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Original Article

Morphological Study of Variation of The Pterion in Dry Adult Human Skulls

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ABSTRACT

Background: The pterion is an important cranial landmark with significant neurosurgical relevance due to its proximity to vital neurovascular structures.
Material and Methods: A morphological and morphometric study was conducted on dry adult human skulls to document variations in pterion type, presence of epipteric bones, and distances from adjacent cranial landmarks.
Results: The sphenoparietal type was the most prevalent configuration, with minimal bilateral variation. Epipteric bones were infrequently observed. Morphometric measurements demonstrated high symmetry and consistency.
Conclusion: Detailed knowledge of pterion morphology and morphometry is essential for safe surgical approaches and accurate anatomical localization.

Keywords*: Pterion, Epipteric bone, Morphometry, Skull anatomy.*

INTRODUCTION

The pterion is a critical anatomical and craniometric landmark on the lateral aspect of the human skull where four bones - the frontal, parietal, temporal (squamous part) and greater wing of the sphenoid - converge in an irregular H-shaped sutural pattern. This region holds clinical significance for neurosurgeons, anatomists, anthropologists, and forensic experts because it approximates essential intracranial structures, including the anterior division of the middle meningeal artery and components of the lateral cerebral fissure, making precise knowledge of its morphology and positional relationships vital for surgical safety and efficacy. Morphological variations in the pterion, traditionally classified according to Murphy into sphenoparietal, frontotemporal, stellate, and epipteric types, reflect differences in sutural articulation and have been shown to vary across populations, sexes, and sides of the skull [1,2].

The study of these variations is not merely academic; it has direct implications for neurosurgical approaches, especially pterional and keyhole craniotomies, where accurate localization minimizes operative time and reduces complications such as inadvertent injury to vascular and neural structures. Additionally, the presence of epipteric (wormian) bones - accessory sutural ossicles - can alter the expected anatomy and potentially mislead surgeons during landmark-based localization [3,4]. Variation in pterion morphology has also been explored in the context of craniofacial growth, evolutionary anthropology, and forensic identification, further underscoring its multidisciplinary relevance [5].

Recent morphometric investigations have quantified the distances from the centre of the pterion to reliable bony landmarks such as the frontozygomatic suture, zygomatic arch, and adjacent cranial base structures. These measurements aid in developing population-specific surgical maps that improve the precision of surgical entry points and enhance outcomes [6]. A recent meta-analysis confirms that the sphenoparietal type remains the most prevalent across diverse ethnic groups, followed by epipteric, frontotemporal, and stellate types, and also highlights statistically significant differences in morphometric distances around the pterion between geographic populations, which may stem from genetic and environmental influences on cranial development [7].

Morphological studies from various regions, including South Asia and Africa, demonstrate that accurate characterization of pterion types and morphometry improves the understanding of regional anatomical variability, which is crucial in settings where individualized imaging may not always be available prior to emergency surgical intervention [8]. Furthermore, the incorporation of precise morphometric data into preoperative planning can reduce the risk of complications associated with surgical access to the anterior and middle cranial fossae and aid in the avoidance of inadvertent penetration of the middle meningeal artery or temporalis muscle [9]. The literature also emphasizes the importance of documenting the incidence and morphometric relationships of epipteric bones, which, though less common, may significantly affect the structural integrity of the pterion and its use as a reliable landmark [10].

The aim of the present study was to establish the incidence of various pterion types and epipteric bones and to measure the distances from the centre of the pterion to the frontozygomatic suture, zygomatic arch, lesser wing of the sphenoid, and optic canal in dry adult human skulls.

MATERIAL AND METHODS

The present study was conducted with the aim of establishing the incidence of various types of pterions, determining the incidence of epipteric bones, and measuring the distances from the centre of the pterion to selected cranial landmarks, namely the frontozygomatic suture, zygomatic arch, lesser wing of the sphenoid, and optic canal. The study was carried out on dry adult human skulls to document morphological and morphometric variations of the pterion.

The study material comprised a total of **50 dry, grossly normal adult human skulls** obtained from the anatomy departments of **Government Medical College, Surat**, and **SMIMER Medical College, Surat**. Skulls showing any gross deformity, damage, or pathological changes affecting the pterion region were excluded from the study. Information regarding the age and sex of the skulls could not be considered due to the absence of reliable documentation. Each skull was examined on both the right and left sides, yielding a total of 100 pterions for observation.

