Original Article

Anatomical Variations of Foramen Vesalius in the Middle Cranial Fossa and its Clinical Significance

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Abstract

Objective: To evaluate the occurrence of foramen Vesalius and correlate the findings with clinical significance.

Material and Methods: After getting ethical approval certificate from the concerned authorities, the study was conducted on 27 dry adult human skulls that were acquired from the Anatomy Department at Khyber Medical College, Peshawar. A total of twenty-seven dry adult human skulls were selected for the study. These were then studied for the presence or absence of the foramen. If present, variations were then seen in its symmetry, diameter, shape, and any increase in its number. After the collection of data, descriptive statistics were calculated.

Results: Among the 27 skulls, 11 (40.7%) were noted to have Foramen Vesalius. Out of the 11 skulls with Foramen Vesalius, 9 (82%) had a unilateral foramen, while 2 (18%) had it bilaterally. In unilateral cases, the foramen was more common on the right side as compared to the left. In skulls with the foramen, the mean maximum diameter was 0.52±0.83 mm on the right side and 0.33±0.72 mm on the left side. Foramen Vesalius was identified as round in 10 (77%) and oval in 3 (23%) of the total foramina seen, with no irregularly shaped foramina. However, there was no statistical significance in the difference between the maximum dimensions on the right and left sided foramen Vesalius. However, there was no statistical significance in the difference between the maximum dimensions on the right and left sided foramen Vesalius.

Conclusion: Foramen Vesalius exhibited variations in its occurrence, symmetry, and morphology in 41% of the skulls included in the study. The variations observed could be attributed to developmental factors. The findings in this study are significant to anatomists and are equally important for clinicians who use this foramen in order to approach the middle cranial cavity for various procedures.

Keywords: Foramen Vesalius, middle cranial fossa, greater wing of sphenoid.

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Introduction

Sphenoid bone is a butterfly-shaped bone that makes up a part of the skull. It is divided into four parts, i.e. the body, the greater wing, the lesser wing and the pterygoid process. Most of the sphenoid bone is made up of the greater wing. It is a symmetrical extension of the sphenoid bone where its inner surface makes up the bult of the floor of the middle cranial fossa.[1] The middle cranial fossa houses an intricate labyrinth of foramina for major neurovascular structures.[2] The greater wing of the sphenoid itself has multiple symmetrical foramina among which three are constant, i.e. foramen rotundum, ovale and spinosum, and others are small and inconsistent like the foramen Vesalius.[3]

Foramen Vesalius (FV) is also called the sphenoidal emissary foramen, foramen venosum and canaliculus sphenoidalis.[4] This foramen may be inconstant; if present, it is generally symmetrical and lies antero-medially to the foramen ovale and postero-medial to the foramen rotundum.[5,6] If present, it allows the emissary vein to connect the intracranial cavernous sinus to the extracranial pterygoid venous plexus.[7,8]

The importance of evaluating the foramina at the base of skull has been demonstrated previously in literature. FV is clinically important from a neurosurgical point of view because it lies in between foramen ovale and foramen rotundum, but particularly closer to the foramen ovale.[9] Due to this close proximity, during neurosurgery the needle may be misplaced during percutaneous intervention while treating trigeminal neuralgia, leading to intracranial bleeding and other severe complications.[10] The passage of nervoulus sphenoidalis lateralis with the accessory meningeal artery in 20% of cases poses a risk of iatrogenic injury during surgery.[11]

This foramen's location is significant as it allows infection to spread from an extracranial source to the cavernous sinus via the emissary vein of Vesalius.10 Due to its anatomical position and its variation, it is important to evaluate the occurrence along with the morphometry of FV which could assist surgeons in careful planning leading to a safer percutaneous approach to the middle cranial fossa via the foramen ovale.[3,12]

This study aims to identify variations in the frequency, shape, and diameter of the FV. This will help anatomists, surgeons and radiologists in better understanding the anatomy of the skull and help in better planning of management in clinical settings as described above.

