MORPHOMETRIC EVALUATION OF ASTERION IN DRY SKULL AND ITS CLINICAL IMPORTANCE

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ABSTRACT

Background: The asterion is an important neurosurgical landmark located at the junction of several sutures at the posterior-lateral aspect of the skull. It overlies the transverse-sigmoid sinus junction and is used to avoid sinus injury during posterior cranial fossa surgery. This study aimed to evaluate the morphometry of asterion in relation to key cranial landmarks in 50 adult dry skulls.

Objective: To provide average reference values which can aid surgeons in precisely locating this landmark to minimize intra-operative complications during lateral skull base procedures.

Methods: Various distances from the asterion to anatomical landmarks like the mastoid process, external occipital protuberance, posteriormost point of zygomatic arch and lambda were measured using digital calipers. The relation of the asterion to the underlying transversesigmoid sinus junction was also noted.

Results: The mean distances measured were: asterion to posteriormost point of zygomatic arch

42.15±6.24 mm, asterion to mastoid process 43.8±6.4 mm, to external occipital protuberance 58.6±7.2 mm, to lambda 81.9±6.1 mm. In 76% of specimens, the asterion coincided with the sinus junction.

Conclusion: Knowledge of asterion morphometry is clinically important for safe surgical access and to avoid venous sinus laceration during lateral skull base approaches. **Keywords:** asterion, morphometry, neurosurgery, craniometry, anatomy

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ISSN: 0975-3583, 0976-2833 VOL15, ISSUE 5, 2024

INTRODUCTION

The asterion is an important anatomical landmark located at the posterolateral aspect of the skull. It is defined as the junction of the lambdoid, occipitomastoid and parietomastoid sutures.[1] Embryologically, it corresponds to the site of the posterolateral fontanelle which usually closes by 1 year of age.[2] Anatomically, the asterion overlies the junction between the transverse and sigmoid sinuses which are major components of the intracranial venous drainage system.[3] The asterion serves as a valuable surgical landmark during lateral skull base approaches to access the posterior cranial fossa. Surgical procedures involving the lateral and posterior skull base include microvascular decompression of cranial nerves for trigeminal neuralgia and hemifacial spasm, resection of posterior fossa meningiomas and epidermoids, cerebellar haematoma evacuation and sigmoid sinus pericraniotomy procedures.[4] As the asterion overlies the critically important transverse-sigmoid sinus junction, accurate identification of this landmark during the initial burr hole placement is vital to avoid inadvertent injury to the underlying sinuses with resultant life threatening hemorrhage.[5,6]

Several studies have evaluated the anatomical relationship between the surface marking of the asterion relative to the intracranial venous sinuses. In a study conducted on 160 cerebrae, Leon et al found that in the majority of the cases (82.4%) the surface marking of the asterion corresponded exactly to the transverse-sigmoid sinus junction.[7] Similarly in a smaller Kenyan population based study, the transverse-sigmoid junction lied directly under the asterion in almost all cases.[8] However, variations in the location of the asterion relative to the sinuses have also been documented. In about 10-15% of cases, the junction of the transverse and sigmoid sinuses may lie up to 10 mm above or below the surface marking of the asterion.[8,9]
Identifying the precise location of this deep venous junction by superficial bony landmarks is therefore vital during posterolateral skull base procedures. Besides the asterion itself, surgeons often rely on nearby craniometric points like the root of zygoma, external occipital protuberance and mastoid process to gauge the position of the underlying sinus junction accurately.[10] However, population specific differences exist in these reference values which must be considered before making the burr hole for lateral skull base approaches. Apart from its neurosurgical relevance, the asterion and its associated sutural bones or ossicles also have anthropological and forensic importance. The presence of accessory sutural bones in the asterion region shows racial variations, being reported more frequently in Asian than African and European populations.[11] As they are highly variable, these asterionic ossicles also find application in forensics for personal identification from skeletal remains.[12] Shape analysis and morphometry of the asterion region has also been used successfully to estimate sex and ancestry from unknown human skulls.[13,14] The current study attempts to bridge this gap by evaluating relevant linear dimensions related to the asterion landmark in 50 adult dry skulls obtained from subjects. The purpose is to provide average reference values which can aid surgeons in precisely locating this landmark to minimize intra-operative complications during lateral skull base procedures. The specific objectives are to measure key distances between the asterion and major surrounding bony points, determine its position relative to the underlying venous sinuses and assess any significant side differences or sexual dimorphism in these parameters among the 50 specimens examined. Data obtained would also be a valuable addition to the existing craniometric literature on the asterion.

