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The Morphometric Study of Parietal Emissary Foramen Related with Clinical Implications in Thais

Estudio Morfométrico del Foramen Emisario Parietal Relacionado con las Implicaciones Clínicas en Tailandeses

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SUMMARY: Parietal emissary foramina (PEF) are an important structure which the parietal emissary vein passes through. Aims of this study were to study morphometry of the PEF and its clinical implications. The present study examined in 800 parietal bones (400 Thai skulls; 200 males and 200 females). A total of 587 emissary foramina were found in 344 skulls. The PEF were found on the right side (298), left side (256). One hundred fifty-five unilateral, 189 bilateral, and 33 center of PEF were found in our study. The average of foramina to sagittal suture were 5.67 ± 2.73 mm on the right and 5.91 ± 2.37 mm on the left in male, while in female it was 5.28 ± 2.61 mm on the right and 5.48 ± 2.54 mm on the left. The shape was mostly circular with mean diameter of 1.27 ± 0.56 mm on the right, 1.23 ± 0.52 on the left and 1.11 ± 0.49 mm at the center in male. In female, the mean diameter of 1.19 ± 0.42 mm on the right, 1.12 ± 0.41 mm on the left and 1.60 ± 0.92 mm at the center. The ratio of distance from the external occipital protuberance (EOP)to PEF and to glabella in males on the right side is 0.342 cm. (3/8) and 0.349 cm. (3/8) on the left side. While the ratio of females is 0.367 cm. (3/8) and 0.388 cm. (3/8), respectively. Our finding obtained in this study scientists can be essentially benefited for anatomists, radiologists, neurosurgeons, and forensic to aware this anatomical structure.

KEY WORDS: Parietal emissary foramen; Skull; Morphometric; Neurosurgery; Clinical implication

INTRODUCTION

Parietal emissary foramina (PEF), located between middle third and posterior third of the parietal bone, are an important structure which the parietal emissary vein passes through. They act as the drainage passage of the brain, balancing the intracranial and extracranial pressure (Gangmei *et al*., 2018; Halagatti & Sagar, 2018; Magalhães *et al*., 2018). They are one of the emissary foramina that is frequently neglected during brain surgery, massive bleeding can occur (Murlimanju *et al*., 2015). Moreover, they are also one of the routes of infection since they connect the intracranial to the extracranial. It is also believed that they lower the intracranial pressure by draining the blood out of the skull. If one of these foramina is calcified, it might cause the patient to experience migraine (Magalhães *et al*.) or might be associated with cerebral venous anomalies, irregular suture fusion and deviations of the sagittal suture (Wu *et al*., 2013). Moreover, knowing their variations and locations are fundamental and would help the radiologist to improve the diagnostic approach to the lesion on the parietal bone.

According to Wysocki *et al*. (2006), the PEFis 2 times larger in diameter in Polish female than in male. Even how, a contradiction of this statement is reported. This evidence raises the question of whether the PEF can be an indicator for sex determination in forensic circumstance. To the best of our knowledge, we decided to determine the difference and the ability of the PEF to be used as a sex determination factor from morphometric of PEF in a Thai population.

From the literature reviews, these foramina have not yet been studied in a Thai population. As a consequence, being able to know more would be useful since morphology of skull is different in each population. Our study aims to

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get the best use of all the parameters obtained, to be beneficial for anatomists, radiologists, neurosurgeons, and forensic scientists.

MATERIAL AND METHOD

This study was approved by the Research Ethics Committee of the Faculty of Medicine at Chiang Mai University (clearance no.7327/2563).

The Sample Collection. The samples were of all modern Thais obtained from the Forensic Osteology Research Center (FORC), Faculty of Medicine, Chiang Mai University. The sample in present study consisted of 800 parietal bones (400 Thai crania,200 males and 200 females), with a mean age of 66.62 (SD=15.71) years for males and 66.89 (SD=16.01) years for females. Any skull with deformities from pathologic diseases, or those damaged at glabella and parietal bone were excluded.

