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Original Research Article

Morphology of Pterion and Analysis of Epipteric Subtype in Indian Population

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Abstract:
Background: Pterion is the junction of the frontal, parietal, greater wing of the sphenoid and the squamous part of the temporal bone. The sphenoparietal, frontotemporal, stellate and epipteric pteria types were described earlier. Pterion is a commonly used neurosurgical landmark and thus in-depth knowledge of the pteric area and its variants could be valuable. The current study determines pterion morphology (variant types' frequency), as well as the presence of epipteric bones in dried skulls.
Materials and Methods: Fifty adult dried skulls of both right and left sides (100 sides) were observed for pterion types, symmetry, epipteric pterion subtypes, and sub-subtypes of the trisutural epipteric pterion subtype. The data was statistically analyzed.
Results: The sphenoparietal pterion was the commonest type (78%), followed by epipteric (16%), frontotemporal pterion (4%) and by the stellate (2%). Pterion was symmetric in 40 (80%) of the skulls - 34 SP-SP type, 4 E-E type, 1 FT-FT type and 1 ST-ST type. In asymmetrically pairing skulls, the commonest pterion types were the SP-E (n=8; 16%) and the SP-FT (n=2; 4%). Of the epipteric pterion type, quadrisutural (6%), trisutural (6%), and multiple (1%) subtypes were observed in this study; bisutural subtype was not observed. Of the four sub-sub types of trisutural epipteric pterion, 5 posterior and 1 anterior were observed in this study; superior and inferior subsubtypes was not observed.
Conclusions: Recognition of the possible variability in pterion morphology, as well as possible occurrence of epipteric bones may render pterional craniotomy safer during neurosurgical procedures.
Keywords: Epipteric Bone, Cranium, Frontotemporal Pterion, Sphenoparietal Pterion, Stellate Pterion.

Introduction

Pterion, an H-shaped small circular area, is a point of convergence of the frontal, sphenoid, parietal and squamous part of the temporal bone. It has a divergent morphology being a meeting point of skull base, calvarium, and the facial skeleton. It also forms the floor of the temporal fossa [1]. Pterion is a reference cranial landmark for the anterior branch of the middle meningeal artery, the Broca's motor speech area, the insula, and the stem of lateral sulcus [2, 3]. In addition, age and gender determination in forensic and archeological cases could be based on pterion [4, 5].

The epipteric bones (EBs) are sutural/Wormian bones which may also be present in the H shaped suture. Knowledge of pterion types and the presence and distribution EBs are important to prevent complications when drilling burr holes [6]. The current study aims to study the pterion morphology (variant types' frequency), as well as the frequency of EBs and their relationship with pterion sutures in dried skulls.

Materials and Methods

Fifty adult skulls were selected from 57 adult skulls, irrespective of sex, from the osseous collections of the A J Shetty Institute of Medical sciences, Karnataka, India. Ethics approval and consent was as per protocol of the institute for the cadaveric material. Skulls in which the pterion was damaged (n=4) or could not be clearly identified because of sutural fusion (n=3) were excluded. Skulls were of predominantly South Indian origin. Selected skulls were investigated both on the right (R) and left (L) sides, a total of 100 sides.

Morphological classification of pterion: All pteria were classified into 4 types, based on Murphy's classification [8]: Sphenoparietal (SP), frontotemporal (FT), stellate (ST) and epipteric (E) pteria (see Figure 1).

