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Variant Anatomy of The External Surface of The Mastoid Bone in A Kenyan Population

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Abstract

Background: The external surface of the mastoid part of the temporal bone is crucial for localising the mastoid antrum and avoiding facial nerve injury during middle ear surgeries. Its morphology varies by sex, ethnicity, and side, but there's a dearth of information specific to Kenyans. **Objective:** The study aimed to document the variant anatomy of the mastoid part of the temporal bone in a Kenyan population. **Materials and Methods:** A cross-sectional study was conducted on 105 dry sexed skulls from the National Museums of Kenya. The study examined the suprameatal spines and depressions, and the presence of mastoid grooves and canals on the mastoid process's external surface. Using a digital Vernier caliper, distances and lengths were measured and statistically analyzed. **Results:** The crest type suprameatal spine was the most common (75.2%), while the triangular type was present in 15.8% of skulls. Suprameatal depressions were shallow in 67.1% and deep in 24.3% of the sides. Mastoid grooves and canals were present in 30.5% and 16.2% of sides, respectively, with both being present on the same side in 24.3% of cases. Distance measurements between structures varied slightly between the left and right sides. **Conclusion:** Suprameatal spines and depressions were found in the majority of skulls studied, providing surgeons with reliable landmarks for localizing the deeply seated mastoid antrum. Surgeons should also be aware of the high prevalence of mastoid grooves to prevent iatrogenic vascular injuries.

Keywords: Variant, mastoid, external, Kenyan

Introduction

The external surface of the mastoid part of the temporal bone bears the surgically important suprameatal triangle (SMT). This triangle is identified during mastoidectomies as a quick guide to locate the mastoid antrum which lies 12 -15 mm deep to it (1). Within this triangle a suprameatal depression may be observed. It could be shallow or deep as described first by Peker et al. (2). The deeper the depression, the shorter the distance to the mastoid antrum. Anterior to the SMT, a bony projection called the suprameatal spine (SMS) can be identified (3). The SMS is surgically important as an aid in localising nearby foramina during skull base surgeries (4). The types of SMSs have been identified and reported with side and sex differences as absent, crest and triangular (2,5). The SMS is also used as a bony landmark during retrolabyrinthine approaches to the posterior cranial fossa and the mastoid antrum (6). Previous studies have reported sex, side and population specific differences in the morphology of the SMT (2,5). However local data on the morphology of the SMT still remains scarce.

The mastoid process is an inferior projection of the temporal bone (3). On its lateral aspect, it contains mastoid canals and mastoid grooves in approximately 50% of adult skulls (7). These two structures, when present, lodge within them a branch of the occipital or posterior auricular artery which supplies the scalp in about 53% of skulls (8). The presence of these structures has been described in Indian, Japanese and Egyptian populations with interethnic differences reported (5, 7-10) . These vessels can be injured and thus cause troublesome bleeding during cortical mastoidectomies (8). The presence and morphology of these structures has however not been described in a Kenyan population.

Due to the proximity of the mastoid grooves (MGs) and canals (MCs) to the suprameatal triangle on the mastoid process, this study proposed to approximate the distances between the SMT and the MG/MC. This may aid in preoperative planning in order to prevent inadvertent bleeding of the vasculature in the MGs and MCs during these surgeries as drilling proceeds posteriorly intraoperatively (6, 11).

Materials and methods

This was a descriptive cross-sectional study carried out at the Osteology department, National Museums of Kenya. The sample size for this study was calculated using the following formula adapted from Rosner, B., (2015);

$$n_1 = \frac{(\sigma_1^2 + \sigma_2^2/\kappa)(z_{1-\frac{\alpha}{2}} + z_{1-\beta})^2}{\Delta^2}$$

$$n_2 = \frac{(\kappa * \sigma_1^2 + \sigma_2^2)(z_{1-\frac{\alpha}{2}} + z_{1-\beta})^2}{\Delta^2}$$

Where: n_1= sample size of Group 1; n_2= sample size of Group 2; σ = standard deviation of Group 1; σ = standard deviation of Group 2 ; Δ = difference in group means; κ = ratio = n_2/n_1 ; $Z_{1-\alpha/2}$ = two-sided Z value (Z=1.96 for 95% confidence interval).; $Z_{1-\beta}$ = power. In this study the values substituted for the groups were those of the sides (i.e. right and left) of the temporal bone. Ghonaimi et al., (5) studied the morphometry of the mastoid canal and suprameatal triangle with gender determination. In this study the mean length of the mastoid canal on the right side was 7.5 ± 3.69 mm while on the left it was 6.08 ± 3.64mm. A power of 80%, and a 95% confidence interval was chosen to calculate the sample size as follows:

$$n_1 = n_2 = \frac{(3.69^2 + 3.64^2/1)(1.96+0.84)^2}{1.42^2}$$

$$n_1 = n_2 = 104.46 \approx 105 skulls$$

Ethical approval and consideration

Approval for 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 use of the premises for the data collection procedures. Skulls included in the study were obtained from the osteology department of the national museums of Kenya. These were dry sexed and were confirmed to be of adults as indicated on the boxes from which they were drawn. Dry adult skulls with demonstrable mastoid deformities were excluded.

