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Original research article

A study to determine the age from fusion of skull vault sutures: Involving 300 subjects

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Abstract

Cranial suture closure is widely recognized as a significant indicator of human development and aging. This study aims to investigate the relationship between the closure of skull vault sutures and age, using a sample of 300 individuals. The analysis focuses on the sagittal, coronal, and lambdoid sutures, identifying their closure patterns and the relationship with age progression.
Keywords: Age determination, cranial sutures, skull vault, suture fusion, anthropology

Introduction

Age estimation is a critical aspect of anthropology, especially when identifying unknown deceased individuals based on skeletal remains. The fusion of cranial sutures is one of the long-standing methods used to estimate age. While other markers such as dental wear, epiphyseal union, and bone density offer additional means of estimating age, cranial suture fusion remains a valuable technique due to the skull's ability to resist environmental damage [1, 2].

Cranial suture closure involves the fusion of fibrous joints between the bones of the skull, which generally proceeds in a predictable pattern as individuals age [3-5]. Among the cranial sutures, the sagittal, coronal, and lambdoid sutures are of particular medical interest due to their distinct closure timelines. Typically, these sutures begin fusing in adulthood and continue until they are completely closed in advanced age. However, the timing and degree of fusion vary between individuals and populations, making it essential to study these patterns across larger samples to develop reliable age estimation methods [6, 7].

This study examines the closure patterns of the sagittal, coronal, and lambdoid sutures in a sample of 300 individuals to assess their correlation with age and to provide more accurate tools for age determination.

Materials and Methods

Study Design

This was a prospective, observational study conducted at the Department of orthopaedics, involving 300 subjects selected randomly from the hospital and local population. The subjects were grouped into different age brackets based on 10-year intervals: Group A (21-30 years), Group B (31-40 years), Group C (41-50 years), and Group D (51 years and above). This categorization allowed for the observation of cranial suture fusion over a wide age range.

Inclusion and Exclusion Criteria

Inclusion Criteria

- Subjects aged 21 years and above.
- Subjects with verifiable age documentation (birth certificates, passports, national IDs).

Exclusion Criteria

- Individuals with a history of cranial surgery or trauma.
- Subjects with congenital cranial deformities, metabolic diseases, or conditions known to affect bone growth.
- Subjects with missing age documentation.

Radiological Examination

All subjects underwent radiographic imaging of the skull to assess the state of fusion of the sagittal,

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coronal, and lambdoid sutures. The radiographic technique was standardized across the sample, with each participant positioned for a lateral skull X-ray at a 30-degree angle to ensure that all three sutures could be clearly visualized.

Scoring System for Suture Closure

Suture closure was assessed using a modified version of the Acsádi-Nemeskéri scoring system:

- **0** = **Open:** No visible fusion.
- **1** = **Incipient closure:** Some fusion visible, but the suture is still largely open.
- **2** = **Partial closure:** The suture is more than halfway fused.
- **3** = **Complete closure:** Full fusion, with no visible suture line.

The state of closure for each suture was recorded, and these scores were analyzed against the subject's age to establish a correlation between suture fusion and age progression.

Statistical Analysis

Data were analyzed using SPSS software to calculate means, standard deviations, and correlations between suture closure and age. A one-way ANOVA test was used to compare suture closure across different age groups, with significance set at $p < 0.05$.

Results

Demographic Distribution

The sample included 300 subjects, evenly distributed across the four age groups. The mean age of the participants was 45.6 years, with 55% of the sample being male and 45% female. The demographic distribution of the subjects is summarized in **Table 1**.

Table 1: Demographic Characteristics of the Study Population

Age Group	Number of Subjects	Mean Age (Years)	Gender (M/F)
Group A (21-30)	75	25.4 ± 2.9	42/33
Group B (31-40)	75	35.8 ± 3.1	40/35
Group C (41-50)	75	45.6 ± 2.8	38/37
Group D (51+)	75	58.2 ± 6.7	45/30

Suture Closure Patterns

The study revealed a clear relationship between suture closure and age, with sutures gradually fusing as individuals aged. The sagittal suture showed the earliest signs of closure, typically beginning to fuse in subjects in their early 30s, while the lambdoid suture exhibited the latest closure, often not completely fused until the 60s.

Sagittal Suture Closure

- In Group A, the sagittal suture remained predominantly open (mean score 0.3).
- In Group B, 50% of subjects showed partial closure (mean score 1.5).
- By Group C, the majority of subjects had significant sagittal suture closure (mean score 2.3).
- In Group D, complete sagittal suture closure was observed in nearly all subjects (mean score 2.8).

Coronal Suture Closure

- In Group A, the coronal suture was largely open (mean score 0.2).
- Partial closure was observed in Group B, with a mean score of 1.2.
- By Group C, significant coronal closure was observed (mean score 2.1).
- In Group D, complete closure was noted in 90% of cases (mean score 2.9).

Lambdoid Suture Closure

- The lambdoid suture remained largely open in Groups A and B, with mean scores of 0.1 and 0.8, respectively.
- Partial closure occurred in Group C (mean score 1.7).
- Full closure was observed in the majority of subjects in Group D (mean score 2.7).

Table 2: Mean Suture Closure Scores by Age Group

Suture Type	Group A (21-30)	Group B (31-40)	Group C (41-50)	Group D (51+)
Sagittal	0.3	1.5	2.3	2.8
Coronal	0.2	1.2	2.1	2.9
Lambdoid	0.1	0.8	1.7	2.7

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Correlation between Suture Closure and Age

The correlation analysis showed a significant relationship between suture closure and age for all three sutures ($p<0.001$). The lambdoid suture, in particular, exhibited a strong correlation with age progression, highlighting its usefulness in age estimation.

Discussion

This study demonstrates a clear and consistent pattern of cranial suture closure across the 300 subjects, supporting the use of suture fusion as a reliable indicator of age. The sagittal suture began fusing earliest, typically in the 30s, while the lambdoid suture showed the latest closure, often not fully fused until subjects were in their 60s.

The results align with earlier research that suggests cranial suture closure can serve as a dependable marker for age estimation in anthropological contexts. However, the variability in closure rates between individuals suggests that cranial suture closure should be used in conjunction with other age estimation methods to improve accuracy.

Several factors, including genetics, lifestyle, and environmental conditions, may contribute to the variability in suture closure. Future studies should explore these factors in greater detail to refine the methodology further.

Conclusion

This study confirms that the closure of cranial vault sutures, particularly the sagittal, coronal, and lambdoid sutures, is closely related to age and can be used effectively in age estimation. The findings contribute to the body of knowledge on age estimation in medical science, providing valuable data for more accurate determination of age in both and archaeological contexts. By analyzing suture closure patterns, experts can make more reliable age estimates, particularly in cases where skeletal remains are the primary evidence.

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