

## Estimation of Sex by Pattern of Calcification of First Costal Cartilage in North Indian Population

**Received:** 15 August 2022, **Revised:** 21 September 2022, **Accepted:** 22 October 2022

**Parul Upadhyay<sup>1</sup>, S.K. Rathee<sup>2</sup>.**

1. "Assistant Professor, Department of Anatomy, Santosh Deemed to be University, Delhi NCR".
2. "Senior Professor and Head, Department of Anatomy, PGIMS, Rohtak".

### Abstract

**Objective-** Estimation of sex by pattern of calcification of first costal cartilage in North Indian Population.

**Methods-** The present study has been conducted in the "Department of Anatomy in collaboration with the Department of Forensic Medicine and Department of Radiology, PGIMS, Rohtak".

The specimen consisted of 50 pairs of first ribs and manubrium from both sexes, aged between 15 and 30 years, in order to determine the pattern of calcification. Specimens were taken from "cases of medico-legal autopsies" performed in the "Department of Forensic Medicine" with the legal heir of the deceased's consent, and they were radiographed in the "Department of Radiology".

**Results-** In the present study, calcification was observed in cartilages of both sexes aged above 16 years. Type A (marginal bracket), type A 1 (marginal linear) and type B (central) pattern were found more frequently in females on both sides with an estimated predictive value of 66.32%, 50.27% and 100% respectively. Type C (mixed) pattern occurred more frequently in males on both sides with estimated predictive value to be 100%.

**Conclusion-** There was no evidence of bilateral asymmetry between the calcification patterns on the right and left sides. This means that the first costal cartilage's calcification displays a clear pattern in respect to the sex at issue.

### 1. Introduction

There are twelve pairs of ribs, of which the first, second, tenth, eleventh, and twelfth are atypical and articulate posteriorly with the vertebral column and anteriorly with costal cartilage<sup>1</sup>. The first costal cartilage, which extends from the front of the ribs and primarily consists of hyaline cartilage, significantly enhances the thoracic region's mobility and flexibility. Chondrosternal joint refers to the joint that develops between costal cartilage and the sternum<sup>2</sup>. The cartilages at the anterior end of the ribs form a primary cartilaginous joint in this area. On radiographs, the earliest costal cartilages are noticeable when they have developed calcification.

After adolescence, the first costal cartilages are vulnerable to calcification<sup>3</sup>. Since it is unusual in that it demonstrates ossification occurring throughout adult life, calcification of the first costal cartilage is a topic of study. Although sickness may be involved by interfering with the normal blood calcium balance, this ossification is independent to disease or habit<sup>4,5,6</sup>.

### 2. Material and Methods

The present investigation was carried out in the anatomy department of the Pt. B.D. Sharma Post Graduate Institute of Medical Sciences, Rohtak, in

# Journal of Coastal Life Medicine

collaboration with the departments of forensic medicine and radiology.

To determine the age of fusion in the sternal end of the first rib's costal cartilage in the North Indian population, a specimen of 50 pairs of first ribs with manubrium from both sexes, aged 15 to 30, was used. The samples were obtained through medico-legal autopsies performed in the Department of Forensic Medicine with the proper authorization from the decedent's legal heir. The document's most recent addition is a sample consent form.

### 3. Inclusion Criteria

Specimens from the bodies whose autopsies have been performed within 24 hours of death were analyzed.

### 4. Exclusion Criteria

“The following cases have been excluded from the study:

1. Accident/Trauma cases where first rib or manubrium were fractured.
2. Cases in which first rib or manubrium were distorted during autopsy.
3. Cases in which first rib or manubrium showed any dislocation or malunion.”

### 5. Preliminary Data Recorded

“The recorded data comprises of the following information:

1. Postmortem report number.
2. Age and sex of the person.
3. Time of death of the person.
4. Time of postmortem”.

### 6. Method of Extraction

For examination, the manubrium and 2-3 cm of the costal cartilage-covered sternal ends of the first rib were removed. The upper section of the thorax's muscles and skin were reflected laterally after a midline thoracic incision, and samples were then obtained. As soon as the clavicle was raised, the manubrium and the first rib 2-3 cm laterally to the costochondral junction were cleansed on both sides, and the aforementioned section was dissected and removed from the deceased person's body. “The samples have tags and numbers to identify them. “The specimens were kept in the glass container filled with saturated solution of sodium chloride for 6-8 weeks so that the soft tissues” which was adherent to the bone macerates and then these specimens were cleaned, dried and then radiographed to see the patterns of calcification first costal cartilage with manubrium.

