



Rare anatomical variation of the mastoid foramen and its clinical and surgical implications: case report

Varição anatômica rara do forame mastoideo e suas implicações clínico-cirúrgicas: relato de caso



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Abstract

The mastoid foramen is an osseous structure located on the posterior aspect of the mastoid process. This foramen may exhibit variations in size, diameter, laterality, number, location, and even sex and ancestry. Few studies investigate the anatomical variations in this bony structure. The present study reported a morphometric analysis of the increased diameter of the mastoid foramen in a 25-year-old male patient. In this context, our findings highlight the importance of describing the changes in the diameter of the mastoid foramen and their clinical and surgical implications.

Keywords: Skull base, Mastoid foramen, Neurosurgery, Temporal bone, Mastoid, Anatomic variation

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Resumo

O forame mastoideo é um acidente ósseo localizado na porção posterior do processo mastoideo e pode apresentar variações em tamanho, diâmetro, lateralidade, quantidade, localização e até mesmo em relação ao sexo e à ancestralidade. Existem poucos relatos na literatura sobre variações anatômicas nesse acidente ósseo. Este estudo apresenta uma análise morfométrica sobre o diâmetro aumentado do forame mastoideo em paciente masculino de 25 anos. Nesse quadro, notou-se a importância de descrever as alterações do diâmetro do forame mastoideo e suas implicações clínico-cirúrgicas.

Palavras-chave: Base do crânio; Forame mastoideo; Neurocirurgia; Osso temporal; Processo mastoideo; Variação anatômica.

INTRODUCTION

The mastoid foramen (MF) is an osseous structure located on the posterior aspect of the mastoid process or the occipitomastoid suture of the temporal bone¹. The mastoid emissary vein (MEV), which joins the posterior auricular or occipital veins to the sigmoid sinus, passes through it. Additionally, a meningeal branch of the occipital artery may also traverse it². The MF may present anatomical variations, being single, multiple, or absent. An increase in its diameter is a clinically relevant finding and may impact surgical and diagnostic procedures in several areas (e.g., neurosurgery, plastic surgery, and otologic surgery)^{1,3}.

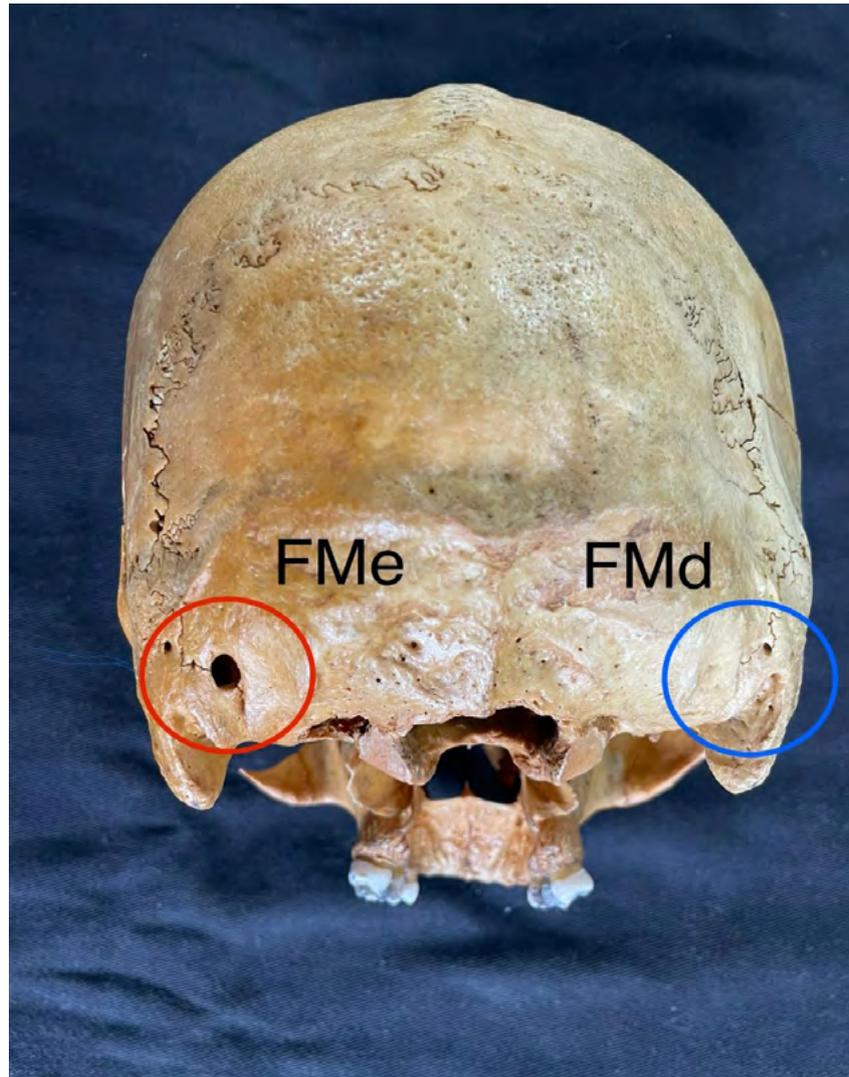
Prior knowledge of MF anatomy and variations (e.g., increased diameter, vascular components comprised) is essential, since injuries to this structure cause profuse bleeding and may lead to severe complications during surgical intervention^{1,4}. However, literature still lacks studies on MF morphology, clinical implications, and consequences.