Morphological and Morphometric measurements

Morphological patterns are classified by modified Murlimanju *et al*. (Fig. 1) as follows:

I. If there is no PEF on both parietal bones, then it is classified as absent.
II. If the PEF is presented on the sagittal suture, then it is classified as center.
III. If there is one PEF, then it is classified as unilateral (single).
IV. If there are two PEF on the same side of the parietal bone, then it is classified as unilateral (double).
V. If there are three PEF on the same side of the parietal bone, then it is classified as unilateral (triple).
VI. If there is one PEF on both sides of the parietal bones, then it is classified as bilateral (double).
VII. If the PEF is presented on both sides of the parietal bones and there are three PEF in total, then it is classified as bilateral (triple).
VIII. If the PEF is presented on both sides of the parietal bones and there are four PEF in total, then it is classified as bilateral (quadruple).

Next, a total of 5 skull parameters were taken as follows:

Two measurements which consisted of the measurement of distance from the tip of external occipital protuberance (EOP) to glabella and to PEF were made by tape measure.

Moreover, the ratio of distance from the EOP to PEF and to glabella (EOP-PEF / EOP-glabella) was calculated from those two measurements.

Lastly, two measurements including: the diameter of the PEF, and the distance between the PEF and sagittal suture were measured transversely by Image J analysis software (ImageJ v1.44, US National Institutes of Health, Bethesda, MD, USA).

Statistics analysis. Descriptive statistical analysis such as frequency, percentage, mean, and standard deviation was used for all quantitative variables. For test of the difference between sexes, the independent sample t-test and Mann-

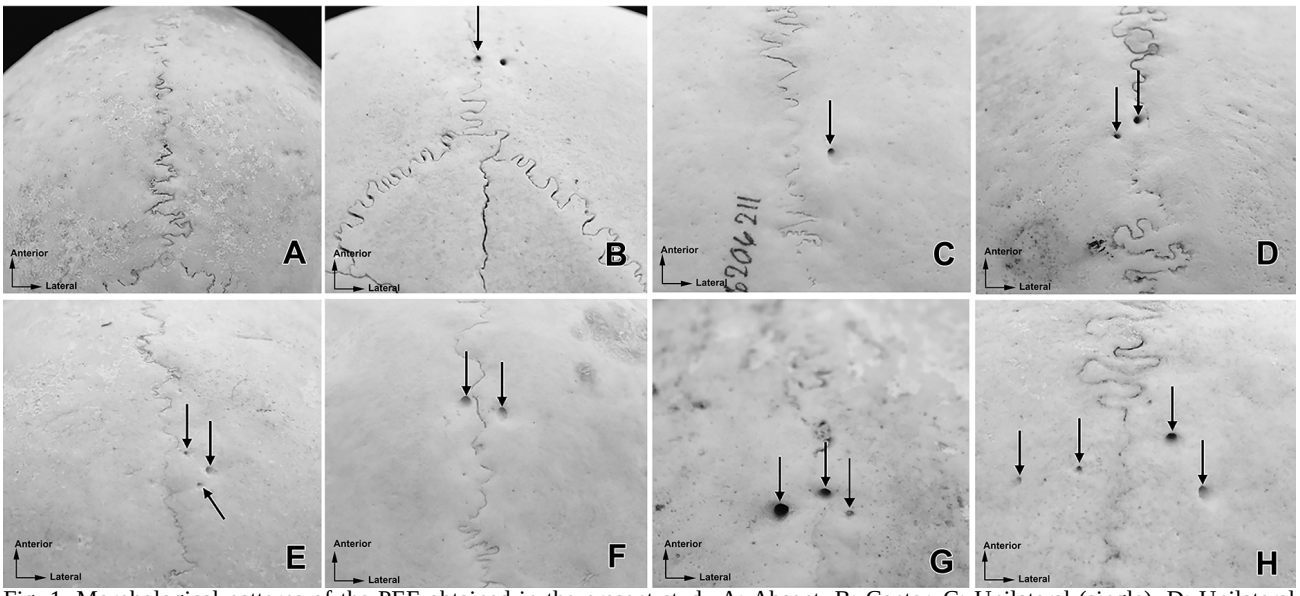

Fig. 1. Morphological patterns of the PEF obtained in the present study A: Absent, B: Center, C: Unilateral (single), D: Unilateral (double), E: Unilateral (triple), F: Bilateral (double), G: Bilateral (triple), H: Bilateral (quadruple).