Data Collection Procedures

Morphology of the suprameatal triangle

The anterior border of the suprameatal triangle was inspected in each skull for the presence or absence of a spine. When present, the SMS type was determined as either of crest or triangular morphology. Within the suprameatal triangle, inspection was done to determine the presence or absence of a depression. When present, the SMD was classified as either shallow ($\leq$ 2.99mm) or deep ($\geq 3.00mm$) by use of a digital Vernier calliper (0.01mm precision).

Mastoid grooves and canals

The external surface of the mastoid process was examined and classified as either relatively smooth or grooved. When grooved, the structures were grouped as either being mastoid grooves or mastoid canals. A metallic wire was passed through the mastoid canal to confirm its patency. Only those skulls with canals patent to the metallic wire were considered to possess mastoid canals. The length of the mastoid canal and groove was measured by passing the metallic wire then its length taken with the help of a Vernier calliper. The length was measured from the superior to inferior apertures as shown in *Figure 1*.

Distances from the suprameatal triangle to mastoid grooves and canals

A digital Vernier callipers with a precision of 0.01mm was used to measure distances from the midpoint of the posterior border of the SMT to the:

1. superior end of the mastoid groove/canal **(A)**,
2. inferior end of the mastoid groove/canal (**B**) and
3. midpoint of the mastoid groove/canal **(C).** as shown in (*Figure 2*)

Photography, data analysis and presentation

Photographs were taken using a 12 MP (f/1.8, 26mm wide, 1/2.55", 1.4µm, dual pixel PDAF, OIS) phone camera. Parametric data (confirmed using 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 for generating tables and charts. This was done using SPSS 25.0 (Version 25.0, Chicago, Illinois). Independent variables included the gender and side of skull while the dependent variables taken were lengths and measurements. Paired and independent t-tests were used to compare the morphometric parameters with respect to side and sex respectively. An ANOVA test was run to determine the differences in distances between the SMT and the mastoid grooves and canals. When statistically significant differences were observed, ANOVA was followed up by a Tukey post hoc test to determine exactly where the difference was. Chi-square tests were used to assess associations between categorical data. P-value of $\leq$ 0.05 was considered significant at a confidence interval of 95%.

Results

Of the 105 skulls examined, 74 (70.5%) were male and 31 (29.5%) were female.

Morphology of the suprameatal triangle

The boundaries of the suprameatal triangle at the base of the mastoid process were clearly delineated and the anterior margin was inspected for a spine. Out of the 210 sides examined, suprameatal spines were present in 191 (91.0%) sides and absent in 19 (9.0%). Of the ones present, 158 (75.2%) exhibited crest types of SMSs and 33 (15.8%) had a triangular type of SMS. The side distribution (laterality) of SMS types were as displayed in *Table 1*. Out of the 210 sides examined, suprameatal depressions were present 192 sides (91.4%) and absent in 18 (8.6%). Of those present, 141 (67.1%) were shallow and 51 (24.3%) deep.

Side distribution (laterality) of SMD types were as displayed in *Table 2*.

