RESEARCH PAPER

Pterion Morphology: A Radiological Perspective

Rinke Choudhary[1], Deepali Kate[2*], Kumar Satish Ravi [3] Prasad Hegde[4] Avinash Munshi[5] Renu Chahuan[6] Sangita Chauhan[7]

[1]PhD Scholar, Department of Anatomy, National Institute of Medical Sciences & Research, Jaipur, India
[2*]Professor, Department of Anatomy, National Institute of Medical Sciences & Research, Jaipur, India
[3]Professor and Head, Department of Anatomy, National Institute of Medical Sciences & Research Jaipur, India
[4]Professor and Head, Department of Radiology, National Institute of Medical Sciences & Research Jaipur, India
[5]Professor, Department of Radiology, National Institute of Medical Sciences & Research, Jaipur, India
[6]Professor and Head, Department of Anatomy, University College of Medical Sciences and GTB hospital, Delhi, India
[7]Professor and Head, Department of Anatomy, National Institute of Medical Sciences & Research Jaipur, India

***Corresponding Author:** Dr. Deepali Kate
*Email: drd.kate@gmail.com

Abstract
Background: The pterion is a crucial cranial landmark with significant neurosurgical importance due to its close relationship with vital neurovascular structures. Variations in its morphology and localization are essential considerations in surgical planning and radiological interpretation.
Objective: To evaluate the morphological variations of the pterion in adult males and females of North-Western India (Rajasthan) using computed tomography (CT), and to assess gender-based differences
Materials and Methods: This retrospective study was conducted using 118 CT scans (59 males and 59 females) collected from the Department of Radiology, NIMS Tertiary Care Hospital, Jaipur, Rajasthan. Only adult subjects within a defined age range were included. Pterion morphology was classified into five types: sphenoparietal, frontotemporal, stellate, epipteric, and atypical variants. Observations were made using craniolateral views of CT scans.
Results: The sphenoparietal type was observed as the most predominant form in both sexes. Other types, including frontotemporal, stellate, epipteric, and atypical variants, were also identified with varying frequencies. Minor differences in distribution patterns were noted between males and females.
Conclusion: This CT-based study highlights significant morphological diversity of the pterion in the Rajasthan population. Knowledge of these variations, including atypical forms, is essential for radiologists and neurosurgeons to minimize surgical risks and improve clinical outcomes. The findings also contribute valuable regional data for anatomical and radiological reference.
Keywords: Pterion, Computed Tomography, Morphology, Craniolateral View, Rajasthan, Neurosurgery
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Introduction

The skull, when viewed laterally, is divided into facial, temporal, and occipital regions. The temporal region contains an important anatomical landmark known as the pterion. The pterion is an H-shaped sutural junction formed by the articulation of the frontal, parietal, squamous temporal, and greater wing of the sphenoid bones, located in the supratemporal fossa. It corresponds to the site of the anterolateral (sphenoidal) fontanelle in the neonatal skull, which usually closes within the first few months after birth.[1]

The term pterion is derived from the Greek word pteron, meaning wing, and was introduced into anatomical literature by Bland-Sutton.[2] Owing to its relatively constant location and close relationship with important intracranial structures such as the anterior division of the middle meningeal artery, lateral (Sylvian) fissure, insula, and Broca's motor speech area, the pterion serves as an important craniometric and neurosurgical landmark.[3] Consequently, it is widely utilized in pterional craniotomy for surgical access to lesions of the anterior and middle cranial fossae and for vascular pathologies including aneurysms.[4] Morphologically, the pterion demonstrates variations in sutural pattern. Murphy described four classical types—sphenoparietal, frontotemporal, stellate, and epipteric.[5] Such variations may be influenced by age, sex, laterality, and ethnicity.[6] The epipteric type is of particular clinical significance because sutural bones in this region may mimic fracture lines on radiological imaging.[7] Traditionally, studies of pterion morphology have been performed on dry skulls. However, advances in imaging techniques, particularly computed tomography (CT) with three-dimensional reconstruction, have enabled precise and non-invasive evaluation in living individuals.[8] CT-based assessment allows accurate evaluation of both morphological variations and the spatial relationship of the pterion with adjacent anatomical structures, which is valuable for radiological interpretation and preoperative planning. [9] Despite its clinical relevance, literature focusing on CT-based evaluation of pterion morphology

*Author for Correspondence: drd.kate@gmail.com

in the North-Western Indian population remains limited. Therefore, the present study was undertaken to analyse the morphological types of the pterion using CT imaging in adult males and females of Rajasthan and to evaluate variations with respect to sex and side.