All measurements were performed using a properly aligned **Vernier caliper**, selected to ensure accuracy and precision. Observations included the classification of pterion types, presence or absence of epipteric bones, and morphometric measurements of distances from the centre of the pterion to predefined anatomical landmarks. Pterion types were identified and classified as sphenoparietal, frontotemporal, or stellate based on the pattern of sutural articulation. In the sphenoparietal type, the centre of the pterion was defined as the midpoint of the horizontal limb of the H-shaped articulation formed by the greater wing of the sphenoid and the parietal bone. In the frontotemporal type, the centre was taken as the midpoint of the horizontal limb of the H-shaped articulation formed by the frontal and temporal bones. In the stellate type, the meeting point of all four bones was considered as the centre of the pterion.

The presence of epipteric bones was noted as either present or absent on each side. Morphometric measurements were recorded in millimetres. The distance from the centre of the pterion to the frontozygomatic suture was measured by placing the fixed arm of the Vernier caliper on the frontozygomatic suture and the movable arm on the midpoint of the pterion. The distance from the centre of the pterion to the zygomatic arch was measured from a standardized point on the upper border of the zygomatic arch, defined as the midpoint between the jugal point at the anterior end of the upper border of the zygomatic arch and a point at the level of the tip of the articular tubercle of the root of the zygoma. The distance from the centre of the pterion to the lesser wing of the sphenoid was measured by placing the fixed arm of the caliper on the lateral end of the lesser wing of the sphenoid, while the movable arm was positioned on the midpoint of the pterion. Similarly, the distance from the centre of the pterion to the optic canal was measured by placing the fixed arm on the margin of the optic canal and the movable arm on the centre of the pterion. All distances were measured to the nearest 0.1 mm.

All observations and measurements were recorded systematically and tabulated for analysis. The incidence of various types of pterion on the right and left sides was calculated, along with their combined incidence on both sides. The incidence of epipteric bones associated with different pterion types on both sides was also calculated. Mean values and standard deviations were computed for the distances from the centre of the pterion to the frontozygomatic suture, zygomatic arch, lesser wing of the sphenoid, and optic canal separately for the right and left sides.

Statistical analysis was performed using **Epi Info software version 6.04d**. Results were interpreted based on p-values, with a value greater than 0.05 considered statistically not significant, a value less than or equal to 0.05 considered statistically significant, and a value less than or equal to 0.01 considered highly significant.

RESULTS

The distribution of the various types of pterion observed in the present study is detailed in **Table 1**. The sphenoparietal type was overwhelmingly the most prevalent variant, accounting for the vast majority of pterions on both the right and left sides, thereby confirming it as the dominant morphological pattern in the studied population. The frontotemporal and stellate types were encountered infrequently, indicating that these variants are relatively uncommon. Epipteric pterion was observed in a small number of skulls and was noted only on the right side, highlighting the low incidence of epipteric bones in this sample. The overall distribution demonstrates minimal side-to-side variation, suggesting a largely symmetrical occurrence of pterion types.

The morphometric relationship between the centre of the pterion and the frontozygomatic suture is presented in **Table 2**. The mean distance from the centre of the pterion to the frontozygomatic suture was found to be nearly identical on the right and left sides, with a very small standard deviation, indicating consistent anteroposterior positioning of the pterion relative to this easily identifiable surface landmark. This close symmetry underscores the reliability of the frontozygomatic suture as a reference point for locating the pterion during surgical approaches.

The distance of the centre of the pterion from the zygomatic arch is shown in **Table 3**. The measurements revealed closely comparable mean values on both sides of the skull, with minimal variability. This finding reflects a stable vertical relationship between the pterion and the zygomatic arch, which is of particular importance in pterional craniotomies, where the zygomatic arch serves as a readily palpable landmark for surface localization of deeper cranial structures.

