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Research Article

Estimation of Age from Macroscopic Sagittal Suture Closure in an Indian Population

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Abstract: Age estimation of an individual whether live or dead or from recovered human remains is very important in a Medicolegal cases. The aims and objectives of the study was to see the chronology and pattern of union of sagittal suture; to know the relationship between closure of cranial suture and age of deceased; to formulate a practical method for age estimation based on the closure of cranial sutures using the data collected. The strongest positive correlation of ectocranial with endocranial suture is found in the age group of 30-39 years for sagittal sutures.
Keywords: Age, Sagittal, Cranial Suture, India.

INTRODUCTION

Age estimation of an individual whether live or dead or from recovered human remains is very important in a Medicolegal cases. Estimation of age is not an easy task because as age advances there is wide variation in estimated ages and the actual age.

The purpose of age determination is for employment, marriage, majority, management of property, voting right, competency as witness and testamentary capacity. The significance of determination of the age is most important in criminal cases, such as rape, infanticide, kidnapping, prostitution, juvenile delinquency and criminal responsibility.

A reasonably correct estimation of age in elderly people is essential in legal, medical, social and administrative matters i.e. to fixing of age for regularization of employment, superannuation, pension settlements, senior citizen benefits, old age and good behavior of the prisoner [1].

The methods to estimate the age at death of human skeletal remain unsatisfactory. Age of individuals under 25 years can be calculated with relative accuracy, based on the order of epiphysis-diaphysis closure of the long bones; the order of tooth eruption from infancy to about 17 to 25 years; the closure of the spheno-occipital suture is before 20, or at the least 25 years; and the union of the medial clavicular epiphysis between 25 and 28 years.

In a skeletal series then, the question is how to make observations on age of death of adult individuals of 28 years and older.

Old ages especially above 30 years pose a problem. One of the most common methods for age estimation has been the cranial suture closure [2]. The method of determining age by cranial suture closure is not only due to the greater interest in the skull, but also because the cranium is frequently the best preserved portion of the archaeologically recovered skeleton.

Reliable determination of age, sex, race, and stature of the individual from bone, region wise studies are very vital as racial or ethnic variation arises in different geographical regions. The pattern of cranial suture may change with time probably under influence of genetic factors and environmental factors such as dietary habits, daily water intake and climatic condition.

The current study is carried for determination of cranial suture closure in different age group which would help in formulating the reference value pertaining to central Indian population. Also, to study the chronology and pattern of union of cranial sutures namely sagittal suture, to detect bilateral variation in

cranial suture if any, and to know the relationship between closure of cranial suture and age of deceased.

MATERIALS AND METHODS

All the subjects brought for medicolegal autopsies were examined in the Department of Anatomy and Forensic Medicine at our Institute of Government Medical College and Hospital during the period from July 2010 to April 2013. Subjects were permanent resident of Nagpur region of India and were above the age of 20 years of known ages. The number of calvaria seems to be fair representations of the population of the area. In each instance, the calvarium was removed with help of electric saw. Care was taken that the transverse cut passed well below the lambda. The calvarium was cleaned of soft tissue on both sides particularly were suture were located was air dried, which made the suture more prominent. On both sides base of the skull the lower part of the coronal and lambdoid were cleaned both ectocranially and endocranially. When required, the sutures on the calvarium were immediately photographed both outer and inner sides separately.

The extent of obliteration was noted both ectocranially and endocranially by Ascadi and Nemeskri scale. The sagittal suture was divided into four equal parts from bregma to lamda: S1, S2, S3, and S4. Closure of each segment of a suture was scored both for ectocranial and endocranial surfaces separately as per Ascadi and Nemerescki method.

Scale for closure: Acsadi- Nemeskeri complex method

0 = Open. There is still little space left between edges of adjoining bones.

1 = Incipient closure. Clearly visible as a continuous often zigzagging line.

2 = Closure in process. Line thinner, less zigzags, interrupted by complete closure

3 = Advanced closure. Only pits indicate where the suture is located

4 = Closed. Even location cannot be recognized.

