Original Research Article

Foramen of Vesalius: Prevalence, Morphology, Embryological Basis and Clinical Implications

Murlimanju BV[1], Reddy GR[1], Latha VP[1], Vasudha VS[1], Rao CP[2], Mangala MP[1], Ashwin K[1], Rajanigandha V[1]

[1]Department of Anatomy, Kasturba Medical College, Mangalore 575004, Manipal University, Manipal, Karnataka, India.
[2]Department of Anatomy, A.J. Institute of Medical Sciences, Kuntikana, Mangalore 575004, Karnataka, India.

Abstract

The objectives of the present study were to find the prevalence of foramen of Vesalius and to discuss its morphology. The embryological basis of this foramen and its surgical highlights are emphasized. The study comprised 78 human adult dried skulls, which were obtained from the anatomy laboratory of our institution. The greater wing of the sphenoid bone was macroscopically observed for the presence of foramen of Vesalius. It was observed that the foramen was present in 29 skulls (37.2%). It was seen bilaterally in 13 (16.7%) skulls and unilaterally in 16 (20.5%) specimens.Anatomical literature has explained the variation of this foramen by the developmental considerations. We believe that the details of this foramen are known to have significant implications for the medical and surgical literature. The details are also enlightening to the clinical anatomists and other broad specialties of medicine.This sphenoidal emissary foramen contains a bridging vein, which connects the pterygoid venous plexus with the cavernous sinus. This communication is clinically important, since an extra cranial infection may sometimes reach the cavernous sinus through this foramen, which may lead to cavernous sinus thrombosis. Foramen of Vesalius can get injured during the trigeminal nerve block technique performed for the trigeminal neuralgia. In this procedure, the foramen can get hurt by a displaced instrument, which would end up in intracranial bleeding, which can spread the extracranal infection into the cavernous sinus. This may lead to serious disorders like Tolosa Hunt and Gradenigo syndromes.

Keywords: Foramen ovale, middle cranial fossa, morphology, skull base, sphenoid bone

Correspondence:

Murlimanju BV, Department of Anatomy, Kasturba Medical College, Manipal University, 575004 Mangalore, India. Tel: +91 824 2211746 Fax: +91 824 2421283 Email: flutesnowmm@gmail.com

Date of submission: 24 May, 2014 Date of acceptance: 14 Jan, 2015

Introduction

The anomalous foramen which is found anteriorly and medial to the foramen ovale is considered as the foramen of Vesalius (FV). The foramen rotundum is situated medial to the FV (1). It is also known as sphenoidal emissary foramen, since it contains a bridging vessel (2), which communicates the pterygoid plexus of veins of the infratemporal fossa with the cavernous sinus of middle cranial fossa (3). This emissary foramen is considered as one among the smaller in the human cranium (4) and is clinically important since an extra cranial infection may reach the cavernous sinus (5) through this foramen, which may lead to cavernous sinus thrombosis. Bergman et al. (6) reported that, FV transmits the accessory meningeal artery in about 20% of cases. It was observed that a tiny, lateral sphenoidal nerve may transmit too in this opening (7). Anatomical variants of FV can be described by the embryological basis (5). It was described that sphenoidal emissary foramen (FV) is present unilaterally or bilaterally in 40% of the skulls

(8). Andreas Vesalius reported that the existence of this foramen is extremely rare; however its significance cannot be ignored as the pitfall in the skull base, due to its significant morphological variants (4). Though the morphology of this foramen is clinically important, there are not many reports available in the literature. This was the initiative to conduct this investigation, the researchers and clinicians examining this foramen may have an anatomical reference with this article. The objectives of the present investigation were to find the prevalence of this foramen and to discuss its morphology. The embryological basis and surgical highlights are emphasized.

Meaterials and Methods

The present study was performed on human adult dry skulls of the collections of the anatomy laboratory of our institution. The skulls which could not be evaluated bilaterally like the one which were damaged or with partly broken surroundings were excluded from the present study. The examination comprised 156 sides from 78 skulls, of these, 47 belonged to males and 31 belonged to females. The dorsal aspect of the greater wing of sphenoid bone was macroscopically observed for the existence of an anomalous foramen (FV) which is located between the foramen ovale and foramen rotundum. The patencies of foramina were confirmed by passing a 24-gauge needle through each of the foramen. The prevalence of FV was estimated; the difference between the left and right sides and difference with respect to gender were analyzed. Few skulls exhibited the blind canal and were not considered as FV. The morphological frequency of the present study was analyzed with the earlier reports which were available.

