

A Morphometric Study of Foramen Ovale in Dried Human Skulls

ZAHRA HAIDER BOKHARI¹, MAHJABEEN MUNIRA², S. M. SAMEE³, RAAFEA TAFWEEZ⁴

ABSTRACT

Background: The foramina of the skull & the variations in their size & shape are of immense clinical significance due to the neurovascular structures that pass through them. The knowledge of these variations helps in the correct interpretation of radiographs & can help the surgeon in operating this area.

Aim: To study the morphological & morphometric details & variations in foramen ovale in dried human skulls.

Methods: Fifty five adult human skulls were obtained from the bone bank of King Edward Medical University. The foramen ovale was examined to assess its length, breadth, shape & presence of any accessory bony structures like a spine, tubercle, bony plate or septum. The area of the foramen was calculated from the values obtained.

Results: In our study the shape of foramen ovale was oval in 72.7% on right & 74.5% on left side & was round in 16.3% on right & 12.7% on left side. A bony spine was present in 5 skulls, bony plate in 4 skulls & an osseous lamina in one skull. The mean length of foramen ovale on right side was 7.04 ± 1.08 & on the left side was 7.18 ± 1.14 . The mean width of the foramen on the right side was 5.15 ± 0.92 & left side was 3.99 ± 0.86 .

Conclusions: Foramen ovale is subjected to a wide range of variations in size, shape & the presence of accessory bony structures from its margins. These variations might have profound surgical & diagnostic importance.

Keywords: Variations, Foramen ovale, greater wing of sphenoid, mandibular nerve, trigeminal neuralgia.

INTRODUCTION

Foramen ovale is one of the several foramina present on the base of the skull¹. It is an oval osseous aperture with its long axis directed anteriorly & laterally. It is present in the greater wing of sphenoid bone, near the superior end of posterior margin of lateral pterygoid plate². It lies posterolateral to the foramen rotundum, anteromedial to the foramen spinosum, & lateral to foramen lacerum. It connects the infratemporal fossa with the middle cranial fossa³. It transmits the mandibular division of the trigeminal nerve, the lesser petrosal nerve, the accessory meningeal artery & an emissary vein that connects the cavernous sinus with the pterygoid venous plexus. The otic ganglion lies immediately below the foramen in the infratemporal fossa⁴. As the mandibular nerve occupies most of the space in this foramen, any abnormal osseous protrusions arising from its margins may compress the nerve. It may provoke paraesthesia or neuralgia if it compresses the sensory branches of the nerve whereas

compression of the motor component of the nerve may lead to weakness or paresis of the innervated muscles⁵. The sphenoid bone (having a body, a pair of greater wings & a pair of lesser wings) develops by both intra-membranous & endochondral ossification. The body of sphenoid (basisphenoid) develops mainly from presphenoid & postsphenoid centers. It is the postsphenoid center in the body which is associated with the development of the greater wing of sphenoid that lodges foramen ovale. The greater wing is formed by endochondral ossification – the mandibular nerve gets surrounded by cartilage to form this foramen⁶.

Entrapment of mandibular nerve as it crosses the foramen ovale is hypothesized to be the primary cause of trigeminal neuralgia. Several studies have shown that the foramen ovale on the right side is narrower compared to the left. This could be the possible reason for a higher incidence of trigeminal neuralgia on the right side⁷. Anatomical knowledge of foramen ovale is important for several neurosurgical & diagnostic procedures related to middle cranial fossa. This foramen helps to access the trigeminal nerve when administering anaesthesia to the mandibular nerve. It enables percutaneous biopsy of a cavernous sinus tumours, CT guided transfacial FNAC techniques for the diagnosis of meningiomas, squamous cell carcinoma & Meckel cave lesions. The

¹Associate Professor Anatomy dept. KEMU.

²Associate Professor Anatomy, KEMU, Lahore.

³Associate Professor Anatomy Department, Ghazi Khan Medical College, D.G. Khan.

⁴Professor of Anatomy, KEMU.

Correspondence to Dr. Zahra Haider Bokhari; 81, 2 C 1, Township, Lahore. Cell No: 03214465981. Email zabokhari59@yahoo.com

foramen also serves as a route of spread of nasopharyngeal carcinoma inside the cranial cavity⁸.

The position & location of foramen ovale is important in these diagnostic procedures. Presence of atypical foramina ovalia may lead to atypical morphometry which may hinder these procedures leading to several clinical complications. Hence prior knowledge of variation in the foramen have to be kept in mind.