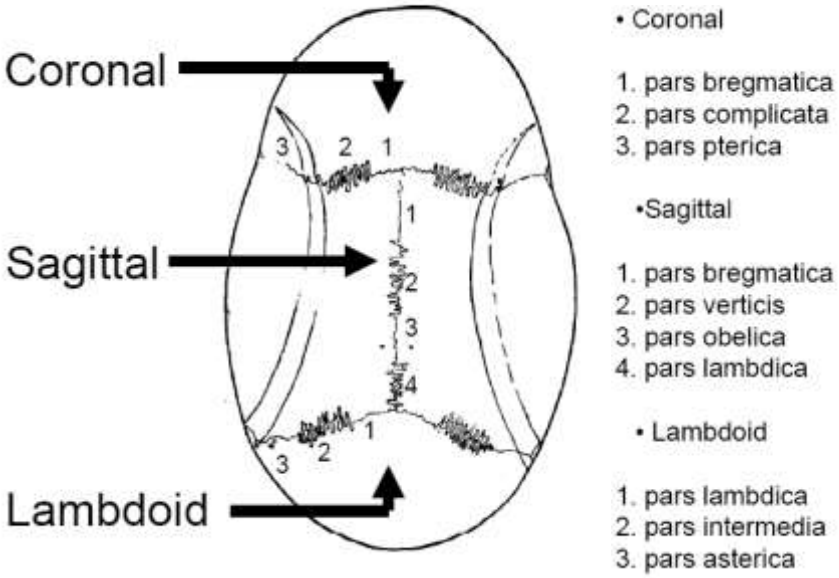

Fig. 1: Showing Coronal, Saggital, Lambdoid sutures

Statistical analysis

Sagittal scores were expressed in mean and standard deviation. These sutures scores were compared between male and female for ectocranial and endocranial closure by performing unpaired t-test. Mean suture closure were also compared between ectocranial and ectocranial closure by unpaired t-test. Correlation coefficient calculated to assess the Correlation between ectocranial and endocranial for different sutures for different age groups and also for male and female separately. p-value < 0.05 was considered as statistical significant, Data was analyzed using statistical software STATA version 10.0.

RESULTS

In the present study total 193 cases were studied. Male predominance over female was observed of which male cases were 133 and female were 60.

Table 2 shows the distribution of cases according to age and gender. Age of the persons examined varied from 20 t0 94 years. Cases were divided into 10 years interval. It was observed that maximum numbers of cases were in age groups of 20 to 29 years. There were total 46 cases in age group of 20-29 years including 31 males and 15 females. In 30-39 age groups there were total 38 cases of which 21 were males and 17 females. There were total 29 cases in age

group of 40-49 years including19 males and 10 females. In 50-59 years age group there were total 23 cases out of which 21 were males and 2 females. There were total 23 cases in age group of 60-69 years including 20 males and 3 females. In age group above 70 years there were total 34 cases out of which 21 are males and 13 females.

Table 3 shows correlation of Ectocranial with endocranial sutures in different age group. In age group of 20-29 years a significant positive correlation in sagittal sutures ($r = 0.4845, p < 0.01$). In age group of 30-39 years a significant positive correlation in sagittal sutures ($r = 0.9325, p < 0.01$). In age group of 40-49 years a significant positive correlation in sagittal sutures ($r = 0.8396$, $p < 0.01$). In age group of 50-59 years a significant positive correlation in sagittal sutures ($r = 0.6223$, $p < 0.01$). In age group of 60-69 years a significant positive correlation in sagittal sutures ($r = 0.7717$, $p < 0.01$). In age group of more than 70 years a significant positive correlation in sagittal sutures ($r = 0.5560$, $p < 0.01$) was observed. Thus, strongest positive correlation was found in the age group of 30-39 years for sagittal sutures ($r = 0.9325$, $p < 0.001$)

Table 4 shows correlation of ectocranial with endocranial sutures in different age group of males. Strongest positive correlation was found in the age group of 30-39 years for sagittal sutures ($r = 0.9331, p < 0.001$)

Table 5 shows correlation of ectocranial with endocranial sutures in different age group of females. Strongest positive correlation was found in the age group of 40-49 years for sagittal sutures ($r = 0.9969, p < 0.001$).

Table 6 shows mean ectocranial suture closure of sagittal. Sagittal sutures closes seems to close (mean 0.02 at 20-29 age group to 3.57 at more than 70 age group). There is total mean of 1.86 for sagittal.

Table 7 shows mean endocranial suture closure of sagittal. Sagittal suture start to close at age of 20 to 29 years. Sagittal suture shows near complete closure at age of 50 to 59 years (mean> 3). Sagittal sutures seems to close (mean 0.16 at 20-29 age group to 3.83 at more than 70 age group). Near complete closure of sagittal suture was observed >50 years (mean 3.0). There is total mean of 2.39 for sagittal.

