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Research Article

Determination of Skull Age using Cranial Sutures

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Abstract

The method of determining age by cranial suture closure has always been more generally used because the cranium is the best preserved portion of the recovered skeleton that resists putrefaction and not easily destroyed. Age estimation using cranial suture closure is of paramount importance and requires special attention in cases where bodies are found in decomposed, multilated state or only fragmentary remains are discovered. This study aims at estimating the age of the skull using endocranial suture closure in line with Ascadi-Nemeskeri scale system of aging the skull. This study was conducted on 114 human crania gotten from Nigeria higher Institutions. Ascadi-Nemeskeri scale of suture closure was used to access the age after cleaning the endocrania. Scale of endocranial suture closure from 0-4 was observed in 16 parts as done by Ascadi-Nemeskeri. The sutures studied includes: the coronal, sagittal and lambdoid sutures. Data were analysed using the statistical package of social science (SPSS) version 20. It was observed that almost complete closure of coronal suture occurs at the age range of 40 to 50 years, almost complete closure of sagittal suture occurs at the age range of 45 to 75 years and that of lambdoid suture occurs at the age range of 45 to 55 years. Cranial sutures is one of the important anatomical landmark that can be used to estimate age of an individual especially in cases where the individual's age is unknown. This work has shown a statistical link between cranial sutures and skull age ($p = 0.00$).

Keywords: Cranial Sutures; Age Estimation; cranium; Ascadi-Nemeskeri

Abbreviations

S1: Pars Bregmatica (i.e., First Part) of Sagittal Suture; S2: Pars verticis (i.e., second part) of Sagittal Suture; S3: Pars Obelica (i.e., Third Part) of Sagittal Suture; S4: Pars lambdicia (i.e., Fourth Part) of Sagittal Suture; C1: Pars Bregmatica (i.e., First Part) of Coronal Suture; C2: Pars Complicate (i.e., Second Part) of Coronal Suture; C3: Pars Pterica (i.e., Third Part) of Coronal Suture; L1: Pars Lambdicia (i.e., First Part) of Lambdoid Suture; L2: Pars Intermedia (i.e., Second Part) of Lambdoid Suture; L3: Pars Asterica (i.e., Third Part) of Lambdoid Suture; CHS, NAU: College of Health Sciences, Nnamdi Azikiwe University, Anambra State; UNEC: University of Nigeria, Enugu Campus; COOU, Uli: Chukwuemeka Odumegwu Ojukwu University, Uli, Anambra State; ESUT: Enugu State University of Technology

Introduction

Age estimation is an integral part of the biological profile employed by forensic anthropologists in order to assist in achieving an identification of an unknown deceased individual [1]. Reconstruction of biological profile of unknown individuals would be incomplete without age determination [2]. Its estimation is of paramount importance and requires special attention in cases where bodies are found in decomposed, mutilated state or only fragmentary remains are discovered. The oldest and most controversial age indicator is cranial suture closure [3].

Cranial suture closure has long been recognized as a character of human development related to aging. For this reason, it has been

utilized for archaeological and forensic studies to determine the age at death of unidentified and skeletonized individuals [3]. Cranial sutures generally fuse with increasing age, although there is considerable variability in closure rates and patterns [4]. This variability leads to the question of the value of cranial suture closure as a method of estimating age at death.

The aim of this study is to determine the skull age using cranial sutures.

The study will provide useful information in the field of forensic research, which will help determine the age of known or unknown deceased individual using the cranial sutures of their skull bone.

Materials and Methods

This cross-sectional study was carried out primarily in the Anatomy Department of College of Health Sciences, Nnamdi Azikiwe University, Nnewi Campus, Anambra state, and other Nigerian higher Institutions which includes: Chukwuemeka Odumegwu Ojukwu University, Uli Campus, Anambra state, University of Nigeria, Enugu Campus, Enugu state and Enugu State University of Technology, Enugu State after obtaining a letter of permit from the Institutional Ethical Committee. A total of 114 human skulls were obtained for this research work.

Inclusion criteria

- Only South-Eastern Nigerian Universities as mentioned above was used for the cadaveric study of the cranial sutures of the human skull.
- Only unfractured skulls were used for this study.
- Skulls without any form of deformity were included in this study.

Exclusion criteria

- Cases with a severe head injury (on the basis of history and external examination), which may hamper the examination of suture closure.
- Cases with any congenital or hereditary bony deformity on the basis of history and external examination.
- Fractured or deformed skull were excluded from this study.

