

Original research article

## Estimation of Age by Epiphyseal Union of Lower end Humerus, Upper end Radius and Ulna

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### Abstract

**Background:** Determination of age of majority is essential at the time of employment, marriage, fixation of criminal responsibility, judicial punishment, exercise of adult franchise etc. Determination of age forms a major help in solving many medico legal issues. The study of epiphyseal union of bone is considered a reasonable scientific & accepted method of estimation of age by the court of law all over the world. It is the maximum of age estimation that we should combine information from as many epiphyses as possible to provide the most accurate estimate of biological age and therefore chronological age.

**Material and methods:** The study was conducted at the department of Anatomy with the help of department of Radiology, PMCH, Patna. The material for study consisted of 100 subjects between the age of 11 and 18 years (52 males, 42 females) Source of subjects were from a nearby school. Students of Patna Bihar region were taken for study. The age was verified by checking the date of birth from school admission records. Among these students of 11 to 15 years were students who were in fifth to tenth standards.

**Conclusions:** There was difference between the age of epiphyseal union of lower end humerus and upper end ulna and upper end radius among the males and females. In general the fusion of epiphyses occurs 3-4 years earlier in females as compared to the fusion in males.

**Keywords:** Epiphyseal union, lateral epicondyle, capitulum, trochlea, medialepipicondyle, upper end radius, and ulna.

### Introduction

There is variation in the ages of epiphyseal union because there are numerous factors affecting the union of epiphyses of bones especially in a vast country like India with diverse population. It is essential to know the local data for each population in interest of the people. Ossification of the elbow region is complex. The distal Humerus has 4 secondary ossification centers: those for the capitulum and trochlea and those for the medial and lateral epicondyles. Typically, none of these centers are ossified at birth. Capitulum is the first secondary center to ossify, usually followed by the medial epicondyle, the trochlea, and the lateral epicondyle. The age at which ossification centers are first seen varies considerably; maturation usually proceeds earlier in girls than in boys. With this in mind, the average age at which the centers are seen first in 50% of children is 3 months of age for the capitulum, 5 years for the medial epicondyle, 8 years for the trochlea, and 10 years for the lateral epicondyle. Therefore elbow region is a major region where the particular range of age from 12- 18 years estimation can be done more confidently and efficiently when compared to any other region used at once at a time for age

estimation. The corresponding ages at which the ossification centers of the proximal forearm bones appear are 4.5 years for the radial head and 9 years for the olecranon. The acronym CRMTOL is used to describe the usual order of appearance of all 6 elbow centers: capitellum, radial head, medial epicondyle, trochlea, olecranon, and lateral epicondyle. These ossification centers vary not only with regard to the age of the patient at the time of development but also with regard to their radiographic appearances. Study of estimation of age by appearance of ossification centre and their fusion can be done by a radiological method and is fairly accurate guide to determine the age of the person up to the age of 25 years. Every legal procedure requires the estimation of age, every judicial act entitles first the age to which it is applied. Determination of age of majority is essential at the time of employment, marriage, fixation of criminal responsibility, judicial punishment, exercise of adult franchise, etc. For the estimation of age there are various methods. The main kinds are the pubertal changes, tooth eruption, changes in the structure of the teeth, height, appearance of ossification centre and fusion, progress in the ossification of bones.

### **Aim**

The aim of the study is to determine the age of epiphyseal union of lower end humerus and upper end radius and ulna.

### **Review of Literature**

In the year 1905 Pryor used roentgen rays to study the time of appearance and completion of ossification of bones. He studied 554 subjects (male and female) between the age group of 3 months to 14 years of age. He concluded that the bones of female ossify in advance of male. In 1906 Pryor made the following observation. The ossification is bilaterally symmetrical. The bones of the first child ossify, as a rule, sooner than those of the subsequent children. Balthazar and Labrum in 1911 adopted the method of assessing the age by "Haversian canal technique". According to them it was possible to assess the approximate age of a person beyond the age of 10 years by determining a mean diameter of the Haversian canals. They also prescribed a precise method of performing it.<sup>6</sup> Stevenson in 1924 studied the union of epiphyses with diaphyses in the skeleton for the first time. He studied 110 skeletons between 15-28 years of age. Girdany & Golden (1952) observed that the time of appearance of centres of ossification differs considerably in two sexes and even in the same sex, normal individual variation is great. Modi (1952) stated that different states of India have different climates, different nutritional status and different geographical outline along with other different factors. It was extremely difficult to formulate a uniform standard for the determination of age from the union of epiphyses for whole of India. Dreizen, Richard and Snodgrass (1957) analyzed X-rays of 950 American children between age group of one month to 15 years to find out any difference in the degree of ossification on two sides. They concluded that although the homologous parts of the two sides of skeleton might show considerable difference in development, yet for all practical purposes the discrepancies between the two sides were also insignificant that they do not constitute a source of error in the estimation of ossification status of the bones. Aggarwal and Pathak (1957) after conducting a radiological study of the main joints of the extremities in Punjabi girls between the age group 11.5-20.5 years made the following observations. Bajaj et al observed that age of fusion of epiphyses in Indian subjects residing in Delhi was about 1-2 years. They did not find any difference in the ossification of left and right side. Bhattacharjee and Aggarwal (1968) suggested that for average data of epiphyseal union in India, work was required to be done in different states of India covering both sexes in different age groups and then obtaining a mean value. Mukherjee in 1981 put forth his view in his book that besides the assessment of epiphyseal union in different bones, other factors which contribute to a great extent in determining the age of an adolescent were. a) Growth of hairs b) height and weight c)