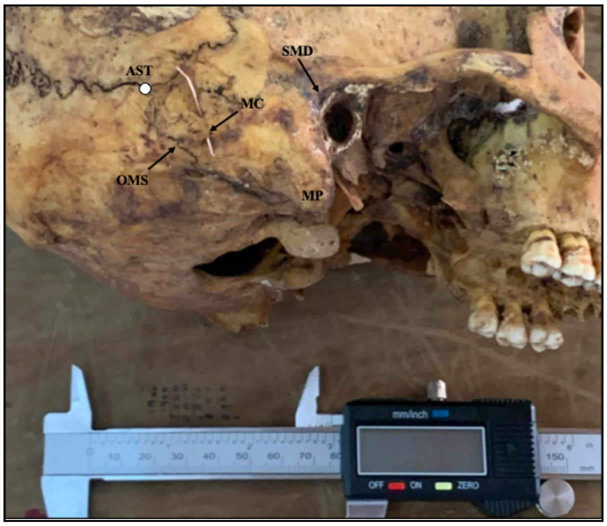


Figure 1

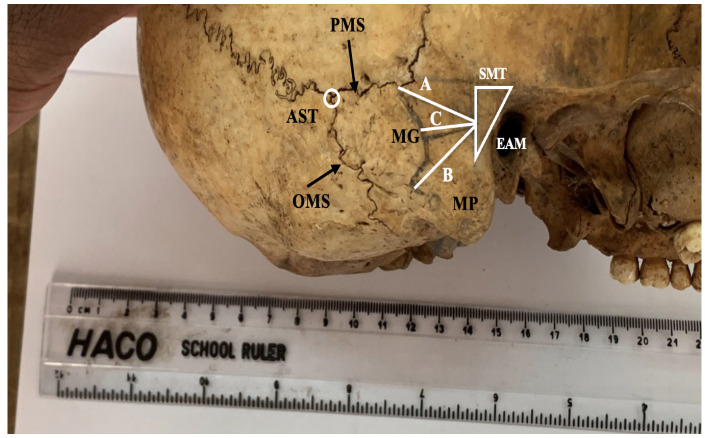


Figure 2

Figure 1. *Diagram illustrating a probed mastoid canal. MC -mastoid canal, AST - asterion, OMS -occipitomastoid suture, SMD- suprameatal depression, MP- mastoid process.* ***Figure 2.*** *External surface of the mastoid part of the temporal bone. EAM; External Acoustic Meatus; SMT (triangle)- suprameatal triangle; MP- Mastoid Process; OMS- Occipitomastoid suture; AST (circled)- Asterion; PMS-Parietomastoid Suture.MG -mastoid groove; AST – asterion; OMS -occipitomastoid suture; MP- mastoid process.*

Mastoid grooves and canals

Of the 210 sides examined, 61(29.0%) sides were relatively smooth while 149 (71.0%) were grooved. Of the grooved mastoid processes, 64 (30.5%) had mastoid grooves, 34 (16.2%) mastoid canals while 51(24.3%) had both mastoid grooves and canals. Mastoid grooves were present bilaterally in 15 (14.3%) skulls, unilaterally on the right in 17(16.2%) skulls and on the left in 12 (11.4%) skulls. The proportion of grooved skulls was higher in males when compared to females (p-value: **0.003**). The mean length of mastoid grooves and canals on the right was 15.48 ± 6.97mm in males and 15.24 ± 6.17mm in females. The mean length of mastoid grooves and canals on the right was 15.92 ± 7.55mm in males and 16.54 ± 6.38mm in females.

Distances from the SMT to the mastoid canals and grooves

In skulls that had mastoid grooves (MGs) and mastoid canals (MCs) the mean distance on the right to the superior end of the groove/canal was 26.69 ± 5.89 mm while on the left it was 27.12 ± 5.43mm. The mean distance on the right to its midpoint was 25.08 ± 6.10 mm while on the left it was 24.64 ± 5.33mm. To the inferior end, the distance on the right was 26.47 ± 26.47 mm while on the left it was 25.94 ± 5.02mm as shown in *Table 8 and Table 9.* No statistically significant gender or side differences were observed on the right (p-value: 0.212). On the left and right the distance from the SMT was shortest to the midpoint of the mastoid groove/ canal. The distance on the left was shorter to the midpoint than the superior end and this was statistically significant (p-value: 0.011).

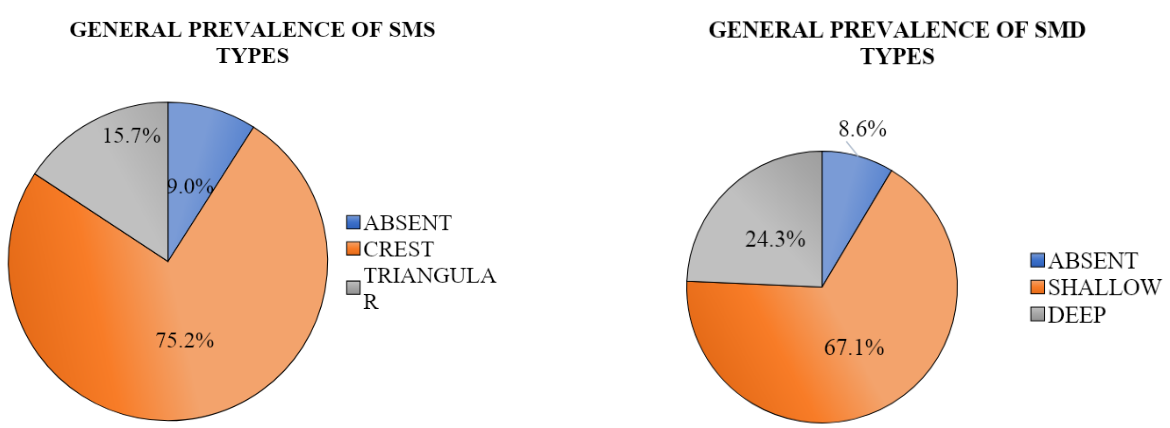
Table 1. Side distribution (laterality) of suprameatal spine (SMS) types.

SMS type	Bilateral	Unilateral right	Unilateral left
Absent	3 (2.9%)	4 (3.8%)	9 (8.6%)
Crest	66 (62.9%)	11 (10.5%)	15 (14.3%)
Triangular	8 (7.6%)	13 (12.4%)	4 (3.8%)

Table 2. Side distribution of suprameatal depression (SMD) types.

