RESEARCH PAPER

Morphometric study of pterion and its relation with middle meningeal artery in dry human skulls

Devendra Pal Singh[1], Ganesh Khemnar[2]

[1] Ph.D Student, Department of Anatomy, Pacific Institute of Medical Science, Sai Tirupati University, Udaipur, Rajasthan

[2] Professor & HOD, Department of Anatomy, Pacific Institute of Medical Science, Sai Tirupati University, Udaipur, Rajasthan

Corresponding Author: Devendra Pal Singh, Email: devendr1189@gmail.com

Received: 2nd Mar, 2026 | **Revised:** 14th Mar, 2026 | **Accepted:** 4th Apr, 2026 | **Available Online:** 20th Apr, 2026

ABSTRACT

The pterion is an important clinically significant landmark located on the lateral aspect of skull (norma lateralis), where four bones named frontal bone, sphenoid bone, parietal bone and temporal bone meet and is closely related with the middle meningeal artery (MMA). Variation in morphology and positioning of pterion are utmost important during the neurosurgical procedure, especially in pterional craniotomy and the management of the extradural hematoma.

Aim: To study the morphological types of the pterion and evaluation of its morphometric relationship with the middle meningeal artery in dry human skulls.

Material and method: A cross sectional, observational study was conducted on 100 dry human skulls with the unknown age and gender obtained from the Department of Anatomy, Pacific Institute of Medical Sciences, Sai Tirupati University, Udaipur, Rajasthan. According to the Murphy's classification, pterion were classified as Sphenoparietal, Frontotemporal, Stellate and Epipteric. From pterion to the different cranial landmark, the distance was measured from the center of the pterion to the frontozygomatic suture, external auditory meatus, mastoid process and optic canal. For locating the center of pterion, perpendicular bisector theorem was considered.

Result: The sphenoparietal type of pterion was the most common. Sphenoparietal 104 types of pterions was found to be the commonest followed by frontotemporal 46, stellate 28, and epipteric 22. The overall mean distance from the center of pterion to the groove for middle meningeal artery (MMA) was 11.76mm. Statistically significant differences were observed between pterion types and their vicinity to MMA.

Conclusion: The pterion shows significant morphological and morphometric variation with important clinical implications. Knowledge of these variations is essential to reduce clinical complications during cranial surgical procedures.

Keywords: Pterion, Pterional craniotomy, Middle meningeal artery, Morphometry, Dry skulls.

How to cite this article: Singh DP, Khemnar G. Morphometric study of pterion and its relation with middle meningeal artery in dry human skulls. Int J Drug Deliv Technol. 2026;16(32s):807-811. DOI: 10.25258/ijddt.16.32s.89

Source of support: Nil.

Conflict of interest: The authors declare no conflict of interest.

Introduction

The pterion is a clinically significant landmark situated on the lateral surface of the skulls in norma lateralis. Pterion is formed by the union of four cranial bones like frontal bone, parietal bone, sphenoid bone and temporal bone [1,2]. These four bones are united with each other and formed a H shaped cranial suture. This H shaped cranial suture formed by union of four cranial bones is called pterion. It represents a thinnest area of the cranial vault and related to the vital neurovascular structures, particularly the anterior branch of the middle meningeal artery (MMA) [3-5]. Due to pterional anatomically vulnerability, the pterion is frequently involved in traumatic injuries and it is a key access point in neurosurgical procedure such as pterional craniotomy [6,7]. Based on Murphy's classification the morphological variation of the pterion types has been classified into sphenoparietal, frontotemporal, stellate, and epipteric type of pterions [8-10]. These variation shows populations-based differences and it may impact on

the surgical approaches, radiological interpretation and the risk of vascular injuries [11-13]. Several studies conducted in Indian population has been consistently reported and the widely spread pterional type was the sphenoparietal type of pterion [14-17].

