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ORIGINAL RESEARCH

Observation on Closure of Cranial Sutures to Estimate Age and Variation with Respect to Sex and Race: A Post-mortem Study Conducted at RIMS, Ranchi, Jharkhand, India

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ABSTRACT

Background: Age estimation helps in both civil as well as criminal cases. Cranium is a well preserved part of human skeleton, so it has a great value for estimation of age by a forensic expert. Importance of cranial suture closure has been accepted with some range. **Materials and method:** The study was conducted on 100 subjects (50 males and 50 females both having tribals and non-tribals) brought for medicolegal autopsy at RIMS Ranchi.The subjects were divided into five age groups viz. 20-30 years, 30-40 years, 40-50 years, 50-60 years and 60 years onwards; each age group consisting of 20 individuals. **Results:** Status of closure with age at 9 ecto-cranial suture landmarks were studied. The nine landmarks studied were- Mid Lambdoid (ML), Mid Coronal, Anterior Temporoparietal (AT), Posterior Temporoparietal (PT), Superior Sphenotemporal (SST), Lambda(L), Bregma (B), Anterior Sagittal (AS) and Obelion (O). Meindl and Lovejoy scoring system with some modifications was used. **Conclusion:** Males show earlier closure than females. Tribals show earlier closure than non-tribals. No bilateral variation was observed in paired cranial sutures.

Keywords: Identification, Sutural landmarks, Race, Autopsy, Composite score.

INTRODUCTION

Age estimation helps in both civil as well as criminal cases such as identification, consent, rape, marriage, employment, retirement benefits etc. Chronological age coincides with the skeletal age with some biological variations. Complete skeleton is rarely recovered or preserved and skeletal material can be easily fragmented. Cranium is a well preserved part of human skeleton, so it has a great value for estimation of age by a forensic expert. Sutures are limited to skull, occurring where ever margins or broader surfaces of bones meet and articulate, separated only by a zone of connective tissue, the sutural ligament or membrane[1]. Cranium has two surfaces; outer ectocranium and the inner endocranium. In the vault of skull, closure of sutures begins on the inner side 5-10 years earlier than on the outer side[2]. Cranial suture closure has maximum number of age markers (i.e many sutures) as compared to any bone in the body which have only few age markers (ossification centres and epiphyseal joints). Importance of cranial suture closure has been accepted with some deviations(range). This study was carried out to ascertain cranial suture closure as an age indicator

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using the ectocranial suture landmarks. The study was carried out on the dead bodies of mixed (tribal and non-tribal) population of district Ranchi, sent for medico-legal autopsy at RIMS Ranchi during the study period i.e. from 1st of August 2011 to 31stof July 2012.

OBJECTIVES

1. To observe the pattern of closure of cranial sutures for the estimation of chronological age.
2. To observe the pattern of closure of cranial sutures with respect to sex as well as race of similar age groups.
3. To observe the bilateral variability of closure of paired cranial sutures.

MATERIALS AND METHODS

The study was conducted on 100 subjects (50 males and 50 females both having tribals and non-tribals) brought for medicolegal autopsy at RIMS Ranchi.The subjects were divided into five age groups viz. 20-30 years, 30-40 years, 40-50 years, 50-60 years and 60 years onwards; each age group consisting of 20 individuals (combinations of males and females and tribals and non-tribals).Each age group contained 10 male and 10 females which was further divided into tribals and non-tribals. Total number of tribal males was 19, non-tribal males was 31, tribal females was 22 and that of non-tribal females was 28.

Composition of population under study with respect to age, sex and race

Age Group	Sex	Composition	Number
20-30	Male	Tribal	5
		Non-Tribal	5
	Female	Tribal	5
		Non-Tribal	5
30-40	Male	Tribal	2
		Non-Tribal	8
	Female	Tribal	5
		Non-Tribal	5
40-50	Male	Tribal	7
		Non-Tribal	3
	Female	Tribal	4
		Non-Tribal	6
50-60	Male	Tribal	2
		Non-Tribal	8
	Female	Tribal	2
		Non-Tribal	8
>60	Male	Tribal	3
		Non-Tribal	7
	Female	Tribal	6
		Non-Tribal	4