Therefore, this study aimed to describe an anatomical variation of the MF, highlighting its increased diameter, and to discuss its clinical implications relevant to surgical and diagnostic procedures in this specific region.

CASE REPORT

This research was conducted in a forensic anthropology and osteology laboratory at a higher education institution. During the routine process of washing and drying the skeletal collection for storage, a rare anatomical variation of the left MF was identified in a skull of a 25-year-old male (Figure 1).

Figure 1. Posteroinferior view of the skull showing the right and left mastoid foramina, with a variation on the left side.



Legend: Left mastoid foramen (LMF); Right mastoid foramen (RMF).

A thickness caliper, a curved Castroviejo-type compass, and a digital caliper were used for the morphometric analysis.

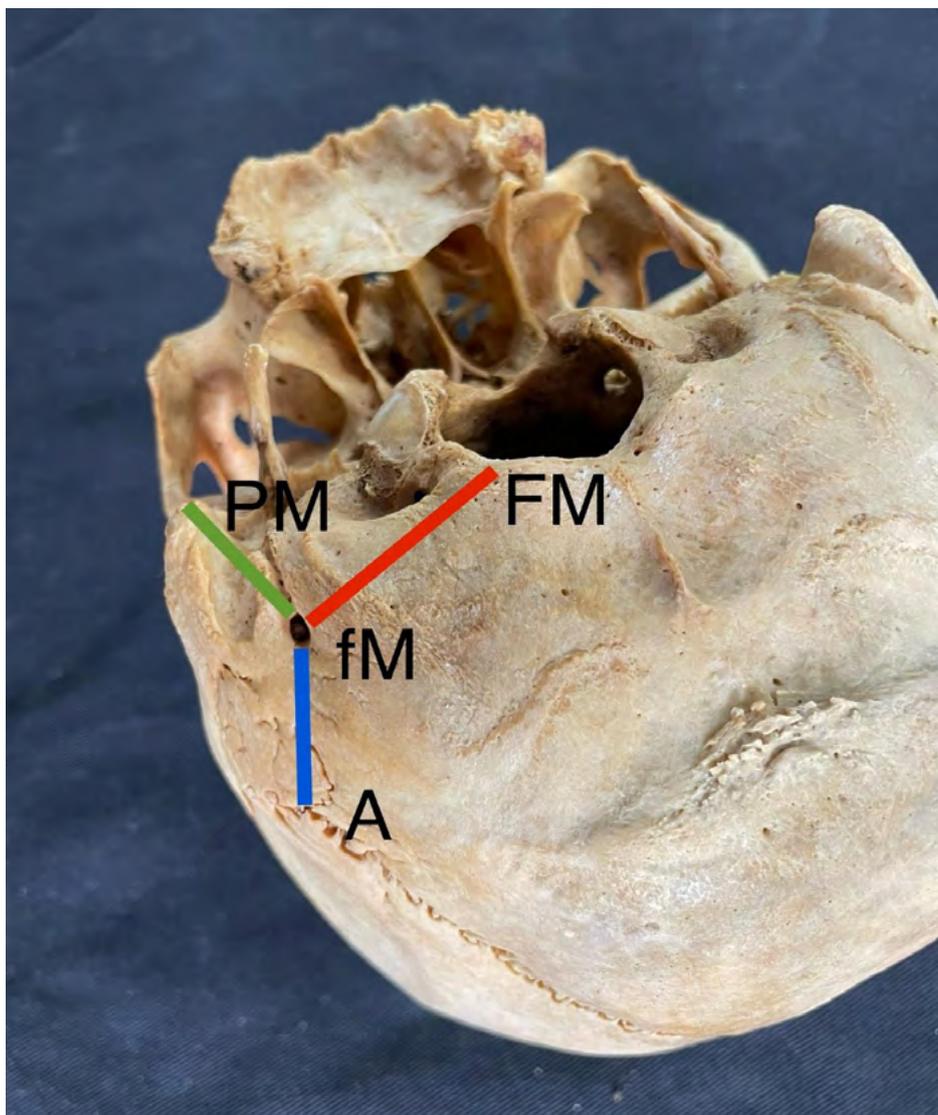
Figure 2 shows the morphological and morphometric variables analyzed during the study: (1) MF presence; (2) foramina number; (3) MF location in the occipitomastoid suture; (4) MF diameters; (5) MF position in the auriculo-orbital plane (Frankfurt Plane), and the distances between the MF and specific anatomical landmarks, such as: (6) the distance between the MF and the apex of the mastoid process; (7) the distance between the MF and the foramen magnum; and (8) the distance between the MF and the asterion.