The middle meningeal artery arises from the first (mandibular) part of maxillary artery, which is one of the terminal branches of external carotid artery. The middle meningeal artery (MMA) is the largest and most clinically significant meningeal artery. It is the principal arterial supply to the dura mater in the cranial cavity it enters into the cranial cavity through the foramen spinosum and supply the dura mater [18-19]. The close proximity of middle meningeal artery with the pterion making it more vulnerable to the injuries during cranial trauma or surgical intervention, often resulting in extradural hematoma. Therefore, the detailed morphometry evaluation of the pterion in relation with the middle meningeal artery (MMA) and surrounding anatomical landmarks is essential for harmless surgical planning [20-24].

Materials and Methods

Study design: Cross sectional study

Sample size: 100 dry human skulls.

Inclusion criteria

- Dry human skulls
- Properly intact pterion
- Clearly visible the sutural pattern

Exclusion criteria

- Damaged and absent pterion
- Cranial trauma
- Unossified bone
- Absence of groove for middle meningeal artery.

Methodology

According to Murphy's classification pterion was classified into four types-sphenoparietal, frontotemporal, stellate and epipteric pterion. The center the pterion was determined using the perpendicular bisector method. Distance from the pterion to the frontozygomatic suture (P-FZ), external auditory meatus (P-EAM), mastoid process (P-PM), optic canal (P-OC) and the distance from the pterion to the groove for middle meningeal artery on the internal aspect were measured with the help of vernier caliper. Each measurement was recorded twice and an averaged to ensure the accuracy. High resolution was taken for documentations.

Statistical analysis

The data was entered into the Microsoft excel in the frequency, percentage and descriptive statistics; t-tests, chi-square tests, and correlation analyses was performed. p-value <0.05 was considered statistically significant.

Result

The current study was performed on the 100 dry human skulls, there is 100 on right side of skulls and 100 on left side of the skulls, pterion was measured. The sphenoparietal types of pteron was the most frequently observed pterion 104 (52%), followed by frontotemporal 46 (23%), stellate 28 (14%) and epipteric types 22 (11%) [Table/Fig-1]. According to the murphy's classification four types of normal pterion was found in the current study [Table/Fig-1]. Measurements were recorded from the midpoint of pterion to the different landmarks was represented a mean and standard deviation in [Table/Fig.-2]. On the Norma Lateralis of the skull FZ was at the distance of 32.74 on left side and at a mean distance of 32.69 on the right side from the midpoint of the pterion. At anterosuperior margin of external acoustic meatus the Mean P-EAM distance was 55.27 and 55.28 on the left and right side respectively and 62.32 on the left side and 62.32 on the right side of the anteroinferior margin of mastoid process respectively. On the other hand internal aspect of the skull the midpoint of the pterion at the mean distance of 40.45 mm (left) and 40.44 mm (right) away from the lateral margin of optic canal. Based on the distance from the pterion to the MMA, the table-3 classifies skulls into three categories: less than 10 mm, 10-15 mm, and greater than 15 mm. Among skulls of the sphenoparietal type, 45% have the middle meningeal artery (MMA) situated within a distance of less than 10 mm, 35% fall between 10 to 15 mm, and 20% are more than 15 mm from the MMA. 40% of skulls in the frontotemporal group are less than 10 mm, 40% are between 10-15 mm, and 20% are more than 15 mm. Of the stellate type skulls, 50% fall within the distance range of less than 10 mm, 30% fall within the range of 10-15 mm, and 20% extend beyond 15 mm. The epipteric type is characterised by 42% of skulls having a middle meningeal artery (MMA) less than 10 mm, 38% falling between 10-15 mm, and 20% exceeding 15 mm. This table offers a visual representation of the spatial correlation between the pterion and MMA across several types of pterions.

