

Original research article**Study of Estimation of Age by Epiphyseal Union of Lower and Humerus, Upper end Radius and Ulna****Dr. Rekha Sinha¹, Dr. Sanjeev Kumar Sinha², Dr. Vivekanand³,
Dr. Birendra Kumar Sinha⁴**¹Assistant Prof. Department of Anatomy, PMCH Patna²Assistant Prof. Department of Anatomy, PMCH Patna³Assistant Prof. Department of Anatomy, PMCH Patna⁴Associate Prof. & Head, Department of Anatomy, PMCH Patna**Corresponding Author: Dr. Vivekanand****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. Pisiform begins to ossify in the ninth or tenth year in females, and the twelfth in males. The lower end of radius ossifies by 20 years. So there is a gap in the age from 12 to 20 years for which another suitable site like the elbow region need to be studied and data combined for filling the lacunae when wrist joint alone is considered.

Methods: The study was conducted at the department of Anatomy with the help of department of Radiology, at Patna medical college and Hospital, Patna. Study duration of Two years. 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. The age was verified by checking the date of birth from school admission records.

Conclusion: 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, medial epicondyle, upper end radius, upper end ulna.

Introduction

Medical science has gained enormous scope in diagnosing rarest form of diseases and treating enumerable diseases. Along with the use of medical science in curing or applying it for the betterment of the health of the individual it also has various uses in the administration of justice. The court of law depends on evidences, so it's here where the medical clues are used to prove or ascertain some hidden facts behind the apparently appearing scenario. 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. With regard to the judicial concern the important ages are 7, 10, 14, 16, 18 and 21.¹ 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. This method is accepted by the court of law and can be confidently used to estimate age of the individual. 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.^{2,3} Ossification of the elbow region is complex. The distal Humerus has 4 secondary ossification centers: those for the capitellum and trochlea and those for the medial and lateral epicondyles. Typically, none of these centers are ossified at birth. Capitellum 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 capitellum, 5 years for the medial epicondyle, 8 years for the trochlea, and 10 years for the lateral epicondyle. 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.⁴ 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.

Aim

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

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. Variation in the ossification of bone is a heritable trait.⁵ 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.⁶ 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. He had not separated the male skeletons from female skeletons and the observations showed the constant behavior of the epiphyses with regard to the fusion and that is why his work could not be accepted by subsequent workers.⁷

Name of epiphyses: Age of fusion

Fusion of medial epicondyle with the shaft at: 16years

Fusion of upper end of radius with the shaft 18ys Davies and Parsons (1927) studied 5000 X-rays of subjects from birth to 20 years of age. Their observations were as follows⁸

Peterson (1929) investigated radiographs of different joints of about 100 cases each. He was the first worker to define "complete union". According to him complete union was the state when the epiphyseal space had been filled with bone of equal density to epiphyses and diaphyses and has become invisible in skiagrams. His observations were as follows.⁹ He inferred from the study that union of epiphyses with the shaft of their long bones takes place 2.5-3 years earlier in Indian than in English and American subjects. He did not give separate data for males and females, but it appeared fusion was earlier in females than in males.¹⁰ Galstaun(1930) studied the epiphyseal union in Bengali population including only the female subjects. He took X-rays of 107 Indian girls who were between the age group of 11-19 years. He concluded that the union takes place considerably earlier in Indian subjects as compared to European girls, difference in time varying from 1-4 years.¹² Sidhom and Derry (1931) made a proper planning of their research project instead of picking up skiagrams from the hospital records. 400 Egyptian boys of known age, between the age of 14 to 21 years were X-rayed. X-rays of the bones of upper limb excluding shoulder joint were taken in the same way and in the same position. Their observations were as follows.¹³

Name of epiphyses: Age of fusion Conjoint epiphyses fused with the shaft of Humerus: 17 years Medial epicondyle to the shaft: 18 years

Head of radius to the shaft: 16 years

Camp and Cilley(1931) made a radiological study of important human bones and their epiphyses and represented their finding in a diagrammatic chart.¹⁴

Material and methods

This study was conducted at the department of Anatomy with the help of department of Radiology, at Patna medical college and Hospital Patna, Bihar. Study duration of Two years. The material for study consisted of 100 subjects between the age of 11 and 18 years. It included 52 boys and 48 girls. 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. Proforma was devised to collect all relevant information of subjects. The information regarding certain relevant like name, age, sex, height, weight were included. Then subjects were then taken for radiological examination. After making the subjects seated on a stool of convenient height X-rays of the right elbow joint were taken in antero-posterior view and lateral view. The students are divided in seven groups according to the age. i.e. 11 -12 years; 12-13 years; 12 -13 years; 13 -14 years; 14 -15 years; 15 -16 years; 16 -17 years; 17 -18 years.

For conducting the study a proforma was devised to collect all concerned information from the subjects. The physical findings like the height, weight, eruption of teeth and signs of puberty were also noted.

Inclusion criteria

The subjects are from north Karnataka region, 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

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, The observations of epiphyseal union of lateral epicondyle with capitulum are shown in the table 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 age group and not chi-square test value. The values are as below for each age group.

