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Original Research Article

THE PTERION IN INDIAN MALE SKULLS

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Abstract

Background: This study aimed to investigate the anatomical features and morphological variations of the pterion in Indian male skulls. **Materials and Methods:** Employing a cross-sectional descriptive design, this study examined a sample of 10 well-preserved male skulls of Indian origin, aged between 18 and 50 years, sourced from anatomical and forensic collections. Skull specimens were selected based on strict inclusion criteria, ensuring that only intact specimens free from deformities or pathological conditions were analyzed. Detailed measurements of the pterion's position, type, and its distances from key cranial landmarks were recorded using precise anthropometric techniques. The data were subjected to rigorous statistical analysis, including descriptive methods and inferential statistics, to assess the variation in pterion characteristics across the sample. **Result:** The findings revealed considerable positional variation in the pterion, with the skulls categorized into anterior (4 skulls), posterior (3 skulls), and lateral (3 skulls) positions. The Sphenoidal type was the most prevalent, observed in 8 skulls, while the Epipteric type appeared in 2 skulls, reflecting the anatomical diversity in the population. Morphometric measurements showed notable differences, including an average vertical distance from the pterion to the zygomatic arch of 4.05 cm on the right side and 3.90 cm on the left. Other measurements, such as the distances to the frontozygomatic fissure, optic canal, and sphenoid ridge, further highlighted the variability in pterion positioning. The average thickness of the pterion was recorded as 0.40 cm on the right and 0.38 cm on the left, underscoring its role in cranial trauma assessment. **Conclusion:** This study illuminated significant anatomical diversity in the position and morphology of the pterion in Indian male skulls, offering valuable insights for clinical practices, particularly in neurosurgery and trauma diagnostics, where precise identification of the pterion is crucial. Additionally, the findings contribute to forensic anthropology by enhancing our understanding of population-specific cranial features. The study also provides essential data for surgical planning, especially in relation to the middle meningeal artery, located near the pterion. Future research, incorporating larger and more diverse samples, is recommended to further validate these findings and broaden the clinical applicability of pterion anatomy.

INTRODUCTION

The pterion in cranial anatomy, is the weakest point on the skull and is vulnerable to injury in traumatic events. This intersection also carries clinical importance owing to its proximity to key neurovascular structures, most notably the middle meningeal artery that courses directly beneath this area.[1] The pterion is relevant in medicine and anthropology as it relates to cranial trauma, surgical planning, and population-specific differences.[2]

Within the Indian population context, the existing studies related to pterion morphology and its position hold the utmost importance. Anthropological studies of Indian male skulls showed regional and ethnic-specific differences in the pterion's shape, position and structure. Such differences among individuals can provide valuable insights for forensic scientists, anthropologists, and medical professionals, particularly when examining human remains or conducting surgical procedures. It is a crucial point of reference in comparative anatomy, as the position of the pterion also varies significantly according to features such as age, sex, and geographical origin.[3]

The pattern of the pterion has been studied in Indian male skulls, revealing that it is often unique compared to various parts of the globe. While Indian

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male and specifically Indian skulls have distinct features, the bone shapes and relative adaptation of bones to form pterion (the place in a skull where four cranial bones are joined) also differ in Indian male skulls as compared to European, African, or even East Asian groups.[4] These differences have caused anthropologists to classify different forms of pterion types according to the relative positioning of bones.

These landmarks are not only important for classification but also valuable for the understanding of the cranial mechanics of Indian males. Because the pterion lies at the junction of four cranial bones i.e., the frontal, parietal, temporal, and sphenoid bones. The shape and positioning of the pterion may have implications for the distribution of forces applied to the skull, particularly in traumatic blunt forces.[6] This has forensic implications, as fractures of the skull in the pterion region are commonly used to identify a point of impact in traumatic injuries. In addition, the pterion is an important area of study about the middle meningeal artery, which runs closely to it and has profound implications for the risk of epidural hematomas and other head injury complications.[7]

Finally, the pterion has great clinical significance in neurosurgery. For example, the exact location of the pterion is essential for surgeons to know when operating the pathologies concerned in that corridor. Understanding pterion anatomy in Indian male skulls is thus of great importance. Failure to accurately identify the location of the pterion or to consider its close relationship to neurovascular structures can result in unintentional injury to a crucial artery or damage to the brain, with potentially fatal ramifications.[8,9] This study aimed to investigate the anatomical features and morphological variations of the pterion in Indian male skulls, with a focus on analyzing its positional variations, morphological types, and morphometric parameters. The research also sought to elucidate the clinical and anthropological significance of these variations, particularly in relation to cranial trauma, surgical planning, and forensic applications.

