Original Research Paper

Age Determination from of Ossification Center Fusion around Knee Joint in Mumbai Region: A Radiological Study

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Abstract

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. This radiological study was carried out with the objective to assess the general skeletal maturity around knee joint, of subjects in Mumbai region. 170 males between age group of 3-25 years and 66 females between age group of 3-23 years attending the outpatient department of this hospital were selected. Age confirmed from history and noting the birth dates from driving license, passport, rations card or voter's card. The cases were 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. At the end conclusions were drawn which are compared with available results of various previous studies.

Key Words: Epiphyseal Fusion, Ossification Centres, X-rays

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. The determination of age presents a task of considerable importance from the view-point 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.

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The present study was carried out to study roentgenographically the epiphysial appearance and union at the knee joint especially lower end of Femur, Upper end of Tibia and Fibula. This study was carried out in subjects between age group of 3 to 25 years attending outpatient department of this hospital.

Aims and Objectives:

- To assess the skeletal maturity Knee joint for a known chronological age in subjects of Mumbai region.
- Comparative study of appearance & fusion of ossification centers at Knee joint with known standards
- To evaluate sex related variation & its correlation with age.
- To know variation if any & exception of appearance & fusion of centers of ossification.
- To evaluate the medico legal aspects of different ages.
- To suggest any additional radiological investigation to aid and to reduce range in determining age.

Material and Methods:

The study was carried out in Grant Medical College and Sir J. J. Hospital in Mumbai which is a tertiary referral centre attached to Government Medical College with the objective to assess the general skeletal maturity of knee joint of subjects in Mumbai region.

Total 170 males and 66 females

between age group of 3-25 years attending the outpatient department of this hospital were selected. Age confirmed from history and noting the birth dates from driving license, passports ration card or voter's card. The cases selected after ruling out the nutritional, developmental, and endocrinal abnormality which affects the skeletal growth. X-ray of Knee joints were taken at Department of Radio-diagnosis. The epiphysis of Knee joints were observed for appearance (A) and non-appearance (NA) and different phases of fusion were graded according to William Sangma et al and Mckern and Stewart [13] into five stages as follows:

- **Stage 1(F1)Non-union:** when the epiphysial cartilage did not begin to decrease in thickness
- **Stage 2 (F2) Commence of union:** when the thickness of epiphysial cartilage was found to be reduced appreciably ($1/4^{th}$ 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 epiphysial cartilage was bony in architecture and its density indistinguishable from the epiphysis and diaphysis in its neighbourhood but an epiphysial line called epiphysial scar could still be distinguished. (3/4 united)
- **Stage 5 (F5) Complete union**: with absence of epiphysial scar.

Skeletal maturity was evaluated radiologically studying the various centres of ossification and the results were compared with the previous known standard studies.

For lower end of Femur and upper end of tibia only last two stage of fusion cases were taken in this paper as its ossification centres appears just before birth, remaining cases were in early stages of fusion And for upper end of Fibula both Appearance and last two stages of fusion were taken.

Observations and Results:

In our study regarding fusion of lower end of femur in males F1 stage of fusion was seen in 11 cases (100%) at 3-12 years age group. F2 stage of fusion was seen in 27 cases (87%) at 3-12 years age group, in 2 cases (6.5%) at 12-13 years and 13- 14 years age group respectively. (Table 1)

F3 stage of fusion was seen in 9 cases (34.6%) at 3-12 years age group, in one case (3.8%) at 12-13 years age group and in eight cases (30.8%) at 13–14 years age group, in 5 cases (19.3%) at14-15 years' age group and in three cases (11.5%) at 15 – 16 years age group.

F4 stage of fusion was seen in 6 cases (17.1%) at 15-16 years age group, in 10 cases (28.6%) at 16-17 years age group, in 16 cases (45.7%) at 17–18 years age group and in 3 cases (8.6%) at 18-19 years age group.