Method

After reflecting the scalp, coronal, sagittal, lambdoid sutures were studied applying Ascardi Nemeskeri scale endocranially. The calvarium was cleaned of soft tissues remainants which made the sutures more prominent. The obliteration of the sutures was ascertained endocranially. Degree of closure was scored in 16 parts of the main cranial sutures as has been done by Ascardi-Nemeskeri. The data collected was used for the age estimation of the skull.

The coronal suture was studied in three parts on right side and left side each; sagittal suture in four parts and lambdoid sutures in three parts each on right and left side. Endocranial sutures were simply divided in sections of equal length.

Scale for closure: Ascadi-Nemeskeri estimation method

The followings are Ascardi and Nemeskeri method which is used for this research work.

- A score of 0 was assigned to the skull when the suture is open.
- A score of 1 was assigned to the skull when there is an early closure.
- A score of 2 was assigned to the skull when 50% of the suture is closed.
- A score of 3 was assigned to the skull when only pits indicate where the suture line was.
- A score of 4 was assigned to the skull when the suture is totally obliterated.

Mean endocranial closure stages were calculated for the three main sutures by adding the scored closure stages of the different sections and dividing the result by number of sections which compose the suture in question.

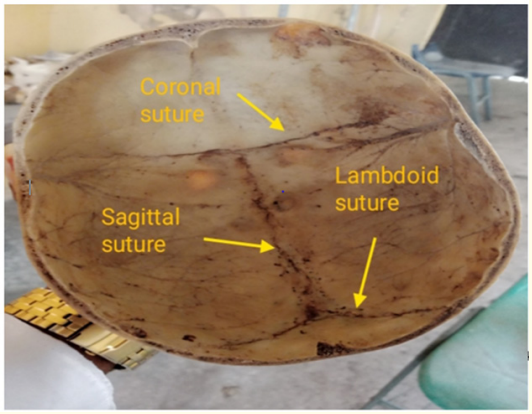

Figure 1: Image showing coronal, sagittal and lambdoid endocranial sutures which was taken during the course of the study.

Figure 2: Image showing the subparts of the endocranial sutures of coronal, sagittal and Lambdoid sutures which was taken during the course of the study.

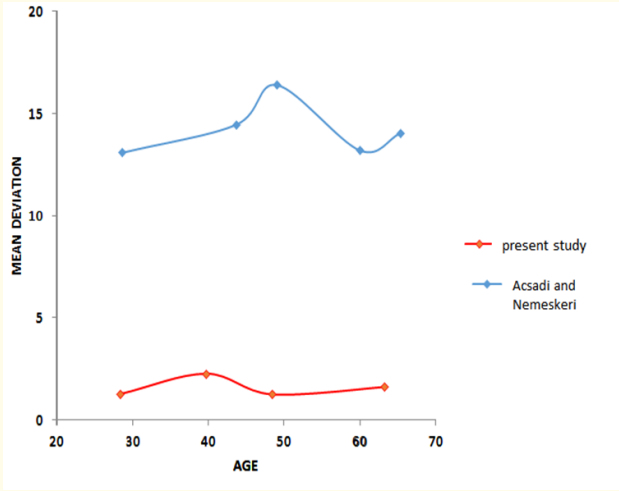

Figure 3: Mean deviations, (El real age-estimated age1 in), reported by Acsadi and Nemeskeri (1970) for traditional scoring method applied to endocranial suture closure and those found in the present study.

Results and Discussion

Cranial suture	Age Range	Mean Age	Frequency (N)	Std. Deviation	Mean Deviation
open suture (0)	15-40	28.40	5	1.673	1.280
early closure present (1)	30-60	39.70	57	2.872	2.268
50% of suture closed (2)	35-65	48.39	41	1.610	1.258
Presence of only pit (3)	45-75	-	-	-	-
suture totally obliterated (4)	50-80	63.27	11	2.572	1.619
Total		44.61	114	8.280	6.4263

Table 1: The table shows the frequency of the cranial suture closure and their estimated age range as reported by Ascadi-Nemeskeri.

Open suture		Cranial suture					Total
		Early closure present	50% of suture closed	Presence of only pit	Suture totally obliterated		
School	CHS, NAU	2	25		-	6	53
	UNEC	3	12		-	1	25
	COOU ULI	0	11	4	-	2	17
	ESUT	0	9	8	-	2	19
Total		5	57	41	-	11	114

Table 2: Frequency distribution of cranial sutures and the schools they are obtained from.

