

## Radiologic Study of the Incidence of Ossification of the Manubriosternal Joint in Adult Nigerians

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### Review Article

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**Abstract:** The manubriosternal joint is a symphysis between the manubrium and the body of the sternum. The surfaces of the articulating bones have a hyaline cartilage with a fibro-cartilaginous disc between them. It is said to undergo endochondral ossification from the fifth week of intrauterine life. This ossification process is usually completed in a smaller percentage of the population. Aim: This study is intended to find out the incidence of ossification of the joint in adult Nigerians through radiological studies. Materials and Methods: Being a retrospective study, laterally projected chest X-ray radiographs of 1,000 adult Nigerians between 25-85 years of age were obtained from the University of Port Harcourt Teaching Hospital and examined. The radiographs were categorized into six groups, each group having ten years interval. The age and sex of the individuals were got from their medical records. From the radiographs, the number that showed complete ossifications was noted. Results and Discussions: The result of the study showed that the mean age of complete ossification of the manubriosternal joint was 63.30+17.16 and 70.80+15.20 years in males and females respectively. Conclusion: It was also observed that the incidence of ossification was higher in females than males and complete ossification occurred in 128 of every 1000 Nigerian adults, which gives a 12.8% incidence.

**Keywords:** Ossification, Incidence, Manubrium, Sternum.

## INTRODUCTION

### THE MANUBROSTERNAL JOINT

This is one of the two joints of the sternum, the other being the xiphisternal. It exists between the first two parts of the sternum-the manubrium and body of sternum. It fuses to become a synostosis in older individuals. [1] The manubrium starts fusing with the body of the sternum at the age of 40 and usually complete by 50 years. [1]

### THE MANUBRIUM

This is the upper most part of the sternum, and is referred to as "handle" in Latin. This is because it resembles the handle of a sword with the sterna body forming the blade. The manubrium is the widest and thickest of the three parts of the sternum. It has an easily palpated concave centre at the superior border called the jugular notch (suprasternal notch). The notch is deepened in an articulated skeleton (and in life) by the medial (sternal ends of the clavicles, which are much larger than the relatively small clavicular notches in the manubrium that receives them, forming the sternoclavicular (SC) joints. Inferolateral to the clavicular notch, the costal cartilage of the first rib is

tightly attached to the lateral border of the manubrium-the synchondrosis of the first rib [2].

### THE BODY OF THE STERNUM

The sternal body is longer, narrower and thinner than the manubrium. It is located at the level of T5-T9 vertebrae. Its width varies because of the scalloping of its lateral borders by the costal notches. In young people, four sternbrae articulate with each other at primary cartilaginous joints (sternal synchondrosis). These joints begin to fuse from the inferior end between puberty (sexual maturity) and age 25 [2].

The nearly flat anterior surface of the body of sternum is marked in adult by three variable transverse ridges, which represent the lines of fusion (synostosis of its four originally separate sternbrae) [2].

### JOINT TYPE

The manubriosternal joint is more specifically described as a secondary cartilaginous joint. It is connected entirely by cartilage (fibrocartilage or

hyaline) so that more movement is allowed between the two [3].

#### **PATTERN OF ARTICULATION**

Being a symphysis, the manubrium and body of sternum are covered with hyaline cartilage and have a thick, fairly compressible pad of fibrocartilage between them [3].

The manubrium and body of sternum lie in slightly different planes superior and inferior to their junction to form a projecting sterna angle (of Louis) [2].

#### **THE STERNAL ANGLE**

This is the anterior angle formed by the junction of the manubrium and the body of the sternum. It is also called the angle of Louis or manubriosternal joint itself. It is a palpable clinical landmark. The angle is approximately 140 degrees. It is named after Pierre Charles Alexandria Louis, French physician of the 1800s, who was one of the first to bring mathematics, disproving bloodletting as a practice by showing statistically that it did not work [3].