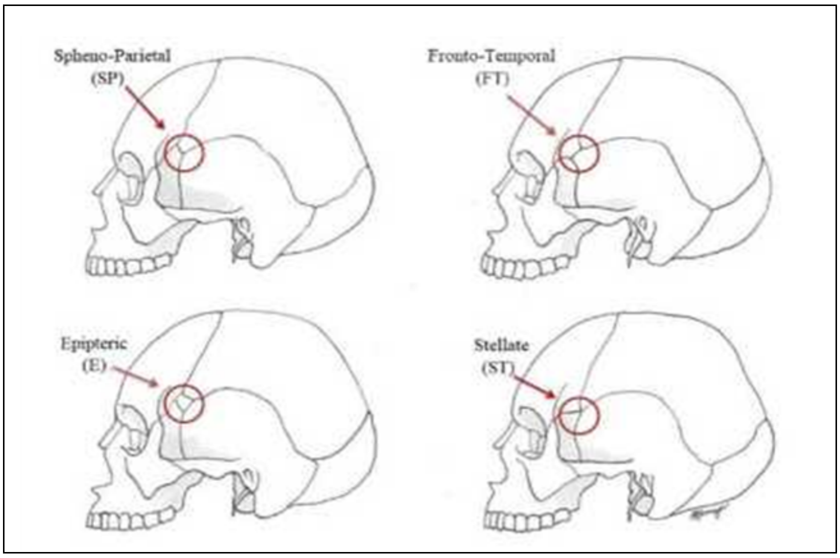

**Figure 1. Four types of pterion based on Murphy's classification.
Adapted from: Gamet (2017) [7].**

Epipteric bones number and distribution: In skulls with E pterion, EBs were further classified into 4 subtypes based on Natsis classification: quadrisutural, trisutural, bisutural and multiple [9] (see Figure 2A). Trisutural EBs was further subclassified as superior, inferior, anterior and posterior (see Figure 2B).

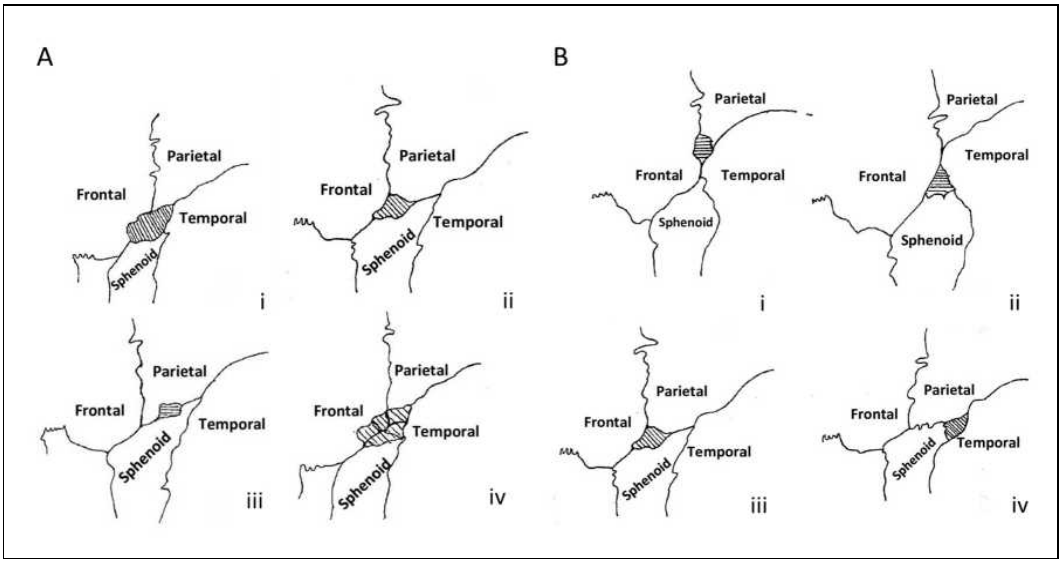

**Figure 2. (A) Four sub types of epipteric type of pterion - Quadrisutural (i) Trisutural (ii) Bisutural (iii) Multiple (iv). (B) Four sub-sub types of epipteric pterion trisutural subtype - Superior (i) Inferior (ii) Anterior (iii) Posterior (iv).
Adapted from: Natsis (2020) [9].**

Statistical Methods

The frequency of each morphological types of pterion were expressed in percentage. Chi-Square/Fisher's Exact test was applied to investigate side asymmetry. For all analyses, p value <0.05 was considered statistically significant. Statistical analysis was carried out using IBM SPSS Statistics for Windows, version 21.0.

Results

Pterion Morphology: In the present study, of the 100 sides analysed, all pteria types (SP, FT, ST and E) were identified (see Figure 3).