MATERIALS & METHODS

After taking approval from the Ethical review board of the institution; This study was carried out on fifty five adult human skulls of unknown gender obtained from the bone bank of King Edward Medical University, Lahore. The greater wing of sphenoid bone was examined for the presence of foramen ovale. The patency of the foramen was checked by passing a probe through it to reach the infra temporal fossa. Skulls in poor condition or the ones that were fractured or damaged in the area of greater wing of sphenoid bone or in which the foramen were occluded were excluded from the study. The parameters studied were:

- Shape of the foramen
- Presence of any abnormal bony structure like a tubercle, a spine, septa or bony plate.
- Length of the foramen (maximum anteroposterior diameter)
- Width of the foramen (maximum transverse diameter)

The length & breadth of the foramina were taken by placing a pair of dividers on the transverse & anteroposterior diameters & then carefully transferring this measurement to a meter scale for readings. From these values area "A" of the foramina was calculated by using the formula $(\pi \times L \times B) / 4$ or $[(3.142 \times L \times B) / 4]$ ⁹. Photographs were taken.

RESULTS

Morphology: This study was carried out on 110 foramen ovale from 55 dry adult human skulls. Various shapes of the foramen were observed out of which it was typically oval in 81 sides (40 right & 41 left. Table 1). Around foramen ovale was found in 16 sides (9 right & 7 left, Table 1, Fig. 5,1), an almond shaped foramen was seen in 05 halves of skulls (3 right & 2 left Table 1). A triangular shaped foramen ovale was present in 05 sides (2 right & 3 left) & a slit like foramen was observed in 01 skull on the right side (Table 1, Fig.2). In one skull each, a diamond shaped & an irregular shaped foramen, both on the left side were seen (Fig. 1 & 4 respectively). A bilateral oval foramen ovale was found in 35 (63.6%)

skulls, a bilateral round foramen was present in one (1.8%) skull & a bilateral triangular foramen was also present in one skull (1.8%) (Fig. 3). In 05 skulls (3 right & 2 left (Table 1, Fig. 5) a spine was projecting from the margin of the foramen. A bony plate was projecting into the foramen in 4 sides (2 right & 2 left) & an osseous lamina was dividing the foramen into two halves in one skull on the left side (Table 2).

Morphometry: In our study the mean length of foramen ovale on the right side was 7.04 ± 1.08 mm & 7.18 ± 1.14 mm on the left side (Table 3). The observed maximum & minimum length of foramen ovale was 10 & 4.4 mm on the right side & 11 & 4.6 mm on the left side respectively (Table 3). However the difference between the lengths of the foramen on the two sides was not statistically significant. The mean width of foramen ovale was 4.15 ± 0.92 mm on the right side & 3.99 ± 0.86 mm on the left side (Table 3). The maximum width on the right side was 6 mm on the right & 6 mm on the left side. The minimum width was 2.00 mm on the left side 2.1 mm on the right side sides (Table 3). There was no significant difference in the width of the foramen on two sides. The mean area based on the formula mentioned above was 21.7 ± 4.94 mm² on the right side & 21.08 ± 4.69 mm² on the left side. There was no statistically significant difference between the two sides (Table 3).

Data analysis of the obtained values was carried out using Statistical Package for Social Sciences (SPSS) version 16. Mean & standard deviation of each measurement was calculated. Differences between right & left sides were analyzed. Student's t-test & Pearson's coefficient test were used to analyze the data and p value < 0.05 was considered statistically significant.

Fig.1: Right round shaped (white arrow) & left diamond shaped (red arrow) foramen ovale



Fig. 2: Right triangular (white arrow) & left slit like (red arrow) foramen ovale



Fig. 4: Right triangular (red arrow) & left irregular shaped (white arrow) foramen ovale



Fig.3: Bilateral triangular foramen ovale



Fig. 5: Spine projecting from the margin of right foramen ovale (red arrow), left oval foramen ovale (white arrow).

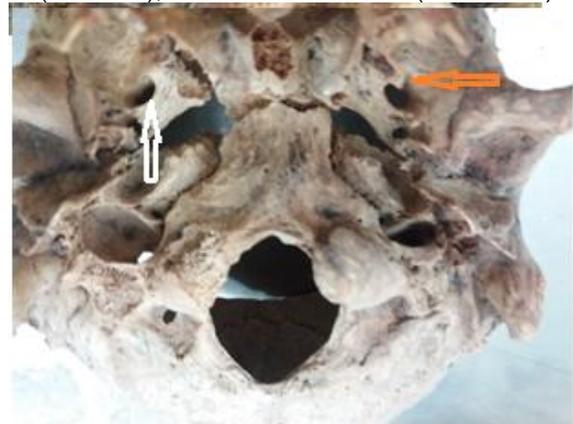


Table 1: Variations in shape of foramen ovale

Shapes	RIGHT SIDE	LEFT SIDE
Oval	40(72.7%)	41(74.5%)
Round	9(16.3%)	7(12.7%)
Almond	3(5.4%)	2(3.6%)
Triangular	2(3.6%)	3(5.4%)
Slit like	1(1.8%)	0
Diamond	0	1(1.09%)
Irregular	0	1(1.09%)