#### **SPECIAL FACTS ABOUT THE MANUBRIOSTERNAL JOINT (STERNAL ANGLE, ANGLE OF LOUIS)**

- It lies at the level of the T4 and T5 intervertebral disc and the space between the 3<sup>rd</sup> and 4<sup>th</sup> thoracic spinous processes.
- It marks the level of the second costal cartilage.
- It marks approximately the beginning and end of the aortic arch [18].
- It marks the level of the bifurcation of the trachea into the left and right bronchi.
- It also marks the bifurcation of the pulmonary trunk into the left and right pulmonary arteries [3]
- It marks the inferior limit of the superior mediastinum [18].
- Sometimes 30% cavitations appear in the fibrocartilaginous disc so that the joint may appear to be synovial, but this is simply a degenerative change that does not alter the fact that the joint is a symphysis [9]
- A limited amount of movement is permitted, and occurs with each thoracic respiratory movement [6]
- The fibrocartilaginous disc is anchored to the ventral and dorsal surfaces of the sternum by ligaments [7]
- The joint is supplied by the second intercostals nerve [7]
- The joint allows protraction and retraction of the thorax [7]
- Posterior to the manubriosternal joint are the structures of mediastinum [7]

#### **OSSIFICATION (SYNOSTOSIS) OF THE MANUBRIOSTERNAL JOINT**

This involves the deposition of calcium (calcification), as well as fusion of the manubrium and body of sternum to form the manubriosternal joint. Fusion is usually initiated by the formation of ossification centres (primary and secondary) in the contributing adjacent bones.

The centres of ossification begin to make their appearance about the sixth month of intra-uterine life [5]. In general, the sternum as a whole is said to develop from a variable number of ossification centres [5-10]. These centres are segmentally arranged in sets of one, two, or more per segment. In each segment, the centres may be single and median, paired (laterally, obliquely, or vertically) or multiple and irregularly disposed. All the centres are endochondral, being embedded in a mass of cartilage which presents, approximately, the shape of the definitive sternum [11]. Normally, during foetal life, the presternum becomes demarcated from the mesosternum by a fibrous lamina which develops across the cartilaginous sternum at the level of the second costal cartilages. This fibrous lamina is the anlage of the secondary cartilaginous joint which is usually found between the manubrium and mesosternum in adults [10].

#### **TYPES OF SYNOSTOSIS AT THE MANUBRIOSTERNAL JOINT**

Synostosis at the manubriosternal joint would seem to be of two kinds namely:

- Primary (matrical) synostosis
- Secondary (sclerotic) synostosis

##### **Primary**

“Matrical” synostosis results from the obliteration of a primary cartilaginous joint between manubrium and mesosternum during early life.

##### **Secondary**

“Sclerotic” synostosis results from the obliteration of a secondary cartilaginous joint between manubrium and mesosternum during late adult life [16].

#### **NORMAL ANATOMY OF THE MANUBRIOSTERNAL JOINT**

Normal finding of the manubriosternal joint vary and include narrowing, irregularly and ankylosis. Proliferative changes are common during the degenerative process, and they include osteophyte formation and sclerosis [9]. The normal anatomical variation of this joint on radiographs has been based on a classification into grades. The classification comprised the following four grades:

**Grade 1-**No narrowing, sclerosis, or irregularity.

**Grade 2-** narrowing, sclerosis, or irregularity and cystic defects.

**Grade 3-** characterized by partial fusion.

**Grade 4-** characterized by complete fusion.

It should be noted that minimal sclerosis, cystic defects and slight narrowing and indentations of the articular surface are common findings in normal manubriosternal joint. Although fusion is considered to be one of the criteria for abnormal manubriosternal joint, it may occur in the normal population. These degenerative fusions are often associated with bridging osteophytes. However, more commonly in the normal manubriosternal joint, a continuity of the bone surface at the junction is smooth rather than irregular or hypertrophic, making it difficult to distinguish nonpathologic fusion from arthritic ankylosis [13].

Irregularity at the manubriosternal joint has been shown to be due to unequal growth of the ossification centre and may be complicated by herniation of cartilaginous material on either side of the joint. This is analogous to the development of Schmorl's mode in the spine and is not a result of arthritic involvement [13].

Ankylosis is a complete loss of movement in manubriosternal joint caused by fusion of its bony surfaces. It may be due to degeneration as a result of inflammation, infection, or injury, or be produced surgically by surgery to fuse a diseased manubriosternal joint in order to correct its deformity or to alleviate persistent pain [15].

There have been some literatures by other authors who worked on manubrium and ossification in other populations [5-17].

#### **AIM AND OBJECTIVE(S)**

This study was aimed at determining the incidence of ossification of the manubriosternal joint in adult Nigerians using radiological methods.

To determine the percentage of ossification of the joint adult Nigerians, ascertain the age of ossification with respect to gender in Nigerian adults and compare the present study with the works done by earlier researchers

#### **MATERIALS AND METHODS**

##### **Research Design**

A retrospective and analytical study conducted with the aid of study materials provided by the Radiology Department of the University of Port Harcourt Teaching Hospital (UPTH).