The MF was present on both sides of the occipitomastoid suture in the analyzed skull, totaling three foramina: two on the left and one on the right side. On the right side, the MF was

located on the occipitomastoid suture, while the left side showed two distinct locations: laterally to the suture and another increased MF was located on the suture.

MF diameters were measured on the right and left sides. On the right side, the superoinferior diameter was 3 mm and the laterolateral was 2 mm. On the left side, the diameter was 11 mm for the superoinferior and 9 mm for the laterolateral. All three foramina were located below the auriculo-orbital plane (Frankfurt Plane). The distances between the MF and the apex of the mastoid process were 36 mm on the right and 34.2 mm on the left. The distance between the MF and the foramen magnum was 40 mm on the right and 35 mm on the left. Additionally, the distance between the MF and the asterion was 19 mm on the right and 20.5 mm on the left.

Figure 2. Superficial landmarks and their distances from the mastoid foramen: green, apex of the mastoid process–mastoid foramen; red, foramen magnum–mastoid foramen; blue, asterion–mastoid foramen.



Legend: Asterion (A); foramen magnum (FM); mastoid foramen (MF); mastoid process (MP).

DISCUSSION

The MF is highly prevalent in human skulls, mainly at the occipitomastoid suture of the temporal bone^{1,5,6}. This foramen may vary in size, diameter, side, number, location, and regarding sex and ancestry⁷. The development of the temporal bone is influenced by the vessels present in the mastoid canals, beginning in the squamous portion at the eighth week of fetal life, while the petrous part forms between the fifth month of pregnancy and the first year of life². In this context, the present report aimed to clarify aspects of the morphology and morphometry of this structure. Our findings contribute to understanding MF anatomical variations, including its increased diameter and associated clinical implications.

Galvão *et al.* (2024) analyzed 78 human skulls and observed the MF on at least one side of each. On the right side, the MF was identified in 98.72% (n = 77) of the skulls, while the left side showed 93.59% (n = 73)⁸. Yurdabakan *et al.* (2023), using computed tomography of 472 patients, found a lower frequency, with the MF present in 85% of skulls, of which 67.80% appeared on the right side and 65.70% on the left⁵. Similarly, Kim *et al.* (2014), analyzing 176 skulls, reported comparable frequencies regarding laterality, with the MF present on the left side in 76.13% and on the right side in 72.86%⁶. In contrast to previous studies, Zhou W *et al.* (2023) reported a discrepancy between the sides, with a higher prevalence on the right side (92%) compared to the left (72%)⁹. Furthermore, Kim *et al.* (2014) observed that among the analyzed skulls, 81.82% had a single MF, 16.67% presented double MF, and 1.51% had triple MF⁶.