SMD type	Total skulls examined	Bilateral	Unilateral right	Unilateral left
Absent	105	3 (2.9%)	4 (3.8%)	8 (7.6%)
Shallow		57 (54.3%)	18 (17.1%)	9 (8.6%)
Deep		17 (16.2%)	6 (5.7%)	11 (10.5%)

Figure 3. General prevalence of suprameatal spine (SMS) and suprameatal depression (SMD) types



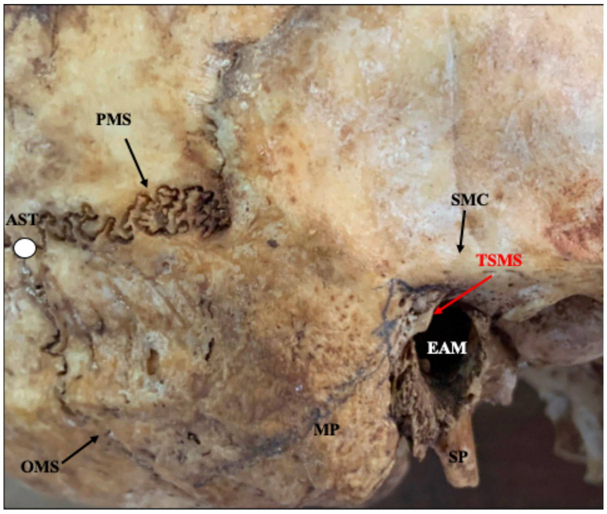


Figure 4.