Whitney U test were used. The Statistical Package for the Social Sciences version 26 (SPSS 26.0) (IBM Corp., Armonk, NY, USA) was used to analyze the data. The significance test with p-value of 0.05 or less were considered statistically significant.

RESULTS

Morphological observation. A total of 587 emissary foramina were found in 344 skull samples: 173 (50.29 %) male skulls (68 unilateral, 105 bilateral presentation), and 171 (49.7 %) female skulls (87 unilateral, 84 bilateral). The parietal emissary foramina were found on the right side (298 foramina; 147 for males and 151 for females), left side (256 foramina; 142 for males and 114 for females), and center (33 foramina; 19 for males and 14 for females), respectively.

One hundred and fifty-five unilateral, 189 bilateral, and 33 center presentation of PEF were found in our study (Table I). The frequency of distribution of the number of emissary foramen showed 135 singer (87.10 %), 19 double (12.26 %), and 1 triple (0.64 %) type for unilateral presentation. Moreover, the result showed 156 double (82.54 %), 31 triple (16.40 %), and 2 quadruple (1.06 %) type for bilateral presentation, respectively – see Figure 1.

In aspect of shape of the foramen, three different forms were found i.e., circular (94 %), oval (4 %), and irregular (2 %), respectively.

Morphometric measurements. Table II shows descriptive statistics for each measurement and test of differences between males and females. All data shows that there are no significant differences between sex and foramen diameter on both sides, excepted EOP to glabella measurement.

The ratio of distance from the EOP to PEF and to glabella is determined by dividing the distance from EOP to PEF by the total distance from EOP to glabella. The ratio of males on the right side is 0.342 (3/8) and 0.349 (3/8) on the left side. While the ratio of females is 0.367 (3/8) cm and 0.388 (3/8) cm, respectively.

Table I. Distribution of presentation of PEF.

Distribution of presentation of PEF	Total	Male	Female
Absent	56 (14.00 %)	27 (48.21 %)	29 (51.79 %)
Present	344 (86.00 %)	173 (50.30 %)	171 (49.70 %)
Unilateral	155 (45.06 %)	68 (43.87 %)	87 (56.13 %)
Right only	90 (58.06 %)	35 (38.89 %)	55 (61.11 %)
Left only	50 (32.26 %)	27 (54.00 %)	23 (46.00 %)
Center	21* (13.55 %)	10 (47.62 %)	11 (52.38 %)
Bilateral	189 (54.94 %)	105 (55.56 %)	84 (44.44 %)
With Center	12* (6.35 %)	9 (75.00 %)	3 (25.00 %)

*Skulls presented with unilateral foramen were more than 155 because we include center with right or left.

Table II. Descriptive statistics for each measurement and test of differences between male and female means obtained in present study.

Measurement	Total			Male			Female		
	Mean ± SD	Min	Max	Mean ± SD	Min	Max	Mean ± SD	Min	Max
PEF Diameter right[a]	1.23±0.50	0.04	3.96	1.27±0.56	0.23	3.96	1.19±0.42	0.04	3.26
PEF Diameter left[a]	1.18±0.47	0.26	3.52	1.23±0.52	0.28	3.52	1.12±0.41	0.26	2.28
PEF Diameter center[a]	1.32±0.73	0.39	3.46	1.11±0.49	0.57	2.38	1.60±0.92	0.39	3.46
PEF to sagittal suture right[a]	5.48±2.67	0.12	17.35	5.67±2.73	0.15	17.35	5.28±2.61	0.12	12.63
PEF to sagittal suture left [a]	5.72±2.45	0.12	12.9	5.91±2.37	0.51	12.05	5.48±2.54	0.12	12.9
EOP to glabella [b]	30.34±1.62	24.20	34.5	30.75±1.59	24.20	34.5	29.91±1.55	25.70	34.20
EOP to PEF right [b]	10.53±1.23	4.70	13.80	10.44±1.64	4.70	13.1	10.54±1.05	7.50	13.80
EOP to PEF left [b]	10.71±1.13	4.90	14.10	10.74±1.25	4.90	13.5	10.67±0.97	8.00	14.10
EOP to PEF center	10.55 ± 2.05	5.00	15.00	10.36 ± 2.25	5.00	13.49	10.83 ± 1.69	8.60	15.00