	R-value	P-value
Cranial suture vs school	0.006	0.946
Cranial suture vs age	0.953	0.00

Table 3: Pearson's Correlation showing the relationship between cranial suture and schools and between cranial suture and Age. p-value is significant at $p < 0.05$.

The table below shows that school had no significant relationship ($P > 0.55$) with cranial suture while Age and cranial suture had a significant relationship ($p = 0.00$)

The table below shows the summary of the hypothesis tests of cranial sutures which carries a significant impact on skull age. The dependent variable CS was regressed on predicting variable SA to test the hypothesis H1. SA significantly predicted CS, F (550.530), $P < 0.00$, which indicates that SA can play a significant role in determining CS ($B = -3.274$, $p < 0.00$). These results clearly direct the positive effect of the SA. Moreover, the $R2 = 0.908$ depicts that the model explains 90.7% of the variance in CA.

Hypothesis	Regression weights	Beta coefficient	R^2	F	T-value	P-value	Hypothesis supported
H1	SA-CS	-3.274	0.908	550.530	-20.854	0.00	yes

Table 4: Regression analysis of age estimation of cranial sutures.

Note: CA: Cranial Sutures; SA: Skull Age; R^2: Coefficient of Regression; p-value: Probability Value

The table below shows the pattern of closure of the sagittal suture endocranially thus; fourth part of the sagittal suture (S4) closes first at the age of 15-40 years followed by the third part (S3) at 30-60 years and second part (S2) at 35-65 years and finally the first part (S1) at 45-75 years. The age range were obtained using Ascadi-Nemeskeri scoring method.

	S1	S2	S3	S4
Endocranially (Age group in yrs)	45-75	35-65	30-60	15-40

Table 5: Age distributions of the sections of the sagittal suture endocranially.

Sagittal suture

The table below shows the pattern of closure of the coronal suture endocranially; thus, the third part of the coronal suture (C3) on both sides closes first at the age of 15-40 years followed by the second part (C2) at 30-60 years and finally, the first part (C1) at 35-65 years. The age range were obtained using Ascadi-Nemeskeri scoring method.

	C1	C2	C3
Endocranially (Age group in yrs)	35-65	30-60	15-40

Table 6: Age distribution of the sections of the coronal suture endocranially.

Coronal suture

The table below shows the pattern of closure of the lambdoid suture endocranially thus; the first part of the lambdoid suture (L1) on both sides closes first at the age of 15-40 years followed by the second part (L2) at 30-60 years and finally the third part (L3) at 35-65 years. The age range were obtained using Ascadi-Nemeskeri scoring method.

	L1	L2	L3
Endocranially (Age group in yrs)	15-40	30-60	35-65

Table 7: Age distribution of the sections of the lambdoid suture endocranially.

Lambdoid suture

No single skeletal indicator of age at death is ever likely to accurately reflect the many factors which accumulate with chronological age, each of which can contribute valuable information to the age estimate. Any indicator which both significantly reflects biological age and whose informational content is independent of other indicators will be useful to a final age estimate, whether under forensic or archaeological conditions [5]. The data gotten from the study demonstrate that cranial suture closure is such a criterion.

In forensic or anthropological practice, the degree of closure of cranial sutures is widely used in various methods of age determination, in particular those of Ascadi and Nemeskeri.

From this present study, the age of the cadavers varied from 15-80 years. Age groups were classified to 30-year interval. It was observed that maximum number of cases were in 30-60 years age group which shows that cadavers brought to most Nigerian Institutions for practicals falls mostly within that age range in terms of age distributions. Skulls with early closure (1) was most prominent with a frequency of 57 and a mean age of 39.70 followed by the skulls with 50% of the suture closed (2) with a frequency of 41 and a mean age of 48.39, skulls whose sutures has obliterated (3) has frequency of 11 with a mean age of 63.27 while that of open sutures (0) has 5 with a mean age of 28.40. There's no cranium from this study that shows the presence of only pit where the suture was. The age range was determined using the age range developed by Ascadi and Nemeskeri (1970) [9].

Table 3.2 shows frequency distributions of the various cranial sutures in relation to the schools they are sourced from. Hence, from this study, it can be observed that the Nigerian higher institutions have more crania with open sutures than other categories of sutures and thus fell under 30-60 years age range with mean age of 39.70. This explains that most cadavers brought to Nigerian higher Institutions for dissection falls mainly within this age range.

