

Original Research Paper

Application of Software Tool for Sex Determination from Calcification Pattern of Rib Cartilage in Digital Radiographs

¹Harish Kumar S Agarwal, ²Swati S Shah, ³M Ziyauddin Saiyed, ⁴C B Jani

Abstract

Sexual dimorphism can be studied by observing calcification pattern of rib cartilage, which is gender specific and have peculiar changes those occur at various ages. Various studies have been carried out in past for identifying specific gender from calcification pattern of rib cartilages. Present study was conducted at GCS Medical College, Hospital & RC, Ahmedabad, comprising of total 2291 digital radiographs of chest region (1240 males, 1051 females) of subjects of known age ranging from one day to 92 years. These radiographs were in "jpg format" and observed with "Microsoft Office Picture Manager 2007" by two methods- method I & method-II. Certain technical applications were incorporated in method-II to know the accuracy of computer software in interpretation of digital radiographs for gender determination. After analyzing and applying suitable statistical tests it was concluded that use of computer software for observing calcification of costal cartilages can yield better accuracy in determination of gender. To the best of our belief and knowledge such type of study is hardly reported in bio-medical journals.

Key Words: Calcification; Microsoft Office Picture Manager; Rib cartilage; Sexual dimorphism

Introduction:

Sex determination in clinical Forensic Medicine is not routinely used as from the external/ physical examination it can be easily established. Radiographs of chest region are always not easy to established the sex if mammary shadow is not present like in mass disaster, fragmented body. [1]

So preparing a good data base from living subjects by observing calcification pattern of rib cartilage on radiographs proves to be useful. Various studies also have been undertaken in past to observe patterns of calcification at rib cartilages, which are reported to be useful, convenient and sex specific. [2]

Present study was carried out to evaluate specific pattern of calcification for identification of sex with the help of computer software (Microsoft office picture manager 2007).

Aims and Objectives:

1. To observe the pattern of calcification at the costo-chondral junction in both sexes in digital radiographs
2. To correlate the average age of appearance of sex specific calcification pattern of rib cartilage;
3. To compare the findings of present study with different studies &
4. To evaluate accuracy of two different methods i.e. without and with incorporation of computer software) in above context.

Materials and Methods:

Present retrospective cross-sectional study was undertaken after approval by Ethics committee of GCSMCH & RC, Ahmedabad. Soft copy of digital radiographs of chest region collected in "jpg format" (taken for non-research diagnostic purpose) available in Department of Radio diagnosis, GCSMCH & RC Ahmedabad from 1-02-12 to 30-04-12 were considered for the purpose of study.

In this study we included Subjects of known sex and age and excluded all Subjects with history of trauma to chest region, congenital abnormality and any disease affecting thoracic region. Samples include patients residing in Ahmedabad city. However, it cannot be considered as geographical population because specific duration of habitat could not be established with absolute certainty.

Corresponding Author:

¹Assistant Professor

Dept. of Forensic Medicine

GCS Medical College, Ahmedabad

E-mail: drhkagarwal20@gmail.com

²Prof & HOD, Dept. of Radiodiagnosis

³Assist. Prof., Dept. of Forensic Medicine

⁴Prof & HOD, Dept. of Forensic Medicine

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After blinding digital radiographs were observed by two methods:

- **Method I:** Pattern of calcification at costochondral junction of 2nd, 3rd, 4th ribs on both sides in both sexes in digital radiograph of 3520 (W) X 4280 (H) pixel and 14% zoom in was observed in Microsoft Office Picture Manager software 2007, and results were tabulated.
- **Method II:** Digital radiographs observed by method I were cropped and resized to 150% using Microsoft Office Picture Manager software 2007 that lead to 6426 (W) X 5220 (H) size of the images and observed in 10-20% zoom in, which makes any digital image more informative even for small area of interest in question.