The pattern of costal cartilage calcification was classified according to the study done by Rao and Pai<sup>7</sup> as follows:

None- No calcification.

Type A- Marginal square bracket type: “Calcification is commencing at costochondral junction and extends along the upper and lower margin of the cartilage bar, directed towards the sternum”.

Type A<sub>1</sub>- Marginal linear type: “calcification is mainly confined to the upper and lower margins of the cartilage bar”.

Type B- “Central or tongue shaped type of costal cartilage calcification”.

Type C- Mixed calcification: “combination of Type A, Type A<sub>1</sub>, Type B”

# Journal of Coastal Life Medicine

The results were tabulated and analysed by entering them into a Microsoft Excel spreadsheet, which was then properly coded in SPSS (Statistical Package for Social Sciences) for Windows version 20.0. Following tabulation of the frequency distribution of the costal cartilage calcification patterns in both boys and females, an estimated "Predictive value" was generated using the following formula for each of the calcification patterns identified in the study: "Predictive Value =  $P1/P1+P2$ , where P1 represents the prevalence of a pattern in the sex that the pattern

is projected to occur in and P2 represents the prevalence of the same pattern in the obverse sex".

## 7. Results

The present study was conducted in "Department of Anatomy" on 50 pairs of first costal cartilage along with manubrium in either of sex retrieved from "Department of Forensic Medicine, Pt. B. D. Sharma PGIMS, Rohtak" in association with "Department of Radiology, Pt. B. D. Sharma PGIMS, Rohtak". For this purpose, 50 pairs (100) of first costal cartilage along with manubrium were taken.

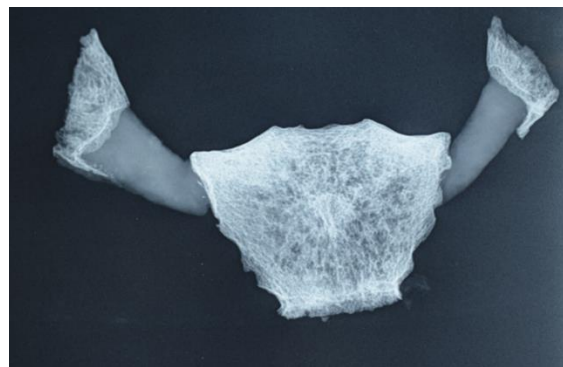


Figure 1: "None- No calcification".

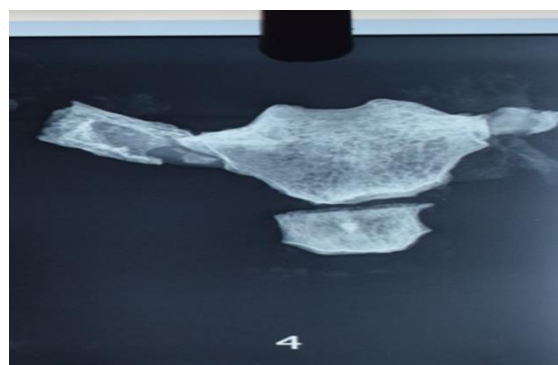
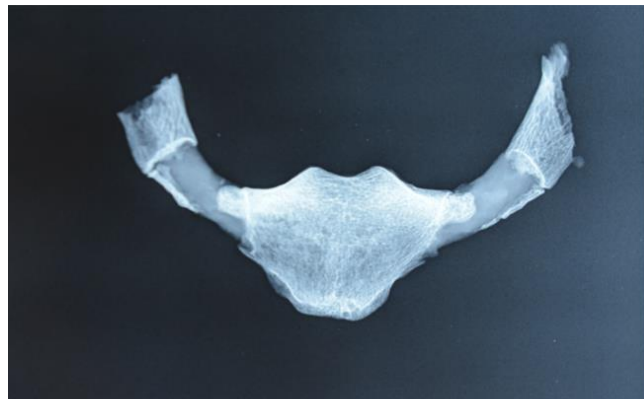
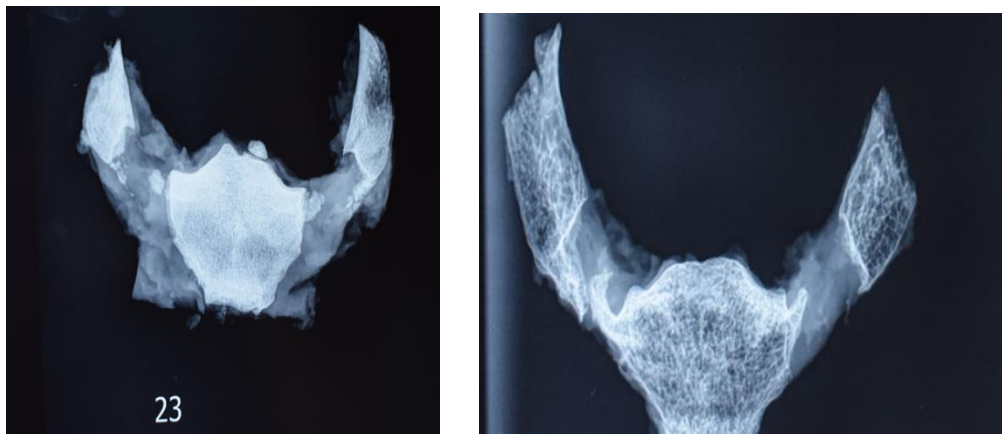


