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Original Article

Observation on the Closure of Cranial Sutures to Estimate Age from Skull Bones in Jharkhand Population

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ABSTRACT

Identification of deceased is an essential part of the post-mortem examination. Age is one of the important parameters for the identification of an individual whether the individual is alive, dead or human remains. The determination of age is needed for employment, marriage, majority, management of property, voting right, competency as witness and testamentary capacity. The significance of determination of age is most important in the criminal cases, such as rape, infanticide, juvenile delinquency and criminal responsibility. Age estimation can be done in various methods, including macroscopic examination of dental development and eruption, epiphyseal union of long bones, degeneration of pelvic articular surfaces and cranial sutures, as well as microscopic examination of long bones in histological analysis. Due to progressive development of bones, ageing of skeletons under the age of 25 can be more easily accomplished utilising the order of epiphyseal fusion in the long bones. Dental eruption is also a reliable indicator of age between infancy and 17 to 25 years. Cranial suture closure can be utilised to estimate age in living and death.

Keywords: Age, Cranial suture closure, Dental eruption, Epiphyseal union, Identification

INTRODUCTION

Identification is recognition of an individual by means of various physical features and biological parameters, which are unique to each individual. There are various established parameters for identification of an individual. These are external features (such as birth marks, scar, tattoo marks, occupational marks, malformations), personal features (such as clothes, speech, habits, intelligence, handwriting), assessment of age and sex, determination of race and stature, anthropometric measurements, fingerprints, footprints, lip prints, DNA fingerprinting, DNA profile and others[1,2,3]. Question of identification arises in every medico-legal case be it civil or criminal.

The determination of sex is a major criterion for the identification of an individual. It segregates lot of cases for easy and quick identification in a given sample. Age estimation is an integral part of the biological profile in achieving an identification of unknown deceased individual. Obliteration of skull sutures in late age, practically when all the teeth have erupted and epiphyses have fused, that is after 21 years of age gives fairly accurate idea.

The idea of cranial bones fuse progressively with age has been in existence since at least the sixteenth century; however, its utilisation as a method of age assessment has been quite controversial since the mid-twentieth century[4]. Only handful of studies has been reported in India. Today, it is still utilised in the absence of other evidence or in conjunction with other methods.

MATERIALS AND METHODS

The study was conducted on cases coming for medico-legal post-mortem examination in the Department of Forensic Medicine and Toxicology, Rajendra Institute of

Medical Sciences, Ranchi. Total 100 such cases were taken up for the study. Age was confirmed by documentary evidences like birth certificates, identification cards, ration card and others. Unknown, unclaimed bodies and cases showing deformed or diseased or fractured skull excluded from the study. After reflecting the scalp, the calvarium was cleaned and made dry of soft tissues on both sides to make sutures more prominent and the coronal, sagittal, lambdoid sutures were studied applying Acsadi–Nemeskeri scale[5]. Photographs were taken in all the cases. The obliteration of the sutures was ascertained endocranially as well as ectocranially. In both cases, degree of closure was scored. The coronal suture was studied in three parts on either side; sagittal suture was studied in four parts and lambdoid sutures in three parts each on either side. Ectocranially, the different sections were distinguished by differences in the character of the suture. Consequently, the endocranial sutures were simply divided in sections of equal length.

Scale for Closure: Acsadi–Nemeskeri Complex Method

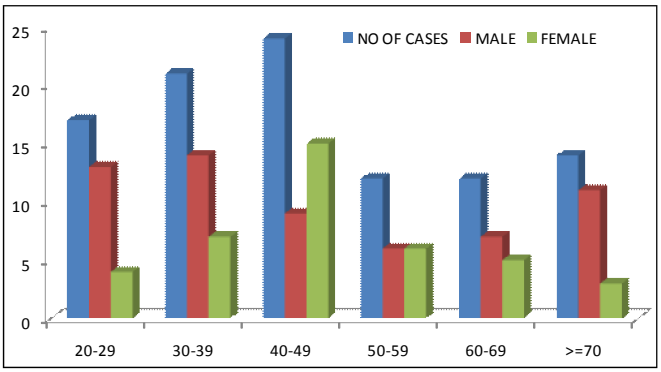
- 0 = open. There is still little space left between edges of adjoining bones.
- 1 = incipient closure. Clearly visible as a continuous often zigzagging line.
- 2 = closure in process. Line thinner, less zigzags, interrupted by complete closure.
- 3 = advanced closure. Only pits indicate where the suture is located.
- 4 = closed. Even location cannot be recognised.

OBSERVATION AND RESULTS

The age varied from 20 to 82 years. The age groups were classified into six groups at 10-year interval so as to compare with previous studies. The first age group is of between 20 and 29 years which consists of 17 (17%) cases of which 13 are males and 4 are females. The second group is of between 30 and 39 ages, which has 21 (21%) cases of which 14 are males and 7 are females. The maximum number of cases, 24 (24%) belong to 40 to 49 age group which has 9 males and 15 females. There are 12 (12%) number of cases each in 50 to 59 (6 males, 6 females) and 60 to 69 (7 males, 5 females) age group. And the last age group is of ≥70 years which has 14 (14%) number of cases with 11 males and 3 females (Table 1 and Graph 1).