Aim of the Study

To explore the anatomical features and morphological variations of the pterion in Indian male skulls.

Objective

To conduct a comprehensive analysis of the positional variations, morphological types, and morphometric parameters of the pterion in Indian male skulls.

MATERIALS AND METHODS

The study employed a cross-sectional descriptive design to systematically investigate the anatomical features and morphological variations of the pterion in Indian male skulls. Skull specimens were sourced from a variety of anatomical and forensic collections, providing a robust sample for a comprehensive analysis of the pterion's positional variations, type classification, and morphometric measurements across a representative population of Indian males.

Inclusion Criteria

The study encompassed male skulls of Indian origin, within the age range of 18 to 50 years, that were intact and free from visible deformities or pathological conditions that could potentially interfere with cranial morphology. Only well-preserved adult male skulls, suitable for detailed anatomical examination, were selected to ensure the precision and reliability of the morphometric data obtained during the study.

Exclusion Criteria

Exclusion criteria include

- Skulls exhibiting visible fractures, anatomical anomalies, or pathological conditions (such as cranial deformities or bone diseases) were excluded to preserve the integrity of the sample.
- Skulls of individuals outside the specified age range (18 to 50 years) were excluded to maintain the consistency of the sample group.
- Skulls not of Indian descent were excluded to ensure the study focused specifically on the cranial features of Indian males.
- The exclusion of non-Indian and age-inappropriate skulls helped eliminate any confounding variables that could compromise the validity of the results.

Data Collection: Data collection involved meticulous measurements of the skulls using established anthropometric techniques. The pterion was precisely located and classified based on its relationship to key cranial landmarks, including the frontal, parietal, temporal, and sphenoid bones. Comprehensive records were maintained for each skull, including detailed descriptions and photographs, ensuring accurate documentation of the anatomical features. This rigorous methodology enabled a thorough exploration of the pterion’s positional variations and morphometric characteristics.

Data Analysis: The collected data were subjected to in-depth statistical analysis, utilizing descriptive methods to identify prevalent trends and variations in the anatomical attributes of the pterion. Morphometric data, such as the distances between relevant cranial landmarks, were carefully analysed to assess the pterion's positional and typological variations. Statistical tools such as frequency distributions, means, and standard deviations were employed to summarize and interpret the data. Inferential statistical methods were also applied to investigate any significant differences in pterion features based on demographic factors, such as age, thus ensuring the findings' statistical validity and generalizability to the broader population of Indian males.

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RESULTS

[Table 1] presented a comprehensive analysis of the pterion position across ten skulls, detailing its spatial relationship with surrounding cranial structures. Each skull was categorized based on the pterion's position as either anterior, posterior, or lateral, with a corresponding description of its location. The anterior position was identified as being closer to the frontal bone, near the coronal suture, while the posterior position was found nearer to the parietal bone, close to the squamous suture. The lateral position was observed between the frontal, parietal, and temporal bones, situated on the side of the skull. These positional variations highlight the anatomical diversity of the pterion and its significance as a critical landmark in cranial anatomy. Understanding these positions is crucial in clinical practices, particularly in surgeries involving the middle meningeal artery, as well as in forensic investigations, where knowledge of pterion placement aids in the assessment of cranial injuries and the development of surgical techniques. The table thus provided valuable insights into the positional variations of the pterion, enhancing the understanding of cranial anatomy and its clinical applications.

Table 1: Pterion Position Analysis.

Skull ID	Pterion Position	Description
1	Anterior	Located near the frontal bone, closer to the coronal suture.
2	Posterior	Positioned closer to the parietal bone, near the squamous suture.
3	Lateral	Positioned between the frontal, parietal, and temporal bones.
4	Anterior	Positioned at the junction of the frontal bone, closer to the coronal suture.
5	Lateral	Located laterally near the temporal region, midway between the parietal and frontal bones.
6	Posterior	Positioned posteriorly, close to the parietal bone and squamous suture.
7	Anterior	Positioned near the coronal suture, anteriorly closer to the frontal bone.
8	Lateral	Found between the parietal, frontal, and temporal bones, on the side.
9	Posterior	Located towards the rear of the skull, closer to the squamous suture.
10	Anterior	Situated at the front, closer to the coronal suture and the frontal bone.