After unblinding the data, radiographs were categorized into age groups and suitable statistical tests were applied by using SPSS software version 15.0. Calcification at costochondral junction was classified mainly into four patterns as mentioned in the study done by Olga Rejtarova et al. [3]

Type I – Peripheral Pattern (P): characterized by calcification of the inferior and superior Costal-cartilage margin. (Fig. 1)

Type II a – Central Lingual Pattern (Cl): characterized by pyramidal-shaped central tongues of calcification beginning in the fossae costarum. (Fig. 3)

II b- Central Globular Pattern (Cg); characterized by centrally-placed, smoothly contoured globules of calcification

II C – Central Lingual and Globular Pattern (Clg)

Type III – Mixed (Peripheral and Central) Pattern (Fig. 2)

Type IV – Indifferent Pattern: Incipient calcification without differentiation into sex specific pattern

Observations and Results:

Out of total 2291 radiographs of known age and sex in the present study, 54.12% (n=1240) were males and 45.88% (n=1051) were females. Maximum number of subjects 17.58% (n=403) belonged to age group 31-40 years as compared to rest. (Table 1)

In present study cases of age range 21-60 years outnumbered other age groups. In age group 21-30 years, out of 160 radiographs of male, calcification was observed in 50 radiographs by method I; while the number increased to 86 by method II. In age group 31-40 years, out of 213 radiographs of male, calcification was observed in 153 radiographs by method I; while the number increased to 186 by

method II. In age group 41-50 years, out of 183 radiographs of male, calcification was observed in 158 radiographs by method I; while the number increased to 183 by method II. In age group 51-60 years, out of 197 radiographs of male, calcification was observed in 191 radiographs by method I; while the number increased to 197 by method II. (Table 2)

In other age groups very little or no increase in number of radiographs showing calcification was observed by method II. For comparison of radiographs showing calcification by method I and by method II, Chi-square test was applied. It was found that calcification observed by method I and by method II was significantly different ($p < 0.05$) in age group 21-60 yrs. Below the age of 20 years and above 91 years, no statistically significant difference was found ($p > 0.05$). (Table-2)

In case of female cases of age range 21-50 years outnumbered other age groups. In age group 21-30 years, out of 136 radiographs of female, calcification was observed in 55 radiographs by method I; while the number increased to 117 by method II.

In age group 31-40 years, out of 190 radiographs of female, calcification was observed in 164 radiographs by method I; while the number increased to 190 by method II. In age group 41-50 years, out of 213 radiographs of female, calcification was observed 193 radiographs by method I; while the number increased to 213 by method II. In other age groups very little or no increase in number of radiographs showing calcification was observed by method II. (Table 3)

For comparison of radiographs showing calcification by method I and by method II, Chi-square test was applied. It was found that calcification observed by method I and by method II was significantly different ($p < 0.05$) in age group 11-50 years. Below the age of 10 years and above 51 years, no statistically significant difference was found ($p > 0.05$). (Table 3) In our study Type I number of digital radiographs showed calcification by Method II were more as compared to Method I in age group 11 to 70 years.

In age group 1 day -10 years and more than 71 years number of radiographs observed by two methods were same.

In Type II number of digital radiographs showed calcification by Method II were more as compared to Method I in the age group 11 to 50 years. Age group 1 day -10 years, 71-80 years and age above 90 years showed equal number of radiographs by two methods. Age group 51-

60 years, 61-70 years and 81-90 years showed less number of cases by Method II.

In Type III number of digital radiographs showed calcification by Method II were more as compared to Method I in age group 21 to 70 years. In age group 1 day -20 years and age more than 71 years number of radiographs observed by two methods was same. In Type IV number of digital radiographs observed by Method II was more or equal to Method I, except in age group 11-20 years which showed less number of cases by Method II. (Table 4)

In this study males showed Type I calcification pattern (Fig. 1) predominantly (61.5%) followed by Type III (Mixed) pattern (Fig. 2) (19.7%) while females primarily showed Type II calcification pattern (89.2%) followed by Type IV pattern (Indifferent). On applying Chi-square test, p -value was <0.0001 . (Table 5)

Discussion:

It is noteworthy that the sample size of present study is more than two times the other studies. [3-5] Study by Rejtarová O et al [3] comprised of 1044 radiographs, Navani et al [4] comprised of 1000 radiographs and Khatri et al [5] comprised of 1000 radiographs.

