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Analysis of the Asterion Morphology in Relation to Its Clinical Significance

Análisis de la Morfología del Asterion en Relación con su Importancia Clínica

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SUMMARY: The asterion presents a significant anthropological marking and meeting point between three sutures. It is a surface landmark for the transverse-sigmoid venous sinus complex and is also a surgical landmark for access to the posterior cranial fossa, giving it clinical importance. The aim of this research was to analyze the shape of the asterion and to set the measurement methods that will determine distance between the asterion and surrounding features. The study sample, as a part of the Osteological collection of the Department of Anatomy, Faculty of Medicine Novi Sad, consisted of 43 skulls. Morphometric analysis was related to the measurement of the defined parameters and descriptive analysis presented the classification of asterion in relation to the presence of sutural bones, as well as the determination of the position of the asterion according to the transverse-sigmoid venous complex. There was a statistically significant difference between male and female skulls for all the measured parameters. The results show that 34.88 % were type 1 (one or more sutural bones are present) and 65.12 % were type 2 asteria (no sutural bones are present). More frequent occurrence of asteria type 2 was seen on both, male and female skulls. The most frequent position of the asteria on both sides of the skull was in the transverse-sigmoid venous complex (76.92 % on the right side vs. 72.22 % on the left cranial side). Clinical significance of knowing the area of asterion is reflected in order to make the surgical, as well as diagnostic procedures, as successful as possible.

KEY WORDS: Asterion; Morphometry; Sutural bones; Posterior cranial fossa.

INTRODUCTION

Anthropological landmarks, which are marked in Figure 1, were the subject of numerous studies conducted at the Institute of Anatomy, Faculty of Medicine in Novi Sad (Knezi *et al*., 2020; Pupovac *et al*., 2020; Radosevic *et al*., 2020). This study was carried out in order to highlight the significance of the basic morphological researches, as well as to contribute to the preservation of their knowledge.

The asterion presents a significant anthropological marking in which the posterior or mastoid angle of the parietal bone meets the occipital bone and the mastoid process of the temporal bone. It is the meeting point between three sutures – lambdoid, parieto-mastoid and occipito-mastoid suture, and it resambles a star, so the name asterion is derived from the ancient Greek language (*αοτηρ, ερος, δ – aster, star*). Due to the similarity with the appearance of the Mercedes-Benz logo, the Mercedes-Benz point is also the term for the asterion, that can be found in the Anglo-saxon literature. In the newborn

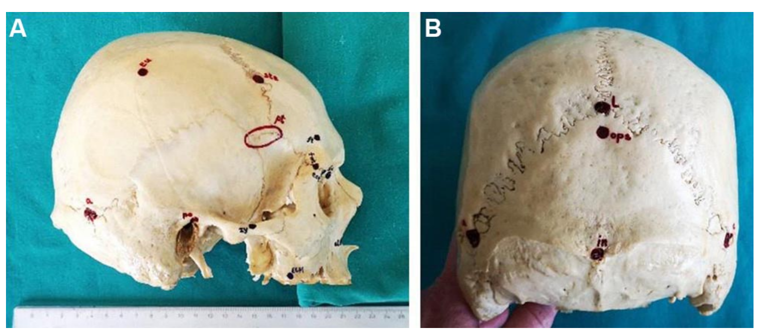

Fig. 1. Anthropological landmarks marked on norma lateralis (A) and norma occipitalis (B) of the skull, which is a part of the osteological collection of the Institute of Anatomy, Faculty of Medicine in Novi Sad.

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skull there is a postero-lateral or mastoid fontanelle covering the asterion region (Standring, 2005).

