

## AGE DETERMINATION BY RADIOLOGICAL EPIPHYSEAL FUSION OF ELBOW AND WRIST IN ADOLESCENT POPULATION IN MALWA REGION OF MADHYA PRADESH

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### ABSTRACT

**Background:** Law crime and punishment is entirely based on the criminal responsibilities and age of the person. In modern society, the crime against the children and adolescent and crime by the children and adolescent are increasing enormously. Hence, estimation of age has gained much importance, especially in medico legal cases. In the present study, we determine the bone age based on fusion of epiphysis of long bones around elbow and wrist for apparently normal adolescent between the age group of 12-20 years for the population of Malwa region of Madhya Pradesh. **Materials and Method:** The study was carried out on adolescent population of Malwa region of Madhya Pradesh. The study was done from August, 2007 to September, 2008. In this study, we take normal healthy adolescents between age group of 12-20 years. We consider their document evidence for their age like date of delivery details, birth certificates, school records etc. We only consider the population of Malwa region. **Results:** On the basis of our criteria, our study was done on 500 subjects with 265 males and 235 females between the 12-20 age groups from Malwa region of Madhya Pradesh. The history of all the subjects was including name, sex, socioeconomic status, religion and dietary habits. Majority of the subjects in the study were males and the sex ratio were similar to the sex ratio of Madhya Pradesh. **Conclusion:** There was no difference in age of fusion in individuals of different religions in Malwa region. There is difference of 1-3 years in age of fusion from Western population. Fusion occurs earlier than Western population suggesting climatic, dietetic and hereditary factors as aetiology. Similar differences can see in other studies in India. There was no variation on the basis of diet and occupation seen in study group. There was no appreciable difference in the age of complete union of epiphysis on both right and left side of body. The results are showed in the tables.

**Keyword:** elbow and wrist, children and adolescent, plain X-ray

### INTRODUCTION

Law crime and punishment is entirely based on the criminal responsibilities and age of the person. In modern society, the crime against the children and adolescent and crime by the children and adolescent are increasing enormously. Hence, estimation of age has gained much importance, especially in medico legal cases. There are various methods of age

estimation for various age groups. Since the inventions of X-rays on November 8, 1895 by Wilhelm Conrad Roentgen, radiography became the primary modality for estimation of age, either by dental or by bone X-rays. In adolescent the appearance and fusion of epiphysis detected by radiography is the most accurate method. Because of

easy availability and high reliability even after 125 years, X-rays continue to be the primary and most widely practiced method of age determination.

Previous studies have suggested that the various factors such as climate, diet and sex have influence on bone growth and maturation. Owing to the variation in climatic, dietetic, hereditary and other factors, affecting the peoples of various regions of the country, so a uniform standard data cannot be formulated. In the previous studies, it was discovered that union epiphysis occurs 2-3 years earlier in Indians compare than Europeans and Americans. Union epiphysis also occur earlier in females than males.

Recently, the number of false age related documents increase for the use of courts and other medico legal agencies. So, the determination of age of an individual has great interest in medico legal and academics. So, the demand for radiological age estimation also increases in the world. The principle means of age estimation are teeth, height, weight, ossification of bones and minor signs.

Reporting on medico-legal practice in India, a survey committee recommended to the government of India in the year 1964 that a zone wise study for the problem of determination of age is to be encouraged. There are about 500 cases referred for expert opinion to the department of radio diagnosis per year from various medico legal agencies in the Malwa region. The number of cases increases day by day. Hence this study was undertaken to provide authentic and reliable data to aid such medico legal purpose in department of radio diagnosis in my hospital, Indore. Malwa region of Madhya Pradesh includes district of Dewas, Dhar, Indore, Jhabua, Mandasaur, Neemuch, Rajgarh, Ratlam, Shajapur, Ujjain, parts of Guna and Sehore.

In the present study, we determine the bone age based on fusion of epiphysis of long bones around elbow and wrist for apparently normal adolescent between the age group of 12-20 years for the population of Malwa region of Madhya Pradesh. We also find the age at which more than 50% cases have the fusion. Present study was also compared with other studies in India.

## **MATERIAL AND METHODS**

The study was carried out on adolescent population of Malwa region of Madhya Pradesh. The study was done from August, 2007 to September, 2008.