The MF was identified bilaterally, with a single pattern on one side and a double pattern on the other, corroborating previous reports of bilateral and multiple variation. However, the literature indicates that this pattern is not uniform across different populations. The morphological aspects of the MF may vary among populations, depending on the ethnic group, underscoring the importance of morphometric studies in understanding this structure within the Brazilian population.

Wysocki *et al.* (2006) analyzed the area of the MF in 50 men and 50 women and reported that, in men, the mean values were 7.29 mm² on the left side and 7.48 mm² on the right, while in women, the mean values were 4.10 mm² and 6.19 mm², respectively¹⁰. Chaiyamoong *et al.* (2023) observed that the diameter of the external opening of the communicating MF was 2.43 ± 0.79 mm, approximately twice the value recorded in non-communicating MFs, whose mean diameter was 1.14 ± 0.56 mm. Furthermore, the authors reported a case in which two external MFs shared a single internal opening, resulting in bifurcation of the MEV¹¹.

The MF tends to be small or absent at early ages. In a study by Robson *et al.* (2000) involving 77 children, the MF was not identified or had a diameter of about 1 mm in children under two years old¹². Additionally, Hauser *et al.* (1989) analyzed 100 skulls and classified the MF size based on the diameter of the wire able to pass through it, categorizing it as small (1 mm), medium

(2 mm), or large (2.6 mm)¹³.

Cases of abnormally large MFs have been described. Cheatle (1925) and Hauser (1989) reported MFs with diameters up to 10 mm, emphasizing that these occurrences are rare and often associated with the absence or reduction of the sigmoid sinus^{13, 14}. Boyd (1930) also described enlarged MFs, including a case in which rickets led to narrowing of the jugular foramen and enlargement of the MF, measuring 8 mm externally and 6 mm internally¹⁵. Cheatle (1925) reported large-diameter foramina, a left measuring 10 mm and a right measuring 6 mm, both associated with a small jugular foramen¹⁴. Hauser *et al.* (1989) considered a 7 mm MF as large¹³.

Yurdabakan *et al.* (2023) described a diameter ranging from 0 to 4 mm, with a mean of 3.39 mm⁵. Kim *et al.* (2014) examined 80 skulls and 26 hemi skulls and found a mean diameter of 1.64 mm (1.73 mm on the left and 1.47 mm on the right). In 15% of hemi skulls, the MF exceeded 2.5 mm, and in 4.3%, it surpassed 4 mm, with a maximum of 7 mm⁶. Hernández *et al.* (2014) classified foramina with diameters greater than 4 mm as dilated, highlighting their clinical relevance due to increased risk of bleeding during surgical procedures in the mastoid region³. Conversely, foramina smaller than 0.8 mm were considered small⁶.

In this study, the left MF presented a significantly larger diameter, measuring 9 mm in the laterolateral and 11 mm in the superoinferior dimension. These values exceed those reported in the literature, evidencing a rare and clinically relevant variation. This finding highlights the importance of considering these variations in clinical practice and diagnostic interpretation, given their implications in neurosurgical procedures and anatomical assessments, particularly considering morphological differences among ethnic groups. Since previous studies were conducted in distinct populations, recognizing that genetic and environmental factors may influence these variations is essential, highlighting the need for further investigations in different populations.

Although recent studies have explored the prevalence, morphometry, and anatomical variants of the MF and MEV, a gap in this topic remains. The prevalence of the MF is closely related to the presence of the MEV⁵. The MEV is classified as rudimentary (<0.8 mm) or dilated (>4 mm), with the latter being less prevalent⁵. Our report observed a dilated MF on the left side, consistent with the classification proposed by Hernández (2014) for dilated MEV, since the superoinferior diameter measured 11 mm, significantly exceeding the parameters for a rudimentary MEV.

