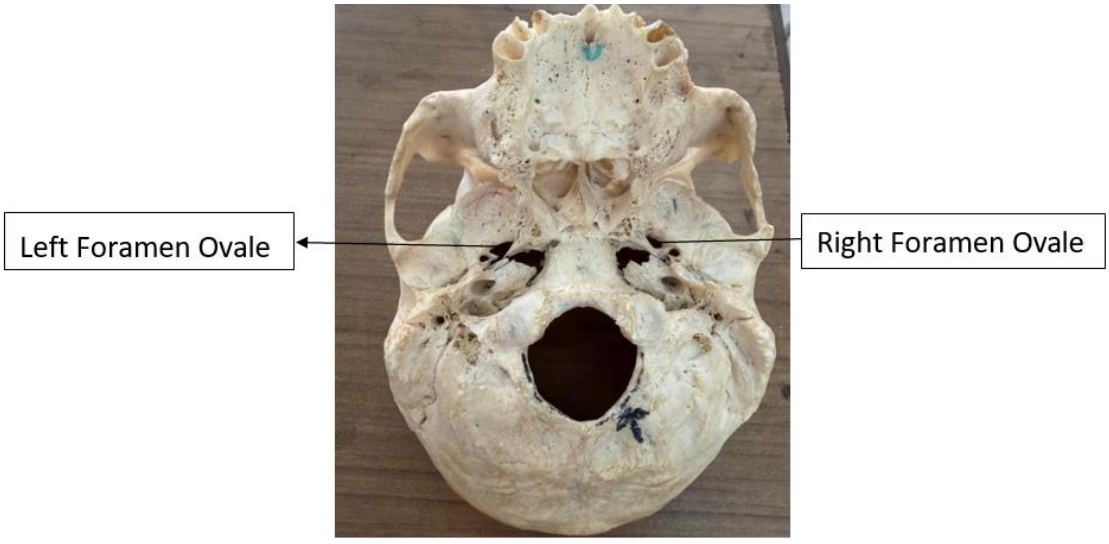

Fig.3 Base of Skull shows Foramen Ovale with almond shapes.

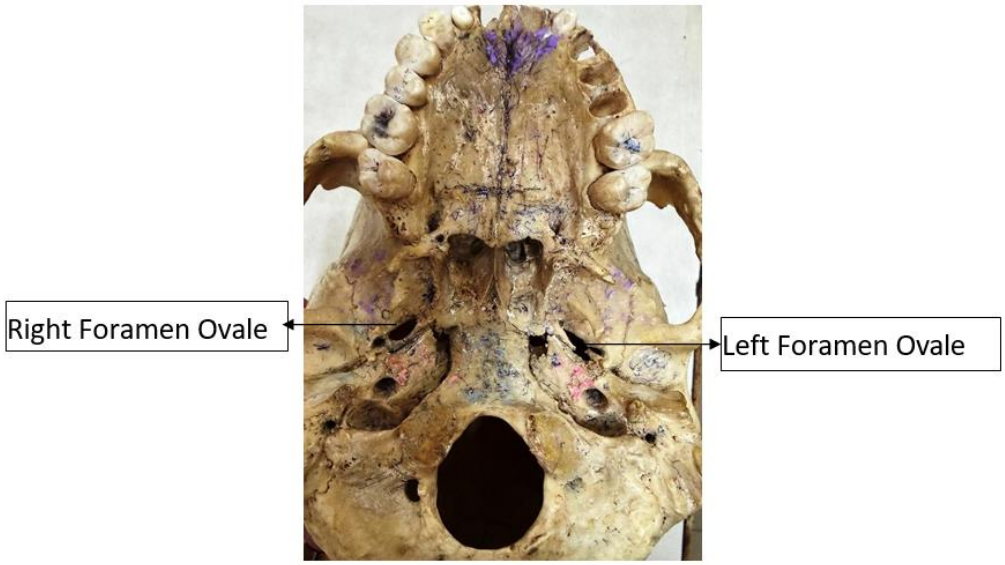

Fig.4 Base of Skull shows foramen ovale with large oval in right and slit like in left.