Inclusion criteria and Exclusion criteria

Inclusion criteria

1. Cases over 20 years of age.
2. Cases with all intact sutures.

Exclusion criteria

1. Damaged skull with damaged sutures.
2. Congenital anomaly of skull.

Cranial Landmarks under consideration

- Following landmarks were studied:-

1. Mid Lambdoid (ML)
2. Lambda (L)
3. Obelion (O)- point on the Sagittal suture located at the level of parietal foramina near the Lambdoid suture.
4. Anterior sagittal (AS)- Junction of anterior 1/3rd and posterior 2/3rdof Sagittal suture.
5. Bregma (B)
6. Mid coronal
7. Superior sphenotemporal. (SST)
8. Anterior temporoparietal (AT)
9. Posterior temporoparietal (PT)

Scoring system used

- Meindl and Lovejoy scoring system with some modifications-

– Open- No evidence of closure at ectocranium
– Minimal closure- some closure has occurred
– Advanced closure- some portion not completely fused
– Complete closure- only pits or slight depression present.

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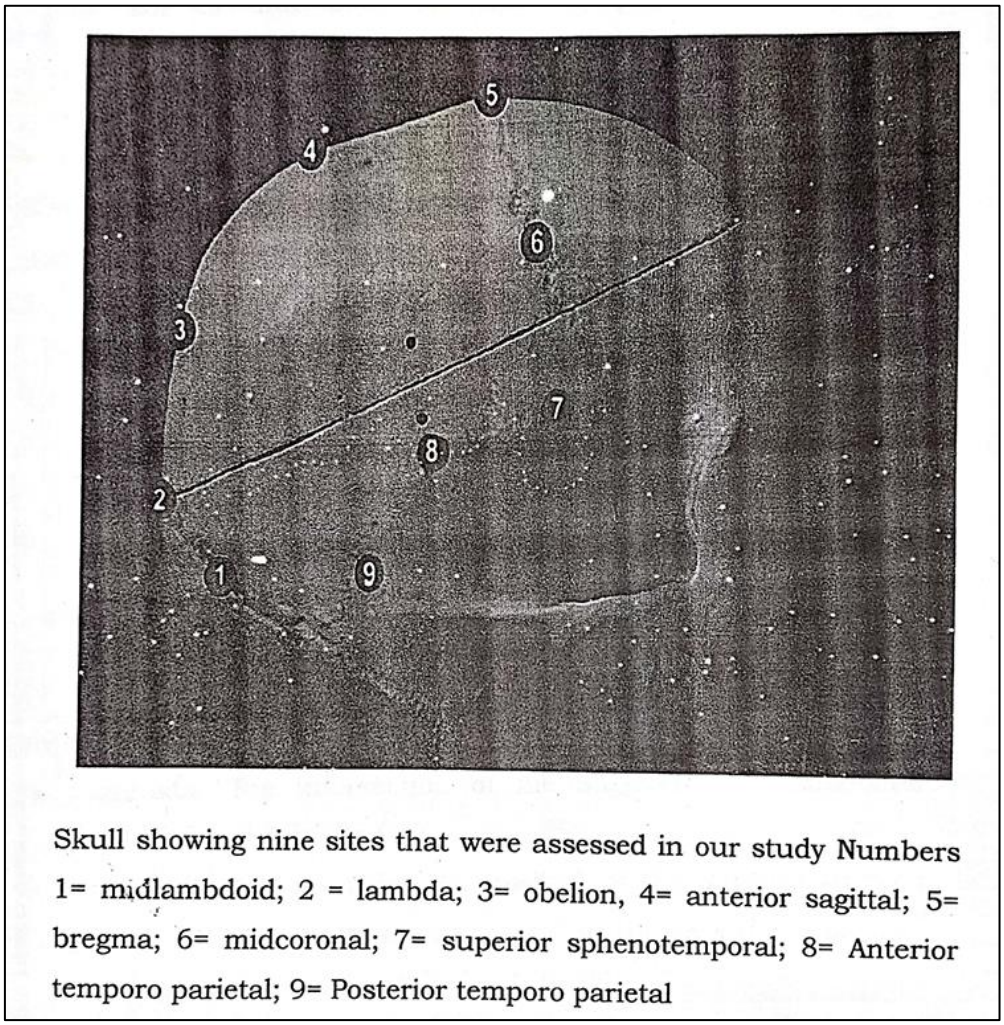
OBSERVATION AND RESULTS



Skull showing nine sites that were assessed in our study Numbers 1= midlambdoid; 2 = lambda; 3= obelion, 4= anterior sagittal; 5= bregma; 6= midcoronal; 7= superior sphenotemporal; 8= Anterior temporo parietal; 9= Posterior temporo parietal

