

Original Research Paper

Significance of Costochondral Junction of the Fourth Rib In Age Determination in North Kerala Population

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Abstract

Determination of age of an individual is one of the most important factors in establishment of identity. The present study was conducted on post-mortem specimens obtained from 100 males and 50 females above the age of 16 years in the population of North Kerala. The study used the phase evaluation chart to establish the age of an individual. In the male rib specimens, correct age could be predicted in 68% cases with evaluation of articular facet, firmness and texture combination. In the female rib specimen, it age could be estimated in 73% cases using firmness and shape of the rim combination. The results of the present study showed that it was a good method of assessment of age in a high percentage of cases even when only ribs are available. The method was very relevant at an application level when scattered bony remnants are obtained, to establish the identity in cases of mass disasters.

Key Words: Age determination, Fourth rib, Costochondral junction, North Kerala population

Introduction:

The estimation of age is an essential part of all Forensic scientific investigations involving skeletal remains of unknown individuals. Assessment of gross morphologic changes in bones is a more rapid method of age estimation and its accuracy is enhanced when more than one criterion is chosen.

Krogman [1] gives a comprehensive study of the ageing of persons from bones including cranial sutures, pubic symphysis, vertebral bodies, sacrum, sternii and ribs amongst others. Kerley ER [2] in an osteological study noticed that the sternal extremity of the rib is billowy in adolescence; cup shaped with sharp margins in middle age and irregular in later years. Loth et al [3] worked on age estimation from the study of ribs and confirmed the observations made earlier by Kerley. [2]

They developed a system in which each rib was analyzed on the basis of changes noted in articular facet – Pit depth, Pit shape and Rim & Wall configuration, each of which was divided into six stages. Results indicated that the age at death could be estimated from a rib within about two years in the second decade to about seven years in the 5th and 6th decades.

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Pit shape and Rim & Wall configurations yielded better results than about pit depth alone.

Iscan M Y [5] introduced the sternal end of the right fourth rib as a site for age estimation. The sample consisted of 118 white males of verified age, sex and race and the ribs were assigned to one of the nine phases (0 to 8).

It was observed that metamorphosis was most rapid and uniform from the mean age of 17-28yrs (phases 1 to 4). The rib morphology was more varied after age 39 (phases 5 to 8), resulting in wider range of predicted age.

Iscan M Y et al [5] carried out a study of the right fourth ribs of 86 white females. He found that the female ribs showed both earlier initial pit formation and a different morphologic pattern of ageing as compared with males.

The most rapid metamorphoses occurred in mean ages 14-28 (phases 1 to 4) with changes noticeable at 3-4 years intervals. After mean age 28, this process slowed, expanding the interval between phases to 10-15yrs. Loth S R et al [6] studied changes in the ribs 3 and 5 along with those that were seen on the fourth rib.

The results of this analysis indicated that in >79% of cases, all three ribs (3, 4 & 5) fell into the same phase and intercostal differences were within one phase for 98% of the sample and so it was concluded that the age could be assessed from these adjacent ribs also using the phase method.

Yavuz M F et al [7] applied the rib phase standards to a Turkish sample of 150 males and 144 females of known age and each rib was

phased according to the standards developed by Iscan M Y. The phase estimations were subjected to an analysis of variance and the results indicated that Turkish ribs did not show racial variation.

Variation as measured by standard deviation increased from phase 5 on in both sexes. Russell K F et al [8] applied the phase method to the fourth rib. Measures of race differences in 4th rib morphology were included and the result was that Americans of African origin showed a non-significant trend for the rib changes to be delayed compared to Americans of European descent

Oettle A C et al [9] studied 395 sternal ends of fourth ribs (265 male, 74 female of South African Black population) collected during the period 1994 – 96 and found the phase method employed by Iscan M Y et al acceptable, although it was less accurate to predict age in this population.

Materials and Methods:

The present study was carried out on 117 males and 53 female post-mortem specimens. The specimens were obtained from consecutive cases of known identity and age.

Decomposition changes or cause of death was not considered as exclusion criteria.

In the selected cases general examination followed by examination of sternum and its union and other abnormalities was done.

Methodology:

The method of preparation of the specimen was based on the technique described by Iscan M Y et al. [3] each of the rib samples was individually examined under natural lighting with the aid of a hand lens.

The phase evaluation method devised by Iscan M Y [3] was used to classify the ribs.

Each of the seven morphological changes was graded and the most suitable coding was given for each. Viewing and smooth running of fingertips on the bone assessed the texture (T) of the bone.

The weight (H) of the bone and its firmness (F) has reference to density and was assessed by pressing them in between the thumb and index finger. Gross examination of the articular surface (A), walls of the pit (W), edges (E) and the shape of the rim (S) was done. The specimen belonged to that phase where five or more of the parameters tallied.

