

ORIGINAL PAPER

Age determination from radiological study of epiphysial appearance and union of distal end of tibia

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ABSTRACT

Introduction: The bones of human skeletons develop from separate ossification centers. From these centers ossification progresses till the bone is completely formed. These changes can be studied by means of X-rays and these changes are age related. It is therefore possible to determine the approximate age of an individual by radiological examination of bones till ossification is complete. **Methods:** This roentgenographic study was carried out with the objective to assess the general skeletal maturity of distal end of Tibia, of subjects in Mumbai region. 208 males and 68 females between age group of 3-25 years attending the outpatient department of this hospital are selected. Age confirmed from history and noting the birth dates. The cases selected after ruling out the nutritional, developmental, and endocrinal abnormality which affects the skeletal growth. Data analysis was done in P4 computer using HPSS software. **Result:** In Present study Distal end of Tibia, the complete union of epiphysis is seen by 16-18 years in males(16%) and 14 -16 years in females(18.4%). **Conclusion:** At the end conclusions were drawn which are compared with available results of various previous studies.

Keywords: X-Ray, ossification centre, epiphysial cartilage

INTRODUCTION

To establish exact identity of an individual age determination is essential not only in cases of living but also for the dead too. Age has to be determined not only for identification purpose but also for various civil and criminal purposes.¹ The determination of age presents a task of considerable importance from the viewpoint of the administration of justice. It is not possible to enunciate a hard and fast rule for age determination from this union for the whole India because India is composed of areas which differ in climatic, dietetic and disease factors which affect skeletal growth. Determination of the age of an individual from the appearance and the fusion of the ossification centers is a well accepted fact in the field of medical and legal professions.²

The present study was carried out to study roentgenographically the epiphysial union of Distal end of Tibia in subjects between age group of 3 to 25 years in males and 3 to 23 years in females attending outpatient department of this hospital. Until the teenage years, the diaphyses of the long bones are separated from their epiphyses on both the ends. There are hundreds of ossification centers in the bones of the body. The appearance and fusion of some centers in the bones with others of the same bones form the basis of estimation of age. The long bones of lower limb play a vital role in assessment of age both in living and dry remains. A wide range of work has been carried out on the estimation of age by this method in various provinces of India as well as foreign country and from that it is clear that there is remarkable variation amongst the data not only in India but also abroad owing to disparities in climatic conditions and socioeconomic status.

Objectives

- To assess the skeletal maturity of distal end of tibia for a known chronological age in subjects of Mumbai region.
- To comparative study of fusion of distal end of Tibia with known standards.
- To evaluate sex related variation and its correlation with age.
- To know variation if any and exception of fusion of distal end of Tibia.
- To evaluate the medico legal aspects of different ages.
- To suggest any additional radiological investigation to aid and to reduce range in determining age.

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METHODS

The study was carried out in Grant Medical College and Sir JJ Hospital in Mumbai which is a tertiary referral centre attached to Government Medical College. 208 males and 68 females between age group of 3-25 years attending the outpatient department of this hospital are selected. Age confirmed from history and noting the birth dates. The cases selected after ruling out the nutritional, developmental, and endocrinal abnormality which affects the skeletal growth. X-ray of Distal end of Tibia is taken at department of radio diagnosis. The epiphyses of distal end of Tibia were observed appearance (A) and nonappearance (NA) and different phases of fusion were graded according to Dr. William Sangma² and Mckern and Stewart³ 5 stages as follows:

Stage 1 (F1): Non union – when the epiphysal cartilage did not begin to decrease in thickness.

Stage 2 (F2): Commence of union – when the thickness of

Skeletal maturity was evaluated radiologically studying Greater Trochanter ossification and the results were compared with the previous known standard studies. Only last two stages of fusion cases were taken in this paper, remaining cases were in early stages of fusion.

RESULTS

Fusion of distal end of Tibia in males: It is clear from **Table 1** that in male subjects in between age group 3 to 12 years cases were seen in F1, F2, and F3 stage of fusion. In between 12-13 years age group 5(10.2%)cases were in F2 stage of fusion and 18.5% cases were in F3 stage of fusion. In 13 to 14 years age group 4.1% cases were in F2 stage of fusion and 25.9% cases were in F3 stage of fusion. In majority of cases in age group 14-15(35%), 15-16(50%) and 16-17(15%) show near fusion (F4), where as in age groups 16-17(3.2%) and 17-18 (12.2%) onwards majority of cases showed complete fusion (F5).

Table 1 Incidence and extent of fusion of Distal end of Tibiain different age groups in males

Extent of Appearance & fusion	3-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-25	Total
	Cases (%)	Cases (%)	Cases (%)	Cases (%)	Cases (%)	Cases (%)	Cases (%)	Cases (%)	Cases (%)	Cases (%)	Cases (%)	Cases (%)
F1	18 (100)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	18 (100)
F2	41 (83.6)	5 (10.2)	2 (4.1)	1 (2.0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	49 (100)
F3	10 (37.0)	5 (18.5)	7 (25.9)	5 (18.5)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	27 (100)
F4	0 (0)	0 (0)	0 (0)	7 (35.0)	10 (50.0)	3 (15.0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	20 (100)
F5	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	3 (3.2)	12 (12.8)	26 (27.5)	11 (11.7)	15 (16.0)	27 (28.7)	94 (100)

epiphysal cartilage was found to be reduced appreciably (1/4th united)

Stage 3 (F3): Incomplete union – when the epiphysis has begun to fuse with shaft and complete union was well underway (1/2 united)

Stage 4 (F4): Complete union – when the epiphysal cartilage was bony in architecture and its density indistinguishable from the epiphysis and diaphysis in its neighbourhood but an epiphysal line called epiphysal scar could still be distinguished (3/4 united)

Stage 5 (F5): Complete union – with absence of epiphysal scar.