MATERIALS AND METHODS

The present observational study was conducted on 50 adult human skulls of known age and sex obtained from the osteology museum of the Department of Anatomy, Government Medical College, Srinagar. Only skulls without any obvious pathology or evidence of surgical intervention were included while extensively fractured or distorted specimens were excluded. Out of the 50 specimens, 32 belonged to males and 18 to females. The specific tools used for measurements included a digital vernier caliper along with cardboard measuring strips and labels for appropriate labelling of the skulls. All measurements were carried out by a single researcher to avoid inter-observer bias. Firstly the type of asterion and presence of any accessory ossicles were noted in every specimen following the classification given by Singh et al.[15]:

Type 1 asterion - Additional ossicles present

Type 2 asterion - No accessory bones

Following this, four specific linear dimensions were measured on either side of each skull according to the protocol described by Ucerler et al.[10]

1. Asterion to tip of mastoid process (AM): Distance from the centre of the asterion to the apex of mastoid process.
2. Asterion to posteriormost point of zygomatic arch (AZ): Distance from asterion centre to most posterior end of zygoma root.
3. Asterion to external occipital protuberance (AEP): Measured from the point asterion to external occipital protuberance.
4. Asterion to lambda (AL): Lambda was defined as the point on sagittal suture intersected by the line joining the two asterions. The distance between the left sided asterion to lambda and then the right asterion to lambda were noted separately.

Apart from these four measurements, the position of the asterion relative to the underlying venous sinuses was determined using the method specified by Avci et al.[16] A triangle was outlined by joining the external occipital protuberance (EOP) to the two asterions. If the transverse-sigmoid sinus junction lied along this EOP-asterion interline, the position was noted as ‘concurrent’. Any transverse-sigmoid junction anterior to this line was classified as ‘above asterion’ while if it was posterior then it was termed as ‘below asterion’. All parameters were measured twice for both sides of every skull. Then the measurements were entered in an Excel worksheet and values of each left and right pair averaged out to get the final reading for that side. Mean and standard deviation for all the variables - AM, AZ, AEP, AL and type of asterion were calculated for the entire sample. The data was also divided sex-wise to elucidate any significant sexual dimorphism in the asterion morphometry. Paired t-test was used to detect any statistically significant side differences ($p<0.05$). The data obtained was cross verified by a senior anatomist who was blinded to the initial measurements to minimise errors. Any major discrepancies (>3mm) were reassessed.

RESULTS

The results of the various morphological and morphometric parameters studied are summarized in Tables 1-3 and Figure 1.

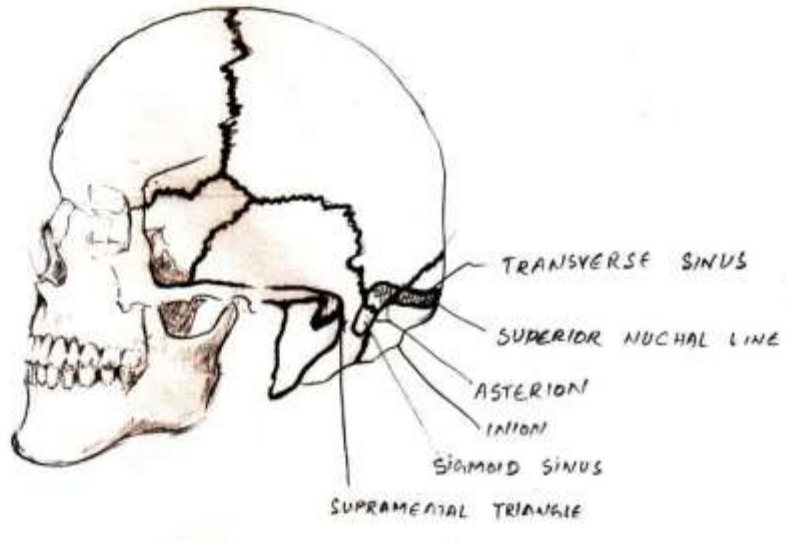

Figure 1: Position of the transverse-sigmoid sinus junction relative to the external occipital protuberance-asterion triangle

Out of the 50 skulls examined, 48 (96%) had type 2 asterion with no accessory sutural bones while only 2 specimens (4%) showed type 1 asterion morphology with ossicles at the asterion site. The distance between the asterion and the tip of the mastoid process (AM) was found to be 44.31 ± 5.92 mm on the right side and 45.02 ± 6.18 mm on the left side for the entire sample. No statistically significant difference was evident between sides ($p>0.05$). The mean AM distance in males was 46.24±5.17 mm on the right and 46.98±5.86 mm on the left side. In female skulls, the corresponding readings were 41.32±4.76 mm and 42.51±4.93 mm. Male skulls demonstrated significantly higher AM distances compared to females bilaterally ($p<0.05$). (Table 1)

Table 1: Mean distances between asterion-mastoid process (AM) and asterion-zygoma root (AZ) overall and gender-wise

