Original Article

http://dergipark.org.tr/en/pub/anatomy
Received: August 29, 2021; Accepted: December 15, 2021
doi:10.2399/ana.21.1053714

The relationship between the mastoid triangle and localization of the Asterion

Anıl Didem Aydın Kabakçı[1], Duygu Akın Saygın[1], Mustafa Büyükmumcu[2], Muzaffer Sindel[3], Eren Öğüt[4], Mehmet Tuğrul Yılmaz[1], Gökalp Şahin[1]

[1]*Department of Anatomy, Meram Faculty of Medicine, Necmettin Erbakan University, Konya, Turkey*
[2]*Department of Anatomy, Faculty of Medicine, Bezmialem Vakıf University, İstanbul, Turkey*
[3]*Department of Anatomy, Faculty of Medicine, Akdeniz University, Antalya, Turkey*
[4]*Department of Anatomy, Faculty of Medicine, Bahçeşehir University, İstanbul, Turkey*

Abstract

Objectives: The relationship between the mastoid triangle and the localization of the Asterion can be used in craniotomy and posterolateral surgical approaches. Therefore, we aimed to identify the relationship between the localization of the Asterion and mastoid triangle in dry skulls and its effect on surgery.

Methods: Our study was performed on 93 adult skulls obtained from bone collections of the Anatomy Departments of Necmettin Erbakan University and Akdeniz University. The mastoid triangle, Asterion and linear distances between them were measured for to determine the localization of the Asterion.

Results: The Asterion was located just above the Frankfurt horizontal plane on the left sides of the skulls in 54 (58.1%) specimens and on the right sides of the skulls in 71 (76.3%). It was located below the Frankfurt horizontal plane on the left sides of the skulls in 39 (41.9%) specimens; and on the right sides of the skulls in 19 (20.4%). There was a positive correlation between the distance of Asterion to apex of the mastoid process (r=0.832).

Conclusion: The relationship between the mastoid process and the Asterion can be used for determination of the dural venous sinuses and neighboring neurovascular structures, in retrosigmoid posterolateral surgical approaches.

Keywords: anthropometric measurements; Asterion; craniometry; mastoid triangle; skull; surgical landmarks

Anatomy 2021;15(3):189–197 ©2021 Turkish Society of Anatomy and Clinical Anatomy (TSACA)

Introduction

Surface landmarks are useful in detecting the venous sinuses and neurovascular structures in neurosurgical approaches directed to reach the posterior fossa and posterolateral cranial base.[1] The mastoid area of the skull is particularly resistant to physical injury due to its compact structure and anatomical location. Thus, it may stay intact in otherwise damaged and fractured skulls.[2] The mastoid triangle (MT) is an essential surgical zone for transmastoid cisternoscopy, and surgical approaches directed to cerebellopontine triangle, mastoid antrum and dural venous sinuses. Therefore, anthropometric measurements of MT and nearby surgical landmarks, such as mastoid process (MP), should be considered in surgery to prevent damage to the auricular branch of the lesser occipital nerve, great auricular nerve, emissary vein, sigmoid and transverse sinuses.[3–5] Another surgical landmark is the Asterion which located at the junction of transverse and sigmoid sinuses, frequently used for posterolateral surgical approaches.[1,3,5,6] The position of the Asterion and other prominent anatomical landmarks provide orientation for clinical and surgical interventions.[7] Various researchers have investigated the anatomical variations related with the MP, MT and Asterion according to ethnicity, sexual

This study was an oral presentation at the16th National Anatomy Congress on 11–14 September 2014, Malatya, Turkey.

dimorphism and sex determination.[8–11] However, the correlation between the MT and the location of Asterion is still needed to be investigated in more details. Therefore, in this study, we aimed to identify the relationship between the localization of Asterion and MT in dry skulls and its surgical significance.

Materials and Methods

Measurements were performed on 93 adult Turkish dry skulls with unknown age and sex obtained from bone collections of the Anatomy Departments of Necmettin Erbakan University and Akdeniz University. Skulls with any pathologies, fractures and deformities were not included to the study. Both measurements were recorded bilaterally using an electronic digital caliper (INCA, DCLA-0605, 0.6–150 mm, USA). Same researchers performed the measurements and repeated them twice to ensure measurement reliability and minimize individual variability.

The following measurements were performed on both sides (**Figures 1a**, **b**, **2a**, **b** and **3b**):

- The length of mastoid process (L-MP): The distance between the Frankfurt Horizontal Plane (FHP is the horizontal plane extending between the uppermost point of the external acoustic meatus and the infraorbital margin) and the apex of the MP.
- The mediolateral diameter of the mastoid process (MLD-MP): The width between the medial and lateral surface of the MP.
- The anteroposterior diameter of the mastoid process (APD-MP): The width of the MP in the anterior-posterior direction.
- The distance between Asterion and the root of the zygomatic arch (A-ZA).
- The distance between Asterion and the apex of the mastoid process (A-AMP).
- The distance between Asterion and suprameatal spine (A-SS).
- The distance between Asterion and porion (A-P).
- The distance between the Porion and the apex of the mastoid process (P-AMP).
- The distance between Opisthion and the apex of the mastoid process (O-AMP).
- The transverse distance between the apex of the mastoid process (WBM).
- The area of the mastoid region (AMR).

