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Original Research Paper

Gross and Radiological Study of Fusion of the Sternebrae of Mesosternum for Determination of Age in Native Population of Haryana

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Abstract
Now a day, determination of age and sex of skeleton remains or of advanced decomposed body is an important task for the Forensic Expert to help in the investigation of concern case. It may arise in case of homicide, fire, explosion or mass disasters such as flood, earthquake, railway or aircraft accidents, etc. for determination of identity. In developing countries like India, because of illiteracy, ignorance regarding the age proof is much more. importance of official records like birth and death, vast majority of population fail to give information of such vital events to the appropriate authorities entitled with these jobs. This causes paucity in such information when needed in a medico legal case. Sternum as a single bone can be used for age determination in young adult, middle age and old persons.
The present study has been conducted in the Department of Forensic Medicine and Radiology, Pt. B. D Sharma Post Graduate Institute of Medical Sciences (PGIMS), Rohtak, with an attempt to study the mesosternum of sternum in the purview of existing parameters of the determination of age. It includes a study of fusion of sternebrae with each other in relation to age. A total of 200 Sternums of known age and sex (100 males and 100 females) of aged group 10-35 years, were collected from identified dead bodies that were brought to the Department of Forensic Medicine for post-mortem examination. The study was conducted by gross and radiological methods and finding were correlated by statistical methods. The study showed that the fusion of sternebrae of mesosternum occurs between 15-25 years, from below upward.
Keywords: *Sternum, Mesosternum, Sternebrae, Gross and Radiological findings, Fusion.*

Introduction

The age of the subject at death along with sex are the most important parameters and constitute vital indications of identity excluding a sizable portion of the population and narrowing down the field of investigation whether the context is bioarcheological, paleontological or forensic in nature. Determination of age at death from the

adult skeleton is one of the most important objectives of Forensic Medicine. Unless the age of a person is determined, the identity of a person, live or dead, stands incomplete.[1]

Various studies have been done on estimating the age of an individual from the ends of long bones, clavicle, hip bone, etc. on a routine basis.[2] However, age determination from other bones has proved useful, when the former are rendered unusable and incomplete due to natural or physical forces. Study of sternum as an individual parameter for determination of age and sex has been attempted by various workers. The first recorded study on the sternum for age determination is by Wenzel in 1788. He described the difference in the ratio between the length of manubrium and that of mesosternum in both sexes. It was followed by the studies of Fiegel (1837), Dwight (1890) and Ashley (1956).[3]

The pioneers in the field of skeletal age determination, Todd and Stewart made it very clear that every bone has the potential to show the effects of age.[4] In this regard, Sternum can chosen for age determination because it shows changes with the advancement of age.

Ossification of bones provides a very useful method of estimation of age in the living. These changes can be made out by X-rays and thus provide the medico-legal specialist with a very strong tool.[5] Sternum as a single bone can be used for age determination in young adult, middle age and old persons. It becomes even more important when only the trunk of a person is available for age determination. Moreover, it can be removed easily during autopsy without causing any deformity in the dead body.

The stages of Radiological epiphysial closure were first described by McKern and Stewart in their study conducted in 1957, as used by Sangma et al.[6] Another grading system has been used by Bhise et al which is the modification of above grading system, which is a more practical of the above grading system.-

Stage I (F1): **Non-union**- When epiphysial cartilage does not begin to decrease in thickness.

Stage II (F2): Commencement of fusion- 1/4th united with decreased thickness.

Stage III (F3): Incomplete union- ½ united with epiphysial and shaft fusion starting.

Stage IV (F4): **Complete union**- when the epiphysial cartilage is bony in architecture and its density is not distinguishable from epiphysis and diaphysis in the surrounding area, but epiphysial line (epiphysial scar) is visible.

Stage V (F5): Complete union, no scar line is visible.

The present study is an attempt to study the mesosternum of sternum in the purview of existing parameters of the determination of age. It includes a study of fusion of sternebrae with each other in relation to age.

