Mastoid Emissary Foramina And Their Surgical Relevance: An African Osteological Study

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Abstract

Background: The mastoid emissary vein (MEV) is a small venous channel connecting intracranial and extracranial venous systems. It travels in the mastoid foramen and usually occurs singly or multiply. Recognition of MEVs during neurosurgery is essential to avoid haemorrhage or thromboembolism of the sigmoid sinus. Data on their characterization and occurrence in the African setting still remains scarce. This study aimed to assess the prevalence of these foramina and shed light on their significance in neurosurgery. **Methods:** This descriptive cross-sectional study was conducted on 105 dry sexed skulls obtained from the National Museums of Kenya. The mastoid bones were examined for the number of mastoid foramina and the relative distances of each foramen to the asterion and tip of the mastoid process. Distances were recorded by use of a digital Vernier calliper (precision of 0.01mm) and data were analysed using SPSS (version 26.0). **Results:** Mastoid emissary foramina were observed in 80 skulls on the right side (88.1%) skulls and in 76 (86.2%) skulls on the left. The mean distance to the asterion was 21.09 ± 6.74 mm and 28.56 ± 5.81 mm to the tip of the mastoid process. **Conclusion:** The mastoid emissary foramina which represent channels of MEVs are relatively constant structures in African skulls. Neurosurgeons should take caution given their high prevalence and approximate locations using the findings in this study to prevent haemorrhage or thromboembolism.

Keywords: *Mastoid emissary vein, foramina, African*

Introduction

The mastoid emissary foramen (MEF) is a conduit for the mastoid emissary vein that connects the extracranial venous plexuses with the intracranial dural venous sinuses (1). The MEF has been approximated to lie at an average distance of 21.14 mm from the asterion and 33.65 mm from the tip of the mastoid process (1). These foramina are often numerous and classified based on their number, according to Louis et al. They classified types I through IV in ascending numbers from 1, with type V being the absent type (2). Mastoid emissary veins are found in close relation to the occipitomastoid suture. Here, they specifically connect the sigmoid sinus and the suboccipital venous plexus. These veins are valveless, which poses a risk of spreading infection from extracranial veins into the dural venous sinuses (3). Mastoid emissary veins have also been implicated in protecting the brain from thermal damage by acting as a cooling system (4).

The mastoid emissary veins are significant in rectosigmoid approaches to lesions in the posterior cranial fossa. In these surgeries, it is important to locate the veins in order to prevent iatrogenic haemorrhage and thus hypotension (5). Furthermore, when neuro- or otologic surgeons use the suboccipital approach to access the cranial activity, postoperative air embolism may occur as a complication if not anticipated. (6). The utility of mastoid emissary veins has also been implicated as an access route for the endovascular treatment of dural arteriovenous fistulas (7). Finally, the mastoid emissary veins are key to venous drainage of the posterior cranial fossa, and their ligation may be associated with ischemia and haemorrhage (6). The presence of these structures has been mentioned in other races with a prevalence of between 72 and 98%; however, data on the population of blacks, especially Africans, remain sparse (2, 3, 8). Given the rapid advances in regional neurointerventional and neurosurgical procedures, this requires characterization of these structures in our setting. These data would aid in the preoperative planning of rectosigmoid and transmastoid approaches of the cranial fossa by neurosurgeons in order to prevent any of the listed complications. Therefore, this study aimed to classify and accurately localize the MEF in the African population, thereby emphasizing the importance of these structures in neurosurgery.

Materials and methods

This study was a descriptive cross-sectional study carried out at the osteology department of the national museums of Kenya. Approval for the use of cadaveric material for research is provided for in the Human Anatomy Act, Cap. 249 (1967), and the Human Tissues Act, Cap. 252 (1968) of the Laws of Kenya. The study was conducted in accordance with the ethical guidelines stated in the Declaration of Helsinki. Permission was sought from the Osteology Department of the National Museums of Kenya for the use of the premises for the data collection procedures. The skulls included in the study were sexed and confirmed to be those of adults as indicated on the boxes from which they were drawn. Those skulls with demonstrable mastoid deformities were excluded. On the mastoid part of the temporal bone, the mastoid emissary foramina were considered as follows. If an external opening in the stated location on the posterior aspect of the mastoid was detected along with a corresponding internal opening, the mastoid emissary foramen (MEF) was considered present. A probe was passed through this foramen to confirm its patency. The number of MEF on each skull side was counted and classified according to Louis et al. 's classification (types I-IV based on increasing number of foramina, and type V based on absence of foramina). Additionally, the distance of the mastoid foramen to the asterion and the tip of the mastoid were also measured by use of a digital vernier calliper (precision of 0.01 mm) as shown in figures 2 and 3. Photographs were taken using a 12 MP (f/1.8, 26 mm wide, 1/2.55", 1.4μm, dual pixel PDAF, OIS) phone camera. Parametric data (confirmed using the Kolmogorov-Smirnov test for normality) were expressed as the mean value ± standard deviation and summarized using descriptive statistics, i.e., frequencies, means, and standard deviations. Paired and independent t-tests were used to compare the morphometric parameters with respect to side and sex, respectively. This was done using SPSS 25.0 (version 26.0, Chicago, Illinois). A p-value of 0.05 was considered significant at a 95% confidence interval.