Aim

To evaluate the morphological variations of the pterion in adult males and females using computed tomography

Objectives

- To identify, classify, and determine the frequency distribution of pterion morphological types on craniolateral CT images in the study population.
- To compare the morphological variations of the pterion between right and left sides and between male and female CT scans.

Materials and Methods

This retrospective observational study was conducted in the Department of Radiology at NIMS Tertiary Care Hospital, Jaipur, Rajasthan. A total of 118 cranial computed tomography (CT) scans were included, comprising 59 males and 59 females aged between 18 and 65 years. Demographic details such as age and sex were obtained from patient records. Prior informed consent had been obtained at the time of imaging

Only CT scans with clearly visualized pterion regions were included in the study. Pediatric cases, scans with cranial fractures, deformities, or any pathological lesions affecting the pterion region, as well as poor-quality images, were excluded.

Ethical approval for the study was obtained from the Institutional Ethics Committee of NIMS University, Jaipur (NIMSUR/IEC/2024/929).

Methodology

All CT scans were analyzed on craniolateral images using appropriate imaging software. The pterion was identified on both the right and left sides and classified into five morphological types based on sutural morphology, following Murphy's [5]classification (1956), as adapted for radiological evaluation in previous CT-based studies (Rafi et al., 2020)[10]

- Sphenoparietal
- Frontotemporal
- Stellate
- Epipteric

Interestingly, an atypical variant of the pterion was observed in the present CT-based study, which, to the best of our knowledge, has not been documented in previous radiological studies.

Parameters Assessed

- **Age-wise Analysis:**

Subjects were grouped based on age ranges (e.g., 18–30, 31–45, 46–55, 56-65 years), and variation in pterion morphology across age groups was assessed.

- **Side-wise Comparison:**

Each pterion was analyzed separately on the right and left sides to assess bilateral symmetry or asymmetry.

- **Sex-wise Comparison:**

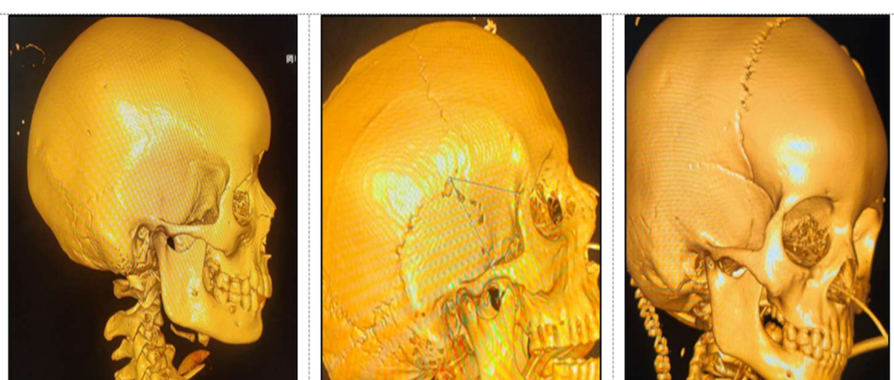
The distribution of pterion types was compared between male and female subjects.

Statistical Analysis

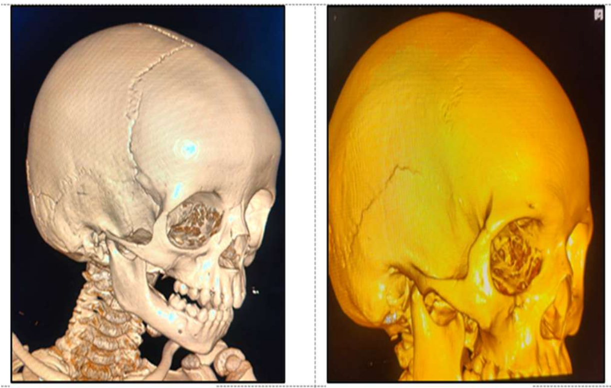
The data were compiled using Microsoft Excel and analysed with SPSS Software (version 21), and subjected to statistical analysis. Descriptive statistics were used to summarize the data, and results were expressed as frequencies and percentages for categorical variables such as age groups, pterion types, side (right and left), and sex (male and female).