- Right mid lambdoid (RML) and left mid lambdoid (LML)

Age Group	Sex	Composition	Number	Mean Score
20-30	Male	Tribal	5	0
		Non-Tribal	5	0
	Female	Tribal	5	0
		Non-Tribal	5	0
30-40	Male	Tribal	2	1
		Non-Tribal	8	1
	Female	Tribal	5	0.75
		Non-Tribal	5	0.66
40-50	Male	Tribal	7	2.14
		Non-Tribal	3	2
	Female	Tribal	4	1.2
		Non-Tribal	6	1
50-60	Male	Tribal	2	2.5
		Non-Tribal	8	2.57
	Female	Tribal	2	2
		Non-Tribal	8	1.87
>60	Male	Tribal	3	3
		Non-Tribal	7	2.71
	Female	Tribal	6	2.83
		Non-Tribal	4	3

- No closure in 20-30 years age group.

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- Closure begins 30 years onwards.
- Minimal closure- 30-40 years.
- Minimal to advanced closure- 40-50 years.
- Advanced closure- 50-60 years.
- Advanced to complete closure- 60 years onwards.
- Closure starts earlier in tribal population and males.
- No bilateral variation observed.

- **Right coronal (RC) and left coronal (LC).**

Age Group	Sex	Composition	Number	Mean Score
20-30	Male	Tribal	5	1.2
		Non-Tribal	5	0.8
	Female	Tribal	5	1.2
		Non-Tribal	5	0.5
30-40	Male	Tribal	2	3
		Non-Tribal	8	2.28
	Female	Tribal	5	2.75
		Non-Tribal	5	2.67
40-50	Male	Tribal	7	3
		Non-Tribal	3	2
	Female	Tribal	4	3
		Non-Tribal	6	2.6
50-60	Male	Tribal	2	3
		Non-Tribal	8	3
	Female	Tribal	2	3
		Non-Tribal	8	3
>60	Male	Tribal	3	3
		Non-Tribal	7	3
	Female	Tribal	6	3
		Non-Tribal	4	3

- Closure begins during 20-30 years.
- Earliest closure occurs in tribal males.
- Complete closure in tribal population during 40-50 years of age.
- Complete closure in all groups after 50 years of age.
- No bilateral variation observed in right and left coronal sutures.

- **Right anterior temporoparietal (RAT) and left anterior temporoparietal (LAT).**

Age Group	Sex	Composition	Number	Mean Score
20-30	Male	Tribal	5	0.2
		Non-Tribal	5	0.4
	Female	Tribal	5	0.2
		Non-Tribal	5	0.25
30-40	Male	Tribal	2	2
		Non-Tribal	8	1.57
	Female	Tribal	5	1
		Non-Tribal	5	0.83
40-50	Male	Tribal	7	2.71
		Non-Tribal	3	2.66
	Female	Tribal	4	2.8
		Non-Tribal	6	1.6
50-60	Male	Tribal	2	3
		Non-Tribal	8	3
	Female	Tribal	2	2.5
		Non-Tribal	8	2.6
>60	Male	Tribal	3	3
		Non-Tribal	7	3

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	Female	Tribal	6	3
		Non-Tribal	4	3

- Closure begins- 20-30 years.
- Minimal closure- 30-40 years.
- Minimal to advanced closure- 40-50 years.
- Complete closure in tribal and non tribal males- 50-60 years.
- Complete closure in tribal and non-tribal females- after 60 years.
- No bilateral variation observed.

- **Right posterior temporoparietal (RPT) and Left posterior temporoparietal (LPT).**

Age Group	Sex	Composition	Number	Mean Score
20-30	Male	Tribal	5	0
		Non-Tribal	5	0
	Female	Tribal	5	0
		Non-Tribal	5	0
30-40	Male	Tribal	2	0
		Non-Tribal	8	0.28
	Female	Tribal	5	0
		Non-Tribal	5	0
40-50	Male	Tribal	7	1
		Non-Tribal	3	0.66
	Female	Tribal	4	0.2
		Non-Tribal	6	0.2
50-60	Male	Tribal	2	2
		Non-Tribal	8	2
	Female	Tribal	2	1.5
		Non-Tribal	8	1.37
>60	Male	Tribal	3	2.66
		Non-Tribal	7	2.42
	Female	Tribal	6	2.5
		Non-Tribal	4	2.76

- No closure until 40 years except few minimal closure in non-tribal males.
- Closure begins 40 years onwards and advances fast in tribal males.
- Minimal to advanced closure- 50 years onwards.
- Advanced to complete closure- 60 years onwards.
- This suture takes maximum time for complete closure.
- No definite relationship with sex and race concluded.
- No bilateral variation observed.