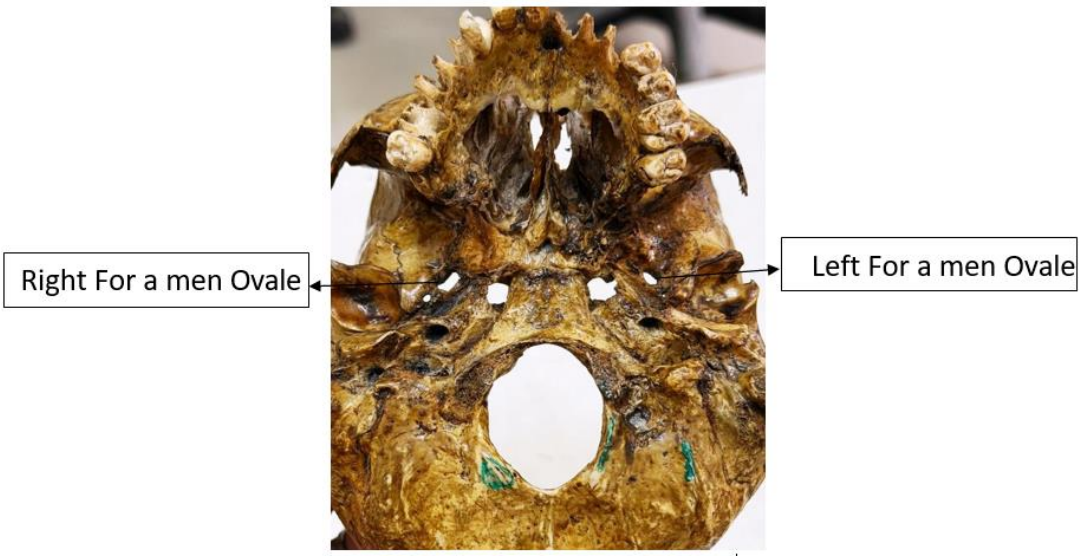

Fig.5 Foramen Ovale showing irregular shape in right and oval shape in left and different size.

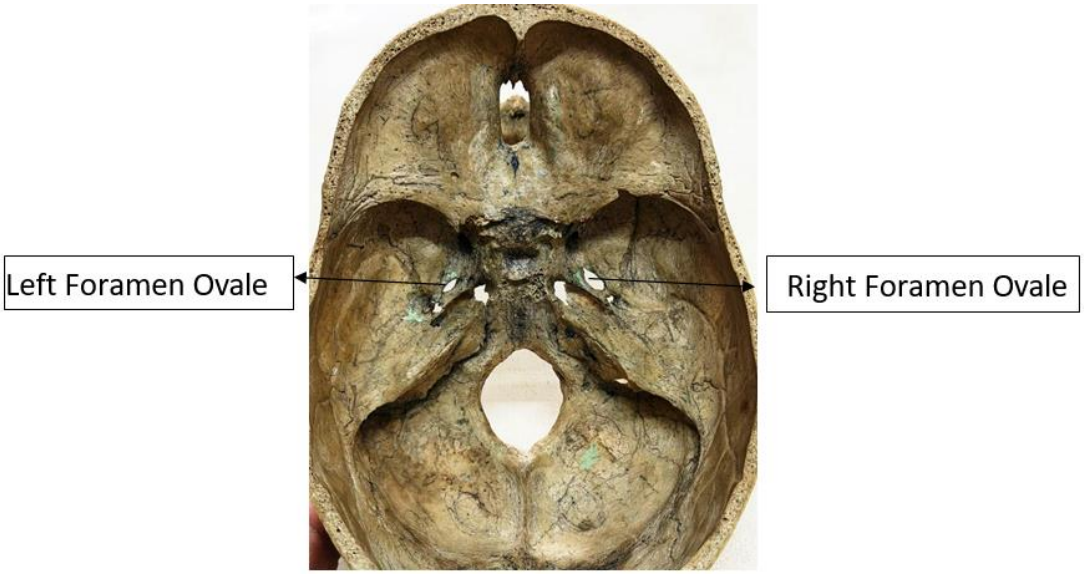

Fig.6 Foramen Ovale showing large almond shape in right and small oval in left.