To assess the association between categorical variables—namely, pterion type with side (right vs left) and pterion type with sex (male vs female)—the Chi-square (χ^2) test of independence was applied. This test was used to determine whether there was a statistically significant difference in the distribution of pterion types across sides and between genders.

A p-value of less than 0.05 was considered statistically significant. In the present study, the p-values obtained in all comparisons were greater than 0.05, indicating that there was no statistically significant association between pterion type and side, as well as between pterion type and sex



A: Sphenoparietal *B: Epipteric* *C: Stellate*



D: Frontotemporal E: Atypical

Fig. 1: Morphological classification of pterion types as observed on craniolateral computed tomography (CT) images. (A) Sphenoparietal; (B) Epipteric; (C); Stellate; (D) Frontotemporal; (E) Atypical configuration.

Results:

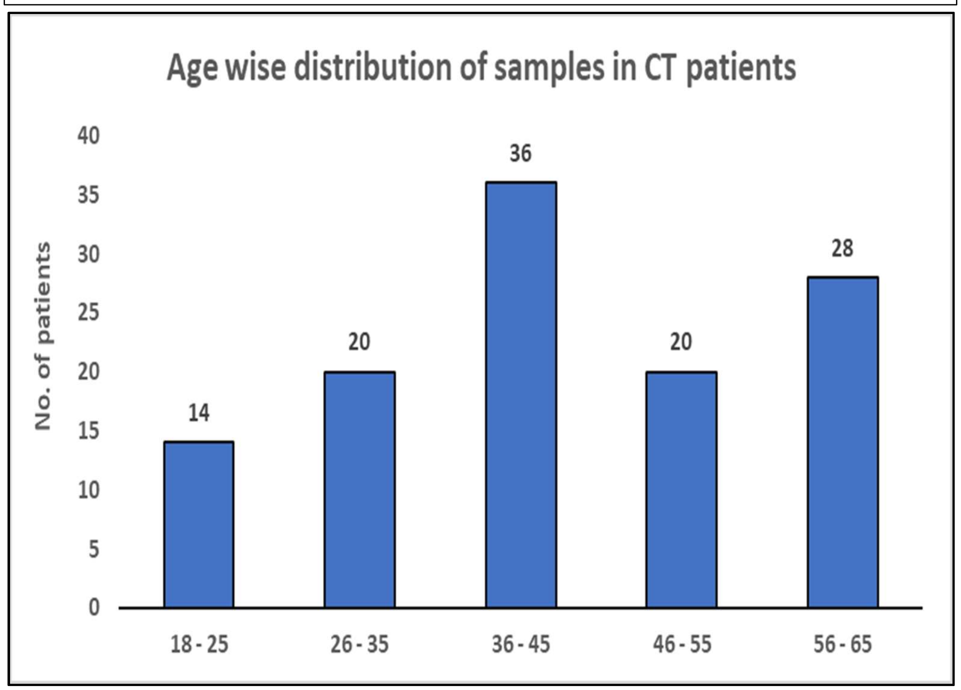
1. Age-wise distribution of pterion types (Table 1, Figure 2)

The majority of subjects belonged to the 36–45 years age group (30.51%), followed by 56–65 years (23.73%), while the least were in the 18–25 years group (11.86%).