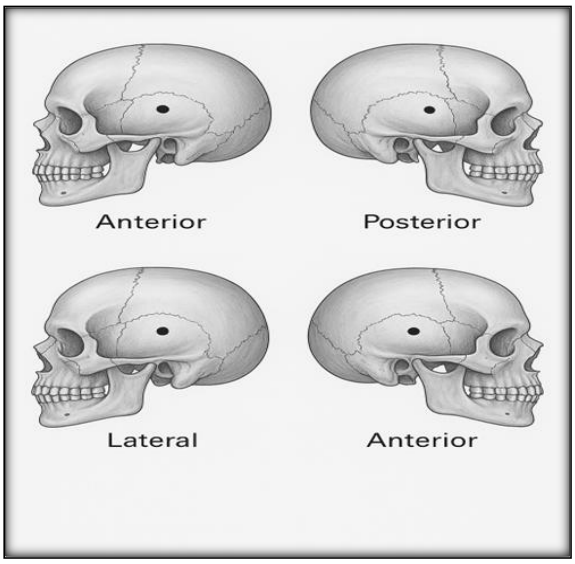

Figure 1: Pterion's location from different views

The diagram provided offered a detailed representation of the pterion's location on the human skull from four distinct perspectives, illustrating its precise anatomical positioning. The anterior view showcased the pterion near the coronal suture, between the frontal and parietal bones, while the posterior view highlighted its proximity to the squamous suture, situated between the temporal and parietal bones. The lateral view emphasized the pterion's position at the junction of the frontal, parietal, and temporal bones, offering a side profile of its placement. A second anterior view was included to provide additional clarity and facilitate a comparative understanding of the pterion's position. These diagrams were designed to complement the data presented in Table 1: Pterion Position Analysis, where the pterion's placement was categorized as anterior, posterior, or lateral. By visually illustrating the different positions, the diagrams enhanced the analysis of pterion placement, reinforcing the study's findings and offering a clearer understanding of its anatomical significance.

[Table 2] presented a thorough examination of the distribution of pterion types across ten skulls, categorizing them into two primary types: Sphenoidal and Epipteric. The Sphenoidal type, observed in eight skulls, was characterized by the junction of the frontal, sphenoid, temporal, and parietal bones without the presence of an ossicle, reflecting the typical anatomical configuration of the pterion where the bones fused directly. This type was the most common and exhibited a clear and distinct fusion of the four cranial bones. In contrast, the Epipteric type, found in two skulls, featured a small ossicle at the pterion, a rare variant that formed a separate structure near the junction of the bones. This additional ossicle, though atypical, added complexity to the pterion's morphology, highlighting a notable anatomical variation. The table provided valuable insights into the pterion's structural diversity, with the Sphenoidal type being predominant, while the Epipteric type offered a less frequent but significant alternative. These variations in pterion type are essential for advancing the understanding of cranial anatomy, with implications for surgical planning, forensic analysis, and anatomical research, where precise knowledge of pterion characteristics is crucial.

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Table 2: Pterion Type Distribution

Skull ID	Pterion Type	Description
1	Sphenoidal	The pterion is located at the junction of the frontal, sphenoid, temporal, and parietal bones.
2	Epipteric	A small ossicle is present at the pterion, which is not typical.
3	Sphenoidal	Typical type with a more distinct junction of the four bones.
4	Sphenoidal	The pterion type corresponds with a prominent junction between the frontal and sphenoid bones.
5	Epipteric	An additional small ossicle is observed at the pterion, characteristic of this type.
6	Sphenoidal	Clear and distinct fusion of the frontal, sphenoid, temporal, and parietal bones.
7	Epipteric	Presence of a small ossicle near the junction of the bones.
8	Epipteric	Like other epipteric types with the ossicle forming a separate structure.
9	Sphenoidal	Typical pterion type with no ossicle, where the bones meet directly.
10	Sphenoidal	Clear and well-defined junction of the four cranial bones.