Figure 2: "Type A- Marginal bracket type of pattern calcification".



❖ Figure 3: “Type A1- Marginal linear type of pattern of calcification”.



❖ Figure 4: “Type B- Central or tongue type pattern of calcification”.

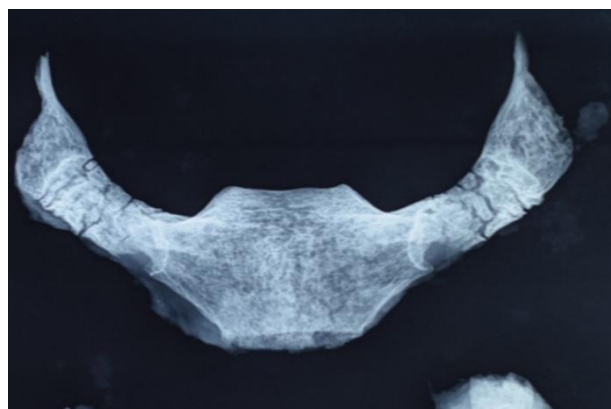


Figure 5: “Type C- Mixed type (Combination of type A, type A1, type B)”.

Costal cartilage calcification pattern type	Sex predicted by pattern	Estimated predictive value	
		Right	Left
Type A	Female	66.32%	66.32%
Type A <sub>1</sub>	Female	50.27%	50.27%
Type B	Female	100%	100%
Type C	Male	100%	100%

**Table 1:** Frequency distribution of first costal cartilage calcification patterns for males and females on both sides.

**Table 2:** Estimated predictive value of first costal cartilage calcification on both side

	Male				Female			
	Number of cases		Percentage (%)		Number of cases		Percentage (%)	
	Right	Left	Right	Left	Right	Left	Right	Left
None	5	5	20	20	0	0	-	-
Type A	5	5	20	20	10	10	40	40
Type A <sub>1</sub>	13	13	52	52	14	14	56	56
Type B	-	-	-	-	1	1	4	4
Type C	2	2	8	8	-	-	-	-
Total	25	25	100	100	25	25	100	100

## 8. Discussion

**Table 3:** Comparison on pattern of first costal cartilage calcification

Authors	Number of patterns	Type of patterns
Sanders CF <sup>8</sup> (Africa)	3	Male type (Marginal), common female type (central), uncommon female type
Elkeles <sup>9</sup> (London) (30-80 years age group)	3	Short linear and ring like, granular type, band type
Rao and Pai <sup>7</sup> (Karnataka) (1-80 years age group)	5	None, Type A (marginal bracket), Type A <sub>1</sub> (Marginal linear), Type B (central), Type C (Mixed).
Navani et al <sup>10</sup> (Boston) (10-95 years age group)	3	Marginal, central and mixed
Zhanger et al <sup>11</sup> (China) (10-90 years age group)	4	Central, peripheral, mixed, no calcification

# Journal of Coastal Life Medicine

<b>Present study (15-30 years age group)</b>	<b>5</b>	<b>None, Type A, Type A<sub>1</sub>, Type B, Type C</b>
--	----------	---

