

## RESEARCH PAPERS

**Morphology and the position of the pterion in a Sri Lankan population**

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**Running title:** Morphology and position of the pterion

**Abstract**

**Objective:** The present study was conducted to describe the morphology of the pterion, and its position in an adult Sri Lankan population.

**Materials and methods:** Fifty eight pteria of twenty nine adult skulls of known gender in a Sri Lankan population were analyzed to determine the sutural morphology of the pterion, and its precise location in relation to the posterolateral aspect of the frontozygomatic suture, midpoint of the zygomatic arch, anterior and superior most point of the external auditory meatus, and the inferior most point of the mastoid process.

**Results:** The predominant type of pterion observed was sphenoparietal (82.5%), followed by stellate (8.7%), frontotemporal (5.3%), and epipteric types (3.5%). The mean distances from the center of the pterion to the

frontozygomatic suture were measured as  $31.11 \pm 5.02$  mm and  $26.98 \pm 3.45$  mm; to the zygomatic arch,  $38.92 \pm 3.55$  mm and  $36.16 \pm 3.83$  mm; to the mastoid process,  $81.54 \pm 4.62$  mm and  $77.79 \pm 3.88$  mm; and to the external acoustic meatus,  $53.62 \pm 2.58$  mm and  $51.91 \pm 2.98$  mm, in males and females, respectively.

**Conclusion:** The pterion in the males was positioned at a higher point from the zygomatic arch than in females while sphenoparietal type of pterion predominates in the Sri Lankan population

**Keywords:** morphology, morphometry, pterion, variations

**Introduction**

The pterion is described as an irregular H-shaped sutural confluence formed by the frontal, parietal, squamous part of the temporal and greater wing of the sphenoid on the norma lateralis of the skull [1,2]. It is stated to lie approximately 4 cm above the zygomatic arch and 3.5 cm behind the



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frontozygomatic suture [2]. The pterion is an important neurosurgical landmark as it overlies both the anterior branch of the middle meningeal artery and the stem of the lateral (Sylvian) cerebral fissure [2]. In addition, structures such as the middle cerebral artery, anterior pole of the insula and the Broca's motor speech area in the dominant hemisphere are also related to the pterion [1,2].

The calvarium in the region of the pterion is particularly thin, making it vulnerable to fracture during trauma. An injury to this point of the skull would damage the anterior branch of the middle meningeal artery producing a significant extradural hematoma [3]. The pterional approach is one of the most commonly used neurosurgical approaches in surgical interventions dealing with extradural hemorrhages as well as tumors involving the inferior aspect of the frontal lobe, such as olfactory meningiomas [4], neurosurgical interventions involving the Brocas motor speech area [5], lipomas of the Sylvian fissure [6], and in repairing aneurysms of the middle cerebral artery as well as those of the upper basilar complex [7,8].

Even though the pterion serves as an important exrtacranial reference point in most neurosurgical approaches 6, its location cannot be easily determined. To ascertain its precise location various palpable bony landmarks have been utilized [5]. Significant variations have been reported in the literature with regard to the position of the pterion in relation to the to the zygomatic arch and frontozygamtic suture [5, 9-11].

Despite its neurosurgical significance, data pertaining to bony articulations or sutural morphology of the pterion, and its accurate anatomical location in Sri Lankans have been scarcely discussed. The present study was conducted to determine the morphology of the pterion, and its precise position with reference to surrounding anatomical landmarks in an adult Sri Lankan population.

### **Materials and Methods**

Fifty seven pteria in twenty nine adult dry skulls (16 male and 13 female) selected from the skeletal collection in the Department of Basic Sciences, Faculty of Dental Sciences, University of Peradeniya, Sri Lanka were analyzed. Approval for this study was granted by the Faculty Research Committee of the Faulty of Dental Sciences, University of Peradeniya (number FDS-FRC/2014/06). The sex and age of all skulls were retrieved from the personal records of body donors. The skulls with no apparent gross pathology, deformity, or traumatic lesions and those in which the suture pattern of the pterion could be clearly identified were included in the study. Skulls in which the pterion pattern could not be clearly identified owing to breakage or advanced synostosis were excluded.