Heron's Mastoid Triangle Area Formula (A) was calculated as[8,10,11] (**Figure 3a**):

$$A=\sqrt{s(s-a)(s-b)(s-c)} \quad s=(a+b+c)/2$$

a: The distance between Asterion and Porion; **b**: The distance between the Porion and the apex of the mastoid process; **c**: The distance between Asterion and the apex of the mastoid process

The localization of the Asterion in reference to the FHP was evaluated between 0–2 (0: at the same level; 1: above the FHP; and 2:below the FHP). The data were analyzed using SPSS (Statistical Package for Social Sciences) for Windows (Version 21, Chicago, IL, USA). The data were expressed as number, percentage, mean±standard deviation (SD), maximum and minimum

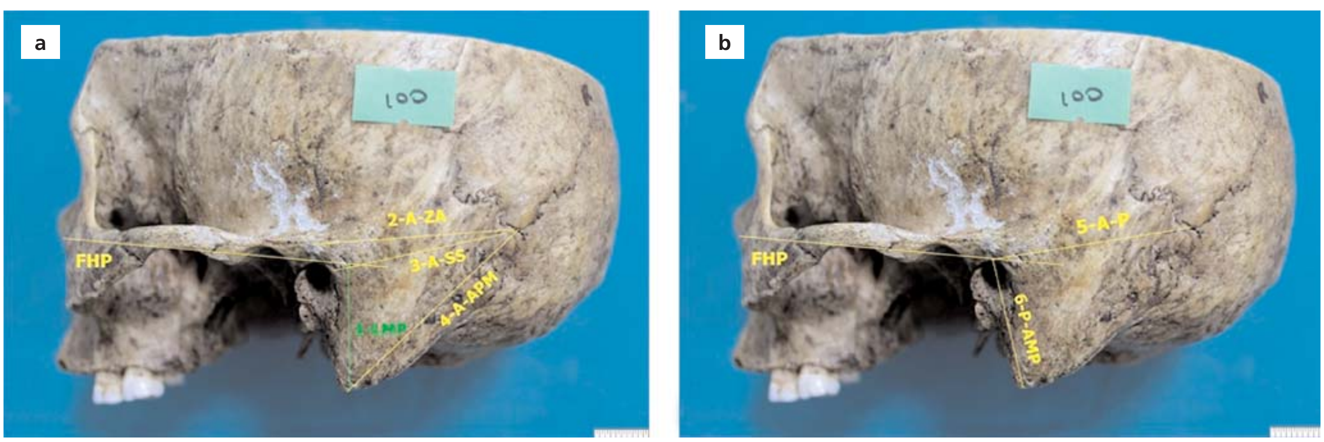

Figure 1. Morphometric measurements for to determine mastoid triangle. (**a**) **1-LMP:** length of the mastoid process; **2-A-ZA:** distance between Asterion and the root of the zygomatic arch; **3-A-SS:** distance between Asterion and suprameatal spine; **4-A-AMP:** distance between Asterion and the apex of the mastoid process; **FHP:** Frankfurt horizontal plane. (**b**) **5-A-P:** distance between Asterion and Porion; **6-P-AMP:** distance between Porion and the apex of the mastoid process.

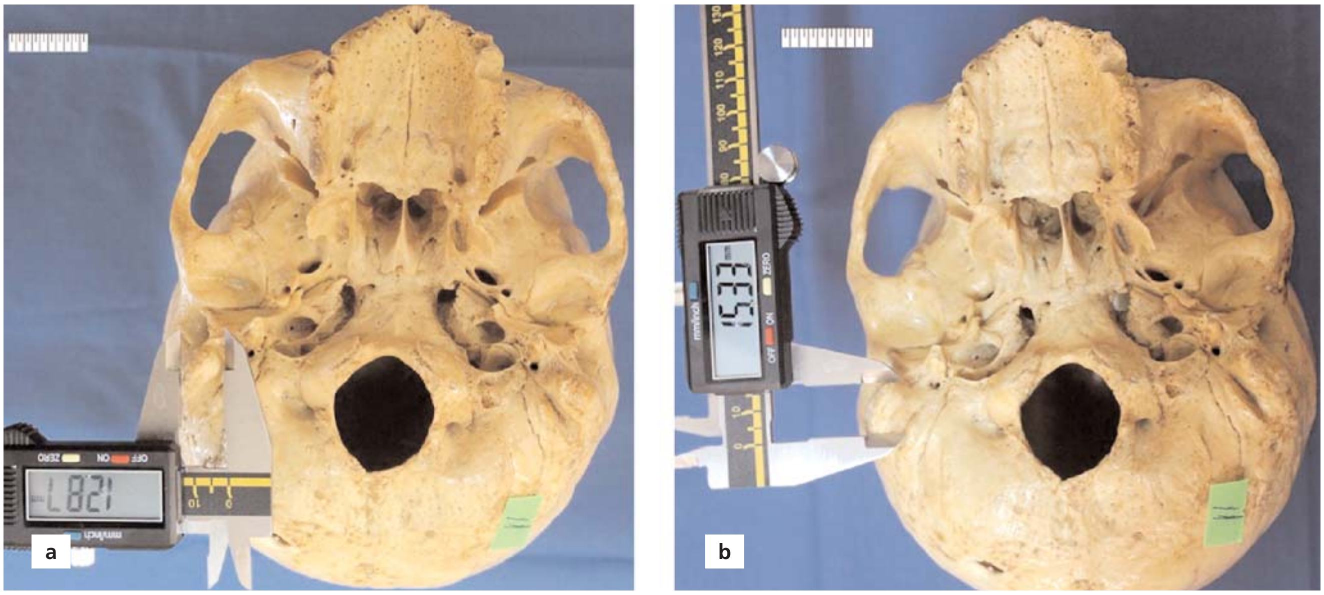

Figure 2. (**a**) Measuring the medio-lateral diamater of mastoid process; (**b**) measuring the antero-posterior diamater of mastoid process.