In this study, we take normal healthy adolescents between age group of 12-20 years. We consider their

document evidence for their age like date of delivery details, birth certificates, school records etc. We only consider the population of Malwa region. We exclude the population with any chronic illness like congenital heart disease, short stature, severe malnutrition, endocrinal disorders and chronic drug intake (e.g. anti-epileptic drugs, steroids). Based on the inclusion and exclusion criteria 500 cases were consider for the study. The height, weight and sex were recorded for the each case. X-rays of both elbow and wrist, Antero-posterior view was taken. Radiological assessment was done using X-ray lobby. The findings and results were compared with the other standard Indian studies.

The X-rays of wrist were taken with A-P view at 40-44 KVp and 4 – 8 mAs (Centering at mid carpal area). The X-ray of elbow was taken with A-P view at 42-44 KVp and 4–8 mAs (Centering at mid carpal area). The tube current was fixed at 40 inches and tube current at 100 mA.

Some precautions were taken while obtaining the radiographs to ensure safety of the subjects and people involved. The experience personnel, consultants and radiographers were consulted before starting the study. The newer machine installed in our department of radio diagnosis under IAEA and BARC guidelines were used after proper testing. Each child was made to wear double lead aprons while taking the radiographs exposing only the area of interest to the field of radiation. Additional lead plates were kept to protect the gonads. Proper positioning of the subject and the X-ray tube was done so that only the required minimal area is exposed to radiation. Collimators were set to focus on the area of interest minimizing the chance of exposure to the rest of the body. Similarly, we had followed many conditions to take the X-ray for elbow and wrist.

## **RESULTS**

On the basis of our criteria, our study was done on 500 subjects with 265 males and 235 females between the 12-20 age groups from Malwa region of Madhya Pradesh. The history of all the subjects was including name, sex, socioeconomic status, religion and dietary habits. Majority of the subjects in the study were males and the sex ratio were similar to the sex ratio of Madhya Pradesh. The plain X-ray with AP view of both wrists and elbows were taken and evaluated. The percentage of fusion of individual epiphysis of bones for both male and female was calculated and presented in the table. Maximum number of subjects in the study was in the

age group of 14-16 for both males and females. Most of the subjects belonged to middle class in both males and females. Maximum numbers of subject were from Hindu family. The numbers of vegetarian subject were more compared to non-vegetarians. Majority populations were students. Most of subjects were students. The documentary age did not appear to be correct in some cases.

All male subjects of 14-16 and female subjects of 12-14 shows fusion of trochlea to capitulum (Table 1). All most all males of 16 years and above and females of 12-14 years showed lateral epicondyle fusion to capitulum (Table 2). All males in 16-18 years and females in 14-16 years had age of fusion of medial epicondyle to shaft (Table 3). All males of 18-20 and females of above 16 years show fusion of head of radius (Table 4). Males of 18-20 years and females of 16-18 years showed complete fusion of the epiphysis of olecranon (Table 5). Fusion of distal epiphysis of radius showed fusion at 14-16 years in male and 18-20 in females (Table 6). More than three fourth in age group of 18-20 showed fusion in males and all age group 16-18 showed fusion in the distal epiphyses of ulna (Table 7). There was a difference of one to two years in the age of epiphyseal fusion between males and females. The epiphyses fused earlier in females as compared to males. Epiphysis around elbow fused in two third cases by 16-18 years in males and 14-16 years in females. We show the age at which all cases show fusion at various epiphysis (Table 8). The age range at which more than two third cases show epiphyseal fusion showed in table 9. Unfused epiphysis of medial epicondyle with fusion of other epiphysis of merus, head of radius and unfused wrist epiphysis showed in figure 1. Complete fusion of epiphyses with disappearance of epiphyseal lines around wrist and elbow showed in the figure 2.

## DISCUSSION

In the present study 500 subjects of age group 12-20 were taken. These individuals belong to Malwa region of Madhya Pradesh. Regarding fusion of trochlea epiphysis to capitulum, Galstaum et al (6) reported age of fusion to be 11-15 years in males and 9-13 years in females. In our study, it was 12-14 years in males and 12-14 years in females. Basu and Basu (7) study Bangali Hindu females and reported age of fusion 12-13 years.

In our study on Malwa population, fusion of lateral epicondyle to capitulum occurred at 13-15 years in males and 12-14 years in females similar to study of Galstaum et al.(6) for Bengalese population. Basu

and Basu (7) consider the study for the Bengali Hindu females and found this age to 12-13 years. Pillai et al (10) found this age 13-14 years. Hepworth (11) found it to be 14-15 years in Punjabis.