The sutural pattern of the pterion was observed on both the left and right sides of each skull, and recorded based on Murphy's classification [15] (Figure 1. A-D).

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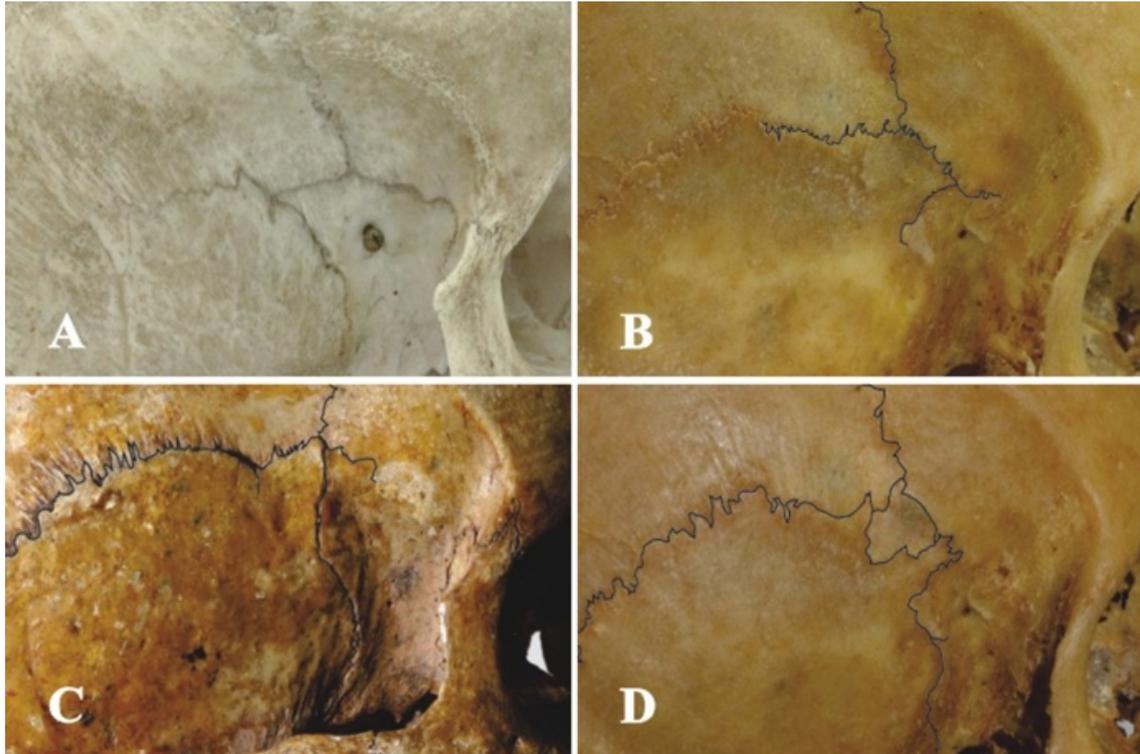


Figure 1: Types of pterion A - Sphenoparietal type of pterion, B - Frontotemporal type of pterion, C - Stellate type of pterion, D - Epipteretic type of pterion

Accordingly, the pterion is classified into four types, the sphenoparietal, frontotemporal, stellate and epipteretic, based on the bony articulations. In the sphenoparietal type the greater wing of the sphenoid and the parietal bone are in direct contact (Figure 1-A). The frontotemporal is the type where the frontal bone and squamous part of the temporal bone are in direct contact (Figure 1-B). The stellate type is where all the four bones articulate at one point to form a letter K (Figure 1-C), and the epipteretic type is where a sutural bone is lodged between the four bones forming the pterion (Figure 1-D). In addition, the following parameters on the right and left sides were measured using a digital vernier caliper to the nearest 0.01mm (Mitutoyo, Japan):