a: millimeter (mm); b = centimeter (cm);PEF: Parietal emissary foramina; EOP: external occipital protuberance; * Significant difference between sexes: males-females value (p-value < 0.05).

DISCUSSION

Morphological and Morphometric study. The parietal emissary foramina are on the posterior part of the parietal bones which act as communication routes for emissary vessels, anastomosis with scalp arteries: occipital and superficial temporal arteries, a middle meningeal branch and a pericranial artery (Yoshioka *et al*., 2006). These foramina also help in relieving increased intracranial pressure and regulating intracranial temperature by draining the blood (Murlimanju *et al*.). Our foramina come in variety of shapes from circular, oval to irregular which correlates with previous studies e.g., Mann (1990), Griessenauer *et al*. (2013) and Murlimanju *et al*.

Previously, these foramina were found to be able to distinguish sexes with the female foramen area bigger than males in Polish population with the diameter between 1-2 mm (Wysocki *et al*.); however, our study found that the diameter of the foramen has no difference between sexes. Piagkou *et al*. (2013) stated that enlarged parietal foramen is the foramen with 5 mm or more in diameter. While this variation was found in many studies (Boyd, 1930; Stallworthy, 1932; Piagkou *et al*.), ours did not – see Table II. In the present study, the diameter of the PEF was approximately the same in men and women (2-3 mm), and distinct enlarged parietal foramina was not found. Thus, arguments appeared in the study and no differences were found between the sexes which is the interesting difference found in our data.

Furthermore, there were no significant differences among sex in foramina distance to sagittal suture and to EOP. The distance from the left and right foramina to the sagittal suture is almost equal in both males and females. This symmetrical distance obtained in this present study is consistent with de Souza Ferreira *et al*. (2021). Apart from this, the distance from EOP and glabella has significant differences between sex since male skull is larger in terms of size and body proportion than females (Techataweewan *et al*., 2018). Among females, the forehead is straight and sexual dimorphism of the glabella and EOP is more curved and less pronounced than males do. Therefore, the distance from EOP and glabella by using tape measure is only one measurement that can be valuably applied for sex determination in forensic circumstances, especially in a Thai population in future study.

The likelihood of morphological and morphometrical differences between our result and previous studies might be due to the diverse environment geography, differences in lifestyles, as well as nutritional status in different geographical groups, e.g., the rate of foramen obliteration and disparity are quite varied in various populations. Calcification of the foramina is useful for age assumption, especially in elderly since calcifications are found mostly in elderly, showing the variability in the number of parietal foramina in different studies (Table III).

Clinical Implication. These foramina have variety of clinical applications and will be discussed as follows: While operating the scalp, especially in the parietal region, one of the pitfalls during surgery is neglecting the presence and variations of the parietal emissary foramina (Keskil *et al*.,

Table III.Comparison of the PEF prevalence among previous studies.

