Original Research Paper

A Radiological Study of Age Estimation from Epiphyseal Fusion of Distal End of Femur in the Central India Population

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Abstract

There is no statistical data to establish variation in epiphyseal fusion in population in population of central India. This significant oversight can lead to exclusion of persons of interest in a forensic investigation. Epiphyseal fusion of the distal femur 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). Observations made were compared with the previous radiological studies.The ossification at distal end of femur 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.

Key Words: Epiphyseal Union, Knee Joint, Distal end of femur

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.

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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 in adequate material or recording of incorrect ages of the subjects. [10]

It was, therefore, decided to reinvestigate the problem in the central part of India by radiological examination, taking care that adequate material was examined and only those subjects investigated whose ages has been recorded with reasonable degree of accuracy.

Aims and Objectives:

1. To estimate age from epiphyseal fusion in distal end of femur at knee joint.
2. To asses age specific difference in epiphyseal fusion at distal end of femur.
3. To compare bisexual difference in epiphyseal fusion at distal femur.
4. To assess and evaluate the difference in the epiphyseal fusion at distal end of femur 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. 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 distal end of Femur.

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)**

Observationand Result:

In this study Males showed partial fusion in 12(14.63%) in 14-15 years of age group. 8(9.76%) in 15-16 years age group. 10(12.20%) cases and 2(2.44%) cases in 16-17 years and 17-18years of age group respectively at distal end of Femur. (Table 2)

While distal end of Femur in males was completely fused in 2(2.4%) cases in 15-16years, 6(7.32%) cases showed complete fusion in 16-17 years and 12(14.63%) cases seen in 17-18 years of age group. In 22(26.83%) cases complete fusion was seen in age group of 18-20 years. (Table 2)

Females showed partial fusion in 1(1.47%), 4(5.88%), 5(7.35%) cases in 13-14 years, 14-15years and 15-16years respectively. There was exception in 18-19 years of age group where only one case Showed partial fusion in our study. (Table 3)

Present study showed complete fusion of distal end of Femur in females in 4(5.88%) and 7(10.29%) cases in 14-15 years and 15-16 years of age group respectively. It was completely fused in all 41(60.30 %) cases between 16-20 years of age group. (Table 3))

Discussion:

Out of 150 subjects 82 males and 68 females from age group of 13-20 years, were studied for epiphyseal fusion of distal end of Femur and examine radiologically in this study. (Table 1) The distal end femur in males shows complete fusion in all 22(26.83%) cases in 18-20 years of age group. (Table 4)

The observation of present study was consistent with study of Saxena and Vyas [21] who conducted their work on population of Madhya Pradesh, Narain and Bajaj [19] and Das Gupta et al [21] study on the population of Uttar Pradesh along with Bokaria et al study in the population of Rajasthan [14] and Kausar and Varghese [23] study in the population of Karnataka.

The higher limit in present study also coincides with work of Flecker in the Australian [13], Davies and Parson [11] in the population of England, Stevenson in the population of United State and Paterson [24], in the population of UK.

It was also observed that Study done by Hepworth in the population of Punjab [12], Pillai [18] in the population of Madras and Galstaun in the population of Bengali in India [16], did not match with the observation of present study, rather their observations showed early fusion by about 1-2 years in distal end of Femur.

Distal end of Femur in female showed complete fusion in 41(60.30%) cases between 16-20 years of age groups, except in 18-19 years of age group where 1(1.47%) case showed partial fusion.

The observations of this study are in accordance with Das Gupta et al [21] study in the population of Uttar Pradesh, Basu and Basu's observations among Hindu population [15], finding of Bokariya et al [14] in the population of Rajasthan, Kausar and Varghese [23] who conduct study in the population of Karnataka, Paterson [17] in the population of UK. The finding of present study also coincides with study of Flecker. [13]

Summary and Conclusions:

The ossification at distal end of femur 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. 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.