values. The relationship between the parameters was analyzed by paired sample t-test (for to evaluate the parameters of MT and MP on both sides) (**Tables 1** and **2**), chi-square analysis (for localization of the Asterion) (**Table 3**) and Pearson correlation test (for determining the correlation between the parameters) (**Table 4**). For all analyses; p<0.05 was considered as statistically significant.

Results

The findings showed that the length of mastoid processes (MP) on the right side was 25.50±5.49 mm and 25.82±4.35 mm on the left. However, there were no significant differences among sides (**Table 1**). The mediolateral diameters (MLD) of the MP were 12.70±4.29 mm on the right side

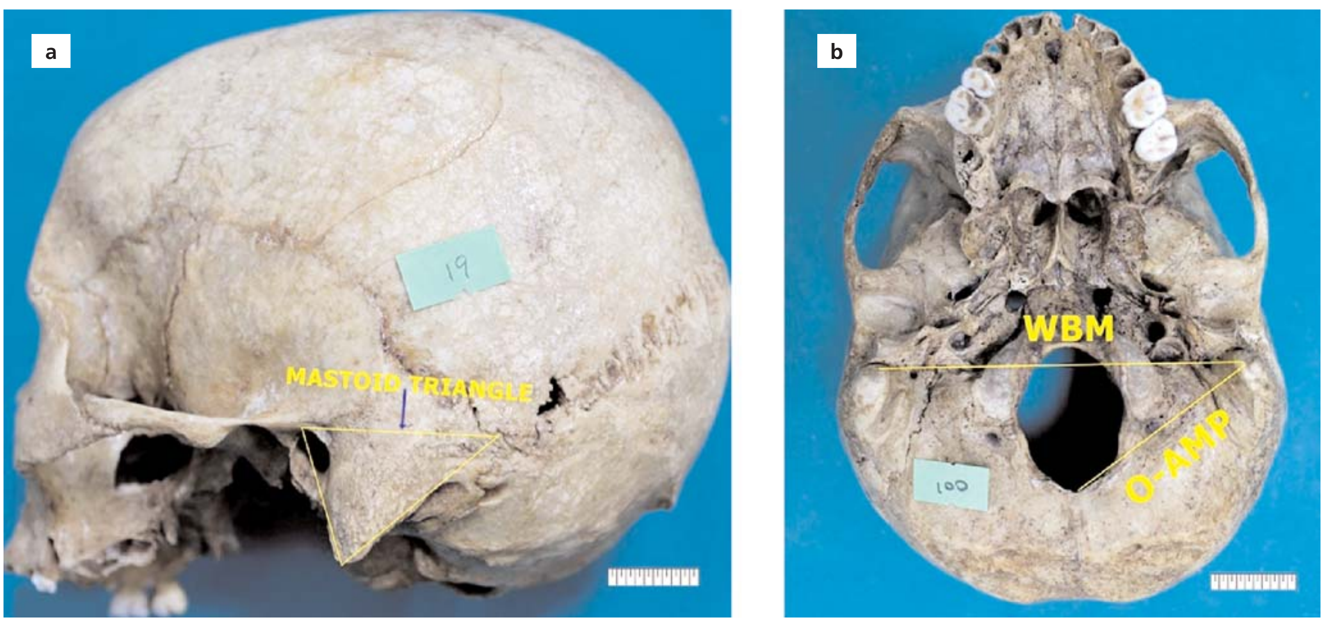

Figure 3. (**a**) Mastoid triangle; (**b**) O-AMP: distance between Opisthion and the apex of the mastoid process; WBM: The transverse distance between the apex of the mastoid process on both sides.

Table 1

The mean, standard deviation, minumum, maximum values of paramaters according to sides (mm).

	Right					Left				
Parameters	**n**	**Mean**	**SD**	**Min.**	**Max.**	**n**	**Mean**	**SD**	**Min.**	**Max.**
LMP	93	25.50*	5.49	10.90	38.25	93	25.82*	4.35	15.33	38.79
MLD	93	12.70*	4.29	6.72	25.39	93	11.39†	2.18	7.05	20.88
APD	93	15.71*	2.76	10.31	23.02	93	15.26*	3.04	9.42	24.27
A-ZA	93	42.75*	4.90	25.65	57.27	93	44.05*	7.15	32.79	64.91
A-AMP	93	49.58*	5.31	36.42	66.50	93	49.24*	5.06	38.23	64.72
A-SS	93	42.40*	7.21	2.11	53.67	93	42.80*	4.45	34.38	66.18
A-P	93	49.50*	4.59	32.10	62.52	93	48.86*	4.61	29.12	60.54
P-AMP	93	33.14*	4.22	23.30	55.36	93	32.41*	4.69	23.92	57.74
O-AMP	93	58.00*	4.36	44.93	71.19	93	57.74*	5.35	28.71	69.21
AMR	93	737.55*	134.40	420.77	1152.33	93	718.34*	142.16	371.44	1273.80