##### **Data Collection**

A total of 1,000 laterally projected chest X-ray radiographs were used for this study. The radiographs were those of adult Nigerians between 25 to 85 years of age. They were categorized into six groups with ten years intervals as follows: 25-35, 36-45, 46-55, 56-65, 66-75, and 76-85 years. The age and sex of the individuals were obtained through their medical records.

The radiographs were placed vertically on the X-ray viewing equipment whose switch connecting it to the source of electrical supply has been put on. This allowed the manubriosternal joint to be adequately seen and studied. From examination, it was seen that a completely ossified joint appeared white, a dark or grey appearance of the joint indicated that the joint had not ossified while a partially ossified joint appeared somewhat between white and dark.

**Data Analysis:** The statistical analysis was done using SPSS [19]

The percentage incidence was calculated using the formula:

$$\% I.O = \frac{\text{Total number of completely ossified radiographs}}{\text{Total number of radiographs used}} \times 100$$

The difference in age and sex with respect to incidence of ossification was also determined.

##### **Exclusion Criteria**

- Radiographs of individuals below 25 years of age were not examined.

##### **Inclusion Criteria**

- Both the male and female radiographs were examined to avoid gender indifference.
- Only radiographs of adult Nigerians were used to eliminate all forms of inconsistencies.
- Radiographs of individuals from various states were examined for a definitive population study.
- Only radiographs obtained through lateral projects were examined for an adequate observation of the manubriosternal joint.

#### **RESULTS AND DISCUSSIONS**

In table 1 the distribution of cases according to sex and age was shown with 66-75 age brackets having the highest number of cases while 36-45yrs and 56-65yrs had equal number of cases.

**Table-1: Distribution of Cases According to Sex and Age**

Age group (years)	Males	Females	Total no. of cases
25-35	140	24	164
36-45	132	24	156
46-55	132	24	162
56-65	132	24	156
66-75	152	32	184
76-85	148	30	178
<b>Total</b>	<b>840</b>	<b>160</b>	<b>1,000</b>

In table 2 distributions of data according to complete, partial and no fusion of the manubrium with the body of the sternum showed that the males in age

group 76 to 85yrs had 36% cases with complete fusion which was considered the highest while 25-35yrs had the least percentage of cases of complete fusion.

**Table-2: Distribution of the Incidence of Ossification of the Manubriosternal Joint Age and Sex**

Age group (years)	% INCIDENCE					
	Complete		Partial		Absent	
	M	F	M	F	M	F
25-35	8	3	32	12	100	9
	5.71	12.50	12.86	50.0	71.43	37.50
36-45	12	0	29	0	91	24
	9.09	0	21.97	0	68.94	100
46-55	12	0	0	0	12.4	26
	8.82	0	0	0	91.18	100
56-65	14	4	0	0	118	20
	10.60	16.67	0	0	89.46	83.33
66-75	16	6	0	0	136	26
	10.53	18.75	0	0	89.49	81.25
76-85	36	17	0	0	112	13
	24.32	56.67	0	0	75.68	43.33

In table 3 age group 25 to 85 years, the males had a total of 98 cases of complete fusion of the manubrium with the body of the sternum that is 11.47%

while there were 30 cases amongst the females that is 18.75%.

**Table-3: Fusion of the Manubrium with the Body of the Sternum in Age and Sex**

Age group (years)	Complete			Partial			Absent			Total no. of cases
	M	F	Total	M	F	Total	M	F	Total	
25-35	8	3	11	32	12	44	100	9	109	164
36-45	12	0	12	29	0	29	91	24	115	16
46-55	12	0	12	0	0	0	124	26	150	162
56-65	14	4	18	0	0	0	118	20	138	156
66-75	16	6	22	0	0	0	136	26	162	180
76-85	36	17	53	0	0	0	112	13	125	178
<b>Total</b>	<b>98</b>	<b>30</b>		<b>61</b>	<b>12</b>	<b>73</b>	<b>681</b>	<b>118</b>	<b>799</b>	<b>1,000</b>

In table 4, age bracket between 25 to 85 years, showed complete ossification of the

manubriosternal joint that is 12.80%. Partial ossification was 7.30% while non-fusion was 79.9%.