Although the pattern of formation of the asterion is not clarified completely, it is believed that genetic factors have a significant influence. Gene MSX2, that encodes the factor of transcription, plays a crucial role in craniofacial morphogenesis, also affecting the fusion of sutures (Liu *et al*., 1999). During the linear growth of the skull cap, bones that surround the asterion begin to ossify, and the process of ossification ends by the end of the second year of life. Mastoid fontanelle ossifies by the end of the first year of life. Sometimes new centers of ossification occur, known as sutural bones (Standring, 2005). According to Murphy (1956) sutural bones occur during the normal development process, which is genetically determined, while on the other hand Hess (1946) and Finkel (1971) believe that sutural bones are formed as a consequence of some pathological processes and that they are present in pathological conditions, such as hydrochephalus. Sutural bones are mostly found in the lambdoid suture (Jos Hemalatha & Arumugam, 2016).

The asterion can be classified according to the presence of sutural bones as asterion type 1 – sutural bones are visible, and type 2 – sutural bones are not visible (Sudha *et al*., 2013). In 8-15 % of general population there is a presence of sutural bones in the asterion region (Jos Hemalatha & Arumugam, 2016).

The existance of the human skeleton sexual dimorphism and its importance in the medico-legal research have long been recognized. For easier sex determination Saavedra de Paiva & Serge (2003) made a great contribution by describing triangular area using the following craniometric points: mastoidale, asterion and porion (MAP). They found a significant difference in this triangle area between left and right side by comparing male and female skulls, and thus have classified MAP method as one of the most commonly used in the anthropological studies. Reports related to this method are available for different racial and ethnic background (Keen, 1950; Giles & Elliot, 1963; Defrise-Gussenhoven, 1966; Bouliner, 1968; Steyn & Iscan, 1998).

Structures that are located near the asterion are: mastoid process, zygomatic arch, external occipital protuberance and lambda, and they all together are used as starting points in different morphometric analysis (Akkasoglu *et al*., 2019). The distance between the asterion and the root of the zygomatic arch, as well as the distance between the asterion and the tip of the mastoid process are important when planning a surgical approach to the mastoid antrum, cerebellopontine triangle, as well as during the performance of the transmastoid approach (Ozveren *et al*., 2002; Galindo-de León *et al*., 2013). Multispiral imaging techniques of computed tomography and magnetic resonance both use the method of fading to precisely determine the position of asterion in relation to the transverse and sigmoid venous sinuses, and in order to facilitate the access to the posterior cranial fossa (Urnis *et al*., 1997). In that manner, it can be concluded that precious position of the asterion is important for neurosurgeons and maxillofacial surgeons, as it is the surface point for the orientation of the transverse-sigmoid venous sinus complex (Day *et al*., 1996), and also surgical landmark for the retro-sigmoid craniotomy, approaching method to the posterior cranial fossa (Martínez *et al*., 2005; Ucerler & Govsa, 2006).

The aim of this research was to analyze the shape of the asterion and to set the measurement methods that will determine distance between the asterion and surrounding features, as well as to establish a place of safe approach to the structures of the posterior cranial fossa and posterolateral cranial base.

MATERIAL AND METHOD

The study was conducted at the Department of Anatomy at the Faculty of Medicine in Novi Sad (Serbia), and it was approved by members of the Ethics Committee for clinical trials (Faculty of Medicine, University of Novi Sad). The study sample, as a part of the Osteological collection of the Department of Anatomy, consisted of 43 thoroughly boiled, cleaned and macerated skulls of unknown age. On 39 skulls the asteria were clearly noticed on both sides, right sides of four skulls were damaged and these asteria were excluded from the study. In that regard, 82 asteria were analyzed (43 left and 39 right).

The Protocol for visual determination of skull sex, modified by Ferenbach and Buikistra and taken from the Warlath *et al*. (2004), was used. From a total sample of 43 skulls, 26 were male and 17 were female.

This was a two-part research.

Morphometric analysis. Morphometric analysis was related to the measurement of the following parameters (Fig. 2):

A - PZ (asterion - zygomatic process of temporal bone), A - PM (asterion - most prominent point of the mastoid process apex), A - POE (asterion - external occipital protuberance, its most prominent point - inion), A - SSM (asterion - suprameatal spine/fovea of temporal bone).

Fig. 2. Morphometric analysis of the asterion region.