Note: Values in the same row which are not sharing the same subscript are significantly different on each side (p<0.05). Cells with no subscript are not included in the test. Tests assume equal variances. Tests are adjusted for all pairwise comparisons within a row of each innermost sub-table using the Bonferroni correction. **A-AMP:** distance between asterion and the apex of the mastoid process; **AMR:** area of the mastoid region; **A-P:** distance between asterion and porion; **APD:** the antero-posterior diamater of mastoid process; **A-SS:** distance between asterion and suprameatal spine; **A-ZA:** distance between asterion and the root of the zygomatic arch; **LMP:** length of mastoid process; **MLD:** medio-lateral diamater of mastoid process; **n:** number of the specimens; **O-AMP:** distance between opisthion and the apex of the mastoid process **P-AMP:** distance between porion and the apex of the mastoid process; **SD:** standard deviation. *The difference between mean values on each side is not statistically significant.

and 1.39±2.18 mm on the left. The difference in between both sides was statistically significant (p<0.005) (**Table 1**). The bimastoid width was 103.37±6.62 mm (**Table 2**).

Asterion was classified into three types in reference to the FHP (**Table 3**). Accordingly, in Type 1; Asterion was at the same plane as the FHP. In Type 2; Asterion was just above the FHP, and in Type 3; it was below the FHP. In 54 of the specimens (58.1%) Asterion was just above the FHP, and in 39 (41.9%) below the FHP on the left sides of the skulls. In 3 of the specimens (3.2%) Asterion was at the same level as the FHP, in 71 (76.3%) just above the FHP, and in 19 (20.4%) below the FHP on the right

Table 2

The mean, standard deviation, minimum and maximum values of bimastoid width (mm).

	n	**min.**	**max.**	**mean**	**SD**
WBM	93	79.25	116.36	103.3797	6.62375

n: number of the specimens; **SD:** standard deviation; **WBM:** transverse distance between the apex of the mastoid process of the both sides.

Table 3

Classification of Asterion in reference to the FHP.

		Right		Left				
		n	**%**	**n**	**%**	**X^2**	**df**	**p**
AS_FHP_TYPE	Type 1 (at the same level with FHP)	3	3.2%	0	0.0%	12.21	2	0.002
	Type 2 (above the FHP)	71	76.3%	54	58.1%			
	Type 3 (below the FHP)	19	20.4%	39	41.9%			

n: number of specimens; **χ^2:** chi-square value; **df:** degree of freedom.

Table 4
Correlation between mastoid triangle and mastoid process.

Parameters		AMR	WBM	O-AMP	P-AMP	A-P	A-SS	A-AMP	A-ZA	APD	MLD	LMP	SIDE
Side	r	-.070	.b	-.027	-.082	-.070	.034	-.033	.107	-.078	-.189*	.033	1
	p	.345	.000	.712	.266	.339	.649	.656	.147	.288	.010	.659	
LMP	r	.594*	.361*	.230*	.619*	.126	.137	.480*	.381*	.401*	.499*	1	
	p	.000	.000	.002	.000	.086	.061	.000	.000	.000	.000		
MLD	r	.151†	.076	.086	.162†	.006	.038	.142	.264*	.453*	1		
	p	.040	.468	.245	.027	.936	.603	.053	.000	.000			
APD	r	.361*	.205†	.069	.385*	.118	.107	.283*	.302*	1			
	p	.000	.049	.348	.000	.110	.148	.000	.000				
A-ZA	r	.462*	.250†	.211*	.201*	.538*	.443*	.539*	1				
	p	.000	.016	.004	.006	.000	.000	.000					
A-AMP	r	.832*	.478*	.442*	.475*	.743*	.581*	1					
	p	.000	.000	.000	.000	.000	.000						
A-SS	r	.458*	.461*	.269*	.163†	.630*	1						
	p	.000	.000	.000	.027	.000							
A-P	r	.681*	.428*	.402*	.274*	1							
	p	.000	.000	.000	.000								
P-AMP	r	.843*	.224†	.171†	1								
	p	.000	.031	.020									
O-AMP	r	.359*	.678*	1									
	p	.000	.000										
WBM	r	.399*	1										
	p	.000											
AMR	r	1											

*Correlation is significant at the 0.01 level (2-tailed); †Correlation is significant at the 0.05 level (2-tailed). **r**: spearman correlation coefficient.

side of the skulls. This localization of the Asterion was statistically significant among sides (χ^2=12.21, p=0.002) (**Table 3**). Moreover, the correlation between parameters A-AMP and AMR (r=0.832), A-AMP and A-P (r=0.743), A-P and AMR (r=0.684), P-AMP and AMR (r=0.843), O-AMP and WBM (r=0.678) was statistically significant (**Table 4**).

