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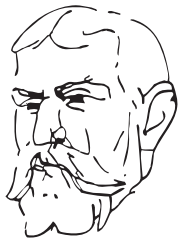

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ORIGINAL ARTICLE

ANATOMICAL VARIATIONS OF THE PARIETAL FORAMEN AND ITS RELATIONS TO THE CALVARIAL LANDMARKS: A CROSS-SECTIONAL CADAVERIC STUDY

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ABSTRACT

The aim: Estimate the prevalence of the parietal foramen in the adult human skulls of Ukrainian origin, and study its morphology and relationships to main anatomical landmarks of the skull.

Materials and methods: A cross-sectional observational study of PF was conducted with 42 random cadaveric adult human skull roofs (calvaria) collected from the laboratory and museum of Human Anatomy Department, Kharkiv National Medical University, Ukraine. The patency and the length of the PF canal were determined, and PF external/internal diameters and the distance to the calvarial landmarks from PF were measured using the caliper. Mean and standard deviation were calculated to compare with the existing data.

Results: In the present study 85.7% (n = 36) of the calvaria had the PF, 54.8% (n = 23) had bilateral location of PF, 30.9% (n = 13) had unilateral presence of PF (right side: 23.8%, n=10 and left side: 7.1%, n=3), and 14.3 % (n = 6) demonstrated bilateral absence of PF.

Conclusions: An anatomical variation in parietal foramen is not uncommon, and the differences can be based on multiple factors like geography and race. It is important to have detailed information on anatomical variations in different population groups to facilitate surgical and radiological interventions.

KEY WORDS: Parietal Foramen, Parietal Bone, Skull, Calvaria, Anatomical Variations

Wiad Lek. 2022;75(7):1648-1652

INTRODUCTION

Gaining new knowledge and establishing patterns of variability in cranial foramina, especially those that are small in size and significantly variable in their topography, their presence, and content, is important in areas such as neurosurgery, maxillofacial surgery, three-dimensional diagnosis, and minimally invasive interventions [1, 2].

It is known that the calvaria and the skull base contain numerous openings permeated with vital vascular or nerve formations. Detailed knowledge of the anatomy of these holes is important not only for understanding the local topography but also for the differentiation of normal and potentially anomalous structures [1, 3, 4]. Many researchers believe that misunderstanding variations in such formations leads to frequent damage to blood vessels or nerves during active manipulation of tools around the areas with cranial foramina [5, 6]. Detailed anatomy of the emissary foramina is important for understanding epilepsy and risk factors for seizure development [7, 8].

Particularly important and vulnerable in such cases are the foramina of the skull, through which the emissary veins pass, connecting the dural venous sinuses, diploic canals, and extracranial veins of the head [9]. Also in such openings, the arterial branches participating in the blood supply of the dura mater can pass [10].

The parietal foramen (PF) is one of these important emissary openings that have practical significance. The PF contains the emissary vein, which connects the superficial veins of the head and superior sagittal sinus and has a bilateral drainage function, which in pathological conditions can be a way for infection [11]. In addition, there is a vessel that forms an arterial anastomosis with the middle meningeal artery and branches of the superficial temporal artery [11, 12]. This arterial anastomosis can be a source of significant bleeding in case of a craniotomy in the parietal area [13].

THE AIM

To estimate the prevalence of PF in the adult human skulls of Ukrainian origin, and to study their morphology and relationships to main anatomical landmarks of the skull.

