



Correlation between Estimated and Actual Age of Fusion of Mesosternum with Manubrium Sterni and Xiphisternum

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Abstract

Objectives: This article documents the correlation between age of estimated and observed age of fusion of sternum bone, particularly when evaluating skeletonized human remains.

Methods: Soft tissues removed from the macerated sterna by blunt dissection and the fusion of body of sternum with manubrium sterni and xiphisternum are recorded.

Results: On statistical analysis for correlation between actual and estimated age correlation coefficient is 0.908 and p-value is 0.0001 that is statistically significant.

Conclusion: The correlation results indicate that there is statistically insignificant difference between the actual age of the subject and estimated age from fusion of sternal joints. None of studies assesses on determination of age from sternum has compared actual age of the individuals with estimated age devised from Sternal samples.

Keywords: Xiphisternum; Sternum; Mesosternum; Manubrium sterni; Morphological variation

Introduction

During development age is typically estimated via assessment of the appearance, changing morphology, and fusion of ossification centers. Once adulthood is reached age estimation becomes more challenging but is still possible from a variety of joint areas throughout the skeleton including the pubic symphysis, auricular surface, cranial sutures, and sternal rib ends. This form of age assessment relies on the degenerative changes that occur at these areas of the skeleton and is less precise than age estimation in the juvenile [1]. Thus due to the progressive development of bones, aging of skeletons under the age of 25 can be more easily accomplished utilizing the order of epiphyseal fusion in the long bones [2]. Post-maturations, the adult skeleton is

constantly degenerating. These degenerative changes are not as easily or as well documented as developmental changes; they can be influenced by factors including habitual activities and the health of an individual in addition to their age [3].

When estimating age, researchers assess a variety of developmental factors such as the analysis of suture closure for estimating age has been frequently utilized [4]. The fusion of cranial bones progressively with age has been in existence since at least the 16th century [5]. However, this fusion of cranial sutures is considerably variable in closure rates and patterns [6]. This variability leads to the question of the value of cranial suture closure as a method of estimating age at death [7]. Thus, its utilization as a method of age assessment has been quite controversial since the mid-20th century [8].

These studies are the result of a trend towards improvement in quantitative methods in forensic anthropology.

Materials and Methods

The present study is descriptive (cross sectional) study and conducted in the Department of Forensic Medicine, Lady Hardinge Medical College, New Delhi the study population comprised of all the cases with known age more than 30 years brought for medicolegal autopsy. The age of study population is obtained from the nearest relatives and police, and was verified by necessary government documents such as matriculation certificate, PAN card, Aadhaar card, Ration card or Voter's I.D. The age of the subject is rounded off to full years (6 months and above will be considered 1 year. A total of 100 cases from identified dead bodies were taken for the study. Only identified bodies with known age more than 30 years were included whereas decomposed and putrefied bodies or cases where sternum is deformed, diseased and fractured were excluded from the study.

Material used in the Study

The study instruments comprised of i) A pre-designed proforma to record relevant findings, ii) Thick rubber gloves and plastic apron, iii) Sodium hypochlorite, iv) Brain Knife, v) Tub to keep sternum, vi) Scalpel, vi) Autopsy instruments such as scalpel with blade, brain knife, bone cutter, rib shear and autopsy saw

Methodology

Sterna were removed from the cadavers by sectioning the costal cartilages just besides the costo-chondral junction. The sterna thus collected were marked, numbered, and then put in a water bath containing solution of sodium hypochlorite for a week for maceration. The sternum was then cleaned and examined intermittently to look for maceration on the 3rd, 5th and 7th days. After maceration and cleaning all the remains of the muscle and ligaments the sterna were dried at room temperature.