Table 8 shows ectocranial sagittal sutures closure scoring. There is mean closure of sagittal sutures S1 (mean 0.02 at age group 20-29 years and 3.5 at age group of more than 70 years). Within the sagittal suture S4 (pars Lambdica) appears to fuse much faster (mean value 0.043 at 20-29 age group and 3.73 at more than 70 years), S1 (pars bregmatica) seems to close (mean 0.02 at 20-29 age group to mean 3.5 at more than 70 years), S2 (Pars vertices) closes (mean 0.02 at age group to mean 3.47 at more than 70 years), S3 (pars obelica) (mean 0.021 at age group to mean 3.58 at more than 70 years). Total mean value is 2.06 for S4, 1.95 for S3, 1.73 for S2 and 1.69 for S1). Thus, S4 closes earlier followed by S3, S2 and then S1.

Table 9 shows mean and SD of endocranial sagittal sutures closure. Within the sagittal suture S4 (pars Lambdica) appears to fuse much faster (mean value 0.17at 20-29 age group and 3.97 at more than 70 set), S1 (pars bregmatica) seems to close (mean 0.11 at 20-29 age group to mean 3.79 at more than 70 years), S2 (Pars vertices) closes (mean 0.15 at age group to mean 3.73 at more than 70 years), S3 (pars obelica) (mean 0.21 at age group to mean 3.85 at more than 70 years). Total mean values are 2.59 for S4, 2.45 for S3, 2.26 for S2 and 2.26 for S1). S4 closes earlier followed by S3, S2 and S1.

Table 10 and 11 show correlation of age with sagittal ectocranial sutures. There is positive correlation between all the suture closures with advancing age. A highly significant and strong positive correlation was observed in age group of 30-39 years while weak correlation was seen in age group of 20 – 29 years.

DISCUSSION

The estimation of age of a person starts from conception to death. During the course of development the body undergoes certain sequential changes which can be observed scientifically & these data help in fixing age of individual with certain degree of scientific accuracy. The ageing of human remains is based upon a detailed knowledge of biological changes that occur during development, growth and maturation. The exact chronology of these changes is dependent upon physiological variations in any one individual. Skulls can provide a lot of information about age at death and that is the reason why there are many age determination methods based on cranial features. In the present study, macroscopic findings are studied for closure of sagittal, coronal and lambdoid suture to determine age.

There was male predominance over female. Maximum cases were from age group 20-39 years (46) while minimum number cases were from age group 50-59 and 60-69 years (23 cases). Also in males, maximum number cases (31) was found in the age group of 20-29 years while maximum numbers of female cases (17) were in the age group of 30-39 years. The findings in present study are similar to the studies done by Alves J *et al*. [3], Gaur V.B *et al*. [4], Sahani D *et al*. [5], Jangietrew B *et al*. [6], Perizonius W [7].

From the results, various points are discussed under following heads-

- Comparison of ages of ectocranial sutures as given by various workers from various regions of India and from other countries with the findings of present study.

- Comparison of the ages of endocranial suture as given by various workers from various regions of India and from other countries with the findings of present study.
- Comparison between endocranial and ectocranial suture with those given by other workers.
- Sexual differences in the closure of sutures

Comparison of ages of ectocranial sutures as given by various workers from various regions of India and from other countries with the findings of present study

Sagittal suture (Table 8, 10)

In present study we found that ectocranially the sagittal suture start to fuse at age of 20-29 years and completion was seen at more than 70 years. Within the sagittal suture S4 (pars Lambdica) appears to fuse much faster (mean value 0.043 at 20-29 age group and 3.73 at more than 70 years), followed by S3 (pars obelica; mean 0.021 at age group to mean 3.58 at more than 70 years), S2 (Pars vertices) closes (mean 0.02 at age group to mean 3.47 at more than 70 years), and S1 (pars bregmatica) seems to close (mean 0.02 at 20-29 age group to mean 3.5 at more than 70 years). Total mean value is 2.06 for S4, 1.95 for S3, 1.73 for S2 and 1.69 for S1). Thus, S4 closes earlier followed by S3, S2 and then S1. A highly significant and strong positive correlation of ectocranial sagittal suture closure was observed in age group of 30-39 years while weak correlation was seen in age group of 20 – 29 years.