Table 1: Distribution of cases-according to age group and sex

Age group	No of cases	Male	Female
20–29	17	13	4
30–39	21	14	7
40–49	24	9	15
50–59	12	6	6
60–69	12	7	5
≥70	14	11	3
Total	100	60	40



Graph 1: Graph of distribution of cases-according to age group and sex

In our study, when ectocranial sagittal sutures were observed that S1 (pars bregmatica) closure though started, it was never complete. There was no complete closure (value 4) even in ≥70 years age group and closure is very variable (Table 2).

Within the sagittal suture, S4 (pars lambdica) appears to fuse much faster, starting at 25 years in male and shows complete closure in 45.5% males of ≥70 age group ectocranially (Table 3). S4 (pars lambdica) closes earlier, followed by S3 (pars obelica) (Table 4), S2 (pars vertices) (Table 5) and lastly S1 (pars bregmatica) (Table 2).

In coronal suture, in 50–59 age group, right side showed earlier closure as compared with the left side both ectocranially and endocranially. C1 (pars bregmatica) (Table 6) closes early then C2 (pars complicata) (Table 7) and lastly C3 (pars pterica) (Table 8) on the left side, whereas C3 (pars pterica) (Table 9) closes early then C2

Table 2: Sagittal suture S1(Closure's scoring)

Age Group		Sagittal Suture (Closure's Scoring)									
		S1(Pars Bregmatica) Ectocranial					S1(Pars Bregmatica) Endocranial				
		0	1	2	3	4	0	1	2	3	4
20–29 (*N* = 17; 17%)	M (*N* = 13; 76.5%)	11 (64.7%)	2 (11.8%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	11 (64.7%)	2 (11.8%)	0 (00%)	0 (00%)
	F (*N* = 4; 23.5%)	4 (23.5%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	4 (23.5%)	0 (00%)	0 (00%)	0 (00%)
30–39 (*N* = 21; 21%)	M (*N* = 14; 66.7%)	2 (9.5%)	9 (42.9%)	3 (14.3%)	0 (00%)	0 (00%)	0 (00%)	2 (9.5%)	9 (42.9%)	3 (14.2%)	0 (00%)
	F (*N* = 7; 33.3%)	3 (14.3%)	4 (19.1%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	3 (14.3%)	4 (19.1%)	0 (00%)	0 (00%)
40–49 (*N* = 24; 24%)	M (*N* = 9; 37.5%)	4 (66.7%)	5 (20.8%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	4 (66.7%)	5 (20.8%)	0 (00%)
	F (*N* = 15; 62.5%)	8 (33.3%)	7 (29.2%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	8 (33.3%)	7 (29.2%)	0 (00%)
50–59 (*N* = 12; 12%)	M (*N* = 6; 50%)	0 (00%)	3 (25%)	3 (25%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	3 (25%)	3 (25%)	0 (00%)
	F (*N* = 6; 50%)	4 (33.3%)	1 (8.3%)	0 (00%)	1 (8.3%)	0 (00%)	1 (8.3%)	3 (25%)	1 (8.3%)	1 (8.3%)	0 (00%)
60–69 (*N* = 12; 12%)	M (*N* = 7; 58.3%)	0 (00%)	4 (33.3%)	1 (8.3%)	2 (16.7%)	0 (00%)	0 (00%)	0 (00%)	4 (33.3%)	1 (8.3%)	2 (16.7%)
	F (*N* = 5; 41.7%)	2 (16.7%)	1 (8.3%)	2 (16.7%)	0 (00%)	0 (00%)	0 (00%)	2 (16.7%)	1 (8.3%)	2 (16.7%)	0 (00%)
≥70 (*N* = 14; 14%)	M (*N* = 11; 78.6%)	0 (00%)	0 (00%)	6 (42.9%)	5 (35.7%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	6 (42.9%)	5 (35.7%)
	F (*N* = 3; 21.4%)	0 (00%)	2 (14.3%)	1 (7.1%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	2 (14.3%)	1 (7.1%)	0 (00%)

Table 3: Sagittal suture S4(Closure's scoring)

Age Group		Sagittal Suture (Closure's Scoring)									
		S4 (Pars Lambdica) Ectocranial					S4 (Pars Lambdica) Endocranial				
		0	1	2	3	4	0	1	2	3	4
20–29 (*N* = 17; 17%)	M (*N* = 13; 76.5%)	8 (47.1%)	5 (29.4%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	8 (47.1%)	5 (29.4%)	0 (00%)	0 (00%)
	F (*N* = 4; 23.5%)	3 (17.6%)	1 (5.9%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	4 (23.5%)	0 (00%)	0 (00%)	0 (00%)
30–39 (*N* = 21; 21%)	M (*N* = 14; 66.7%)	1 (4.8%)	5 (23.8%)	8 (38.1%)	0 (00%)	0 (00%)	0 (00%)	1 (4.8%)	5 (23.8%)	8 (38.1%)	0 (00%)
	F (*N* = 7; 33.3%)	2 (9.5%)	2 (9.5%)	3 (14.3%)	0 (00%)	0 (00%)	0 (00%)	2 (9.5%)	2 (9.5%)	3 (14.3%)	0 (00%)
40–49 (*N* = 24; 24%)	M (*N* = 9; 37.5%)	0 (00%)	5 (20.8%)	4 (16.7%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	5 (20.8%)	4 (16.7%)	0 (00%)
	F (*N* = 15; 62.5%)	0 (00%)	3 (12.5%)	12 (50%)	0 (00%)	0 (00%)	0 (00%)	1 (4.2%)	2 (8.3%)	12 (50%)	0 (00%)
50–59 (*N* = 12; 12%)	M (*N* = 6; 50%)	0 (00%)	2 (16.7%)	4 (33.3%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	2 (16.7%)	4 (33.3%)	0 (00%)
	F (*N* = 6; 50%)	0 (00%)	5 (41.7%)	0 (00%)	1 (8.3%)	0 (00%)	0 (00%)	1 (8.3%)	4 (33.3%)	1 (8.3%)	0 (00%)
60–69 (*N* = 12; 12%)	M (*N* = 7; 58.3%)	0 (00%)	0 (00%)	4 (33.3%)	3 (25%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	4 (33.3%)	3 (25%)
	F (*N* = 5; 41.7%)	1 (8.4%)	0 (00%)	4 (33.3%)	0 (00%)	0 (00%)	0 (00%)	1 (8.4%)	0 (00%)	4 (33.3%)	0 (00%)
≥70 (*N* = 14; 14%)	M (*N* = 11; 78.6%)	0 (00%)	0 (00%)	2 (14.2%)	4 (28.6%)	5 (35.8%)	0 (00%)	0 (00%)	2 (14.2%)	4 (28.6%)	5 (35.8%)
	F (*N* = 3; 21.4%)	0 (00%)	0 (00%)	3 (21.4%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	3 (21.4%)	0 (00%)