Measurements were performed using Vernier calliper (scale of 0.05 mm) and the obtained results were processed by Student's t test.

Descriptive analysis. Acording to the presence/absence of the sutural bones in the asterion region, the asteria were classified as type 1 if sutural bones (one or more) were present and type 2 if there were no sutural bones in the asterion region.

From the entire sample, 22 skulls were open and the transverse-sigmoid venous sinus complex could be clearly seen (nine skulls were undamaged on both sides; on eight skulls only left side was undamaged and on five skulls only right one). In that manner, the relationship asterion –venous sinus complex was described with the aim to emphasize the importance of safe posterolateral cranial base approach to the contents of the posterior cranial fossa and also to take into account the possibility of injury to the venous sinus during surgical approach.

In regard to its position, asteria were classified into three categories, which we marked with numbers: 1 - asterion was placed in the venous sinus complex, 2 - asterion was placed above the complex; 3 - asterion was placed below the complex.

RESULTS

Morphometric analysis. Tables I and II show statistically processed data of the morphometric analysis for the left and right asterion regions, respectively, with minimum and maximum values for four measured parameters, mean values and standard deviations.

It can be seen that there is a statistically significant difference for three measured parameters (A-PM, A-POE, A-SSM) between male and female skulls, while no statistically significant difference was noted for the parameter A-PZ on the left side of the obtained skulls. Results presented in the Table II show that statistically significant difference exists for all measured parameters on the right side of the skull sample between male and female.

Table III shows results that were obtained by comparing the entire sample of skulls in relation to sex, regardless of orientation, while Table IV contains data

Table I. Results of the morphometric analysis of the left asterion regions considering male and female skulls (n=43). All measures are presented in milimeters.

Parameter	Male skulls (n=26)			Female skulls (n=17)			p
	X±SD	Maximum	Minimum	X±SD	Maximum	Minimum	
A - PZ	54.11±4.08	61.70	46.10	52.45±3.71	58.80	47.40	0.12
A - PM	52.36±5.39	60.00	43.80	46.02±3.22	51.30	40.20	0.00
A - POE	66.63±3.55	75.00	60.40	63.84±2.98	68.40	59.40	0.01
A - SSM	43.97±3.31	50.70	38.00	41.94±3.15	45.40	37.00	0.04

*p<0,05

Table II. Results of the morphometric analysis of the right asterion regions considering male and female skulls (n=39). All measures are presented in milimeters.

Parameter	Male skulls (n=22)			Female skulls (n=17)			p
	X±SD	Maximum	Minimum	X±SD	Maximum	Minimum	
A - PZ	55.51±3.18	62.00	51.50	52.96±4.29	61.10	46.50	0.03
A - PM	52.94±5.50	61.60	42.40	47.59±3.73	53.00	45.50	0.00
A - POE	65.73±3.94	73.80	59.00	62.81±3.53	70.00	56.00	0.02
A - SSM	43.76±2.78	49.90	39.20	41.98±2.57	46.40	37.20	0.03

*p<0,05

Table III. Results of the morphometric analysis of the entire skull sample (n=43) in relation to sex. All measures are presented in milimeters.

Parameter	Male skulls (n=26)			Female skulls (n=17)			p
	X±SD	Maximum	Minimum	X±SD	Maximum	Minimum	
A - PZ	54.81±3.68	62.00	46.10	52.70±3.94	61.10	46.50	0.01
A - PM	52.65±5.38	65.00	42.40	46.81±3.51	53.00	40.20	0.00
A - POE	66.18±3.73	75.00	59.00	63.33±3.24	70.00	56.00	0.00
A - SSM	43.87±3.01	50.70	38.00	41.96±2.82	47.00	37.00	0.01

*p<0,05

Table IV. Results of the morphometric analysis of the entire skull sample (n=43) in relation to left/right orientation. All measures are presented in milimeters.