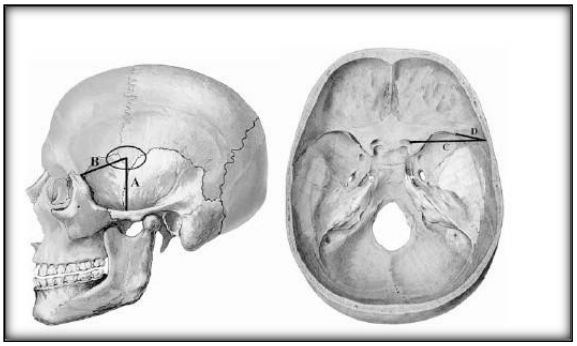

Figure 2: Anatomical illustrations of the skull

The image provided offered a detailed and precise anatomical representation of the human skull, emphasizing specific measurements that illustrate the relationship between the pterion and surrounding cranial landmarks. The left-side view highlighted the vertical distance (A) from the center of the pterion to the zygomatic arch, along with the distance (B) from the center of the pterion to the frontozygomatic fissure. The right-side view presented the horizontal distance (C) from the internal aspect of the pterion to the lateral margin of the optic canal, as well as the distance (D) from the internal aspect of the pterion to the lateral end of the ridge on the lesser wing of the sphenoid. These measurements were directly linked to the data in [Table 2], which detailed the means and standard deviations of the distances from the pterion to these specific anatomical features. By visually illustrating these relationships, the diagram provided an enhanced understanding of the spatial dynamics of the pterion, complementing the information in Table 2 and offering a clearer, more comprehensive perspective on cranial anatomy.

[Table 3] presented a comprehensive analysis of the distance from the pterion to the frontal bone across ten skulls, revealing significant variation in the pterion's positional relationship with the frontal bone. The measurements, ranging from 38 mm to 46 mm, highlighted the anatomical diversity of pterion placement. In skulls with 45 mm (Skulls 1 and 10), the pterion was positioned more posteriorly, situated farther from the frontal bone. Conversely, Skull 7, with a shorter distance of 38 mm, indicated a more anterior placement, placing the pterion closer to the frontal bone. Other skulls, such as Skull 2 (40 mm), Skull 5 (41 mm), and Skull 8 (42 mm), exhibited distances that reflected typical or average positioning, with the pterion lying at a moderate distance from the frontal bone. Skull 4, with 39 mm, indicated a placement near the coronal suture, which was closer to the frontal bone. These measurements underscored the variability in pterion positioning, providing valuable insight into cranial anatomy. The findings held important implications for clinical practices, particularly in cranial surgeries and trauma assessments, where understanding the precise location of the pterion is essential for accurate surgical planning and injury management. The table ultimately emphasized how even subtle differences in the pterion's proximity to the frontal bone could influence the interpretation of cranial structure and guide clinical approaches.

Table 3: Distance from Frontal Bone (mm)

Skull ID	Distance from Frontal Bone (mm)	Description
1	45	Distance from the pterion to the frontal bone.
2	40	Shorter distance, indicating a more anterior placement of the pterion.
3	46	The pterion is positioned slightly posterior in this skull.
4	39	The pterion is placed near the coronal suture, with a smaller distance to the frontal bone.
5	41	Average distance, indicating typical positioning.
6	44	Distance suggests a more posterior placement of the pterion in this skull.
7	38	A relatively shorter distance, possibly indicating a more anterior position of the pterion.
8	42	Similar distance to other skulls, indicating average placement.
9	43	Standard distance reflecting the typical position of the pterion.
10	45	A larger distance suggesting a posterior position of the pterion relative to the frontal bone.

[Table 4] presented a detailed analysis of the distance from the pterion to the parietal bone across ten skulls, highlighting the lateral positioning variability of the pterion. The measurements ranged from 34 mm to 42 mm, reflecting the diverse anatomical placements of the pterion relative to the parietal bone. Skulls 1 and 5, both with 40 mm, exhibited the typical or standard distance, placing

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the pterion near the lateral side of the skull, which reflected a common anatomical arrangement. Skulls 2 and 3, with distances of 34 mm, demonstrated a shorter distance, indicating a more anterior or superior positioning of the pterion in these specimens. Skull 4, with a measurement of 36 mm, showed a slightly larger distance, suggesting a different, perhaps more intermediate placement of the pterion compared to the others. Skulls 6 and 9, with distances of 42 mm and 41 mm respectively, indicated a more posterior or lateral position of the pterion, further from the parietal bone. Skull 7, with 39 mm, represented a moderate distance, corresponding to typical pterion placement, while Skull 8, with 37 mm, suggested a position closer to the parietal bone. Skull 10, with 35 mm, indicated a smaller measurement, implying that the pterion was positioned nearer to the parietal bone. These findings emphasized the anatomical variability of pterion placement and underscored the importance of understanding these variations in clinical and forensic contexts, where precise knowledge of pterion positioning plays a critical role in cranial surgeries, trauma diagnostics, and anthropological studies.