Types of pterion	Total (n = 200) n(%)	Side	
		Left (n=100) n(%)	Right (n=100) (%)
Sphenoparietal	104 (52%)	56	48
Fronto-	46	25	21

temporal	(23%)		
Stellate	28 (14%)	12	16
Epipteric	22 (11%)	7	15
Total	200	100	100

Table 1: Number of skull bone 100, distribution of Pterion Types (N=200) both sides:

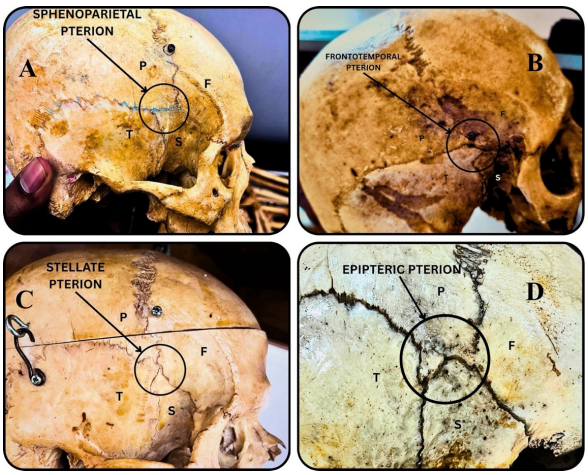

Fig. 1: Lateral view of skulls showing four types of pterion: (A) Sphenoparietal type (B) Frontotemporal type (C) Stellate type (D) Epipteric type.

Landmarks from the pterion	Left-side (n=100)		Right-side (n=100)		t-value	p-value
	Mean	SD	Mean	SD		
Pterion to frontozygomatic suture (P-FZ)	32.74	0.42	32.69	0.37	0.89	0.37
Pterion to external auditory meatus (P-EAM)	55.27	0.25	55.28	0.15	0.34	0.73
Pterion to mastoid process (P-PM)	62.32	0.18	62.32	0.15	0.00	1.00
Pterion to optic canal (P-OC)	40.45	0.26	40.44	0.22	0.29	0.77

Table 2: Comparison of Distances from Pterion to Adjacent Cranial Landmarks on Both Sides.

Pterion Type	<10 mm from MMA (%)	10-15 mm from MMA (%)	>15 mm from MMA (%)
Sphenoparietal	45	35	20
Frontotemporal	40	40	20
Stellate	50	30	20
Epipteric	42	38	20

Table 3: Distribution of MMA Proximity by Pterion Type:

Pterion Type	Mean (mm)	SD (mm)	n	p-value
Sphenoparietal	10	0.3	104	<0.001
Frontotemporal	11.8	0.5	46	0.581
Stellate	15.6	0.6	28	<0.001
Epipteric	15.1	1.3	22	<0.001

Table 4: Association Between Pterion Type and Proximity to Middle Meningeal Artery:

The overall mean distance of the middle meningeal artery (MMA) from the pterion was 11.76 mm[Table/Fig.-4]. On comparison with this reference value, the mean distance for the sphenoparietal (10.0 ± 0.3 mm), stellate (15.6 ± 0.6 mm), and epipteric (15.1 ± 1.3 mm) types was found to be highly significant ($p < 0.001$). In contrast, the frontotemporal type (11.8 ± 0.5 mm) did not show a statistically significant difference from the overall mean ($p = 0.581$).

Calculation

Overall mean $= \sum(\text{mean} \times n) / (\sum n)$

Sphenoparietal $\rightarrow 10 \times 104 = 1040$

Frontotemporal $\rightarrow 11.8 \times 46 = 542.8$

Stellate $\rightarrow 15.6 \times 28 = 436.8$

Epipteric $\rightarrow 15.1 \times 22 = 332.2$

Sum $= 1040 + 542.8 + 436.8 + 332.2 = 2351.8$

Total n = 104 + 46 + 28 + 22 = 200

=(10×104 + 11.8×46 + 15.6×28 + 15.1×22) / (104+46+28+22) = 2351.8 / 200 = 11.76 mm

Discussion

This present study was conducted on an amount of 200 pterion types both side of the skull left and right out of 100 skulls. The most commonest type of pterion observed in this study was sphenoparietal type of pterion which coincides with the other studies.

Gaining a comprehensive understanding of the complex anatomical variations of the pterion and its connection to adjacent structures is essential for enhancing surgical results and spreading knowledge in clinical anatomy.