Moreover, the MEV passes through the MF, establishing a connection between the sigmoid sinus (an intracranial venous structure), the extracranial, the posterior auricular, and the occipital veins, assisting in cranial venous drainage⁴. In this context, if the sigmoid sinus does not develop adequately, the transverse sinus may compensate by externalizing through an enlarged MF. This behavior may suggest that a larger MF is an anatomical adaptation to this condition². The MF, usually small, may increase in size if the MEV is more developed. This enlargement of the MF and MEV is associated with a reduction of the jugular foramen, one of the main venous drainage

channels of the cranium. If the jugular foramen does not develop properly (congenital stenosis), the MEV may compensate by enlarging and become the primary drainage route for the venous sinuses of the posterior cranial fossa².

In cases of intracranial hypertension, hypoplasia, or aplasia of the internal jugular vein, the MEV tends to increase and dilate. In these situations, blood flow is altered, typically characterized by slow and low volume, resulting in faster and more voluminous flow, which leads to variations in the MF¹. Thus, the significant increase observed in the MF diameter confirms the rare variation and emphasizes the importance of considering these anatomical variations in clinical practice and diagnostic interpretation, especially when the MEV may be altered.

MFs with diameters greater than 4 mm are considered dilated and have surgical relevance. Knowledge of this variation is essential in retrosigmoid neurosurgeries, as manipulation of the posterior mastoid region can lead to massive hemorrhage due to the complex vascular anatomy^{2,3}. Wang *et al.* (2021) state that identifying variations in cranial foramina is fundamental to understanding the local vascular neuroanatomy and distinguishing normal from anomalous anatomical structures². Additionally, injury to the MEV is difficult to dissect and restore blood flow. Zhou *et al.* (2023) observed that during mastoid craniectomy in 161 patients, bone wax migrated to the sigmoid sinus, causing venous thrombosis in seven cases, exclusively in patients with MF > 4 mm⁹.

Although the frequency of dilated MFs varies among studies, the clinical relevance of these variations is unquestionable. In the study by Hernández *et al.* (2014), only 5.06% of the 150 MFs analyzed were considered dilated, while 94.94% fell within normal parameters³. This finding reinforces that, despite being less common, anatomical variations of the MF may have significant implications in neurosurgical procedures and should be considered during mastoid approaches.

The anatomy of the MF and MEV is especially relevant in posterior fossa and mastoid region surgeries to avoid complications, such as bleeding and vascular injuries³. Generally, the MEV has a small diameter (between 0.84 and 0.85 mm), and the caliber of the MF corresponds to that of the vein passing through it³. The risk of injury and hemorrhage during neurosurgical procedures increases when the diameter of the MEV deviates from expected standards. Additionally, due to the absence of valves, blood flow in the MEV may occur retrogradely, facilitating the spread of intracranial infections⁶. Therefore, understanding the variations of existing MFs is fundamental to minimizing potential surgical complications.

The finding of a dilated MF with a superoinferior diameter of 11 mm is a scarce anatomical variation with clinical and surgical impact. Clinically, its presence may indicate compensatory vascular adaptations, such as in cases of jugular foramen hypoplasia or intracranial hypertension, and is associated with an increased risk of intracranial infections due to retrograde flow in the MEV. Surgically, the dilated MF may predispose to massive hemorrhage, especially in retros-

igmoid approaches and mastoid procedures, requiring caution to avoid severe venous injuries. Thus, this report highlights the importance of considering these anatomical variations in surgical planning and imaging interpretation, contributing to a safer and more precise approach in neurosurgery.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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None.

AUTHORS CONTRIBUTIONS

FAP: Conceptualization, Data curation, Investigation, Methodology, Project management, Resources, Supervision, and Writing – Original draft, Writing – Review and Editing. **JPPS:** Writing – Original draft, Supervision and Writing – Review and Editing. **AAISG:** Writing – Original draft, Supervision and Review – Review and Editing. **MFA:** Writing – Original draft, Supervision and Review – Review and Editing. **IFGG:** Writing – Original draft, Supervision and Writing – Review and Editing. **RCFC:** Resources, Supervision, and Writing – Review and Editing. All authors have read and approved the published version of the manuscript.