eruption of teeth d) growth of hairs e) changes in external genitalia f) development of breast g) onset of menstrual cycle. Daisy Sahni in 1981 did a radiological examination of elbow and wrist joints of both sides in 125 Chandigarh girls aged 13-19 years shows that a complete fusion of the medial epicondyle with the metaphyses occurs between 13-19 years of age. Median ages of fusion of epiphyses with metaphyses were found to be Medial epicondyle – 14 years, 4 months and 4 days and Upper end of Radius - 12 years 1 month and 26 days Hugo in 2008 with a sample of 121 individuals between the ages of 9 and 29 (females 65, Males 56) derived from Lisbon documented skeletal collection. Epiphyseal union was seen at 16 anatomical locations, using three stage scheme (1)no union; (2) partial union; (3) complete union, all traces of fusion have disappeared. In the upper limb the epiphyses of the elbow are at around 11- 15 yrs of age. According to the study by Aggarwal in 2009, four different centres of ossification appear at the lower end of humerus. The first centre to appear is in the capitulum, which appears in the second year, followed by the medial epicondyle at 4– 7 years, the trochlea at around 8–9 years and the lateral epicondyle at around 10–12 years. The centres for the capitulum, trochlea and lateral condyle unite to form a conjoint epiphysis at around 12 years, which unites with the shaft at between 11 and 15 years in females and 12 and 17 years in males. The medial epicondyle joins the shaft separately at between 13 and 16 years. The head of the radius appears by year 5 and that of the ulna between 8 and 10 years. Both unite with the shaft at 12- 14 years in females and 13–16 years in males

### **Material and methods**

This study was carried out of two years, the study was conducted at the department of Anatomy with the help of department of Radiology, at Patna medical college and Hospital Patna Bihar. The material for study consisted of 100 subjects between the age of 11 and 18 years. It included 52 boys and 48 girls. Source of subjects were from a nearby school. Students of Patna origin were taken for the study. The age was verified by checking the date of birth from school admission records. Among these students of 11 to 15 years will be those students who are in fifth to tenth standards. Subjects of age 16 to 18 years shall be taken from students doing para medical courses. The information regarding certain relevant like name ,age , sex ,height, weight were included. Then subjects were then taken for radiological examination. After this observations shall be made regarding earliest age showing epiphyseal union and most delayed age of union and the range of union of epiphysis studied.

### **Inclusion criteria**

The age of the subjects were confirmed from the birth certificates/ school records. The subjects underwent a brief clinical examination and history taking to rule out any cases of chronic illness and fractures which were excluded from the study.

### **Exclusion criteria**

Subjects with any gross skeletal deformity and those with history or evidence of previous fractures near elbow joint were excluded from the study.

### **Results and Observations**

The X-ray films of the elbow joint were studied and observations were made under following the males and female subgroups.

\*Elbow Joint

\*Fusion of lateral epicondyle with the capitulum.

\*Fusion of capitulum with the trochlea.

\*Fusion of distal conjoint epiphyses with the shaft.

\*Fusion of medial epicondyle with the shaft.

\*Fusion of upper end of radius with the shaft.

\*Fusion of upper end of ulna with the shaft.