Discussion

Evaluation of the relationships between the bony landmarks on dry skulls are still gold standard to determine ideal surgical navigation for surgeries directed to various structures within the skull. MT is such a landmark area being formed by connecting the imaginary lines between Porion, Asterion and mastoid end-points. The postero-superior angle of this dimorphic triangle is formed by Asterion.[6] Previous studies in the literature have been conducted to determine the relations in between these bony landmarks.[5,6] Galindo-de León et al.[5] used the root of the zygomatic arch, suprameatal spine, the apex of the MP, external occipital protuberance and FHP to define a safe zone in neurosurgical approaches. In addition to provide surgical landmarks, these morphometric points and areas can also be used for sex determination.[9,10,12] However, Kanchan et al.[11] stated that MT was a poor predictor of gender and had limited value without a population reference. We also aimed to contribute to the literature by evaluating the correlation between the MT and Asterion.

The relation of Asterion to the MT have been conducted in previous studies.[1–3,5–7,13,14] The distance between Asterion and the apex of the mastoid process (A-AMP) was revealed as 49.20±4.68 mm by Day et al.,[13] 49.70±4.80 mm by Martinez et al.,[14] 47.89± 3.72 mm for the right side and 47.62 ± 2.87 mm for the left side by Mwachaka et al.,[3] 49.1±5.4 mm by Ucerler and Govsa,[1] 51.53±4.97 mm by Galindo-de Leon et al.,[5] 43.65±6.75 mm for the left side and 45.01± 6.04 mm for the right side by Akkaşoğlu et al.,[6] 50.2±0.58 mm for the right side and

48.7±0.56 mm for the left side by Çalışkan et al.[7] in various populations. However, Kemkes and Göbel[15] found the A-AMP as 49.4±5.1 mm (right), 49.4±5.5 mm (left) in females, and 50.2±4 mm (right), 50.5±4.8 mm (left) in males in German population. Yilmaz et al.[16] reported the A-AMP distance as 5.06 cm (right), 5.07 cm (left) in males, and 4.89 cm on both sides in females. Moreover, they concluded that the parameters were nearly the same on both sides for both genders.[16] Passey et al.[2] determined A-AMP distance as an average of 50.00±9.75 mm in males and 49.84±6.97 mm in females over 100 radiographs (p<0.001). Helmy et al.[17] revealed that the A-AMP distance was 5.21 cm (right), 5.24 cm (left) in males, and 4.72 cm (right), 4.80 cm (left) in females. Consistent with the literature, our study showed the A-AMP distance was 49.58±5.31mm (right) and 49.24±5.06 mm (left) in Turkish dry skulls. These findings suggest that A-AMP distance has a consistent and symmetrical distribution regardless of the ethnicity. Moreover, we found a positive correlation between the A-AMP and AMR (r=0.832), A-AMP and A-P (r=0.743). Correlation between Asterion and the measurements related with MT indicates that the MT is affected by the localization of the Asterion. These parameters may also vary depending on ethnicity.

The root of the zygomatic arch and the apex of the mastoid process can be used to determine the localization of the Asterion. Mwachaka et al.[3] reported that the distance between Asterion and the root of the zygomatic arch (A-ZA) was 59.06±2.72 mm (male) and 58.75±2.02 mm (female) (p=0.060). Moreover, their findings showed that A-ZA were 58.44±2.12 mm on the left and 58.85±2.25 mm on the right side (p=0.065). Çırpan et al.[18] determined A-ZA as 55.11±3.86 mm (right) and 54.37±4.35 mm (left). Furthermore, it was reported to be 43.95 ± 7.02 mm and 43.97±7.37 mm in a study by Akkaşoğlu et al.[6] The data obtained from our study were compatible with the studies of Akkaşoğlu et al.,[6] while it was less than the findings of previous studies. **Table 5** summarizes the previous studies that evaluated the distances of the Asterion to the various bony landmarks and their relations.

The size of the MT may be an indicator of gender and/or the position of the Asterion. It was reported that the total MT area was 1447.70 mm^2 or larger in the skulls belonging to males, and less than or equal to 1260.36 mm^2 in the skulls belonging to females (95% confidence).[19] In German population, Kemkes and Göbel[15] found the total MT area as 1434.3 mm^2 in males and 1315 mm^2 in females. The same area was revealed as 1418.9 mm^2 in males and 1209.1 mm^2 in females in the Portuguese.[15] In another study, Galdames et al.[10] stated that the total MT areas were 1389.55 mm^2 in males and 1296.22 mm^2 in females. In the present study, the findings showed that the total area of the MT was 1455.89 mm^2. Considering the correlation between the MT and the Asterion, we suggest that MT can be used in localization of the Asterion.

The Asterion has been proposed as a major landmark combined with petrosal approaches to the cranial base.[1] Furthermore, determining the junction of the transverse-sigmoid sinus according to the localization of Asterion is essential for posterolateral surgical approaches. Mwachaka et al.[3] determined the location of Asterion at the junction of the transverse-sigmoid sinus in 72 (80%) skulls. Moreover, they stated that in only one case (1.1%), it was just below junction.[3] Fang et al.[4] reported that 44 (68.75%) Asterion was located at the junction of the transverse-sigmoid sinus. Moreover, they concluded that the root of the zygomatic arch and the apex of the mastoid process could be used to determine the exact position of Asterion.[4] However, the same type was found in 11 (55%) according to the Çırpan et al.[19] A study by Galindo-de Leóne et al.[5] revealed that the intersection of the transverse and sigmoid sinuses was at the level of Asterion in 82.4% of cases, above the Asterion in 12.5% of the cases, and below it in 5.1% . The most common type in respect of the location of Asterion was Type 2 in Turkish dry skulls. Our measurements confirmed that the Asterion were located just above the FHP in majority of the cases (**Table 3**). The localization of the Asterion may differ in populations depending on ethnicity, and it may be affected by epigenetic, embryological or environmental factors.