Results

We examined 105 intact skulls bilaterally i.e., 210 hemicrania. Of these 74 (70.5%) were male and 31 (29.5%) were female. When the number of mastoid emissary foramina (MEF) were compared on the right and the left there was no significant difference noted (right: *p*-.08, left, p-.92). MEF were observed bilaterally in 64 skulls, unilaterally either on the left or right in 28 skulls and absent in 13 skulls as shown in table 1. Mastoid emissary foramina were observed in 80 skulls on the right side (88.1%) and in 76 (86.2%) skulls on the left. The number of mastoid emissary foramina were also recorded as shown in table 2, with the maximum number of MEF being recorded as 3 on either skull side as illustrated in figure 1A-D. The mean distance to the asterion on the right was 20.63 ± 6.31 mm and on the left, 21.61 ±7.18mm. The mean distance to the tip of the mastoid process was 28.30± 5.16mm on the right and 28.82 ± 6.41mm on the left as shown in table 3.

Table 1. Laterality of mastoid emissary foramina

Side distribution	n	%
Bilateral	64	61.0
Right MEF	12	11.4
Left MEF	16	15.2
Absent bilaterally	13	12.4
Total	105	100.0

Table 2. Side distribution of the mastoid emissary foramina

Number of MEFs on right			Number of MEFs on the left	
	n	%	n	%
Single (Type I)	54	51.4	52	49.5
Double (Type II)	24	22.9	19	18.1
Triple (Type III)	2	1.9	5	4.8
Absent (Type V)	25	23.8	29	27.6
Total	105	100.0	105	100.0

Table 3. Relative distances of the mastoid emissary foramina to the asterion and tip of the mastoid process.

	Right (mm)	Left (mm)	Overall (mm)	p-value
Distance to the asterion	20.63 ± 6.31	21.61 ±7.18	21.09 ±6.74	.355
Distance to the tip of the mastoid process	28.30± 5.16	28.82 ±6.41	28.56 ±5.81	.468