1. The linear distance from the center of the pterion to the posterolateral aspect of the frontozygomatic suture (P-FZS)
2. The vertical distance from the center of the pterion to the midpoint of the zygomatic arch (P-ZA)
3. The distance from the center of the pterion to the anterior and superior most point of the external auditory meatus (P-EAM)
4. The distance from the center of the pterion to the inferior most point of the mastoid process (P-MP)

All measurements were recorded by one investigator. In order to minimize the intraobserver error, three repeated measurements were made for each

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observation at different sittings and the average of the three measurements was taken for further analysis.

### Statistical analysis

Results were expressed as means and SDs and the differences in the distance between the pterion and selected anatomical landmarks between the sides and sexes were analyzed using the Students' t-test and a  $P < 0.05$  was considered as statistically significant. Statistical Package for Social Sciences (SPSS), 19<sup>th</sup> version was used for analyses.

### Results

The occurrence of different types of pteria in the male and female skulls is shown in Table 1.

The type of pteria observed on the right and left sides of the skulls are also presented in Table 1.

The sphenoparietal pterion was the most common type present on both right and left sides.

The means and associated standard deviations of measurements taken from the pteria to various anatomical landmarks are presented in Table 2.

The distances of the pterion to the frontozygomatic suture (P-FZS), midpoint of the zygomatic arch (P-ZA), anterior and superiormost point of the external auditory canal (P-EAC) and, the inferiormost point of the mastoid process (P-MP) were compared between the male and female skulls. A comparison between the left and right sides of the skulls was also done (Table 2).

Table 1: The incidence of different types of pteria on different sides and sexes

Type of pterion	Side			Sex		
	Right% (n=29)	Left% (n=28)	Total% (n=57)	Male % (n=31)	Female% (n=26)	Total % (n=57)
Sphenoparietal	79.4	85.7	82.5	91.4	73.1	82.5
Frontotemporal	7.0	3.6	5.3	3.2	7.6	5.3
Stellate	10.2	7.1	8.7	3.2	15.5	8.7
Epipteric	3.4	3.6	3.5	3.2	3.8	3.5

All four types of pteria described by Murphy [15] were observed. The sphenoparietal type was the predominant type in both males (91.4%) and females (73.1%). This was followed by the stellate type (15.5%) in females, and in males stellate, frontotemporal and epipteric types occurred in similar frequencies.

The study revealed significant differences in the position of the pterion between the sexes but the differences between the sides were not significant.

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Table 2: Means and standard deviations of the linear distances (in mm) between the pterion and specific landmarks according to the side and sex of crania

Distance (mm)	Side		p-value	Sex		
	Right(n=29)	Left (n=28)		Male(n=29)	Female(n=22)	p-value
	Mean±SD	Mean±SD		Mean±SD	Mean±SD	
P- FZS	28.99±5.03	29.59±4.75	$P > 0.05$	31.11±5.02	26.98±3.45	$P < 0.05$
P-ZA	37.20±4.52	38.54±3.10	$P > 0.05$	38.92±3.55	36.16±3.83	$P > 0.05$
P-EAM	52.90±2.95	52.87±2.83	$P > 0.05$	53.62±2.58	51.91±2.98	$P < 0.05$
P-MP	80.61±5.05	79.36±4.35	$P > 0.05$	81.54±4.62	77.79±3.88	$P < 0.05$

## Discussion

The pterion is an important neurosurgical landmark as it is the primary site for pterional surgical approach used for a variety of anterior and middle cranial fossae pathologies. Hence, it is essential for a neurosurgeon to be familiar with the sutural morphology and precise position of the pterion prior to surgery.