Complete fusion (F5) was seen in 18 cases (26.9%) at 18-19 years age group, in 7 cases (10.4%) at 19–20 years age group, in 15 cases (22.4%) at 20-21 years age group and in 27 cases (40.3%) at 21–25 years age group. (Table 1)

In present study various stages of fusion of lower end of femur in females were seen as F1 stage in seven cases (100%) at 3-11 years age group. F2 stage of fusion was seen in 11 cases (84.6%) at 3-11 years age group, in 1 case (7.7%) at 11-12 years and 12-13 years age group respectively.

F3 stage of fusion was seen in 3 cases (30%) at 3-11 years age group, in 2 cases (20%) at 11-12 years age group, in one case (10%) at 12–13 years & 14–15 years age group respectively and in three cases (30%) at 13–14 years age group. (Table 2)

F4 stage of fusion was seen in three cases (30%) at 14-15 years age group & 16-17 years age group respectively and in four cases (40%) at 15-16 years age group. Complete fusion (F5) was seen in 2 cases (7.7%) at 16-17 years age group, in four cases (15.4%) at 17–18 years age group, in 6 cases (23.1%) at 18–19 years age group, in three cases (11.5%) at 19–20 years age group and in 11 cases (42.3%) at 20 – 23 years age group. (Table 2)

Extent of appearance and fusion of upper end of tibia in males in our study is observed as F1 stage of fusion was seen in 12 cases (100%) at 3–12 years age group.

F2 stage of fusion was seen in 28 cases (90.3%) at 3-12 years age group, in two cases (6.5%) at 12-13 years and in one case (3.2%) 13–14 years age group. F3 stage of fusion was seen in seven cases (26.8%) at 3-12 years age group, in one case (3.8%) at 12–13 years age group and in nine cases (34.4%) at 13-14 years age group, in four cases (15.4%) at14-15 years' age group and in five cases (19.2%) at 15-16 years age group. (Table 3)

F4 stage of fusion was seen in one case (6.3%) at 14 -15 years age group, in five cases (31.3%) at 15–16 years age group, in eight cases (50%) at 16–17 years age group and in 12.5% cases at 17-18 years age group.

Complete fusion (F5) was seen in two cases (2.4%) at 16-17 years age group, in 14 cases (16.5%) at 17–18 years age group, in 20

cases (23.5%) at 18-19 years age group, in seven cases (8.2%) at 19-20 years age group, in 15 cases (17.6%) at 20-21 years age group and in 27 cases (31.8%) at 21-25 years age group. (Table 3)

In present study regarding fusion of upper end of Tibia in females subjects F1 stage of fusion was seen in nine cases (100%), F2 stage of fusion was seen in seven cases (100%) at 3-11 years age group. (Table 4) F3 stage of fusion was seen in five cases (41.7%) at 3-11 years age group, in three cases (25%) fusion occurred at 11–12 years age group, in one case (8.3%) at 12-13 years and in three cases (25%) at 13–14 years age group. (Table 4)

F4 stage of fusion was seen in one case (11.1%) at 12-13 years age group & 16-17 years age group respectively and in four cases (44.4%) at 14-15 years age group, in three cases (33.3%) at 15-16 years age group.

Complete fusion (F5) was seen in one cases (3.4%) at 15-16 years age group, in four cases (13.8%) at 16-17 years age group and 17-18 years age group respectively, in six cases (20.7%) at 18-19 years age group, in three cases (10.3%) at 19-20 years age group and in 11 cases (37.9%) at 20-23 years age group.

Discussion:

Distal end of Femur:

In present study males showed epiphyseal union at 18-19 years age group and earliest union occurred at 18 years. Females showed epiphyseal union at 16-17 years age group and earliest union occurred at 16 years. This observation of fusion of distal end of Femur is two year later in both males and females as that given in Galstaun study in Bengalis population. [5]

Proximal end of Tibia:

In present study males show epiphyseal union at 17-18 years age group and earliest union occurred at 16-17 years but after 17–18 years age group there is no F4 stage of fusion.