Material & Methods

Place of study: -The present study was conducted in the Department of Forensic Medicine and Radiology, Pt. B. D Sharma Post Graduate Institute of Medical Sciences (PGIMS), Rohtak.

A total of 200 Sternums of known age and sex (100 males and 100 females) were collected from identified dead bodies that were brought to the Department of Forensic Medicine for post-mortem examination. The information of each case was recorded on a Proforma that included PMR number, sex, age, date of birth and gross & radiological findings. Informed consent was obtained from the nearest of the kin accompanying the dead body to the mortuary on a standard Consent Form.

The study was conducted on individuals aged between 10-35 years. Deceased with any congenital anomalies, partially destroyed, fractured, burnt, deformed or abnormal sternum were excluded from study.

Examination

After removal of sternum from the body, these were put in plastic jars containing solution of sodium-hypochloride and jars were labeled with the case details. These were kept for a week for maceration and cleaned and examined intermittently. After cleaning all the remains of

attached muscles and ligaments from the sterna, these were dried and examined grossly for degree of fusion by observing the separation of sternal elements. Thereafter, un-seperated sterna were placed in labeled plastic pouches and taken to Radiology Department for X-ray examination. Each specimen was radiographed using Siemens Heliophos D 500 mA X-ray machine, with its inferior surface resting directly on the cassette, 100 cm from the X-ray source with an exposure of 42 kVp and 5 mAs. The cassettes were processed with digital AGFA CR System. Antero-posterior view of the bones were X-rayed to study fusion between segments of mesosternum.

The films were examined for the presence of fusion between the segments of mesosternum. Thereafter, the mesosternum were cut vertically in midline for gross examination for fusion of sternbrae. Then, epiphysial closure of mesosternum were graded based on method used by Bhise et al.

Observation & Results

Table 1: Distribution of subjects on basis of age and sex (n=200)

Age Groups	Gender				Total (n=200)	
	Female (n=100)		Male (n=100)			
	(n)	(%)	(n)	(%)	(n)	(%)
10-15 years	20	50.0%	20	50.0%	40	100%
16–20 years	20	50.0%	20	50.0%	40	100%
21–25 years	20	50.0%	20	50.0%	40	100%
26–30 years	20	50.0%	20	50.0%	40	100%
31–35 years	20	50.0%	20	50.0%	40	100%
Total	**100**	**50.0%**	**100**	**50.0%**	**200**	**100%**

The above table depicts the age and sex wise distribution of the mesosternii taken for study. Equal number of samples (n=20) were taken in the different age groups.

Table 2: Distribution of fusion of 1st and 2ndSternebrae among males and females as observed by gross examination (n=200)

Age Group	Gender	1st and 2nd Sternebrae		Total (n= 200)	Significance*
		No fusion	Complete fusion		
10-15 years	Male	20 (100.0%)	0 (0.0%)	20 (100%)	p=1.000
	Female	20 (100.0%)	0 (0.0%)	20 (100%)	
16–20 years	Male	20 (100.0%)	0 (0.0%)	20 (100%)	p=1.000
	Female	20 (100.0%)	0 (0.0%)	20 (100%)	
21–25 years	Male	15 (75.0%)	5 (25.0%)	20 (100%)	p=0.723
	Female	14 (70.0%)	6 (30.0%)	20 (100%)	
26–30 years	Male	0 (0.0%)	20 (100.0%)	20 (100%)	p=1.000
	Female	0 (0.0%)	20 (100.0%)	20 (100%)	
31–35 years	Male	0 (0.0%)	20 (100.0%)	20 (100%)	p=1.000
	Female	0 (0.0%)	20 (100.0%)	20 (100%)	
Total		**109 (54.5%)**	**91 (45.5%)**	**200 (100%)**	
p-value > 0.05 is not statistically significant					

*Chi-square test

Table 3: Distribution of fusion of 2nd and 3rdSternebrae among males and females as observed by gross examination (n=200)

