

# Age Estimation from Radiological Evaluation of Epiphyseal Union of Related Bones Around Elbow Joint: A Cross Sectional Study from Central India (Chhattisgarh)

Aloke Mazumder<sup>1</sup>, Ninad Nagrale<sup>2</sup>

<sup>1</sup>Associate Professor, Forensic Medicine & Toxicology, Malda Medical College, Malda (WB), <sup>2</sup>Associate Professor, Forensic Medicine & Toxicology, Shri Shankaracharya Institute of Medical Sciences, Bhilai (CG)

## Abstract

Radiological evaluation of the skeletal age represents an important tool for the estimation of the chronological age in the living. The aim of our study was to evaluate the relationship between the chronological age and degree of epiphyseal fusion around elbow joint in population of Chhattisgarh (Central India) and to compare our results with the results of similar studies. The study was carried out in 100 healthy subjects (40 girls and 60 boys) aging from 13 to 20 years. The obtained results from the radiographs revealed that the complete fusion of epiphysis of elbow joint is seen at 16-20 years. Females were consistently developing epiphyseal union at a younger age than their male counterparts. Results also suggest that the age of epiphyseal union is found to vary greatly all over the world indicating the need for separate standards of age of epiphyseal union for separate regions.

**Key Words:** epiphyseal union, elbow joint, distal end of humerus.

## Introduction

Accurate age estimation of living persons provides an authentic official document to prove their chronological age, important for humanitarian, administrative & legal purposes. Radiographic evaluation of the skeletal age is one of the most reliable methods of the four pillars for age estimation. Nevertheless this method is only an estimate, having an inherent degree of error due to variation in human skeletal development. The aim of our study was to evaluate the relationship between the chronological age and the degree of epiphyseal fusion around elbow joint in population of Chhattisgarh (Central India) and to compare our results with the results of similar studies. Present study has been undertaken in an indigenous population of Chhattisgarh from ossification around elbow joint radiographically.

## Aims & Objectives

5. To evaluate age specific difference in epiphyseal union at elbow joint.
6. To estimate age from epiphyseal union at elbow joint.
7. To compare bisexual difference in epiphyseal union at elbow joint.
8. To compare the findings in the epiphyseal union at elbow joint in Central Indian population with other parts of India on the basis of previous studies.

## Material & Method

The present study was carried out in the Department of Forensic Medicine & Department of Radiology, SSIMS, Bhilai, Chhattisgarh (Central India). A total of 100 individuals participated in this study. The subjects included were students of 13-20 years of age from schools & colleges from Bhilai city. They are born to parents living in Central India and have lived here since birth. The subjects do not have any disease/deformity pertaining to bones or chronic disease affecting the general health. An informed consent was taken from all subjects prior to each investigation.

---

### Corresponding author:

**Ninad Nagrale**

Associate Professor, Forensic Medicine & Toxicology, Shri Shankaracharya Institute of Medical Sciences, Bhilai (CG)

**Procedure of Radiography:** After taking written consent, thorough physical examination & radiological evaluation was done. X-Rays of right elbow joint were taken with the help of X-Ray machine in the Department of Radiology. Minimum shots were taken to expose the joints involved in study. Minimum & appropriate voltage settings of X-Ray machine were applied so as to avoid unnecessary radiation exposure of the subjects. All the radiological procedure was undertaken according to the

prescribed standards. Skeletal maturity was evaluated according to the Jit & Kulkarni's<sup>17</sup> classification of four stages: Appearance, Non fusion, Partial fusion & Complete fusion ("A", "NF", "PF", "CF" respectively). The master chart was prepared and tabulated as per code given above. It was classified, analysed and compared with known standards. At the end conclusions were drawn, which were compared with available results of various previous studies.

