

Bilateral metamorphological variation at sternal end of fourth rib

Mahesh Chand Meena*, Yashoda Rani, Mukta Rani

Department of Forensic Medicine and Toxicology, LHMC & Assoc. Hospitals, New Delhi, India

Received July 27, 2012
Accepted February 3, 2013

Abstract

The sternal surface of the 4th rib has been suggested as a useful predictor of age estimation. Morphologic methods are fast and easy to use for purpose of age determination. The sternal ends of the ribs are a reliable method of age estimation from younger to old age. Iscan et al developed a phase analysis method for the right 4th rib that was sex and race specific. The purpose of this study is to determine the accuracy of the standards of age estimation from the left 4th in comparison to right fourth rib using the phase analysis for the Indian population. The sample consisted of right and left 4th ribs from 63 female and 101 males. Comparison of phase variation between right and left fourth ribs indicates that the average of an individual's phase score in males is not significantly different in either the left or right rib.

Keywords: *Age estimation, rib phase method, bilateral variation*

Introduction

Age has always been of great interest to everyone especially for forensic expert and anthropologists. Researchers have studied this process to understand its origin, evolution and consequences. Usually, individuals are more conscious and worried about what happens to the external body, but the aging process affects every part of the organism, at every biological level, including the skeleton. Forensic expert and anthropologists have been involved directly in diagnosing the skeletal age of individuals for forensic and archaeological purposes. Some of these specialists have investigated skeletal changes throughout life and have developed various methods to estimate age at death.

In forensic medicine, determination of identity of individuals whether alive or dead is always required (Iscan et al., 1984). Age determination is also one of the more difficult aspects of the investigation of death of a skeletonised individual. While there have been a number of fairly accurate techniques developed on age determination from the skeleton such as cranial suture closure (Mann et al., 1991, 1987), pubic

* Corresponding author: Department of Forensic Medicine and Pathology, LHMC & Assoc. Hospitals, 110001 New Delhi, India (e-mail: drmahe2012@gmail.com)

symphyseal metamorphosis (Snow, 1983; Klepinger et al., 1992; Murray and Murray, 1991), morphologic changes of the sternal end of the rib; microscopic analysis of bone (osteon counting) (Nelson, 1992; Stout, 1986; Dudar et al., 1993), Microscopic analysis of structures within long bone cortical segments is another valuable technique (Kerley, 1970; Thompson, 1979). Among these, sternal end of the rib is argued to be more reliable for age estimation from late adolescence to old age (Iscan et al., 1984, 1985, 1987; Iscan and Loth, 1986a, 1986b; Loth et al., 1994). Microscopic analysis requires training, equipment and time. Morphologic examination is more rapid and easier. Pubic symphysis and cranial sutures have a high degree of individual variation (Snow, 1983; Klepinger et al., 1992). The morphologic changes of the rib by normal aging process are sex specific (Iscan et al., 1984; Dudar et al., 1993; Iscan et al., 1986; Loth et al., 1994). Iscan's rib phase method had gained widespread acceptance for both age and sex (Iscan et al., 1984, 1986, 1987; Loth et al., 1994), and the need of modifications for different human populations has been explored (Loth et al., 1994).

In our previous study we determined the usability of Iscan's phase method for Indian people (Meena et al., 2012) and this study was performed to determine the applicability of the standards of age estimation from the right IV rib by phase analysis method on the left IV ribs for Indian population. The statistical analysis did not show difference between the phases of American and Indian people at the right IV rib. The aims of this study is applicability of the standards of age estimation from the right IV rib, for left IV rib in Indian population or determine the bilateral metamorphological variation in right and left IV ribs in Indian population for each phase

Materials and methods

This study includes 63 female and 101 male cases with known age, and sex, specimens were collected from the individuals during standard post-mortem examinations at the Lady Hardinge Medical College mortuary. The individual ribs were then placed in glass containers bearing identification numbers. These glass containers were filled with water and the ribs were left to soak for several weeks. As soon as the soft tissues could be removed with ease, the ribs were removed from the water filled glass containers; these were then individually marked with an indelible pen. The ribs were finally cleaned, removing any remaining soft tissue, after which they were dried and marked by using an indelible pen and attaching labels. The rib samples were examined and the chronological age was estimated according to the Iscan method that was defined for American population. The morphologic changes in the form, shape, texture and overall quality of specimens were evaluated without any knowledge about the patients. The ages were then compared with the phase assigned according to Iscan's 9 phases. Weighted Kappa statistics were used to define the agreement rate among phases. Kappa values greater than 0.75 are taken to represent excellent agreement beyond chance, values between 0.40 and 0.75 are taken to represent fair to good agreement and values below 0.40 are taken to represent poor agreement beyond chance.

Results

The phase distribution of 63 females and 101 males is shown on Table 1. When statistically analysed the phases, the morphologic changes of the all right and left IV ribs of male and female were in concordance with Iscan's phase method defined for American population. However right and left IV ribs of males and females have statistically significant ($P < 0.001$) difference compared by Iscan's phase method. The cases were one phase low or high. These phase mistakes (in concordance) are

summarized at Table 2.