Table 4: Sagittal suture S3(Closure's scoring)

Age Group		Sagittal Suture (Closure's Scoring)									
		S3 (Pars Obelica) Ectocranial					S3 (Pars Obelica) Endocranial				
		0	1	2	3	4	0	1	2	3	4
20–29 (*N*=17; 17%)	M (*N*=13; 76.5%)	8 (47.1%)	4 (23.5%)	1 (5.9%)	0 (00%)	0 (00%)	0 (00%)	8 (47.1%)	4 (23.5%)	1 (5.9%)	0 (00%)
	F (*N*=4; 23.5%)	4 (23.5%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	3 (17.8%)	1 (5.8%)	0 (00%)	0 (00%)
30–39 (*N*=21; 21%)	M (*N*=14; 66.7%)	9 (42.9%)	5 (23.8%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	9 (42.9%)	5 (23.5%)	0 (00%)	0 (00%)
	F (*N*=7; 33.3%)	5 (23.8%)	2 (9.5%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	5 (23.5%)	2 (9.5%)	0 (00%)	0 (00%)
40–49 (*N*=24; 24%)	M (*N*=9; 37.5%)	0 (00%)	8 (33.3%)	1 (4.2%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	8 (33.3%)	1 (4.2%)	0 (00%)
	F (*N*=15; 62.5%)	2 (8.3%)	6 (25%)	7 (29.2%)	0 (00%)	0 (00%)	0 (00%)	2 (8.3%)	6 (25%)	7 29.2%)	0 (00%)
50–59 (*N*=12; 12%)	M (*N*=6; 50%)	0 (00%)	5 (41.6%)	1 (8.4%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	5 (41.6%)	1 (8.4%)	0 (00%)
	F (*N*=6; 50%)	0 (00%)	5 (41.6%)	0 (00%)	1 (8.4%)	0 (00%)	0 (00%)	1 (8.4%)	4 (33.3%)	1 (8.4%)	0 (00%)
60–69 (*N*=12; 12%)	M (*N*=7; 58.3%)	0 (00%)	0 (00%)	5 (41.7%)	1 (8.3%)	1 (8.3%)	0 (00%)	0 (00%)	0 (00%)	5 (41.7%)	2 (16.7%)
	F (*N*=5; 41.7%)	1 (8.3%)	1 (8.3%)	1 (8.3%)	0 (00%)	2 (16.7%)	0 (00%)	1 (8.3%)	1 (8.3%)	1 (8.3%)	2 (16.7%)
≥70 (*N*=14; 14%)	M (*N*=11; 78.6%)	0 (00%)	1 (7.2%)	7 (50%)	3 (21.4%)	0 (00%)	0 (00%)	0 (00%)	1 (7.2%)	7 (50%)	3 (21.4%)
	F (*N*=3; 21.4%)	0 (00%)	3 (21.4%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	3 (21.4%)	0 (00%)	0 (00%)

Table 5: Sagittal suture S2(Closure's scoring)