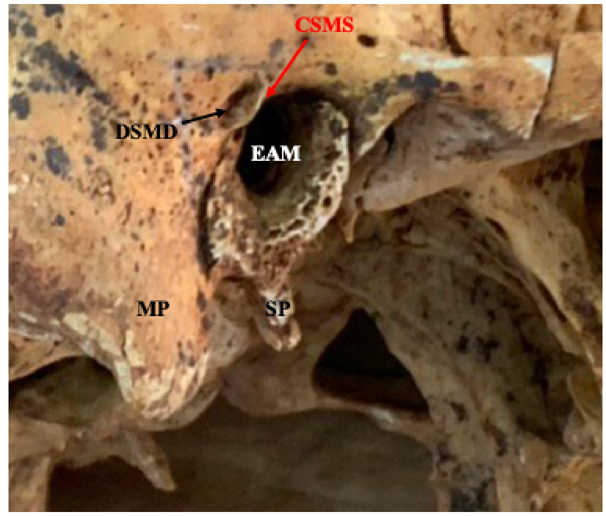


Figure 5

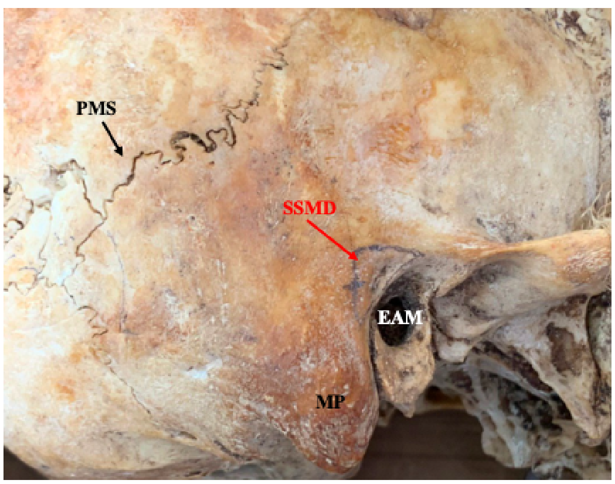


Figure 6

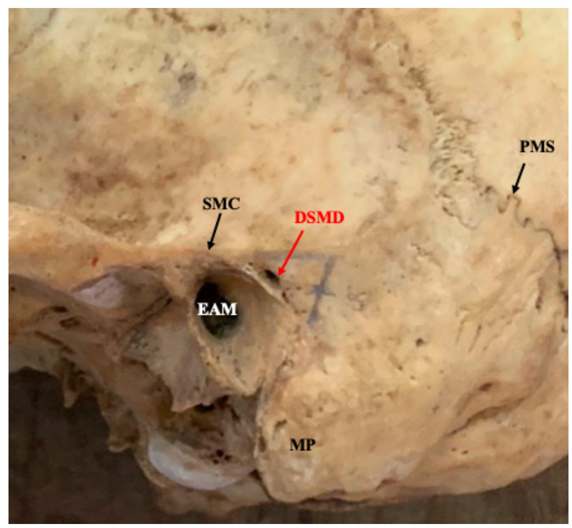


Figure 7

Figure 4. Right triangular suprameatal spine (red arrow). TSMS -Triangular Suprameatal spine; SMC-Supramastoid Crest; EAM; External Acoustic Meatus; SP; Styloid process; MP- Mastoid Process; OMS-Occipitomastoid suture; AST- Asterion; PMS- Parietomastoid Suture. **Figure 5**: Right crest type of SMS (red arrow). CSMS - Crest Suprameatal Spine; DSMD - Deep Suprameatal Depression; EAM – External Acoustic Meatus; MP – Mastoid Process; SP – Styloid Process. **Figure 6:** Right shallow SMD (red arrow). SSMD – Shallow Suprameatal Depression; PMS – Parietomastoid Suture; MP – Mastoid Process; EAM-External Acoustic Meatus. **Figure 7:** Left deep SMD (red arrow). DSMD- Deep Suprameatal Depression; SMC – Supramastoid Crest; EAM – External Acoustic Meatus; MP – Mastoid Process; PMS – Parietomastoid Suture.

Figure 8. Morphological distribution of mastoid grooves and canals

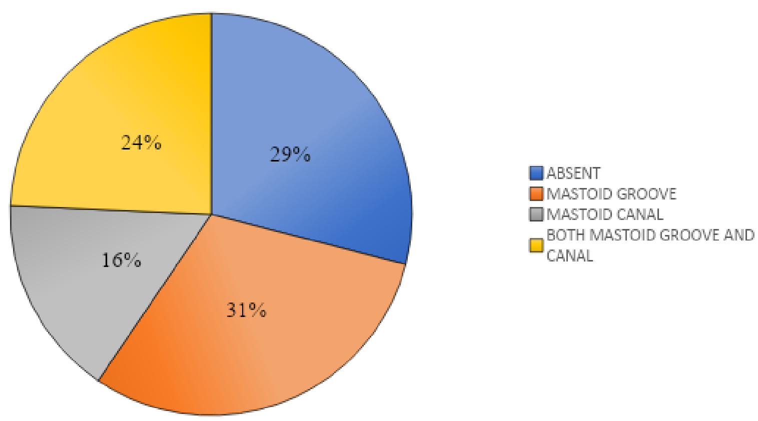


Table 3. Mean distances of the mastoid canals and grooves from the suprameatal triangle (SMT) on the right.

Distance from right SMT	**n**	**Range (mm)**	**Mean ± Std. Deviation (mm)**	**p-value**
To superior end	74	3.13 - 37.65	26.69 ± 5.89	0.212
To midpoint	74	2.41 - 37.29	25.08 ± 6.10	
To inferior end	74	2.01 - 38.93	26.47 ± 5.97	

Table 4. Mean distances of the mastoid canals and grooves from the suprameatal triangle (SMT) on the left.

Distance from left SMT	**n**	**Range (mm)**	**Mean ± Std. Deviation (mm)**	**p-value**
To superior end	76	3.00 - 39.40	27.12 ± 5.43	0.016
To midpoint	76	2.89 - 38.30	24.64 ± 5.33	
To inferior end	76	2.15 - 36.62	25.95 ± 5.02	

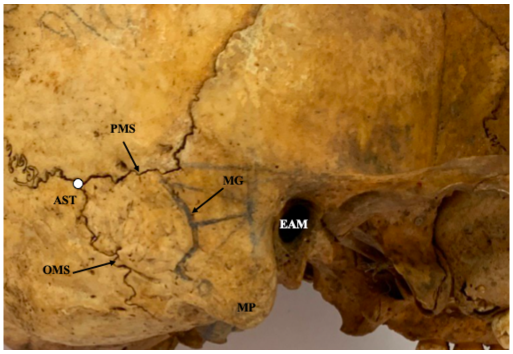


Figure 9. Right mastoid groove.

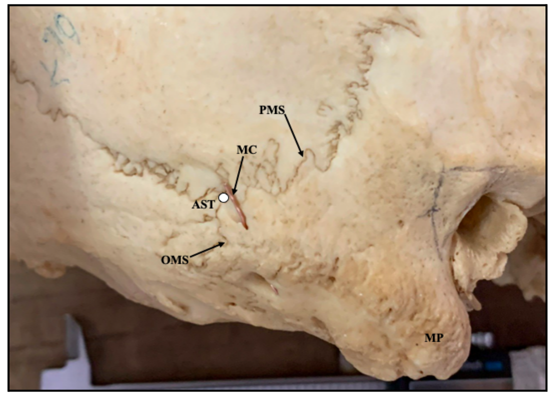


Figure 10. Right mastoid canal (probed).