Table 2: Incidence of Accessory bony structures in Foramen Ovale

Accessory bony structures	RIGHT SIDE	LEFT SIDE
Spine	3(5.4%)	2(3.6%)
Bony plate	2(3.6%)	2(2.6%)
Osseous lamina	0	1(1.09%)

Table 3: Length & Width of foramen ovale on two sides

Values	Length		Width		Area	
	Right	Left	Right	Left	Right	Left
Maximum	10	11	6	6	32.97	31.4
Minimum	4.4	4.6	2	2.1	13.5	13.1
Mean	7.04	7.18	4.15	3.99	21.74	21.08
Standard deviation	1.08	1.14	0.92	0.86	4.94	4.69
p value	>0.05		>0.05		>0.05	

DISCUSSION

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 procedure¹⁰. This would help to decrease patient morbidity & also reduce the cost significantly.

In our study with regards to variation in shape of the foramen, the oval shape was the commonest, 73.6% followed by round, almond shaped, triangular, irregular, diamond shaped & slit like shapes. Similar findings have been reported by other researchers in their studies^{9,11}. Our findings were consistent with those of Patel & Mehta¹² who, in their study on 200 foramina have reported an oval shaped foramen in 69.5% round in 27.5% & almond shaped in 12% foramina. An irregular foramen was mentioned in two studies^{13,14}. A triangular foramen that we reported in our study was not reported by any of the above mentioned studies.

In a study carried out in India in 2016 they observed bilaterally symmetrical foramen ovale in 30 out of 50 skulls; of which bilateral oval was present in 24 and bilateral almond shaped was present in 4 skulls¹⁵. Sharma & Garud have reported a bilateral oval in only 15 out of 35 skulls while bilateral almond shaped was present in 7 cases¹. We also observed bilateral oval foramen in 63.6% cases, while bilateral round & bilateral triangular was observed in 1.8% each. Bilateral round & bilateral triangular that we reported in our study was not mentioned in the studies quoted above.

We observed bony outgrowths in the form a spine & bony plate arising from the margins of foramen ovale. In one skull the foramen was divided into two halves by a bony septum. Similar findings have been reported by other studies¹⁷. It is claimed that these osseous deformities indicate bony outgrowth during the process of development¹⁸.

Several studies on the morphometry of the foramen ovale have been carried out worldwide. A study in India has reported a mean antero-posterior length of 7.0±2.17mm on right side and 6.8±1.40mm on left side¹⁹. Similar length of the foramen has been reported by other studies^{20,21} these findings corroborated with ours. We reported maximum length of the foramen was 10 mm on the right & 11 mm on the left side & the minimum length was 4.4 on the right & 4.6 on the left side. similar findings were quoted in another study²².

The mean width of the foramen ovale in our study was 4.15±0.92 mm on the right side & 3.99±0.86mm on the left. Similar results have been mentioned by Mishra in his study on 50 skulls (8.3). Other studies also mention results close to ours^{23,24}.

The mean area observed in an Indian study was 30.808±7.545 mm² on the right & 31.310±8.262 mm² on the left side²⁵. Similar results were mentioned in another study⁹. Our study showed different results. This difference could be attributed to ethnic & racial variations.

This study is of importance to surgeons & anatomists as it present anatomical variations in dimensions & shape of foramen ovale. A surgeon has to be aware of these variations as the bony obstructions can interfere with needle placement into the foramen in diagnostic detection of tumours, trigeminal neuralgia etc. From a radiological point of view, these changes can be misinterpreted as morbid changes even though they are variations in normal anatomy. Failure to cannulate the foramen properly may lead to severe adverse effects.

