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Anatomy

Metopic Suture in Adult North Indian Skulls: A Case Series with Morphological and Clinical Observations

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Abstract **Original Research Article**

Introduction: The metopic suture, also known as the frontal suture, is a vertical fibrous suture located between the two halves of the frontal bone. It extends approximately from the nasion to the bregma and normally undergoes progressive obliteration during childhood. Persistence of the complete metopic suture into adulthood is termed metopism, whereas incomplete persistence is described as a partial metopic suture. Although generally considered an anatomical variant, recognition of a persistent metopic suture is important because it may mimic a frontal bone fracture on radiological imaging. ***Materials and Methods:*** The present observational study was conducted on 146 dry adult human skulls obtained from the Department of Anatomy, Adesh Institute of Medical Sciences and Research, Bathinda. The skulls were examined macroscopically for the presence or absence of a persistent metopic suture. The persistent sutures were categorized as complete or partial, and their morphological pattern was recorded as linear or non-linear. ***Results:*** Among the 146 adult skulls examined, persistent metopic sutures were identified in 5 skulls (3.42%). Complete metopic sutures were observed in 3 skulls (2.05%), while partial metopic sutures were present in 2 skulls (1.36%). Four metopic sutures were classified as linear (2.73% of the total skulls) and one was non-linear (0.68%). ***Conclusion:*** The present study demonstrates the persistence of metopic sutures in a North Indian skull sample, with complete metopism observed in 2.05% of the skulls. Awareness of this anatomical variation is important in anatomy, radiology, neurosurgery and forensic medicine because a persistent metopic suture may be mistaken for a frontal bone fracture.

Keywords: Metopic suture; metopism; frontal bone; cranial sutures; anatomical variation; North Indian population.

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INTRODUCTION

The frontal bone develops from two membranous ossification centers that are initially separated by a median frontal or metopic suture. The metopic suture extends between the nasion and bregma and normally undergoes progressive fusion during childhood. Persistence of this suture into adult life is referred to as metopism. [1,2] The timing of physiological closure shows some variation between individuals and populations.[2]

The metopic suture is of particular anatomical and clinical interest because its persistence represents a normal anatomical variant rather than a pathological defect. Complete persistence extending from the nasion to the bregma is generally termed complete metopism, whereas persistence involving only a portion of the frontal bone is described as an incomplete or partial metopic suture. [1,3]

The incidence of metopism varies considerably among different populations. Agarwal *et al.,*in a large study of 1276 adult Indian skulls, reported complete metopism in 2.66% of skulls. [4] Yadav *et al.,* examined 1020 adult skulls from North India and found complete metopism in 3.5% of skulls, while partially persistent metopic sutures were considerably more frequent.[5] Mangalgiri *et al.,* reported complete metopism in 3.95% of 253 adult skulls from Central India.[6] These findings indicate regional and population-related variation in the persistence of the metopic suture.

Morphological variation of the metopic suture has also been documented. Murlimanju *et al.,* observed complete and incomplete forms and described incomplete sutures with linear, V-shaped and double patterns.[3] Similarly, Andrade *et al.,* reported complete, linear, V-shaped, U-shaped and Y-shaped forms in adult dry skulls from coastal Karnataka.[7] More recently, Sharma *et al.,* reported metopic sutures in 3.7% of 54 adult dry skulls and emphasized the importance of differentiating metopism from a frontal bone fracture.[8]

The clinical importance of recognizing a persistent metopic suture is particularly relevant in radiology and trauma. On skull radiographs or computed tomography, a persistent metopic suture may resemble a linear fracture. Knowledge of its typical anatomical location and appearance can therefore prevent misinterpretation. [3,8] It is also of interest in forensic anthropology because cranial sutural variations contribute to the assessment of population variation and skeletal morphology.

Despite several studies from different regions of India, regional data remain useful because the frequency and morphology of metopic sutures vary between populations. Therefore, the present study was undertaken to determine the prevalence of complete and partial metopic sutures and to document their morphological patterns in adult dry skulls representing the North Indian population.

MATERIALS AND METHODS

Study Design and Setting

The present study was conducted as a descriptive observational osteological case series in the Department of Anatomy, Adesh Institute of Medical Sciences and Research (AIMSR), Bathinda, Punjab, India. The study was undertaken to document the occurrence, extent and morphological pattern of persistent metopic sutures in adult human skulls.