Table 1: Phase distribution of the cases according to right 4th rib

Phase	Male	Female	Total
0	2	1	3
1	5	3	8
2	10	4	14
3	11	12	23
4	11	12	23
5	9	9	18
6	20	7	27
7	19	7	26
8	14	8	22
Total	101	63	164

Table 2: Phase mistakes in comparison to right IV rib

Rib	Cases with 0 phase mistakes N (%)	Case with (±) 1 phase mistakes N
Male (left IV rib)	92(91.09%)	9
Female (left IV rib)	59(93.65%)	4

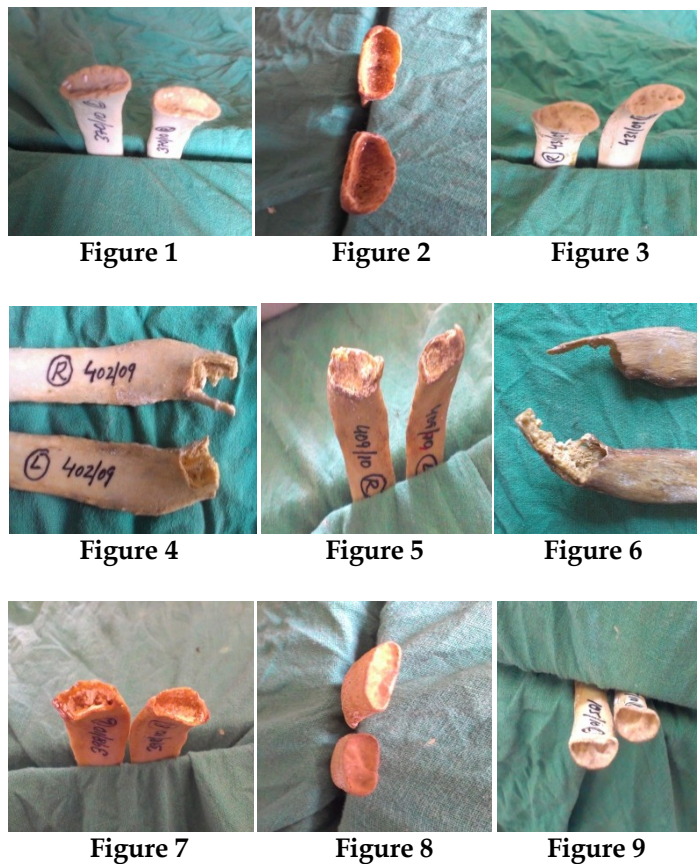


Figure 1-9: Comparison of phase variation between right and left fourth ribs in an individual's (exist bilaterally in same phase)

Table 2 shows that 91.09% cases exist bilaterally in same phase in males and in females 93.65% cases exist bilaterally in same phase in fourth rib. Phase variations were seen in some fourth ribs, in both male and female. In males, 8.91% cases showed bilateral phase variation, and in females, 6.35% cases showed bilateral phase variation. Comparison of phase variation between right and left fourth ribs in males indicates that the average of an individual's phase score in males is not significantly different in either the left or right rib.

Weighted kappa values of the left IV, according to the right IV rib phase distribution for female were 0.97 showing an excellent agreement. The weighted Kappa values of the left 4th ribs according to the right 4th for male are 0.95 respectively. The weighted Kappa values of the left IV male ribs and left IV female ribs according to the right 4th rib are 0.95 and 0.97 (excellent agreement) (Figure 1-9)

Discussion

Factor that has been credited with the effectiveness of the rib as a site for age estimation is the relative lack of direct functional stress at the costochondral junction. Iscan et al. (1986) and Loth and Iscan (1994) compared age assessment from the ribs and pubic symphysis of the same individuals and found that the rib phase estimates were nearly twice as likely to be correct and with much less variability. As these authors suggested, the pelvis is directly involved in weight bearing, locomotion, pregnancy and parturition. Thus, there is considerable functional stress on the symphysis and this varies greatly by sex and even on the individual level. The rib, on the other hand, is only directly affected by breathing, and this activity has little variation among healthy individuals. While thoracic region is involved with upper body and extremity motion, the ribs themselves have no direct involvement. The similarities in the aging process in the ribs of these two diverse populations underscores the lack of influence of functional factors, such as physical activity on the rib.

Several other factors may affect the use of a method of age estimation from the skeleton. These factors include occupation, inter-observer error, general health, human variability, and the effects of disease. The main health problems that affect bone remodelling are endocrine disorders, chronic lung disease or medication. Intercostal variations, degree of physical activity, diet and racial differences may be some other affecting factors (Iscan et al. 1987; Loth et al., 1994). Racial differences are a product of both genetics and environment. It is reported to be relatively low in age determination from the adult skeleton. Iscan et al. (1987) found differences in the ribs both in rate and morphological pattern of aging between whites and blacks.