Results

The present study observed that the foramen was present in 29 skulls (37.2%) and was absent in 49 skulls (62.8%). The FV was identified anteromedially to the foramen ovale in all the specimens (Fig. 1A & 1B). It was seen bilaterally in 13 (16.7%) skulls and unilaterally in 16 (20.5%) specimens, 9 (11.5%) were right sided and 7 (8.9%) were left sided (Table 1). So it was observed totally on 42 sides of the skulls, 22 (28.2%) right sided and 20 (25.6%) left sided. The significant difference was not found in the prevalence of FV with respect to the side. There was female predominance in the incidence (Male: Female; 11: 18) compared to male skulls. We did not observe any double or multiple foramina among our specimens. The confluence between the foramen ovale and the FV was not observed in the present study. The data of the present study was compared with the reports of earlier study and are discussed.

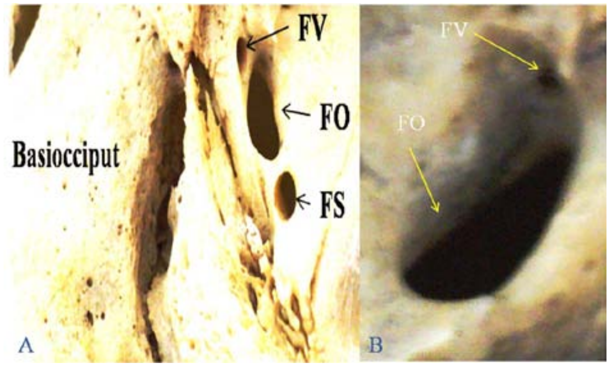

Figure 1: A) Photograph of the left side of the skull showing the foramen of Vesalius (FV) situated anteromedial to foramen ovale (FO) in the middle cranial fossa (FS: foramen spinosum). B) closer view (right sided).

Table 1: Side wise and gender wise distribution of foramen of Vesalius (n=29)

	Bilateral (n=13, 16.7%)	Unilateral (n=16, 20.5%)	
		Right	**Left**
Total (n=29, 37.2%)	13	9	7
Male (n=11)	4	5	2
Female (n=18)	9	4	5

Discussion

The middle cranial fossa anatomy is complex and a thorough knowledge of its landmarks is essential in order to explore the contents with a minimal risk (2). The information on foramina of skull has been increasingly important because of the advanced radiological investigations like nuclear magnetic resonance (NMR) and computerized axial tomogram (CT scan). These investigations are making difficult diagnosis of pathologic conditions of skull more simpler (9). The emissary sphenoidal foramen, noted for the first time by Andreas Vesalius, has been explained as a tiny variable opening in the sphenoidal greater wing (10). When present, this foramen is found anterior and medial to the oval foramen, foramen spinosum and the carotid canal (4). Vesalius, in his textbook, described that the FV 'is rarely seen unilaterally and much more rarely bilaterally' (11). There is a wide range of prevalence of FV reported by various authors. The prevalence of FV were reported earlier by Williams et al. (12), 8.5%; Wysocki et al. (13), 17%; Kodama et al. (14), 21.7% and Reymond et al. (15) in 22% of the cases. In contrast, Gupta et al. (5), Shinohara et al. (4) and Boyd (16) reported the prevalence rate of 32.8%, 33.7% and 36.5% respectively. It is observed that the prevalence of the present study (37.2%) is consistent with the previous reports. According to Bergman et al. (6) and Lang (7), the foramen can be seen up to 40% of cases. It is interesting to note that Ginsberg et al. (17) and Kaplan et al. (18) reported very high incidence of FV, 71.8% and 100% respectively. This may be due to the fact that, Kaplan et al. (18) examined only 10 skulls and their sample size was very small to interpret. In the present study, the foramen was absent on both sides in 62.8% of the cases, which is similar to the findings of Boyd (16) and Shinohara et al. (4), in their study the absence of foramen was observed in 63.5% and 66.2% of the cases, respectively.