- **Right superior sphenotemporal (RSST) and Left superior sphenotemporal (LSST)**

Age Group	Sex	Composition	Number	Mean Score
20-30	Male	Tribal	5	0
		Non-Tribal	5	0
	Female	Tribal	5	0
		Non-Tribal	5	0
30-40	Male	Tribal	2	1.5
		Non-Tribal	8	1.43
	Female	Tribal	5	1
		Non-Tribal	5	0.5
40-50	Male	Tribal	7	2.57
		Non-Tribal	3	2.33
	Female	Tribal	4	2
		Non-Tribal	6	1.4
50-60	Male	Tribal	2	3
		Non-Tribal	8	2.71

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	Female	Tribal	2	2.5
		Non-Tribal	8	1.375
>60	Male	Tribal	3	3
		Non-Tribal	7	2.85
	Female	Tribal	6	3
		Non-Tribal	4	3

- No closure in 20-30 years age group.
- Closure begins- 30 years onwards.
- Minimal to advanced closure- 40-50 years.
- Near complete closure- 50 years onwards.
- Sequence of closure- tribal male followed by non-tribal male followed by tribal female followed by non-tribal female.
- No bilateral variation observed.

- **Bregma (B).**

Age Group	Sex	Composition	Number	Mean Score
20-30	Male	Tribal	5	1.2
		Non-Tribal	5	0.8
	Female	Tribal	5	0.8
		Non-Tribal	5	1
30-40	Male	Tribal	2	3
		Non-Tribal	8	2.42
	Female	Tribal	5	2.5
		Non-Tribal	5	2.17
40-50	Male	Tribal	7	3
		Non-Tribal	3	3
	Female	Tribal	4	2.8
		Non-Tribal	6	2.2
50-60	Male	Tribal	2	3
		Non-Tribal	8	3
	Female	Tribal	2	3
		Non-Tribal	8	3
>60	Male	Tribal	3	3
		Non-Tribal	7	3
	Female	Tribal	6	3
		Non-Tribal	4	3

- Closure begins during 20-30 years.
- Complete closure in tribal males- after 30 years. For others, it is advanced to complete closure during 30-40 years.
- Complete closure- after 50 years.
- Complete closure earlier in males as compared to females.
- Sequence of closure- Tribal male followed by non-tribal male followed by tribal female followed by non-tribal female.

- **Anterior sagittal (AS).**

Age Group	Sex	Composition	Number	Mean Score
20-30	Male	Tribal	5	1.2
		Non-Tribal	5	1
	Female	Tribal	5	1
		Non-Tribal	5	0.6
30-40	Male	Tribal	2	3
		Non-Tribal	8	2.28
	Female	Tribal	5	2.25
		Non-Tribal	5	2.33
40-50	Male	Tribal	7	3
		Non-Tribal	3	3

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	Female	Tribal	4	3
		Non-Tribal	6	2.8
50-60	Male	Tribal	2	3
		Non-Tribal	8	3
	Female	Tribal	2	3
		Non-Tribal	8	3
>60	Male	Tribal	3	3
		Non-Tribal	7	3
	Female	Tribal	6	3
		Non-Tribal	4	3

- Minimal closure- 20-30 years.
- Earliest complete closure- tribal males- 30 years onwards.
- Little variation in rest of the population during 30-40 years.
- Complete closure except non-tribal female- after 40 years.
- Complete closure in non-tribal female- after 50 years.
- Males earlier than females; tribal population earlier than non-tribal population.

- **Lambda (L).**

Age Group	Sex	Composition	Number	Mean Score
20-30	Male	Tribal	5	0
		Non-Tribal	5	0
	Female	Tribal	5	0
		Non-Tribal	5	0
30-40	Male	Tribal	2	1.5
		Non-Tribal	8	1.28
	Female	Tribal	5	1.25
		Non-Tribal	5	1.17
40-50	Male	Tribal	7	2.57
		Non-Tribal	3	2
	Female	Tribal	4	1.4
		Non-Tribal	6	2
50-60	Male	Tribal	2	3
		Non-Tribal	8	2.57
	Female	Tribal	2	3
		Non-Tribal	8	2.625
>60	Male	Tribal	3	3
		Non-Tribal	7	3
	Female	Tribal	6	3
		Non-Tribal	4	3

- No closure before 30 years.
- Minimal closure- 30-40 years.
- Advanced closure- 40-50 years.
- Advanced to complete closure- 50-60 years.
- Complete closure- After 60 years of age.
- Closure occurs earlier in tribal males.
- No much variation in tribal and non tribal females.