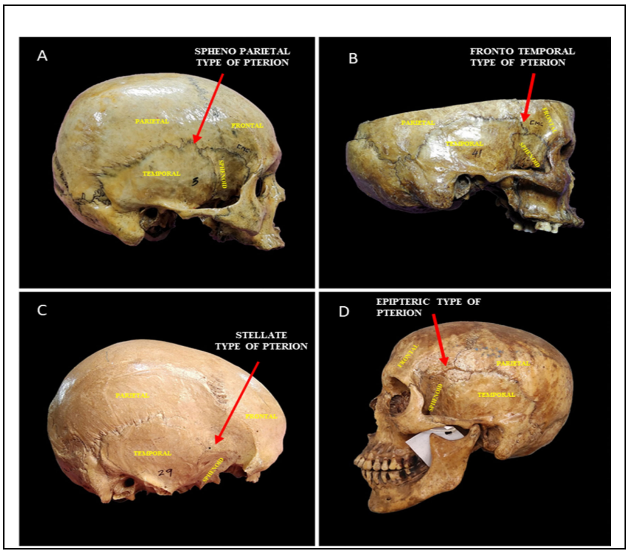

Figure 3. Lateral view of skulls showing four types of pterion: (A) Sphenoparietal type (B) Frontotemporal type (C) Stellate type (D) Epipteric type.

SP pterion was the predominant type seen in 78% (R:40; L 38), followed by E Pterion in 16% (R:7; L9), FT pterion in 4% (R:2; L:2) and ST pterion in 2% (R:1; L:1) (see Table 1).

Table 1. Frequency of pterion types: (n=100 sides, 50 skulls)

	Pterion Types			
	Spheno parietal type (SP)	**Frontotemporal type (FT)**	**Stellate type (ST)**	**Epipteric type (E)**
Right	40 (40%)	2 (2%)	1 (1%)	7 (7%)
Left side	38 (38%)	2 (2%)	1 (1%)	9 (9%)
Total	**78 (78%)**	**4 (4%)**	**2 (2%)**	**16 (16%)**

Bilaterality of pterion types:

Pterion was symmetric in 40 (80%) of the skulls - 34 SP-SP type, 4 E-E type, 1 FT-FT type and 1 ST-ST type. In asymmetrically pairing skulls, the commonest pterion types were the SP-E (n=8; 16%) and the SP-FT (n=2; 4%). The combination types showed significant difference (p<0.001) both for symmetry and asymmetry (see Figure 4)

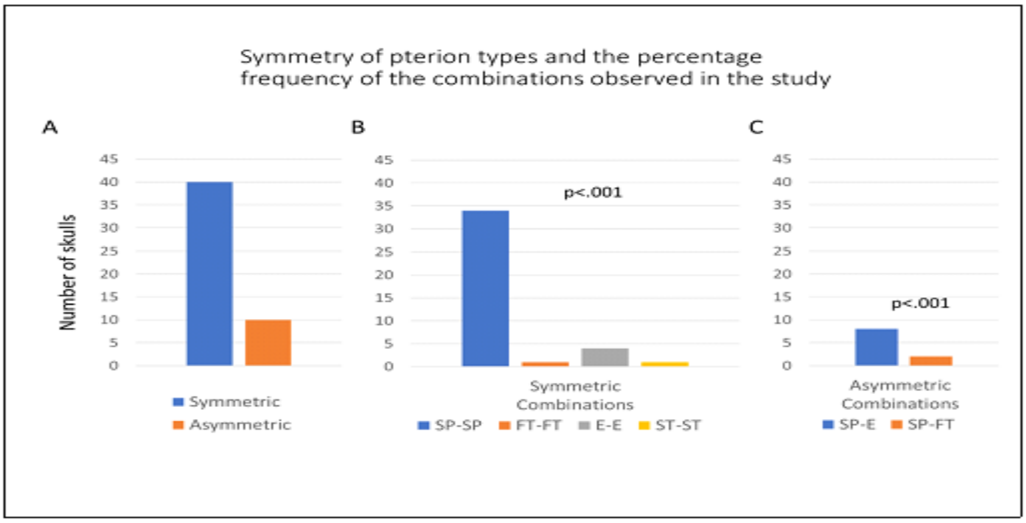

Figure 4. Frequency of pterion types based on symmetry on right and left sides, and frequency of the combinations observed in the study.
Note: SP-SP, sphenoparietal-sphenoparietal; FT-FT, frontotemporal-frontotemporal; Eepipteric epipteric; ST-ST, stellate-stellate; SP-E, sphenoparietal-epipteric; SP-FT, sphenoparietal-frontotemporal.