Age Group		Sagittal Suture (Closure's Scoring)									
		S2 (Pars Vertices) Ectocranial					S2 (Pars Vertices) Endocranial				
		0	1	2	3	4	0	1	2	3	4
20–29 (*N*=17; 17%)	M (*N*=13; 76.5%)	11 (64.7%)	1 (5.9%)	1 (5.9%)	0 (00%)	0 (00%)	0 (00%)	11 (64.7%)	1 (5.9%)	1 (5.9%)	0 (00%)
	F (*N*=4; 23.5%)	4 (23.5%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	4 (23.5%)	0 (00%)	0 (00%)	0 (00%)
30–39 (*N*=21; 21%)	M (*N*=14; 66.7%)	2 (9.5%)	12 (57.1%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	2 (9.5%)	12 (57.1%)	0 (00%)	0 (00%)
	F (*N*=7; 33.3%)	3 (14.3%)	4 (19.1%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	3 (14.3%)	4 (19.1%)	0 (00%)	0 (00%)
40–49 (*N*=24; 24%)	M (*N*=9; 37.5%)	0 (00%)	9 (37.5%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	9 (37.5%)	0 (00%)	0 (00%)
	F (*N*=15; 62.5%)	2 (8.3%)	13 (54.2%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	2 (8.3%)	13 (54.2%)	0 (00%)	0 (00%)
50–59 (*N*=12; 12%)	M (*N*=6; 50%)	0 (00%)	6 (50%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	6 (50%)	0 (00%)	0 (00%)
	F (*N*=6; 50%)	4 (33.4%)	1 (8.3%)	0 (00%)	1 (8.3%)	0 (00%)	1 (8.3%)	3 (25%)	1 (8.3%)	1 (8.3%)	0 (00%)
60–69 (*N*=12; 12%)	M (*N*=7; 58.3%)	0 (00%)	3 (25%)	3 (25%)	1 (8.3%)	0 (00%)	0 (00%)	0 (00%)	3 (25%)	3 (25%)	1 (8.3%)
	F (*N*=5; 41.7%)	3 (25%)	1 (8.3%)	1 (8.3%)	0 (00%)	0 (00%)	0 (00%)	3 (25%)	1 (8.3%)	1 (8.3%)	0 (00%)
≥70 (*N*=14; 14%)	M (*N*=11; 78.6%)	0 (00%)	1 (7.2%)	5 (35.7%)	5 (35.7%)	0 (00%)	0 (00%)	0 (00%)	1 (7.2%)	5 (35.7%)	5 (35.7%)
	F (*N*=3; 21.4%)	0 (00%)	3 (21.4%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	3 (21.4%)	0 (00%)	0 (00%)

Table 6: Coronal suture CL1(Closure's scoring)

Age Group		Coronal Suture (Closure's Scoring)									
		CL1 (Pars Bregmatica) Ectocranial					CL1 (Pars Bregmatica) Endocranial				
		0	1	2	3	4	0	1	2	3	4
20–29 (*N* = 17; 17%)	M (*N* = 13; 76.5%)	10 (58.8%)	3(17.7%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	10 (58.8%)	3(17.7%)	0 (00%)	0 (00%)
	F (*N* = 4; 23.5%)	4 (23.5%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	4 (23.5%)	0 (00%)	0 (00%)	0 (00%)
30–39 (*N* = 21; 21%)	M (*N* = 14; 66.7%)	4 (19.1%)	10(47.6%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	4 (19.1%)	10(47.6%)	0 (00%)	0 (00%)
	F (*N* = 7; 33.3%)	7 (33.3%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	7 (33.3%)	0 (00%)	0 (00%)	0 (00%)
40–49 (*N* = 24; 24%)	M (*N* = 9; 37.5%)	3 (12.5%)	6(25%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	3 (12.5%)	6 (25%)	0 (00%)	0 (00%)
	F (*N* = 15; 62.5%)	5 (20.8%)	4(16.7%)	6 (25%)	0 (00%)	0 (00%)	0 (00%)	5 (20.8%)	5 (20.8%)	5 (20.8%)	0 (00%)
50–59 (*N* = 12; 12%)	M (*N* = 6; 50%)	0 (00%)	5(41.7%)	1 (8.3%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	5 (41.7%)	1 (8.3%)	0 (00%)
	F (*N* = 6; 50%)	0 (00%)	0(00%)	2 (16.7%)	4 (33.3%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	3 (25%)	3 (25%)
60–69 (*N* = 12; 12%)	M (*N* = 7; 58.3%)	0 (00%)	4(33.3%)	2 (16.7%)	1 (8.3%)	0 (00%)	0 (00%)	0 (00%)	4 (33.3%)	2 (16.7%)	1 (8.3%)
	F (*N* = 5; 41.7%)	2 (16.7%)	2(16.7%)	1 (8.3%)	0 (00%)	0 (00%)	0 (00%)	2 (16.7%)	2 (16.7%)	1 (8.3%)	0 (00%)
≥70 (*N* = 14; 14%)	M (*N* = 11; 78.6%)	0 (00%)	3(21.4%)	3 (21.4%)	5 (35.8%)	0 (00%)	0 (00%)	0 (00%)	3 (21.4%)	3 (21.4%)	5 (35.8%)
	F (*N* = 3; 21.4%)	0 (00%)	3(21.4%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	3 (21.4%)	0 (00%)	0 (00%)

Table 7: Coronal suture CL2(Closure's scoring)