The finding in the present study are similar with study of Dobson [8]. Vault suture were completely closed and obliteration was advanced at pars obelica and pars bregmatica of the sagittal suture. Mckern and Stewart [9] observed that the vault suture closure tends to begin in first and fourth part of sagittal suture and final stage of closure tend to be seen in first and second part of sagittal suture. Pommerol [10] found that individuals under 35 years of age had open cranial sutures while around 40 years, the sagittal suture begins to close. Kijnagram [11] sagittal suture began to obliterate at between 30-40 years and was complete between 50-60 years. Johnson [12] observed highest correlation coefficient (r=0.50) for the sagittal suture with advancing age. Sahani D *et al*. [13] opined that maximum cases of complete closed sagittal suture in males were seen in more than 60 years while in females it was observed between 46-50 years. Vij K [14], Reddy KSN [15] opined that ectocranially the closure of sagittal suture occurs at 30-40 years in posterior one third, 40-50 years in anterior one third and 50-60 years in middle one third. Jangjetrew B [6] ectocranial sagittal sutures began at 17-45 years in male and 21-47 years in female, complete closure at 17 to 83 years in males and 28 to 72 years in females. Gaur VB *et al*. [6] observed that complete absence of closure of sutures indicates the age of an individual to be below 30 years while complete fusion occurs above 40 years Alves J *et al*. [3] observed that the suture was more preserved in the group of younger age between 20 and 35 years, but in the groups of superior ages, association of relation is not observed. Parmar P and Rathod [16] observed suture closure for sagittal suture at age group of 50-60 years. The findings in the present study are in contrast with studies of Topinard [17] observed that below 35 years the suture was open while the posterior part of sagittal suture started closing at about 40 years. Todd and Lyon [18-21] found that the sagittal suture closure starts at 22 years and completed at the 35 years.

Comparison of the ages of endocranial suture as given by various workers from various regions of India and from other countries with the findings of present study

Sagittal suture (Table 7, 9)

In our present study we found that endocranially sagittal suture start to close at age of 20-29 years, near complete closure was seen above 50 years(mean value >3) and total closure occurs at the age of more than 70 years. Within the sagittal suture S4 (pars Lambdica) appears to fuse much faster (mean value 0.17at 20-29 age group and 3.97 at more than 70 set), S3 (pars obelica; mean 0.21 at age group to mean 3.85 at more than 70 years), S2 (Pars vertices; mean 0.15 at age group to mean 3.73 at more than 70 years) and S1 (pars bregmatica) seems to close (mean 0.11 at 20-29 age group to mean 3.79 at more than 70 years). Total mean values are 2.59 for S4, 2.45 for S3, 2.26 for S2 and 2.26 for S1). S4 closes earlier followed by S3, S2 and S1.

The finding in the present study are similar with study of Pommerol [10] who found that individuals under 35 years of age had open cranial sutures while around 40 years, the sagittal suture begins to close, Parsons and Box [22] The sagittal sutures showed fair amount of endocranial suture closure above 30 years. All endocranial sutures were usually obliterated over 50 years and always after 60 years. Tiengpitak [23] reveled that closure of endocranial suture began between 23-37 years and complete between 31-71 years. Jangjetrew B [6] they found that closure begin to close at 21 -45 years in male and 26-47 years in female, complete closure was found at 21 to 83 years in male and 26 to 74 years in female . Sahani D *et al*. [13] opined that maximum cases of complete closed sagittal suture in males were seen in more than 60 years while in females it was observed between 46-50 years Reddy [15] was observed that closure start at age of 25 years.

The findings of present study are in contrast with the study of Todd and Lyon [19-22] who found that the sagittal suture closure starts at 22 years and completed at the 35 years.

Table 1: Gender-wise distribution of cases

Gender	Numbers (N)
Male	133
Female	60
Total	193

Table 2: Distribution of cases according to age and gender

Age group	N	Male	Female
20-29	46	31	15
30-39	38	21	17
40-49	29	19	10
50-59	23	21	02
60-69	23	20	03
≥70	34	21	13
Total	193	133	60

Table 3: Showing correlation of ectocranial with endocranial sutures in different age groups

Age group	N	S
20-29	46	0.4845 0.0006
30-39	38	0.9325 <0.0001
40-49	29	0.8396 <0.0001
50-59	23	0.6223 <0.0001
60-69	23	0.7717 <0.0001
≥ 70	34	0.5560 0.0006

Table 4: Showing correlation of ectocranial with endocranial sutures in different age groups of males

Age group	N	S
20-29	31	0.5449 0.0015
30-39	21	0.9331 <0.0001
40-49	19	0.7983 <0.0001
50-59	21	0.6647 0.0010
60-69	20	0.7407 0.0002
≥70	21	0.8942 <0.0001

Table 5: Showing correlation of ectocranial with endocranial sutures in different age groups of females

