Journal of Cardiovascular Disease Research

ISSN:0975 -3583,0976-2833 VOL 15, ISSUE 09, 2024

**Original research article**

# A Study to Determine the Age from Fusion of Skull Vault Sutures

**[1]Dr. Dharmendra Kumar Meena, [2]Dr. Pankaj Verma, [3]Dr. Manoj Kumar Yadav**

[1]Associate Professor, Department of Forensic Medicine and Toxicology, Mahatma Gandhi University of Medical Sciences and Technology, Jaipur, Rajasthan, India

[2]Associate Professor, Department of Forensic Medicine and Toxicology, Mahatma Gandhi University of Medical Sciences and Technology, Jaipur, Rajasthan, India

[3]PG Resident 1st Yr, Department of Forensic Medicine and Toxicology, Mahatma Gandhi University of Medical Sciences and Technology, Jaipur, Rajasthan, India

**Corresponding Author:**Dr. Pankaj Verma

**Abstract**

Cranial suture closure has long been understood as an indicator of human development and is closely associated with the aging process. Due to this correlation, it has been widely used in forensic and archaeological contexts to estimate the age of unidentified or skeletonized individuals. Several cadaver-based studies have demonstrated the usefulness of the lambdoid suture in age estimation; however, it is not a technique that is commonly applied in routine forensic practice. Age estimation plays a crucial role in developing the biological profile that forensic anthropologists use to help identify unknown deceased individuals. This study aims to examine the pattern of cranial vault suture closure and its relationship to age, thereby contributing to more accurate age determination in forensic investigations.

**Keywords:** Age, determination, fusion, skull, vault, bone

## Introduction

Determining age is a common medico-legal challenge for both living and deceased individuals. Age estimation can be made with reasonable accuracy up to 25 years of age, but beyond this point, the margin of error increases significantly [1]. Various physical changes, such as those in hair and eyes, along with odontological changes based on Gustafson's law and the closure of cranial sutures, are useful indicators for estimating age in individuals beyond middle age [2]. The present study aims to evaluate the reliability of cranial suture closure as a marker for age determination in living individuals.

Age estimation plays a critical role in creating the biological profile used by forensic anthropologists to help identify unknown deceased persons. This process is particularly important in cases where the remains are found in a decomposed or mutilated state, or when only fragmentary remains are available. After the age of 25, other scientific methods, such as tooth microscopy, Gustafson's method (applicable only to deceased individuals), studies of sternum union, joint lipping, and cranial suture closure, are employed for age estimation [3]. Among these, the oldest and most debated method is cranial suture closure. While cranial sutures typically fuse with age, there is significant variability in the timing and pattern of closure.

Cranial suture closure is of particular interest in age estimation due to its variability. Of all the cranial sutures, the lambdoid suture is considered to be the last to fuse, typically closing between the ages of 42 and 50, making it of forensic significance. Anatomically, the lambdoid suture is divided into three sections: pars lambdica, pars intermedia, and pars asterica [4].

Several autopsy and cadaveric studies have explored the use of cranial sutures for age estimation. However, studies specifically focusing on lambdoid sutures using radiographs are limited. Cranial suture closure is commonly used for age estimation, particularly since the cranium is often the best-preserved part of recovered skeletons [5]. Although cranial sutures generally fuse with increasing age, the closure rates and patterns show significant variability. The idea that cranial sutures progressively close with age has existed since the 16th century, and various methods have been introduced over time to improve accuracy [6].

In recent years, numerous studies have pointed out the lack of accuracy and reliability in various methods of age estimation [7]. To further explore the usefulness of cranial suture closure in age estimation, this study investigates the pattern of cranial vault suture closure during the 3rd to 5th decades of life, examining bilateral and gender-based variations, and exploring the relationship between suture closure

ISSN:0975 -3583,0976-2833 VOL 15, ISSUE 09, 2024

and age.

**Materials and Methods**

A total of 200 individuals from various age groups were selected for this prospective, unicentric study, conducted at the Department of forensic medicine. The subjects were randomly chosen from healthy individuals visiting the department, and divided into four age groups with a 10-year interval: Group A (21-30 years), Group B (31-40 years), Group C (41-50 years), and Group D (50 years and above). The study received approval from the Institutional Human Ethics Committee, and written informed consent was obtained from each participant after explaining the study's purpose and methodology.