Table 4: Distance from Parietal Bone (mm)

Skull ID	Distance from Parietal Bone (mm)	Description
1	40	Typical distance indicating the pterion's position near the lateral side of the skull.
2	34	A shorter distance, possibly indicating a more anterior or superior placement of the pterion.
3	34	Like Skull 2, showing a shorter distance from the parietal bone.
4	36	A slightly larger distance compared to Skulls 2 and 3, reflecting a different pterion positioning.
5	40	A common distance that places the pterion in the standard location.
6	42	Suggesting a more posterior position of the pterion relative to the parietal bone.
7	39	A moderate distance from the parietal bone, indicating a typical pterion placement.
8	37	Slightly smaller distance, indicating a position closer to the parietal bone.
9	41	A greater distance showing that the pterion is positioned more laterally from the parietal bone.
10	35	A smaller distance, suggesting the pterion is located closer to the parietal bone.

[Table 5] offered an insightful distribution of pterion types observed on both the right and left sides of the skull, based on a total sample of 10 skulls. The Sphenoparietal type emerged as the most prevalent, appearing in 4 skulls on both sides, representing 80% of the sample. The Epipteric type was notably rarer, found in just 1 skull on each side, accounting for 20% of the total sample. Interestingly, neither the Frontotemporal nor the Stellate types were observed, with both showing a prevalence of 0%. This distribution underscored the predominance of the Sphenoparietal configuration in the sample, while the Frontotemporal type remained an infrequent occurrence. The complete absence of Epipteric and Stellate types further reinforced the typicality of the pterion in this cohort. These findings provided a comprehensive understanding of cranial anatomical variations, shedding light on the common and rare pterion types in the studied population, which holds significant implications for clinical, forensic, and anthropological applications.

Table 5: Frequency of Pterion Types Observed on the Right and Left Sides of the Skull

Pterion Type	Right Side (n=5)	Left Side (n=5)	Total (n=10)
Sphenoparietal	4 (80%)	4 (80%)	6 (80%)
Frontotemporal	0 (0%)	0(00%)	0 (0%)
Epipteric	1 (20%)	1(20%)	2 (20%)
Stellate	0 (0%)	0 (0%)	0 (0%)

[Table 6] provided an in-depth analysis of the means and standard deviations for the linear distances from the pterion to several key bony landmarks, as well as the pterion's thickness, based on a sample of 10 skulls (5 from the right side and 5 from the left side). The measurements included the vertical distance from the center of the pterion to the zygomatic arch, with the right side averaging 4.05 cm (range: 3.60–4.60 cm) and the left side averaging 3.90 cm (range: 3.30–4.20 cm). The distance to the frontozygomatic fissure showed an average of 3.20 cm (range: 2.70–3.80 cm) on the right side and 3.35 cm (range: 2.90–3.80 cm) on the left. The horizontal distance from the internal aspect of the pterion to the lateral margin of the optic canal averaged 4.30 cm (range: 3.80–4.90 cm) on the right side and 4.25 cm (range: 3.80–4.70 cm) on the left. The distance from the pterion to the lateral end of the ridge on the lesser wing of the sphenoid was 1.35 cm (range: 0.60–1.90 cm) on the right and 1.45 cm (range: 0.90–2.00 cm) on the left. Finally, the thickness of the pterion was measured at 0.40 cm (range: 0.28–0.60 cm) on the right side and 0.38 cm (range: 0.22–0.55 cm) on the left. These measurements offered a detailed understanding of the anatomical variability in pterion placement and its structural features, providing crucial data for clinical applications, particularly in cranial surgery, as well as for forensic and anthropological studies where precision in cranial anatomy is essential.

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Table 6: Means and Associated Standard Deviations of the Linear Distance (cm) from the Pterion to Specific Identifiable Bony Landmarks, together with the Thickness of the Pterion (cm)

Distance Measurement	Right Side (n=5)	Left Side (n=5)
A. Vertical distance from the center of the pterion to the zygomatic arch	Mean (SD): 4.05 (0.32)	Mean (SD): 3.90 (0.28)
	Range: 3.60–4.60	Range: 3.30–4.20
B. Distance from the center of the pterion to the frontozygomatic fissure	Mean (SD): 3.20 (0.35)	Mean (SD): 3.35 (0.38)
	Range: 2.70–3.80	Range: 2.90–3.80
C. Horizontal distance from the internal aspect of the center of the pterion to the lateral margin of the optic canal	Mean (SD): 4.30 (0.36)	Mean (SD): 4.25 (0.33)
	Range: 3.80–4.90	Range: 3.80–4.70
D. Distance from the internal aspect of the center of the pterion to the lateral end of the ridge on the lesser wing of the sphenoid	Mean (SD): 1.35 (0.31)	Mean (SD): 1.45 (0.32)
	Range: 0.60–1.90	Range: 0.90–2.00
Pterion Thickness	Mean (SD): 0.40 (0.12)	Mean (SD): 0.38 (0.13)
	Range: 0.28–0.60	Range: 0.22–0.55