The elements of each sternum - manubrium, body and xiphoid process were examined for their fusion. The manubrio-sternal and the xiphisternal articulations were

carefully examined for degree of fusion: complete, partial, non-fusion and graded accordingly. Non-fusion (Grade-0) was seen as a dark black radiolucent line in the joint with complete separation of bone pieces, partial fusion (Grade-1) is seen as gap between joint begins to decrease with fusion of less or more than half of joining surface and a visible white dense line, complete fusion is seen without any gap between bony pieces with no visible white dense line with a homogenous radio opacity. Sternal samples with fused manubrio-mesosternal joints measurements are difficult to analyze since the true location of the joint may be hard to identify. Those sternae lacking obvious fusion lines were not used. Only samples possessing clear fusion lines were retained for measurement.

Statistical Analysis

All measurements were recorded and entered into Windows Excel for data collection and subsequently transposed to a commercially available software (Statistical Package for Social Sciences, version 21.0, SPSS Inc., Chicago, Illinois, USA and statistically evaluated according to age and gender. Both descriptive and analytical statistics were used. The continuous variables were presented as the mean \pm standard deviation, whereas the categorical variables were displayed as the number or the frequency. The chi-square test was used to compare the categorical variables. For the continuous variables, Student's t test was performed. A P-value less than 0.05 was considered statistically significant for all the statistical data.

Observation and Results

Out of a total of one hundred samples of sternum retrieved from dead bodies, 11 males (15.7%) and females (36.6%) belonged to 30-40 years age bracket and 21 (30%) males and 1 (3.3%) female in 41-50 years. 20 (28.5%) male and 7 (23.3%) female sternum samples were in 51-60 age groups whereas 18 (25.7%) males and 11 (36.6%) females belonged to >60 years age group. On statistical analysis fisher's test value is 12.99 and p-value is 0.004. Distribution of sternum samples according to age groups is shown in Table 1 is showing gender variations in samples of sternum in different age groups.

Variable	Age groups (Years)			
	30-40	41-50	51-60	>60
Male (70)	11 (15.7%)	21 (30%)	20 (28.5%)	18 (25.7%)
Female (30)	11 (36.6%)	1 (3.3%)	7 (23.3%)	11 (36.6%)

Table 1: Age Distribution of sternum samples.

Grades of Fusion of Mesosternum with Manubrium Sterni

Out of a total of one hundred sternum samples retrieved from dead bodies, mesosternum is not fused (Grade 0) with manubrium sterni in 22 (22%) samples of sternum in age group 30-40 years and 41-50 years each, and 14 (14%) and 0 cases in age groups between 51-60 years and >60 years

respectively. Partial fusion (Grade 1) was seen in only 13 (13%) sternum samples in 51-60 years age groups. It is found completely fused (Grade 2) in 29 (29%) cases in age group > 60 years. On statistical analysis fisher exact value is 1.287 and p value is 0.577. The grades of fusion of mesosternum with manubrium sterni is shown in Table no. 2.

Age Groups (Years)	Fusion of Mesosternum with Manubrium Sterni (M)		
	Non-Fusion (Grade 0)	Partial Fusion (Grade1)	Complete Fusion (Grade2)
30-40	22 (22%)	0	0
41-50	22 (22%)	0	0
51-60	14 (14%)	13 (13%)	0
>60	0	0	29 (29%)

Table 2: Grades of fusion of mesosternum with manubrium sterni.

Grades of Fusion of Mesosternum with Xiphisternum

Out of a total of one hundred sternum samples retrieved from dead bodies, mesosternum is not fused (Grade 0) with xiphisternum in 10 (10%) samples in age group 30-40 years. Partial fusion (Grade 1) is seen in 10 (10%) samples in age

groups between 30-40 years. It is found completely fused (Grade 2) in none of the sternum samples in age group 30-40 years, 22 (22%) samples in 41-50 years, 27 (27%) samples in 51-60 years age group and 29 (29%) samples in > 60 years age group. On statistical analysis chi square value is 5.372 and p value is 0.071. Distribution of grades of fusion is shown in Table no. 3.