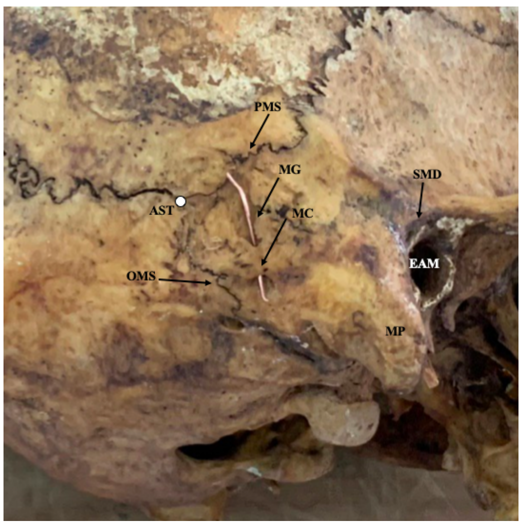


Figure 11. Right mastoid groove and mastoid canal (probed)

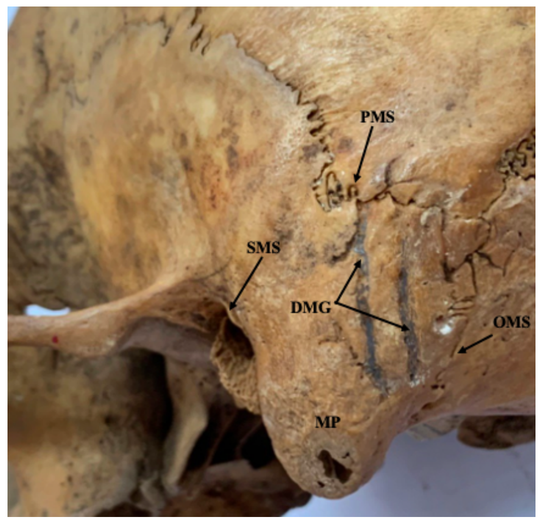


Figure 12. Left double mastoid grooves.

Figure 9: *Photograph showing a right mastoid groove on the mastoid process. MG - Mastoid Groove; PMS – Parietomastoid Suture; AST – Asterion; OMS – Occipitomastoid suture; MP – Mastoid process; EAM – External Acoustic Meatus.* ***Figure 10:*** *Photograph showing a probed right mastoid canal with a metallic wire to confirm patency. MC - Mastoid Canal; PMS – Parietomastoid Suture; AST – Asterion; OMS – Occipitomastoid suture; MP – Mastoid process.* ***Figure 11:*** *Photograph showing a right mastoid groove (MG) superior to a mastoid canal (MC). The mastoid canal was probed to confirm its patency. MG - Mastoid Groove; MC – Mastoid canal; PMS – Parietomastoid Suture; AST – Asterion; OMS – Occipitomastoid suture; MP – Mastoid process; SMD – Suprameatal depression; EAM – External Acoustic Meatus.* ***Figure 12:*** *Photograph showing a left double mastoid groove grooving the mastoid process. DMG – Double Mastoid Groove; PMS – Parietomastoid Suture; OMS – Occipitomastoid suture; MP – Mastoid process; SMS – Suprameatal Spine.*

Discussion

Our study found the suprameatal spine (SMS) and depression (SMD) to be relatively consistent anatomical landmarks in Kenyan skulls, appearing in 91.0% and 91.4% of cases respectively. These features can be leveraged to localize the mastoid antrum during mastoidectomies. The mastoid antrum is typically situated 12 - 15mm deep from the external surface of the mastoid part of the temporal bone, specifically within the surgically important suprameatal triangle (SMT). The SMD is a key component of this triangle, and its depth can influence the distance to the mastoid antrum - the deeper the depression, the shorter the distance. Further, the SMS can act as a bony landmark during retrolabyrinthine approaches to the posterior cranial fossa and the mastoid antrum. This study emphasizes the potential of using these consistent landmarks (SMS and SMD) to effectively locate the mastoid antrum during surgical procedures. However, further research is recommended to confirm the direct relationship between these spines and the antrum, enhancing surgical precision and patient outcomes. The prevalence of mastoid grooves in this study was the highest recorded when compared to previous studies on Anatolian and Egyptian populations. Surgeons should thus be aware of these structures when operating in this region especially with the introduction of cochlear implant surgeries in Kenya. The approximate distances obtained from the SMT to the mastoid grooves and canals lied between 2.01- 39.40 mm and may act as a guide in making postauricular incisions.

Morphology of the suprameatal triangle

Similar to previous findings, the most prevalent suprameatal spine (SMS) type was the crest type (73.3% on the right and 77.1% on the left) (2, 5). In this study, the prevalence of the triangular type of SMS was lower than those reported in Anatolian, Egyptian and Turkish populations. Aslan et al., (2004) suggested that in skulls with triangular types of SMSs the mastoid antrum is found in a deeper location. Surgeons operating in this area should therefore expect to find the mastoid antrum deeper than usual in approximately 16% of skull sides during mastoidectomies. Moreover, the distance between the SMS and the lateral semicircular canal (LSSC) is longer in skulls with a triangular SMS when compared to crest types (12). Ear surgeons operating in this area should therefore expect to find the LSSC about 2 mm deeper than usual in approximately 16% of skull sides. Aslan et al. (12) suggested that skulls with an absent type of SMS have a longer distance between the linea temporalis inferior and the middle fossa dural plate when compared to skulls with crest types. This implies surgeons can augment surgical exposure of the mastoid antrum in Kenyan skulls in about 19% of skull sides. No statistically significant sex or side differences were observed for SMS types (p: values: 0.063 and 0.144 respectively).