Fusion of Distal end of Tibiain Females: It is clear from **Table 2** that in Female subjects in between age group 3 to 11 years cases were seen in F1, F2 and F3 stage of fusion. In between 11-12 years age group 50% cases were in F3 stage of fusion. In between 12-13 years age group 33.3% cases were in F3 stage of fusion. In majority of cases in age group 13-14(75%) and 14-15 (25%) show near fusion (F4), where as in age groups 14-15(7.9%), 15-16(10.4%) and onwards majority of cases showed complete fusion (F5).

DISCUSSION

It is clear from the results that in this study distal end of Tibia, the complete union of epiphysis is seen by 16-18 years in males and 14-16 years in females. Finding of fusion of Distal end of

Table 2 Incidence and extent of fusion Distal end of Tibiain different age groups in females

Extent of appearance & fusion	3-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-23	Total
	Cases (%)	Cases (%)	Cases (%)	Cases (%)	Cases (%)	Cases (%)	Cases (%)	Cases (%)	Cases (%)	Cases (%)	Cases (%)	Cases (%)
F1	10 (100)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	10 (100)
F2	10 (100)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	10 (100)
F3	1 (16.7)	3 (50.0)	2 (33.3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	6 (100)
F4	0 (0)	0 (0)	0 (0)	3 (75.0)	1 (25.0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	6 (100)
F5	0 (0)	0 (0)	0 (0)	0 (0)	3 (7.9)	4 (10.5)	5 (13.2)	4 (10.5)	6 (15.8)	3 (7.9)	13 (34.2)	38 (100)

Table 3 Comparison of time of fusion of Distal end of Tibia in years

Author	Year	Race	Sex		
			Males (Yrs)	Females(Yrs)	Mixed (Yrs)
Galstaun	1937	Bengalis (Indians)	16	14-14.4	-----
Pillai	1936	Madrasi	-----	-----	14 - 17
Flecker	1932	Australia	17	14	-----
Davies & parson	1927	English	-----	-----	17 -18
Hepworth	1929	Panjab	-----	-----	16.5 -17.5
Parikh	1990	Indian	-----	-----	16-18
Basu&basu bengali females	1957	Bengali hindu females	-----	14	-----
Present study	2010	Mumbai (indian)	16-18	14-16	-----

Tibia in present study correlates with Gaulstaun study in Bengalies,⁴ Pillai study in Madrasis,¹ Fleckers study in Australians,⁵ Hepworths study⁶ in Punjabis in males and Basu and Basu's⁷ study in Bengali Hindu females. The only documented study done previously in Mumbai region was by Homi S Mehta⁸ in Mumbai region, which does not include this center. As compare to Devis and Parsan study¹ in Australians and Hepworth study⁶ in Punjabis fusion occur one year earlier in females.

The variation in time of fusion of different bones of lower limb has been established long back. Countable differences are noticed in the appearance and fusion activities of ossification centers depending on race geographic distribution and sex. The process of ossification may also be influenced by food habit, nutritional status, infectious disease, hormonal and metabolic disorders and physical activity. The long bones of lower limb play a vital role in assessment of age both in living and dry remains. Currently there is an obvious lack of standards for epiphyseal union for the purposes of assignment of chronological age.

While most researchers determine union visually, some scholars advocate the use of radiographs to determine the degree of union. While selecting the patients following criteria are to be kept in consideration.

- i. They are born to parents living in that particular region and subject is living in the same region since birth.
- ii. They have authentic documentation of their date of birth.
- iii. The subjects should not have any bony deformity or pathology and should not have any known chronic disease affecting the general health of person.
- iv. Subjects from all strata of society are included.

Similar care should be taken regarding centering of the X-ray tube over the epiphyses as it is quite easy to give an un-united epiphysis the appearance of union by directing the cone of X ray obliquely. The observations thus made by different authors for lower end of tibia are shown in Table III.

In this study distal end of Tibia, the complete union of epiphysis is seen by 16-18 years in males and 14-16 years in females. The present study signifies that all centres in females mature 1-2 years earlier than in Males. This observations correlates with

the previous studies done. Comparison of observations of present study has been made with other studies in table-3 with reference to age of fusion in both sexes.

CONCLUSION

Such type of work has been carried out by different researchers from time to time. Most of them have shown regional as well as sexual variations in time of occurrence of epiphysis of bones of lower limb. Apart from consideration of centers of ossification by Dr. Homi S Mehta for population of Mumbai region additional center of ossification have been studied in this study which will be helpful to arrive at correct diagnosis with closer range. Distal end of Tibia, the complete union of epiphysis is seen by 16-18 years in males (16%) and 14-16 years in females (18.4%). The present study findings are close to Galstaun, Pillai, Flecker, Hepworth, Basu and Basu and Parikh.

As this study is done in Mumbai region the application of standards can be considered ideal for application in Mumbai region. Due to very narrow borderline range of differentiation between various stages of fusion (i.e. Stage 1 to Stage 5), it is difficult to consider stage of fusion as age indicator.

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