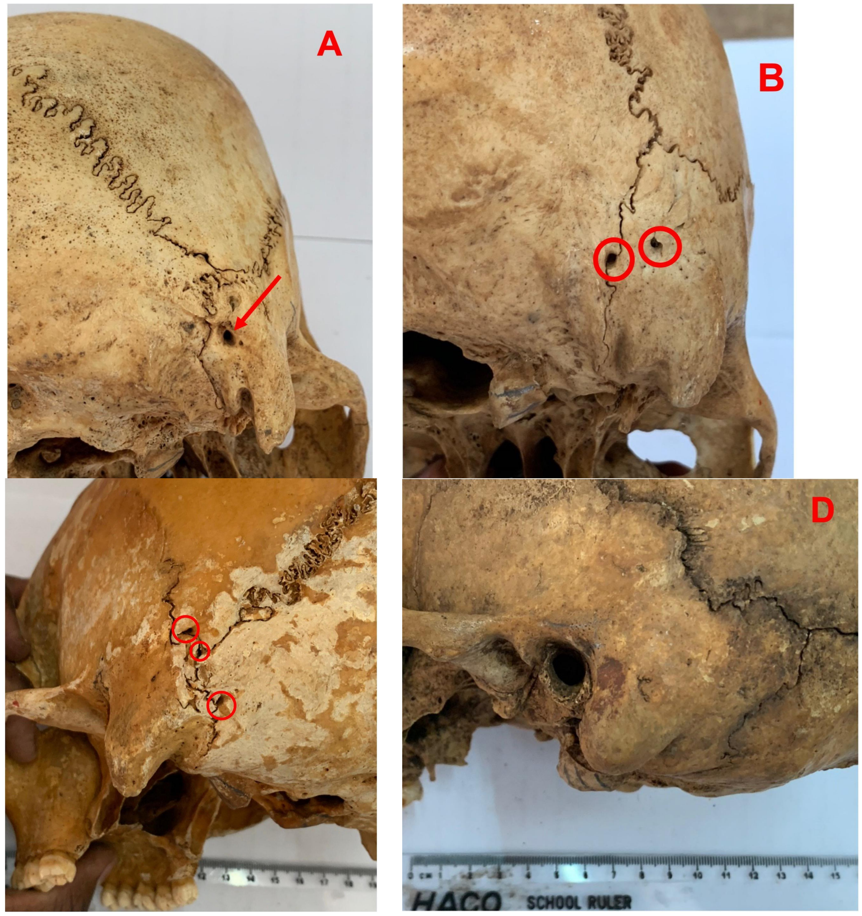

Figure 1A-D: Photographs illustrating the types of mastoid emissary foramina: A-type I (single foramen); B- type II (double foramina); C- type III (triple foramina); D- type V (absent foramen).

Discussion

This study, which was conducted on 105 dry human skulls, was compared with other populations with similar study designs. In this study, mastoid foramina were observed at least unilaterally in 92 of the 105 skulls (87.6%). They were most frequently observed bilaterally, and the average distances on the right and left to the asterion or the mastoid tip were similar on both sides.

Number of MEFs

The prevalence of mastoid emissary foramina (MEF) in this study was 87.6%. This figure was similar to previous studies done in South Indian, Caucasian, and Brazilian populations, where the prevalence rate ranged between 82.0 and 91.70%, as shown in Table 4. In this study, types I, II, III, and V mastoid emissary foramina were recorded according to Louis et al.'s classification. The most frequent type was type (I), with only one mastoid emissary foramen being observed on the right (51.4%) or the left (49.5%). This was in concordance with the study done by Louis et al., where the most common type was type I at 55%, whereas according to Hampl et al., the most frequently observed type was type II (5).

Approximate distances

In this study, the mean distance to the asterion was 21.09 ±6.74 mm and 28.56 ± 5.81 mm to the tip of the mastoid process. These figures were similar on both sides of the skull with no significant difference in the distances. The average distance to the asterion was similar to Reis et. al who reported a figure of 21.44mm from the asterion (8). In this same study the mean distance from the MEF to the tip of the mastoid was 33.65mm. The slight difference in this distance could be attributed to their low sample size of 15. Contrary to these findings, Louis et. al recorded an average of 55.2 mm to the mastoid tip ±6.41mm while to the asterion 35.4 mm ±2.3 mm (2). From these findings it appears that the distance to the tip of the mastoid process is quite variable depending on the population. This thus necessitates the utilization of population specific parameters to estimate the approximate location of these foramina.

Surgical relevance

The mastoid emissary foramen with its vasculature is an important anatomic landmark for the junction between the transverse and sigmoid dural venous sinuses (5).In neurosurgical approaches to lesions of the posterior cranial fossa and cerebellar pontine angle, accurate localization of the mastoid foramen and its emissary veins is important to prevent inadvertent bleeding and, in severe instances, hypotension (5). As a result, some authors recommend that the MEV be exposed in a circular fashion along with the junction of the transverse and sigmoid sinuses to prevent bleeding (12). Further, localization and preservation of these veins is important, as in a previous case report cerebellar ischemia was noticed following coagulation of blood in these veins (13). Surgeons using the lateral suboccipital approach to access the posterior cranial fossa should be cautious of air embolism passing through the MEVs and into the dural sinuses (2).Surgeons operating in this region should also be aware of the approximate location of these veins, as the mastoid emissary veins have been implicated as conduits of infection (12). In the hands of an unaware or inexperienced surgeon, this could lead to thrombosis of the nearby sigmoid sinus.

Conclusion

Localization of the mastoid emissary foramina with their mastoid emissary veins in the African black population has been missing in literature for decades. Given the advances in various neurosurgical techniques around the mastoid region, we hope that neurosurgeons will use the numbers provided in this study to assist in preoperative planning. This ultimately reduces the likelihood of sigmoid sinus thromboembolism, air embolism, intraoperative bleeding, or hypotension at the severe end of the spectrum.

Table 4. *Quantitative representation of MEF in various populations*

	n	Study type	Prevalence rate (%)	Population
Koesling et. al. (9)	223	CT	82.0	Caucasian
Reis et al. (8)	15	Human cadaveric	89.0	*
Kim et al. (3)	106	Dry skull	83.7	Australian
Louis et al.(2)	100	Dry skull	85.0	*
Pereira et al.(10)	31	Dry skull	82.4	Brazilian
Murlimanju et al. (11)	48	Dry skull	91.7	South Indian
Hampl et al.(5)	295	Dry skull	94.2	Caucasian
Current study	105	Dry skull	87.6	Black African

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