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Title of article: **STUDY ON EPIPHYSEAL UNION AT THE KNEE JOINT AMONG THE ADOLESCENTS OF EASTERN ODISHA**

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ISSN: 0975-3583,0976-2833 VOL 16, ISSUE 5, 2025

Abstract

Age is in fact a decisive factor in various medico-legal matters including criminal procedures (assault, sexual offences, kidnapping) and civil matters (succession, marriage, employment). Age plays a vital role in determining the nature of the offence, the applicable laws, and the potential penalties. The age is a determining factor whether the child will be held criminally responsible or not. Fusion of epiphyses of bones is considered as one of the methods for age estimation. The present cross sectional descriptive study was carried out at a tertiary health care centre in coastal Odisha from September 2010 to August 2012. The epiphyseal union at the knee joint among 124 subjects (70 males and 54 females) among the adolescent population between 13 to 19 years have been studied radiologically to assess the skeletal maturity. Our study concluded that complete epiphyseal union of lower end of femur in case of males occurs at 15-17 years while in case of females it occurs at 14-17 years. The complete epiphyseal union of upper end of tibia in case of males occurs at 15-17 years while in case of females it occurs at 14 - 17 years. The complete epiphyseal union of upper end of fibula in both the sexes occurs at 15-18 years. The epiphyseal union around the knee joint occurs earlier in females than males among the adolescents. Findings of the radiological study of different stages of epiphyseal union of long bones are helpful in estimating the age of an individual.

Key Words: Radiological study, Epiphyseal union, Knee joint

ISSN: 0975-3583,0976-2833 VOL 16, ISSUE 5, 2025

Introduction

Determination of age is required in identification of an individual, forensic investigations, employment, marriage and while rendering justice. Age is one of the important and primary data of identification. Most of the times the chronological age of a person is debatable as documents in support of that particular age are not proper and sometimes manipulated. Physical, dental and radiological data are taken into consideration for determination of age of an individual. Both in civil and criminal cases age determination of persons are usually requested by the courts. Mostly, in children and adolescents, skeletal age and chronological age tally with each other[1]. Age determination from long bones may also be required in cases of skeletonized or partially skeletonized bodies where there are cephalo-facial injuries, mutilated bodies with dismemberments or crushing or defacing injuries.

The knee region forms a complex articulation between the bones of the leg and the thigh. Though these ages are fairly constant for a particular bone, there are great variations with racial, geographic, climatic & various other factors[2]. Bone maturation is determined by changes in the epiphyseal growth plates, which culminate in a line of fusion, and these changes are genetically determined and follow a chronology[3]. These changes can be visualized using imaging technique like X-ray and data extracted from the images of different stages of skeletal maturity can be used to determine the age of a bone. It is evident that there is significant difference in the age of epiphyseal union in different populations even within a country[4]. Union of epiphysis with diaphysis depends on nutritional status, climatic conditions, hormonal influence, genetic factors, physical activity etc. Determination of the age of an individual from the appearance and the fusion of the ossification centres is a well-established and accepted method in medico legal cases.

Many authors have been done research on the estimation of age by this method in various parts of India and abroad and it has become evident that data are different not only in different parts of India but also abroad due to multiple factors as already stated.

ISSN: 0975-3583,0976-2833 VOL 16, ISSUE 5, 2025

Materials and methods

The present cross sectional descriptive study study was carried out in the department of Forensic Medicine and Toxicology of a tertiary care centre in coastal Odisha from September 2010 to August 2012. A total of 124 subjects (70 males and 54 females) between the age group 13 to 19 years coming to department for medicolegal examination and age estimation purposes were selected for this study. Age was confirmed from history and other documents suggesting date of birth. Subjects showing evidence of nutritional and vitamin deficiency and endocrine disorder, congenital abnormalities, hereditary diseases and cases with trauma to the knee joint showing gross physical deformity have been eliminated from the study. Radiological examination of knee joints were done and different stages of epiphyseal union were studied.