Previous studies have revealed that the localization of the Asterion varies depending on cephalocaudal orientation.[1] Since the Asterion is usually positioned close to the transverse–sigmoid sinus junction, the burr hole on the Asterion may directly impact the sinus, causing injury and bleeding.[1] It has also been reported that the first trephine should be positioned 15 mm below the Asterion to limit the potential damage to the transverse sinus.[5] At about 50 mm posterior to the suprameatal spine and 11.5 mm inferior to the FHP, a retrosigmoid transtemporal approach can be performed.[1] According to Çırpan et al.,[19] surgical approaches through the 10 mm superior or inferior to the Asterion have a significant risk of damaging the sigmoid and transverse sinuses. Therefore, Asterion can be consistently determined using the parameters in relation with the MT.[3] Approaches directed to posteroinferior side of the Asterion are the safest methods to prevent lacerating the transverse-sigmoid sinus complex. Therefore, the burr hole must be located posteroinferior to the Asterion for posterolateral approaches.[14] The result of our study showed that the Asterion was 42.6 mm behind the suprameatal spine, 49.42 mm above the MP, and 17.5 mm

Table 5

Comparison of our measurements with other researchers.

Researchers	Samples	A-AMP	A-ZA	A-P	P-AMP 7
Day et al.[13]	100 dry skulls	49.20±4.68	53.88±5.09	-	-
Martínez et al.[14]	25 skulls of adult cadavers	49.70±4.80	55.42±4.92	-	-
Ucerler and Govsa[1]	16 skull bases, 24 half-skull bases, 17 fixed male cadaver heads and 10 fixed male half cadaver heads	49.1±45.4	54.6±5.5	-	-
Kemkes and Göbel[15]	97 skulls (German forensic medicine sample)	Female R: 49.4±5.1 Female L: 49.4±5.5 Male R: 50.2±4 Male L: 50.5±4.8	-	Female R: 46.3±3.7 Female L: 46.2±4.4 Male R: 48.6±3.3 Male L: 48.4±3.5	Female R: 28.9±3.6 Female L: 29.2±3.4 Male R: 30.9±2.6 Male L: 30.9±3.1
Kemkes and Göbel[15]	The Portuguese cemetery sample consisted of 100 skulls	Female R: 45.8±4.6 Female L: 46.0±4.3 Male R: 49.5±5.2 Male L: 49.2±4.9	-	Female R: 45.1±2.9 Female L: 44.9±3.6 Male R: 47.7±3.8 Male L: 47.1±3.3	Female R: 28.4±2.6 Female L: 27.8±2.8 Male R: 31.5±3.7 Male L: 30.9±3.7
Galdames et al.[10]	81 human skulls of Brazilian individuals	Female R: 48.34±3.87 Female L: 50.17±5.18 Male R: 50.21±4.96 Male L: 50.22±4.95	-	Female R: 46.74±3.30 Female L: 47.53±3.80 Male R: 47.45±3.46 Male L: 47.1±3.46	Female R: 27.55±2.78 Female L: 29.74±4.14 Male R: 30.72±2.73 Male L: 29.22±2.73
Mwachaka et al.[3]	50 adult dry skulls	R: 47.89± 3.72 L: 47.62 ± 2.87	R:58.85±2.50 L:58.44±2.12	-	-
Saini et al.[9]	138 adult skulls (104 male, 34 femlae)	Male: 47.83±4.06 Female: 43.00±4.32	-	Male: 47.89±3.17 Female: 44.69±3.75	Male: 31.77±3.07 Female: 27.98±3.47
Galindo-de León et al.[5]	88 dry skulls	R: 43.65 ± 6.75 L: 45.01± 6.04	54.74±4.46	-	-
Kanchan et al.[11]	118 dry skulls (69 male, 49 female)	Male: 48.68±4.66 Female: 47.16±4.74	-	Male: 43.97±3.24 Female: 42.31±3.74	Male: 27.43±3.05 Female: 25.73±2.54
Gangrade et al.[24]	100 dry skulls (50 male, 50 female)	Female R: 49.06±3.02 Female L: 48.51±3.27 Male R: 52.39±4.32 Male L: 52.4±5.46	-	Female R: 46.98±2.98 Female L: 46.59±2.88 Male R: 49.02±4.07 Male L: 49.25±4.08	Female R: 28.47±2.16 Female L: 28.28±2.31 Male R: 31.53±3.20 Male L: 30.48±3.56
Jain et al.[25]	100 dry skulls	R:4.95±0.81 L:4.92±0.81	-	R: 4.59±0.71 L: 4.60±0.71	R: 3.13±0.53 L: 3.10±0.51
Yilmaz et al.[16]	CT images of 140 individuals (70 men, 70 women)	Female R: 4.89±0.32 Female L: 4.89±0.32 Male R: 5.06±0.46 Male L: 5.07±0.46	-	Female R: 4.61±0.35 Female L: 4.60±0.31 Male R: 4.93±0.38 Male L: 4.98±0.38	Female R: 2.89±0.24 Female L: 2.90±0.24 Male R: 3.12±0.29 Male L: 3.13±0.29
Fange et al.[4]	CT angiography images of 32patients	R: 49.10±3.56 L: 48.70±2.23	R:54.6±5.50 L:54.1±5.42	-	-
Sukre et al.[26]	132 dry human skulls (80 male, 52 female)	Male:48.33±0.64 Female:42.59±1.12	-	Male: 44.96±0.57 Female: 40.46±1.03	Male: 29.86±0.41 Female: 25.12±0.69
Akkaşoğlu et al.[6]	20 dry skulls	R: 45.01± 6.04 L: 43.65 ± 6.75	R: 43.95±7.02 L: 43.97 ±7.37	-	-
Madhumathi et al.[27]	30 human skulls	R: 45.63± 5.22 L: 44.49±5.18	-	R: 40.93± 5.29 L: 40.45±5.77	R: 23.26±4.52 L: 23.01±4.15
Çırpan et al.[19]	172 human skulls	R: 48.00± 5.04 L: 47.63±5.15	R: 55.11±3.86 L: 54.37±4.35	-	-
Caliskan et al.[7]	20 skulls and 18 hemi skulls	R: 5.02±0.58 cm L: 4.87±0.56 cm	-	-	-
Passey et al.[17]	110 human skulls (55 male, 45 female)	Male: 50.00±9.75 Female: 49.84±6.97	-	Male: 44.11±6.82 Female: 39.72±5.72	Male: 21.21±2.15 Female: 31.66±3.21
Helmy et al.[18]	CT images of 132 adult Egyptian patients (66 male, 66 female)	Female R:4.72±0.55 Female L:4.80±0.54 Male R:5.21±0.56 Male L:5.24±0.59	-	Female R: 4.50±0.40 Female L: 4.62±0.38 Male R: 4.88±0.44 Male L: 4.97±0.43	Female R: 2.88±0.30 Female L: 2.88±0.38 Male R: 3.24±0.39 Male L: 3.15±0.40
Our study	93 dry skulls	R: 49.58±5.31 L: 49.24±5.06	R: 42.75±4.90 L: 44.05±7.15	R: 42.4±7.21 L: 42.8±4.45	R: 33.14±4.22 L: 32.41±4.69