Age Group	Gender	2nd and 3rd Sternebrae		Total (n= 200)	Significance*
		No fusion	Complete fusion		
10-15 years	Male	20 (100.0%)	0 (0.0%)	20 (100%)	p=1.000
	Female	20 (100.0%)	0 (0.0%)	20 (100%)	
16–20 years	Male	13 (65.0%)	7 (35.0%)	20 (100%)	p=0.288
	Female	16 (80.0%)	4 (20.0%)	20 (100%)	

21–25 years	Male	0 (0.0%)	20 (100.0%)	20 (100%)	p=1.000
	Female	0 (0.0%)	20 (100.0%)	20 (100%)	
26–30 years	Male	0 (0.0%)	20 (100.0%)	20 (100%)	p=1.000
	Female	0 (0.0%)	20 (100.0%)	20 (100%)	
31–35 years	Male	0 (0.0%)	20 (100.0%)	20 (100%)	p=1.000
	Female	0 (0.0%)	20 (100.0%)	20 (100%)	
Total		**69 (34.5%)**	**131 (65.5%)**	**200 (100%)**	
p-value > 0.05 is not statistically significant					

*Chi-square test

Table 4: Distribution of fusion of 3rd and 4thSternebrae among males and females as observed by gross examination (n=200)

Age Group	Gender	3rdand 4thSternebrae		Total (n= 200)	Significance *
		No fusion	Complete fusion		
10-15 years	Male	13 (65.0%)	7 (35.0%)	20 (100%)	p=0.519
	Female	11 (55.0%)	9 (45.0%)	20 (100%)	
16–20 years	Male	0 (0.0%)	20 (100.0%)	20 (100%)	p=1.000
	Female	0 (0.0%)	20 (100.0%)	20 (100%)	
21–25 years	Male	0 (0.0%)	20 (100.0%)	20 (100%)	p=1.000
	Female	0 (0.0%)	20 (100.0%)	20 (100%)	
26–30 years	Male	0 (0.0%)	20 (100.0%)	20 (100%)	p=1.000
	Female	0 (0.0%)	20 (100.0%)	20 (100%)	
31–35 years	Male	0 (0.0%)	20 (100.0%)	20 (100%)	p=1.000
	Female	0 (0.0%)	20 (100.0%)	20 (100%)	
Total		**24 (12.0%)**	**176 (88.0%)**	**200 (100%)**	
p-value > 0.05 is not statistically significant					

*Chi-square test

From the above tables (table no. 2, 3, 4), it is observed that, in males, the earliest complete fusion of 1st and 2nd sternebrae was seen in age group 21-25 years (5 out of 20 i.e 25.0 %); 2nd and 3rd sternebrae in age group 16-20 years (7 out of 20 i.e 35.0 %); 3rd and 4th sternebrae in age group 10-15 years (7 out of 20 i.e 35.0 %). In females, the earliest complete fusion of 1st and 2nd sternebrae was seen in age group 21-25 years (6 out of 20 i.e 30.0 %); 2nd and 3rd sternebrae in age group 16-20 years (4 out of 20 i.e 20.0 %); 3rd and 4th sternebrae in age group 10-15 years (9 out of 20 i.e 45.0 %). The difference of fusion of all sternebrae among males and females were found to statistically not significant.

Table 5: Distribution of fusion of 1st and 2ndSternebrae among males and females according to radiological findings (n=200)

Age Group	Gender	1stand2ndSternebrae				Total (n= 200)	p-value*
		No fusion	Commence-ment of fusion	Incomplete fusion	Complete fusion		
10-15 years	Male	20 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	20 (100%)	1.000
	Female	20 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	20 (100%)	
16–20 years	Male	20 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	20 (100%)	1.000
	Female	20 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	20 (100%)	
21–25 years	Male	3 (15.0%)	6 (30.0%)	6 (30.0%)	5 (25.0%)	20 (100%)	0.727
	Female	4 (20.0%)	3 (15.0%)	7 (35.0%)	6 (30.0%)	20 (100%)	
26–30 years	Male	0 (0.0%)	0 (0.0%)	0 (0.0%)	20 (100.0%)	20 (100%)	1.000
	Female	0 (0.0%)	0 (0.0%)	0 (0.0%)	20 (100.0%)	20 (100%)	
30–35 years	Male	0 (0.0%)	0 (0.0%)	0 (0.0%)	20 (100.0%)	20 (100%)	1.000
	Female	0 (0.0%)	0 (0.0%)	0 (0.0%)	20 (100.0%)	20 (100%)	
Total		**87 (43.5%)**	**9 (4.5%)**	**13 (6.5%)**	**91 (45.5%)**	**200 (100%)**	
p-value > 0.05 is not statistically significant							