Criteria for union

The different phases of epiphyseal union will be graded into five stages according to McKern and Stewart (1957)

(i) **Non-union:** When the epiphyseal cartilage does not begin to decrease in thickness (0 degree union)

(ii) **Beginning union:** When the thickness of the epiphyseal cartilages is reduced (1st degree union)

(iii) **Incomplete union** (Active union): When the epiphyses begin to fuse with the shaft (2nd degree union)

(iv) **Recent union:** When the epiphyseal cartilage is bony in architecture and its density indistinguishable from the epiphyses and diaphysis in its neighbourhood, but the epiphyseal scar is still distinguished (3rd degree union)

(v) **Complete union** with absence of epiphyseal scar (4th degree union).

ISSN: 0975-3583,0976-2833 VOL 16, ISSUE 5, 2025

Results:

TABLE 1: Stages of epiphyseal union of lower end of femur in males and females

Age group	Number of cases	Stages of epiphyseal union										
		Male					Female					
		0	1	2	3	4	Number of cases	0	1	2	3	4
13-14	2	1 50%	1 50%	0	0	0	5	0	1 20%	4 80%	0	0
14-15	9	0	1 11.2%	4 44.4%	4 44.4%	0	13	0	0	2 15.4%	1 7.7%	10 76.9%
15-16	12	0	0	0	8 66.7%	4 33.3%	14	0	0	0	5 35.7%	9 64.3%
16-17	14	0	0	0	0	14 100%	10	0	0	0	0	10 100%
17-18	17	0	0	0	0	17 100%	7	0	0	0	0	7 100%
18-19	16	0	0	0	0	16 100%	5	0	0	0	0	5 100%

Stage-1 epiphyseal union of lower end of femur was observed at 13-14 years of age in 50 % and 20 % of cases among males and females respectively. Stage-4 epiphyseal union of lower end of femur was observed in all cases among both males and females in the age group 16-17 years. (**Table 1**).

ISSN: 0975-3583,0976-2833 VOL 16, ISSUE 5, 2025

TABLE 2: Stages of epiphyseal union of upper end of tibia in males and females

Age group	Number of cases	Stages of epiphyseal union										
		Male					Female					
		0	**1**	**2**	**3**	**4**	**Number of cases**	**0**	**1**	**2**	**3**	**4**
13-14	2	1 50%	1 50%	0	0	0	5	0	2 40%	3 60%	0	0
14-15	9	**0**	1 11.1%	**0**	8 88.9%	**0**	13	0	0	1 7.7%	0	12 92.3%
15-16	12	0	0	0	4 33.3%	8 66.7%	14	0	0	0	7 50 %	7 50%
16-17	14	0	0	0	0	14 100%	10	0	0	0	0	10 100%
17-18	17	0	0	0	0	17 100%	7	0	0	0	0	7 100%
18-19	16	0	0	0	0	16 100%	5	0	0	0	0	5 100%

Stage-1 epiphyseal union of upper end of tibia was observed at 13-14 years of age in 50 % and 40 % of cases among males and females respectively. Stage-4 epiphyseal union of upper end of tibia was observed in all cases among both males and females in the age group 16-17 years. (**Table 2**).

ISSN: 0975-3583,0976-2833 VOL 16, ISSUE 5, 2025

TABLE 3: Stages of epiphyseal union of upper end of fibula in males and females

Age group	Number of cases	Stages of epiphyseal union										
		Male					Female					
		0	**1**	**2**	**3**	**4**	**Number of cases**	**0**	**1**	**2**	**3**	**4**
13-14	2	0	2 100%	0	0	0	5	5 100%	0	0	0	0
14-15	9	4 44.5%	2 22.2%	3 33.3%	0	**0**	13	0	2 15.4%	3 23.1%	8 61.5%	0
15-16	12	0	0	0	6 50%	6 50%	14	0	0	0	10 71.4%	4 28.6%
16-17	14	0	0	0	4 28.6%	10 71.4%	10	0	0	0	4 40%	6 60%
17-18	17	0	0	0	0	17 100%	7	0	0	0	0	7 100%
18-19	16	0	0	0	0	16 100%	5	0	0	0	0	5 100%

Stage-1 epiphyseal union of upper end of fibula was observed at 13-14 years of age in 100 % of cases among males. While among females 100 % of cases show stage-0 epiphyseal union in the age group 13-14 years. Stage-4 epiphyseal union of upper end of fibula was observed in all cases among both males and females in the age group 17-18 years. (**Table 3**).