Similar to a study conducted in a Turkish population the most prevalent suprameatal depression (SMD) type was the shallow and the least prevalent was the absent type. Contrary to these findings, a study on Egyptian skulls reported the deep type as the most prevalent on both the right and left sides (5). The deeper the SMD the easier the localisation of the suprameatal triangle (SMT) and thus easier access to the mastoid antrum. This implies that localisation of the suprameatal triangle could possibly be aided by the presence of a deep type of SMD in Kenyan skulls, in approximately 24% of sides.

Contrary to previous studies no significant sex or side differences in suprameatal depression (SMD) types were observed (p values: 0.138 and 0.377 respectively) probably due to the disparity in proportions of sexed skulls studied. Both Egyptian and Anatolian populations have reported higher incidences of shallow types of SMDs in females when contrasted with males (2, 5).

Mastoid grooves and canals

The general prevalence of mastoid grooves (61.0%) was highest in this population when compared to Japanese (13.6%) and Indian populations (18.0% - 20.0%) (7,8,10). In the present study, the general prevalence of mastoid canals was 32.4%. This was within the range of 7.7% - 59.2% reported in previous studies (9,10). However, the prevalence in a Kenyan population was lower than that observed in South Indian (59.2%), Indian (53.0%) and Japanese (52.4%) populations as shown in *Table 7*. The prevalence of mastoid canals in this study was comparable to the findings of a study done on Egyptian skulls (28.0%) by Ghonaimi et al. (5). Both mastoid groove and canal were observed in 24.3% of the skulls studied which was much higher than the prevalence of 2.0% observed in Indian skulls (8). Otologic surgeons should therefore expect to find these structures with their vasculature during cortical mastoidectomies in approximately 30% of skulls.

The mode of ontogenesis of this part of the temporal bone could possibly explain the occurrence of mastoid canals containing vessels. In the embryo the bone develops from two components: surrounding mesenchyme and a cartilage epiotic centre. These form the squamous and petromastoid portions respectively. The squamous plate grows posteriorly and covers a large area of the lateral surface of the petromastoid bone. The ascending branch of the occipital artery lies on the developing petromastoid portion in foetal life. The vessel likely to be buried by the ossifying squamotemporal bone forming a bridge of bone anterior to the vessel hence a mastoid canal (8,9).

With the relatively higher prevalence of mastoid grooves and canals in the Kenyan population, knowledge of the anatomy of this region is fundamental in preoperative planning for procedures involving mastoidectomies such as cochlear implant surgeries. This would probably prevent iatrogenic haemorrhage when the vasculature is present.

Distances between the suprameatal triangle and mastoid grooves/canals

Due to the proximity of the mastoid canals and grooves with their vasculature to the SMT, the distances between the SMT and the mastoid grooves and canals were approximated. This is because during mastoidectomies once the suprameatal triangle (SMT) is identified, drilling proceeds in an anteroposterior direction and thus there is likelihood of iatrogenic haemorrhage of these vessels when present (Hadimani and Bagoji, 2013; Choi et al., 2014). The distances from the posterior border of the SMT to the mastoid grooves/canals range between **2.01mm – 39.40mm**. Surgeons operating in this region should take into account these distances when making retroauricular incisions prior to beginning mastoidectomies as well as during the procedure as drilling proceeds. This would probably reduce the possibility of iatrogenic haemorrhage intraoperatively.

Conclusion

The suprameatal spine and depression are present in approximately 90% of Kenyan skulls. Otologic and neurosurgeons can therefore rely on these structures to localise the deeply seated mastoid antrum. Mastoid grooves in the Kenyan population studied have reported the higher prevalence than to Indian, Japanese and Egyptian populations. Surgeons should thus expect to find these structures on the mastoid process and thus should plan appropriately in order to prevent troublesome bleeding of the vasculature they contain.

Limitations and mitigation

One of the limitations of this study was the possibility of intra-observer errors when measuring distances from the suprameatal triangle to the mastoid grooves/canals. To mitigate this, measurements were taken twice by two different trained observers. Furthermore, all measurements were taken with the same Vernier calliper.