Parameter	Left side (n=43)			Right side (n=39)			p
	X±SD	Maximum	Minimum	X±SD	Maximum	Minimum	
A - PZ	53.41±3.95	61.70	46.10	54.43+3.85	62.00	46.50	0.15
A - PM	49.67±5.54	65.00	40.20	50.67+5.46	61.60	41.90	0.23
A - POE	65.45±3.56	75.00	59.40	64.49+3.99	73.80	56.00	0.15
A - SSM	43.11±3.35	50.70	37.00	43.01+2.80	49.90	37.20	0.45

*p<0,05

obtained by comparing the asteria of the left and right sides, regardless of the sex of the skulls.

It can be observed that, unlike male and female skulls, which differ statistically significantly for all four measured parameters, left and right skulls do not show a statistically significant difference in the size of the measured diameters of the asterion region.

Descriptive analysis. The second part of the study describes the appearance of the sutural bones in the asterion region, according to which asteria were classified into two types: type 1 and type 2. The images of the representative skulls with the asterion type 1 and 2 are shown in Figure 3. Accordingly, the results show that 15 asteria (34.88 %) were type 1, and 28 (65.12 %) were type 2. More frequent occurrence of asteria type 2 was seen on both, male and female skulls (15 (65.38 %) and 11 (64.71 %), respectively), as opposed to asteria type 1 (9 (34.62 %) in male and 6 (35.29 %) on female skulls). Likewise, type 2 asteria were more often observed on both skull sides, left and right (33 (76.74 %) and 32 (82.05 %), respectively) compared to asteria type 1 (10 (23.26 %) on left and 7 (17.95 %) on right side).

As Figure 3 shows, the right asterion was over the posterior cranial fossa and inferior to the transverse-sigmoid venous sinus complex in 23.08 % (3 samples), right on the transverse-sigmoid complex in 76.92 % (10 samples) and none was located superior to the venous sinuses junction. On the left cranial side, the asterion was in position 3 in 22.22 % (4 samples), in position 1 in 72.22 % (13 samples) and just one asterion (5.55 %) was located superior to the transverse-sigmoid venous sinus complex.

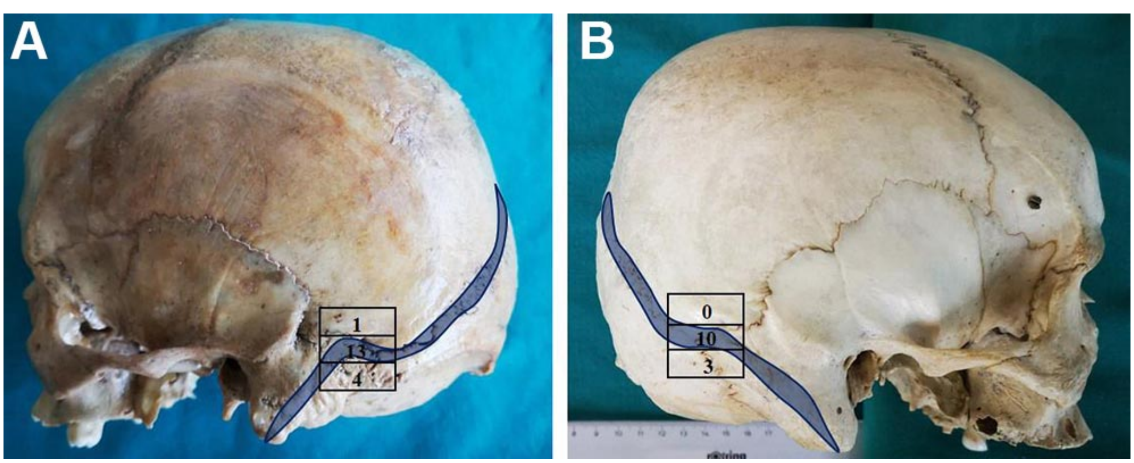

Fig. 3. Left (A) and right (B) side of the skull with frequencies of the asterion position in relation to the transverse-sigmoid venous sinus complex.

