

MORPHOMETRIC AND MORPHOLOGICAL ANALYSIS OF PARIETAL FORAMEN VARIATIONS: IMPLICATIONS FOR NEUROSURGICAL AND VASCULAR PLANNING

Xayrullayev Po'latjon Asadulloxon o'g'li

*Samarkand State Medical University (SamSMU), Year 6,
General Medicine*

Email: xayrullayevpolatjon@gmail.com

Adxamov Asror Adxam o'g'li

*Samarkand State Medical University (SamSMU), Year 6,
General Medicine*

Email: adhamovasror605@gmail.com

Abdunazarov Muhammadali Xojiakbarovich

*Samarkand State Medical University (SamSMU), Year 6,
Faculty of General Medicine*

Email: abdunazarovmuhammadali184@gmail.com

Ziyatov Sardor Kildiyor ugli

*Samarkand State Medical University (SamSMU), Year 4,
General Medicine*

Email: ziyatovs56gmail.com

Abstract

Background. The parietal foramen is a paired anatomical opening situated near the sagittal suture on the posterior parietal bone that transmits the parietal emissary vein (PEV), establishing venous communication between the superior sagittal sinus and the extracranial scalp veins, and occasionally carries a meningeal arterial branch. Its variability is clinically relevant during midline craniotomies, parasagittal surgical approaches, and placement of ventricular or bone-flap hardware, where unrecognized anatomical differences may cause troublesome haemorrhage or venous air embolism.

Objective. To investigate the morphometric and morphological variations of the parietal foramen in dried human skulls and assess their clinical relevance for neurosurgical planning.

Materials and Methods. A total of 29 dried human skulls from the Anatomy Department of Samarkand State Medical University were examined using craniometric methods. Foramen length, width, diameter, shape, and exit orientation were measured with calipers. Statistical analysis was performed in Microsoft Excel 2010.

Results. The mean diameter of the parietal foramen was 0.24 cm on the right side and 0.24 cm on the left, with an overall mean of 0.24 cm. Oval-shaped foramina were most common on the right (50.0%), while stellate shapes predominated on the left (40.7%). Exit orientation varied, with a laterally-medially course most prevalent on the

right (29.2%) and both laterally-medially and anteriorly-superiorly-medially courses most prevalent on the left (25.9%). Absence of the foramen was recorded in 17.2% of right and 6.9% of left sides.

Conclusion. The parietal foramen exhibits significant morphometric and morphological variability, with implications for parasagittal and midline neurosurgical approaches. Preoperative recognition of its dimensions and exit orientations is essential to reduce surgical risks and improve patient outcomes.

Keywords: Parietal foramen, parietal emissary vein, craniometric analysis, anatomical variability, neurosurgical planning, foramen morphology, exit orientation.

Introduction

The parietal foramen, located close to the sagittal suture on the posterior aspect of the parietal bone, serves as a conduit for the parietal emissary vein (PEV), which connects the superior sagittal sinus to the extracranial scalp venous network and, in some individuals, transmits a small branch of the occipital artery toward the dura mater [8]. Like other emissary veins, the PEV is valveless and permits bidirectional flow, contributing to the regulation of intracranial pressure, cranial thermoregulation, and the provision of a collateral drainage route when the dural sinuses or jugular outflow are compromised [7, 12].

The anatomical variability of the parietal foramen — including its prevalence, laterality, size and precise position relative to the sagittal suture and bregma — has been documented across multiple population-based craniometric and radiological studies. Reported prevalence of an identifiable parietal foramen ranges widely, with unilateral or bilateral absence not uncommon, and considerable variation in diameter and shape has been described [3, 8, 9]. Reported mean diameters cluster in the low-millimetre range, with larger openings associated with a wider-calibre emissary vein and correspondingly greater risk of intraoperative venous bleeding [7]. The foramen may occasionally be enlarged or, rarely, absent bilaterally, a feature that has also drawn attention in the context of developmental cranial ossification defects [4].