Age Group		Coronal Suture (Closure's Scoring)									
		CL2 (Pars Complicata) Ectocranial					CL2 (Pars Complicata) Endocranial				
		0	1	2	3	4	0	1	2	3	4
20–29 (*N* = 17; 17%)	M (*N* = 13; 76.5%)	10 (58.3%)	3 (17.7%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	10 (58.3%)	3 (17.7%)	0 (00%)	0 (00%)
	F (*N* = 4; 23.5%)	4 (23.5%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	4 (23.5%)	0 (00%)	0 (00%)	0 (00%)
30–39 (*N* = 21; 21%)	M (*N* = 14; 66.7%)	4 (19.1%)	10 (47.6%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	4 (19.1%)	10 (47.6%)	0 (00%)	0 (00%)
	F (*N* = 7; 33.3%)	7 (33.3%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	7 (33.3%)	0 (00%)	0 (00%)	0 (00%)
40–49 (*N* = 24; 24%)	M (*N* = 9; 37.5%)	1 (4.2%)	8 (33.3%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	1 (4.2%)	8 (33.3%)	0 (00%)	0 (00%)
	F (*N* = 15; 62.5%)	5 (20.8%)	6 (25%)	4 (16.7%)	0 (00%)	0 (00%)	0 (00%)	5 (20.8%)	6 (25%)	4 (16.7%)	0 (00%)
50–59 (*N* = 12; 12%)	M (*N* = 6; 50%)	0 (00%)	3 (25%)	3 (25%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	3 (25%)	3 (25%)	0 (00%)
	F (*N* = 6; 50%)	0 (00%)	0 (00%)	6 (50%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	1 (8.3%)	5 (41.7%)	0 (00%)
60–69 (*N* = 12; 12%)	M (*N* = 7; 58.3%)	1 (8.3%)	1 (8.3%)	5 (41.7%)	0 (00%)	0 (00%)	0 (00%)	1 (8.3%)	1 (8.3%)	5 (41.7%)	0 (00%)
	F (*N* = 5; 41.7%)	2 (16.7%)	2 (16.7%)	1 (8.3%)	0 (00%)	0 (00%)	0 (00%)	2 (16.7%)	2 (16.7%)	0 (00%)	1 (8.3%)
≥70 (*N* = 14; 14%)	M (*N* = 11; 78.6%)	0 (00%)	3 (21.4%)	3 (21.4%)	5 (35.8%)	0 (00%)	0 (00%)	0 (00%)	3 (21.4%)	3 (21.4%)	5 (35.8%)
	F (*N* = 3; 21.4%)	0 (00%)	3 (21.4%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	3 (21.4%)	0 (00%)	0 (00%)

Table 8: Coronal suture CL3(Closure's scoring)

Age Group		Coronal Suture (Closure's Scoring)									
		CL3 (Pars Pterica) Ectocranial					CL3 (Pars Pterica) Endocranial				
		0	1	2	3	4	0	1	2	3	4
20–29 (*N* = 17; 17%)	M (*N* = 13; 76.5%)	9 (53%)	4 (23.5%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	9 (53%)	4 (23.5%)	0 (00%)	0 (00%)
	F (*N* = 4; 23.5%)	4 (23.5%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	4 (23.5%)	0 (00%)	0 (00%)	0 (00%)
30–39 (*N* = 21; 21%)	M (*N* = 14; 66.7%)	0 (00%)	13 (61.9%)	1 (4.8%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	13 (61.9%)	1 (4.8%)	0 (00%)
	F (*N* = 7; 33.3%)	6 (28.5%)	1 (4.8%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	6 (28.5%)	1 (4.8%)	0 (00%)	0 (00%)
40–49 (*N* = 24; 24%)	M (*N* = 9; 37.5%)	0 (00%)	9 (37.5%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	9 (37.5%)	0 (00%)	0 (00%)
	F (*N* = 15; 62.5%)	14 (58.3%)	1 (4.2%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	14 (58.3%)	1 (4.2%)	0 (00%)	0 (00%)
50–59 (*N* = 12; 12%)	M (*N* = 6; 50%)	5 (41.7%)	0 (00%)	1 (8.3%)	0 (00%)	0 (00%)	0 (00%)	5 (41.7%)	0 (00%)	1 (8.3%)	0 (00%)
	F (*N* = 6; 50%)	4 (33.4%)	0 (00%)	1 (8.3%)	1 (8.3%)	0 (00%)	1 (8.3%)	3 (25%)	0 (00%)	2 (16.7%)	0 (00%)
60–69 (*N* = 12; 12%)	M (*N* = 7; 58.3%)	0 (00%)	5 (41.7%)	1 (8.3%)	1 (8.3%)	0 (00%)	0 (00%)	1 (8.3%)	4 (33.4%)	1 (8.3%)	1 (8.3%)
	F (*N* = 5; 41.7%)	2 (16.7%)	1 (8.3%)	2 (16.7%)	0 (00%)	0 (00%)	0 (00%)	1 (8.3%)	2 (16.7%)	1 (8.3%)	1 (8.3%)
≥70 (*N* = 14; 14%)	M (*N* = 11; 78.6%)	0 (00%)	2 (14.3%)	1 (7.2%)	6 (42.7%)	2 (14.3%)	0 (00%)	0 (00%)	2 (14.3%)	1 (7.2%)	8 (57.1%)
	F (*N* = 3; 21.4%)	0 (00%)	2 (14.3%)	1 (7.2%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	3 (21.4%)	0 (00%)	0 (00%)

Table 9: Coronal suture CR3(Closure's scoring)