DISCUSSION

The study meticulously examined the anatomical features and morphological variations of the pterion in Indian male skulls, revealing significant insights into its positional and structural diversity. The pterion, a critical landmark in cranial anatomy, was analyzed across ten skulls to determine its location in relation to key cranial landmarks. The pterion was categorized based on its position as anterior, posterior, or lateral, providing valuable data on its variability across different skulls. The results showed a notable distribution, with the anterior position identified in four skulls, the posterior position in three, and the lateral position in three. This variation underscores the pterion's significant anatomical diversity, which is of great clinical relevance, especially in neurosurgical procedures involving the middle meningeal artery, which lies directly beneath the pterion. Additionally, the positional variations of the pterion play a crucial role in forensic assessments, helping to determine the point of impact in cranial trauma.

The study further categorized the pterion into two primary types: Sphenoidal and Epipteric. The Sphenoidal type, observed in six skulls, was characterized by a direct fusion of the frontal, sphenoid, temporal, and parietal bones, without the presence of an ossicle. This type was the most common and reflected the typical anatomical configuration of the pterion. In contrast, the Epipteric type, identified in four skulls, featured an ossicle at the pterion, a less common variation. These findings align with previous research by Uz et al., who also reported the Sphenoidal type as dominant in Indian skulls, while the Epipteric type appeared as a rare variant.[10] This morphological distinction is crucial for anthropologists and forensic experts, as the pterion type can provide valuable insights into population-specific cranial characteristics and assist in distinguishing between different demographic groups.

The study also offered a detailed examination of the morphometric measurements, including the distance from the pterion to the frontal bone, the distance to the parietal bone, and several other key distances that are critical in cranial surgeries. The vertical distance from the pterion to the zygomatic arch averaged 4.05 cm on the right and 3.90 cm on the left, with a range of 3.60–4.60 cm and 3.30–4.20 cm, respectively. This measurement provided valuable information on the spatial relationship between the pterion and the facial features. Similarly, the distance from the pterion to the frontozygomatic fissure averaged 3.20 cm on the right and 3.35 cm on the left, which is crucial for surgical approaches involving the face and temporal regions. These measurements corroborate the findings of Ma et al., who noted similar anatomical variations in pterion placement across different populations.[11]

The horizontal distance from the pterion to the lateral margin of the optic canal averaged 4.30 cm on the right and 4.25 cm on the left, with ranges of 3.80–4.90 cm and 3.80–4.70 cm, respectively. This distance is particularly significant in neurosurgical procedures, as it indicates the proximity of the pterion to critical neurovascular structures, such as the optic canal, which is essential for accessing deeper regions of the brain. The distance from the pterion to the lateral end of the ridge on the lesser wing of the sphenoid averaged 1.35 cm on the right and 1.45 cm on the left, with ranges of 0.60–1.90 cm and 0.90–2.00 cm, respectively. These measurements are crucial for understanding the anatomical relationship between the pterion and the sphenoid bone, particularly when planning surgeries that involve the cranial base.

Finally, the thickness of the pterion was measured at 0.40 cm on the right and 0.38 cm on the left, with ranges of 0.28–0.60 cm and 0.22–0.55 cm, respectively. This is an important aspect to consider, as the pterion is the weakest part of the skull, and fractures in this area can provide key insights into the mechanisms of traumatic injuries. These findings agree with Prasad and Rout, who emphasized the significance of the pterion's thickness in understanding the skull's response to blunt force trauma.[12]

CONCLUSION

The study confirmed the anatomical diversity of the pterion in Indian male skulls, offering valuable

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insights into its positional variations and morphological types. The data obtained from the study are crucial for clinical applications, particularly in neurosurgery, trauma assessment, and forensic anthropology. Understanding the pterion's anatomy is vital for surgical planning, as improper identification of this landmark could lead to serious neurovascular injuries. The study's findings also contribute to anthropological research by revealing population-specific cranial traits, providing further evidence of the pterion's relevance in comparative anatomy.

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