A-AMP: distance between asterion and the apex of the mastoid process; **A-P:** distance between asterion and proion; **A-ZA:** distance between asterion and the root of the zygomatic arch; **P-AMP:** distance between porion and the apex of the mastoid process (double-digit numbers are in mm, single-digit ones are in cm).

above the FHP in Turkish dry skulls. Therefore, it can be suggested that the burr hole can be positioned at least 17.5 mm inferior to the Asterion to prevent a potential damage to the transverse sinus. The optimal drilling position for a retrosigmoid approach was previously suggested to be at the halfway between the mastoid apex and the Asterion.[20] A 2 cm diameter hole centered on this site proved effective for exposing the associated structures in the cerebellopontine angle. In the retrosigmoid approach, the optimum implant location was suggested to be 1.9±0.1 cm posterior, 1.7±0.1 cm inferior to the Asterion and 3.3±0.2 cm posterior, 2.1±0.1 cm superior to the mastoid notch.[21] Meningiomas which develop at the junction of the sigmoid and transverse sinuses can be removed without major risks.[22] The results of this study suggests aa safe zone posteroinferior to the Asterion and posterosuperior to the MP (and MT) in posterolateral surgical approaches.

The limitation of this study is that this study was conducted on only Turkish dry skulls, and the gender of the skulls were unknown. Further studies should be conducted to investigate the relationship between the Asterion and MT with 3D imaging modalities.

Conclusion

The relationship between the mastoid process and the Asterion can be used for determination of the dural venous sinuses and neighboring neurovascular structures, in retrosigmoid posterolateral surgical approaches. The differences coming from ethnicity and gender should also be kept in mind before planning the surgical approach.

Acknowledgments

The authors would like to express their sincere gratitude to the donors and their families. We also would like to express our special thanks to the academic staff of Anatomy Departments of, Akdeniz University and Necmettin Erbakan University.

Conflict of Interest

None.

Author Contributions

ADAK: project development, data collection, data analysis, writing manuscript; DAS: project development, data collection; MB: project development, data collection; MS: project development, data collection; EO: project development, data collection, writing manuscript; MTY: data analysis; GS: project development, data collection.

Ethics Approval

The present study was approved by the Ethics Committee of Necmettin Erbakan University with protocol ID:2015/160.

Funding

None.

