

Age estimation by radiological assessment of proximal tibial epiphysis

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Abstract: *Introduction:* The age estimation of living individual is of critical importance in forensic practice, there is no statistical data to establish variation in epiphyseal fusion in population of central India. This significant oversight can lead to exclusion of persons of interest in a forensic investigation. *Methodology:* Epiphyseal fusion of proximal end of Tibia in 150 individuals was analyzed on radiological basis to assess the range of variation of epiphyseal fusion at each age. In the study the X ray films of the subjects were divided into three groups on the basis of degree of fusion. Firstly, those which were showing No Epiphyseal Fusion (N), secondly those showing Partial Union (PC), and thirdly those showing Complete Fusion (C). *Result:* Observations made were compared with the previous radiological studies. The process of ossification was completed remarkably faster in females than males. The ossification at proximal end of Tibia at the Knee joint in males and Females is completed in all instances (100%) at the age groups of 18-20 years and 16-20 year respectively. From this study; range of 1-2 years of margin of error can be concluded. *Conclusion:* By comparing the available literature about ossification of long bones, fusion was delayed one to three years in this study with population of Central India than those parts of south India and population of Bengal. By comparing the available literature the age of skeletal maturity in both males and females in this region are nearly similar to those in population of Madhya Pradesh, Uttar Pradesh Rajasthan and Karnataka

Keywords: Epiphyseal Union, Knee Joint, Tibia, Age estimation.

Introduction

Epiphysis of the bones unites during age periods which are remarkably constant for a particular epiphysis [1]. Epiphysis of the bones unites at the particular age and this is helpful in age determination. In law the crime and punishment is entirely based on criminal responsibility and this in turn depend on the age of a person. [2]. Age is helpful in identification of an individual which in turn is helpful in both civil and criminal cases [3]. It has been also stated that the study of epiphyseal union of bones is considered a reasonable scientific and accepted method for age determination by the law courts all over the world [4]. India is a vast country with diversity in social customs, multiple religions, dietary habits and variations in climatic conditions.

In Modi's textbook [5] it is quoted that owing to variation in climatic, dietetic, hereditary and other factors affecting the people of the different states

of India, it cannot be reasonably expected to formulate a uniform standard for the determination of the age of the union of epiphyses for the whole of India. Human growth is continuous process which goes through, first a developmental stage and second, the maintenance of status. In the developmental stage, changes in skeletal and dental morphology occur in an age-age predictive sequence [6].

Reddy KSN stated that the bones of human skeleton develop from a number of ossification centers. At 11-12th week of intrauterine life, there are 806 centers of ossification, at birth there are about 450. The adult human skeleton carries only 206 bones [7]. It has been approved by research that the epiphysio-diaphysial union in Indian occurs about a year or two in advance than the Europeans [8]. Jit and Balbir Singh revealed that Precocity of epiphyseal union has been

attributed to racial and climatic factors [9]. Works in different regions of India-North (Punjab, Delhi and UP), East (Bengal) and South (Chennai) have given different ages of fusion of the epiphysis. Further, workers in the same region have also given different ages of fusion of the epiphysis of the same bone and in the same sex. This difference could possibly be due to inadequate material or recording of incorrect ages of the subjects [10]. It was, therefore, decided to reinvestigate in the central part of India by radiological examination, taking care that adequate material was examined and only those subjects investigated whose ages have been recorded with reasonable degree of accuracy.

Aims and Objectives:

1. To estimate age from epiphyseal fusion in proximal end of Tibia.
2. To assess age specific difference in epiphyseal fusion at proximal end of Tibia.
3. To compare bisexual difference in epiphyseal fusion at proximal end of Tibia.
4. To assess and evaluate the difference in the epiphyseal fusion at proximal end of Tibia in Central part of the India with other part of India on the basis of previous studies.

Material and Methods

The present study was carried out in Department of Forensic Medicine MGIMS Sevagram Wardha. A total of 150 male and females participated in this study. The subjects included students of schools, College from district. Approval from ethical committee and informed consent was taken from all subjects prior to each investigation. The subjects were from 13-20 years of age group. They are born to parents living in Central India and have lived since birth. The subjects do not have any disease/deformity pertaining to bones or chronic disease affecting the general health.

