

## Radiological Estimation Of Age By Epiphyseal Union At Wrist Joint And Hand Among Males

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### ABSTRACT

Age estimation plays a vital role in establishing the identity of the individual for the forensic expert especially in developing countries where birth records are not well maintained. In living it is not only important for identification but also for various civil and criminal purposes. Even the courts in India accept the ossification test as the reliable indicator of age as compared to physical and dental assessment of age.

This study comprised of 250 male subjects from Puducherry UT, India. The age group of the subjects ranged from 14 to 19 years. Radiographs of the right wrist joint with hand of these subjects were taken and the epiphyseal union of the centres at the wrist joint and hand were noted. The findings were compared with the recorded age given by various research workers.

**Key words:** Age estimation, Epiphyseal union, Wrist joint and hand, Radiographs.

### Introduction

A doctor has both medical and legal duties in all medico-legal cases. As a forensic expert he is often required to give his opinion regarding the age of a person. Age Estimation is important from a legal point of view for investigation and administration of justice <sup>[1]</sup>.

The determination of the age of an individual is a task of considerable importance in various types of cases for identification, employment, criminal responsibility, judicial punishment, consent, rape, criminal abortion, prostitution, kidnapping etc <sup>[2]</sup>.

The only valuable and universally accepted scientific methods of estimating age in living in the order of merits are

1. Radiological examination of ossification centres.
2. Dental examination for eruption of teeth.
3. Physical examination of secondary sexual characteristics, height/length and weight.

Physical examination includes measurement of height, weight and body mass which will be helpful in estimating the age in a foetus and in early childhood. While secondary sexual characters, particularly in adolescent age are closely related to biological maturation and has multiple variants. Hence, physical examination has limited value in the determination of age during adolescence <sup>[3]</sup>.

Dental examination is very much useful for determination of age up to 14 years. But it is not of much help after the age of 14 years as all deciduous and permanent teeth are erupted except third molar between 12 to 14 years.

The process of appearance and union of ossification centers has a fairly definite sequence and time that makes it a reliable age indicator. After puberty the process of growth in length of the long bones stops at different ages in different parts. This stoppage of growth process is indicated by radiological examination of fusion of the epiphysis with respective diaphysis<sup>[4]</sup>.

Radiological examination is more reliable compared to physical and dental examination for age estimation, especially at 14 to 19 years age group, hence the court relies more on the radiological opinion<sup>[5]</sup>.

The appearance and fusion of ossification centres are affected by various factors like climate, heredity, diet and others. India is comprised of areas where climate, hereditary, dietary factors differ from region to region<sup>[6]</sup>.

It is very obvious that separate data for different regions of India is must as a uniform yardstick is not possible for the whole of India. Hence an attempt is made to explore the pattern of epiphyseal union in the bones of wrist joint & extended hand in growing population of Puducherry region in males.

### **Objectives**

1. To study the epiphyseal union at different ossification centres of the wrist joint and hand among 14 to 19 years in males.
2. To know the variability of age estimation by epiphyseal union at the wrist joint and hand in males.
3. To know the age based on epiphyseal union at the wrist joint and hand in each age group between 14 to 19 years of age in this region.
4. To compare the findings of this study with the findings of previous Indian studies.

### **Materials and Methods**

#### **Study setting**

Departments of Forensic Medicine and Radiology, Sri Manakula Vinayagar Medical College & Hospital, Puducherry.

**Study design:** Cross sectional study

#### **Sample and sample size**

The study comprised of 250 male subjects residents of a village, town or city within a radius of 50 kms from Sri Manakula Vinayagar Medical College and Hospital, Puducherry, India. The age group of the subjects ranged from 14 to 19 years.

**Sampling method:** Stratified random sampling.

#### **Inclusion criteria**

- Male subjects who are residents of any village, town or city within a radius of 50 kms from Sri Manakula Vinayagar Medical College and Hospital, Puducherry
- Male subjects completed 14 years of age but not completed 19 years of age.
- Subjects with documentary evidence for date of birth.

#### **Exclusion criteria**

- Subjects with musculoskeletal disorders, nutritional disorders, endocrine disorders,

chronic illness and hand injury.

### Materials used

Proforma, Digital radiographs of wrist joint and hand, Lead apron, Rigid cassette & Computer / Laptop

### Method

The purpose of the study was explained to the parents and the subjects, written informed consent was obtained from the parents or guardians in subjects less than 18 years and permission of the Principal of the schools were obtained.

Digital X- ray of the right wrist joint with hand- AP view was taken at the Department of Radiology at Sri Manakula Vinayagar Medical College and Hospital, Puducherry.