**Table-4: The Male and Female Cases for Incidence of Ossification of the Manubriosternal Joint**

Fusion	Male	Female	Total	% incidence
Complete	98	30	128	12.80
Partial	61	12	73	7.30
Absent	681	118	799	79.9
<b>TOTAL</b>	<b>840</b>	<b>160</b>	<b>1,000</b>	<b>100</b>

## DISCUSSIONS

The results of the study showed that in the age group 25-35 years, 140 male cases were studied, 8 (5.71%) cases showed complete fusion, 32 (22.86%) cases showed partial fusion and 100 (71.43%) cases showed absent of fusion. In 24 female cases studied, 3 (12.50%) cases showed complete fusion, 12 (50.0%) cases showed partial fusion and 9 (37.5%) cases showed no fusion.

In the age group of 36-45 years, 132 male cases were studied, 12 (9.10%) cases showed complete fusion, 29 (21.97%) cases showed partial fusion and 91 (68.94%) cases showed no fusion. This study tends to agree with other studies conducted [9, 7] which showed 4 (8.33%) case of complete fusion out of 48 male cases studied at India. This study with respect to the same age group (36-45), also agrees with the previous study conducted [6,5] According to them, out of 95 male cases studied in Chandigarh, India, 8(8.42%) cases showed complete fusion. This slight difference may be resulting from a difference in geographical location and also due to the fact that the authors used fewer cases of radiographs for the study. In the same age group, 24 female cases were studied and none showed complete fusion. This is different from the study conducted [9, 7] using 7 female cases, which showed 1(14.29%) case of complete fusion. This difference may be due to geographical distribution as well as race. But it tends to agree with the study conducted [5] using 6 female cases which showed 0(0%) case of complete fusion.

In the age group of 46-55 years, 136 male cases were studied, 12 (8.82%) cases showed complete fusion while 124(91.18%) cases showed no fusion. In a similar study conducted [1, 2] using 59 male cases, 12(20.34%) cases showed complete fusion. None of the 26 female cases studied showed complete fusion in this age group.

In the age group of 56-65 years, 14 (10.60%) cases showed complete fusion out of the 132 male cases studied while 118(89.46%) cases showed no fusion [9, 7]. Prabh *et al.* [2] and Jyoti *et al.* [3] conducted a similar study on this age group using 39, 25, and 8 male cases. Their result showed 10(25.64%), 6(24.0%) and 3(37.5%) cases of complete fusion respectively. These remarkable differences may be due to differences in geographical distribution and race. In 24 female cases studied, 4(16.67%) cases showed complete fusion while 20(83.33%) cases showed no fusion. Prabh *et al.* [2] and Jyoti *et al.* [3] conducted a similar study on this age group using 4 and 16 female cases respectively. Their result showed 1(24.0%) and 5(31.25%) cases of complete fusion.

152 male cases studied in age group of 66-75 years, 16 (10.53%) cases showed complete fusion while 136(89.47%) cases are yet to fuse completely. 32

female cases were studied, 6 (18.75%) cases showed complete fusion and 26(81.25%) cases showed no fusion.

In the age group 76-85 years, it was observed that 36 (24.32%) cases showed complete fusion out of the 148 male cases studied. 112(75.68%) cases showed no fusion. Out of 30 female cases studied, 17 (56.67%) cases showed complete fusion while 13(43.33%) female cases are yet to fuse completely.

The calculated T-test for complete ossification and non-ossification gave a value of 3.27, which is above 1.96 at  $P=0.05$ . Therefore the result is significant.

## CONCLUSION

The earliest age of ossification of the manubriosternal joint was 27 years in males and 25 years in the females. The incidence of ossification was 5.71% and 12.50% in males and females respectively in the age group 25-35 years.

The latest age of ossification of the manubriosternal joint were 85 in males and 82 in females. The incidence of ossification was 24.32% and 56.67% in males and females respectively in the age group 76-85 years.

The average age of fusion of the manubrium with the body of the sternum was  $63.30 \pm 17.16$  years in males and  $70.80 \pm 15.20$  years in females.

The overall incidence of ossification in males is 11.67% and 18.75% in females, giving a total of 30.42%.

The calculated student T-test for males and females is 0, P value is greater than 0.05 indicating that there is no significant difference in the incidence of ossification of the manubriosternal joint.

The Incidence of ossification of the manubriosternal joint is higher in females than males.

Out of 1000 cases studied in both males and females, 128 (12.8%) cases showed complete ossification. Therefore, the radiological study of the incidence of ossification of the manubriosternal joint in adult Nigerians revealed 12.8% incidence of ossification in every one thousand adult Nigerians.

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