Study Material

A total of 146 dry adult human skulls available in the Department of Anatomy, AIMSR, Bathinda, were included in the study. The skulls represented the North Indian population as documented in the departmental osteological collection. Each skull was examined individually for the presence of a persistent metopic suture.

Examination of Skulls

The skulls were examined macroscopically from the anterior aspect. Particular attention was given to the midline of the frontal bone extending from the Nasion to the Bregma, corresponding to the anatomical course of the metopic suture.

Each skull was carefully inspected for the presence or absence of a visible persistent metopic suture. The identified sutures were documented photographically for morphological assessment.

Classification of Metopic Sutures

The persistent metopic sutures identified during examination were classified according to their extent of persistence into:

- **Complete metopic suture:** persistence of the suture along the frontal midline extending from the nasion toward the bregma (Image 1).
- **Partial metopic suture:** persistence of the suture involving only a portion of the frontal bone (Image 2).

The identified sutures were further categorized morphologically into:

- **Linear type:** a relatively straight and continuous sutural line (Image 1).
- **Non-linear type:** a suture showing deviation from a simple linear configuration (Image 3).

The number of skulls demonstrating each type was recorded.

Data Recording and Analysis

The total number of skulls examined and the number showing persistent metopic sutures were recorded. The prevalence was calculated as the number of skulls demonstrating a particular metopic suture pattern divided by the total number of skulls examined, expressed as a percentage.

The following parameters were recorded:

1. Presence or absence of a persistent metopic suture.
2. Extent of persistence—complete or partial.
3. Morphological pattern—linear or non-linear.

The findings were summarized using descriptive statistics**,** including frequencies and percentages.

Ethical Considerations

As the study involved examination of dry adult human skulls from the departmental osteological collection and did not involve living human participants or collection of personal clinical information, no direct participant intervention was involved. The study was conducted in accordance with the institutional requirements governing the academic use of anatomical specimens.

RESULTS

A total of 146 adult dry skulls were examined. Persistent metopic sutures were identified in 5 skulls, giving an overall prevalence of 3.42%. The remaining 141 skulls (96.58%) did not show a persistent metopic suture.

Table 1: Distribution of metopic suture among the studied skulls

Finding	Number	Percentage
No persistent metopic suture	141	96.58%
Persistent metopic suture	5	3.42%
Total	**146**	**100%**

Among the five skulls demonstrating a persistent metopic suture, 3 were complete and 2 were partial. Thus, complete metopism was observed in 2.05% of the total skulls, while partial metopic sutures were observed in 1.36%. These findings correspond to the observations documented in the original study presentation.

Table 2: Distribution according to extent of metopic suture

Type	Number	Percentage of total skulls
Complete	3	2.05%
Partial	2	1.36%
Total	**5**	**3.42%**

With regard to morphology, 4 sutures were linear, accounting for 2.73% of all examined skulls, while 1 was non-linear, accounting for 0.68%.

Table 3: Morphological pattern of persistent metopic sutures

Morphological type	Number	Percentage of total skulls
Linear	4	2.73%
Non-linear	1	0.68%
Total	**5**	**3.42%**

Thus, among the five skulls with persistent metopic sutures, the linear pattern constituted 80% (4/5) and the non-linear pattern constituted 20% (1/5).

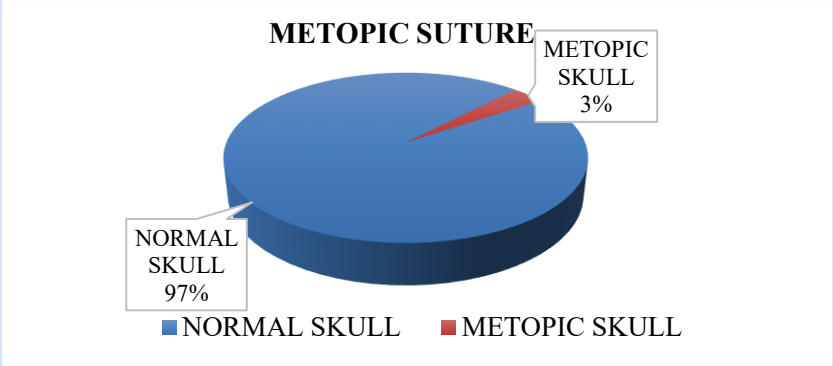




Image 1: Complete and Linear



Image 2: Partial and Linear



Image 3: Non-Linear

DISCUSSION

The present case series evaluated 146 adult dry skulls and identified persistent metopic sutures in 5 skulls (3.42%). Complete metopism was observed in 3 skulls (2.05%), whereas partial persistence was observed in 2 skulls (1.36%). The morphological assessment showed that four of the five persistent sutures were linear, while one demonstrated a non-linear configuration.