DISCUSSION

This research emphasizes the significance of the asterion as a superficial surgical landmark, when approaching the posterior cranial fossa through the lateral part of the base of the skull. It is an indisputable fact that planning the surgical approach relies mainly on the surgeon's knowledge of the superficial anatomy. Different position of the asterion and its distance from the temporal bone and the external occipital protuberance can affect a safe surgical approach to the tympanic cavity, mastoid antrum, membranous labyrinth of the inner ear during transmastoid cisternoscopy and/or the approach to the cerebellopontine angle (Ozveren, 2002; Martínez *et al*., 2005).

With this research, using 43 adult skulls, morphometric and descriptive analysis were demonstrated.

Morphometric analysis. In this study, where measurements of the distance between the asterion and the structures on temporal and occipital bone were made, it was observed that there is a statistically significant difference between male and female skulls. It is expected that values of the measured parameters will be higher on male skulls, but the exception was left A-PZ parameter, for which no statistically significant difference between sexes was shown (p=0.12).

Results of morphometric studies conducted on different populations are shown in the review of Lucena *et al*. (2019). It is apparent that the parameter values in other populations match our results, and discrepancies are found for the parameter A-PZ (45.28±5.40 mm in Brazilian vs. 53.92±3.90 mm in our population), A-PM (65.72±6.64 mm in Brazilian vs. 50.17±5.50 mm in our population), A-POE (57.15±8.38 mm in Indian and 58.88±4.73 mm in Brazilian vs. 64.97±3.77 mm in our population) and A-SSM (39.05±4.17 mm in Brazilian vs. 43.06±3.07 mm in our population). The differences in values obtained by measuring the distance between anthropological points on skulls which belong to the selected populations can be explained by the differences in ethnicity.

Measuring the distance between the asterion and zygomatic, as well as mastoid processes of temporal bone, we have noticed that there is no statistically significant difference between left and right side, as we presented in Table IV. The mean value A-PZ was 53.41±3.95 mm on the left and 54.43±3.85 mm on the right side of the examined skulls, while mean right value A-PZ was 49.67±5.54 mm vs. 50,67±5,46 mm on the left skull side. The differences compared to the study performed on Indian skulls (left A-PZ 57,48±2,68 mm vs. right A-PZ 56,15±2,40 mm; left A-PM 47,45±2,62 mm vs. right A-PM 48,77±2,23 mm) (Patil & Kumar, 2019) could be explained by racial differences.

Descriptive analysis. In the examined sample of 43 skulls approximately equal representation of both types of asteria was observed in male and female skulls; for asterion type 1 34.62 % vs. 35.29 %, and for asterion type 2 65.38 % vs. 64.71 %. Havaldar *et al*. (2015), whose research sample consisted of 250 skulls (148 male and 102 female skulls), found the presence of asterion type 1 in 18.25 % of male skulls and 20.59 % of female skulls. On the other hand, asterion type 2, which, as in our study, was more prevalent than asterion type 1, was found in 81.75 % of male skulls vs. 79.41 % of female skulls.

The asterion type 2 is more common than asterion type 1 in all the studies in the available literature, but the percentage of the two types of asteria representation is significantly different. Although the results of this study are the most similar to the data obtained on the population of Brazil and Mexico, the differences in the results of the studies could be explained by heredity, but also by the significant influence of environmental factors (Lucena *et al*., 2019). The mechanism of formation of sutural bones is still incompletely elucidated. Their presence in the sutures of the skull can be caused by a genetic predisposition (Jos Hemalatha & Arumugam, 2016), while Hess (1946) and Finkel (1971) believe that suture bones occur in pathological conditions, most often in hydrocephalus.