Age Groups (Years)	Fusion of mesosternum with xiphisternum (X)		
	Non-Fusion (Grade 0)	Partial Fusion (Grade1)	Complete Fusion (Grade2)
30-40	10 (10%)	12 (12%)	0
41-50	0	0	22 (22%)
51-60	0	0	27 (27%)
>60	0	0	29 (29%)

Table 3: Grades of fusion of mesosternum with xiphisternum.

Regression Analysis (for sternal samples of males)

In the present study, on regression analysis for males, the regression equation for fusion of mesosternum with manubrium sterni (Grade M) is $38.89+14.56$, value of R is 0.981 and that of R^2 0.963 that is statistically significant. The regression equation for fusion of mesosternum with

Xiphisternum (Grade X) is $31.23+9.73$, value of R is 0.431 and that of R^2 is 0.185 that is statistically significant. On regression analysis for fusion of both Xiphisternum and manubrium sterni with mesosternum (Grade M & X), the regression equation is $33.68+13.92$ (Grade M) and 3.18 (Grade X), value of R is 0.991 and that of R^2 value is 0.981 that is statistically significant.

Variable	Regression equation	Correlation Coefficient (R)	Coefficient of Determination (R^2)
Estimated Age	$38.89+14.56$ Grade M	0.981	0.963 (Significant)
	$31.23+9.73$ Grade X	0.431	0.185 (Significant)
	$33.68+13.92$ Grade M + 3.18 Grade X	0.991	0.981 (Significant)

Table 4: Regression analysis (for sternal samples of males).

Regression Analysis (for sternal samples of females)

In the present study, on regression analysis for females, the regression equation for fusion of mesosternum with manubrium sterni (Grade M) is $32.27+15.52$, value of R is 0.989 and that of R^2 0.977 that is statistically significant. The regression equation for fusion of mesosternum with

Xiphisternum (Grade X) is $29.61+14.04$, value of R is 0.731 and that of R^2 is 0.534 that is statistically significant. On regression analysis for fusion of both Xiphisternum and manubrium sterni with mesosternum (Grade M & X), the regression equation is $33.53+13.69$ (Grade M) and 3.59 (Grade X), value of R is 0.999 and that of R^2 value is 0.998 that is statistically significant.

Variable	Regression equation	Correlation Coefficient (R)	Coefficient of Determination (R ²)
Estimated Age	$32.27+15.52$ Grade M	0.989	0.977 (Significant)
	$29.61+14.04$ Grade X	0.731	0.534 (significant)
	$33.53+ 13.69$ Grade M + 3.59 Grade X	0.999	0.998 (significant)

Table 5: Regression analysis (for sternal samples of females).

Comparison between Actual and Estimated Age

On examination of one hundred samples of sternums for the grades of fusion and estimation of age and correlating with actual age of individual based on documentation, 22 (22%) cases are found equal to actual age in each age group between 30-40 years and 41-50 years; 15 (15%) cases in age group 41-50 years and the estimated age is found equal to actual age in age group 51-60 years. Estimated age is found

equal to actual age in 12 (12%) and 29 (29%) cases in age groups between 51-60 years and > 60 years respectively. Comparison between actual and estimated age is shown in Table no. 6 and 7 are depicting statistical analysis done between actual and estimated age of fusion, the mean value with standard deviation for actual age is 51.28 ± 13.11 and p- value is 0.001 that is statistically significant. Mean and standard deviation for estimated age is 48.98 ± 13.45 and p- value is 0.0001 that is statistically significant.

Actual Age (Years)	Estimated age (Years)			
	30-40	41-50	51-60	>60
30-40	22 (22%)	0	0	0
41-50	0	22 (22%)	0	0
51-60	0	15 (15%)	12 (12%)	0
>60	0	0	0	29 (29%)

Table 6: Comparison between actual and estimated age.

Correlation between Actual and Estimated Age

On statistical analysis done between actual and estimated age of fusion, the mean value with standard deviation for actual age is 51.28 ± 13.11 and p- value is 0.001 that is statistically significant. Mean and standard deviation for estimated age is 48.98 ± 13.45 and p- value is 0.0001 that is statistically significant. Correlation coefficient is 0.908 between actual and estimated age (Table number 7 and 8).