Author	Population	n (dry skull)	Presentation of PEF	Unilateral	Bilateral	Center	Distance to sagittal suture (mm)		Diameter of PEF (mm)
							Right	Left	
Murlimanju *et al.* (2015)	South Indian	58	71.50 %	32.70 %	55.20 %	3.40 %	6.7±2.9	6.8±2.8	N/A
Shantharam & Manjunath (2018)	Indian	78	55.77 %	18.59 %	37.18 %	N/A	7.41±4.86	7.26±3.18	1.99±0.87
Fating & Pawar (2020)	Indian	200	83.50 %	46.50 %	36.00 %	1.00 %	6.28±2.23	6.32±2.06	N/A
Naidoo *et al.* (2020)	South African	100	68.00 %	35.00 %	32.00 %	1.00 %	9.02		1.55
de Souza Ferreira *et al.* (2021)	Brazilian	178	84.30 %	33.70 %	50.56 %	N/A	M: 7.1±2.5 F: 7.4±2.7		N/A
Mahakkanukrauh *et al.* (present study)	Thais	400	86.00 %	45.06 %	54.94 %	9.59 %	5.48±2.67	5.72±2.45	Right: Left: Center: 1.32±0.73

n = sample (dry skull); M = Male; F = Female; N/A = not applicable

2003). This could lead to failure of conducting a safe surgery by causing unintentional destruction of the emissary vessels and nerves. Unawareness of this variation could result in injury of middle meningeal artery (MMA) branches developed around the PEF and thus cause extensive and life-threatening hemorrhage intraoperatively. Furthermore, not knowing the anatomical location of the foramen, surgeons may fail to stop MMA bleeding, such as epidural hematoma in head traumas and aneurysm ruptures, by using the ligating the MMA technique, since the MMA is close to the foramen (Bruner & Sherkat, 2008). In Thais, it is noteworthy that the location of the foramen can be easily scaled by palpating the EOP and measure to about 3/8 of the skull in both left and right side. This would allow neurosurgeon to avoid the emissary vein rupture during operations and to estimate the location of PEF to estimate other related structures from surface anatomy.

According to Yoshioka *et al*., Tsutsumi *et al*. (2016), de Souza Ferreira *et al*. (2021), the incidence of PEF was reported in 50 %, 75 %, and 84.3 % for each study, respectively while in our study, the incidence was 86 %. Also, in our study, no enlarged PEF was found. This could be interpreted that Thai neurosurgeon should be fully aware of the presence of this foramen and rare enlarged PEF could be found during surgery. This could be advantageous for Thais since the biggest diameter found was 3.96 mm and no enlarged PEF was found. Moreover, the location is quite precise, making it easy to be detected and not to be confused with the burr hole in radiologic examination.

Additionally, this foramen can also be applied in forensic field. The epigenetic of adaptation to bipedalism leads to formation of emissary veins and emissary foramen especially in Homo Sapiens and lesser in other species of biped animals (Falk, 1986). This is considered as the characteristic of human skull and can be used as an indicator of human skeletal remains (especially when mixed with other species in fragments) (Boyd). Apart from this, according to Magalhães *et al*., the PEF can be a useful identification of the skull because it is passed down genetically as autosomal dominant traits. If the relatives are aware of its presence, then it is likely to be found in offspring (Ghassibé *et al*., 2006; Griessenauer *et al*.). The PEF is also beneficial for ethnic identifying since PEF in Australian and New Zealand skulls are larger than in the skulls of other races; and a median position is more common, especially in comparison with White races which is usually absent (Boyd). Furthermore, enlarged parietal foramina can occur by inheriting autosomal dominant ALX4 gene which causes delayed intramembranous ossification of calvarial bones. It is reported that enlarged PEF is associated with epilepsy and caput membranaceum (Magalhães *et al*.).

In conclusion, the PEF is a source of intracranial infection, since the veins that pass through this foramen is valveless, causing blood stasis and facilitate bacterial growth. As they connect the extracranial cavity to the intracranial cavity thus promote bacterial spread and cause deeper lying venous sinuses to become septically thrombosed (Boyd; Mortazavi *et al*., 2012). Our results can be interpreted that in Thais, getting an infection through this hole is harder than other ethnicities with larger PEF. Moreover, de Souza Ferreira *et al*. (2021) stated that the PEF is responsible for controlling pressure, temperature, and hemodynamics of brain tissue in the skull in both sexes equally according to its anatomical location that is equal on both sides which is analogous to our results.