- **Obelion (O)**

Age Group	Sex	Composition	Number	Mean Score
20-30	Male	Tribal	5	1.2
		Non-Tribal	5	1.4
	Female	Tribal	5	1.6
		Non-Tribal	5	1
30-40	Male	Tribal	2	3
		Non-Tribal	8	2.25

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	Female	Tribal	5	2.75
		Non-Tribal	5	2.33
40-50	Male	Tribal	7	3
		Non-Tribal	3	3
	Female	Tribal	4	3
		Non-Tribal	6	2.8
50-60	Male	Tribal	2	3
		Non-Tribal	8	3
	Female	Tribal	2	3
		Non-Tribal	8	3
>60	Male	Tribal	3	3
		Non-Tribal	7	3
	Female	Tribal	6	3
		Non-Tribal	4	3

- Minimal closure- 20-30 years age group.
- Earliest start of closure- tribal female.
- Earliest complete closure in tribal male- after 30 years.
- Complete closure in rest of the population- after 40 years.
- Tribal population has earlier closure.
- Non-tribal male and female have nearly similar closure age.

- **Composite score (CS).**

Age Group	Sex	Composition	Number	Mean Score
20-30	Male	Tribal	5	6.4
		Non-Tribal	5	5.28
	Female	Tribal	5	6.2
		Non-Tribal	5	4.2
30-40	Male	Tribal	2	25.5
		Non-Tribal	8	22.25
	Female	Tribal	5	19.75
		Non-Tribal	5	17.33
40-50	Male	Tribal	7	34.57
		Non-Tribal	3	32.33
	Female	Tribal	4	28.6
		Non-Tribal	6	22.8
50-60	Male	Tribal	2	39
		Non-Tribal	8	38.37
	Female	Tribal	2	34.5
		Non-Tribal	8	34.25
>60	Male	Tribal	3	41.33
		Non-Tribal	7	40
	Female	Tribal	6	40.5
		Non-Tribal	4	41.5

- It is the sum total of all sutural scores.
- It gradually increases with age.
- 20-30 years- 4.2-6.4.
- 30-40 years- 17.33-25.5.
- 40-50 years- 22.8-34.57.
- 50-60 years- 34.25-39.
- >60 years- 40-41.5.
- Best correlated to all age groups as compared to any individual score.

DISCUSSION

- Age of closure of different sutures as given by different workers/authors and our study is presented below in tabular form:-

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Sl. No.	Workers/Authors	Sagittal (years)			Coronal (years)	Lambdoid (years)		Temporal (years)		
1.	Apurba Nandi (2010)	45-50			45-50	55-60		70 or above		
2.	R N Karmakar (2010)	30-35			35-40	45-50		55-60		
3.	K S N Reddy (2011)	Ant. 1/3 40-50	Middle 1/3 >50	Post. 1/3 30-40	Lower half-40-50. Upper half-50-60	45		60		
4.	Krogman (1962)	---			26-41	31		50		
5.	Modi (1988)	30-50			40-60	50-70		60-80		
6.	Nageshkumar G Rao (2007)	Ant. 1/3 40-50	Middle 1/3 50-60	Post. 1/3 30-40	Lower half-40-50. Upper half-50-60	Upper-50-60 Mid-lambdoid-60-70		AT 80	PT 80	SST 50-60
7.	Todd and Lyon (1924) at Endocranium	20-29			26-50	26-31		---		
8.	Parikh (1990)	30-35			35-40	45-50		55-60		
9.	Our study	Bregma 50-60	AnteriorSagittal 40-50	Obelion 40-50	40-50	L 50-60	ML >60	AT >60	PT >60	SST >60

CONCLUSION

- Some generalized conclusions drawn from the results of this study are:

1. Sagittal suture is the earliest suture to get obliterated, followed by coronal, followed by Lambdoid, followed by Temporal suture.
2. Composite score of sutures is more reliable indicator for age estimation as compared to an individual suture score.
3. Male population shows early closure as compared to female population.
4. Tribal population shows early closure as compared to non-tribal population.
5. No bilateral variation was observed in any paired cranial suture.

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