

# A Pilot Study to find out Sexual Dimorphism in Human Skulls using Curvilinear Sagittal Suture Length

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## ABSTRACT

**INTRODUCTION:** Identification is the determination of the individuality of a person based on certain physical characteristics, i.e., exact fixation of personality. Correct sex estimation reduces the possible number of individuals that need to be considered by approximately 50%. According to Krogman, sexing can be 90% accurate by skull alone, but till date only a handful of studies have been undertaken to study the relation of cranial suture length with parameters like sex and stature.

**MATERIAL AND METHOD:** This study was conducted on 400 deceased adults brought for post-mortem examination during study period. All the observations related to the current study were done by naked eye and data regarding age, sex and curvilinear length of sagittal suture were recorded.

**RESULTS:** The mean curvilinear length of sagittal suture was  $12.42 \pm 0.74$  cm in females and  $12.76 \pm 0.71$  cm in male and the mean length of the sagittal suture was significantly higher among males as compared to females.

**CONCLUSION:** Curvilinear length of sagittal suture is a reliable predictor of sex.

**KEYWORDS:** Curvilinear length; Sagittal suture; Sexual dimorphism; Identification.

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## INTRODUCTION

Identification is the determination of the individuality of a person based on certain physical characteristics, i.e., exact fixation of personality.<sup>1</sup> Exact identification is particularly important, and at the same time equally difficult, when there is evidence of effacement of identity or when identifying an unknown person; in cases of man-

made mass disasters and natural calamities. Also, with increasing tendency of crime perpetrators towards destroying the identity of the victim, either by acts of commission like dismembering, decapitation, post-mortem burning, dumping in water body, etc. or by intentional neglect by leaving the dead body on terrains like forests, open grounds, farmlands wherein the natural elements like sunlight, rain, wind and scavenging animals act upon the dead; we end up with partly or wholly skeletonized remains of the deceased reaching us from the scene of recovery to our autopsy rooms.<sup>2</sup> Sex, age and stature are primary characteristics of identification.<sup>1</sup>

Correct sex estimation is critically important during identification as it reduces the possible number of individuals that need to be considered by approximately 50%. Therefore, sexing is of greater value than age, stature, and race identification.<sup>3</sup> Generally, DNA analysis for sexing of bones is the most accurate method. However, the high cost along with sophisticated extraction and analysis techniques critically limit its utility. Also, forensic DNA extraction from bone raises several issues, because the samples are very often badly altered and/or in very small quantity.<sup>4,5</sup> Therefore, we have to rely on anthropometric techniques to provide more convenient methods in sex estimation.

In order to predict sex of an individual, metric methods are considered to perform better than morphological methods, as the former eliminates the subjectivity inherent to morphological assessment and thus reduces the inter-observer and intra-observer errors.<sup>6,7</sup> Though metric methods have reasonable accuracy rates, it is evident that one population standard should not be used for another population for sex assessment as there may be a significant variability in sexual dimorphism between populations.<sup>8</sup>

Till date, only a handful of studies have been undertaken to study the relation of cranial suture lengths with parameters like sex and stature. In the current study, we attempt to find whether curvilinear length of sagittal suture has any sexual dimorphism and can it be used as a reliable indicator of sex.

#### MATERIAL AND METHOD

This analytical study with cross-sectional design was conducted on 400 deceased adults brought for post-mortem examination at the Department of Forensic Medicine of B.J. Govt. Medical College

and Sassoon General Hospitals, Pune during April 2021 to May 2022, after obtaining clearance from institutional ethics committee. Deceased individuals of Indian origin, of more than 20 years of age, whose exact age at the time of death was known and confirmed by documentary evidence were included in the study. While known cases of non-Indian origin, unknown deceased individuals where exact age could not be confirmed, known cases of metabolic bone diseases, craniosynostosis, nutritional deficiency, skeletal malformation or deformity, endocrinal disorders, cancers and cases of fresh and healed skull fractures were excluded from the study.