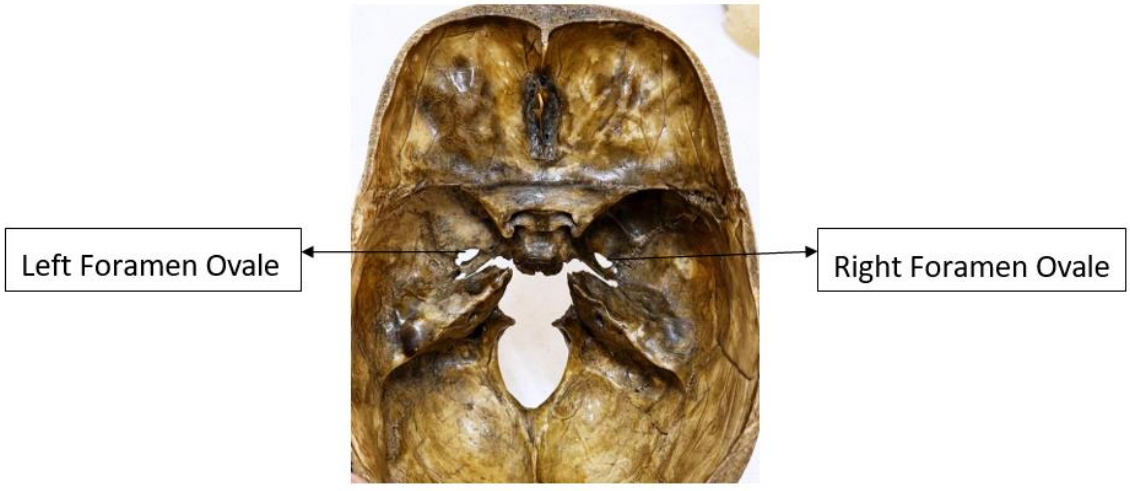

Fig.7 Foramen Ovale showing almond shapes and left Foramen Ovale fused with left Foramen Spinosum.

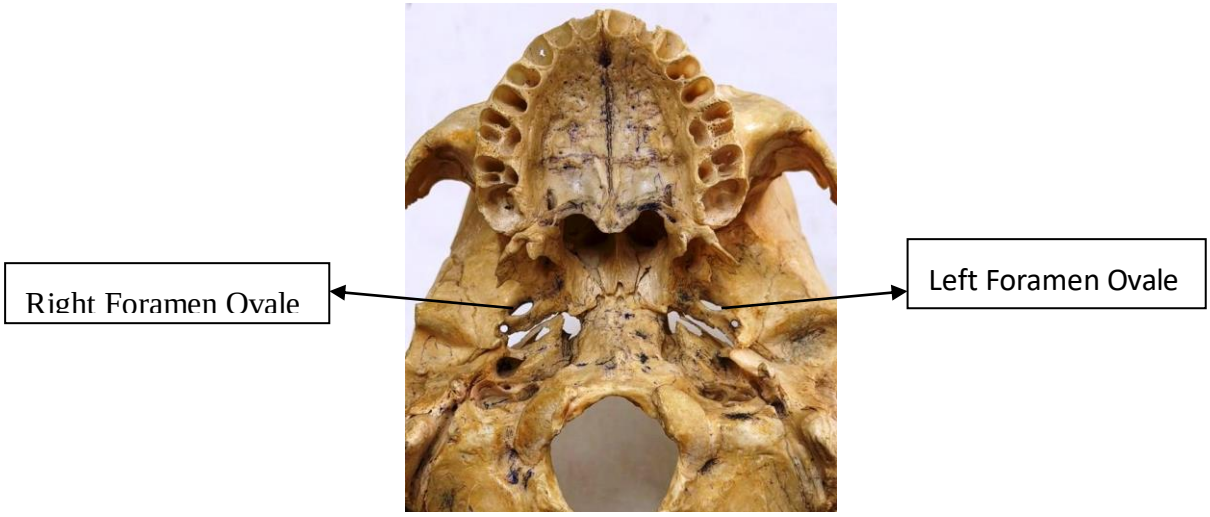

Fig.8 Base of Skull showing Foramen Ovale with almond shapes.