In the present study, FV was observed bilaterally in 16.7% of the skulls which is similar to the findings of Shinohara et al. (4) and Boyd (16), whose observations were 15.5% and 12.5% respectively. The incidence of unilateral foramen in the present study was 20.5% of which 11.5% found on the right side and 8.9% on left side. According to Shinohara et al. (4), the prevalence of FV unilaterally was 18.25% of the skulls, among them 7.75% were right sided and 10.5% left sided. The data of the present study are similar to values found by Shinohara et al. (4) and Boyd (16). In Boyd's (16) specimens, 10.6% of FV were right sided and 11.2% were left sided. The FV were examined radiologically by Ginsberg et al. (17) and its unilateral frequency was 80%. Few authors (5, 14) stated that the FV is more seen bilaterally than unilateral. But in our specimens, the incidences of unilateral cases were more than the bilateral. The famous text book, "De humani corporis fabrica" written by Andreas Vesalius, describes that there are no significant difference observed between the right and left sided (11). In the present study, FV was observed 11.5% cases on right side and 8.9% on left side. Kodama et al. (14), observed no significant difference with respect to the sides. The present study also observed no significant difference between the two sides. There was female preponderance among the incidence of FV in our specimens compared to male skulls. But Kodama et al. (14) reported that no remarkable differences were observed between the genders. Reymond et al. (15) reported that the FV was always single in their specimens. In contrast, the presence of a double FV was noted earlier by Shinohara et al. (4) in 7 out of 400 skulls. Kale et al. (3) reported that, only 4 out of 156 skulls with FV exhibited the duplication of the FV. Among the double FV, 3 were observed on the right side and 1 was on the left. However in the present study, the double or multiple foramina were not observed. Shapiro and Robinson (10) reported that on some occasions the foramen ovale may coalesce with the FV and sometimes the anterior portion of the foramen ovale may be considered to be the FV. But this kind of morphology was not observed in the present study. We believe that the significant morphological differences which are observed in the present study with the other studies may be because of racial variations.

Variability in the morphology of FV can be understood by the embryological basis, the sphenoidal greater wing has a complicated process during the development and the FV is one among the embryological fusion sites during the osteogenesis of the sphenoid bone (5). Most of the central skull base develops from the endochondral type of bone formation and a little contribution, comes from the membranous ossification. At around 82 days, the whole base of the skull will be in cartilaginous form and eventually the ossifying process begins from posterior to the anterior. The pre and postsphenoid centers which appear during the 14 and 17 weeks, would lead to the formation of the sphenoid bone. There is also a little contribution which comes from the ali and orbitosphenoid centers which start during the 15 and 16 weeks of gestation respectively (19). The greater wings of sphenoid develop from the alisphenoid centers. The foramen ovale of humans will be covered by a membranous bone which has been derived from a medial process associated with the scaphoid fossa and a lateral tongue like part, the most posterior part of which is represented in many cases as a process on the lateral margin of the foramen. FV is the point of fusion between the membranous part of the ossification bone and the medial cartilaginous part which is given the name, ala temporalis (3). The morphologically variant foramina and grooves around the foramen ovale region can be understood as they arise from the defects in the parts of the membranous bone and the bridging venous plexus from the middle meningeal vein through pterygoid venous plexus (3). Development of the base of skull begins after the development of spinal cord, cranial nerves, and blood vessels (19). Thus, the presence of FV depends on the individual venous drainage organization (4). However, the factors influencing the formation and presence of foramina such as foramen of Vesalius are not known.

The anatomical characteristics and prevalence of FV is enlightening to the neurosurgeon and other broad specialties of medicine. Shinohara et al. (4) opined that the contents of FV can get injured during trigeminal nerve block technique done for the trigeminal neuralgia which arises due to mandibular nerve pathology. In this procedure, the FV can get hurt by a displaced instrument, which would end up in bleeding intracranial (20) and this was reported in 3.5% of the cases (21). These intracranial venous bleedings can spread the extra cranial infection into the cavernous sinus, which may lead to serious disorders like Tolosa Hunt and Gradenigo syndromes.

In the radiological study, it has been reported that FV can be better observed radiologically by using thin-sliced horizontal CT images (22). During the intervention procedures, the direction, angle and the position of the instrument will change due to the presence of FV. FV is a very important anatomical variation, which has to be noticed by the surgeon since it lies close to the foramen ovale, foramen spinosum, foramen lacerum and carotid canal (23). Due to all these clinical importance, we do believe that the morphological details of FV are known to have significant implications for the neurosurgery in the medical literature. The variation of this foramen was explained by developmental considerations. We state that the morphological data obtained from the present investigation would help the neurosurgeon and neuroscientists to boost their idea of this foramen. It is important to recognize these variants and related neurovascular structures due to their significant implications for surgery and other specialties of medicine. This variant foramen cannot be overlooked during the neurosurgery.

Acknowledgements

The authors thank all the nonteaching members of department of anatomy for their assistance while conducting this investigation.

References

1. 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.

2. Avci E, Kocaogullar Y, Fossett D, Caputy A. Middle fossa surgical anatomy related to the subtemporal preauricular infratemporal approach: an anatomic study. Turk Neurosurg 2001; 11: 38-43.