*Chi-square test

Table 6: Distribution of fusion of 2nd and 3rdSternebrae among males and females according to radiological findings (n=200)

Age Group	Gender	2nd and 3rdSternebrae				Total (n= 200)	p-value*
		No fusion	Commencement of fusion	Incomplete fusion	Complete fusion		
10-15 years	Male	20 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	20 (100%)	1.000
	Female	20 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	20 (100%)	
16–20 years	Male	6 (30.0%)	5 (25.0%)	3 (15.0%)	6 (30.0%)	20 (100%)	0.659
	Female	9 (45.0%)	5 (25.0%)	3 (15.0%)	3 (15.0%)	20 (100%)	
21–25 years	Male	0 (0.0%)	0 (0.0%)	0 (0.0%)	20 (100.0%)	20 (100%)	1.000
	Female	0 (0.0%)	0 (0.0%)	0 (0.0%)	20 (100.0%)	20 (100%)	
26–30 years	Male	0 (0.0%)	0 (0.0%)	0 (0.0%)	20 (100.0%)	20 (100%)	1.000
	Female	0 (0.0%)	0 (0.0%)	0 (0.0%)	20 (100.0%)	20 (100%)	
31–35 years	Male	0 (0.0%)	0 (0.0%)	0 (0.0%)	20 (100.0%)	20 (100%)	1.000
	Female	0 (0.0%)	0 (0.0%)	0 (0.0%)	20 (100.0%)	20 (100%)	
Total		**55 (27.5%)**	**10 (5.0%)**	**6 (3.0%)**	**129 (64.5%)**	**200 (100%)**	
p-value > 0.05 is not statistically significant							

*Chi-square test

Table 7: Distribution of fusion of 3rd and 4thSternebrae among males and females according to radiological findings (n=200)

Age Group	Gender	3rd and 4thSternebrae				Total (n= 200)	p-value*
		No fusion	Commence-ment of fusion	Incomplete fusion	Complete fusion		
10-15 years	Male	7 (35.0%)	4 (20.0%)	2 (10.0%)	7 (35.0%)	20 (100%)	0.795
	Female	5 (25.0%)	5 (25.0%)	1 (5.0%)	9 (45.0%)	20 (100%)	
16–20 years	Male	0 (0.0%)	0 (0.0%)	0 (0.0%)	20 (100.0%)	20 (100%)	1.000
	Female	0 (0.0%)	0 (0.0%)	0 (0.0%)	20 (100.0%)	20 (100%)	
21–25 years	Male	0 (0.0%)	0 (0.0%)	0 (0.0%)	20 (100.0%)	20 (100%)	1.000
	Female	0 (0.0%)	0 (0.0%)	0 (0.0%)	20 (100.0%)	20 (100%)	
26–30 years	Male	0 (0.0%)	0 (0.0%)	0 (0.0%)	20 (100.0%)	20 (100%)	1.000
	Female	0 (0.0%)	0 (0.0%)	0 (0.0%)	20 (100.0%)	20 (100%)	
31–35 years	Male	0 (0.0%)	0 (0.0%)	0 (0.0%)	20 (100.0%)	20 (100%)	1.000
	Female	0 (0.0%)	0 (0.0%)	0 (0.0%)	20 (100.0%)	20 (100%)	
Total		**12 (6.0%)**	**9 (4.5%)**	**3 (1.5%)**	**176 (88.0%)**	**200 (100%)**	
p-value > 0.05 is not statistically significant							