Females show epiphyseal union at 16-17 years age group and earliest union occurred at 15-16 years after 16-17 years there is no F4 stage of fusion. Our findings are close to Parikh, Homi S. Mehta study in Mumbai. Union in females was close to Hepworths study and in males' correlated with Narayan and Bajaj and Flecker work. [7, 8, 10, 12]

Conclusions:

In present study majority of cases show complete union for Lower end of Femur at 18-19 years for males and at 16–17 years for females. These findings are close to study carried out by Parikh, Homi S. Mehta and Narayan & Bajaj because all these studies are done in India and for Upper end of Tibia union was seen at 17 to 18 years for males and 16 to 17 years for females.

These findings are in tandem with study carried out by Homi S. Mehta, Parikh, Narayan & Bajaj because all these studies were done in India. From the present study it can be concluded, that fusion of epiphysis of Lower end of Femur occurs in most of the cases at 18 – 19 years for males and at 16 – 17 years for females and upper end of Tibia fuses at 17 - 18 years in males and 16 to 17 years in females.

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Fig. 1: Fusion Stage 1 (2Yr/F) &2 (5Yr/F) at Lower End of Femur and Upper End of Tibia

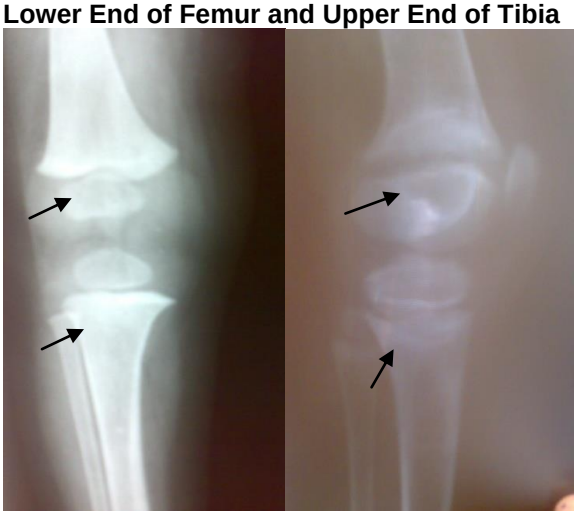

Fig. 2: Fusion Stage 3 (10Yr/F) & 4 (15Yr/F) at Lower End of Femur and Upper End of Tibia

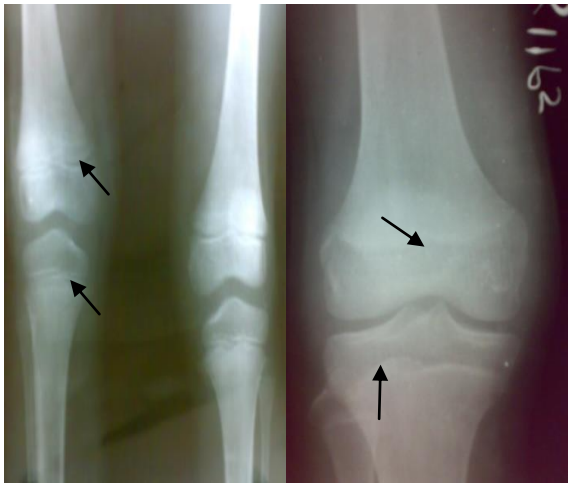

Fig. 3: Fusion Stage 5 (16Yr/F) at Lower End of Femur and Upper End of Tibia

Table 1
Incidence and Extent of Fusion of Lower End of Femur in Different Age Groups in Males

Extent of appearance & fusion	3-12 cases (%)	12-13 cases (%)	13-14 cases (%)	14-15 cases (%)	15-16 cases (%)	16-17 cases (%)	17-18 cases (%)	18-19 cases (%)	19-20 cases (%)	20-21 cases (%)	21-25 cases (%)	Total Cases (%)
NA	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
A	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
F1	11 (100)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	11(100)
F2	27 (87)	2 (6.5)	2 (6.5)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	31(100)
F3	9 (34.6)	1 (3.8)	8(30.8)	5(19.3)	3(11.5)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	26(100)
F4	0 (0)	0 (0)	0 (0)	0 (0)	6(17.1)	10(28.6)	16(45.7)	3 (8.6)	0 (0)	0 (0)	0 (0)	35(100)
F5	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	18(26.9)	7(10.4)	15(22.4)	27(40.3)	67(100)

Table 2
Incidence and Extent of Fusion of Lower End of Femur in Different Age Groups in Females