3. Kale A, Aksu F, Ozturk A, et al. Foramen of Vesalius. Saudi Med J 2009; 30(1): 56-9.

4. Shinohara AL, de Souza Melo CG, Silveira EM, Lauris JR, Andreo JC, de Castro Rodrigues A.. Incidence, morphology and morphometry of the foramen of Vesalius: complementary study for a safer planning and execution of the trigeminal rhizotomy technique. Surg Radiol Anat 2010; 32(2):159–64.

5. Gupta N, Ray B, Ghosh S. Anatomic characteristics of foramen Vesalius. Kathmandu Univ Med J (KUMJ) 2005; 3(2): 155-8.

6. Bergman RA, Afifi AK, Miyauchi R. Illustrated encyclopedia of human anatomic variation: Opus V: Skeletal Systems: Cranium. Sphenoid Bone. http://www.anatomyatlases.org/AnatomicVariants/SkeletalSystem/Text/SphenoidBone.shtml. Last accessed on 4/4/2014.

7. Lang J. Clinical Anatomy of the Head, Neurocranium, Orbit and Craniocervical Region. Berlin: Springer-Verlag, 1983, pp- 233-96.

8. Standring S. Gray’s anatomy. 39th Ed. Spain (SP): Churchill Livingstone, 2005, pp- 460-6.

9. Berge JK, Bergman RA. Variations in size and in symmetry of foramina of the human skull. Clin Anat 2001; 14(6): 406-13.

10. Shapiro R, Robinson F. The foramina of the middle fossa: a phylogenetic, anatomic and pathologic study. Am J Roentgenol Radium Ther Nucl Med 1967; 101(4): 779-94.

11. Hast MH, Garrison DH. Vesalius on variability of the Human Skull: Book I, Chapter V of De humani corporis fabrica. Clin Anat 2000; 13(5): 311-20.

12. Williams PL, Bannister LH, Martin MM, et al. Gray’s Anatomy. 38th ed. London: Churchill Livingstone, 1995, pp- 425-36.

13. Wysocki J, Reymond J, Skarryjski H, Wróbel B. The size of selected human skull foramina in relation to skull capacity. Folia Morphol 2006; 65(4): 301–8.

14. Kodama K, Inoue K, Nagashima M, Matsumura G, Watanabe S, Kodama G. Studies on the foramen Vesalius in the Japanese juvenile and adult skulls. Hokkaido Igaku Zasshi 1997; 72(6): 667–74.

15. Reymond J, Charuta A, Wysocki J. The morphology and morphometry of the foramina of the greater wing of the human sphenoid bone. Folia Morphol (Warsz) 2005; 64(3): 188-93.

16. Boyd GI. Emissary foramina of cranium in man and the anthropoids. J Anat 1930; 65(1): 108–21.

17. Ginsberg LE, Pruett SW, Chen MY, Elster AD. Skull-base foramina of the middle cranial fossa: reassessment of normal variation with high-resolution CT. ANJR Am J Neuroradiol 1994; 15(2): 283-91.

18. Kaplan M, Erol FS, Ozveren MF, Topsakal C, Sam B, Tekdemir I. Review of complications due to foramen ovale puncture. J Clin Neurosci 2007; 14(6): 563–8.

19. Nemzek WR, Brodie HA, Hecht ST, Chong BW, Babcook CJ, Seibert JA. MR, CT and plain film imaging of the developing skull base in fetal specimens. Am J Neuroradiol 2000; 21(9): 1699-1706.

20. Sweet WH, Poletti CE. Complications of percutaneous rhizotomy and microvascular decompression operations for facial pain. In: Schmideck HH, Sweet WH (Eds) Operative neurosurgical techniques: indication, methods, and results. Orlando: Grune and Straton, 1988, pp-1139–44.

21. Sindou M, Keravel Y, Abdennebi B, Szapiro J. Neurosurgical treatment of trigeminal neuralgia. Direct approach or percutaneous method? Neurochirurgie 1987; 33(2): 89-111.

22. Saitou N, Kimura R, Fukase H, Yogi A, Murayama S, Ishida H. Advanced CT images reveal nonmetric cranial variations in living humans. Anthropological Science 2011; 119(3): 231-7.

23. Ozer MA, Govsa F. Measurement accuracy of foramen of Vesalius for safe percutaneous techniques using computer-assisted three-dimensional landmarks. Surg Radiol Anat 2014; 36(2): 147-54.