Epipteric Bone Morphology:

Of the 16 EBs, they were seen in 4 skulls bilaterally and in 8 skulls unilaterally.

Of the four subtypes of EBs quadrisutural was seen in 6% (6 skulls, all unilaterally) (see Figure 3D), trisutural (6%, 5 skulls, 1 skull bilaterally and 4 skulls unilaterally), and multiple (1%, 1 skull unilaterally) were observed in this study (see Figure 5); bisutural subtype was not observed in this study.

Of the four sub-subtypes of trisutural epipteric pterion subtype (n=6), posterior (n=5) and anterior (n=1) were observed in this study (see Figure 5); superior and inferior sub-subtypes was not observed.

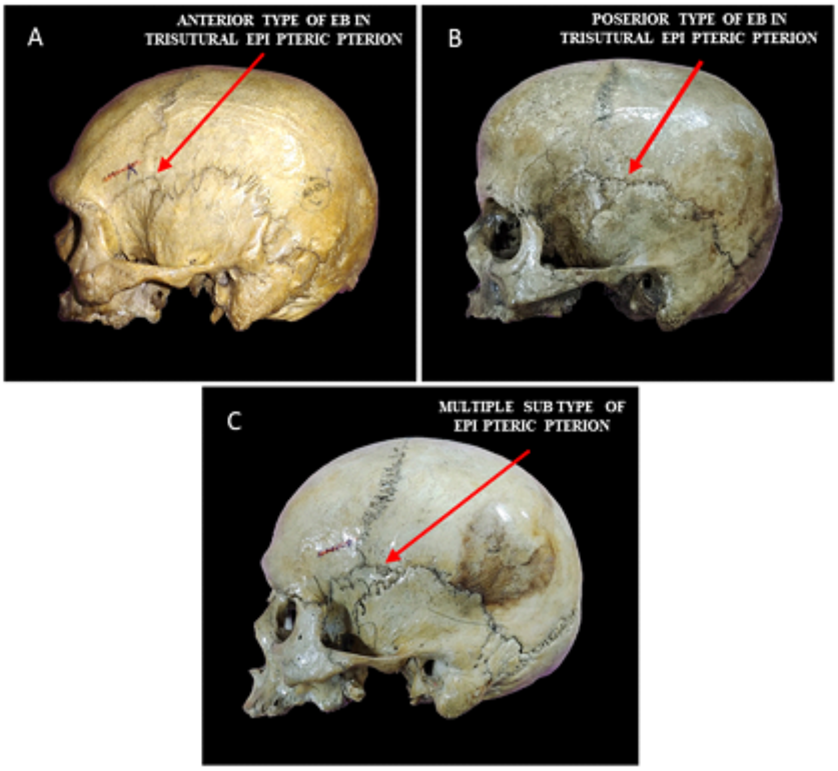

Figure 5. Lateral view of skulls showing anterior (A) and posterior (B) sub-sub types of trisutural epipteric pterion and multiple (C) sub type of epipteric pterion.

Discussion

Pterion is the junction of articulation of the coronal, sphenoparietal, sphenofrontal and sphenosquamosal sutures [10]. It corresponds to the site of the anterolateral (sphenoidal) fontanelle which disappears approximately 3 months after birth [10]. It is the thinnest and weakest spot of the skull, and it is used as an anatomical landmark for the anterior branch of the middle meningeal artery [4]. Pterion could be safely used as a surface landmark in neurosurgical approaches and interventions [3], even in neonates [2]. Its clinical importance derives from the fact that it overlies the anterior (frontal) branch of the middle meningeal artery, which is the most frequent source of acute traumatic epidural hematoma [11]. The knowledge of pterional typical anatomy, as well as its variants is important to neurosurgeons during pterional craniotomy, especially during extradural haematoma evacuation [12].