REFERENCES

1. Syed AZ *et al.* Incidental occurrence of an unusually large mastoid foramen on cone-beam computed tomography and review of the literature. *Imaging Sci Dent.* 2016 Mar; 46(1): 39-45. <https://doi.org/10.5624/isd.2016.46.1.39>
2. Wang C *et al.* Comprehensive review of the mastoid foramen. *Neurosurg Rev.* 2021 Jun;44(3):1255-1258. <https://doi.org/10.1007/s10143-020-01329-9>
3. Hernández-Rodríguez AN, Galindo-de León S, Morales-Avalos R, Theriot-Girón MdC, de la Garza-Castro O, Elizondo-Omaña R, et al. Prevalencia y características morfométricas del foramen mastoideo y vena emisaria mastoidea en población mexicana. *Int J Morphol.* 2014 Jun;32(2):395-398. <http://dx.doi.org/10.4067/S0717-95022014000200001>
4. Reis CV *et al.* Anatomy of the mastoid emissary vein and venous system of the posterior neck region: neurosurgical implications. *Neurosurgery.* 2007 Nov;61(5 Suppl 2):193-200; discussion 200-1. <https://doi.org/10.1227/01.neu.0000303217.53607.d9>.
5. Yurdabakan ZZ, Okumuş Ö, Orhan K. The morphometric analysis of mastoid foramen and mastoid emissary canal on cone-beam computed tomography (CBCT). *Surg Radiol Anat.* 2023;45:303–314. <https://doi.org/10.1007/s00276-023-03089-9>.

6. Kim LK *et al.* Mastoid emissary vein: anatomy and clinical relevance in plastic & reconstructive surgery. *J Plast Reconstr Aesthet Surg.* 2014 Jun;67(6):775-80. <https://doi.org/10.1016/j.bjps.2014.03.002>.
7. Hampl M *et al.* Mastoid foramen, mastoid emissary vein and clinical implications in neurosurgery. *Acta Neurochir (Wien).* 2018 Jul; 160(7): 1473-1482. <https://doi.org/10.1007/s00701-018-3564-2>
8. Galvão IFG, Valença MM, Valente TJMBS, Dantas JMS, Gonçalves AAIS, Campina RCF, *et al.* Análise morfométrica do forame mastóideo e suas possíveis implicações clínicas e cirúrgicas. *An Fac Med Olinda* 2024; 1(12):46 doi: <https://doi.org/10.56102/afmo.2024.365>
9. Zhou W, Di G, Rong J, Hu Z, Tan M, Duan K, Jiang X. Aplicações clínicas da veia emissária da mastoide. *Surg Radiol Anat.* 2023 Jan;45(1):55-63. <https://doi.org/10.1007/s00276-022-03060-0>
10. Wysocki J, Reymond J, Skarzyński H, Wróbel B. The size of selected human skull foramina in relation to skull capacity. *Folia Morphol (Warsz).* 2006;65(4):301-308. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/17171609/>
11. Chaiyamon A, Schneider K, Iwanaga J, Donofrio CA, Badaloni F, Fioravanti A, Tubbs RS. Anatomical study of the mastoid foramina and mastoid emissary veins: classification and application to localizing the sigmoid sinus. *Neurosurg Rev.* 2023 Dec 19;47(1):16. <https://doi.org/10.1007/s10143-023-02229-4>
12. Robson CD, Mulliken JB, Robertson RL, *et al.* Prominent basal emissary foramina in syndromic craniosynostosis: correlation with phenotypic and molecular diagnoses. *AJNR Am J Neuroradiol.* 2000;21(9):1707-1717. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/11039354/>
13. Hauser G, De Stefano GF. Epigenetic variants of the human skull. Stuttgart: E. Schweizerbart-sche Verlagsbuchhandlung; 1989. Disponível em: <https://doi.org/10.1002/ajpa.1330830413>
14. Cheatle A. The mastoid emissary vein and its surgical importance. *Proc R Soc Med.* 1925;18:29-34. <https://doi.org/10.1177/003591572501801223>
15. Boyd GI. The emissary foramina of the cranium in man and the anthropoids. *J Anat.* 1930;65:108-121. Disponível em: <https://pubmed.ncbi.nlm.nih.gov/17104299/>