Clinically, the parietal foramen and its emissary vein are relevant to neurosurgery, particularly parasagittal and midline craniotomies, burr-hole placement, and stereotactic frame or bolt fixation, as well as to scalp and craniofacial reconstructive procedures. Unrecognized variation can result in unexpected venous haemorrhage or, when the vein communicates directly with the sinus during positioning changes, air embolism [7, 12]. Preoperative imaging — including thin-slice CT and cone-beam CT — has been advocated to localize the foramen and estimate the likely calibre of its contained vein before surgery [1, 11, 19].

Despite a substantial body of anatomical literature, standardized, high-resolution morphometric mapping of the parietal foramen and its exit course remains comparatively limited relative to other cranial emissary foramina. This study aims to

characterize the morphometric and morphological features of the parietal foramen in a local cadaveric skull sample and relate these findings to their surgical relevance.

Materials and Methods

The study was conducted using the craniometric method to assess the characteristics of the parietal foramina. Measurements included the shape of the foramen, the shape of its exit course, and the length and width of the foramen. The likely course of the vein was estimated based on the exit orientation of the foramen relative to the sagittal suture.

The study material consisted of 29 dried, intact human skulls, obtained from the Anatomy Department Laboratory at Samarkand State Medical University. No selection criteria for sex or age were applied to the skull specimens.

Craniometric measurements of the foramen shape and diameter were performed using a calibrated metal caliper (Set 3-D of drawing tools, MINPRIBOR USSR, Rylysk, Model U-9, GOST 6100-68). To ensure accuracy and convert measurements to centimeters, an electronic caliper (Matrix Digital Caliper, 150 mm, MTX, 316119) was employed for comparative analysis.

Statistical analysis of the collected data was performed using Microsoft Excel 2010, with appropriate calculation formulas applied to process the measurements.

Results and Discussion

The craniometric measurements revealed that the average length and width of the right parietal foramen were 0.28 cm and 0.23 cm, respectively, while those of the left parietal foramen were 0.28 cm and 0.23 cm. The mean diameter of the foramina was calculated using the ellipse average diameter formula, $D = 2 * a * b / (a + b)$, where "a" represents the approximate length and "b" the approximate width. Based on this formula, the mean diameter of the right foramen was determined to be 0.24 cm, and that of the left foramen was 0.24 cm. The overall mean diameter of both foramina was calculated as 0.24 cm.

No	Right foramen length (cm)	Right foramen width (cm)	Left foramen length (cm)	Left foramen width (cm)
1	0.42	0.33	0.39	0.27
2	0.36	0.32	0.32	0.18
3	0.20	0.16	0.31	0.28
4	0.35	0.13	0.28	0.27
5	Absent	Absent	Absent	Absent
6	0.29	0.17	0.37	0.15
7	0.44	0.17	0.31	0.31
8	0.28	0.32	0.37	0.19
9	0.25	0.26	0.29	0.28
10	Absent	Absent	0.30	0.17

No	Right foramen length (cm)	Right foramen width (cm)	Left foramen length (cm)	Left foramen width (cm)
11	0.21	0.25	0.14	0.12
12	0.17	0.20	0.24	0.22
13	0.38	0.19	0.25	0.22
14	Absent	Absent	0.18	0.17
15	0.19	0.16	0.16	0.29
16	0.32	0.24	0.35	0.23
17	0.39	0.15	0.35	0.26
18	Absent	Absent	0.34	0.20
19	0.18	0.17	0.28	0.15
20	Absent	Absent	0.24	0.15
21	0.16	0.24	0.31	0.30
22	0.36	0.28	0.21	0.28
23	0.18	0.19	0.18	0.17
24	0.27	0.18	0.35	0.31
25	0.23	0.36	Absent	Absent
26	0.21	0.13	0.18	0.23
27	0.40	0.18	0.21	0.27
28	0.27	0.33	0.19	0.26
29	0.26	0.35	0.34	0.19

Table 1. Measurement Results of Length and Width for the Right and Left Parietal Foramen

Analysis of parietal foramen shape revealed distinct patterns on both sides. On the right side, the most common shape was Oval in 12 cases (50.0%), followed by Stellate in 8 cases (33.3%). On the left side, the most common shape was Stellate in 11 cases (40.7%), followed by Ellipse in 7 cases (25.9%). Comprehensive shape data for the parietal foramina are summarized in Table 2.