Observations was made from the X-ray films by noting the stage of epiphyseal fusion . While evaluating, the epiphyseal centre which had not appeared/ appeared but not fused ( stage 1,2) and those epiphyses where fusion started (stage 3) were taken as 'no fusion'. Stage 4 and stage 5 fusion were taken as fusion occurred. The percentage of epiphyseal union of each epiphyses was calculated by including stage 4 and stage 5 of epiphyseal fusion. The average age of epiphyseal union was taken as the youngest age group in which 75% of cases showed complete union. The range of epiphyseal union was fixed from the lower age limit which showed minimum 50 % cases of complete union and upper age limit which showed 100% complete union. The statistical analyses is done using Fischer's exact test and the 'p' value is calculated to show if there is significant difference between the epiphyseal union of each epiphyseal centre with respect to each age group in between the two sexes. If P' value is less than 0.05. The observations of epiphyseal union of lateral epicondyle with capitulum for all the age groups separately for males and females. As our sample size is small we have taken the Fisher's Exact Test p value for each agegroup and not chi-square test value.

(a) P value =	0.500
(b) P value =	0.000
(c) P value =	0.010
(d) P value=	0.035
(e) P value=	0.533
(f) P value=	0.267
(g) No statistics are computed because 'F' value in the test is a constant	

The p value is less than .05 and therefore there is significant difference between the epiphyseal union of lateral epicondyle with capitulum in between males and females in the mentioned age group. When F is a constant there is no difference in that particular age

The observations of epiphyseal union of distal conjoint epiphyses to the shaft for all the age groups separately for males and females.

As our sample size is small we have taken the Fisher's Exact Test p value and not chi-square test value. The values are as below for each age group.

(a) P value =	0.231
(b) P value =	0.002
(c) P value =	0.000
(d) P value=	0.010
(e) P value=	0.051
(f) P value=	0.267
(g) No statistics are computed because F is a constant.	

The p value is less than 0.05 and therefore there is significant difference between the epiphyseal union of distal conjoint epiphyses with the shaft in males and females in the mentioned age group. When F is a constant there is no difference in that particular age group.

Observation in Males:

Average age of epiphyseal union was: 17- 18 years Range of union was: 15- 18 years

Observation in females

Average age of union was: 12 -13 years Range of union was: 12-14 years.

**3 Male 13 yrs L.E.: -, C.T.: ++ , D.C.E.: ++ M.E.: ++ , U.R.: ++ , U.U.:**



**6 Female 11yrs L.E.: - C.T.: -, D.C.E.: -, M.E.: -, U.R.: -, U.U.: -**

### Discussion

The study the average age of complete epiphyseal union of lower end humerus and upper end radius and upper end ulna in the males and females of Patna City was studied and the results compared with the previous studies and a comparative discussion was made.

### FUSION OF LATERAL EPICONDYLE TO CAPITULUM

In the present study the epiphyseal union was seen in the age range of 15-16 years in males and 12-13 years in females.

According to Flecker (1932) the age of epiphyseal union was 13 years in both males' and females in Australia. So the present study showed similarity with Australian girls but in males the fusion is delayed by 2-3 years. Patterson gave the results of his study showing the fusion in English boys and girls at 14 years. The present study showed that the union was delayed by 1 year in males and occurred 1 year earlier in females.

Hepworth (1929) recorded the age of epiphyseal fusion as 14- 15 years in Punjabis. Pillai's study (1936) showed the age of fusion in boys and girls of Madras as 13- 14 years.

Galstaun (1937) recorded the age of fusion in Bengali boys as 11-16 years and 10- 12 years in

girls. According to the present study the age of union was delayed by 4 years in males and 2 years in females when compared to the study of Gaulstaun. Franklin (1962) found the age of union in Maharashtra (Vidharba girls) as 13- 14 years this is seen delayed by one year when compared to the results of our present study. Krishna Reddy (1973) found the age of fusion in Andhra Pradesh population as 14 years in males and 13- 14 years in females. The present study showed the age of union delayed by 1-2 years in males and in females it is one year earlier. R.S. Jnanesh, S Thangaraj Thomas (2006) presented a work in Karnataka showing the age of fusion of Lateral epicondyle in males at 15-16 years and in females at 12-13 years which is similar to our study results. Franklin (1962) found the age of union in Maharashtra (Vidharba girls) as 13- 14 years this is seen delayed by one year by age when compared to the present study. Sidhom and Derry (1931) studied the subjects in Egypt in whom the fusion is delayed in females by 4-5 years in females and in males it occurs at same age as in the present study. In U.S.A. the study carried out by Mckern and Stewart the age of fusion was 16 years in males that is earlier than compared to present study. Pillai (1936) concluded the age of fusion in madras as 17 years in males and females. Galstaun (1937) recorded the age of fusion in Bengali boys as 15-16 years and 14 years in girls. According to the present study the age of union was delayed by 1-2 years in males and similar in females when compared with the work of Galstaun. Mckern and Stewart (1976) in U.S.A. a study gave similar results. Patterson (1929) recorded the age of fusion as 18- 19 years in males and 14 years in females as compared to the present study the age of fusion was delayed by 1 year in males and similar in females in U.K. Sidhom and Derry gave similar figures of age. Pillai (1936) recorded the age of fusion in Madras boys but comparison not possible as any separate data available for both sexes. The present work showed the age of fusion was delayed by 1-2 years in males and by 1 year in females than those of the study of Galstaun (1937) and Basu and Basu (1938) in Bengalis. When compared to Sharma's study (1962) the present study showed delay by 6 months in both sexes. Franklin (1962) showed the epiphyseal union in Maharashtra (Vidharba) region to occur at a age of 14- 15 years in girls which tally with the present study results.