Variable	Mean±SD	p-value
Actual age	51.28 ± 13.11	0.0001
Estimate age	48.98 ± 13.45	0.0001

Table 7: Correlation between actual and estimated age.

Variable	Parameter	Correlation-Coefficient (R)	p-value
Actual age	Estimate age	0.908	0.0001

Table 8: Correlation coefficient and p-value.

Discussion

Out of a total of one hundred samples of sternum retrieved from dead bodies, 11 male (15.7%) and 11 female (36.6%) sterni belonged to 30-40 years age bracket and 21(30%) males and 1(3.3%) female sterni to 41-50 years whereas 20 (28.5%) male and 7 (23.3%) female sternum samples were in 51-60 age groups and 18 (25.7%) male and 11 (36.6%) female sterni belonged to >60 years age group. On statistical analysis fisher's test value is 12.99 and p- value is 0.004 that

is statistically significant. In this study maximum number (28.5%) of male sternum samples belonged to 51-60 years age group whereas females topped the number (36.6%) in 30-40 years and more than 60 years age bracket.

The present study is in agreement with the study by Bruce where maximum number of sternum belonged to males (21.5%) in the 51-60 years age bracket and female sterni (18.4%) in more than 60 years age [9].

The distribution of age in the study of Chandresh I. Tailor is quite different from our study where he studied 116 cases that were more than 10 years of age and more than one third (34.2%) of male were in 21 to 30-year age bracket that was highest among the male group [10]. In the same way, female was highest (27.8%) among 21 to 30 years group. These were cases that were included as they were more than 30 years of age and met all the inclusion criteria. In another study by Chandrakanth HV 2012. a total of 118 sterna (67 males and 51 females) [11] and the male samples were aged between 25 and 74 years whereas the females between 20 and 80 years in study by Sobhan K. Das 14.28% in 30-35 years age amongst male and 13.4% in 36-45 years amongst females [12].

On examination of one hundred samples of sternums for the grades of fusion and estimation of age and correlating with actual age of individual 22 (22%) sternum samples are found equal to actual age of individual in each age group between 30-40 years and 41-50 years; 15 (15%) cases in age group 41-50 years and the estimated age is found equal to actual age in age group 51-60 years. Estimated age is found equal to actual age in 12 (12%) and 29 (29%) cases in age groups between 51-60 years and > 60 years respectively. On statistical analysis done between actual and estimated age of fusion, the mean value with standard deviation for actual age is 51.28 ± 13.11 , t- value is 39.10 and p- value is 0.001 that is statistically significant. Mean and standard deviation for estimated age is 48.98 ± 13.45 , t- value is 36.42 and p- value is 0.0001 that is statistically significant.

The correlation results indicate that there is statistically insignificant difference between the actual age of the subject and estimated age from fusion of sternal joints. None of studies assesses on determination of age from sternum has compared actual age of the individuals with estimated age devised from Sternal samples.

Conclusion

Majority of sternum samples retrieved from dead bodies of individuals brought for postmortem belonged to 51-60 years age group in males and 30-40 years age group in females. Males (70%) outnumbered the females

(30%) in this study. Majority of sternum samples belonged to individual who were moderately built and had non-veg food habits. A good number of samples were retrieved from individuals who were businessman (17%) amongst males and housewife (16%) amongst females. Majority of sternum samples were of individuals from temperate climate and Delhi region. Fusion of xiphisternum starts earlier as compared to fusion of manubrium sterni with mesosternum. Fusion of xiphisternum with mesosternum starts at 30 years and completely fuses at 41 years in both the sexes. Fusion of manubrium sterni with mesosternum starts at 51 years and completely fuses at >60 years. There is statistically insignificant difference between the actual age of the subject and estimated age from examination of sternum samples. This study can be done using radiological method for estimating age by radiological fusion and anatomical fusion can be compared with radiological fusion.

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