In case of fusion of the distal common humeral epiphysis to shaft, Galstaum (6) found age of fusion 16 years in males and 14 years in females. Basu and Basu (7) discovered 13-14 years age of fusion in females. Lall and Townsend (9) study females of U.P. found it to be 14-15 years. Hepworth (11) found it to be 14.5 years in Punjabis. Lall R, Nat SS (8) found this age to be 15-17 years in males of Uttar Pradesh. Pillai et al (10) reported 14-17 years in Madrasi. In the present study the average age of fusion in males to be 16 years and in females 14 years, similar to Galstaum (6).

In the present study, we found that in the males the epiphysis of olecranon started fusing at 14 years and all subjects at 18 years and above showed fusion. Hence the average age of fusion appears to be around 17 years. In females, fusion started at 12 years and all cases above 18 years showed complete fusion. So, the average age in females to be around 15 years. Findings of the our study are similar to the study on Bengalese population of Galstaum et al(6) in which the age of fusion in males was 17 years and females was 15 years. Another study on Bengalese Hindu females by Basu and Basu (7) reported age of fusion in females as 13-14 years. Lall and Townsend (9) found 15 years as age of fusion in females of United Province, while Lall R, Nat SS (8) found age less than or equal to 16 years in males of United Province. Pillai et al (10) reported age of fusion to be 14-16 years in Madrasi.

Galstaum et al (6) study fusion of head of radius on Bengalese and found that the age of fusion as 15 years in males and 14 years in females. Basu and Basu (7) reported age of fusion in Bengali Hindu females as 13-14 years. Lall and Townsend (9) found it to be 16 years in females of United Province, while Lall R, Nat SS (8) found age of fusion in males was 17 years. Pillai et al (10) reported age of fusion to be 14-17 years in Madrasi. Hepworth (11) found it 14-15 years in Punjabis.

In males the epiphysis of head of radius started fusing at 14 years and all subjects as 18 years and above showed fusion. The average age of fusion was found to be around 16 years. In females, fusion started at 12 years and all cases above 16 years showed complete fusion. So, the average age in females appears to be around 14 years. Findings in

males and females are in concordance to Galstaum (6) in females and Pillai (10) in males.

In our study, one third of males subjects had fused distal epiphysis of radius in 14-16 years, two third in 16-18 years and all in 18-20 years. Hence the mean age of fusion appears to be in the range of 16-18 years. More than half of the female subjects in the age group of 14-16 years and more than two third in 16-18 years and all in 18-20 years show fusion. Few cases in age range of 12-14 showed fusion. So the average age in females appears to be around 16-18 years. In the study on Bengali population by Galstaum et al (6) the age of fusion in males was found to be 16-17 years and in females 16.5 years. Basu and Basu (7) reported age of fusion in females to be 16-17 years, similar as findings of Hepworth et al (11) in Punjabis. Lall and Townsend (9) found 18-19 years as age of fusion in females of United Province, while Lall R and Nat (8) found mean age of 20-21 years in males of United Province. For Madrasi, Pillai et al (10) reported age of fusion to be 14-18 years.

Galstaum et al (6) study Bengali population and found that the distal epiphysis of ulna fused at the age of 18 years in males and 17 years in females. In Bengali Hindu females, Basu and Basu (7) reported age of fusion in females 16-17 years. Lall and Townsend (9) found 18-19 years as age of fusion in females of United Province, while Lall R, Nat SS (8) found mean age of 20-21 years in males. In Madrasi, Pillai et al (10) found age of fusion as 14-18 years. In the present study, two third of cases of males in 16-18 years and more than three fourth in 18-20 years showed fusion. Hence it can be concluded that the age of fusion is above 18 years. In females, one third of subjects in 14-16 years and nearly all in 16-18 years show fusion and all in 18-20 years show fusion. Hence the age of fusion appears to be 16-18 years.

According to Galstaum (6), all epiphysis around elbow fuse by age 15 in females and age 17 in males, similar to the findings of our study.

Galstaum G (6) observed in Bengali female subjects that the lower ends of radius had completed fusion by 18 years which is similar with this study. According to Chhokar V et al (12), the distal ends of the radius and ulna fused with the shaft at 17-18 years in females, which is similar with our study. Banerjee KK and Aggarwal BBL (13) stated that the wrist joint epiphyseal union is completed at 18-19 years, which is slightly later than the present study. Saksena and Vyas (14) in Madhya Pradesh observed

100% fusion at 18-19 years in males and 17-18 years, which is almost similar with our study. Kothari DR (15) in Rajasthan showed 17-18 years as the age of complete fusion at the wrist for girls, which is nearly to this series. Prasad RS et al (16) in Bihar stated that if epiphysis at the wrist were fused, it indicated that the age of the girl to be above 16 years similar to the present finding. Kangne RN (17) et al stated that precise age could not be determined by radiological assessment alone. Present studies also prove that.