### Conclusion

The average age of the epiphyseal union was found by taking the youngest age group in which 75% cases showed complete union and the range of epiphyseal union was also noted. For the present study, 100 individuals were studied by radiological examination of the elbow joint which consisted of 52 male and 48 female subjects. The X-ray films were studied and the five epiphyses centres were noted for the stage of fusion which was recorded under five stages.

### References

1. Parikh CK. Parikh's textbook of medical jurisprudence and toxicology. 5th Ed. C.B.S. Publisher and Distribution; 1990: 41
2. G. Some notes on the union of epiphyses in Indian girls. Indian Med. Gaz. 1930;65: 191-192
3. Gupta et. al. A roentgenologic study of epiphyseal union around elbow, wrist and kneejoints and pelvis in Boys and Girls of Uttar Pradesh. J. Indian Med Association. 1974; 62 :10-12.
4. Richard M Shore. Felix S Chew. Imaging in Pediatric Elbow Trauma. Apr 11. 2011:142-56.
5. Pryor J.W. Time of ossification of the bones of the hand of male and female and union of epiphyses with diaphyses. Am J Phys Anthropol. 1933: 8. 401-410.
6. Balthazard and Labrum. J Anat Lond. 1936:70:432-434
7. Stevenson P.H. age order of epiphyseal union in man. Am. Jr. Phys. Anthropol. 7.53-93
8. Davies DA, Parsons FG. The age order of the appearance and union of the normal epiphyses

- as seen by X-rays. *J Anat.* 1927;62:58–71.
9. Paterson RS. A radiological investigation of the epiphyses of the long bones. *J Anat.* 1929;64:28–46
  10. Hepworth SM. On the determination of age in Indians from a study of the ossification of the epiphyses of the long bones. *Ind Med Gaz.* 1929: 128
  11. Borovansky and Hnevkovsky. The growth of the body and the process of ossification in Prague boys. *Jr. Ind. Med. Res.* 1929: 21:683.
  12. Galstaun G. A study of ossification as observed in Indian subjects. *Indian J Med Res.* 1937; 25:267–324
  13. Girgis S. and Derouy, The dates of the union of some epiphyses in Egyptians from X-ray photography. *Jr. Anat. Lond.* 1931; 65: 196-205.
  14. Modi JP. *Modi's Medical Jurisprudence and Toxicology.* 23rd Edn. 2006. Editors: K. Mathiharan and Amrit K. Patnaik, Lexis Nexis Butterworths, Section I: 280-291.
  15. Krogman WM. *The human skeleton in forensic medicine.* 2nd Ed. By, Wilton Marion Krogman and Mehmet Yasar Iscan. Charles C. Thomas publishers; 359- 360, 57, 64-65, 67.
  16. Dreizen S. and Richard M. Bilateral symmetry of skeletal maturity in humans. *Jr. Am. Dis. Of child,* 1957 ; 93: 122-127.
  17. Narayan D, Bajaj ID. Ages of epiphyseal union in long bones of inferior extremity in U.P. subjects. *Indian J Med Res.* 1957;45: 645–649.
  18. Battacharjee P.K, Agarwal. *Medicolegal companion,* 2<sup>nd</sup> Ed. 1968.
  19. Mukherjee J.B. *Textbook of medical jurisprudence and toxicology.* Vol.1: 1<sup>st</sup> Ed. 1981.
  20. Daisy Sahni. A radiologic study of the time of fusion at the elbow and wrist joints in Chandigarh girls. *Jr. Anat. Soc. Ind.* 1981; 99:25-26.

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