ISSN: 0975-3583,0976-2833 VOL 16, ISSUE 5, 2025

Discussion:

In the present study, epiphyseal fusion of the lower end of femur and upper end of tibia and fibula in the males and females of coastal region of Odisha were analysed and the results were compared with the previous studies.

Our study revealed that complete epiphyseal union of lower end of femur in case of males occurs at 15-17 years while in case of females it occurs at 14-17 years. The complete epiphyseal union of upper end of tibia in case of males occurs at 15-17 years while in case of females it occurs at 14 to 17 years. The complete epiphyseal union of upper end of fibula in both the sexes occurs at 15-18 years. The epiphyseal union around the knee joint occurs earlier in females than males among the adolescents.

Our observation in relation to fusion of lower end of femur in males is in line with studies done by other researchers [6,7,12,16] while in case of females it is similar with other authors [6,7,11,13,15-17]. The result of this study in relation to fusion of upper end of tibia in males is in agreement with studies done by [7,15,16] while in females it is in line with [7,10,11,15,16,]. The findings in relation to fusion of upper end of fibula in males is in agreement with studies done by [6,17] while in females it is in line with [6,10,13,15]. Research done by authors like [8,14,18] reveal epiphyseal fusion of bones at the knee joint occur at a later age in contrast with the present study.

ISSN: 0975-3583,0976-2833 VOL 16, ISSUE 5, 2025

Table:4 Gender wise comparison with previous studies of epiphyseal fusion of lower end of femur and upper ends of tibia and fibula with their respective shaft

Author	Lower end of femur		Upper end of tibia		Upper end of fibula	
	Male	Female	Male	Female	Male	Female
Bhise SS et al	18-19	16-17	17-18	16-17	-	-
Hepworth	16.5-17.5	16.5-17.5	16.5-17.5	16.5-17.5	16.5-17.5	16.5-17.5
Galstaun	14-17	14-17	15-17	14-15	11-19	14-16
McKern & Stewart	22	-	23	-	22	-
Das Gupta et al	18-19	16-17	18-19	17-18	-	-
Saxena and Vyas	18-19	18-19	18-19	16-17	18-19	16-17
Agrawal and Pathak	-	15-16	-	15-16	-	15-16
Connor JE et al	17-17.9	17-17.9	18-18.9	17-17.9	17-17.9	17-17.9
Bokariya et al	18-19	16-17	17-18	14-15	18-19	16-17

ISSN: 0975-3583,0976-2833 VOL 16, ISSUE 5, 2025

Jihad A. M. Alzyoud et al	21-22	20-21	21-22	20-22	21-22	20-22
Basu and Basu	-	16	15-16	15-16	16-17	16-17
Pillai	14-17	14-17	14-17	14-17	14-17	14-17
Hansman	14-19	12-17	14.5-19.5	12-17	15-20	12-17
Tirupade et al	18-20	16-20	-	-	-	-
Present study	15-17	14-17	15-17	14-17	15-18	15-18

Conclusion:

The current study is an effort to study the different stages of epiphyseal union at the knee joint among the adolescents of eastern Odisha. The completion of epiphyseal union in this population for the lower end of femur is 15-17 years and 14-17 for males and females respectively. Epiphyseal union in case of upper end of tibia is 15-17 years in case of males while it is 14-17 years in case of females. Epiphyseal union in case of upper end of fibula is 15-18 years in both the sex. The age of epiphyseal union of long bone varies from different regions of a country which is affected by various factors like genetics, hormones, nutrition, physical activity, climate, socio economic status etc. Therefore more number of research should be conducted in various parts of the country and the world to have a standard ossification chart for age estimation which would significantly contribute to forensic and legal fields.

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ISSN: 0975-3583,0976-2833 VOL 16, ISSUE 5, 2025

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ISSN: 0975-3583,0976-2833 VOL 16, ISSUE 5, 2025

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