Radiological examination: The X-ray films were taken and films were developed with the help of experienced technicians. The part taken for X ray was Knee for proximal end of Tibia. Skeletal maturity was evaluated according to the Jits and Kulkarnis classification [10]. For the study the X-ray films were divided into three groups for each epiphysis:

1. Those showing No epiphyseal union (NF)

2. Those showing partial union (PF)
3. Those showing complete union (CF)

Nonfusion: X-Rays showing clear gap between the epiphyseal and diaphyseal end. The saw tooth like appearance have been put into this group of fusion abbreviated as “NF”

Partial Fusion: X-Rays showing a line replacing the hiatus between the epiphyseal and diaphyseal ends and not showing saw tooth like appearance have been put into this group of partial fusion abbreviated as “PF”.

Complete Fusion: X-Rays showing the same bony architecture in the diaphysis and epiphysis and showing scar of the previous stage have been treated as complete fusion and abbreviated as “CF”.

Results

Proximal end of Tibia: Proximal end of Tibia in males shows partial fusion in 12(14.63%) cases in 14-15 year of age group. 9(10.98%) cases in 15-16years of age group. 8(9.76%) and 2(2.44 %) cases in 16-17 years and 17-18years of age groups respectively.

Similarly it Show complete fusion in 1(1.22%), 8(9.76%) and 12(14.63 %) cases in age group of 15-16years, 16-17years and 17-18 years respectively. As the person grows and matures it shows complete fusion in all 22(26.83%) cases between 18-20 years of age group.

Proximal end of Tibia in females shows partial fusion in 1(1.47%) and 2(2.94%) cases in 14-15years and 15-16years of age group respectively. It shows complete fusion in 7(10.29%) and 10(14.71%) cases in 14-15years and 15-16years of age group respectively. It shows complete fusion in all 42(61.77%) cases between 16-20 years of age group.

Discussion

The proximal end of Tibia: Out of 150 subjects 82 males and 68 females from age group 13-20 years, were studied radiologically for epiphyseal fusion of proximal end of Tibia (Table No.1).

Table-1: Age and Gender Wise Distribution of Subjects

Age (yrs)	Males		Females	
	Case	(%)	Case	(%)
13-14	8	9.76	6	8.82
14-15	12	14.63	8	11.76
15-16	10	12.20	12	17.65
16-17	16	19.51	10	14.71
17-18	14	17.07	14	20.59
18-19	10	12.20	8	11.76
19-20	12	14.63	10	14.71
Total	82	100.00	68	100.00

In the age group 13-14 years males shows non fusion in 8(9.76%) cases. In 14-15years of age group partial fusion was seen in 12(14.63%) cases. In 15-16 years of age group partial fusion was seen in 9(10.98%) cases and complete fusion was seen in 1(1.22%) case (Figure No.1).

Fig-1: Lateral & AP View of Knee Joint Showing Partial Fusion Proximal end of Tibia



Similarly 16-17years and 17-18 years age group shows complete fusion in 8(9.76%) and 12(14.63%) cases respectively. The proximal end of Tibia shows complete fusion in all 22(26.83%) cases between 18-20 years of age group (Table no. 2).

Table-2: Proximal end of Tibia Fusion in Males

Age (yrs)	Not Fused (%)	Partial Fusion (%)	Complete Fusion (%)	Total
13-14	8(9.76%)	0(0.00%)	0(0.00%)	8(9.76%)
14-15	0(0.00%)	12(14.63%)	0(0.00%)	12(14.63%)
15-16	0(0.00%)	9(10.98%)	1(1.22%)	10(12.20%)
16-17	0(0.00%)	8(9.76%)	8(9.76%)	16(19.51%)
17-18	0(0.00%)	2(2.44%)	12(14.63%)	14(17.07%)
18-19	0(0.00%)	0(0.00%)	10(12.20%)	10(12.20%)
19-20	0(0.00%)	0(0.00%)	12(14.63%)	12(14.63%)
Total	8(9.76%)	31(37.80%)	43(52.44%)	82(100%)
χ ² -value	133.89			
p-value	0.000, S,p<0.05			

Note: - Figures in parenthesis indicates percentage

The observations of present study matches with work of Das Gupta et al (1974) [11] and Narain and Bajaj (1957) [12] on population of Uttar Pradesh, Saxena and Vyas (1969) [13] in the population of Madhya Pradesh and Flecker (1932) [14] in Australians, Connor JE, Bogue C (2008) [15] in the Irish population, Paterson (1929) [16] in the population of England. Also the observations of present study, matches with observations by Davies and parson (1927) [17] in the population of England, Stevenson (1924) [18] study in the population of US; Schaefer & Black

(2005) [19] in the population of Bosnia, Bokaria et al (2009) [20] in the population of Rajasthan and Kausar, Varghese (2011) [21] in the population of Karnataka.