## Results

**TABLE 1: Age and gender wise distribution of subjects.**

Age in years	Males		Females	
	No	%	No	%
13-14	6	10	4	10
14-15	7	11.67	4	10
15-16	9	15	8	20
16-17	10	16.67	7	17.5
17-18	12	20	7	17.5
18-19	8	13.33	5	12.5
19-20	8	13.33	5	12.5
Total	60	100	40	100

**Table 2: Epiphyseal Fusion of the Composite epiphysis (Capitulum and Lateral region of Trochlea, Medial region of Trochlea, Lateral Epicondyle) with shaft of humerus:**

Age (years)	Males			Females		
	NF	PF	CF	NF	PF	CF
13-14	2 (3.33%)	4 (6.67%)	0 (0%)	0 (0%)	2 (5%)	2 (5%)
14-15	0 (0%)	2 (3.33%)	5 (8.33%)	0 (0%)	1 (2.5%)	3 (7.5%)
15-16	0 (0%)	2 (3.33%)	7 (11.67%)	0 (0%)	0 (0%)	8 (20%)
16-17	0 (0%)	0 (0%)	10 (16.67%)	0 (0%)	0 (0%)	7 (17.5%)
17-18	0 (0%)	0 (0%)	12 (20%)	0 (0%)	0 (0%)	7 (17.5%)
18-19	0 (0%)	0 (0%)	8 (13.33%)	0 (0%)	0 (0%)	5 (12.5%)
19-20	0 (0%)	0 (0%)	8 (13.33%)	0 (0%)	0 (0%)	5 (12.5%)
Total	60 (100%)			40 (100%)		

In males, composite epiphysis shows: non fusion in 2 (3.33%) cases in age group of 13-14 years, partial fusion in 8 (13.33%) cases in age group of 13-16 years

& complete fusion in 50 (83.33%) cases in age group of 14-20 years. Complete fusion is seen in all the subjects

in age group of 16-20 years.

In females, composite epiphysis shows: partial fusion in 3 (7.5%) cases in age group of 13-15 years & complete fusion in 37 (92.5%) cases in age group of 13-20 years. Complete fusion is seen in all the subjects in age group of 15-20 years.

**Table 3: Epiphyseal fusion of Medial Epicondyle with shaft of humerus:**

Males				Females		
Age (years)	NF	PF	CF	NF	PF	CF
13-14	1 (1.67%)	5 (8.33%)	0 (0%)	1 (2.5%)	3 (7.5%)	0 (0%)
14-15	0 (0%)	5 (8.33%)	2 (3.33%)	0 (0%)	2 (5%)	2 (5%)
15-16	0 (0%)	2 (3.33%)	7 (11.67%)	0 (0%)	1 (2.5%)	7 (17.5%)
16-17	0 (0%)	0 (0%)	10 (16.67%)	0 (0%)	0 (0%)	7 (17.5%)
17-18	0 (0%)	0 (0%)	12 (20%)	0 (0%)	0 (0%)	7 (17.5%)
18-19	0 (0%)	0 (0%)	8 (13.33%)	0 (0%)	0 (0%)	5 (12.5%)
19-20	0 (0%)	0 (0%)	8 (13.33%)	0 (0%)	0 (0%)	5 (12.5%)
Total	60 (100%)			40 (100%)		

In males, Medial Epicondyle shows: non fusion in 1 (1.67%) cases in age group of 13-14 years, partial fusion in 12 (20%) cases in age group of 13-16 years & complete fusion in 47 (78.33%) cases in age group of 14-20 years. Complete fusion is seen in all the subjects in age group of 16-20 years.

In females, Medial Epicondyle shows: non fusion in 1 (2.5%) cases in age group of 13-14 years, partial fusion in 6 (15%) cases in age group of 13-16 years & complete fusion in 33 (82.5%) cases in age group of 14-20 years. Complete fusion is seen in all the subjects in age group of 16-20 years.

**Table 4: Epiphyseal fusion of Head of Radius:**

Males				Females		
Age (years)	NF	PF	CF	NF	PF	CF
13-14	3 (5%)	3 (5%)	0 (0%)	1 (2.5%)	3 (7.5%)	0 (0%)
14-15	1 (1.67%)	6 (10%)	0 (0%)	0 (0%)	2 (5%)	2 (5%)
15-16	0 (0%)	3 (5%)	6 (10%)	0 (0%)	0 (0%)	8 (20%)
16-17	0 (0%)	0 (0%)	10 (16.67%)	0 (0%)	0 (0%)	7 (17.5%)
17-18	0 (0%)	0 (0%)	12 (20%)	0 (0%)	0 (0%)	7 (17.5%)
18-19	0 (0%)	0 (0%)	8 (13.33%)	0 (0%)	0 (0%)	5 (12.5%)
19-20	0 (0%)	0 (0%)	8 (13.33%)	0 (0%)	0 (0%)	5 (12.5%)
Total	60 (100%)			40 (100%)		

In males, Head of Radius shows: non fusion in 4 (6.67%) cases in age group of 13-15 years, partial fusion in 12 (20%) cases in age group of 13-16 years & complete fusion in 44 (73.33%) cases in age group of 15-20 years. Complete fusion is seen in all the subjects in age group of 16-20 years.