The prevalence of complete metopism in the present case series is comparable with several previously reported Indian studies. Agarwal *et al.,* examined 1276 adult Indian skulls and reported complete metopism in 2.66% of skulls.[4] Yadav *et al.,* in a large North Indian study involving 1020 skulls, reported complete metopic sutures in 3.5% of cases.[5] The 2.05% prevalence of complete metopism observed in the present series therefore falls within the range reported in Indian populations.

Mangalgiri *et al.,* studied 253 adult skulls from Central India and reported complete metopism in 3.95% of skulls.[6] Their findings, together with those of Yadav *et al.,* demonstrate that the prevalence of metopism can vary considerably between different Indian populations. Such variation may be related to geographical and population differences, sample size and differences in the criteria used for defining complete and incomplete metopic sutures.

A particularly relevant comparison is provided by Yadav *et al.,* who studied adult skulls from North India. They identified a metopic suture of some form in 184 of 1020 skulls (18.04%), including 36 complete sutures (3.5%) and 148 partially obliterated sutures (14.6%).[5] In comparison, the present case series identified persistent metopic sutures in 5 of 146 skulls (3.42%). The difference in overall prevalence may partly be explained by differences in the definition of partial metopic suture and the extent of residual suture considered significant. Therefore, comparisons between studies should take into account the classification system used.

Gupta *et al.,* specifically investigated metopism in adult North Indian skulls from Uttar Pradesh. Their study included 40 skulls, of which 2 skulls (5%) demonstrated metopism.[9] The authors emphasized the regional significance of metopic suture variation and its

potential to simulate a frontal bone fracture on radiographs.[9] The prevalence of complete metopism in their study was somewhat higher than that observed in the present series (2.05%), although the smaller sample size of their study should be considered when comparing the two findings. Their observation nevertheless supports the occurrence of persistent metopic sutures within North Indian populations.

Kundu *et al.,* examined 133 adult dry skulls from Eastern India and found a considerably different pattern of metopic suture persistence. Only one skull (0.82%) showed a complete metopic suture, while incomplete forms were observed in a substantial proportion of the sample. Their morphological classification included V-shaped (11.47%), U-shaped (9.02%), Y-shaped (4.92%) and linear (13.94%) incomplete sutures.[12] In the present case series, four of the five persistent sutures were categorized as linear and one as non-linear. Although our classification was less detailed, the findings of Kundu *et al.,* demonstrate that persistent metopic sutures can show considerable morphological diversity between populations.[12]

Jayanthi and Vardhini reported the incidence of metopism in adult human skulls and further contributed to the Indian literature on this anatomical variation.[10] Their findings support the observation that metopic suture persistence is a recognizable anatomical variant whose frequency differs among study populations. When considered together with studies from North, Central and Eastern India, the available evidence suggests that regional differences may influence the observed frequency and morphology of metopic sutures. [1,4-7,910,12]

The international study by Zdilla *et al.,* provides additional evidence that the prevalence of metopism varies among geographically and craniofacially distinct populations. In their study of 505 adult crania, metopism was identified in 13 skulls (2.57%). The reported prevalence differed among the examined populations, including 8.06% in European crania, 15.38% in East Asian crania, 2.20% in Egyptian crania and 2.86% in Bengali crania. [11] The authors also reported metopism in 3.77% of females and 1.79% of males and emphasized the anthropological, developmental and clinical relevance of the variation.[11] These findings reinforce the importance of considering population characteristics when comparing the incidence of metopism between studies.

Murlimanju *et al.,* demonstrated considerable morphological diversity among persistent metopic sutures. In their study, incomplete sutures included linear, V-shaped and double forms.[3] Andrade *et al.,* similarly reported linear, V-shaped, U-shaped and Y-shaped patterns in adult dry skulls from coastal Karnataka.[7] The present series showed a predominance of the linear pattern, with 4 of the 5 persistent sutures classified as linear. However, because only five positive specimens were identified, the present morphological findings should be interpreted descriptively rather than as evidence of a population-specific predominance.