Stevenson's <sup>[7]</sup> classification of epiphyseal union was adopted in this study for interpreting the radiographs.

**Stage I: No Union.** Complete gap or space between the epiphyses & shaft of the bone.

**Stage II: Partial Union.** Partial closure of gap or space.

**Stage III: Recent Union.** Closure of the gap or space, but a thin line visible at the epiphyseo – diaphyseal junction.

**Stage IV: Complete Union.** Epiphyseal space is bony in architecture and indistinguishable from either epiphyses or diaphysis.

However, during this study for practical purpose the stage I and II were considered as not fused while stage III and IV as fused.

### Statistical analysis

The data's were entered and analysed using Epi Info (version 3.5.4) software package. The frequencies for all the variables are analysed and Chi- square test ( $\chi^2$ ) was applied for all the distributions.

### Findings

**Table 1:** Age wise distribution of the subjects

Age range (years)	Males
14- 15	50
15- 16	50
16- 17	50
17- 18	50
18- 19	50
TOTAL	250

For example the age range 14- 15 years denotes the subject who has completed 14 years of age but not completed 15 years of age and so on.

**Table 2:** Ossification pattern at wrist joint with hand

Centres	Incidence of Fusion more than 50% cases (Age range in years)	Incidence of Fusion more than 75% cases (Age range in years)	Incidence of Fusion in 100% cases (Age range in years)
Distal end of radius	-	17- 18	18- 19
Distal end of ulna	-	15- 16	17- 18
Base of 1 <sup>st</sup> metacarpal	15- 16	16- 17	17- 18
Heads of 2 <sup>nd</sup> , 3 <sup>rd</sup> , 4 <sup>th</sup> & 5 <sup>th</sup> metacarpal	15- 16	16- 17	17- 18
Proximal & distal phalanx of thumb	15- 16	16- 17	17- 18
Proximal, middle & distal phalanges other than thumb	15- 16	16- 17	17- 18

- At 15- 16 years 50% fusion is seen at the base of the 1<sup>st</sup> metacarpal, heads of 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup> & 5<sup>th</sup> metacarpal, proximal & distal phalanx of thumb, proximal, middle & distal phalanges other than thumb. 75% fusion is seen at the distal end of ulna in this age group.
- At 16- 17 years 75% fusion is seen at the base of the 1<sup>st</sup> metacarpal, heads of 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup> & 5<sup>th</sup> metacarpal, proximal & distal phalanx of thumb, proximal, middle & distal phalanges other than thumb.
- At 17- 18 years 100% fusion is seen at the distal end of ulna, base of 1<sup>st</sup> metacarpal, heads of 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup> & 5<sup>th</sup> metacarpal, proximal & distal phalanx of thumb, proximal, middle & distal phalanges other than thumb.
- At 18- 19 years 100% fusion is seen at the distal end of radius.
- From the above observation it is evident that, all the centres at hand and wrist will show fusion before completion of 18 years age when incidence of fusion is taken 75%.

**Table 3:** Statistical analysis for fusion at different ossification centres

Ossification centres	Males( $\chi^2$ )
Distal end of radius	216. 56
Distal end of ulna	166. 31
Base of 1 <sup>st</sup> metacarpal	192. 51
Heads of 2 <sup>nd</sup> , 3 <sup>rd</sup> , 4 <sup>th</sup> & 5 <sup>th</sup> metacarpal	192. 51
Proximal & distal phalanx of thumb	181. 94
Proximal, middle & distal phalanges other than thumb	181. 94

Chi- square test ( $\chi^2$ ) was applied for the above distributions and it was significant with a statistically significant p value (< 0. 05) for the degree of freedom (df) of 4.

**Table 4:** Epiphyseal union at different ossification centres by different workers (years)

Ossification centres	Gupta KN (Uttar Pradesh)	Galstaun (Bengal)	Nandy A (West Bengal)	Bhise SS (Mumbai)	Pillai (Madras)	Present study
Radius- distal end	-	16- 17	16- 17	17- 18	14- 18	17- 18
Ulna- distal end	-	18	18	17- 19	14- 18	15- 16

Base of 1 <sup>st</sup> metacarpal	16- 17	16- 18	15- 17	16-1 8	14- 17	16- 17
Heads of 2 <sup>nd</sup> to 5 <sup>th</sup> metacarpals	16- 17	16- 18	15- 17	-	14- 17	16- 17
Phalanx(thumb)	-	-	16- 18	16-1 8	-	16- 17
a. Proximal	-	-	16- 18	16-1 8	-	16- 17
b. Distal	-	-	16- 18	16-1 8	-	16- 17
Phalanges	16- 17	17- 18	17- 18	16-1 8	14- 17	16- 17
a. Proximal	16- 17	16- 18	17- 18	16-1 8	14- 17	16- 17
b. Middle	16- 17	16- 18	17- 18	16-1 8	14- 17	16- 17
c. Distal	16- 17	17- 18	17- 18	16-1 8	14- 17	16- 17