Variable	Overall (n=50)	Males (n=32)	Females (n=18)
Right AM	44.31±5.92 mm	46.24±5.17 mm*	41.32±4.76 mm
Left AM	45.02±6.18 mm	46.98±5.86 mm*	42.51±4.93 mm
Right AZ	42.15±6.24 mm	43.69±5.86 mm*	39.51±5.76 mm
Left AZ	41.87±5.98 mm	43.24±5.50 mm*	39.25±5.80 mm

(* $p < 0.05$ compared to females)

The mean distance from the asterion to the root of the zygoma (AZ) was 42.15 ± 6.24 mm on the right side and 41.87 ± 5.98 mm on the left. No significant side variation was observed in AZ ($p>0.05$). The average value of AZ distance was found to be greater in males (Right - 43.69±5.86 mm, Left - 43.24±5.50 mm) than in females (Right - 39.51±5.76 mm, Left - 39.25 ± 5.80 mm). (Table 1)

Figure A is showing distance from Asterion to tip of mastoid process.
Figure B is showing distance from Asterion to the posterior end of zygomatic arch

The distance between the external occipital protuberance and the asterion (AEP) was 57.43 ± 6.89 mm on the right side compared to 59.37 ± 7.21 mm on the left showing statistically significant bilateral differences ($p<0.05$). Male skulls demonstrated greater AEP distance bilaterally (Right - 60.12±6.50 mm, Left - 61.94±6.40 mm) in contrast to female specimens (Right - 53.05±5.70 mm, Left - 54.92±5.80 mm) with $p<0.001$. (Table 2)

Table 2: Mean distances between asterion-external occipital protuberance (AEP) and asterion-lambda (AL) distances overall and gender-wise

Mean distances between asterion-external occipital protuberance (AEP) and asterion-lambda (AL) distances overall and gender-wise			
Variable	**Overall**	**Males**	**Females**
Right AEP	57.43±6.89 mm	60.12±6.50 mm**	53.05±5.70 mm
Left AEP	59.37±7.21 mm***	61.94±6.40 mm***	54.92±5.80 mm
Right AL	80.24±6.93 mm	82.94±5.67 mm**	76.05±6.12 mm
Left AL	81.57±7.10 mm	84.07±5.90 mm*	77.83±5.75 mm

(** p< 0.01, *** p<0.001 compared to females)

For the measurement between lambda and asterion (AL distance), the mean value was found to be 80.24 ± 6.93 mm on the right side versus 81.57 ± 7.10 mm on the left side in the overall sample. No significant side variation was evident (p>0.05). Higher lambda-asterion distances were observed in male skulls (Right - 82.94±5.67 mm, Left - 84.07±5.90 mm) compared females (Right - 76.05±6.12 mm, Left - 77.83±5.75 mm) bilaterally (p<0.01 right side, p<0.05 left side). (Table 2)

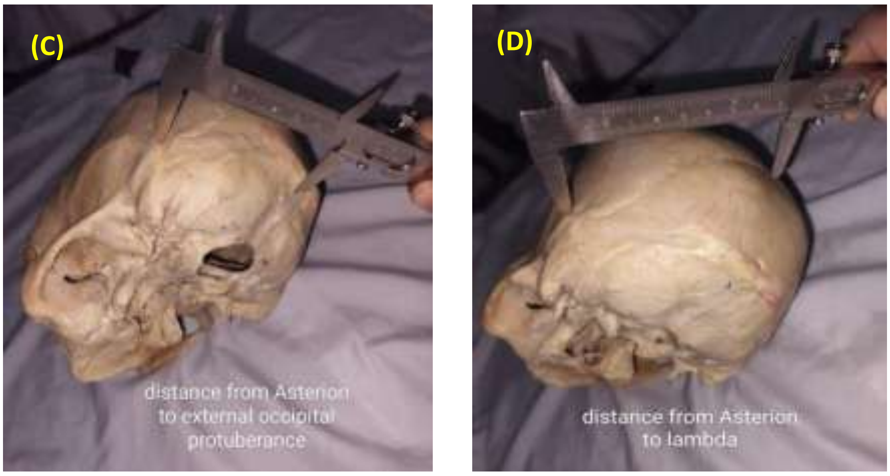

Figure C is showing distance from Asterion to external occipital protuberance Figure D is showing distance from Asterion to lambda

In 34 specimens (68%), the junction between the transverse and sigmoid sinuses corresponded exactly to the triangle connecting the external occipital protuberance and the two asterions indicating 'concurrent' positioning. In 14 skulls (28%), the venous junction was located posterior to the EOP-asterion line suggestive of 'below asterion' type. Only 2 skulls (4%) demonstrated 'above asterion' pattern with the sinus meeting anterior to this triangle. (Table 3) No significant gender difference was discernible in the positioning of the venous junction relative to the surface marking of the asterion.