Age Group		Coronal Suture (Closure's Scoring)									
		CR3 (Pars Pterica) Ectocranial					CR3 (Pars Pterica) Endocranial				
		0	1	2	3	4	0	1	2	3	4
20–29 (*N* = 17; 17%)	M (*N* = 13; 76.5%)	7 (41.2%)	5 (29.4%)	1 (5.9%)	0 (00%)	0 (00%)	0 (00%)	7 (41.2%)	5 (29.4%)	1 (5.9%)	0 (00%)
	F (*N* = 4; 23.5%)	4 (23.5%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	4 (23.5%)	0 (00%)	0 (00%)	0 (00%)
30–39 (*N* = 21; 21%)	M (*N* = 14; 66.7%)	0 (00%)	13 (61.9%)	1 (4.8%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	13 (61.9%)	1 (4.8%)	0 (00%)
	F (*N* = 7; 33.3%)	6 (28.5%)	1 (4.8%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	6 (28.5%)	1 (4.8%)	0 (00%)	0 (00%)
40–49 (*N* = 24; 24%)	M (*N* = 9; 37.5%)	1 (4.2%)	8 (33.3%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	1 (4.2%)	8 (33.3%)	0 (00%)	0 (00%)
	F (*N* = 15; 62.5%)	12 (50%)	3 (12.5%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	12 (50%)	3 (12.5%)	0 (00%)	0 (00%)
50–59 (*N* = 12; 12%)	M (*N* = 6; 50%)	3 (25%)	2 (16.7%)	1 (8.3%)	0 (00%)	0 (00%)	0 (00%)	3 (25%)	2 (16.7%)	1 (8.3%)	0 (00%)
	F (*N* = 6; 50%)	0 (00%)	0 (00%)	5 (41.7%)	1 (8.3%)	0 (00%)	0 (00%)	0 (00%)	1 (8.3%)	5 (41.7%)	0 (00%)
60–69 (*N* = 12; 12%)	M (*N* = 7; 58.3%)	0 (00%)	1 (8.3%)	5 (41.7%)	1 (8.3%)	0 (00%)	0 (00%)	0 (00%)	1 (8.3%)	5 (41.7%)	1 (8.3%)
	F (*N* = 5; 41.7%)	3 (25%)	0 (00%)	1 (8.3%)	1 (8.3%)	0 (00%)	0 (00%)	3 (25%)	0 (00%)	1 (8.3%)	1 (8.3%)
≥70 (*N* = 14; 14%)	M (*N* = 11; 78.6%)	0 (00%)	3 (21.4%)	1 (7.2%)	5 (35.8%)	2 (14.2%)	0 (00%)	0 (00%)	3 (21.4%)	1 (7.2%)	7 (50%)
	F (*N* = 3; 21.4%)	0 (00%)	3 (21.4%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	3 (21.4%)	0 (00%)	0 (00%)

Table 10: Coronal suture CR2(Closure's scoring)

Age Group		Coronal Suture (Closure's Scoring)									
		CR2 (Pars Complicata) Ectocranial					CR2 (Pars Complicata) Endocranial				
		0	1	2	3	4	0	1	2	3	4
20–29 (*N* = 17; 17%)	M (*N* = 13; 76.5%)	10 (58.8%)	3 (17.7%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	10 (58.8%)	3 (17.7%)	0 (00%)	0 (00%)
	F (*N* = 4; 23.5%)	4 (23.5%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	4 (23.5%)	0 (00%)	0 (00%)	0 (00%)
30–39 (*N* = 21; 21%)	M (*N* = 14; 66.7%)	4 (19.1%)	10 (47.6%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	4 (19.1%)	10 (47.6%)	0 (00%)	0 (00%)
	F (*N* = 7; 33.3%)	5 (23.8%)	2 (9.5%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	5 (23.8%)	2 (9.5%)	0 (00%)	0 (00%)
40–49 (*N* = 24; 24%)	M (*N* = 9; 37.5%)	0 (00%)	9 (37.5%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	9 (37.5%)	0 (00%)	0 (00%)
	F (*N* = 15; 62.5%)	5 (20.8%)	6 (25%)	4 (16.7%)	0 (00%)	0 (00%)	0 (00%)	5 (20.8%)	6 (25%)	4 (16.7%)	0 (00%)
50–59 (*N* = 12; 12%)	M (*N* = 6; 50%)	2 (16.6%)	3 (25%)	1 (8.4%)	0 (00%)	0 (00%)	0 (00%)	2 (16.6%)	3 (25%)	1 (8.4%)	0 (00%)
	F (*N* = 6; 50%)	0 (00%)	0 (00%)	6 (50%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	1 (8.4%)	5 (41.6)	0 (00%)
60–69 (*N* = 12; 12%)	M (*N* = 7; 58.3)	0 (00%)	2 (16.7%)	5 (41.6%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	2 (16.7%)	5 (41.6%)	0 (00%)
	F (*N* = 5; 41.7%)	2 (16.7%)	2 (16.7%)	1 (8.3%)	0 (00%)	0 (00%)	0 (00%)	2 (16.7%)	2 (16.7%)	1 (8.3%)	0 (00%)
≥70 (*N* = 14; 14%)	M (*N* = 11; 78.6%)	0 (00%)	3 (21.4%)	2 (14.3%)	6 (42.9%)	0 (00%)	0 (00%)	0 (00%)	3 (21.4%)	2 (14.3%)	6 (42.9%)
	F (*N* = 3; 21.4%)	0 (00%)	3 (21.4%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	3 (21.4%)	0 (00%)	0 (00%)

Table 11: Coronal suture CR1(Closure's scoring)