In this present study, Sagittal suture, endocranially starts fusing within the age range of 15 to 40 years and completion is perfected at the age range of 45 to 75 years and this observation conforms with that reported by Todd and Lyon (1924) [6], while it is in contrast to the observation reported by Pommerol (1869) [7], and Topinard (1885) [8], who indicated endocranial commencement of sagittal suture at a much later age at about 40 years. Also, Khandare., *et al.* (2015) observation on the endocranial fusion of sagittal suture which begins at 25 to 30 years and completes at 61-65 years is in contrast to the age estimation from the present study. These latter workers have reported on very scanty specimen so it can't be considered authentic.

Endocranial fusion of coronal suture was observed as early as 15 to 40 years age range in this present study, and completion occurs by the age of 35 to 65 years. Other workers like Pommerol (1869) [7], Topinard (1885) [8], Ribbe (1885), reported closure between 40 to 50 years. Their study does not indicate whether it was ecto-cranial or endocranial or it was commencement or termination. Khandare., *et al.* (2015) observed that coronal suture starts fusing at 25 to 30 years and completes at 50 to 60 years while Ozo., *et al,* (2019) reported that coronal suture begins endocranial fusion at 21 to 30 years and almost complete closure occurs at 35 years, their observation does not conform with the results gotten from the present study. This may be due to geographical location or nutritional requirements of the individual.

Lambdoid endocranially, starts fusing at the age of 15 to 40 years which shows that it is a year earlier than that reported by Todd and Lyon (1924) [6], while completion is at 35-65 years which corroborates with Modi and parikh according to whom complete closure occurs in between 50-70 years. As per Moondra endocranial closure occurs above 60 years both for male and females. According to J.B. Mukherjee lambdoid suture closes at the age group of 45 to 55 years. According to P.C. Vyas lambdoid suture closes at the age

group of 60 years. The other workers have not reported on lambdoid suture.

This work has shown that the observation of the degree of closure of the cranial sutures allows the age prediction of mature individuals. There thus exists a statistical link between age and the degree of cranial suture closure. The statistical link is important and precise as shown by the confidence interval of this parameter.

Table 3.3 shows that school had no significant relationship (P > 0.55) with cranial suture while Age and cranial suture had a significant relationship (p = 0.00) hence it can be concluded that there is a significant relationship between the cranial sutures and age of an individual at death.

This study also involves the advantage of presenting conclusions from a wide population sample constituted to allow future investigation, whose age and possible pathologies are unknown using the score-system developed by Ascadi and Nemeskeri. Like the study of Todd and Lyon, which uses a reference age estimated by a preliminary method and not an age known with certainty.

The distribution by age group shows that stages 1 and 2 of cranial sutures make up the majority since middle-aged individuals are more numerous, which concords with the fact that the average age of the individuals for each macroscopic stage increases in line with the cranial suture closure stage. In this present study, there is no suture indicating presence of only pit which shows that cadavers within the age range of 45-75 years has never been brought to the institutions where this study took place.

This study upon completion will help forensic researchers or archeologists to determine the ages of unknown individuals whose remains cannot be identified or are beyond recognition.

Conclusion

- This present study was done on 114 cases of post-mortem humans and sutures were studied in different stages of closure i.e., 0, 1, 2, 3 and 4.
- In present study, suture are divided into subparts i.e. sagittal suture in four parts, Coronal and Lambdoid suture into three parts each to determine age. Almost complete Sagittal suture closure occurs first in S4 then S3, S2 and finally S1. Almost complete coronal suture closure occurs first in C3 then C2 and finally C1. Almost complete Lambdoid suture closure occurs first in L1 then L2 and finally L3.
- Suture obliteration occurs earlier on endocranial surface.
- Based on endocranial suture fusion, Coronal suture was first to close followed by Sagittal suture, lambdoid suture sequentially.
- There is no significant variation in suture closure of right and left sides of coronal and lambdoid sutures.
- Cranial sutures is one of the important anatomical landmark that can be used to estimate age of an individual especially in cases where the individuals age is unknown. This work has shown a statistical link between cranial sutures and age of an individual at death (P = 0.00).

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Conflict of Interest

I declare there is no conflict of interest that exist in the cause of this research work.

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