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MAHAKKANUKRAUH, C.; CHITAPANARUX, N.; KWANGSUKSTITH, S.; NAVIC, P. & MAHAKKANUKRAUH, P. Estudio morfométrico del foramen emisario parietal relacionado con las implicaciones clínicas en tailandeses. *Int. J. Morphol., 39(5)*:1283-1288, 2021.

RESUMEN: El foramen emisario parietal (FEP) es una importante estructura a través de la cual atraviesa la vena emisaria parietal. Los objetivos de este estudio fueron estudiar la morfometría del FEP y sus implicaciones clínicas. Se examinaron 800 huesos parietales (400 cráneos tailandeses pertenecientes a 200 hombres y 200 mujeres). Se encontró un total de 587 FEP en 344 cráneos, de los cuales 298 estaban presentes en el lado derecho y 256 en el lado izquierdo, siendo 155 FEP unilaterales, 189 bilaterales y 33 localizados en el centro. El promedio de la distancia de los FEP a la sutura sagital en los hombres fue de 5,67 ± 2,73 mm a la derecha y 5,91 ± 2,37 mm a la izquierda, mientras que en las mujeres fue de 5,28 ± 2,61 mm a la derecha y 5,48 ± 2,54 mm a la izquierda. La forma era mayoritariamente circular con un diámetro medio de 1,27 ± 0,56 mm en el lado derecho, 1,23 ± 0,52 en el lado izquierdo y 1,11 ± 0,49 mm en el centro en los cráneos de los hombres. En las mujeres, el diámetro medio del FEP en el lado derecho fue de 1,19 ± 0,42 mm, en el lado izquierdo 1,12 ± 0,41 mm 1,60 ± 0,92 mm en el centro. La relación de la distancia desde la protuberancia occipital externa al FEP y a la glabela en el lado derecho en los hombres fue de 0,342 cm (3/8) y en el lado izquierdo 0,349 cm (3/8). Mientras en las mujeres fue de 0,367 cm (3/8) y 0,388 cm (3/8), respectivamente. Nuestros hallazgos obtenidos en este estudio puede ser útil para que los anatomistas, radiólogos, neurocirujanos y científicos forenses conozcan esta estructura anatómica.

PALABRAS CLAVE: Foramen emisario parietal; Cráneo; Morfométrico; Neurocirugía; Implicación clínica

REFERENCES

Boyd, G. I. The emissary foramina of the cranium in man and the anthropoids. *J. Anat., 65(Pt. 1)*:108-21, 1930.

Bruner, E. & Sherkat, S. The middle meningeal artery: from clinics to fossils. *Childs Nerv. Syst., 24(11)*:1289-98, 2008.

de Souza Ferreira, M. R.; Galvão, A. P. O.; de Queiroz Lima, P. T. M.; De Queiroz Lima, A. M. B.; Magalhães, C. P. & Valença, M. M. The parietal foramen anatomy: studies using dry skulls, cadaver and in vivo MRI. *Surg. Radiol. Anat., 43(7)*:1159-68, 2021.

Falk, D. Evolution of cranial blood drainage in hominids: enlarged occipital/marginal sinuses and emissary foramina. *Am. J. Phys. Anthropol., 70(3)*:311-24, 1986.

Fating, A. & Pawar, S. Parietal foramina in adult human skulls: an anatomical study. *Med. Innov., 9(2)*:46-9, 2020.

Gangmei, G.; Devi, H. S.; Daimei, T.; Remei, E. & Tunglut, J. Variations of parietal foramen in dried adult human skulls. *ISOR J. Dent. Med. Sci., 17(5)*:26-9, 2018.

Ghassibé, M.; Bernier, V.; Boon, L. M. & Vikkula, M. A novel mutation in the MSX2 homeobox gene of a family with foramina parietalia permagna, headache and vascular anomaly. *Eur. J. Pediatr., 165(10)*:734-5, 2006.