Material and Methods

After getting ethical approval certificate (Under IRB No.:403/DME/KMC) from the concerned authorities, the study was conducted on 27 dry adult human skulls that were acquired from the Anatomy Department at Khyber Medical College, Peshawar. Any skull with the middle cranial fossa deformed or broken was not included in the study. After the inclusion, the skulls were initially checked for the presence of FV. If present, its laterality, i.e. unilateral or bilateral, and its shape were noted. A 0.2 mm probe wire was used to verify the patency of foramina. A digital vernier caliper was used to measure the maximum diameter of the foramen. The caliper used had a precision of 0.01 mm and was appropriately calibrated. The foramen, if present, were also examined for any duplication. Photographs of FV were captured, showcasing different variations.

The data was recorded in a spreadsheet on Microsoft Excel analyzed using Statistical Package for the Social Sciences (SPSS) version 27. The results were then organized into tables for presentation. The maximum diameter of FV of both sides were compared with the significance or p-value set at ≤ 0.05. The results were then checked against those produced by other studies that have been cited in the current study.

Results

The results are presented in tabular form. Table 1 demonstrates the existence and laterality of the foramen along with the total distribution on each side. Among the 27 skulls, the foramen was observed in only 11 (40.7%) skulls. The foramen was predominantly unilateral (9, 82%) compared to bilateral (2, 18%). No duplication was observed. The means of the maximum dimensions measured for the right side was 0.52±0.83mm while on the left it was 0.33±0.72 mm. No statistically significant difference ($p = 0.448$) was seen between the two. Table 2 exhibits that among the 13 foramina observed in the 11 skulls, FV was predominantly round in 10 cases (77%) while oval in 3 cases (23%) and no irregular shaped foramina were observed. The shapes of the foramina seen are shown in Figure 1.

Table 1: *Existence and laterality of the foramen along with the side-wise Distribution*

Laterality	On the Right Side	On the Left Side	Distribution in Skulls with Presence of Foramen (N=11)
Unilateral	6 (55%)	3 (27%)	9 (82%)
Bilateral	2 (18%)		2 (18%)
Total Foramina Seen	8	5	

Table 2: *Morphology of the foramen along with its sidewise distributionMorphology of the Foramen along with its Sidewise Distribution*

Shape	On the Right Side (N=8)	On the Left Side (N=5)	Distribution in Total Foramina Seen (N=13)
Round	5 (38.5%)	5 (38.5%)	10 (77%)
Oval	3 (23%)		3 (23%)
Irregular	0	0	0

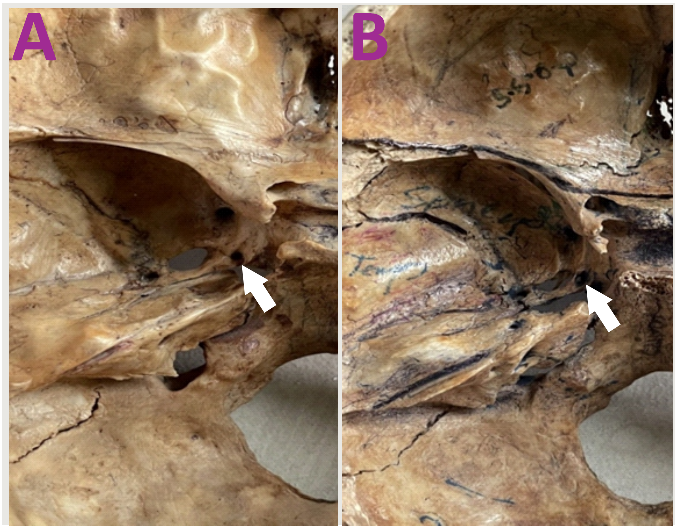

Figure 1:

A) *Round shaped foramen Vesalius (arrow)*

B) *Oval shaped foramen Vesalius (arrow)*

Discussion

The anatomy of the middle cranial fossa is intricate along with its network of foramina and hence a detailed knowledge of its landmarks is crucial to investigate the contents with a minimal risk. FV, also known as the emissary sphenoidal foramen, was first identified by Andreas Vesalius. It is a small orifice that is located at the floor of the middle cranial fossa[13]. When present, the foramen is located anteromedial to the foramen ovale.[14]