Recommendations for further study

We recommend that future studies examine skulls from different age groups to determine the differences in distances between the SMT and MGs and MCs. In addition, radiological methods can be applied to identify the presence, origin, and course of the mastoid vasculature within the mastoid grooves *in vivo.*

Table 5. Comparison of suprameatal spines with other populations

Authors	Population	Suprameatal spine type	Right			Left		
			Male	**Female**	**Total**	**Male (%)**	**Female (%)**	**Total (%)**
Peker et al.(2)	**Anatolian**	**Absent**	12 (3.3%)	26(11.3%)	38(6.4%)	9(2.5%)	16(6.9%)	25(4.2%)
		Crest	287(79.1%)	174(75.3%)	461(77.6%)	285(79.2%)	188(81.4%)	473(80.0%)
		Triangular	64(17.6%)	31(13.4%)	95(16.0%)	66(18.3%)	27(11.7%)	93(15.7%)
Shalaby et al., 2016	**Egyptian**	**Absent**	12(27.3%)	20(35.7%)	32(32.0%)	8(18.2%)	16(28.6%)	24(24.0%)
		Crest	20(45.5%)	20(35.7%)	40(40.0%)	28(63.6%)	24(42.9%)	52(52.0%)
		Triangular	12(27.3%)	16(28.6%)	28(28.0%)	8(18.2%)	16(28.6%)	24(24.0%)
Present study, 2022	**Kenyan**	**Absent**	3(4.1%)	4(12.9%)	7(6.7%)	6(8.1%)	6(19.4%)	12(11.4%)
		Crest	55(74.3%)	22(71.0%)	77(73.3%)	59(79.7%)	22(71.0%)	81(77.1%)
		Triangular	16(21.6%)	5(16.1%)	21(20.0%)	9(12.2%)	3(9.7%)	12(11.4%)

Table 6. Comparison of suprameatal depression (SMD) types with other populations.

Authors	Population	Suprameatal depression type	Right			Left		
			Male	**Female**	**Total**	**Male**	**Female**	**Total**
Peker et.al. (2)	**Anatolian**	**Absence**	6(1.7%)	21(9.1%)	27(4.5%)	9(2.5%)	20(8.7%)	29(4.9%)
		Shallow	103(28.4%)	90(39.0%)	193(32.5%)	93(25.8%)	92(39.8%)	185(31.3%)
		Deep	131(36.1%)	55(23.8%)	186(31.3%)	119(33.1%)	48(20.8%)	167(28.3%)
Ghonaimi et.al. (5)	**Egyptian**	**Absent**	8(18.2%)	20(35.7%)	28(28.0%)	4(9.1%)	16(28.6%)	20(20.0%)
		Shallow	12(27.3%)	20(35.7%)	32(32.0%)	8(18.2%)	20(35.7%)	28(28.0%)
		Deep	24(54.5%)	16(28.6%)	40(40.0%)	32(72.7%)	20(35.7%)	52(52.0%)
Present study, 2022	**Kenyan**	**Absent**	3(4.1%)	4(12.9%)	7(6.7%)	6(8.1%)	5(16.1%)	11(10.5%)
		Shallow	55(74.3%)	20(64.5%)	75(71.4%)	47(63.5%)	19(61.3%)	66(62.9%)
		Deep	16(21.6%)	7(22.6%)	23(21.9%)	21(28.4%)	7(22.6%)	28(26.7%)

Table 7. Comparison of mastoid groove and canal distribution with other populations.

Authors	Population	No. of skulls		Bilateral	Unilateral right side	Unilateral left side	Double mastoid canal	Both mastoid groove and canal	Total
Choudhry et al., (9)	Indian	265	Canals	8(1.5%)	12(2.2%)	21(4.0%)	-	-	41 (7.7%)
Singh et al., (2004)	Japanese	435	Canals	109(25.1%)	49(11.3%)	70(16.1%)	-	-	228(52.4 %)
			Grooves	21.1(4.8%)	20(4.5%)	18(4.13%)	-	-	59(13.6%)
Shaik et al., (7)	South Indian	125	Canals	35(28.0%)	20(16.0%)	19(15.2%)	-	-	74(59.2%)
			Grooves	10(8%)	8(6.4%)	7(5.6%)	-	-	25(20.0%)
Hadimani and Bagoji, (8)	Indian	100	Canals	14(14.0%)	16(16%)	20(20%)	-	02(2.0%)	53(53.0%)
			Grooves	3(3.0%)	6(6%)	9(9%)	1(1%) Unilateral left		18(18.0%)
Ghonaimi et al., (5)	Egyptian	100	Canals	4(4.0%)	12 (12.0%)	12(12.0%)	-	-	28(28.0%)
			Grooves	4(4.0%)	8(8.0%)	8(8.0%)	-	-	24(24.0%)
Present study, (2022)	Kenyan	105	Canals	6 (5.7%)	6(5.7%)	11(10.5%)	1(1.0%) Unilateral left	51(24.3 %)	34(32.4%)
			Grooves	15(14.3%)	17(16.2%)	6(5.7%)	1(1.0%) Unilateral left		64(61.0%)

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