*Chi-square test

From the above table, (table no. 5, 6, 7), it is observed that, the earliest radiological complete fusion of 1st and 2nd sternebrae was seen in age group 21-25 years (5 out of 20 i.e 25.0 %, 6 out of 20 i.e 30.0 %) in males and females respectively; 2nd and 3rd sternebrae was seen in age group 16-20 years (6 out of 20 i.e 30.0 %, 3 out of 20 i.e 15.0 %) in males and females respectively and 3rd and 4th sternebrae was seen in age group 10-15 years (7 out of 20 i.e 35.0 %, 9 out of 20 i.e 45.0 %) in males and females respectively. Commencement of fusion of 1st and 2nd sternebrae was seen in age group 21-25 years (6 out of 20 i.e 30.0% and 3 out of 20 i.e 15%) in males and females respectively; 2nd and 3rd sternebrae was seen in age group 16-20 years (5 out of 20 i.e 25.0% and 5 out of 20 i.e 25%) in males and females respectively and 3rd and 4th sternebrae was seen in age group 10-15 years (4 out of 20 i.e 20.0% and 5 out of 20 i.e 25%) in males and females respectively. Incomplete radiological fusion of 1st and 2nd sternebrae was seen in age group 21-25 years (6 out of 20 i.e 30.0% and 7 out of 20 i.e 35%) in males and females respectively; 2nd and 3rd sternebrae was seen in age group 16-20 years (3 out of 20 i.e 15.0% and 3 out of 20 i.e 15.0%) in males and females respectively and 3rd and 4th sternebrae was seen in age group 10-15 years (2 out of 20 i.e 10.0% and 1 out of 20 i.e 5.0%) in males and females respectively. The difference of fusion of all the sternebrae among males and females wre found to statistically not significant.

The Kappa measure of agreement of fusion of 1st and 2nd sternebrae; 2nd and 3rd starnebrae; 3rd and 4th starnebrae, by gross examination and radiological findings was found to be 0.802, 0.834 and 0.725 respectively.

Discussion

There are considerable variations in ossification of bones in different regions of the same country. These characteristics are influenced by various factors like geographical location, climate, diet, heredity, socioeconomic status, habits, etc. especially in a multi ethnic country like India. Therefore, it is difficult to follow a single standard data for determination of age for the entire country.

Many workers around the world have done a lot of research on estimation of age based on the ossification of long bones. Age of an individual below 25 years can be opined to an age range of 2 years, though the findings get lesser as age progresses. For older individuals, however, age related findings on bones are fewer still. The use of the sternum for age estimation, however, is having greater promise as the changes encourages all ages. However, studies done on the fusion of the sternebrae of mesosternum are scarce.

Keeping the above in view, in the present study, the status of fusion sternebrae of mesosternum for determination of age in males and females of Haryana was studied and the results were compared with previous similar studies.

Table 8: Comparison of Status of Fusion of 1st & 2nd; 2nd & 3rd; 3rd & 4th Sternebrae of Mesosternum with Earlier Studies

Study	Earliest Age of Fusion of Sternebrae of Mesosternum in years					
	1st & 2nd Sternebrae		2nd & 3rd Sternebrae		3rd & 4th Sternebrae	
	Male	Female	Male	Female	Male	Female
Indian Studies						
Rai et al, 2013 (Punjab)[7]	26 – 30	26 – 30	21 - 25	21 - 25	16-20	16-20
Kaneriya et al, 2013 (North west India)[8]	25	25	20	20	15-20	15-20
Tailor et al, 2013 (North West India)[9]	21 – 30	21 – 30	11 - 20	11 - 20	11-20	11-20
Manoharan et al, 2016 (South India)[10]	16 – 21	16 – 21	16	16	14	14
Foreign Studies						
Baker et al, 2005, (Texas)[11]	21 – 30	20	21 - 30	21 - 30	4-10	4-10
Bayarogullari et al, 2014 (Turkey)[12]	21 – 30	21 – 30	21 -30	21 - 30	21-30	21-30
Present Study (Haryana-2016)	**21 – 25**	**21 – 25**	**16 - 20**	**16 - 20**	**10-15**	**10-15**

The present study sample showed an earlier fusion gap of 5 years in earliest age of fusion of 1st and 2nd sternebrae; 2nd and 3rd starnebrae; 3rd and 4th starnebrae of mesosternum as compared to the study of Rai et al in a Punjab population sample, despite both sample being taken from the common population stock.