The study shows that FV was seen in 40.7% (11 out of 27) of the skulls examined, which is consistent with previous studies where the prevalence ranged from 44.4% to 40% and 37%.[9, 13, 15] Among these, 7.4% (2 out of 27) had bilateral foramina, while 33.3% (9 out of 27) had unilateral foramina. These findings are nearly identical to a study where prevalence of this foramen was 28.1%, 21.1% of which were unilateral and 6.9% were bilateral.[5]

Varying authors have reported a wide-ranging prevalence for FV. FV was present in 37%, bilaterally in 16.7% skulls and unilaterally in 20.5%.[13] A slightly high prevalence was observed in another study where FV was seen in 52% of skulls. In 30% of cases, the FV was found bilaterally.[16] It is interesting to note that this foramen shows relatively higher prevalence that was 73%, among which it was present unilaterally in 30.8% and bilaterally in 42.3%.[17] In this study, the values measured for FV's mean maximum dimension differed in comparison to earlier studies. The mean maximum diameter on the right and left sides in this study was 0.52±0.83 mm and 0.33±0.72 mm, respectively.

Majority of the previous studies conducted showed no significant difference between the measurements on right compared to the left side, which is consistent with the findings of this study. However, in a retrospective study conducted on patients with meningiomas who underwent tumor resection it was found that the mean diameter of this foramen was significantly larger on the tumor-affected side.[16] In another study, the author found 4 cases with asymmetrical foramina. Two of these cases were tumors such as nasopharyngeal melanoma and juvenile angiofibroma, one patient with carotid-cavernous fistula and one with neurofibromatosis[18]. Thus, asymmetry in those studies was likely due to a pathological process rather than it being a typical variant.

This study shows that the most common shape was round, which contradicts the findings of another study where the most prevalent shape was oval.[17]

The variations in the anatomical features related to FV can be explained by embryological development of the sphenoid bone. The skull develops after the formation of neurovascular structures i.e., the spinal cord, cranial nerves and the blood vessels. The majority of the base of the skull develops endochondrally while the remaining forms via intramembranous ossification.[19] FV is formed by joining of both the endochondrally formed bone and the intramembranous part. The variations of inconsistent foramina like FV are due to development defects arising in the membranous part as well as due to the variations in the bridging of the venous plexus of each individual. However, the factors influencing the formation and presence of foramina such as foramen Vesalius are still unknown.[13]

Conclusion

FV was found to exhibit significant variability in its presence and shape within the sphenoid bone. The in-depth understanding of sphenoid bone's anatomy, along with the variations and morphology of FV as identified in the present study, is crucial for anatomists. This will help in understanding and further dissemination of this knowledge to new doctors, aid radiologists in their diagnostic studies, and is vital for neurosurgeons managing conditions requiring a micro-neurosurgical approach.