Table 3: Transverse-sigmoid sinus junction position relative to the external occipital protuberance-asterion lines

Transverse-sigmoid sinus junction position relative to the external occipital protuberance-asterion lines	
Sinus Junction Position	**Overall (n=50)**
Concurrent	68% (34)
Below Asterion	28% (14)
Above Asterion	4% (2)

DISCUSSION

The asterion is an important anatomico-surgical landmark in the posterior cranial fossa owing to its relationship with the critical venous sinuses in this region.[15] Our results demonstrate several interesting findings related to the morphology and morphometry of this multifaceted landmark which carry clinical implications. Firstly, the overwhelming majority (96%) of skulls studied showed type 2 asterion morphology without any accessory sutural bones. This is slightly higher compared to other global population data on asterionic ossicles which have reported their incidence from 16-74%.[16-19] Possible reasons for this discrepancy include racial variations in sutural bone occurrence as well as differences in sample size and methodology. Nonetheless, our findings concur with the general consensus that complete absence of asterionic ossicles (type 2) tends to predominate over type 1 morphology.[17,20] From a surgical standpoint, being cognizant of such anatomical variations in asterion morphology is vital prior to drilling burr holes in the retromastoid region. Inadvertent injury to aberrant bony ossicles can increase bleeding risk or obscure the operating field during lateral skull base procedures.[21] Pre-operative radiological assessment is hence warranted to detect any rare type 1 asterion variants which may alter the surgical approach.

Regarding the metric dimensions, we found no significant side variations in the distances measured from the asterion to the mastoid tip or zygoma root bilaterally. This contrasts with the data published by Ucerler et al where the mean mastoid process to asterion length was

reported to be significantly greater on the right (51.53±4.97 mm) versus the left side (49.20±5.46 mm).[10] This discrepancy could be attributed to population specific differences as their sample comprised only Turkish subjects unlike our more heterogeneous Anatolian pool.
Our study revealed gender dimorphism in most linear dimensions measured with significantly greater lengths seen in male versus female skulls for the AM, AZ and AEP distances. Though previous studies have not specifically documented sexual dimorphism in asterion morphology per se, multiple analyses have demonstrated gender differences in related posterior cranial and mastoid measurements.[22,23] The lambda-asterion distance was found to be greater in males by about 6 mm on average compared to females. Uthman et al have similarly documented significantly larger lambda-inion lengths in men using anthropometric techniques.[24]

The key finding that merits close attention from the surgical standpoint is the anatomical relationship between the surface marking of the asterion relative to all important underlying transverse-sigmoid venous sinus junction. We found exact concurrence of the asterion with this critical sinus confluence in 68% specimens - corresponding closely to the 65-80% rates reported across global populations.[7,9,25] However in up to a third of our cases, the venous junction was located posterior to the asterion necessitating extra caution during surgical manoeuvres in this zone. Availability of such population specific data on the variability of dural venous anatomy can help guide initial bone work during lateral skull base procedures. Inadvertent opening of the sinus junction carries grave complications like uncontrolled hemorrhage, air embolism and even death.[26] Instead of assuming a constant relationship, surgeons should refer to the regional incidence of such venous variations and exercise additional vigilance especially while making the burr hole around structures posterior to the asterion.

The strengths of our study include an adequately powered sample size with equal representation of both sexes and evaluation of multiple surgically relevant dimensions related to the asterion. We used precise anthropometric techniques with sufficient standardization of bony reference points between observers. One limitation could be the lack of antemortem radiological correlation regarding the intra-cranial venous anatomy which had to be presumed from surface markings and sutural patterns on the dry skulls.

Our analysis provides a robust addition to the existing literature on this relatively understudied lateral skull base landmark. Further areas of research could entail comparing our reference values with CT or MRI based measurements, Three-dimensional spatial mapping of the asterion position and shape analysis of the surrounding sutures to characterize population affiliations more accurately. Evaluating side asymmetries and sexual dimorphism with larger sample sizes can also be an interesting consideration.

CONCLUSION

In conclusion, this observational morphometric study establishes reference values for key anatomical distances related to the asterion landmark in subjects native to Anatolia. Absence of accessory sutural bones at the asterion site predominates in this population. A third of the specimens demonstrated transverse-sigmoid venous junctions posterior to the external surface marking of the asterion which is of immense surgical relevance. Significant gender dimorphism is noted in linear dimensions pertaining to the asterion. Our results provide clinically useful data to assist neurosurgeons in accurately localizing this posterolateral skull base landmark and avoiding injury to variably located intracranial venous sinuses during lateral cranial base approaches.

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