Extent of appearance & fusion	3-11 Cases (%)	11-12 Cases (%)	12-13 cases (%)	13-14 cases (%)	14-15 cases (%)	15-16 cases (%)	16-17 cases (%)	17-18 cases (%)	18-19 cases (%)	19-20 cases (%)	20-23 cases (%)	Total Cases (%)
NA	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
A	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
F1	7 (100)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	7(100)
F2	11(84.6)	1 (7.7)	1 (7.7)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	13(100)
F3	3 (30)	2 (20)	1 (10)	3 (30)	1 (10)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	10(100)
F4	0 (0)	0 (0)	0 (0)	0 (0)	3 (30)	4 (40)	3 (30)	0 (0)	0 (0)	0 (0)	0 (0)	10(100)
F5	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (7.7)	4(15.4)	6 (23.1)	3(11.5)	11(42.3)	26(100)

Table 3
Incidence and Extent of Fusion of Upper End of Tibia in Different Age Groups in Males

Extent of appearance & fusion	3-12 cases (%)	12-13 cases (%)	13-14 cases (%)	14-15 cases (%)	15-16 cases (%)	16-17 cases (%)	17-18 cases (%)	18-19 cases (%)	19-20 cases (%)	20-21 cases (%)	21-25 cases (%)	Total Cases (%)
NA	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
A	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
F1	12 (100)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	12 (100)
F2	28(90.3)	2 (6.5)	1 (3.2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	31 (100)
F3	7 (26.8)	1 (3.8)	9 (34.6)	4(15.4)	5(19.2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	26 (100)
F4	0 (0)	0 (0)	0 (0)	1 (6.3)	5(31.3)	8 (50)	2 (12.5)	0 (0)	0 (0)	0 (0)	0 (0)	16 (100)
F5	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2(2.4)	14(16.5)	20 (23.5)	7 (8.2)	15 (17.6)	27(31.8)	85 (100)

Table 4
Incidence and Extent of Fusion of Upper End of Tibia in Different Age Groups in Females

Extent of appearance & fusion	3-11 cases (%)	11-12 cases (%)	12-13 cases (%)	13-14 cases (%)	14-15 cases (%)	15-16 cases (%)	16-17 cases (%)	17-18 cases (%)	18-19 cases (%)	19-20 cases (%)	20-23 cases (%)	Total Cases (%)
NA	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
A	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
F1	9 (100)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	9 (100)
F2	7 (100)	0(0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	7 (100)
F3	5 (41.7)	3 (25)	1 (8.3)	3 (25)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	12 (100)
F4	0 (0)	0(0)	1 (11.1)	0(0)	4(44.4)	3(33.3)	1 (11.1)	0 (0)	0 (0)	0 (0)	0 (0)	9 (100)
F5	0 (0)	0(0)	0 (0)	0 (0)	0 (0)	1 (3.4)	4 (13.8)	4 (13.8)	6 (20.7)	3 (10.3)	11(37.9)	29 (100)

Table 5
Comparison of Time of Fusion (In Years)

Author	Year	Race	Sex					
			Males		Females		Mixed	
			Fusion of Lower end of Femur	Fusion of Upper end of Tibia	Fusion of Lower end of Femur	Fusion of Upper end of Tibia	Lower end of Femur	Upper end of Tibia
Galstaun	1937	Bengalis (Indians)	14 - 17	15 – 17	14 - 17	14 - 15		
Pillai	1936	Madrasis	……..	……	……	……	14 - 17	14 – 17
Flecker	1932	Australia	19	18	17	……		
Davies & Parson	1927	English					19	19 – 20
Hepworth	1929	Punjab					16.5 – 17.5	16.5 – 17.5
Homi S.Mehta	1963	Mumbai	18 - 19	17 – 18	16.5 - 17	15 – 15.5		
Parikh	1990	Indian					18 - 20	18 – 20
Narayan &Bajaj	1957	UP	…….	……..	……	…….	18 - 19	18 – 19
Present Study	2010	Mumbai (Indian)	18 - 19	17 – 18	16 - 17	16 - 17	…….	…….