Griessenauer, C. J.; Veith, P.; Mortazavi, M. M.; Stewart, C.; Grochowsky, A.; Loukas, M. & Tubbs, R. S. Enlarged parietal foramina: a review of genetics, prognosis, radiology, and treatment. *Childs Nerv. Syst., 29(4)*:543-47, 2013.

Halagatti, M. & Sagar, S. An anatomical study of parietal emissary foramina in dry adult human skulls. *Int. J. Anat. Radiol. Surg., 7(2)*:20-2, 2018.

Keskil, S.; Gözil, R. & Calgüner, E. Common surgical pitfalls in the skull. *Surg. Neurol., 59(3)*:228-31, 2003.

Magalhães, C. P.; Ferreira, M. R. S.; dos Reis, R. S.; da Silva, F. A.; dos Santos, T. R. & Campina, R. C. F. Existence of enlarged parietal foramina in bone collections. *J. Morphol. Sci., 35(2)*:125-8, 2018.

Mann, R. W. Enlarged parietal foramina and craniosynostosis in an American Indian child. *Am. J. Roentgenol., 154(3)*:658, 1990.

Mortazavi, M. M.; Tubbs, R. S.; Riech, S.; Verma, K.; Shoja, M. M.; Zurada, A.; Benninger, B.; Loukas, M. & Cohen Gadol, A. A. Anatomy and pathology of the cranial emissary veins: a review with surgical implications. *Neurosurgery, 70(5)*:1312-9, 2012.

Murlimanju, B. V.; Saralaya, V. V.; Somesh, M. S.; Prabhu, L. V.; Krishnamurthy, A.; Chettiar, G. K. & Pai, M. M. Morphology and topography of the parietal emissary foramina in South Indians: an anatomical study. *Anat. Cell Biol., 48(4)*:292-8, 2015.

Naidoo, J.; Luckrajh, J. S. & Lazarus, L. Parietal foramen: incidence and topography. *Folia Morphol. (Warsz.)*, 2020. DOI: https://www.doi.org/10.5603/FM.a2020.0140

Piagkou, M.; Skotsimara, G.; Repousi, E.; Paraskevas, G. & Natsis, K. Enlarged parietal foramina: a rare finding in a female Greek skull with unusual multiple Wormian bones and a rich parietal vascular network. *Anat. Sci. Int., 88(3)*:175-80, 2013.

Shantharam, V. & Manjunath, K. Y. Anatomical study of parietal emissary foramina in human skulls. *Int. J. Anat. Radiol. Surg., 7(1)*:AO11-AO14, 2018.

Stallworthy, J. A. A case of enlarged parietal foramina associated with metropism and irregular synostosis of the coronal suture. *J. Anat., 67(Pt. 1)*:168-74, 1932.

Techataweewan, N.; Dudzik, B.; Kitkhuandee, A.; Duangthongphon, P. & Tayles, N. Gender and population variation in craniometry and freehand pass ventriculostomy. *World Neurosurg., 117*:e194-e203, 2018.

Tsutsumi, S.; Nonaka, S.; Ono, H. & Yasumoto, Y. The extracranial to intracranial anastomotic channel through the parietal foramen: delineation with magnetic resonance imaging. *Surg. Radiol. Anat., 38(4)*:455-9, 2016.

Wu, X. J.; Xing, S. & Trinkaus, E. An enlarged parietal foramen in the late archaic Xujiayao 11 neurocranium from Northern China, and rare anomalies among Pleistocene Homo. *PLoS One, 8(3)*:e59587, 2013.

Wysocki, J.; Reymond, J.; Skarzyn´ski, H. & Wróbel, B. The size of selected human skull foramina in relation to skull capacity. *Folia Morphol. (Warsz.), 65(4)*:301-8, 2006.

Yoshioka, N.; Rhoton Jr., A. L. & Abe, H. Scalp to meningeal arterial anastomosis in the parietal foramen. *Neurosurgery, 58(1 Suppl.)*:ONS123-6, 2006.

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