MATERIALS AND METHODS

We aim to estimate the prevalence of PF in the adult human skulls of Ukrainian origin, study their morphological varia-

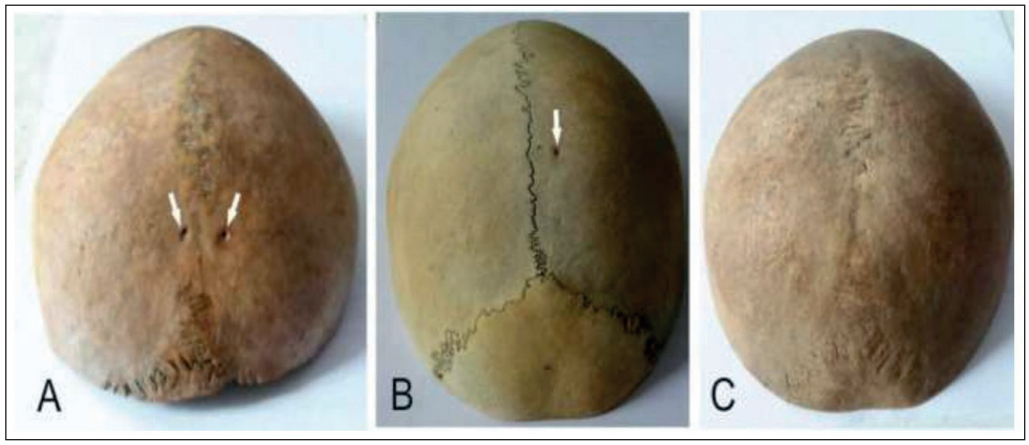

Fig. 1. Picture showing the dry cranial roofs in the present study (A) The bilateral location of the parietal foramen. (B) The unilateral location of the parietal foramen. (C) The cranium without the parietal foramen.

Table I. Table showing the morphological characteristics of the parietal foramina (PF) in the cadaveric adult human skull roofs (calvaria) of the Ukrainian origin

PF (Physical attributes)	Side	Samples	Mean ± Standard Deviation (mm)	Range (mm)	Confidence Interval (95%)	p-value
External Diameter	Right	33	1.7±0.6	0.5 - 3.0	1.49 to 1.91	P < 0.0001 (t= 6.830)
	Left	26	2.7±0.5	1.0 - 2.7	2.51 to 2.89	
Internal Diameter	Right	33	1.0±0.6	0.4 - 2.5	0.795 to 1.21	P = 0.4679 (t= 0.731)
	Left	26	1.1±0.4	0.5 - 1.8	0.946 to 1.25	
Length of the canal	Right	33	5.4±1.7	2.0 - 8.0	4.75 to 6.05	P = 0.0429 (t= 2.071)
	Left	26	6.3±1.6	3.0 -10.0	5.68 to 6.92	

Table II. Table summarizing the distance between parietal emissary foramina (PF) and main calvarial landmarks in the cadaveric adult human skull roofs (calvaria) of the Ukrainian origin

PF-main calvarial landmarks	Side	Samples	Mean ± Standard Deviation (mm)	Range (mm)	Confidence Interval (95%)	p-value
PF-bregma	Right	33	86.3±8.5	70-99	83.4 to 89.2	P = 0.7043 (t= 0.381)
	Left	26	87.2±9.6	62-99	83.5 to 90.9	
PF-vertex	Right	33	43.7±12.9	20-65	39.3 to 48.1	P = 0.6635 (t= 0.437)
	Left	26	45.2±13.3	21-77.5	40.1 to 50.3	
PF-lambda	Right	33	35.7±11.1	22.5-62	31.9 to 39.5	P = 0.8890 (t= 0.140)
	Left	26	36.1±10.6	24-61	32.5 to 39.7	
PF-obelion	Right	23	7.2±3.2	1.0-12.5	5.89 to 8.51	P=0.966031 (t= 0.04)
	Left	23	7.4±3.4	1.0-14.0	6.01 to 8.79	

tions, and establish anatomical relationships to other major landmarks. A cross-sectional observational study was conducted for this purpose taking 42 random cadaveric adult human skull roofs (calvaria) of Ukrainian origin collected from the laboratory and museum of Human Anatomy Department, Kharkiv National Medical University, Ukraine. The exact gender and age of the specimens were not determined. The skulls and bones with visible pathological changes and apparent deformities at the cranial roof were excluded from the study.