Table 1: Frequency distribution of CT patients according to age

Age Interval (In yrs.)	n=118	In%
18-25	14	11.8%
26-35	20	16.95%
36-45	36	30.51%
46-55	20	16.95%
56-65	28	23.73%

Fig. 2: Age-wise distribution of study participants based on CT scans

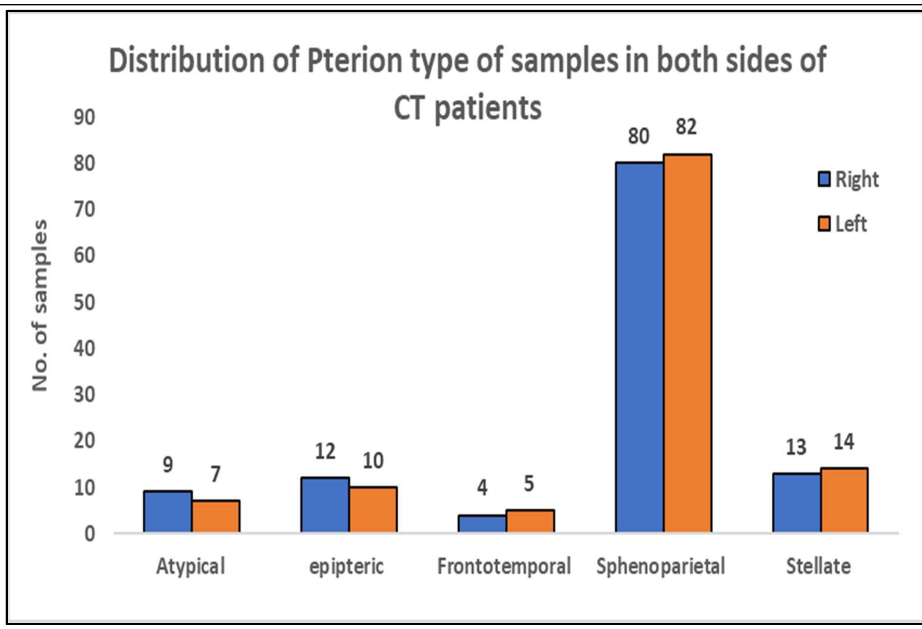


2. Side-wise Distribution of Pterion Types (Table 2, Figure 1, 3)
The sphenoparietal type was the most predominant on both right (67.80%) and left (69.49%) sides. Other types such as epipteric, stellate, frontotemporal, and atypical variants were observed with lower frequencies. No statistically significant association was found between pterion type and side ($\chi^2 = 0.605$, $p = 0.9626$). (Table-2, Figure 1,3)

Table 2: Association of Pterion Type with Side (Right and Left) in Craniolateral CT Images

Type of Pterion	Right	Left	Chi-square test	P - Value	Significance
Atypical	9 (7.63%)	7 (5.93%)	0.605	0.9626	Not Significant
Epipteric	12 (10.17%)	10 (8.48%)			
Frontotemporal	4 (3.39%)	5 (4.23%)			
Sphenoparietal	80 (67.80%)	82 (69.49%)			
Stellate	13 (11.02%)	14 (11.86%)			
Total	118 (100%)	118 (100%)	-	-	-

Fig. 3: Distribution of pterion types on the right and left sides in CT scan samples



*3.*Sex-wise Distribution of Pterion Types (Table 3,4 Figure 4,5)
On gender-based analysis, the sphenoparietal type remained the most common in both males and females on both sides. Minor variations were observed in the distribution of other types; however, these differences were not statistically significant ($p > 0.05$). (Table-3, 4, Figure 4,5).

Table 3: Association of Pterion type with gender in right side craniolateral view of CT scan

Type of Pterion	Male	Female	Chi-square test	P - Value	Significance
Atypical	5(8.48%)	4 (6.78%)	1.187	0.8802	Not Significant
Epipteric	5(8.48%)	7 (11.86%)			
Frontotemporal	2 (3.39%)	2 (3.39%)			
Sphenoparietal	39 (66.1%)	41 (69.49%)			
Stellate	8 (13.56%)	5(8.48%)			
Total	59 (100%)	59 (100%)	-	-	-