Table 11: Comparison of results of previous and present studies on fusion of sternebrae of Mesosternum

Author	Fusion between sternebrae
Douglas J.A Kerr[13]	6th to 25 years
Ashley[14]	At childhood, puberty and at 21 years
Girdany and Golden[15]	1st and 2nd between 12 to 25 years 3rd and 4th between 4 and 8 years
P.V. Guharaj[16]	Between puberty and 25th years
Modi[17]	From below upwards between 14 and 25 years
Parikh C.K[18]	From below upwards between 14 and 25 years
M.K.R. Krishan[19]	From below upwards between 14 and 25 years
Krishan Vij[20]	From below upwards between 14 and 25 years
Present Study (Haryana-2016)	From below upwards between 15 and 25 years

Photo 1: Showing No fusion of all Sternebrae (Gross & Radiological)

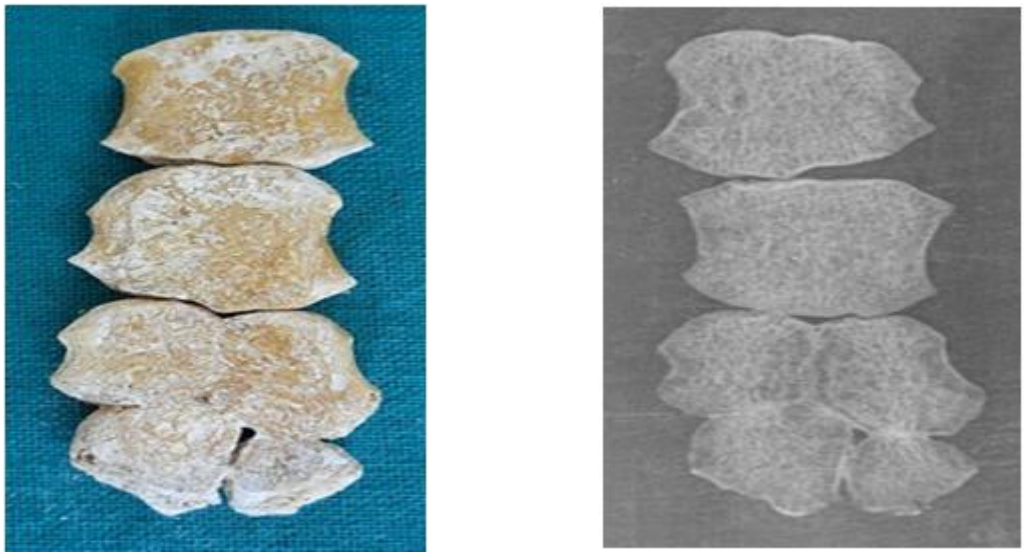

Photo 2: Showing Complete fusion of 3rd and 4th Sternebrae and No fusion of 2nd and 3rd, 1st and 2nd Sternebrae (Gross & Radiological)

Photo 3: Showing Complete fusion of 3rd and 4th Sternebrae, No fusion of 2nd and 3rd; 1st and 2nd Sternebrae (Gross & Radiological)