When only four or less tallied, the articular facet changes, Walls and Edges were selected as the inclusion criteria for selecting the phase in their order since they were the primary changes assessed.

The data obtained from the study was statistically analyzed using ANOVA and regression analysis for the relationship between the actual age of the person and the phase evaluated.

Fig. 1: SL 39 Phase 0

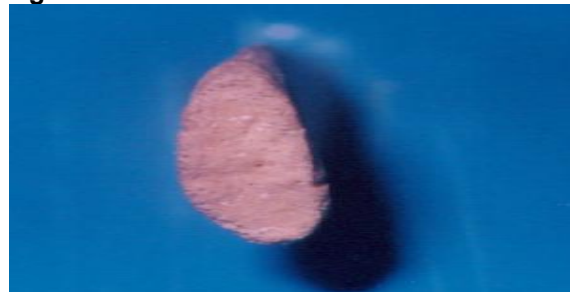


Fig. 2: SL 124 Phase 1

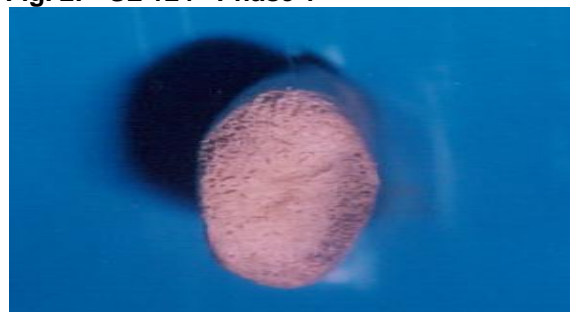


Fig. 3: SL 25 Phase 2



Fig. 4: SL 5 Phase 3



Fig. 5: SL 48 Phase 4



Fig. 6: SL 70 Phase 5



Fig. 7: SL 169 Phase 6



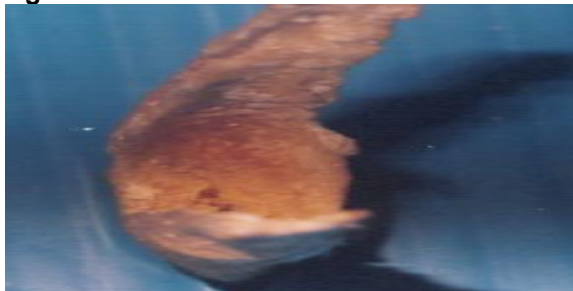
Fig. 8: SL 22 Phase 7



Fig. 9: SL 14 Phase 8



Fig. 10: SL 14 Phase 8



Observations:

Out of the 170 specimens studied 117 were from male and 53 from female persons.

The age ranges of the persons at death ranged from 18- 85 years in the male and from 16-78 years in the females.

Males:

The data obtained from male specimens were statistically analysed by linear regression method applied to individual parameters i.e. Articular surface (A), Calcification (C), Walls (W), Shape of Rim (S), Edges (E), Texture (T), Weight of bone (H) and Firmness (F) collectively and excluding the parameters one by one for their efficiency to indicate the correct age and to find out which one /more of these parameters indicate age better with P value less than 0.01.

When all the parameters were evaluated using linear regression and it was found that the parameters walls, weight and calcification and very high P values and was found to decrease the predictability of age. It was possible to predict age in 69% of male rib specimens.

The parameters (A, E, F, S, T and W) were regressed and it was found that the predictability of age was still accurate in 69% of male rib specimens. Using the 5 parameters (A, E, F, S and T) it was possible to predict age accurately in 69% of male rib specimens.

Using parameters articular facet, firmness and texture, it was possible to predict age accurately in 68% of specimens and precisely in 66% of male rib specimens.

The maximum correlation with age was obtained with the evaluation of articular facet, Firmness and Texture combination and was found to predict the correct age in 68% of cases. Inclusion of other parameters was found to decrease the predictability.

Females:

The female specimens were grouped in decades of age to know the frequency of distribution. When all the parameters were evaluated using linear regression it was seen that calcification and edges had the highest P value and hence decreased the predictability of age. Excluding edges, the other parameters were subjected to linear regression and it was found that calcification had the highest P value and was excluded in the next step.

Excluding calcification, the other parameters were regressed and it was found that texture and walls had high P values.

These parameters in combination had a 75% chance of predicting age. Texture and walls were excluded and other parameters were regressed using linear regression and in 74% of

female rib specimens there could be an accurate analysed age.