REFERENCES

1. Stozitzky N. & RUEDA-ESTEBAN R. Morphometric study of five constant skull base foramina in the muisca population of the tibanica anthropological collection of the universidad de losandes. *Int. J. Morphol.* 2016;34(4):1313-1317,.
2. Standring, S. Middle cranial fossa. In: Gray's anatomy. 40th Ed. Elsevier Churchill Livingstone, New York, 2008. pp.418.
3. Khairnar K. B. and Bhusari P. A. An Anatomical Study on the Foramen Ovale and the Foramen Spinosum. *J ClinDiagn Res.* 2013;7(3): 427-429.
4. Sepahdari AR¹, Mong S. Skull base CT: normative values for size and symmetry of the facial nerve canal, foramen ovale, pterygoid canal, and foramen rotundum. *SurgRadiol Anat.* 2013;35(1):19-24
5. Skrzat J., Walocha J., Zawiliński J. Accessory spine of the foramen ovale. *Folia Morphol.* 2012;71(4):263-266
6. John D A, Thenmozhi. Anatomical Variations of Foramen ovale *J. Pharm. Sci. & Res.* 2015; 7(6):327-329
7. Liu P, Zhong W, Liao C, Liu M, Zhang W. Narrow Foramen Ovale and Rotundum: A Role in the Etiology of Trigeminal Neuralgia. *J Craniofac Surg.* 2016; 27(8):2168-2170.
8. Srimani P et al. Foramina in Alisphenoid - An Observational Study on Their Osseo-Morphology and Morphometry. *International Journal of Anatomy, Radiology and Surgery*, 2014;3(1):1-6
9. Somesh M.S. et al. A Morphometric Study of Foramen Ovale. *Turkish Neurosurgery.* 2011; 21(3):378-383
10. Herta1 J et. Al. An experimental animal model for percutaneous procedures used in trigeminal neuralgia. *ActaNeurochir.* 2017;17:3162

11. Burdan F. et al. Anatomical variances and dimensions of the superior orbital fissure and foramen ovale in adults. *Folia Morphol.*, 2011; 70(4):263–271
12. Patel R, Mehta CD () Morphometry of Foramen Ovale at base of skull in Gujarat IOSR Journal of Dental and Medical Sciences. 2014;13(6): 26-30
13. Somesh MS, Sridevi HB, Prabhu LV, Gangadhara Swamy MS, Krishnamurthy A, Murlimanju BV, et al. A Morphometric study of foramen ovale. *Turkish Neurosurgery.* 2011; 21(3): 378-83.
14. Desai SD, Shaik HS, Muralidhar PS, Thomas ST, Mavishettar GF, Haseena S. Morphometric analysis of foramen ovale. *J Pharm Sci& Res.* 2012; 4(7): 1870-1.
15. Suniti Raj Mishra^{1*}, Sushobhana², Shailendra Singh³, Raveena Singh⁴, AnamikaGaharwar.. Morphometric and Topographic Study of Foramen Ovale in Indian Skulls. *Malaysian Journal of Medical and Biological Research.* 2016;3(2):75-84.
16. Sharma NA., Garud R S. Morphometric evaluation and a report on the aberrations of the foramina in the intermediate region of the human cranial base: A study of an Indian population. *Eur J Anat.* 2011;15 (3): 140-149
17. Karan BK, Surekha DJ, Umarji BN, Patil RJ, Ambali MP. Foramen ovale and foramen spinosum: a morphometric study. *Anatomica Karnataka.* 2012; 6(3): 68-72.
18. Khan AA, Asari MA, Hassan A. Anatomic variants of foramen ovale and spinosum in human skulls. *Int. J. Morphol.* 2012;30(2):445-449.
19. Patil J. et al. The Foramen Ovale Morphometry of Sphenoid Bone in Southern Indian Population. *Journal of Clinical and Diagnostic Research.* 2013;7(12): 2668-2670
20. Rao B.S., YesenderM, Vinila B.H.S. Morphological Variations and Morphometric Analysis of Foramen Ovale with its Clinical Implications. *Int J Anat Res* 2017; 5(1):3394-97.
21. Ray B, Gupta N, Ghose S. Anatomic variations of foramen ovale. *Kathmandu Univ Med J.* 2005;3(1):64-8.
22. Osunwoke E.A, Mbadugha C.C, Orish C.N, Oghenemavwe E.L. and Ukah C.J. Morphometric study of foramen ovale and foramen spinosum of the human sphenoid bone in the southern Nigerian population. *Journal of Applied Biosciences.* 2010;26: 1631 – 1635
23. Saurabh P.K, Vrushali V.N. A Morphometric Study of Foramen Ovale and Foramen Spinosum in Dried Indian Human Skulls. *International Journal of Recent Trends in Science And Technology.* 2013;7(2):74-75
24. Burdan F, Umlawska W, Dworzański W, KlepaczR, Szumiło J, Starosławska E, Drop A. Anatomical variances and dimensions of the superior orbital fissure and foramen ovale in adults. *Folia Morphol.* 2011;70:263–271.
25. Somesh MS et al. A morphometric study of foramen ovale. *Turk Neurosurg.* 2011;21(3):378-83.