References

1. Ucerler H, Govsa F. Asterion as a surgical landmark for lateral cranial base approaches. J Craniomaxillofac Surg 2006;34:415–20.
2. Passey J, Pandey S, Passey N, Singh R, Singh R, Kumar A. Radiographic evaluation of mastoid parameters for sexual differentiation in North Indian population. Cureus 2021;13:e16011.
3. Mwachaka P, Hassanali J, Odula P. Anatomic position of the asterion in Kenyans for posterolateral surgical approaches to cranial cavity. Clin Anat 2010;23:30–3.
4. Fang B, Chen G, Wang L, Zhu X, Hu Q, Zhang J. Skull anatomic landmarks for retrosigmoid craniotomy in a Chinese cohort: a 3D-computed tomography study in vivo. Turk Neurosurg 2016;26:564–7.
5. Galindo-de León S, Hernández-Rodríguez AN, Morales-Ávalos R, del Carmen Theriot-Girón M, Elizondo-Omaña RE, Guzmán-López S. Morphometric characteristics of the asterion and the posterolateral surface of the skull: relationship with dural venous sinuses and neurosurgical importance. Cir Cir 2013;81:251–5.
6. Akkaşoğlu S, Farimaz M, Aktaş HA, Ocak H, Erdal ÖD, Sargon MF, Çalışkan S. Evaluation of asterion morphometry in terms of clinical anatomy. Eastern Journal of Medicine 2019;24:520–3.
7. Çalışkan S, Akkaşoğlu S, Sargon MF, Demiryürek MD. Mastoid process morphometry on dry skulls. The Journal of Kırıkkale University Faculty of Medicine 2020;22:58–63.
8. Bhagya B, Hema N, Ramakrishna A. Validation metrics of the mastoid triangle. Journal of Health and Allied Sciences 2013;3:44–5.
9. Saini V, Srivastava R, Rai RK, Shamal SN, Singh TB, Tripathi SK. Sex estimation from the mastoid process among North Indians. J Forensic Sci 2012;57:434–9.
10. Galdames ICS, Matamala DAZ, Smith RL. Sex determination using mastoid process measurements in Brazilian skulls. International Journal of Morphology 2008;26:941–4.
11. Kanchan T, Gupta A, Krishan K. Estimation of sex from mastoid triangle - a craniometric analysis. J Forensic Leg Med 2013;20:855–60.
12. Passey J, Mishra SR, Singh R, Sushobhna K, Singh S, Sinha P. Sex determination using mastoid process. Asian Journal of Medical Sciences 2015;6:93–5.
13. Day JD, Kellogg JX, Tschabitscher M, Fukushima T. Surface and superficial surgical anatomy of the posterolateral cranial base: significance for surgical planning and approach. Neurosurgery 1996;38:1079–83.
14. Martínez F, Laxague A, Vida L, Prinzo H, Sgarbi N, Soria VR, Bianchi C. Topographic anatomy of asterion. Neurocirugía (Astur) 2005;16:441–6.
15. Kemkes A, Göbel T. Metric assessment of the "mastoid triangle" for sex determination: a validation study. J Forensic Sci 2006;51:985–9.
16. Yilmaz MT, Yüzbasioglu N, Cicekcibasi AE, Seker M, Sakarya ME. The evaluation of morphometry of the mastoid process using multi-

detector computed tomography in a living population. J Craniofac Surg 2015;26:259–63.
17. Helmy M, Elbeshbeshi M, Gadelhak B. Sex determination by metric assessment of mastoid triangle using multidetector computed tomography: Egyptian study. Mansoura Journal of Forensic Medicine and Clinical Toxicology 2021;29:51–62.
18. Çırpan S, Yonguç G, Sayhan S, Eyüboğlu C, Güvençer M. Morphometric evaluation of localisation of asterion for intracranial approaches posterolaterally. Ege Journal of Medicine 2019;58:108–14.
19. De Paiva LAS, Segre M. Sexing the human skull through the mastoid process. Revista do Hospital das Clinicas 2003;58:15–20.
20. Xia Y, Li XP, Han D, Zheng J, Long HS, Shi JF. Anatomic structural study of cerebellopontine angle via endoscope. Chin Med J (Engl) 2007;120:1836–9.
21. Arnold H, Schulze M, Wolpert S, Hirt B, Tropitzsch A, Zimmermann R, Radeloff A, Löwenheim H, Reimann K. Positioning a novel transcutaneous bone conduction hearing implant: a systematic anatomical and radiological study to standardize the retrosigmoid approach, correlating navigation-guided, and landmark-based surgery. Otol Neurotol 2018;39:458–66.
22. Vrionis FD, Robertson JH, Heilman CB, Rustamzedah E. Asterion meningiomas. Skull Base Surg 1998;8:153–61.

ORCID ID:
A. D. Aydın Kabakçı 0000-0003-1594-0188; D. Akın Saygın 0000-0003-4260-9263; M. Büyükmumcu 0000-0002-8475-6061; M. Sindel 0000-0002-6594-1325; E. Öğüt 0000-0003-2506-9883; M. T. Yılmaz 0000-0001-5744-0902; G. Şahin 0000-0002-9738-1828

deomed®

Correspondence to: Anıl Didem Aydın Kabakçı, PhD
Department of Anatomy, Meram Faculty of Medicine,
Necmettin Erbakan University, Konya, Turkey
Phone: +90 332 223 79 36
e-mail: anil_didem_aydin@hotmail.com

Conflict of interest statement: No conflicts declared.

 How to cite this article: Aydın Kabakçı AD, Akın Saygın D, Büyükmumcu M, Sindel M, Öğüt E, Yılmaz MT, Şahin G. The relationship between the mastoid triangle and localization of the Asterion. Anatomy 2021;15(3):189–197.