Pterion morphology was classified into sphenoparietal, frontotemporal, epipteric and stellate types by Murphy in 1956 [8] in a longitudinal study using 368 Australian skulls. The incidence of the various types of pterion was 73.23%, 7.75%, 18.34% and 0.68% for sphenoparietal, frontotemporal, epipteric and stellate types, respectively. Since then, pterion has been extensively studied among different populations and selected studies are summarized in Table 2 for global studies and Table 3 for Indian studies. In the present study there was a higher prevalence of the SP type of pterion followed by the E type, which was similar to that of that of Murhpy [8]and many other subsequent studies [2, 13]. A study conducted in Turkey using 300 dried human skulls stated the presence of sphenoparietal type (96%), frontotemporal (3.7%), epipteric (9%) and stellate type (0.2%) [2]. But some studies have reported a lesser prevalence of E type pterion [14]. Some studies have reported absence of one of the pterion types. A study done on 52 dried adult Sri Lankan skulls reported the sphenoparietal type (74.04%) as the most common type followed by epipteric type (21.15%) and frontotemporal type (4.181%). But they did not find any stellate variety of pterion in their study [15]. Other studies also have reported absence of stellate pterion type like by Lee et al [16] Oguz et al [3] and Ma et al. [11]. Absent E type pterion was reported by Saxena et al. [17], Adejuwon et al. [18] and Kumar et al. [19].

In Indians, the SP pterion frequency ranged between 71.7% and 93.55% (Southern Indians, 8093.55%; Western Indians, 91.7%; Northern Indians, 71.7-89.2%). Studies on other Asian populations have noted similar prevalence patterns. Kenyans had the lowest reported frequency (66%) [20]. The high frequency of SP pterion could be a result of evolution [21], given that it is the commonest type in primates [14, 22]. Variant sutural patterns in pterional area are the outcome of combination of various environmental and epigenetic factors [23].

Table 2: Comparative review of pterion types in different global populations among several studies (order by year of publication)

	Year	Population	Sample N = skulls (sides)	SP (%)	Type of pterion		E (%)
					FT (%)	ST (%)	
Murphy [8]	1956	Australian	368	73.2	7.7	0.7	18.4
Saxena et al.[14]	1988	Nigerian	40 (80)	81.2	11.3	5.0	2.5
Matsumura et al. [24]	1991	Japanese	614	82.4	2.9	0.7	14.0
Asala and Mbajiorgu [16]	1996	Nigerian	212	82.1	23.6	-	5.7
Lee et al.[25]	2001	Korean	149	76.5	-	-	40.3
Ersoy et al. [2]	2003	Turkish	300 (490	96.0	3.8	0.2	9.0
Oguz et al.[3]	2004	Turkish	26 (52)	88.0	10.0	-	2.0
Mwachaka et al. [20]	2009	Kenyan	50	66.0	15.0	7.0	12.0
Apinhasmit et al. [26]	2011	Thais	268 (536)	81.2	1.1	0.4	17.3
Ma et al. [11]	2012	Australian	76	78.4	5.2	-	16.4
Ukoha et al. [27]	2012	Nigerian	56	75.3	19.5	1.7	3.6
Adejuwon et al. [18]	2013	Nigerian	62	86.1	8.3	5.6	-
Natsis et al. [9]	2020	Greek	90	58.3	1.1	25	15.5
Muche, A [28]	2021	Ethiopia	90	84.4	0	2.2	13.3
Uabundit, N et al [4]	2021	Thai	124	62.1	5.2	1.2	11.7

Bilaterality of Pterion Types:

Uabundit et al. have analyzed bilaterality in their study on Thai skulls [4]. They have reported that the majority of the skulls showed bilateral symmetry (83.1%) including the complete synostosis of the pterion. The present study showed similar frequency of 80% bilateral symmetry, but it excluded the skulls with complete synostosis of the pterion since pterion type couldn't be determined in them. They observed bi-spheno-parietal type as the most common combination (54.4%) followed by bi-epipteric (7.3%), and bi-fronto-temporal (4%). Prevalence of the combinations in our study was similar, with 68% bi-spheno-parietal type, 8% bi-epipteric type, and 2% bi-fronto-temporal type. We also noted 2% bi-stellate type.