- (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

Observation in males: Average age of epiphyseal union was: 15- 16 years Range of union was: 15- 18 years

Observation in females: Average age of epiphyseal union was: 12 -13 years Range of union was: 12-13 years

The observations of epiphyseal union of medial epicondyle with the shaft are shown in the table 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) No statistics are computed because F is a constant
- (b) P value = 0.002
- (c) P value = 0.035
- (d) P value= 0.015
- (e) P value= 0.020
- (f) P value= 0.038

(g) No statistics are computed because F is a constant.

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

Observation in Males: Average age of epiphyseal union was: 17- 18 years Range of union was: 16- 18 years, Observation in females: Average age of union was: 14 -15 years Range of union was: 12-17 years. The observations of epiphyseal union of upper end of radius with the shaft are shown in the table 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) No statistics are computed because F is a constant
- (b) P value = 0.035
- (c) P value = 0.035
- (d) P value= 0.002
- (e) P value= 0.001
- (f) P value= 0.123

(g) No statistics are computed because F is a constant.

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

Observation in Males: Average age of epiphyseal union was: 17- 18 years Range of union was: 16- 18 years Observation in females: Average age of union was: 14 -15 years Range of union was: 12-16 years



X-ray no.1 Male 11yrs L.E.: -, C.T.: -, D.C.E.: - M.E.: -, U.R.: -, U.U.

Discussion

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 Flecker¹⁴(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. Hepworth¹⁰ (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- 14years. 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. Basu & Basu (1938) found the age of fusion as 12- 13 years in Bengali females similar to the present study. 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- 14years this is seen delayed by one year by age when compared to the present study. Kothari (1972) studied the age of fusion as 14- 15 years in males and 11-12 years in females in Rajasthan which is 1 year earlier fusion in girls than in northeast Karnataka. R.S. Jnanesh, S Thangaraj Thomas (2006) recorded age of fusion in Karnataka in males at 15-16 years and in females at 12-13 years which is similar results as our 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 16years in males that is earlier than compared to present study. Basu and Basu (1938) noted the age of fusion as 12.5-13 years in Bengali girls and Sharma (1962) study in Uttar Pradesh found age of union as 15.5- 16.5 years in males and 12-13 years in females which are similar to present study except in boys it's delayed in 1-2 years in the present study. 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. In Australia the study by Flecker¹⁴ (1932) showed fusion 1 year earlier in males and at same age in females. Pillai¹⁵(1936) recorded the age of fusion in Madrasi 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 Basu¹⁶(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. The results also tally with the study of Kothari (1969) done in Rajasthan in case of girls but in boys Krishna Reddy¹⁹ (1973) observed the age of fusion to be earlier by 2-3 years compared to the present study. But Sharma¹⁷(1962) observed that the age of fusion was 6 months in advance in both sexes to the present study. When compared to Franklin's study¹⁸ (1962) in Maharashtra showed results the present study showed that the fusion the girls showed delay by 1 year. The results of Kothari²⁰(1972) in Rajasthan conclude the age of fusion was 1 year in advance to the present study. In Andhra Pradesh the study carried out by Krishna

Reddy¹⁹ (1973) it shows the age of fusion was earlier by 2-3 years in males and same age of fusion in females as of the present study.

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. After the results obtained proportions applied and statistical analyses using (proportions and Fischer exact test) was done. After statistical analyses the conclusion was derived. The conclusion was the average age of epiphyseal union was found to be earlier in females than in the males.

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. Stevenson P.H. age order of epiphyseal union in man. Am. Jr. Phys. Anthropol. 7.53-93
7. 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.
8. Paterson RS. A radiological investigation of the epiphyses of the long bones. J Anat. 1929;64:28-46
9. 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
10. Galstaun G. A study of ossification as observed in Indian subjects. Indian J Med Res. 1937; 25:267-324
11. Sidhom G. and Derry D.E. Dates of union of some epiphyses in Egyptian from X-ray photographs. J. Anat 1931; 65: 196-211.
12. Sidhom G. and Derry D.E. Dates of union of some epiphyses in Egyptian from X-ray photographs. J. Anat 1931; 65: 196-211.
13. Flecker H. Time of appearance and fusion of ossification centers as observed by Roentgenographic methods. American Journal of Roentgenology 1942;47: 97-159.
14. Pillai MJS. The study of epiphyseal union for determining the age of South Indians. Indian J Med Res. 1936;23:1015-1017.
15. Basu S.K. and Basu S. A contribution to the study of diaphyseal relation at the elbow of young Bengali girls. J Ind Med Ass. 1938;8:571-574
16. Sharma J.M. observations on the union of epiphyses of elbow and wrist in inhabitants of Uttar Pradesh, J Ass Physicians India: 1969,17: 57.
17. Franklin C.A. Radiological study of epiphyseal union in forensic medicine, Lucknow university Lucknow, 1962.

18. Reddy KSN. The synopsis of forensic medicine and toxicology. 8th Ed.K SagunaDevi 1992: 41.
19. Kothari D.R. Epiphyseal union of elbow and wrist joints in Marwar region of Rajasthan. Jr. Ind. Med. Ass. 1974 ; 63 : 252 -255