Standard texts in anatomy define the pterion as an H-shaped suture at the junction of frontal, parietal, greater wing of the sphenoid and the squamous part of temporal bones [1,2]. Although this is consistent with the majority of skulls, it ignores a large mass of evidence regarding other types of pteria present among different populations. In the present study all four types of pteria described by Murphy [15] were observed. The present study also revealed a predominance of the sphenoparietal type as has been observed in Nigerians [12, 16], Indians [9], Australian Aborigines [15], Turks [10, 17], Thais [5] and the Japanese [18] (Table 3).

The incidence of the frontotemporal type of pterion vary in different groups, being reported as 7.7% in Australian aborigines [15], 10% in Turks [17], 8.3-19.6.% in Nigerians [12, 16], 15% in Kenyans [13], 1.1% in both Thai [5] and West Anatolians [10]. The frontotemporal type occurred in 5.3% of skulls in the present study, which is relatively low when compared to Turks, Kenyans and Nigerians, but high when compared to West Anatolians and Thai populations.

The incidence of stellate type in the current study was 8.7%. The incidence of stellate type is reported to be higher in the Japanese [18] The stellate type was absent in all male skulls in a Turkish population [17] while its incidence in the Thai population was reported to be very low [5] (Table 3). An epipteric type of pterion was observed in a small number of skulls (3.5%) in the present study. This is significantly less than that reported in Australian Aborigine (18.3%) [15] and the Thai (17.4%) populations [5]. From the perspective of a neurosurgeon, this knowledge of variations in the sutural

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Table 3: A comparison of the incidence of different types of pteria in different populations as reported in previous studies

Author	Ethnicity	Type of pterion			
		Sphenoparietal	Frontotemporal	Stellate	Epipteric
Murphy [15]	Australian aborigines	73.2	7.7	0.7	18.3
Aksu et al. [10]	West Anatolian	85.2	1.1	5.5	8.2
Mwachaka et al. [13]	Kenyan	66	15	12	07
Kamath et al. [9]	Indian	79.25	10.25	6.3	4.2
Ukoha et al. [16]	Nigerian	75.5	19.6	1.8	3.6
Apinhasmit et al. [5]	Thai	81.2	1.1	0.4	17.4
Oguz et al. [17]	Turkish	88	10	0	2
Matsumara et al. [18]	Japanese	79.1	2.6	17.7	0.6
Adejuwon et al. [12]	Nigerian	86.1%	8.3%	5.6	0
Present study	Sri Lankan	82.5	5.3	8.7	3.5

morphology is important to avoid untoward surgical complications.

Although the actual determinants of the formation of pterion are not recognized, cranial suture morphogenesis and calvarial bone development is thought to be under genetic influence especially the MSX2 gene [19]. Further, it is reported that the development of calvarial bones is tightly coordinated with the growth of the brain and requires interactions between different tissues within the calvarial sutures [20]. Wang et al [21] hypothesized that skulls with higher ratios of cranial height over cranial length such as in humans are more likely to be subjected to neurocranial growth forces causing the sphenoid bone and parietal bone to meet each other, while skulls in monkeys having very low cranial length-height index are less likely to have this articulation. Hence, a

sphenoparietal pattern of suture predominates in humans while the frontotemporal pterion predominates in primates.

Diverse anatomical landmarks such as the FZS, ZA, glabella, temporozygomatic suture, base of the mandibular fossa, MP have been employed to localize the pterion in previous studies [5, 9-12]. The FZS and ZA are the widely utilized anatomical landmarks to predict the location. The present study also describes the centre of the pterion to be measured as a linear distance above the midpoint of the zygoma and posterior to the posterolateral margin of the FZS. In addition, we utilized the EAM and MP which are easily identifiable and palpable clinically on a patient to localize the pterion.