Age Group		Coronal Suture (Closure's Scoring)									
		CR1 (Pars Bregmatica) Ectocranial					CR1 (Pars Bregmatica) Endocranial				
		0	1	2	3	4	0	1	2	3	4
20–29 (*N* = 17; 17%)	M (*N* = 13; 76.5%)	10 (58.8%)	3 (17.7%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	10 (58.8%)	3 (17.7%)	0 (00%)	0 (00%)
	F (*N* = 4; 23.5%)	4 (23.5%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	4 (23.5%)	0 (00%)	0 (00%)	0 (00%)
30–39 (*N* = 21; 21%)	M (*N* = 14; 66.7%)	4 (19.1%)	10 (47.6%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	4 (19.1%)	10 (47.6%)	0 (00%)	0 (00%)
	F (*N* = 7; 33.3%)	6 (28.5%)	1 (4.8%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	6 (28.5%)	1 (4.8%)	0 (00%)	0 (00%)
40–49 (*N* = 24; 24%)	M (*N* = 9; 37.5%)	0 (00%)	9 (37.5%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	9 (37.5%)	0 (00%)	0 (00%)
	F (*N* = 15; 62.5%)	3 (12.5%)	6 (25%)	6 (25%)	0 (00%)	0 (00%)	0 (00%)	3 (12.5%)	6 (25%)	6 (25%)	0 (00%)
50–59 (*N* = 12; 12%)	M (*N* = 6; 50%)	2 (16.7%)	3 (25%)	1 (8.3%)	0 (00%)	0 (00%)	0 (00%)	2 (16.7%)	1 (8.3%)	3 (25%)	0 (00%)
	F (*N* = 6; 50%)	4 (33.3%)	0 (00%)	2 (16.7%)	0 (00%)	0 (00%)	1 (8.3%)	3 (25%)	2 (16.7%)	0 (00%)	0 (00%)
60–69 (*N* = 12; 12%)	M (*N* = 7; 58.3%)	0 (00%)	0 (00%)	7 (58.4%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	7 (58.4%)	0 (00%)
	F (*N* = 5; 41.7%)	3 (25%)	1 (8.3%)	1 (8.3%)	0 (00%)	0 (00%)	0 (00%)	3 (25%)	1 (8.3%)	1 (8.3%)	0 (00%)
≥70 (*N* = 14; 14%)	M (*N* = 11; 78.6%)	0 (00%)	3 (21.4%)	3 (21.4%)	5 (35.8%)	0 (00%)	0 (00%)	0 (00%)	3 (21.4%)	3 (21.4%)	5 (35.8%)
	F (*N* = 3; 21.4%)	0 (00%)	3 (21.4%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	3 (21.4%)	0 (00%)	0 (00%)

Table 12: Lambdoid suture LR1 (Closure's scoring)

Age Group		Lambdoid Suture (Closure's Scoring)										
		LR1 (Pars Lambdica) Ectocranial					LR1 (Pars Lambdica) Endocranial					
		0	1	2	3	4	0	1	2	3	4
20–29 (*N* = 17; 17%)	M (*N* = 13; 76.5%)	11 (64.7%)	1 (5.9%)	1 (5.9%)	0 (00%)	0 (00%)	0 (00%)	11 (64.7%)	1 (5.9%)	1 (5.9%)	0 (00%)
	F (*N* = 4; 23.5%)	4 (23.5%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	4 (23.5%)	0 (00%)	0 (00%)	0 (00%)
30–39 (*N* = 21; 21%)	M (*N* = 14; 66.7%)	13 (61.9%)	1 (4.8%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	13 (61.9%)	1 (4.8%)	0 (00%)	0 (00%)
	F (*N* = 7; 33.3%)	7 (33.3%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	7 (33.3%)	0 (00%)	0 (00%)	0 (00%)
40–49 (*N* = 24; 24%)	M (*N* = 9; 37.5%)	3 (12.5%)	6 (25%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	3 (12.5%)	6 (25%)	0 (00%)	0 (00%)
	F (*N* = 15; 62.5%)	5 (20.8%)	10(41.7%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	5 (20.8%)	10(41.7%)	0 (00%)	0 (00%)
50–59 (*N* = 12; 12%)	M (*N* = 6; 50%)	1 (8.3%)	4 (33.4%)	1 (8.3%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	5 (41.7%)	1 (8.3%)	0 (00%)
	F (*N* = 6; 50%)	4 (33.4%)	0 (00%)	1 (8.3%)	1 (8.3%)	0 (00%)	1 (8.3%)	3 (25%)	0 (00%)	2 (16.7%)	0 (00%)
60–69 (*N* = 12; 12%)	M (*N* = 7; 58.3%)	0 (00%)	5 (41.8%)	1 (8.3%)	0 (00%)	1 (8.3%)	0 (00%)	0 (00%)	5 (41.8%)	1 (8.3%)	1 (8.3%)
	F (*N* = 5; 41.7%)	1 (8.3%)	3 (25%)	1 (8.3%)	0 (00%)	0 (00%)	0 (00%)	1 (8.3%)	3 (25%)	0 (00%)	1 (8.3%)
≥70 (*N* = 14; 14%)	M (*N* = 11; 78.6%)	0 (00%)	0 (00%)	8 (57.2%)	3 (21.4%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	8 (57.2%)	3 (21.4%)
	F (*N* = 3; 21.4%)	0 (00%)	3 (21.4%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	0 (00%)	2 (14.3%)	0 (00%)	1 (7.1%)

(pars complicata) (Table 10) and lastly C1 (pars bregmatica) (Table 11) on the right side.

In lambdoid suture, L1 (pars lambdica) closes slower and L3 closes fastest of all. L3 (pas asterica) closes early, followed by L2 (pars intermedia) and L1 (pars lambdica). Lambdoid suture has maximum cases of lapsed union, only few cases (14.3%) of L1 (pars lambdica) of both sides show complete closure (Table 12).

When comparison was made between sagittal, coronal and lambdoid suture, overall sagittal suture closes early and then coronal and lambdoid, respectively.