The most common type of asymmetric pterion reported by Uabundit et al.was sphenoparietal-epipteric type (10.5%) that was similar to the present study (16%). We noted spenoparietal- frontotemporal asymmetric combination type in 4%

Epipteric bone morphology:

The second commonest pterion type in this study was E type (16%). It's frequency was similar to that reported in other Indian [29], Nigerian [16], and Kenyan (12%) [20] populations.

Ranke proposed the most suitable hypothesis concerning the EBs occurrence [30]. He suggested that an EB appears in case of fusion failure of the postero-superior border of the greater sphenoidal wing with the rest of the greater wing, during the 4th month of the intrauterine life.

Furthermore, 4 skulls (1 bilateral, 3 unilateral) with relatively large epipteric bones of the trisutural and quadrisutural types were observed. Our study noted that the commonest location of EBs in trisutural epipteric pterion was posterior (83%).

Table 3: Comparative review of pterion types in different global populations among several studies (order by year of publication)

	Year	Population	Sample N = skulls (sides)	Type of pterion			
				SP %)	FT (%)	ST (%)	E (%)
Agarwal et al. [13]	1980	North Indian	450 (900 sides)	71.7	3.3	1.7	23.3
Manjunath et al. [31]	1993	South Indian	172	93.5	3.5	2.9	17.3
Saxena et al. [17]	2003	North Indian	203	87.7	10.0	5.17	-
Zalawadia et al. [32]	2009	West. Indian	42	91.7	2.4	1.2	4.7
Natekar et al. [33]	2011	Indian	150 bones	85.3	8.0	10.6	51.4
Praba and Venkatramaniah. [34]	2012	Indian	50	74.0	3	9.0	14.0
Kumar et al. [19]	2013	Indian	40	86.25	11.25	2.5	-
Sudha et al. [29]	2013	South	150	80.0	3.0	5.3	11.3
Vasudha T.K et al. [35]	2017	South Indian	150	69.33	5.67	11	14

Esroy revealed that existence of an epipteric or wormian bone at the pterion may complicate surgical orientation leading to complication during burr hole surgeries like orbital penetration [2]. Also, they may be mistaken as a skull fracture in x-rays [36].

Pterion is also used in various neurosurgical approaches to anterior and middle skull base lesions [37], anterior and posterior cerebral circulation lesions, middle cerebral artery or upper basilar complex aneurysms, optic nerve and sellar and parasellar area lesions, sphenoidal wing, cavernous sinus, orbit, anterior and medial temporal lobe, midbrain, and posterior-inferior frontal lobe tumors, as well as cerebral tumors [6, 38-43]. Recognition of the possible variants in morphology of the pterion, as well as EBs occurrence may render pterional craniotomy safer among different population groups.

Conclusions

All pteria types were found in the current study and SP pterion was the predominant one, while ST was the less frequently observed. Pterional symmetry existed in the majority of cases. The EBs were observed in 16% and in the majority of the cases were tri- and quatrisutural. Information obtained from the current study may be of significant value in preoperative planning and perioperative navigation.

Ethics approval and consent to participate: Ethics approval and consent was as per protocol of the institute for the cadaveric material, where the cadaveric studies are exempted from ethics approval and consent.

List of abbreviations

EB: Epipteric bone

SP: Sphenoparietal pterion

FT: Frontotemporal pterion

ST: Stellate pterion and epipteric

E: Epipteric pterion

Data Availability: Data can be available upon reasonable request to the corresponding author.

Conflicts of Interest: The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper.

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Authors' contributions: All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by MRT andDBG. RTS contributed to data collection and analysis. The draft was written by all authors in collaboration and all authors read and approved the final manuscript.

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Supplementary Materials: Nil

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