## CONCLUSION

In the present study 500 individuals of age groups 12-20 were radio graphically assessed after proper history and general examination. There was no difference in age of fusion of epiphysis in subjects of different areas of Malwa region. There is difference of 1-2 years in males and females. Fusion occurs earlier in females than males at all epiphysis in study. Similar results was seen in almost all studies throughout world suggesting hormonal factors as aetiology.

There was no difference in age of fusion in individuals of different religions in Malwa region. There is difference of 1-3 years in age of fusion from Western population. Fusion occurs earlier than Western population suggesting climatic, dietetic and hereditary factors as aetiology. Similar differences can see in other studies in India. There was no variation on the basis of diet and occupation seen in study group. There was no appreciable difference in the age of complete union of epiphysis on both right and left side of body. The results are showed in the tables.

There is not much variations in present study findings from the earlier studies conducted in various parts of India at different time periods. The slight variation that appeared may be due to variable factors like climate, diet, hereditary factors or due to statistical reasons or due to less reliable age related documents.

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## Tables

**Table 1: Age of fusion in years of epiphysis of trochlea to capitulum**

Age Group	Males		Females	
	Total	With Epiphyseal Fusion	Total	With Epiphyseal Fusion
10-12	30	10 (33.3%)	25	15 (60%)
12-14	50	35 (70%)	45	45 (100%)
14-16	80	80 (100%)	70	70 (100%)
16-18	60	60 (100%)	55	55 (100%)
18-20	45	45 (100%)	40	40 (100%)

**Table 2: Age of fusion in years of epiphysis of lateral epicondyle to capitulum**

Age Group	Males		Females	
	Total	With Epiphyseal Fusion	Total	With Epiphyseal Fusion
10-12	30	15 (50%)	25	20 (80%)
12-14	50	40 (80%)	45	45 (100%)
14-16	80	75 (93.75%)	70	70 (100%)
16-18	60	60 (100%)	55	55 (100%)
18-20	45	45 (100%)	40	40 (100%)

**Table 3: Age of fusion in years of medial epicondyle to shaft (Distal humeral epiphyses)**

Age Group	Males		Females	
	Total	With Epiphyseal Fusion	Total	With Epiphyseal Fusion
10-12	30	0 (0%)	25	0 (0%)
12-14	50	15 (30%)	45	25 (55.6%)
14-16	80	75 (93.75%)	70	70 (100%)
16-18	60	60 (100%)	55	55 (100%)
18-20	45	45 (100%)	40	40 (100%)

**Table 4: Age of fusion in years of epiphysis of head of radius to shaft**

Age Group	Males		Females	
	Total	With Epiphyseal Fusion	Total	With Epiphyseal Fusion
10-12	30	0 (0%)	25	0 (0%)
12-14	50	5 (10%)	45	30 (66.7%)
14-16	80	40 (50%)	70	65 (93%)
16-18	60	50 (83.3%)	55	55 (100%)
18-20	45	45 (100%)	40	40 (100%)

**Table 5: Age of fusion in years of epiphyses of olecranon**

Age Group	Males		Females	
	Total	With Epiphyseal Fusion	Total	With Epiphyseal Fusion
10-12	30	0 (0%)	25	0 (0%)
12-14	50	0 (0%)	45	15 (33.3%)
14-16	80	10 (12.5%)	70	60 (85.7%)
16-18	60	50 (83.3%)	55	50 (91%)
18-20	45	45 (100%)	40	40 (100%)

**Table 6: Age of fusion in years of epiphyses of distal end of radius**

Age Group	Males		Females	
	Total	With Epiphyseal Fusion	Total	With Epiphyseal Fusion
10-12	30	0 (0%)	25	0 (0%)
12-14	50	0 (0%)	45	5 (11%)
14-16	80	35 (43.75%)	70	40 (57%)
16-18	60	50 (83%)	55	45(81%)
18-20	45	45 (100%)	40	40 (100%)