Advances in cranial base surgery have made it necessary to access the petroclival area as a site of traumatic, vascular, inflammatory and neoplastic lesions (Ucerler & Govsa, 2006). Ucerler & Govsa (2006) observed that the asterion was located over the transverse-sigmoid venous sinus complex in 4 % of cases on the left cranial side. They reported that the asterion is superficial to the venous sinus complex in 86 % on the right and 88 % in the left side, as well as they noticed that it is under the venous blood vessels in 14 % on the right and 8 % on the left cranial side. The sample size of this study is significantly different from the latter, which probably accounts for the difference in the percentages of the results shown, although the general agreement in the results is evident. Martínez *et al*. (2005), described that the asterion is located behind and above the mastoid process, and that in 87.8 % of cases, the lower margin of the transverse venous sinus is located deeper than the asterion. In contrast to them, Uz *et al*. (2001) found the matching of asterion and transverse venous sinus in a significantly lower percentage (54 %). Çirpan *et al*. (2019) pointed out that performing a surgical approach to the posterior cranial fossa 10 mm above and/or below the asterion carries a high risk for damage to the transverse-sigmoid venous sinus complex, and although there is a pronounced discrepancy in the obtained results, it was concluded that the safest surgical approach is to perform about 15-25 mm posteroinferior to the asterion. It was shown that the junction of the transverse and sigmoid venous sinuses is located in the region of the asterion in 82.4 % of cases, above the asterion in 12.5 %, while below it in 5.1 % of cases (Ahad & Thenmozhi, 2015).

CONCLUSION

It is undeniable fact that the success in surgical strategy mainly relies on the surgeon's knowledge of the superficial anatomy. This research aimed at providing information about the asterion as an anatomical landmark. The analysis of the appearance of the asterion, and above all the obtained values of the measured diameters can serve as an important database for improving the safe performance of surgical procedures in the area of the posterior cranial fossa, and also for identifying the sex of human skulls, which gives importance in forensic medicine and anthropology. Also, when describing radiographic images, radiologists and neurosurgeons should be aware of the presence of sutural bones in the corresponding cranial sutures, and not to confuse them with some pathological content.

A significant limitation of this study is the small sample (it is the entire sample of skulls from the Institute of Anatomy, Faculty of Medicine in Novi Sad), and the plan for further research would refer to the collection of skulls from the Institutes of Anatomy of the Medical Faculties in Serbia, in order to highlight the importance of knowing the area of asterion, as well as surface anatomy in general, in order to make the surgical, as well as diagnostic procedures, as successful as possible.

KRSTONOSIC, B.; STIPIC, N.; TURANJANIN, D. & BABOVIC, S. S. Análisis de la morfología del asterion en relación con su importancia clínica. *Int. J. Morphol., 41(6)*:1744-1750, 2023.

RESUMEN: El asterion presenta una importante marca antropológica y punto de encuentro entre tres suturas. Es un punto de referencia de superficie para el complejo del seno venoso sigmoideo transverso y también es un punto de referencia quirúrgico para el acceso a la fosa craneal posterior, lo que le confiere importancia clínica. El objetivo de esta investigación fue analizar la forma del asterión y establecer los métodos de medición que determinarán la distancia entre el asterión y las características circundantes. La muestra del estudio, que forma parte de la colección osteológica del Departamento de Anatomía de la Facultad de Medicina de Novi Sad, estuvo compuesta por 43 cráneos. El análisis morfométrico se relacionó con la medición de los parámetros definidos y el análisis descriptivo presentó la clasificación del asterion en relación a la presencia de huesos suturales, así como la determinación de la posición del asterion según el complejo venoso transverso-sigmoideo. Hubo una diferencia estadísticamente significativa entre los cráneos masculinos y femeninos para todos los parámetros medidos. Los resultados muestran que el 34,88 % eran tipo 1 (hay uno o más huesos suturales presentes) y el 65,12 % eran asteria tipo 2 (no hay huesos suturales presentes). Se observó una aparición más frecuente de asteria tipo 2 en cráneos tanto masculinos como femeninos. La posición más frecuente de la asteria en ambos lados del cráneo fue en el complejo venoso sigmoideo transverso (76,92 % en el lado derecho *vs*. 72,22 % en el lado craneal izquierdo). La importancia clínica de conocer el área de asterion se refleja en que los procedimientos quirúrgicos y de diagnóstico tengan el mejor resultado posible.

PALABRAS CLAVE: Asterión; Morfometría; Huesos suturales; Fosa craneal posterior.

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