Linear regression method was applied to firmness and shape of rim. This combination was found to be able to predict age accurately in 73% of female rib specimens. Firmness was regressed using linear regression method and it was found to predict age in 71% of female rib specimens with P values less than 0.01.

The maximum correlation with age was obtained with the evaluation of Firmness and Shape of the Rim combination and was found to predict the correct age in 73% of cases. The evaluation of Firmness alone was found to predict age accurately in 71% of cases. Inclusion of other parameters was found to decrease the predictability.

Discussion:

Changes in the articular facet of the sternal end of the rib (Phase Method) were studied and the process was started by Kerley E R [2], improved by Loth et al [3] and popularized by Iscan M Y et al. [4] Yavuz M F et al [7] applied the phase analysis to Turkish samples, Russell K F et al [8] conducted the study on Americans of European and African descent, Oettle A C et al [9] used it on the South African Black population, and Pillai G K [10] on the South Kerala population.

All of them approved the repeatability of the method popularized by Iscan M Y et al [4] even though they were not able to get very similar results. They believed that the articular facet underwent metamorphic changes throughout life, which were useful age indicators. The question of racial variation was answered by Iscan M Y et al [11], in their studies, which stated that while the degree of interracial variation did not require new standards but specific modification of the standard for their own population.

The present study was undertaken to develop the specific modifications that are applicable to our population to determine age from the sternal end of fourth rib. The results of present study of the male fourth rib specimen can be compared with the result of the studies of Iscan M Y et al and Pillai G K. [4, 10]

In the male rib specimens of the present study, it was found that the maximum correlation with age was obtained with evaluation of articular facet, firmness and Texture combination and was found to predict the correct age in 68% of cases. (Table 1)

In our study 53 right-sided female rib specimens were studied and phase analyzed.

The results were compared with the results of Pillai G K. [10] In the female rib specimen of the present study, it was found that maximum correlation with age was obtained with evaluation of firmness and shape of the Rim combination and was found to predict correct age in 73% of cases. The evaluation of firmness alone was found to predict age accurately in 71% of cases. (Table 2)

Statistical analysis of the results of the present study confirmed that the sternal ends of the fourth rib showed continuous metamorphosis as a normal regressive change of the ageing process, and its assessment could be used to determine age of the deceased to some extent.

Summary & Conclusion:

The present study was done on 117 males and 53 female postmortem specimens collected from North Kerala population. The study attempts to reevaluate the results of Iscan M Y et al [3] with a view to correlate them with known age in both male and female specimens collected during autopsy, and proposes to utilize it in future in the particular ethnic subgroup from where they were collected.

The sternal end of the fourth rib showed sequential changes of a pit formation when its billowy nature was lost and then it changed into a cup shaped one with anterior and posterior walls with smooth interior surfaces.

The surfaces then lost their smoothness and the rim which was originally smooth and even, oval in shape, became sharp and irregular, scalloped and with window formations.

The overall firmness and texture of the bone also changed from dense, smooth and solid in youth to thin, brittle and porous in the elderly. The present study is a similar one done in an exclusive ethnic subgroup of North Kerala population with the same view.

A similar study had been conducted in South Kerala by Pillai G K. [10] The results of the present study showed that it was a good method of assessment of age in a high percentage of cases even when only ribs are available, mostly like those of previous workers world over, but differed in certain aspects from the South Kerala population.

The results were very relevant at an application level when scattered bony remnants are obtained, to establish the identity in cases of mass disasters.

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Table 1: Comparison of Statistics of Male Rib Specimens

Phase	Age range			Cases in current study	Mean age		
	Pillai G K	Iscan M Y	Present study		Pillai G K	Iscan M Y	Present study
1	16-25	17-18	18-28	7	18.8	17.3	23.5
2	20-29	18-25	20-23	6	24.2	21.9	22.0
3	30-38	19-33	21-28	9	33.5	25.9	24.7
4	34-45	22-35	22-38	13	38.7	28.2	24.7
5	34-56	28-52	28-58	22	47.2	38.8	41.0
6	36-80	32-71	30-80	30	50.6	50.0	51.7
7	60-90	44-85	40-75	17	73.3	59.2	54.9
8	65	44-85	40-85	14	65	71.5	63.0

Table 2: Comparison of Statistics of Female Rib Specimens

Phase	Age range		Cases in current study	Mean age	
	Pillai G K	Present study		Pillai G K	Present study
1	16-23	16-27	3	19.3	20
2	17-25	20-24	4	20.4	21.3
3	20-36	20-40	10	26.6	28.2
4	26-45	25-52	3	40.2	38.3
5	32-60	28-70	13	51.1	46.5
6	60-62	31-78	9	61	54.4
7	65	43-75	7	65	59.9
8	70	60-78	4	70	69.5