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References

1. Pavlović M, Jovanovic I, Trandafilović M, Stojanović V, Antić M, Kokoris J, Stanković M. Morphometric Analysis Of Larger Openings Of The Greater Wing Of The Human Sphenoid Bone. Acta Medica Medianae. 2021;60:15-24. doi:10.5633/-amm.2021.0202
2. Raz A, Olewnik L, Georgiev GP, Iwanaga J, Tubbs RS. Variant Bilateral Foramina of the Middle Cranial Fossa. Cureus. 2022;14(12):e33014. doi:10.7759/cureus.33014
3. Shakya R, Ranjit N, Shrestha S. The Incidence of Atlanto-Occipitalization and Additional Foramina Present in The Dry Skulls of Nepalese Population. Birat Journal of Health Sciences. 2021;6(2):1501-6. doi:10.3126/bjhs.v6i2.40335
4. Hacking C MY, Luijkx T, et al. Foramen Vesalii Radiopaediaorg. 2024. doi:https://doi.org/-10.53347/rID-56255
5. Bayrak S, Kursun-Cakmak ES, Atakan C, Orhan K. Anatomic Study on Sphenoidal Emissary Foramen by Using Cone-Beam Computed Tomography. J Craniofac Surg. 2018;29(5):e477-e80. doi:10.1097/-SCS.0000000000004492
6. Palamenghi A, Cellina M, Ce M, Cappella A, Sforza C, Gibelli D. Correlation Analysis on Anatomical Variants of Accessory Foramina in the Sphenoid Bone for Oncological Surgery. Cancers (Basel). 2023;15(22). doi:10.3390/cancers15225341
7. Jaiswal P, Asopa A. A Morphometric Study of Foramen Ovale in Rajasthan. IOSR Journal of Dental and Medical Sciences. 2023:10-5. doi:10.9790/0853-2203161015
8. Sink Z, Umek N, Cvetko E. Morphometric and morphologic analysis of the foramen spinosum in the Slovenian population with clinical correlations. PeerJ. 2023;11:e16559. doi:10.7717/peerj.16559
9. Natsis K, Piagkou M, Repousi E, Tegos T, Gkioka A, Loukas M. The size of the foramen ovale regarding to the presence and absence of the emissary sphenoidal foramen: is there any relationship between them? Folia Morphol (Warsz). 2018;77(1):90-8. doi:10.5603/FM.a2017.0068
10. Tayebi Meybodi A, Mignucci-Jimenez G, Lawton MT, Liu JK, Preul MC, Sun H. Comprehensive microsurgical anatomy of the middle cranial fossa: Part I-Osseous and meningeal anatomy. Front Surg. 2023;10:1132774. doi:10.3389/fsurg.2023.1132774
11. Alves N, Deana NF. Anatomical study of the Foramen Venosum and its clinical implications. Journal of the Anatomical Society of India. 2017;66(2):123-6. doi:10.1016/j.jasi.2017.03.002
12. Hussain Saheb Shaik MPS, S.D Desai, S.T Thomas, G F Maavishettar, Haseena S. Study of foramen Vesalius in south Indian skulls. Indian Journal of Medicine and Healthcare. 2012;1(1):22-4.
13. Murlimanju BV. aRG, and Latha VP., and Vasudha VS., and Rao CP., and Mangala MP., and Ashwin K., and Rajanigandha V. Foramen of Vesalius: Prevalence, Morphology, Embryological Basis and Clinical Implications Journal of Surgical Academia. 2015;5(1):24-8.
14. S.Vignesh, Ganesh M. Anatomical observations of foramen vesali and its clinical significance. International Journal of Current Advanced Research. 2017;6:2961-3.
15. Parveen N, Singh S, Mishra S. Foramen venosum: a clinicoanatomic insight into its occurrence and morphometry. Surg Radiol Anat. 2023;45(4):409-15. doi:10.1007/s00276-023-03106-x
16. Maeda Y, Mitsuhara T, Saeki K, Hara T, Kuwabara M, Hiroshi K, et al. Relevance of the Foramen of Vesalius for Preoperative Tumor Embolization in Skull Base Meningioma. World Neurosurg. 2024;187:e501-e8. doi:10.1016/j.wneu.2024.04.116
17. Gorurgoz C, Paksoy CS. Morphology and morphometry of the foramen venosum: a radiographic study of CBCT images and literature review. Surg Radiol Anat. 2020;42(7):779-90. doi:10.1007/s00276-020-02450-6
18. Lanzieri CF, Duchesneau PM, Rosenbloom SA, Smith AS, Rosenbaum AE. The significance of asymmetry of the foramen of Vesalius. AJNR Am J Neuroradiol. 1988;9(6):1201-4.
19. Yamamoto M, Jin ZW, Hayashi S, Rodriguez-Vazquez JF, Murakami G, Abe S. Association

between the developing sphenoid and adult morphology: A study using sagittal sections of the skull base from human embryos and fetuses. J Anat. 2021;239(6):1300-17. doi:10.1111/joa.13515

Authors Contribution

RI: Conceptualization of Project

AHK: Data Collection

AS: Literature Search

GA: Statistical Analysis

NH, NM: Drafting, Revision

RI, AHK: Writing of Manuscript