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

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Abstract

Background. The mastoid foramen is a key anatomical structure that transmits the mastoid emissary vein (MEV), providing venous communication between intracranial and extracranial systems. Its variability poses challenges during neurosurgical and otologic procedures, where unrecognized anatomical differences may lead to complications such as hemorrhage or air embolism.

Objective. To investigate the morphometric and morphological variations of the mastoid 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 mastoid foramen was 0.13 cm on the right side and 0.10 cm on the left, with an overall mean of 0.12 cm. Star-shaped foramina were most common (32.1% right, 37.8% left), followed by round shapes (17.8% right, 24.1% left). Exit orientations showed variability: medially-superiorly-posteriorly was most prevalent (34.5% right, 31.03% left). Absence of the foramen was recorded in 24.1% of right and 10.3% of left sides.

Conclusion. The mastoid foramen exhibits significant morphometric and morphological variability, with implications for neurosurgical approaches in the posterior cranial fossa. Preoperative recognition of its dimensions and exit orientations is essential to reduce surgical risks and improve patient outcomes.

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

Introduction

The mastoid foramen, located on the posterior border of the temporal bone, serves as a critical anatomical conduit for the mastoid emissary vein (MEV), which connects the sigmoid sinus to the suboccipital venous plexus and, in some cases, transmits a branch of the occipital artery to the dura mater [8]. The MEV is a valveless vessel, allowing bidirectional blood flow, and plays a significant role in balancing intracranial and extracranial venous pressures, thermoregulation, and providing collateral drainage pathways, particularly in cases of jugular vein obstruction or intracranial hypertension [7, 12].

The anatomical variability of the mastoid foramen—including its prevalence, number, size, and precise location—has been well documented across diverse populations and imaging modalities. Studies have reported a prevalence ranging from 83% to over 90% for the presence of the mastoid foramen, with considerable variation in the number of foramina per individual and in their morphometric characteristics [3, 8, 9]. The mean diameter of the foramen has been reported between 1.3 mm and 3.5 mm, with larger diameters associated with increased risk of intraoperative bleeding [7]. Notably, the foramen may be single, multiple, or absent, and its size and number can be influenced by factors such as sex, cranial morphology, and population-specific traits [4].

From a clinical perspective, the mastoid foramen and MEV are of paramount importance in neurosurgery, otologic surgery, and craniofacial procedures. Unrecognized anatomical variations can lead to significant complications, including uncontrollable hemorrhage, air embolism, and postoperative thrombosis (7, 12). Preoperative identification of these structures using advanced imaging techniques such as cone-beam computed tomography (CBCT) and multidetector CT has been advocated to mitigate surgical risks [1, 11, 19].

Despite extensive anatomical and radiological studies, there remains a need for standardized, high-resolution morphometric mapping of the mastoid foramen exit holes. Current literature often lacks comprehensive, population-based analyses that integrate morphometric data with clinical risk stratification. This review aims to synthesize existing knowledge, highlight methodological advances in exit hole mapping, and identify directions for future research to enhance surgical safety and anatomical understanding.

Materials and Methods

The study was conducted using the craniometric method to assess the characteristics of the mastoid foramina. Measurements included the shape of the foramen, the shape of its exit, as well as the

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length and width of the foramen. The course of the vein was estimated based on the exit shape of the foramen.

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, Rylsk, 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 mastoid foramen were 0.29 cm and 0.24 cm, respectively, while those of the left mastoid foramen were 0.22 cm and 0.19 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 0.13 cm, and that of the left foramen was 0.10 cm. The overall mean diameter of both foramina was calculated as 0.12 cm.

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

No	Right foramina length	Right foramina width	Left foramina length	Left foramina width
1	0,22	0,22	0,18	0,19
2	0,09	0,06	0,08	0,08
3	0,46	0,26	0,23	0,25
4	**Absent**	**Absent**	**Absent**	**Absent**
5	0,16	0,21	0,2	0,2
6	**Absent**	**Absent**	0,25	0,2
7	0,4	0,37	0,23	0,27
8	0,2	0,27	0,2	0,25
9	0,24	0,22	0,24	0,17
10	0,21	0,19	0,31	0,25
11	**Absent**	**Absent**	0,33	0,26
12	0,22	0,2	0,25	0,24
13	**Absent**	**Absent**	0,19	0,14
14	0,22	0,22	0,21	0,22
15	0,21	0,18	0,26	0,21
16	0,18	0,14	0,25	0,16
17	**Absent**	**Absent**	0,27	0,19
18	0,18	0,17	0,19	0,13
19	**Absent**	**Absent**	0,12	0,1
20	0,33	0,32	0,19	0,18
21	0,11	0,9	0,14	0,14
22	0,21	0,13	0,18	0,16
23	0,14	0,17	0,31	0,3
24	0,28	0,38	**Absent**	**Absent**
25	0,22	0,21	0,16	0,17
26	0,26	0,25	0,33	0,3
27	0,24	0,14	0,26	0,15
28	0,24	0,16	0,24	0,15
29	**Absent**	**Absent**	**Absent**	**Absent**