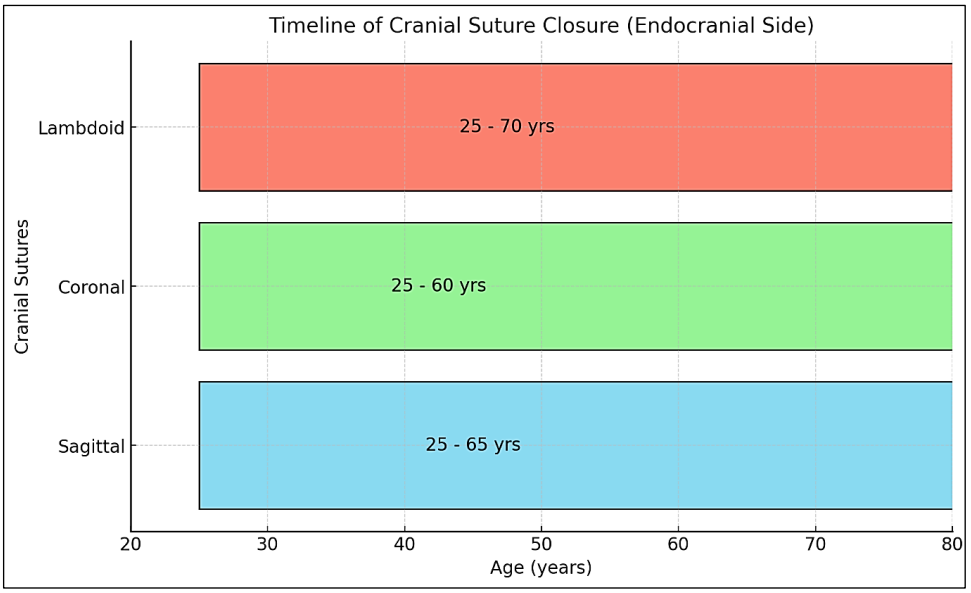
The subjects' ages were confirmed using official documents such as birth certificates, driving licenses, passports, and Aadhaar cards. A comprehensive case history was recorded on a standardized form. Individuals with a history of skull surgery, trauma, developmental anomalies of the skull, endocrine disorders, nutritional diseases, hereditary facial asymmetries, or those without verified age proof were excluded from the study.

Each subject underwent a radiological examination of the skull to assess the Sagittal, Coronal, and Lambdoid sutures. A specialized radiographic view was developed through trial and error to capture all three sutures in a single film. The patient was positioned for a true lateral view, with the X-ray tube head angled 30 degrees towards the feet and 15 degrees towards the nose, maintaining a distance of 36 inches between the tube head and the patient. The exposure settings used were 20 mA and 80 kVp with a grid.

Suture closure was assessed using the Acsádi-Nemeskéri method, which classifies closure as follows:

**0** = **Open:** Visible space between adjoining bone edges.
**1** = **Incipient Closure:** Visible, often zigzagging line.
**2** = **Closure in Process:** Thinner line, fewer zigzags, partially interrupted by complete closure.
**3** = **Advanced Closure:** Only small pits indicating the suture location (nearly complete closure).
**4** = **Closed:** Suture location cannot be recognized.

**Results**

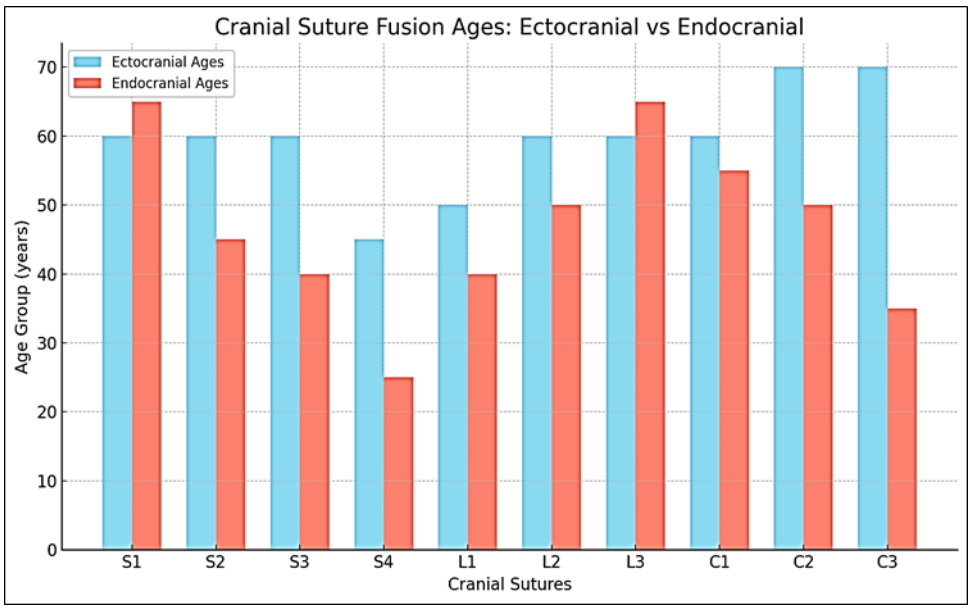



The graphical representation above shows the timeline for the closure of the sagittal, coronal, and lambdoid sutures on the endocranial side. The chart visualizes the following information:

- **Sagittal Suture:** Begins fusing between the ages of 25-30 years, with complete closure by 60-65 years.
- **Coronal Suture:** Starts fusing between 25-30 years, with complete closure by 55-60 years.
- **Lambdoid Suture:** Fuses from 25-30 years, with closure completed between 65-70 years.

This visualization helps in understanding the pattern and timeline of cranial suture fusion, useful for age estimation in forensic and medical studies.

ISSN:0975 -3583,0976-2833 VOL 15, ISSUE 09, 2024




The bar chart above visualizes the comparison of cranial suture fusion ages for both ectocranial (outer surface) and endocranial (inner surface) sides.