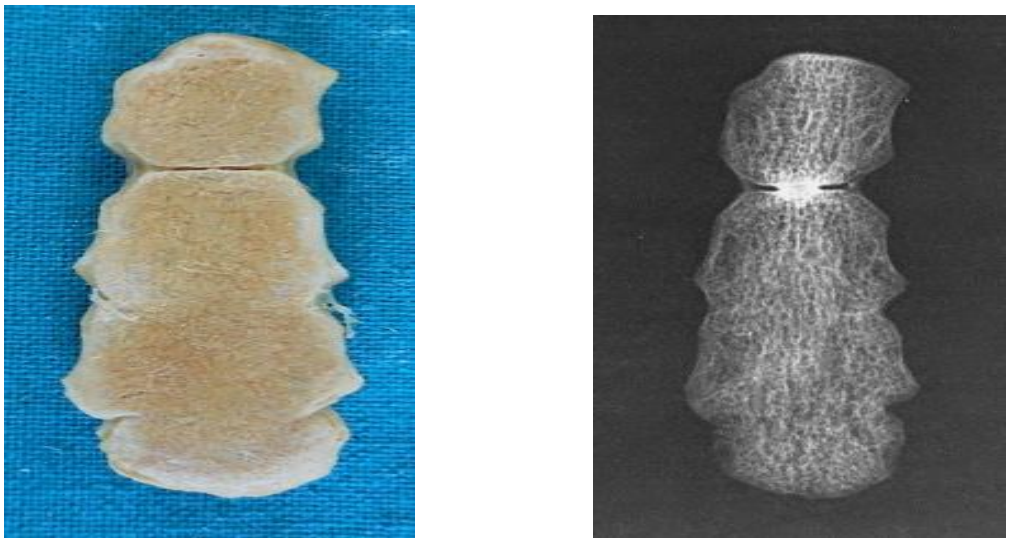

Photo 4. Showing Complete fusion of 3rd and 4th Sternebrae, 2nd and 3rd Sternebrae, No fusion of 1st and 2nd Sternebrae (Gross & radiological)

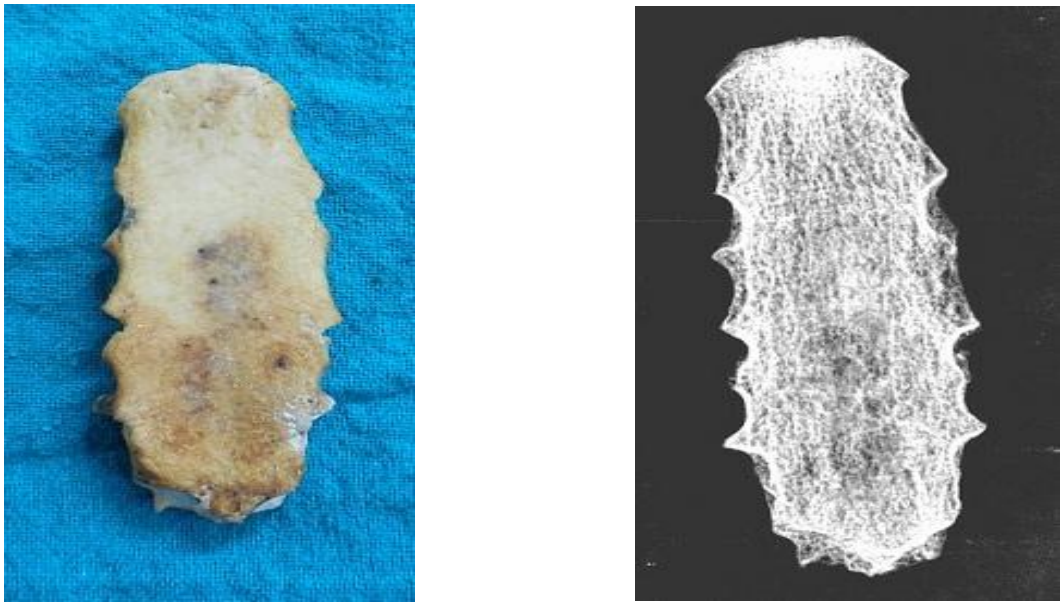

Photo: Showing Complete union of all Sternebrae in 25 year old Male (Gross & Radiological)

Conclusion

The common age range for fusion of the sternebrae are as follows:

(i) $1^{st} – 2^{nd}$ = 21 – 25 years
(ii) $2^{nd} – 3^{rd}$ = 16 – 20 years
(iii) $3^{rd} – 4^{th}$ = 10 – 15 years

The present study has attempted to provide a reference for age determination from the fusion of sternebrae of mesosternum for a population of Haryana. The fusion of sternbrae of mesosternum are independent of sex of individual.