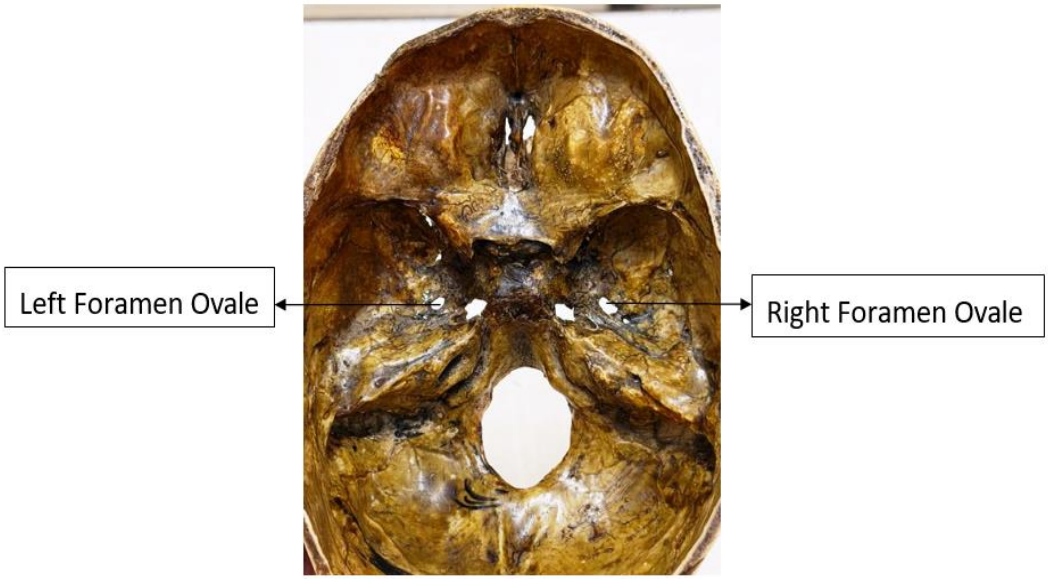

Fig. 9 Middle Cranial fossa showing Foramen Ovale having round shape in left and rectangular in right.

Fig. 10 Picture shows digital caliper measuring foramen ovale.

DISCUSSION

The morphometric and anatomical importance of the foramen ovale in skull base procedures has been emphasized in classical anatomical descriptions and clinical studies. [1, 2, 3] Detailed knowledge of its variations is particularly important during procedures such as percutaneous trigeminal rhizotomy and other skull base interventions. [4, 5]

The present study demonstrated considerable morphological variability of the foramen ovale. The oval shape was the most common on both sides, consistent with findings reported in previous osteological studies. [6, 7, 8, 9, 10] However, round, almond-shaped and irregular forms were also observed, indicating significant anatomical diversity. Similar variations in shape have been described in previous anatomical investigations. [9, 11, 12]Asymmetry between the right and left sides was observed in 59.4% of skulls in this study. Comparable asymmetry has been documented in earlier investigations. [13, 14, 15, 16] These findings suggest that bilateral uniformity of the foramen ovale cannot be assumed clinically. Such asymmetry may influence the ease of needle placement during percutaneous procedures involving the trigeminal nerve.[4, 11] Accessory foramina were observed in 6.25% of skulls. Similar incidence shave been reported in previous studies. [17, 18, 19] Accessory foramina may result from developmental variations in ossification or persistence of vascular channels. [17, 18] Their presence is clinically relevant, as they may lead to misinterpretation on radiological imaging or inadvertent injury during surgical intervention.[5, 11]Partial fusion of the foramen ovale with the foramen spinosum was noted in one skull. Close approximation or fusion of these foramina has also been reported in earlier anatomical studies.[17, 18] Such variations may alter normal anatomical landmarks used during neurosurgical approaches to the middle cranial fossa. [2, 3] Overall, the findings of this study reinforce the importance of a thorough anatomical understanding of the foramen ovale. Preoperative imaging assessment and awareness of possible morphological variations can improve procedural accuracy and minimize complications during interventions involving the middle cranial fossa.[5, 11].

Table.3 Comparison Table of Foramen Ovale Morphology with Previous Studies.

Study	Sample Size	Most Common Shape	Accessory Foramina (%)	Asymmetry (%)
Lang etal (2000)	40 skulls	Oval	5%	50%
Kaur etal (2011)	60 skulls	Oval	7%	60%
Yadav etal (2014)	50 skulls	Oval	8%	56%
Tubbs etal (2016)	100 skulls	Oval	4%	52%
Present study	32 skulls	Oval	6.25%	59.4%

Note: The present study is consistent with previous findings, showing oval as the most frequent shape but highlights higher asymmetry in the sample studied.

Such variations are clinically important as they may lead to difficulty in cannulation of the foramen ovale, misinterpretation in radiological imaging or complications during surgical interventions involving the trigeminal nerve.

CONCLUSION

The foramen ovale exhibits marked morphometric variability in shape, symmetry and presence of accessory foramina. Oval shape predominates, but round, almond- shaped and irregular forms are also encountered. Bilateral asymmetry is common, observed in more than half of the skulls. Accessory foramina and rare fusion with the foramen spinosum, although uncommon, have significant clinical implications for neurosurgeons, radiologists, and pain specialists. Awareness of these variations combined with careful preoperative imaging, can reduce procedural complications during interventions in the middle cranial fossa. The study highlights that variations in the foramen ovale are common and should be carefully considered during clinical and surgical procedures involving the middle cranial fossa. Detailed anatomical knowledge of these emphasizes the importance in both diagnostic and surgical applications which can help reduce iatrogenic injuries.

Clinical Significance

- Useful for neurosurgeons performing trigeminal nerve procedures.
- Important for radiologists interpreting skull base imaging.
- Valuable for anatomists and medical students.

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