The specimens were examined, and the presence of PF was described. The patency and the length of the canal were determined with a standard metal probe. The external and internal diameters of the foramina were measured with the caliper, and the distance from PF to the important calvarial landmarks – craniometrical points obelion, bregma, lambda, and vertex were additionally measured. Mean and standard deviation were calculated to compare with the existing data.

RESULTS

Among 42 calvaria, 85.7% (n = 36) of the calvaria had visible PF located close to the posterior 1/2 of the sagittal suture. Out of all specimens, 54.8% (n = 23) had bilateral location of PF, 30.9% (n = 13) had unilateral presence of PF (right side: 23.8%, n=10 and left side: 7.1%, n=3), and 14.3 % (n = 6) demonstrated bilateral absence of PF (Fig.1).

The external and internal diameters and length of the PF were measured both on the right and left sides (Table I).

Table III. Table summarizing the incidence of the parietal foramen in different populations as observed and reported by various authors and the present study

Authors	Incidence (%)		
	Overall	Unilateral	Bilateral
Boyd, 1930, [21].	60.4	35.9	19.9
Wysocki et al., 2006, [14].	60	-	-
Yoshioka et al., 2006, [15].	50	20	40
Mann et al., 2009, [16].	79.6	34.3	45.3
Murlimanju et al., 2015, [12].	71.5	32.7	55.2
Gangmei et al., 2018 [17]	91.7	29.2	62.5
Naidoo et al., 2020 [22]	68	35	32
Liu et al., 2021, [23].	82.86	-	-
de Souza Ferreira et al., 2021, [25].	84.3	39.0 (in females) 30.0 (in males)	44.7 (in females) 54.9 (in males)
Present study	85.7	30.9	54.8

The range of the external diameter was 0.5-2.7 mm, and the mean was 1.7±0.6 mm and 2.7±0.5 on the right and on the left sides respectively. The internal diameter was from 0.4 mm to 2.5 mm with the mean of 1.0±0.6 mm on the right and 1.1±0.4 mm on the left. The mean external diameter was greater than the internal diameter in both the right ($p<0.0001$) and left ($p < 0.0001$). Both the external and internal diameters appeared to be larger on the left than on the right, but only the differences in the external diameters were significant ($P < 0.0001$, $t= 6.830$).

The length of the canal was established with a wide range of 2.0-10.0 mm with the mean 5.4±1.7 mm on the right and 6.3±1.6 mm on the left side. Also, the length of the PF canals was significantly higher in the left than the right halves of the calvaria ($P = 0.0429$, $t= 2.071$).

We also estimated the amplitude of the distance between the main landmarks of the calvaria and the PF. The distance from the PF to obelion was measured among the group of specimens with the bilateral presence of the PF ($n = 23$). This dimension had a wide range from 1.0 mm to 14.0 mm without significant difference on the sides (7.2±3.2 mm on the right and 7.4±3.4 on the left side, $P=0.966031$, $t= 0.04$). The range of distance between PF and bregma was 62.0-99.0 mm and the mean distance from PF to bregma was 86.3±8.5 mm and 87.2±9.6 mm on the right and on the left respectively. The distance of the PF from lambda ranged 22.5-62.0 mm with an established mean of 35.7±11.1 mm on the right and 36.1±10.6 mm on the left side. And the distance from the PF to the vertex had a range from 20.0 mm to 77.5 mm and the mean distance between the PF and vertex was 43.7±12.9 mm on the right and 45.2±13.3 mm on the left side. There was no significant difference between the PF and mentioned cranial landmarks depending on the right or left side (Table II).