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### **The pterion and zygomatic arch**

In the present study, the pterion was located  $37.20 \pm 4.52$  mm and  $38.54 \pm 3.10$  mm above the ZA on the right and left side, respectively. In a West Anatolian population [10] the pterion was located  $40.02 \pm 4.06$  mm and  $39.88 \pm 4.01$  mm above the zygoma on the right and left side, respectively. Similarly, in a Turkish population [17] the mean distance between pterion and the ZA was found to be  $40.5 \pm 3.9$  mm and  $38.5 \pm 2.5$  mm on the right and left side, respectively. In a study on Thai skulls [5] the pterion was typically located  $38.48 \pm 4.38$  mm superior to the ZA. In a comparative study between the Nigerian and Indian skulls, the mean distance between the center of the pterion and the ZA was 39.6 mm and 38.6 mm, and 37.8 mm and 36.1 mm in Nigerians and in Indians, on the right and the left sides, respectively [23].

A comparison of the position of the pterion in males and females and on the right and left sides of crania of different population groups as reported in previous studies are summarized in Table 4.

The position of the pterion in relation to the ZA in the present sample is relatively similar to those reported by Rao et al. [24] in an Indian population. It is widely reported that the pterion of males is positioned at a higher location than in females [9, 12, 14]. The present study too demonstrated a similar observation.

### The pterion and FZS

The pterion has been reported to lie 30.0 to 35.0 mm behind the FZS [1, 2]. The current study demonstrated that the pterion was located  $29.00 \pm 5.03$  mm and  $29.60 \pm 4.75$  mm posterior to the FZS on the right and left side, respectively. In a study among male Turks, [17] the pterion was located  $33.0 \pm 4.0$  mm and  $34.4 \pm 3.9$  mm behind the FZS on the right and left side, respectively. Higher values observed in the study of Turks could be attributed to the fact that the sample consisted of only male skulls. It is well documented that male skulls have larger dimensions than those of females [1]. It is interesting to note that in the study done on Nigerian male skulls [16], the pterion was located  $27.4 \pm 0.70$  mm and  $27.4 \pm 0.60$  mm on the right and left side, respectively. Lee et al. [25] on a sample of Korean skulls reported that the pterion was located  $26.8 \pm 4.5$  mm from the FZS, while Ma et al. [26] observed that the pterion was located at a mean of  $26.6 \pm 4$  mm behind the posterolateral margin of the FZS in a sample of Indian skulls. In the present study, in males and females, the pterion was located  $31.11 \pm 5.02$  mm and  $26.98 \pm 3.45$  behind the FZS. It is important to note that the position of the pterion varies in different population groups and that it is closer to the FZS than reported in some previous studies [17] and textbooks [2]. The basis for these population based differences has been attributed to genetic and environmental factors.

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Table 4. A comparison of pterion position in males (m) and females (f) and on the right (r) and left (l) sides of crania of different population groups as reported in previous studies

Author	P-ZA	P-FZS	P-EAC	P-MP
Rao et al., South India [24]	(r)37.74±3.66 (l)37.07±4.19	(r)30.48±4.06 (l)30.39±4.70	(r)51.81±4.08 (l)51.54±3.89	(r)80.40±6.43 (l)79.68±6.08
Aksu et al., West Anatolia [10]	(r)40.02 (4.06) (l)39.88 (4.01)	(r)31.80±4.51 (l)31.44±4.73	(r)53.29±4.55 (l)56.22±0.60	(r)82.48 (5.45) (l)81.81(5.50)
Kamath et al., India [9]	(r) 36.09±4.00 (l) 35.45±3.77 (m)36.85±4.12 (f)34.35±3.18	(r) 31.00±4.10 (l) 30.92±4.13 (m)31.90±4.14 (f) 29.72±3.75		
Apinhasmit et al., Thailand [5]	38.48±4.38	31.12± 4.89		
Oguz et al., Turkey [17]	(r)40.5±3.9 (l)38.5±2.5	(r)33.0±4.0 (l)34.4±3.9		
Adejuwon et al., Nigeria [12]	(m)39.74±0.51 (f) 37.95±0.66 (r) 39.1±0.58 (l) 38.77±0.63	(m)31.87±0.64 (f)30.35±0.84 (r)31.52±0.68 (l)30.82±0.81		
Present study	(m)38.92±3.55 (f)36.16±3.83 (r)37.20±4.52 (l) 38.54±3.10	(m)31.11±5.02 (f)26.98±3.45 (r) 29.00±5.03 (l) 29.60±4.75	(m)53.62±2.58 (f) 51.91± 2.98 (r) 52.90±2.95 (l) 52.87±2.83	(m)81.54±4.62 (f) 77.79±3.88 (r) 80.61±5.05 (l) 79.36±4.35