This study only tests their view on the applicability of the method to both sides of the body. The sternal extremity of the rib undergoes continuous metamorphosis as a normal part of the aging process. The rates of these changes are paralleled to age and these changes are also different in females and males requiring the development of different standards. Female ribs begin to show changes earlier than males (Iscan et al., 1985).

In this study, we examined bilateral variations in sternal end of fourth rib. Thus, the phase method of age determination is safely used in this study. There are some -1 or +1 phase variations at sternal end of rib whether left or right. Weighted Kappa values of the left IV rib according to the right 4th rib phase distribution for females were 0.97 showing an excellent agreement. The weighted kappa values of the left IV ribs according to the right 4th for males were 0.95 are in excellent agreement values beyond chance. Similarly Aktas et al. (2004) founds intercostal variation is not

observed in the in male and female in Turkish population. Yoder et al. (2001) obtains a similar finding that the left ribs IV–IX were found not to vary significantly from their right counterparts. Although only right rib II was found to vary significantly from rib IV, use of the other ribs in the series should be undertaken with caution due to questions concerning their statistical significance (Yoder et al., 2001). The statistically significant variation among ribs in men, not in women, might be explained by a few hypotheses. Individual differences in the rate of growth and remodelling among ribs in the late phases might mainly be affected by phenotypic factors. In Indian the male population has more differences in life standards than women, such as nutrition, disease, sport activities, type of work. This variation may be accepted minimum because Kappa statistic defines agreement with the IV rib. This minimum variation rate must not cause a disadvantage to be able to use different ribs, and right or left ribs in age estimation. This hypothesis was strongly supported by weighted Kappa statistics that showed excellent agreement rate.

Conclusion

We conclude that Iscan's rib phase analysis method is applicable for using in age estimation for Indian population. Tests were performed between phase scores obtained from right and left ribs; right IV rib phase scores and scores obtained from the left IV ribs were found not to vary significantly from their right counterparts. This phase analysis method is used in left IV rib, with little variations in Indian population.

Bibliography

- Aktas EO, Kocak A, Aktas S, Yemiscigil A. (2004) Ribs variation for age estimation. Are the standards for the right 4th rib applicable for other ribs? *Coll Antropol* 28 (Suppl. 2):267–272.
- Dudar JC, Pfeifer S, Saunders SR. (1993) Evaluation of morphological and histological adult skeletal age at death estimation techniques using ribs. *J Forensic Sci* 38:677–685.
- Iscan MY, Loth SR, Wright RK. (1984) Age estimation from the rib by phase analysis: white males. *J Forensic Sci* 29:1094–1104.
- Iscan MY, Loth SR, Wright RK. (1985) Age estimation from the rib by phase analysis: white females. *J Forensic Sci* 30:853–863.
- Iscan MY, Loth SR, Wright RK. (1987) Racial variation in the sternal extremity of the rib and its effect on age determination. *J Forensic Sci* 32:452–466.
- Iscan MY, Loth SR, (1986a) Determination of age from the sternal rib in white males: a test of the phase method. *J Forensic Sci* 31:122–132.
- Iscan MY, Loth SR. (1986b) Determination of age from the sternal rib in white females: a test of phase method. *J Forensic Sci* 31:990–999.
- Kerley ER. (1970) Estimation of skeletal age: after about age 30 years. In: TD Stewart, editor. *Personal identification*. Washington: National Museum of Natural History, p 57–70.
- Klepinger LL, Katz D, Micozzi MS, Carrol L. (1992) Evaluation of cast methods for estimating age from the os pubis. *J Forensic Sci* 37:763–770.
- Loth SR, Iscan MY, Scheuerman EH. (1994) Intercostal variation at the sternal end of rib. *Forensic Sci Int* 65:135–143.
- Mann RW, Jantz RL, Bass WM, Willey PS. (1991) Maxillary suture obliteration: a visual method for estimating skeletal age. *J Forensic Sci* 36:781–791.
- Mann RW, Symes SA, Bass WM. (1987) Maxillary suture obliteration: aging the human skeleton based on intact or fragmentary maxilla. *J Forensic Sci* 32:148–157.
- Meena MC, Rani Y, Naik SK, Murarib A. (2012) Age estimation from the IV rib by phase analysis in Indian males. *Aus J Forensic Sci* 44(3):261–271.
- Murray KA, Murray T. (1991) A test of the auricular surface aging technique. *J Forensic Sci* 36:1162–1169.

- Nelson R. (1992) A microscopic comparison of fresh and burned bone. *J Forensic Sci* 37:1055-1060.
- Snow CC. (1983) Equations for estimating age at death from the pubic symphysis: a modification of the McKern-Stewart method. *J Forensic Sci* 28:864-870.
- Stout SD. (1986) The use of bone histomorphometry in skeletal identification: the case of Francisco Pizarro. *J Forensic Sci* 31:296-300.
- Thompson DD. (1979) The core technique in the determination of age at death in skeletons. *J Forensic Sci* 24:902-915.
- Yoder C, Ubelaker DH, Powell JF. (2001) Examination of variation in sternal rib end morphology relevant to age assessment. *J Forensic Sci* 46:223-227.