**Table 7: Age of fusion in years of distal epiphyses of Ulna**

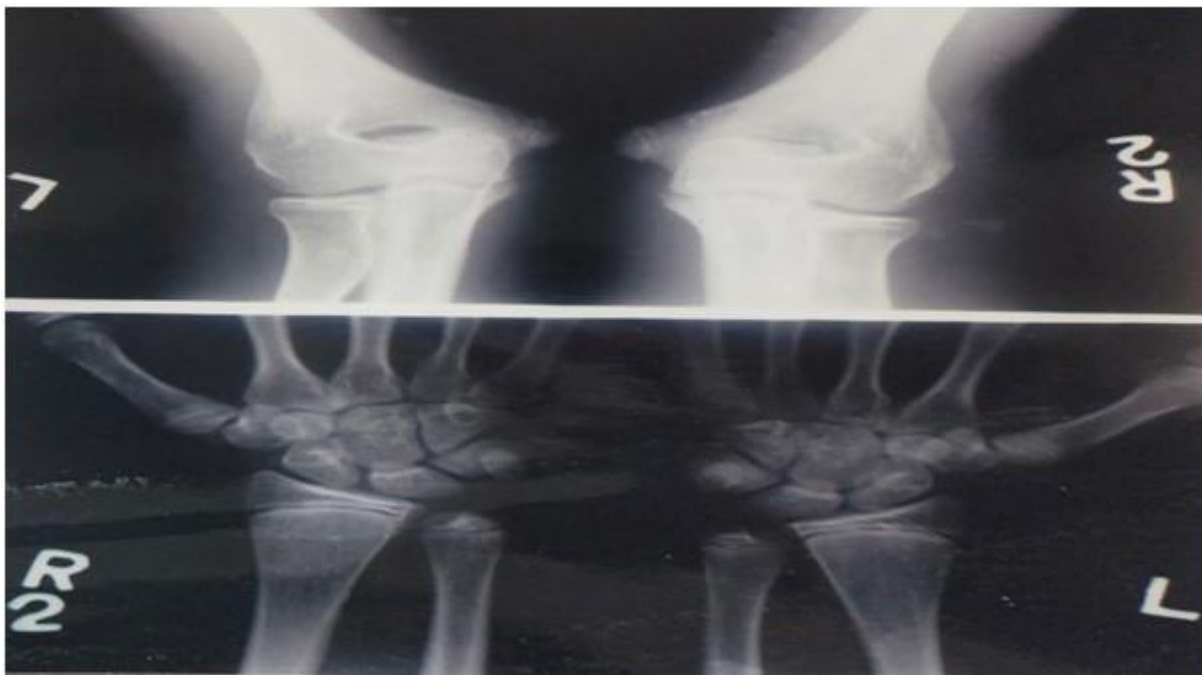
Age Group	Males		Females	
	Total	With Epiphyseal Fusion	Total	With Epiphyseal Fusion
10-12	30	0 (0%)	25	0 (0%)
12-14	50	0 (0%)	45	0 (0%)
14-16	80	10 (12.5%)	70	30 (42.8%)
16-18	60	40 (66.6%)	55	50 (90.9%)
18-20	45	40 (88.8%)	40	40 (100%)

**Table 8: Age at which all cases show fusion at various epiphyses**

Epiphysis	Male	Female
Trochlea to Capitulum	14 yrs	12 yrs
Lateral Epicondyle to Capitulum	16 yrs	12 yrs
Distal Humeral Epiphysis	16 yrs	14 yrs
Head of Radius	18 yrs	16 yrs
Olecranon Process	18 yrs	18 yrs
Distal end of Radius	18 yrs	18 yrs
Distal end of Ulna	.>20 yrs	18 yrs

**Table 9: Age range at which more than two third cases show epiphysis fusion**

Epiphysis	Male	Female
Trochlea to Capitulum	12 -14 yrs	12-14 yrs
Lateral Epicondyle to Capitulum	12-14 yrs	10-12 yrs
Distal Humeral Epiphysis	14-16 yrs	14-16 yrs
Head of Radius	16-18 yrs	12-14 yrs
Olecranon Process	16-18 yrs	14-16 yrs
Distal end of Radius	16-18 yrs	16-18 yrs
Distal end of Ulna	16-18 yrs	16-18 yrs



**Fig.1: Unfused epiphysis of medial epicondyle with fusion of other epiphysis of merus, head of radius and unfused wrist epiphysis**



**Fig.2: Complete fusion of epiphyses with disappearance of epiphyseal lines around wrist and elbow**