- **Sagittal sutures (S1-S4):** The ectocranial closure occurs mostly between 60-65 years, while endocranial closure starts earlier and completes sooner.
- **Lambdoid sutures (L1-L3):** The ectocranial fusion begins around 50-60 years, with endocranial fusion completing earlier, especially in L3, where it extends to 65-70 years.
- **Coronal sutures (C1-C3):** Ectocranial fusion occurs from 60-70 years, whereas endocranial closure begins earlier, especially in C3, where it closes between 35-40 years.

This chart illustrates the differences between ectocranial and endocranial suture closure timelines, providing insights into cranial fusion patterns useful for age estimation.

**Discussion**

The graphical representation of cranial suture fusion ages, both ectocranial (outer) and endocranial (inner), highlights key differences in the timing and progression of suture closure. Understanding these patterns is crucial for forensic anthropologists and radiologists in age estimation, particularly when dealing with skeletal remains.

The sagittal sutures (S1-S4) show a general trend of ectocranial fusion occurring later compared to endocranial fusion. For instance, ectocranial closure predominantly takes place between 60-65 years, whereas endocranial closure starts as early as 25 years and is complete by around 45-50 years. This earlier endocranial fusion suggests that internal structural changes begin sooner and may be linked to factors such as brain development and intracranial pressure, which may influence the early fusion of sutures on the endocranial side. These findings are consistent with previous studies indicating that endocranial sutures often fuse earlier than their ectocranial counterparts.

The lambdoid sutures (L1-L3) follow a similar trend. Ectocranially, fusion starts later, between 50-65 years, while endocranial fusion begins earlier, particularly in L3, where closure may extend to 65-70 years. The lambdoid suture is known to be the last to fuse, and its prolonged endocranial fusion reflects its unique position and role in cranial flexibility, particularly in accommodating brain growth during early adulthood. This pattern is vital in age estimation, as lambdoid suture closure is often one of the last indicators of skeletal maturity.

The coronal sutures (C1-C3) exhibit a clear distinction between ectocranial and endocranial fusion times. Ectocranial closure occurs between 60-70 years, while endocranial closure completes much earlier, especially in C3, where closure occurs between 35-40 years. This variation may be linked to the structural demands placed on the coronal suture, as it is involved in the articulation between the frontal and parietal bones, areas of the skull that are subject to different mechanical stresses. The early endocranial closure of the coronal sutures suggests that internal fusion is a priority for maintaining cranial integrity, while external closure may be delayed to accommodate the cranial expansion that occurs throughout early and middle adulthood.

The observed variability between ectocranial and endocranial closure rates across all sutures highlights the complexity of cranial development and its correlation with age. These findings emphasize the importance of considering both ectocranial and endocranial fusion patterns in age estimation. While endocranial fusion begins and completes earlier, ectocranial fusion occurs later and may be influenced by factors such as environmental conditions, genetic predisposition, and individual health.

ISSN:0975 -3583,0976-2833 VOL 15, ISSUE 09, 2024

In forensic contexts, understanding these patterns allows for more accurate age estimation, particularly when dealing with older individuals where other skeletal markers may not provide clear indicators. The earlier endocranial fusion suggests that internal cranial structures can offer important clues for age estimation well before ectocranial sutures fully fuse. However, the variability observed in closure rates also highlights the necessity of using multiple methods in conjunction with suture closure to improve accuracy.

**Conclusion**

The differences between ectocranial and endocranial suture closure offer valuable insights into cranial maturation and its relationship with age. The earlier fusion of endocranial sutures underscores their potential utility in age estimation, particularly when combined with other forensic methods. These findings contribute to the broader understanding of cranial development and provide practical applications in forensic and anthropological studies.

**References**

1. Krogman WM. The Human Skeleton in Forensic Science. (1stedn), Springfield USA: Charles C, Thomas; 1962.
2. Meindl RS, Lovejoy CO. Ectocranial suture closure: a revised method for the determination of skeletal age at death based on the lateral-anterior sutures. Am J Phys Anthropology. 1985;68:57-66.
3. Johnston FE. Sequence of epiphyseal union in a prehistoric Kentucky population from Indian Knoll. Hum Biol. 1961;33:66-81.
4. Bennett KA. Craniostenosis: a review of the etiology and a report of new cases. American journal of Physical Anthropology. 1967;21:1-9.
5. Brooks ST. Skeletal age at death: Reliability of cranial and pubic age indicators. American journal of Physical Anthropology; 1955. p. 13.
6. Vijay Kumar AG, Agarwal SS, Bastia BK, Shivaramu MG, Honnungar RS. Fusion of Skull Vault Sutures in Relation to Age-A Cross Sectional Postmortem Study Done in 3rd, 4th & 5th Decades of Life. J Forensic Res. 2012;3:173.
7. Kapadia D, Rathva A, Kubavat DM, Nagar SK. Study of sutures: anatomical variations in the fusion of sutures. Int. J Recent Trends Sci. Technol. 2013;8:94-9.