Present study also includes radiographs of age less than 10 years which were not included in previous two studies. [3, 4]

Furthermore present study incorporated application of a computer soft-ware [Microsoft Office Picture Manager 2007], which none of the authors [3-5] used or mentioned about in previous studies. It is obvious from table-2 and table-3 that the "hypothesis of no difference" in both sexes by two different methods is rejected; meaning thereby there is significant difference ($p<0.05$) in calcification observed by method I and method II. Number of radiographs showing calcification by method II in the present study 1738 (75.86%) is quite higher than observed by Rejtarová O et al [3] 538 radiographs (51.53%).

However, Navani et al [4] reported calcification in 776 radiographs (77.60%), which is just higher than the present study.

It was probably because Navani et al [4] did not include age group up to 10 years whereas present study included 217 radiographs (9.47%) of same age group and none of them showed calcification (calcification least likely in this age group). If age group 1 day- 10 years in present study is excluded from calculation, it becomes (83.79%), which comes out to be more than that of Navani et al. [4]

On evaluation of the differences between method I and II as per table- 2 and 3; it is evident that in age groups 11-60 years in both

sexes, 218 more radiographs (15.39%) showed calcification by method II as compared to method I. This increase in number manifests in all the patterns of calcification such as in Type I (474 subjects by method I to 545 in method II), Type II (774 to 885), Type III (191 to 211) and in Type IV showed 76 to 97 cases.

In present study in age group 51-70 yrs, the number of subjects showing Type II calcification pattern by method II were less as compared to method I, this is probably due to shifting of cases from Type II to Type I when observed by method II.

On analysis it is evident that only 2 female subjects detected in Type I pattern of calcification by method II. (Table 6) Thus it can be safely inferred that observing digital radiographs as compared to non-digital one for sex determination is more accurate. Furthermore a digital radiograph observed with computer software application in the present study is either at par or has yielded better results than other methods.

Comparison of findings of present study by method II with previous studies showed that all three studies individually and collectively show Type I as male and Type II as female pattern of calcification. (Table 7)

Number of cases of male subjects showing Type I pattern calcification was less than others. This variation can be explained by three possibilities:

- Sample population in all three studies belongs to different geographical region and the sample size is also different.
- Samples in other studies were non digital radiographs, whereas in the present study.
- Samples were digital radiographs; yielding better visualization and hence better interpretation.

In present study radiographs of male showing Type III pattern were much higher as compared to others, meaning thereby that method II is better in differentiating Type I from Type III pattern in radiographs of male. In the present study, radiographs of Type IV pattern in both genders were fewer as compared to other two studies, implying that method II is better in excluding the Indifferent pattern.

Conclusion:

It is safe to conclude that different patterns of calcification at rib cartilage observed in digital radiographs are sex specific. That is to say male subjects predominantly show Type I pattern and female subjects predominantly show Type II pattern. Calcification at rib cartilage

starts at the age of 21 years in both sexes and increases with age.

Distribution of sex specific patterns of calcification in various age groups was consistent with observations in previous studies. Method II more accurately differentiate Type I (male) pattern of calcification of rib cartilage.

Observing patterns of calcification at rib cartilage of 2nd, 3rd, 4th ribs on both sides in both sex in digital radiographs in Microsoft Office Picture Manager 2007 after cropping and resizing the image to 150% [that leads to size of image 6426 (W) X 5220 (H) and observing in 10-20% zoom in yields better results as compared to observing original images.

Hence incorporation of such useful software or any other similar suitable software technique for sex determination in medico-legal cases or even for research purposes seems to be useful.