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Analysis of the mastoid foramen shape revealed distinct patterns on both sides. On the right side, the most common shape was star-shaped, observed in 9 cases (32.1%), followed by a round shape in 5 cases (17.8%). Similarly, on the left side, the star-shaped foramen was predominant, identified in 11 cases (37.8%), with a round shape observed in 7 cases (24.1%). Comprehensive measurement data for the mastoid foramina are summarized in **Table 2.**

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

No	Right foramina shape	Left foramina shape
1	Ellipse	Stellate
2	Stellate	Round
3	Stellate	Stellate
4	**Absent**	**Absent**
5	Ovale	Round
6	**Absent**	Round
7	Round	Stellate
8	Stellate	Ovale
9	Ovale	Stellate
10	Stellate	Ovale
11	**Absent**	Ellipse
12	Round	Stellate
13	**Absent**	Ellipse
14	Triangle	Round
15	Stellate	Ellipse
16	Ellipse	Stellate
17	**Absent**	Stellate
18	Round	Ellipse
19	**Absent**	Stellate
20	Round	Stellate
21	Stellate	Stellate
22	Stellate	Round
23	Ellipse	Ellipse
24	Ellipse	**Absent**
25	Triangle	Ellipse
26	Round	Round
27	Stellate	Stellate
28	Stellate	Round
29	**Absent**	**Absent**

As an additional aspect in measuring the mastoid foramina of the skull, the "shape of the exit from the foramen" was also highlighted, indicating the presence of small grooves from the foramen both externally along the path and internally, thinning medially or, in rare cases, laterally (1 case, as indicated in **Table 3**).

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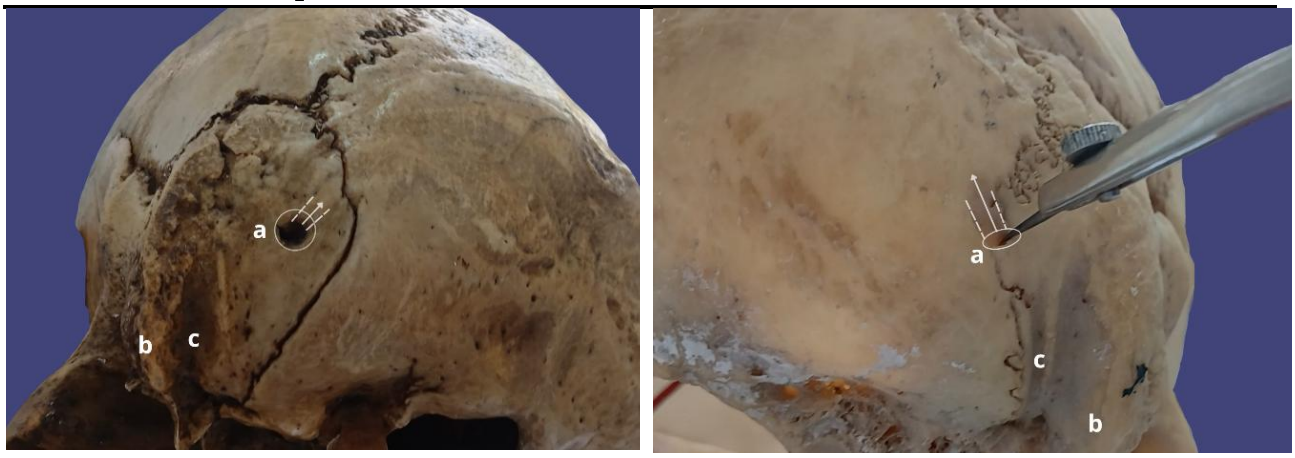

Figure 7. Key characteristics of the mastoid foramina and related anatomical structures.

Element (a) depicts the circle/oval shape, illustrating the diameter and length of the foramina at defined borders, with an arrow indicating the predicted path of the emissary mastoid vein exiting the foramen and a dashed line marking the edges of the groove forming the exit.
Element (b) represents the mastoid process with its posterior border.
Element (c) shows the mastoid notch.

Craniometric evaluation of the mastoid foramen exit orientations provided detailed insights into their anatomical variations. For the right mastoid foramen, the most prevalent exit orientation was medially-superiorly-posteriorly, observed in 10 cases (34.5%), followed by medially-superiorly in 6 cases (20.69%) and medially-posteriorly in 5 cases (17.24%). Complete absence of the right foramen was noted in 7 cases (24.14%). A single case of a medially-superiorly-ventrally oriented foramen exit was identified, suggesting a potential anatomical anomaly. For the left mastoid foramen, the predominant exit orientations were medially-superiorly-posteriorly and medially-posteriorly, each observed in 9 cases (31.03%), followed by medially-superiorly in 4 cases (13.79%) and medially-inferiorly in 3 cases (10.34%). Absence of the left foramen was recorded in 3 cases (10.34%). A single case of a strictly medial exit was noted, indicating a complete lack of groove formation.
The total presence of foramina on the right and left sides is 82.7% (48 cases), a significant indicator highlighting the prevalence of this emissary foramen.