Age group	N	S
20-29	15	_
30-39	17	0.8895 <0.0001
40-49	10	0.9969 <0.0001
50-59	2	-1.0000 -
60-69	3	0.8660 0.3333
≥70	13	0.8441 0.0003

Table 6: Showing mean ectocranial closure stages of three sutures

Age group		sagittal
20-29	Mean	0.02
	SD	0.15
30-39	Mean	1.48
	SD	0.69
40-49	Mean	2.00
	SD	0.54
50-59	Mean	2.46
	SD	1.48
60-69	Mean	2.85
	SD	0.61
≥70	Mean	3.57
	SD	0.60
Total	Mean	1.86.
	SD	1.33

Table 7: Showing mean endocranial closure stages of three sutures

Age group		sagittal
20-29	Mean	0.16
	SD	0.39
30-39	Mean	2.33
	SD	0.56
40-49	Mean	2.81
	SD	0.49
50-59	Mean	3.23
	SD	0.46
60-69	Mean	3.42
	SD	0.45
≥70	Mean	3.83
	SD	0.27
Total	Mean	2.39
	SD	1.41

Table 8: Mean and SD of ectocranial sagittal suture closure scoring

Age group		ECTO S1	ECTO S2	ECTO S3	ECTO S4
20-29	N	46	46	46	46
	Mean	0.02	0.02	0.021	0.043
	SD	0.15	0.15	0.15	0.20
30-39	N	38	38	38	38
	Mean	1.18	1.18	1.73	1.81
	SD	0.73	086	0.76	0.76
40-49	N	29	29	29	29
	Mean	1.76	1.82	2.20	2.20
	SD	0.57	0.71	0.56	0.86
50-59	N	23	23	23	23
	Mean	2.26	2.30	2.47	2.82
	SD	0.62	0.56	0.59	0.72
60-69	N	23	23	23	23
	Mean	2.56	2.82	2.95	3.08
	SD	0.51	0.71	0.70	0.94
≥70	N	34	34	34	34
	Mean	3.5	3.47	3.58	3.73
	SD	0.75	0.75	0.65	0.51
Total	N	193	193	193	193
	Mean	1.69	1.73	1.95	2.06
	SD	0.32	1.37	1.36	1.45

Table 9: Mean and SD of endocranial sagittal suture closure scoring

Age group		ENDO S1	ENDO S2	ENDO S3	ENDO S41
20-29	N	46	46	46	46
	Mean	0.11	0.15	0.21	0.17
	Std deviation	0.38	0.42	0.46	0.44
30-39	N	38	38	38	38
	Mean	2.02	2.13	2.55	2.63
	Std deviation	0.71	0.74	0.60	0.54
40-49	N	29	29	29	29
	Mean	2.62	2.58	2.93	3.10
	Std deviation	0.57	0.62	0.45	0.77
50-59	N	23	23	23	23
	Mean	3.04	3.13	3.17	3.60
	Std deviation	0.64	0.54	0.65	0.58
60-69	N	23	23	23	23
	Mean	3.74	3.21	3.34	3.65
	Std deviation	0.51	0.60	0.57	0.64
≥70	N	34	34	34	34
	Mean	3.79	3.73	3.85	3.97
	Std deviation	0.41	0.45	0.36	0.17
Total	N	193	193	193	193
	Mean	2.26	2.26	2.45	2.59
	Std deviation	1.44	1.40	1.41	1.52

Table 10: Showing correlation of age with ectocranial sutures

Age group	Sagittal
20-29	0.2255 0.1318
30-39	0.7449 <0.0001
40-49	0.1020 0.5987
50-59	0.2997 0.1648
60-69	0.2794 0.1966
≥70	0.5566 0.0006

Table 11: Showing correlation of age with endocranial sutures

Age group	sagittal
20-29	0.4835 0.0007
30-39	0.7646 <0.0001
40-49	0.0179 0.9264
50-59	0.0432 0.8447
60-69	0.3294 0.1249
≥70	0.5213 0.0016

CONCLUSION

Age estimation from the skull suture is a reliable parameter. The strongest positive correlation of ectocranial with endocranial suture was found in the age group of 30-39 years for sagittal sutures. Suture obliteration starts earlier on endocranial surface than on the ectocranial. Endocranial sagittal suture start to close at 20 to 29 years near complete closure occurs by the

age of 50 to 59 years and complete closures occur by the age of more than 70 years. Ectocranial union start in the age group of 20-29 years in sagittal maximum closure occurred in the age group above 70 years.

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