No	Right foramen shape	Left foramen shape
1	Stellate	Stellate
2	Stellate	Ellipse
3	Round	Oval
4	Oval	Stellate
5	Absent	Absent
6	Oval	Ellipse
7	Oval	Stellate
8	Oval	Round
9	Stellate	Ellipse
10	Absent	Stellate

No	Right foramen shape	Left foramen shape
11	Oval	Oval
12	Stellate	Round
13	Oval	Ellipse
14	Absent	Oval
15	Oval	Stellate
16	Oval	Stellate
17	Stellate	Oval
18	Absent	Stellate
19	Stellate	Stellate
20	Absent	Ellipse
21	Stellate	Round
22	Round	Stellate
23	Oval	Oval
24	Ellipse	Ellipse
25	Oval	Absent
26	Oval	Oval
27	Oval	Stellate
28	Ellipse	Ellipse
29	Stellate	Stellate

Table 2. Results of Shape Measurement of the Parietal Foramen on the Right and Left Sides

As with the mastoid and other cranial emissary foramina, the "shape of the exit" was also assessed for the parietal foramen, describing the orientation in which the contained vein was estimated to leave the outer table of the skull toward the scalp, guided by the direction of the associated bony groove.

Craniometric evaluation of the parietal foramen exit orientation showed considerable variability. On the right side, a laterally-medially coursing exit was most prevalent (Laterally - Medially in 7 cases (29.2%)), followed by a posteriorly-medially orientation (Posteriorly - Medially in 6 cases (25.0%)). Complete absence of the right parietal foramen was noted in 5 cases (17.2%). On the left side, laterally-medially and anteriorly-superiorly-medially exit orientations were equally the most prevalent (Laterally - Medially in 7 cases (25.9%); Anteriorly - Superiorly - Medially in 7 cases (25.9%)). Absence of the left parietal foramen was recorded in 2 cases (6.9%).

The total presence of parietal foramina on the right and left sides combined was 87.9% (51 of 58 sides examined), underscoring the frequency with which this emissary pathway must be anticipated during parasagittal and midline surgical approaches.

No	Right foramen exit orientation	Left foramen exit orientation
1	Anteriorly - Superiorly - Medially	Anteriorly - Medially
2	Laterally - Medially	Laterally - Medially
3	Posteriorly - Medially	Anteriorly - Superiorly - Medially
4	Anteriorly - Medially	Laterally - Medially
5	Absent	Absent
6	Posteriorly - Medially	Anteriorly - Medially
7	Anteriorly - Medially	Anteriorly - Medially
8	Laterally - Medially	Posteriorly - Superiorly - Medially
9	Laterally - Medially	Anteriorly - Superiorly - Medially
10	Absent	Anteriorly - Superiorly - Medially
11	Posteriorly - Medially	Laterally - Medially
12	Anteriorly - Medially	Anteriorly - Superiorly - Medially
13	Laterally - Medially	Anteriorly - Medially
14	Absent	Posteriorly - Superiorly - Medially
15	Laterally - Medially	Laterally - Medially
16	Laterally - Medially	Anteriorly - Superiorly - Medially
17	Posteriorly - Superiorly - Medially	Anteriorly - Superiorly - Medially
18	Absent	Posteriorly - Medially
19	Anteriorly - Medially	Posteriorly - Medially
20	Absent	Laterally - Medially
21	Posteriorly - Medially	Posteriorly - Superiorly - Medially
22	Laterally - Medially	Posteriorly - Superiorly - Medially
23	Anteriorly - Superiorly - Medially	Laterally - Medially
24	Posteriorly - Medially	Posteriorly - Superiorly - Medially
25	Anteriorly - Superiorly - Medially	Absent
26	Anteriorly - Superiorly - Medially	Anteriorly - Superiorly - Medially
27	Anteriorly - Superiorly - Medially	Anteriorly - Medially
28	Anteriorly - Medially	Laterally - Medially
29	Posteriorly - Medially	Posteriorly - Superiorly - Medially