Age of skeletal maturity in both males and females in this region are nearly similar to those of Madhya Pradesh, Uttar Pradesh and Rajasthan. As this study is done in Central India region the application of standards of this study may be considered ideal for application in the region of Central India.

Population in Central India is mixed type comprising of various religions and castes. 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. For estimation of age relevant joints should be radiologically examined for different centres and opinion should be arrived considering the status of multiple centers.

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Fig. 1: Lateral & AP View of Knee Joint Showing Partial Fusion Distal End of Femur

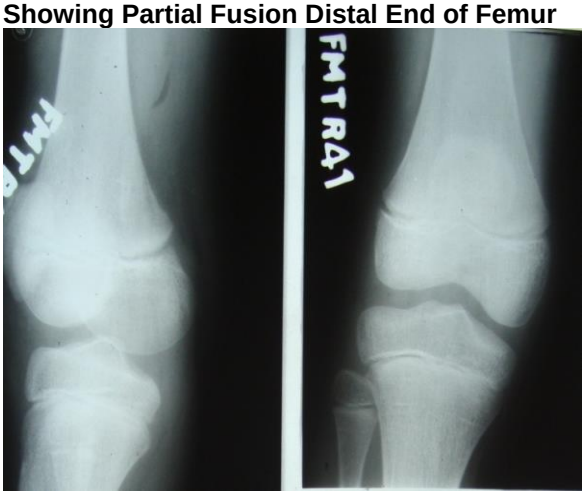

Table 1: Age and Gender Wise Distribution

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

Table 2
Distal End of Femur 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)	8(9.76)	2(2.44)	10(12.20)
16-17	0(0.00)	10(12.20)	6(7.32)	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)	32(39.02)	42(51.21)	82(100)
ϰ2-value	132.10			
p-value	0.000, S,p<0.05			

Note: - Figures in parenthesis indicates percentage

Table 3
Distal End of Femur Fusion in Females

Age(yrs)	Not Fused (%)	Partial Fusion(%)	Complete Fusion (%)	Total
13-14	5(7.35)	1(1.47)	0(0.00)	6(8.82)
14-15	0(0.00)	4(5.88)	4(5.88)	8(11.76)
15-16	0(0.00)	5(7.35)	7(10.29)	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)	1(1.47)	7(10.29)	8(11.76)
19-20	0(0.00)	0(0.00)	10(14.71)	10(14.71)
Total	5(7.35)	11(16.18)	52(76.47)	68(100)
ϰ2-value	76.14			
p-value	0.000, S,p<0.05			

Note: - Figures in parenthesis indicates percentage

Table 4
Comparison of Age of Fusion in Distal Epiphyseal End of Femur

S.N.	Researcher	Region	Age of fusion	
			Male	Female
1	Stevenson (1924) [24]	USA	19	19
2	Davies and Parson (1927) [11]	England	19	19
3	Hepworth (1929) [12]	Punjabi	16½-17 ½	16 ½-17 ½
4	Paterson (1929) [17]	UK	18	16-17
5	Todd (1930) [25]	USA	17½-18½	17½-18½
6	Flecker (1932) [13]	Australians	19	17
7	Pillai (1936) [18]	Madrasis	14-17	14-17
8	Galstaun (1937) [16]	Bengalis	14-17	14-17
9	Basu and Basu (1938) [15]	Hindu(Bengal)	-	16
10	Narain and Bajaj (1957) [19]	Uttar Pradesh	18-19	18-19
11	Saxena and Vyas (1969) [20]	Madhya Pradesh	18-19	18-19
12	Das Gupta et al (1974) [21]	Uttar Pradesh	18-19	16-17
13	Schaefer and black(2005) [22]	Bosnian	17-20	-
14	Connor JE, Bogue C(2008) [26]	Irish	17-17.9	17-17.9
15	Bokariya et al (2009) [14]	Rajasthan	18-19	16-17
16	Kausar and Varghese (2011) [23]	Karnataka	18-18 ½	16-16 ½
17	**Present Study (2013)**	**Central India**	**18-19**	**16-17**