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Fig.1: Typical Peripheral Pattern (Type-I) of Calcification [male aged 58 year] by Method II



Fig. 2: Mixed Pattern Calcification (Type III= Type I+ Type II) Swiss cheese Pattern [Male Aged 66yrs] By Method II

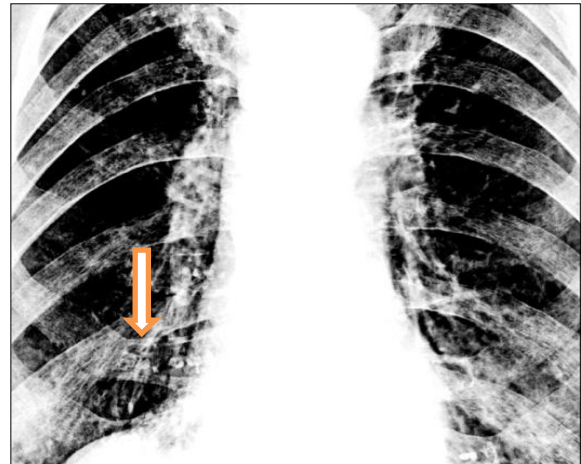


Fig. 3: Central lingual Pattern (Type-II a) of Calcification [Female aged 65 years] by Method II

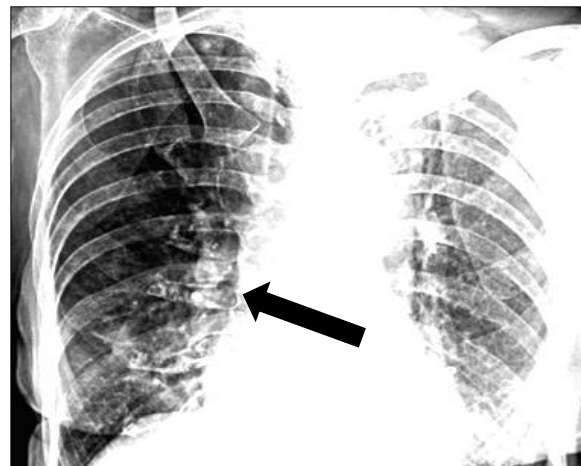


Fig. 4: Crab Claw Pattern (Type-II A) Calcification [Female Aged 70 Years] By Method II



Table 1: Age and Gender Wise Distribution of Subjects

Age grps (Yrs)	Male (%)	Female (%)	Total (%)
1 day-10 yrs	136 (5.94)	81 (3.53)	217 (9.47)
11-20	126 (5.49)	124 (5.41)	250 (10.90)
21-30	160 (6.98)	136 (5.93)	296 (12.91)
31-40	213 (9.29)	190 (8.29)	403 (17.58)
41-50	183 (7.99)	213 (9.29)	396 (17.28)
51-60	197 (8.60)	140 (6.11)	337 (14.71)
61-70	147 (6.42)	121 (5.28)	268 (11.70)
71-80	66 (2.89)	39 (1.70)	105 (4.59)
81-90	11 (0.48)	07 (0.30)	18 (0.78)
>91	01 (0.43)	00	01 (0.44)
Total	1240 (54.12)	1051 (45.87)	2291 (100)

Table 3: Female Subjects Showing Calcification in Method I and Method II

Age grps (Yrs)	Female	Calcification in females		p-value
		Method I (%)	Method II (%)	
1 day-10 yrs	81	00	00	0
11-20 yrs	124	15 (12.09)	28 (22.58)	<0.05
21-30 yrs	136	58 (42.64)	117 (86.02)	<0.05
31-40 yrs	190	164 (86.31)	190 (100)	<0.05
41-50 yrs	213	193 (90.61)	213 (100)	<0.05
51-60 yrs	140	140 (100)	140 (100)	>0.05
61-70 yrs	121	121 (100)	121 (100)	>0.05
71-80 yrs	39	39 (100)	39 (100)	>0.05
81-90 yrs	07	07 (100)	07 (100)	>0.05
>91 yrs	00	00	00	0
Total	1051	737 (70.11)	855 (81.35)	<0.05