Table 3. Results of the Measurement of Parietal Foramen Exit Orientation

Conclusion

The parietal emissary vein (PEV), together with its associated parietal foramen, represents a clinically significant anatomical structure characterized by notable variability in prevalence, morphology, and dimensions. Consistent with findings for other cranial emissary systems, considerable differences in the size, shape and exit course of the parietal foramen were observed across individuals and between sides in the same skull [3, 7, 9, 12].

The calibre of the PEV is expected to vary with foramen diameter, and larger openings are presumed to carry a correspondingly higher risk of venous bleeding during parasagittal craniotomy, burr-hole trephination, or stereotactic bolt placement

[5, 12]. Beyond surgical risk, the PEV may contribute to collateral venous drainage of the superior sagittal sinus in pathological states such as sinus thrombosis or elevated intracranial pressure [7]. Preoperative thin-slice CT or cone-beam CT (CBCT) can assist in localizing the foramen and anticipating its contained vessel prior to midline surgical interventions [3, 11].

Further research with larger, multi-population samples and advanced imaging modalities is warranted to better characterize parietal foramen variability and its practical implications for neurosurgical and craniofacial planning. Comprehensive anatomical knowledge of this structure remains important for minimizing surgical risk and improving patient outcomes [4, 5].

References:

1. Akram, Waqar, et al. "Morphometric and morphological evaluation of cranial emissary foramina using cone-beam computed tomography." *International Journal of Academic Medicine and Pharmacy* 6.1 (2024): 96-98.
2. Forámenes Emisarios del Cráneo Humano. "Emissary foramina of the human skull: anatomical characteristics and its relations with clinical neurosurgery." *International Journal of Morphology* 31.1 (2013): 287-292.
3. Demirpolat, Gülen, E. Bulbul, and B. Yanik. "The prevalence and morphometric features of the parietal emissary vein on multidetector computed tomography." *Folia Morphologica* 75.4 (2016): 448-453.
4. Eisová, Stanislava, et al. "Normal craniovascular variation in two modern European adult populations." *Journal of Anatomy* 235.4 (2019): 765-782.
5. Hampl, Martin, et al. "Parietal foramen, parietal emissary vein and clinical implications in neurosurgery." *Acta Neurochirurgica* 160 (2018): 1473-1482.
6. Haroun, H. "Emissary veins and foramina: topography, incidence, and clinical significance." *MOJ Anatomy & Physiology* 10.1 (2023): 27-30. DOI: 10.15406/mojap.2023.10.00334
7. Kim, Leo KP, Chris S. Ahn, and Antonio EL Fernandes. "Parietal emissary vein: anatomy and clinical relevance in plastic & reconstructive surgery." *Journal of Plastic, Reconstructive & Aesthetic Surgery* 67.6 (2014): 775-780.
8. Louis, Robert G., et al. "Clinical anatomy of the parietal and occipital emissary veins in a large series." *Surgical and Radiologic Anatomy* 31 (2009): 139-144.
9. Murlimanju, B. V., et al. "Parietal emissary foramina: an anatomical morphological study with discussion on their evolutionary and clinical implications." *Anatomy & Cell Biology* 47.3 (2014): 202-206.
10. Syed, Ali Z., et al. "Incidental occurrence of an unusually large parietal foramen on cone-beam computed tomography and review of the literature." *Imaging Science in Dentistry* 46.1 (2016): 39-45.
11. Temiz, Mustafa, et al. "Morphometric and morphological evaluation of cranial emissary canals using cone-beam computed tomography." *Science Progress* 106.2 (2023): 00368504231178382.
12. Zhou, Wei, et al. "Clinical applications of the parietal emissary vein." *Surgical and Radiologic Anatomy* 45.1 (2023): 55-63.