All observations related to current study were done by naked eye at the time of medico-legal post-mortem examination of deceased. Data regarding age, sex and curvilinear length of sagittal suture were recorded. During post-mortem examination, after standard reflection of scalp, soft tissue over the skull vault was removed thoroughly to expose the sagittal suture from the bregma (anterior junction of sagittal and coronal sutures) up-to the lambda (posterior junction of coronal and lambdoid sutures). Curvilinear length of sagittal suture (i.e. distance between lambda and bregma) was measured with the help of a non-stretchable thread and a graduated scale.

#### RESULTS

Out of the 400 individuals included in the study, 317 (79.2%) were males while 83 (20.75%) were females. Thus, the sample showed male preponderance (Table 1).

**Table 1:** Sex-wise distribution of cases

Sex	Frequency (n)	Percent (%)
Female	83	20.75
Male	317	79.25
Total (N)	400	100.0

For the 83 female crania examined, the minimum and maximum ages were 20 years and 99 years respectively with mean age being  $48.69 \pm 21.67$  years. For the 317 male crania examined, the minimum and maximum ages were 20 years and 85 years respectively with mean age being  $46.06 \pm 15.78$  years. On applying Mann-Whitney U test (p-value=0.001, significant), we found that the mean age of

females in study population is significantly higher as compared to males (Table 2).

All individuals were grouped as per their ages in a range of 10 years as shown in Table 3.

**Table 2:** Sex-wise mean age

Sex	Mean age (in years)	Minimum age (in years)	Maximum age (in years)	Std. dev.	P value (as per Mann Whitney U Test)
Female (n= 83)	48.69	20	99	21.67	0.001
Male (n= 317)	46.06	20	85	15.78	(Significant - S)

**Table 3:** Sex-wise and age group-wise distribution of cases

Age group (in years)	Females		Males		Total		P value (as per Chi square test)
	No.	Sex-wise percentage distribution within age group	No.	Sex-wise percentage distribution within age group	Total cases within age group (N=400)	Percentage distribution of total cases within age group	
20-29	25	34.25	48	65.75	73	18.25	0.1 (Not Significant -NS)
30-39	11	13.58	70	86.42	81	20.25	
40-49	7	9.59	66	90.41	73	18.25	
50-59	11	14.1	67	85.9	78	19.5	
60-69	10	21.74	36	78.26	46	11.5	
70-79	11	34.38	21	65.63	32	8	
80-89	6	40	9	60	15	3.75	
90-99	2	100	0	0	2	0.5	
Total	83	20.75	317	79.25	400	100	

The values from the table show that there was no significant difference between the females and males with regards to age range in our study population.

The values from the tables 4 and 5 show that there was no significant difference in the mean outcomes of length of the sagittal suture within the different age ranges in the female and male individuals.

**Table 4:** Mean length of sagittal suture in each age group (Females) (n=83)

Age group (in years)	Mean length (in cm)	Std. dev.	Minimum length (in cm)	Maximum length (in cm)	P value (as per Krusal-Wallis test)
20-29	12.12	0.84	10.50	13.70	0.222 (NS)
30-39	12.81	0.51	11.70	13.70	
40-49	12.32	0.73	11.00	13.00	
50-59	12.71	0.85	11.50	13.70	
60-69	12.54	0.71	11.00	13.50	
70-79	12.40	0.58	11.60	13.30	
80-89	12.48	0.60	12.00	13.40	
90-99	12.25	0.35	12.00	12.50	

**Table 5:** Mean length of sagittal suture in each age group (Males) (n=317)

Age group (in years)	Mean length (in cm)	Std. dev.	Minimum length (in cm)	Maximum length (in cm)	P value (as per Kruskal-Wallis test)
20-29	12.68	0.74	11.00	14.20	
30-39	12.74	0.75	11.00	14.50	
40-49	12.90	0.69	11.00	14.20	
50-59	12.73	0.76	11.10	14.60	0.222
60-69	12.70	0.71	10.00	14.00	(NS)
70-79	12.84	0.55	12.00	14.00	
80-89	12.72	0.38	12.30	13.50	
90-99	–	–	–	–	