Fig.4: Gender-wise distribution of pterion types on the right side in CT scan

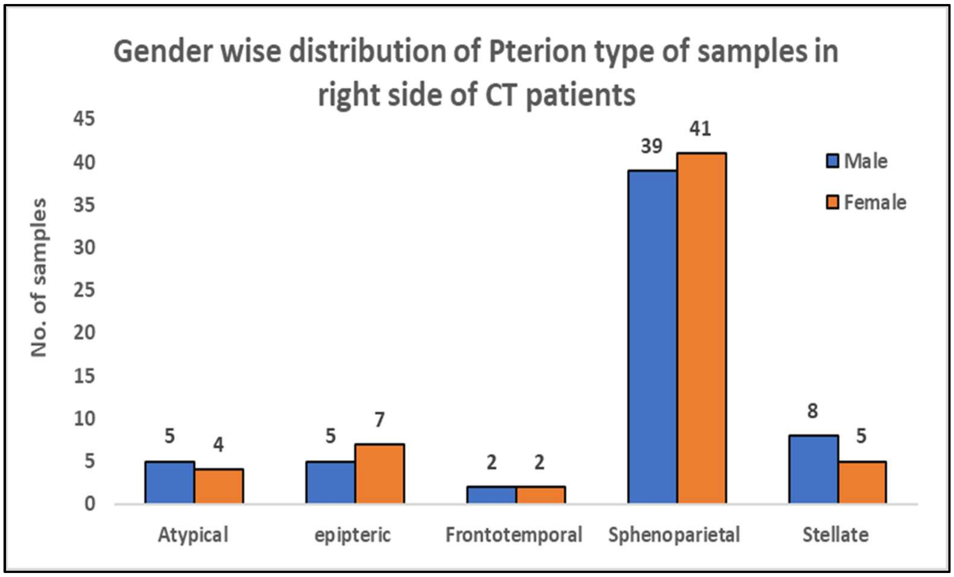
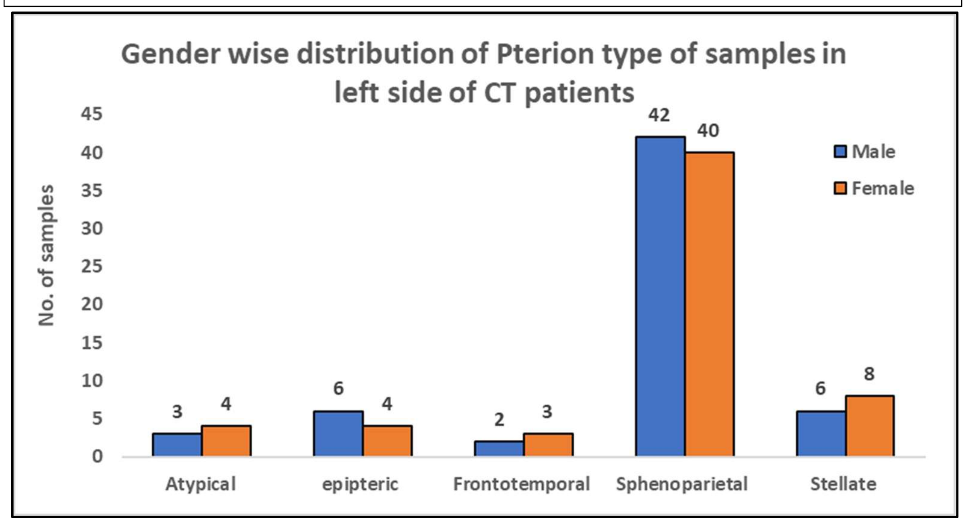


Table 4: Association of Pterion type with gender in left side craniolateral view of CT scan

Type of Pterion	Male	Female	Chi-square test	P - Value	Significance
Atypical	3 (5.09%)	4 (6.78%)	1.077	0.8978	Not Significant
Epipteric	6 (10.17%)	4 (6.78%)			
Frontotemporal	2 (3.39%)	3 (5.09%)			
Sphenoparietal	42 (71.19%)	40 (67.80%)			
Stellate	6 (10.17%)	8 (13.56%)			
Total	59 (100%)	59 (100%)	-	-	-

Fig.5: Gender-wise distribution of pterion types on the left side in CT scan



Discussion:

The present study evaluated the morphological variations of the pterion in an adult North-Western Indian population using computed tomography. The findings demonstrated that the sphenoparietal type was the predominant pterion morphology, followed by stellate, epipteric, atypical, and frontotemporal patterns. These observations are consistent with classical anatomical descriptions and radiological studies. [5 8]