Table 2: Male Subjects Showing Calcification in Method I and Method II

Age grps (Yrs)	Calcification in males			p-value
	Male	Method I (%)	Method II (%)	
1 day-10 yrs	136	00	00	0
11-20	126	01 (0.79)	06 (4.76)	>0.05
21-30	160	50 (31.25)	86 (53.75)	<0.05
31-40	213	153 (71.83)	186 (87.32)	<0.05
41-50	183	158 (86.33)	183 (100)	<0.05
51-60	197	191 (96.95)	197 (100)	<0.05
61-70	147	147 (100)	147 (100)	>0.05
71-80	66	66 (100)	66 (100)	>0.05
81-90	11	11 (100)	11 (100)	>0.05
>91	01	01 (100)	01 (100)	>0.05
Total	1240	778 (62.73)	883 (71.20)	<0.05

Table 4

Comparison of Calcification Patterns in Both Sexes by Two Different Methods of Observation

Age grps(Yrs)	Type I		Type II		Type III		Type IV	
	Method I	Method II	Method I	Method II	Method I	Method II	Method I	Method II
1day-10yrs(217)	00(0.00)	00(0.00)	00(0.0)	00(0.0)	00(0.0)	00(0.0)	00(0.00)	00(0.00)
11-20 (250)	0(0.0)	04(1.60)	12(6.40)	29(11.6)	00(0.0)	00(0.0)	04(1.60)	01(0.40)
21-30 (296)	33(11.14)	64(21.62)	53(17.90)	113(38.17)	07(2.36)	11(3.71)	15(5.06)	15(5.06)
31-40 (403)	88(21.83)	102(25.31)	184(45.65)	205(50.86)	39(9.67)	45(11.16)	06(1.48)	24(5.95)
41-50 (396)	100(25.25)	109(27.52)	201(50.75)	223(56.31)	35(8.83)	45(11.36)	15(3.78)	19(4.79)
51-60 (337)	143(42.43)	154(45.69)	144(42.72)	139(41.24)	30(8.90)	30(8.90)	14(4.15)	14(4.15)
61-70 (268)	85 (31.71)	87(32.46)	131(48.88)	128(47.76)	39(14.55)	39(14.55)	13(4.85)	14(5.22)
71-80 (105)	22 (20.95)	22(20.95)	40(38.09)	40(38.09)	35(33.33)	35(33.3)	08(7.61)	08(7.61)
81-90 (18)	03 (16.66)	03(16.66)	9(50.00)	8(44.44)	05(27.77)	05(27.77)	01(5.55)	02(11.11)
> 90 (01)	00 (0.00)	00(0.0)	00(0.00)	00(0.0)	01(100)	01(100)	00(0.00)	00(0.0)
Total (2291)	474	545	774	885	191	211	76	97

Table 5: Gender Wise Distribution of Different Patterns of Calcification by Method II

Gender	Type I (%)	Type II (%)	Type III (%)	Type IV (%)	Total (%)	p-value (Chi-square test)
Male	543(61.5)	122(13.8)	174(19.7)	44(4.98)	883(100)	p<0.0001
Female	02(0.2)	763(89.2)	37(4.3)	53(6.2)	855(100)	p<0.0001

Table 6: Gender Wise Comparison of Different Patterns of Calcification by Method I and Method II

Pattern	Method I		Method II	
	Male	Female	Male	Female
Type I (%)	470 (60.41)	4 (0.54)	543(61.5)	02(0.2)
Type II (%)	126 (16.19)	648 (87.92)	122(13.8)	763(89.2)
Type III (%)	151 (19.40)	40 (5.42)	174(19.7)	37(4.3)
Type IV (%)	31 (3.98)	45 (6.10)	44(4.98)	53(6.2)
Total (%)	778 (100)	737 (100)	883(100)	855(100)

Table 7: Comparison of Distribution of Patterns of Calcification with Previous Studies

Study	Type I		Type II		Type III		Type IV	
	Male	Female	Male	Female	Male	Female	Male	Female
Present study- Method II	61.49%	0.23%	13.81%	89.24%	19.70%	4.33%	4.98%	6.19%
Rejtarová O et al [3]	92.91%	0.38%	0%	77.30%	1.49%	8.84%	5.59%	13.46%
Navani S et al[4]	83.33%	4.21%	6.56%	82.36%	0%	0.78%	10.10%	12.63%