DISCUSSION

Evaluating the prevalence of PF we have to take into account existing data that parietal foramen is found in more than half of the population and variations in these foramina is based on multiple factors like geography and race [14, 15]. In the present study, more than 4/5 of samples (85.7%) had PF, comparable to the prevalence observed by Mann [16] and Gangmei et al., [17], but other researchers reported significantly lesser prevalence (Table III). These foramina were located alongside the sagittal suture at its middle or posterior third. Bilateral localizations were the most common, although they may be present on either side or sometimes completely absent [18]. Slightly more than half (54.8%) of our samples had bilateral foramen similar to the study reported by Murlimanju et al., [12]. As we can see from different reports, bilateral localization is more common than unilateral (Table III). It is believed, that the diversity in the location of PF can be attributed to the differences in the process of ossification of the anterior fontanels [19, 12].

Different study populations had reported variable PF diameter, but the abnormally large diameter is uncommon and rarely reported [13, 20]. Diameters are usually found to be larger in people from Australia and New Zealand [21]. Similarly, the shape of the parietal foramina may be round, oval, or slit-like [13, 14]. The dimensions of the foramen and its distance from the sagittal midline affect the shape of the foramina in the relevant area [19]. Variability can be explained by differences in the ossifications as mentioned earlier.

In the present study, we observed the diameter of PF ranging 0.5 – 3.0 mm which is similar to earlier reports. Boyd has found the average size of the PF about 0.5 mm with rare cases larger than 1.5 mm [21]. In the other study, reported by Wysocki et al., the average size found was twice as major in female skulls (3 mm) than in males (1.5 mm) and a range was from 0.38 to 16.8 mm, and sexual dimorphism in the parietal ossification was suggested [14]. The study of Naidoo et al., recorded a mean diameter of 1.55 mm, with a range of 0.74–3.08 mm [22]. Similarly, Liu et al. reported that the mean diameter of the PF on the left and right sides were 1.02±0.72 mm and 1.07±0.67 mm, respectively, and the diameter of the PF on the sagittal suture was 1.77±0.44 mm [23].

The canal between the external and internal openings of the PF was found to have a twisted course. In our samples, the length of the canal on the left was also greater, especially when it followed the inclined course. There is a lack of data regarding this parameter in the literature.

PF is usually enlarged by intracranial space-occupying lesions as they behave like a safety valve to maintain the internal pressure [12]. The practical significance of PF foramina is important because of the emissary vein, which passes through it and connects superficial veins of the head and superior sagittal sinus. Although not frequently present, this vein basically functions as drainage and is a potential pathway for the inward spread of the infection [21, 16, 24]. In addition, they also transmit blood vessels that form an arterial anastomosis between the middle meningeal artery and branches of the superficial temporal artery [10]. It is important to remember that in the case of the parietal craniotomy these blood vessels can cause significant bleeding leading to high morbidity and mortality [6].

Regarding the topography of the PF, our study showed that the most common location of the PF was at the sides of the sagittal suture, middle of the distance between the craniometric points vertex and lambda (Table II). The maximum distance was observed between the PF and the point of bregma (86.3±8.5 mm on the right and 87.2±9.6 mm on the left), and the minimal distance was between PF and the obelion (7.2±3.2 mm on the right and 7.4±3.4 mm on the left) (Table II). Similar data were published by de Souza Ferreira et al., which stated that parietal foramina are located in the proximity of the sagittal suture (male 7.1 ± 2.5 mm vs. female, 7.4 ± 2.7 mm) [25].

This relevant information and characteristics can be used to determine the zone of possible localization of the emissary vessels to avoid accidental damage to these structures and prevent subsequent complications during surgical interventions. Unfortunately, we couldn't make a sufficient comparison as there was a dearth of literature. We believe that our data helps to complement this gap, prove useful in further study, and provide practical application.

CONCLUSIONS

An anatomical variation in parietal foramen is not uncommon, and the differences can be based on multiple factors like geography and race. Detailed anatomical knowledge based on the accumulation and comparison of a large amount of data from different populations for a comprehensive study of the emissary foramina will certainly improve the diagnosis, treatment, and prevention of various pathological conditions of the scalp region. We recommend that regional studies and information be collected and analyzed to incorporate them into different clinical procedures for optimal patient outcomes.

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