Within endocranial sutures, the sagittal suture S4 (pars lambdica) fuses early than the other parts of the sagittal sutures, followed by S3 (pars obelica), S2 (pars vertices) and S1 (pars bregmatica). Regarding coronal suture, 50–59 age group of the left side suture closes earlier compared with the right side. On the left side, C1 (pars begmatica) closes early, then C2 (pars complicata) and lastly C3 (pars pterica), but on the right side, C3 (pars pterica) closure is earlier than C2 (pars complicata) and lastly C1 (pars begmatica).

Endocranially, lambdoid suture showed no significant difference between the right and the left side. In lambdoid suture, L1 (pars lambdica) closes slower than other parts of the lambdoid sutures. L3 (pars asterica) closes early, followed by L2 (pars intermedia) and L1 (pars lambdica).

Sagittal suture endocranially starts fusing at the age of 20 years. In this study, more or less complete union is attained at ≥70 age group. In coronal suture near complete closure occurs by the 50–59 age group and the total closure by ≥70 years age group. Lambdoid suture starts fusing during 20–29 age group and never showed complete closure even in ≥70 years age group.

Overall, sagittal suture closes earlier, followed by coronal and lambdoid suture endocranially.

DISCUSSION

Sagittal Suture

In our present study, we have found that the sagittal suture endocranially starts fusing at 20 years and completion is attained at ≥70 years age group and this is in contrast with that reported by Todd and Lyon (1924), whereas it

is also in contrast to the observation reported by Pommerol (1869) and Topinard (1885), who indicated endocranial commencement of sagittal suture at much later age at about 40 years[6,7,8]. These latter workers have reported on very scanty specimens so it can't be considered authentic. The youngest age at which sagittal suture union was seen is 61 years ectocranially and 60 years endocranially.

Coronal Suture

Although in the present study, endocranial fusion of coronal suture was observed as early as at 20 years and completion by the age above 70 years, but other workers like Pommerol (1869), Topinard (1885), Ribbe (1885) reported closure between 40 and 50 years[7,8]. Their study does not indicate whether it was ectocranial or endocranial or it was commencement or termination. The youngest age at which complete union was seen is at age greater than 70 years ectocranially and 50 years endocranially.

Lambdoid Suture

Lambdoid endocranially starts fusing at the age of 20 years in the present study which shows that it is a year earlier than that reported by Todd and Lyon (1924), whereas completion in our study in age group ≥70 years (only 14.3%). The other workers have not reported on lambdoid suture. Complete union was never seen in lambdoid suture ectocranially, whereas endocranially complete union seen over the age of ≥70 years. Lambdoid suture shows highest cases of lapsed union, whereas Reddy indicates sagittal suture as the highest.

Our Indian data compare well with those of the male whites (Todd and Lyton, 1925). Negro skulls, however, show an earlier date of commencement and closure.

From the present study (see tables), it is clearly evident that endocranial union is a far better parameter for age determination than is the ectocranial union as also established by Todd and Lyon (1924 and 1925), Dwight

S.No.	Workers/Authors			Sagittal	Coronal	Lambdoid
1.	Todd and Lyon (1924)			20–29	26–50	26–31
				20–32	23–25	23–31
2.	Ribbe's (1885)			Closure 21–50 years frequent between 44 and 45 years. Ectocranially sagittal closes first then lambdoid, coronal suture		
3.	Schmidt (1988)			Closure between 25 and 40 and completed 40–60 years		
4.	Modi's (1988)			30–50	40–60	50–70
5.	Reddy (1990) (2)			25–35	40	45
6.	Parikh (1990) (35)			30–50	40–60	50–70
7.	Nandy (1995) (33)			25–45	25–45	27–50
8.	Shapiro and Janzen (1960)			22–35	24–38	26–42
9.	Werner and Fisher's text book			25–40	25	35–45
10.	Vyas (34)			50–55	45–60	60
				50–55	50–60	60
11.	Moondra (32)	Endo	M	46–50	46–50	56–60
			F	46–50	56–60	56–60
		Ecto	M	51–55	51–55	Above 60
			F	40–60	56–60	Above 60
12.	Shetty (2007)	Ecto		>70	Lapsed union	>70
		Endo		60–69	40–49	40–49
13.	Present study (2015)	Ecto		60–69	>70	Lapsed union
		Endo		60–69	50–59	>70

(1890) [6,9]. All the previous work was done in France, Germany and United States of America, under different climatic conditions and in diverse racial groups. In our study, in this geographical area, the obliteration of the skull sutures is earlier in males than the females except the ectosagittal suture in 40–49 age group in which closure was earlier in the females.

CONCLUSION

Suture obliteration starts earlier on endocranial surface than on the ectocranial. Ectocranially, sagittal suture closes early, followed by coronal and lambdoid. Endocranially, sagittal suture closes early, followed by coronal and lambdoid. Although cross-sectional in nature, suture obliteration patterns (totally open, totally closed, partially open and partially closed) are not temporary progressive stages on an age scale, but rather independent permanent phenomena. There is difference in suture closure in males and females. Females showed earlier union than males in the age group 40–49, whereas in the other age groups, suture closure occurred earlier in males. Metopism was observed in 3% of cases. Lapsed union is a major deterrent for age estimation. It is more pronounced in lambdoid suture. There is the fundamental problem of using a method based on a structure which as yet is simply poorly understood. But whatever the underlying biological factors are for suture closure and even if these in the future should be better understood, it is still important to refine the methods of quantifying these structures, to render the methods of quantification as unbiased as possible.

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