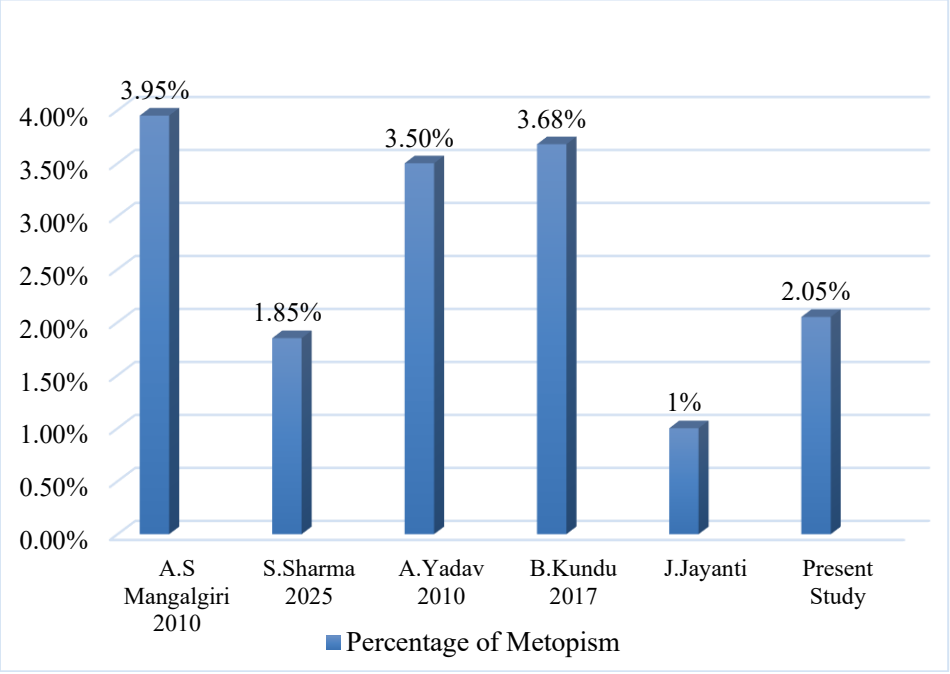
Sharma *et al.,* recently examined 54 adult dry skulls and reported metopic sutures in 3.7% of the sample, with complete and incomplete forms represented.[8] Their overall finding is close to the 3.42% prevalence of persistent metopic sutures observed in the present series. The authors also emphasized the clinical importance of recognizing metopism because it may be confused with a frontal bone fracture.[8]

The radiological significance of metopism is particularly important. A persistent metopic suture follows a characteristic midline course and may demonstrate relatively regular, corticated margins. These characteristics can assist in differentiating it from an acute fracture. [3,8,9] A persistent metopic suture may therefore become an important diagnostic consideration when interpreting skull radiographs or computed tomography in patients presenting after head trauma. Gupta *et al.,* specifically highlighted this potential radiological confusion in their North Indian study.[9]

The surgical relevance of the metopic suture should also be recognized. Persistent sutural anatomy in the frontal region may be encountered during radiological evaluation and procedures involving the anterior cranial region. Knowledge of its possible persistence and morphological variation can therefore assist anatomists, radiologists and neurosurgeons in accurate interpretation of cranial anatomy. [3,11,12]

From a forensic and anthropological perspective, metopism is also relevant as a non-metric cranial trait. Studies from different geographical populations have reported considerable variation in prevalence, supporting the value of documenting regional frequencies. [4-7,9-12] However, metopism should be considered as one cranial morphological feature rather than an isolated criterion for individual identification or population attribution.

The present case series adds data from a North Indian sample and demonstrates both complete and partial forms of persistent metopic suture. The principal limitation is the relatively modest number of positive cases, with only five skulls demonstrating persistence. In addition, demographic information such as age and sex was not available for individual skulls. The morphological classification was also limited to linear and non-linear categories, whereas several previous studies have used more detailed patterns such as V-shaped, U-shaped, Y-shaped and double sutures. [3,7,13] Larger studies using standardized morphological classification and documented demographic characteristics would provide further information regarding population-specific variation.



CONCLUSION

The present study demonstrates that persistent metopic sutures occur as an anatomical variation in adult skulls of the studied North Indian population. Among 146 skulls, persistent metopic sutures were identified in 3.42%, with complete metopism in 2.05% and partial persistence in 1.36%. The linear morphological pattern was predominant.

Although metopism is an anatomical variant, its recognition has practical importance. A persistent metopic suture may be mistaken for a frontal bone fracture during radiological examination, particularly in trauma cases. Knowledge of its anatomical location and morphological appearance is therefore important for anatomists, radiologists, neurosurgeons and forensic experts. The findings also contribute to the available regional data on metopic suture variation in the Indian population.

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