Table 3. Results of the Measurement of Foramina Exit

No	Right foramina exit shape	Left foramina exit shape
1	Medially – Superiorly - Posteriorly	Medially – Superiorly – Posteriorly
2	Medially – Superiorly - Posteriorly	Medially – Superiorly – Posteriorly
3	Medially – Superiorly - Ventrally	Medially – Superiorly – Posteriorly
4	**Absent**	**Absent**
5	Medially – Superiorly - Posteriorly	Medially – Superiorly
6	**Absent**	Medially – Inferiorly
7	Medially – Superiorly - Posteriorly	Medially – Inferiorly
8	Medially - Posteriorly	Medially – Superiorly

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9	Medially – Superiorly - Posteriorly	Medially – Superiorly
10	Medially – Superiorly - Posteriorly	Medially – Posteriorly
11	**Absent**	Medially – Posteriorly
12	Medially – Superiorly	Medially – Superiorly - Posteriorly
13	**Absent**	Medially – Superiorly - Posteriorly
14	Medially - Posteriorly	Medially – Posteriorly
15	Medially – Superiorly - Posteriorly	Medially – Posteriorly
16	Medially – Superiorly - Posteriorly	Medially – Posteriorly
17	**Absent**	Medially – Posteriorly
18	Medially – Superiorly - Posteriorly	Medially – Posteriorly
19	**Absent**	Medially – Posteriorly
20	Medially – Superiorly	Medially
21	Medially – Superiorly	Medially – Superiorly – Posteriorly
22	Medially – Posteriorly	Medially - Inferiorly
23	Medially – Superiorly	Medially – Superiorly – Posteriorly
24	Medially – Superiorly	**Absent**
25	Medially – Superiorly	Medially – Superiorly – Posteriorly
26	Medially – Superiorly - Posteriorly	Medially – Superiorly
27	Medially – Posteriorly	Medially – Superiorly – Posteriorly
28	Medially – Posteriorly	Medially – Posteriorly
29	**Absent**	**Absent**

Conclusion

The mastoid emissary vein (MEV), along with its associated mastoid foramen (MF) and mastoid emissary canal (MEC), represents a clinically significant anatomical structure characterized by notable variability in prevalence, morphology, and dimensions. Numerous studies have consistently reported a high prevalence of the MEV, ranging from 83.5% to 98%, with significant differences in the number and size of mastoid foramina observed across individuals [3, 7, 9, 12].

The diameter of the MEV varies widely, with larger veins (>2.5 mm) posing a higher risk of profuse intraoperative bleeding and complications [5, 12]. The length of the MEV and its relationship to surrounding anatomical landmarks, such as the asterion, further underscores the importance of individualized surgical planning [8]. Beyond surgical risks, the MEV plays a role in collateral venous drainage in pathological conditions such as internal jugular vein obstruction and intracranial hypertension [7]. Preoperative imaging using thin-slice CT or cone-beam CT (CBCT) has proven valuable in identifying these anatomical variations and guiding safe surgical interventions [3, 11].

Further research involving larger sample sizes, advanced imaging modalities, and cross-population comparisons is necessary to deepen our understanding of MEV variability and its implications for neurosurgery and otologic procedures. Comprehensive anatomical knowledge remains crucial for minimizing surgical risks and improving patient outcomes [4, 5].

References:

1. Akram, Waqar, et al. "Morphometric and morphological evaluation of mastoid emissary canal using cone-beam computed tomography." International Journal of Academic Medicine and Pharmacy 6.1 (2024): 96-98.

Web of Medicine: Journal of Medicine, Practice and Nursing
webofjournals.com/index.php/5

2. del Cráneo Humano, Forámenes Emisarios. "Emissary foramens 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 mastoid 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. "Mastoid foramen, mastoid 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. "Mastoid 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 mastoid and occipital emissary veins in a large series." Surgical and Radiologic Anatomy 31 (2009): 139-144.
9. Murlimanju, B. V., et al. "Mastoid 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 mastoid 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 mastoid emissary canal using cone-beam computed tomography." Science Progress 106.2 (2023): 00368504231178382.
12. Zhou, Wei, et al. "Clinical applications of the mastoid emissary vein." Surgical and Radiologic Anatomy 45.1 (2023): 55-63.

Web of Medicine: Journal of Medicine, Practice and Nursing
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