**Table 6:** Sex-wise mean length of sagittal suture:

Sex (N=400)	Mean length (in cm)	Std. dev.	Minimum length (in cm)	Maximum length (in cm)	P value (as per Mann Whitney U test)
Female (n=83)	12.42	0.74	10.50	13.70	0.0001
Male (n=317)	12.76	0.71	10.00	14.60	(S)

**Table 7:** Findings of present study as compared with those of previous researchers:

Sr. No.	Name of the worker	Method of measuring length of Sagittal Suture	Males			Females		
			N	Mean length (in cm)	SD	N	Mean length (in cm)	SD
1	Rao et al <sup>23</sup>	Curvilinear length	87	12.92	0.77	–	–	–
2	Narasimhamurthy et al <sup>21</sup>	Straight length	50	12.41	0.74	50	11.93	1.01
3	Sobh and Gheat <sup>3</sup>	Curvilinear length	48	11.9	1.6	32	10.8	1.6
4	Present study	Curvilinear length	317	12.76	0.71	83	12.42	0.74

Thus, age was ruled out as a confounding factor in the current study population.

For the 83 female crania examined, the minimum length of sagittal suture was 10.5 cm while the maximum length was 13.7 cm with mean length being  $12.42 \pm 0.74$  cm. For the 317 male crania examined, the minimum length of sagittal suture was 10 cm while the maximum length was 14.6 cm with mean length being  $12.76 \pm 0.71$  cm. On applying Mann-Whitney U test (p-value= 0.0001, significant), we found that the mean length of the sagittal suture was significantly higher among males as compared to females (Table 6).

#### DISCUSSION

Since bones resist putrefaction and destruction for a long time, they are a reliable source to determine

age, sex, race and stature of the individual. The cranium is frequently the best preserved portion of the recovered skeleton.<sup>9</sup> It is due to its relatively higher resistance to environmental and animal destruction than other bones. The pelvis and the skull are known to be the most sexually dimorphic bones in the skeleton.<sup>10</sup> According to Krogman, sexing can be 90% accurate by skull alone.<sup>11</sup> The fact that sexual dimorphism exists between male and female human skulls morphologically as well as morphometrically is very well documented by numerous researchers.<sup>12-17</sup>

Cranial sutures help us estimate the age, origin, ancestry, sex (to some extent), identity and stature.<sup>18</sup> It is a well known fact that cranial sutures fuse earlier in males as compared to females<sup>1,19</sup> but some researchers do not agree with this generalisation.<sup>18,20</sup>

Narasimhamurthy *et al*<sup>21</sup> and Talokar and Lade<sup>22</sup>

recommended bregma-lambda length (BLL) as a measurement for sex estimation. However, these studies measured the straight distance between bregma and lambda using a slide calliper rather than the length of the sagittal suture along its curvature, as was done in the present study. Their results, also pointed that sagittal suture measurements can be a helpful tool in sex estimation.

Sobh and Gheat in their study used the curvilinear lengths of coronal and sagittal sutures for determining sex. They showed that the combined length of the coronal and sagittal sutures was the best sex discriminator; followed by coronal suture length; and sagittal suture length. Furthermore, they developed three regression models to predict sex from these suture lengths. If the suture length (s) is (are) applied in the formula and the result of the equation is higher than a cut-of value, the sex was predicted to be male. The highest accuracy could be obtained by the equation that included the lengths of the coronal and sagittal sutures together (76% accuracy); followed by coronal suture length (75% accuracy); then the sagittal suture length (71% accuracy).<sup>3</sup>

Table 7 shows us the findings of other studies and

the comparison with our study. In all the studies, it is found that the length of sagittal suture is greater in males than in females. As of now, we could not find any study in the literature where the opposite or contradictory findings were established.

Current study is limited by the fact that the number of female individuals in our sample size is considerably less as compared to their male counterparts. Therefore, in future such study should be performed on equal numbers of females and males. Secondly the method used for measurement can have measurement and observation errors and hence in future studies, to rule out these errors, sophisticated instruments which can be calibrated should be used.

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#### CONCLUSION

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Curvilinear length of sagittal suture is more in males as compared to in females, and hence it can be considered a reliable predictor for determination of sex.

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