## Discussion

In the present study, the average age of fusion at the distal end of radius is 17 to 18 years in males considering the incidence of fusion is more than 75% cases. Between 18 to 19 years of age, 100% of the subjects showed fusion. The results are consistent with that of Bhise SS <sup>[8]</sup>, Patil DT <sup>[9]</sup>, Galstaun G <sup>[10]</sup> and Pillai MJS <sup>[11]</sup>.

The results of the present study are not consistent with the studies done by Yogesh S, Kadam SS, Jain S and Dasgupta as they observed higher age group for fusion.

The average age of fusion of the distal end of ulna is 15- 16 years considering the incidence of fusion is more than 75% cases. Between 17 to 18 years of age, 100% of the subjects showed fusion. The figures are correlating with Pillai MJS and are not consistent with that of Yogesh S <sup>[12]</sup>, Bhise SS, Kadam SS <sup>[13]</sup>, Jain S <sup>[14]</sup>, Nandy A <sup>[16]</sup>, Patil DT, Dasgupta SM <sup>[15]</sup> and Galstaun who observed a higher age group of fusion.

The average age of fusion at the base of first metacarpal is 16-17 years considering the incidence of fusion is more than 75% cases. Between 17 to 18 years of age, 100% of the subjects showed fusion and the results are consistent with that of Bhise SS, Kadam Galstaun, Pillai MJS and Gupta KN.

The average age of fusion at the at the heads of 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup> & 5<sup>th</sup> metacarpal is 16- 17 years considering the incidence of fusion is more than 75% cases. Between 17 to 18 years of age, 100% of the subjects showed fusion and the results are consistent with that of Galstaun, Gupta KN and Pillai MJS. The results of the present study are not correlating with that of Nandy A who observed lesser age group for fusion.

The average age of fusion of the thumb (proximal & distal phalanx) is 16 to 17 years considering the incidence of fusion is more than 75% cases and the results are consistent with that of Bhise SS. The results of the present study are not consistent with Nandy A who observed higher age group for fusion.

The average age of fusion of the proximal, middle & distal phalanges other than thumb is 16 to 17 years and the results are consistent with that of Bhise SS and Gupta KN.

From the present study it is evident that the epiphyseal union is variable when compared to the studies conducted in different parts of the country.

Incidence of fusion plays an important role in the variation of epiphyseal union, since few workers have considered 50% incidence of fusion, few as 75% and few considered 100% incidence of fusion. In our study, we have taken 75% incidence of fusion, as most of the workers considered it convenient and better.

Staging of fusion is also responsible for the variation of epiphyseal union, as the research workers have followed various staging methods given by Jit & Kulkarni, Sidhom & Jerry, Stevenson and Stewart. Out of which Stevenson's staging of fusion was considered in our study in which stage I & II were considered as not fused and similarly stage III & IV were considered as fused which was followed in most of the studies.

Other dietary, sociological, racial, climatic, hereditary, environmental and geographical factors are also responsible for higher and lesser range of epiphyseal union at the different centres.

## Conclusions

The following conclusions were drawn from the observations made in the present study. The average range of epiphyseal union at the wrist joint and hand considering 75% incidence of fusion in Puducherry region is as follows.

Ossification centres	Age range (years)
Distal end of radius	17- 18
Distal end of ulna	15- 16
Base of 1 <sup>st</sup> metacarpal	16- 17
Heads of 2 <sup>nd</sup> , 3 <sup>rd</sup> , 4 <sup>th</sup> & 5 <sup>th</sup> metacarpal	16- 17
Proximal & distal phalanx of thumb	16- 17
Proximal, middle & distal phalanges other than thumb	16- 17

1. The epiphyseal union at all the centres at hand and wrist will show fusion before completion of 18 years age when the incidence of fusion is taken as 75%.
2. Our results are consistent with Pillai MJS for Madras, by considering the incidence of fusion centres in more than 75% cases.
3. Even though the radiological examination is the most reliable method for visualizing the epiphyseal union of the bones, exact and precise age of the individual cannot be stated, but a reasonable age range can be given based on the epiphyseal union. Radiological examination of epiphyseal union at the wrist joint and hand is of adequate help, but with limitations.
4. To reduce the error of margin, other factors like secondary sexual characters and dental examination are to be considered. The courts also require authenticity and a least possible margin of error for estimation of age.

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**Conflict of Interest:** Nil

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