Murphy, in his classical anthropological study, described the four principal morphological types of the pterion and reported sphenoparietal articulation as the most common

form.[5] The present findings are in close agreement with Murphy's observations.
In Indian populations, Singh et al. reported predominance of the sphenoparietal type in dry human skulls.[8] Similarly, Ma et al., in a CT-based study, demonstrated that the sphenoparietal type was the most frequent morphological configuration.[3] These findings support the results of the present study conducted in the Rajasthan population.
Comparable observations have also been reported in other populations. Oguz et al. documented predominance of the sphenoparietal type in Turkish skulls.[6] Lee et al. reported similar findings in Korean subjects, while Apinhasmit et al. observed comparable results in Thai skulls.[11 12] These studies suggest a relatively conserved global pattern with minor regional variation.
The epipteric type, although less frequent, remains clinically important. Urzi et al. emphasized that sutural bones in the pterion region may mimic fracture lines on imaging. [7] Caliskan et al. further highlighted the usefulness of multidetector CT in distinguishing normal sutural variants from traumatic fractures. [9]
In the present study, no statistically significant difference was observed between the right and left sides, indicating a high degree of bilateral symmetry. Similar findings were reported by Mwachaka et al. in Kenyan skulls.[13] No significant sexual dimorphism was observed in the present study. Recent computed tomography–based studies of neurocranial structures have also reported that sex-related differences may vary across cranial regions and are not uniformly expressed. [14] Adejuwon et al. also observed negligible gender-based differences.[15]
Regional comparative studies by Saxena et al. and Krishnamurthy et al. demonstrated that although the general morphological pattern of the pterion remains constant, minor differences may occur due to genetic, developmental, and environmental influences. [16 17]
The present study is particularly relevant because it provides CT-based data from the Rajasthan population. Evaluation in living individuals preserves anatomical relationships and offers clinically relevant information for preoperative planning. Recent radiological studies by Rojas et al. and Hwang and Hwang have further emphasized the importance of accurate pterion localization in radiological interpretation and neurosurgical planning. [18 19]
Rafi et al., in a cranial CT study of Pakistani males, similarly reported the utility of CT-based assessment in neurosurgical landmark identification.[10] Recent studies in Indian populations by Rahul Sharma et al. have further emphasized the surgical relevance of pterion morphology and its anatomical variability. [20] Likewise, a recent meta-analytic evaluation by George Triantafyllou et al. highlighted that detailed knowledge of pterion variability is important for improving neurosurgical precision and preoperative planning. [21]
Thus, the present study reinforces the predominance of the sphenoparietal type in the North-Western Indian population and demonstrates minimal variation with respect to side and sex. CT-based evaluation improves diagnostic accuracy and assists both radiologists and neurosurgeons.

Conclusion
The present CT-based study shows that the sphenoparietal type is the predominant pterion morphology in the North-Western Indian population, with other variants occurring less frequently. No significant side- or sex-based differences were observed. CT imaging provides a reliable and non-invasive method for evaluating pterion morphology in living individuals. These findings aid neurosurgeons in safer surgical planning and help radiologists differentiate normal sutural variants from fracture lines.

Limitations
The present study has certain limitations that should be considered while interpreting the results. As a single-center, retrospective study with a relatively limited sample size, the findings may not be fully generalizable to the broader population. The analysis was confined to morphological classification and did not include detailed morphometric measurements, which could have enhanced its clinical relevance. Moreover, potential ethnic and subpopulation variations were not explored. The retrospective design may introduce selection bias, and the lack of assessment of interobserver variability may influence the reproducibility of the findings. Additionally, inherent limitations of CT imaging, particularly resolution constraints, may affect the accurate identification of smaller sutural bones, especially epipteric variants

Future Perspectives
Further studies involving larger, multi-centric populations are recommended to improve the generalizability of the findings. The integration of three-dimensional CT reconstruction along with detailed morphometric analysis may provide more precise anatomical and surgical landmarks. Additionally, comparative studies across different ethnic and geographical populations could help in understanding the genetic and developmental influences on pterion morphology. Correlating CT findings with intraoperative neurosurgical observations may further enhance clinical applicability and surgical accuracy.

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