Different patterns of calcification of first rib with its costal cartilage have been studied by different authors<sup>7,9,10,12</sup>. In the present study, five types of patterns (No calcification, Marginal bracket type, Marginal linear type, Central type and Mixed type) have been studied for the first rib costal cartilage calcification as described in previous sections. The type of patterns observed in the present study are almost similar to the patterns observed by Navani et al, Rao and Pai and Sanders. The number of patterns observed in the present study are five which is similar to those reported by Rao and Pai. However, the number of patterns observed by Elkeles, Sanders, Navani et al are only three. This discrepancy may be due to the technique used to radiograph the specimens in different studies. According to Elkeles, standard chest radiographs frequently fail to reveal the degree and extent of calcium deposits in the ventral costal cartilages. In the present study standard radiograph techniques have been used and the sample after procurement has been cleaned properly and the soft tissues covering the sample have been removed, hence a greater number of patterns have been observed. The differences in the number of patterns observed may also be since different studies studied on different

age groups. Zhang et al stated that Since all studies to date have used traditional X-ray techniques, practically all have simply shown the degree of costal cartilage calcification without providing a precise estimate of the calcium content.

Because the hyaline costal cartilage is a flexible link connecting the bony ribs to the sternum, several patterns of costal cartilage calcification can be detected. It is known to ossify (also known as calcify) in humans. Alkaline phosphatase is a secreted enzyme by chondrocytes that breaks down alkaline phosphate to release phosphate ions. This latter substance reacts with soluble calcium in the tissue fluid to precipitate calcium phosphate in the matrix of cartilage tissue. Calcification is the name for this process<sup>12,13,14,15</sup>

## 9. Conclusion

With a predictive value of 66.32% and 100%, respectively, the central and marginal bracket types of calcifications were more common in females. With an estimated predictive value of 100%, mixed type of calcification occurred more frequently in males. This means that there is a clear relationship between the sex involved and the first costal cartilage's calcification.

# Journal of Coastal Life Medicine

## References

- [1] Standing S. Gray's Anatomy. 41<sup>st</sup> ed. London: Elsevier Limited; 2016.
- [2] Cunningham DJ. Cunningham's manual of practical Anatomy. 15<sup>th</sup> ed. New York: Oxford University press; 2008.
- [3] Datta AK. Essentials of Human Anatomy. 9<sup>th</sup> ed. Kolkata: Current Books International; 2014.
- [4] King JB. Calcification of costal cartilages. Br J Radiol. 1939; 12(133): 2-12.
- [5] Vastine JH. Genetic influence of osseous development with particular reference to the deposition of calcium in the costal cartilages. American J Roentgenol. 1948; 59(2): 213-21.
- [6] Ray K, Bardhan J, Sarkar KN. A study of calcification of costal cartilages (1st To 7th) in different age groups and its effect on chest expansion in both male and female. J dental Med Sci. 2017; 16(3): 115-23
- [7] Rao NG, Pai LM. Costal cartilage calcification pattern-a clue for establishing sex identity. Forensic Sci Int. 1988; 38(3-4): 193-202.
- [8] Sanders CF. Sexing by costal cartilage calcification. Br J Radiolog. 1966; 39(459): 233.
- [9] Elkeles A. Sex differences in the calcification of costal cartilages. J Am Geriatr Soc. 1966; 14(5): 456-62.
- [10] Navani S, Shah JR, Levy SP. Determination of sex by costal cartilage calcification. Am J Roentgenol Radiother. 1970; 108(4): 771-4.
- [11] Zhang S, Zhen J, Li H, Sun S, Wu H, Shen P, Chen Z, Yang C. Characteristics of Chinese Costal Cartilage and Costal Calcification Using Dual-Energy Computed Tomography Imaging. Sci Rep. 2017; 7(1): 1-10.
- [12] Inoi T. Estimation of sex and age by calcification pattern of costal cartilage in Japanese. Nihon Hoigaku Zaashi. 1997; 51(2): 89-94.
- [13] Vastine JH. Genetic influence of osseous development with particular reference to the deposition of calcium in the costal cartilages. American J Roentgenol. 1948; 59(2): 213-21.
- [14] Ray K, Bardhan J, Sarkar KN. A study of calcification of costal cartilages (1st To 7th) in different age groups and its effect on chest expansion in both male and female. J dental Med Sci. 2017; 16(3): 115-23.
- [15] Raghvendra DR, Nirmala D. Multiple ossified costal cartilages for 1st rib. Int J Anat Res. 2014; 2(4): 744-47.