The present study demonstrates the predominance of the sphenoparietal type of pterion, a finding consistent with previous studies conducted in Indian and other populations. This supports the concept that the sphenoparietal configuration represents the most stable anatomical pattern [14-17]. The mean distance between the pterion and MMA observed in this study bring into line with earlier morphometric analyses highlighting the close anatomical relationship between these structures [18-20,22]. Significant variations were noted between different types of pterion, particularly stellate and epipteric types, which may stance a higher surgical risk. The moderate correlation between pterion distances and surface landmarks supports the use of these landmarks during neurosurgical procedures, especially in resource-limited surroundings [21–23]. Bilateral symmetry observed in this study further validates the reliability of standardized anatomical reference points. Overall, the findings emphasize the importance of understanding pterion morphology and its vascular relationships to minimize complications during cranial surgeries [24].

Conclusion

The pterion exhibits significant morphological and morphometric variations with a close anatomical relationship to the middle meningeal artery.

Knowledge of these variations is essential for neurosurgeons to reduce intraoperative vascular injury and improve surgical outcomes. The data provided by this study contribute valuable population-specific anatomical information for clinical and academic use.

Bibliography

1. Muche A. Positions and types of pterion in adult human skulls: a preliminary study. **Ethiop J Health Sci.** 2021;31(4):875–884. doi:10.4314/ejhs.v31i4.23
2. Nayak GY, Mohanty BB, Das SR. Morphometric study of pterion and its clinical significance. **Asian J Pharm Clin Res.** 2017;10(10):142–144.
3. Plummer SC. Research on the surgical anatomy of the middle meningeal artery. **Ann Surg.** 1896;23(5):540–572.
4. Sant'Anna MAF, Luciano LL, Chaves PHS, et al. Anatomy of the middle meningeal artery. **Arq Bras Neurocir.** 2021;40(4):e339–e348.
5. Martínez JL, Domingo RA, Sattur M, et al. The middle meningeal artery: branches, dangerous anastomoses, and implications in neurosurgery and neuroendovascular surgery. **Oper Neurosurg.** 2022;22(1):1–13.
6. Kresimir Lukic I, Gluncic V, Marusic A. Extracranial branches of the middle meningeal artery. **Clin Anat.** 2001;14(4):292–294.
7. McLennan JE, Rosenbaum AE, Haughton V. Internal carotid origins of the middle meningeal artery. **Neuroradiology.** 1974;7(5):265–275.
8. Chmielewski P, Skrzat J, Walocha J. Clinical importance of the middle meningeal artery. **Folia Med Cracov.** 2013;53(1):41–46.
9. Baugnon KL, Hudgins PA. Skull base fractures and their complications. **Neuroimaging Clin N Am.** 2014;24(3):439–465.
10. Gindha GS, Mir NS, Agarwal R. Morphometric study of pterion in dry human skull bone in North Indian population. **Hum Biol Rev.** 2017;6(1).
11. Vikram Rao KE, Rao BS, Vinil BH. Morphology and morphometric analysis of pterion with its neurosurgical implications. **Int J Anat Res.** 2017;5(1):3384–3388.
12. Priya A, Jain A. Morphological and morphometric study of pterion in adult dry human skulls. **Acad Anat Int.** 2020;6(2):63–68. doi:10.21276/aanat.2020.6.2.14
13. Gupta V, Sharma A, Kapoor K. Pterion: morphometry and surgical significance. **Int J Anat Res.** 2022;10:8197–8205. doi:10.16965/ijar.2021.185
14. Roy P, Deb N, Kar M, Khatun A. Location and morphological study of pterion – a landmark for keyhole neurosurgical

procedures. **J Clin Sci Res.** 2023;12(1):24–27.

15. Aggarwal N, Kaur N, Patra A, Gupta M. Analysis of the variations in the morphology and topography of the pterion and their implications in neurosurgery. **Asian J Neurosurg.** 2023;18(3):581–586. doi:10.1055/s-0043-1772759
16. Tolahunase MR, Gagare DB, Rajaneesh TS. Morphology of pterion and analysis of epipteric subtype in Indian population. **Int J Pharm Clin Res.** 2024;16(3):68–75.
17. Silva TH, Ellwanger JH, Moraes D, et al. Morphometric analysis of the middle meningeal artery organization in humans. **J Neurol Surg B Skull Base.** 2013;74(2):108–112.