The spatial relationship between the centre of the pterion and the lateral end of the lesser wing of the sphenoid on the sphenoid ridge is illustrated in **Table 4**. The mean distances on the right and left sides were almost identical, and the small standard deviations indicate a high degree of consistency. This uniformity emphasizes the predictable anatomical relationship between the pterion and the sphenoid ridge, which is clinically significant during surgical procedures involving the anterior and middle cranial fossae.

The distance from the centre of the pterion to the optic canal is presented in **Table 5**. The mean values were identical on both sides, with very minimal variation, demonstrating remarkable bilateral symmetry. This consistent relationship highlights the importance of the pterion as a dependable external landmark for estimating the location of critical intracranial structures such as the optic canal, thereby reinforcing its relevance in neurosurgical planning and anatomical orientation.

Table 1: Percentage incidence of various types of pterion

Type of pterion	Right (50 sides)	Percentage (%)	Left (50 sides)	Percentage (%)	Total (100 sides)
Sphenoparietal	48	96	46	92	94
Frontotemporal	1	2	0	0	1
Stellate	1	2	2	4	3
Epipteric	2	4	0	0	2

Table 2: Distance of centre of pterion from the frontozygomatic suture

Side	Number of pterions observed	Mean distance (cm)	Standard deviation
Right	50	3.85	0.068
Left	50	3.83	0.074

Table 3: Distance of centre of pterion from the zygomatic arch

Side	Number of pterions observed	Mean distance (cm)	Standard deviation
Right	50	3.91	0.056
Left	50	3.88	0.078

Table 4: Distance of centre of pterion from the lateral end of the lesser wing of sphenoid on sphenoid ridge

Side	Number of pterions observed	Mean distance (cm)	Standard deviation
Right	50	1.73	0.029
Left	50	1.74	0.030

Table 5: Distance of centre of pterion from the optic canal

Side	Number of pterions observed	Mean distance (cm)	Standard deviation
Right	50	4.44	0.035
Left	50	4.44	0.031

DISCUSSION

The present study provides detailed morphological and morphometric data on the pterion, reinforcing its importance as a critical surgical and anatomical landmark. Recent literature emphasizes that the predominance of the sphenoparietal type is a consistent finding across multiple populations, supporting the concept that this configuration represents the most stable and evolutionarily conserved pattern of pterion formation [11]. The high incidence of this type observed in the current study aligns with recent morphometric analyses that highlight minimal interpopulation variability for the sphenoparietal variant, particularly in South Asian and African populations [12].

The presence of epipteric bones, although infrequent, has been recognized as a clinically relevant variation due to its potential to obscure sutural anatomy and complicate landmark-based neurosurgical approaches. Contemporary studies have shown that epipteric bones may contribute to erroneous identification of the pterion during pterional craniotomy, thereby increasing the risk of vascular injury if not anticipated [13]. The low incidence of epipteric bones observed in the present study corroborates findings from recent morphometric surveys, which suggest that while epipteric bones are uncommon, their documentation remains essential due to their surgical implications [14].

Morphometric measurements from the centre of the pterion to surface landmarks such as the frontozygomatic suture and zygomatic arch demonstrated minimal bilateral variation, reflecting a high degree of anatomical symmetry. This observation is clinically significant, as recent neurosurgical literature underscores the reliability of these landmarks for estimating the location of the pterion in emergency situations where advanced imaging may not be readily available [11][15]. Furthermore, the consistent distances noted between the pterion and deeper cranial structures such as the lesser wing of the sphenoid and optic canal emphasize the utility of pterion-based measurements in guiding surgical access to the anterior and middle cranial fossae.

Recent anatomical syntheses highlight that precise morphometric knowledge of the pterion reduces operative time and minimizes complications related to inadvertent penetration of the middle meningeal artery and surrounding neurovascular structures [12][15]. Thus, the findings of the present study contribute valuable region-specific data that can enhance surgical precision and anatomical education, particularly in resource-limited settings.

CONCLUSION

The present study confirms that the sphenoparietal type is the most prevalent form of pterion, with a low incidence of epipteric bones. The morphometric relationships of the pterion to adjacent surface and deep cranial landmarks demonstrate high bilateral symmetry and consistency. These findings underscore the importance of detailed anatomical knowledge of pterion variations and measurements, which is essential for safe neurosurgical approaches, accurate anatomical orientation, and clinical applications involving the lateral skull.

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