### The pterion and EAM

In this study, the mean distance between the center of the pterion and the anterior and superior most point of the EAM was measured as  $52.90 \pm 2.95$  mm and  $52.87 \pm 2.83$  mm on the right and left side, respectively. Although this landmark is easily identifiable and palpable, very few studies have investigated its utility in localizing the pterion. Previously, Aksu et al. [10] has reported this measurement to be  $53.29 \pm 4.55$  mm and  $56.22 \pm 4.60$  mm on the right and left side, respectively, in West Anatolians, while Rao et al. [24] reported them as  $51.81 \pm 4.08$  and  $51.54 \pm 3.89$  in a south Indian

population. Although we did not detect any differences between the sides in this measurement, the difference between males and females was significant ( $p < 0.05$ ). The difference between males and females has not been investigated in previous studies of Aksu et al. [10] and Rao et al. [24] as the samples of these studies consisted of skulls of unknown sex.

### The pterion and MP

The mean distance between the pterion and inferior most point of the MP was  $81.54 \pm 4.62$  mm and  $77.79 \pm 3.88$  mm in males and females, respectively, and

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80.61± 5.05 and 79.36 ±4.35 on the right and left side, respectively. The difference in relation to sex was significant while the side differences showed no significance.

The present study demonstrates significant differences in the distances of the P- FZS, P-ZA, P-EAM and P-MP in relation to sex indicating that the position of the pterion exhibits sex dimorphism. As most studies are based on skulls of unknown sex, the sex dimorphism in the position of the pterion has not been analyzed.

However, in a study by Kamath et al. [9] in skulls of known sex in an Indian population, significant sex differences were observed in relation to P-ZA and P- FZ. Their study however, did not analyze the distance of P-EAM and P-MP.

Interestingly, the position of the pterion in relation to ZA, PFZ, EAM and MP did not display any significant side related differences in our sample, suggesting that the location of the pterion is bilaterally symmetrical in any one individual (Table 2). Similar observations have been reported in other investigations conducted in Nigerian [12], Anatolian [11] and in Indian [9] skulls. In a study done in Indian skulls [26] the center of the pterion was found to be at a mean distance of 26 mm behind and 11 mm above the posterolateral margin of the FZS. According to Ma et al. [26] these measurements were both reliable and remarkably consistent between sides and sexes. However, Apinhasmit in their study involving 268 Thai skulls

observed statistically significant side differences in the position of the pterion.

## Conclusion

The pterional approach has been the most commonly used method in neurosurgery to approach pathologies of the anterior and middle cranial fossae such as aneurysms, olfactory meningiomas and Sylvian fissure lipomas. The present study has shown that sphenoparietal type of pterion predominates in the Sri Lankan population. A detailed knowledge of different bony articulations of the pterion and its precise position in relation to various palpable bony landmarks would be of immense benefit to surgeons while performing the pterional approach.

## Conflict of interests

None declared.

## Acknowledgments

The authors wish to thank Mr. Vinod Viduranga, Audiovisual Technical Officer, Mr Manjula Dissanayake, Department of Basic Sciences, Faculty of Dental Sciences, University of Peradeniya, for the technical support provided.

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