References

1. Rao Nagesh Kumar G. Textbook of Forensic Medicine and Toxicology. 1st ed, New Delhi: Jaypee Brothers Medical Publishers (P) Ltd; 2000. p. 89
2. Banerjee KK, Agarwal BB. Estimation of age from epiphyseal union at the wrist and ankle joints in the capital city of India. J Forensic Sci Int.1998;98(1):31-9
3. Ashley GT. The human sternum — The influence of sex and age on its measurements. J Forensic Med. 1956;3: 27-43.

4. Krogman WM, Iscan MY.The Human Skeleton in Forensic Medicine, 2nd ed, USA: Chales C. Thomas Publishers; 1986. p. 134-44
5. Agrawal A. Age Estimation in the living: in matters civil and criminal. J Anat. 2009; 1(2):1-25.
6. Sangma WB, Marak FK, Singh MS, Kharrubon B. A Roentgenographic study for age determination in boys of North-Eastern Region of India. J Ind Acad Forensic Med. 2006;28(2):55-9.
7. Bhise SS, Chikhalkar BG, Nanandkar SD, Chavan GS. Age determination from Radiological study of Epiphysial appearance and union around wrist joint and hand. J Ind Acad Forensic Med. 2011;33(4):292-3.]
8. Gargi J, Rai G, Chanana A, Tayal I. Medico-legal Importance of sternum in age estimation-An autopsy study. J Punjab Acad Forensic Med Toxicol. 2013;13(2):80-5.
9. Kaneriya D, Umervanshi B, Patil D, Mehta C, Chauhan K. and Vora R. Age determination from fusion of the sternal elements. Int J of basic app Med sci. 2013; 3(2):22-9.
10. Tailor C, Silajiya D, Govekar G, Chaudhari V, Rajdev B, Gajera C. Age determination by gross and radiological aspect of sternum. J Ind. Acad Forensic Med. 2013;35(1):21-5.
11. Manoharan C, Dhanalakshmi V, Thangam D, Edwin Joe A. Indian Journal of Forensic and Community Medicine, April-June 2016;3(2):128-132.
12. Baker BJ, Dupras TL, and Tocheri MW. The Osteology of Infants and Children. College Station: Texas A&M University Press; 2005. p. 192.
13. Bayarogullan H, Yengil E, Davran R, Aglagul E, Karazincin S, Balci A. Evalution of the Postnatal Development of Sternum and starnal variation using multidetector CT. Diagn Interv Radiol. 2014; 20(1): 82-89.
14. Douglas J, Kerr A. Forensic Medicine, 6th ed. London: Adam and Charles Black; 1954. p. 50.
15. Ashley GT, editor. Frezer's Anatomy of Human skeleton, 2nd ed. London: Butterworth; 1956. p. 56-9.
16. Girdany and Golden. A radiographic database for estimating biological parameters in modern subadults. American Journal of Roentgenology, 1952;68 (3):63-5.
17. Guharaj PV. Forensic Medicine, 1st ed. New Delhi: Orient Blackswan, 1982. p. 27 & 33.
18. Mathiharan K, Patnaik AK, editors. Modi's Medical Jurisprudence and Toxicology. 23rd ed. New Delhi: Lexis Nexis Butterworth; 2003. p. 286.
19. Parikh CK. Jurisprudence and Toxicology, 5th ed. Mumbai: Bombay Medical Publisher; 1990. p. 41.
20. Krishnan MKR. Hand book of Forensic Medicine, 3rd ed. Mumbai: Kothari book depot; 1971. p. 33.
21. Vij K. Textbook of Forensic Medicine and Toxicology. 6th ed. New Delhi: Reed Elsevier India (P) Limited. 2014. p. 42.