Study of Pillai (1936) [22] in the population of Madras, Galstaun (1937) [23] in the population of Bengali (India), does not match with the observation of present study, rather their observations shows early fusion by about 1-3 years in proximal end of Tibia. The proximal end of tibia in females in the age

group of 13-14years shows non fusion in 6(8.82%) cases. In the age group of 14-15years 1(1.47%)case shows partial and 7(10.29%) cases shows complete fusion in the age group of 15-16years 2(2.94%)cases shows partial fusion and

10(14.71%) cases shows complete fusion. The proximal end of Tibia shows complete fusion in all 42(61.77%) cases between 16-20 years of age groups (Table No. 3).

Table-3: Proximal end of Tibia Fusion in Females

Age(yrs)	Not Fused (%)	Partial Fusion (%)	Complete Fusion (%)	Total
13-14	6(8.82%)	0(0.00%)	0(0.00%)	6(8.82%)
14-15	0(0.00%)	1(1.47%)	7(10.29%)	8(11.76%)
15-16	0(0.00%)	2(2.94%)	10(14.71%)	12(17.65%)
16-17	0(0.00%)	0(0.00%)	10(14.71%)	10(14.71%)
17-18	0(0.00%)	0(0.00%)	14(20.59%)	14(20.59%)
18-19	0(0.00%)	0(0.00%)	8(11.76%)	8(11.76%)
19-20	0(0.00%)	0(0.00%)	10(14.71%)	10(14.71%)
Total	6(8.82%)	3(4.41%)	59(86.76%)	68(100%)
χ ² -value	75.46			
p-value	0.000, S,p<0.05			

Note: - Figures in parenthesis indicates percentage

Table-4: Comparison of Age of Fusion in Proximal end of Tibia

S.N.	Researcher	Region	Age of fusion	
			Male	Female
1	Stevenson (1924) [18]	United States	19	19
2	Davies and Parson (1927) [17]	England	19-20	19-20
3	Hepworth (1929) [24]	Punjabi(India)	16½-17 ½	16½-17 ½
4	Paterson (1929) [16]	UK	18-19	16
5	Flecker (1932) [14]	Australians	18	-
6	Pillai (1936) [22]	Madrasis	14-17	14-17
7	Galstaun (1937) [23]	Bengalis	15-17	14-15
8	Basu and Basu (1938) [25]	Hindu(Bengal)	15-16	15-16
9	Narain and Bajaj(1957) [12]	Uttar Pradesh	18-19	18-19
10	Saxena and Vyas (1969) [13]	Madhya Pradesh	18-19	16-17
11	Das Gupta et al (1974) [11]	Uttar Pradesh	18-19	17-18
12	Schaefer & Black (2005) [19]	Bosnian	17-20	-
13	Connor JE, Bogue C (2008) [15]	Irish	18-18.9	17-17.9
14	Bokariya et al (2009) [20]	Rajasthan	17-18	14-15
15	Kausar and Varghese (2011) [21]	Karnataka	17 ½ -18	16-16 ½
16	Present study	Central India	18-19	16-17

The present study matches with Saxena and Vyas (1969) in the population of Madhya Pradesh, Paterson (1929) in the subjects of England, Kausar Varghese (2011) study in the population

of Karnataka. Observation of present study also matches with Hepworth's(1929) [24] study in the Punjabi population, Das Gupta et al (1974) in the population of Uttar Pradesh

and Connor JE, Bogue C (2008) in the Irish population. Study of Pillai (1936) in the population of Madras, Galstaun (1937) and Basu and Basu (1938) [25] in the population of Bengal in India, does not match with the observation of present study, rather their observations shows early fusion by about 1-2 years in proximal end of Tibia (Table No.4).

Conclusions

This study was conducted exclusively on the young indigenous population of Central India keeping in mind that very less literature about the age estimation from ossification of Proximal end of Tibia is available involving this particular region of India. The ossification of proximal end tibia in Males and Females is completed in all instances (100%) at the age groups of 18-20 years and 16-20 year respectively. The process of ossification was completed remarkably faster in females than males which correspond with the available literature.

By comparing the available literature about ossification of long bones, fusion was delayed one to three years in this study with population of Central India than those parts of south India and population of Bengal. By comparing the available literature the age of skeletal maturity in both males and females in this region are nearly similar to those in population of Madhya Pradesh, Uttar Pradesh Rajasthan and Karnataka. The opinion about age should always be given in the range. From this study, range of 1-2 years of margin of error can be concluded.

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