In females, Head of Radius shows: non fusion in 1 (2.5%) cases in age group of 13-14 years, partial fusion in 5 (12.5%) cases in age group of 13-15 years & complete fusion in 34 (85%) cases in age group of 14-20 years. Complete fusion is seen in all the subjects in age group of 15-20 years.

**Table 5: Epiphyseal fusion of olecranon process of ulna:**

Males				Females		
Age (years)	NF	PF	CF	NF	PF	CF
13-14	2 (3.33%)	4 (6.67%)	0 (0%)	2 (5%)	2 (5%)	0 (0%)
14-15	1 (1.67%)	6 (10%)	0 (0%)	0 (0%)	2 (5%)	2 (5%)
15-16	0 (0%)	3 (5%)	6 (10%)	0 (0%)	0 (0%)	8 (20%)
16-17	0 (0%)	0 (0%)	10 (16.67%)	0 (0%)	0 (0%)	7 (17.5%)
17-18	0 (0%)	0 (0%)	12 (20%)	0 (0%)	0 (0%)	7 (17.5%)
18-19	0 (0%)	0 (0%)	8 (13.33%)	0 (0%)	0 (0%)	5 (12.5%)
19-20	0 (0%)	0 (0%)	8 (13.33%)	0 (0%)	0 (0%)	5 (12.5%)
Total	60 (100%)			40 (100%)		

In males, olecranon process shows: non fusion in 3 (5%) cases in age group of 13-15 years, partial fusion in 13 (21.67%) cases in age group of 13-16 years & complete fusion in 38 (63.33%) cases in age group of 15-20 years. Complete fusion is seen in all the subjects in age group of 16-20 years.

In females, olecranon process shows: non fusion in 2 (5%) cases in age group of 13-14 years, partial fusion in 4 (10%) cases in age group of 13-15 years & complete fusion in 34 (85%) cases in age group of 14-20 years. Complete fusion is seen in all the subjects in age group of 15-20 years.

### Discussion

**Table 6: Showing comparison of ages (years) of union of epiphyses around Elbow joint given by various workers with findings of present study:**

Researcher	Composite epiphysis		Medial epicondyle		Radial head		Ulnar Olecranon	
	Male	Female	Male	Female	Male	Female	Male	Female
Lal & Nat (1934) (U.P.)1	17	-	-	-	17	-	-	-
MJS Pillai (1936) (South India)2	14	14	17	17	17	17	-	-
Galstaun (1937) (Bengal)3	16	14	16	14	16-17	14-15	16	15
Basu & Basu (1938) (Bengal)4	-	13-14	-	13 ½ -14	-	13 ½ -14	-	13 -14
Lal & Townsend (1939) (U.P.)5	-	15	-	-	-	16	-	-
Gupta et al (1974) (U.P.)6	-	-	18-19	17-18	16-17	17-18	-	-
Sahni & Jit (1995) (Punjab)7	-	-	-	16	-	16	-	-
Nemade K et al (2007) (Vidarbha)8	16-17	14-15	17-18	15-16	17-18	15-16	-	-
Sidhom & Derry (1931) (Egyptian)9	17-18	20-21	-	-	19-20	-	-	-
Ledger & Wasson (1941) (Pakistan)10	14-15	14-15	17-18	14-15	17-18	14-15	-	-
Frazer (1958) (European)11	17	14	18	15	16-17	14-15	-	-
Gray (1995) (European)12	16	14	20	20	17	14	-	-
Present study	16-17	15-16	16-17	16-17	16-17	15-16	16-17	15-16

**Composite epiphysis:** The observations of present study for males, matches with works of Lal & Nat (1934)<sup>1</sup> in Uttar Pradesh, Nemade K et al (2007)<sup>8</sup> in Vidarbha, Sidhom & Derry (1931)<sup>9</sup> in Egyptians & Frazer (1958)<sup>11</sup> in Europeans. For females, the observations match with the findings of MJS Pillai (1936)<sup>2</sup> in South Indians, Galstaun (1937)<sup>3</sup> in Bengalis, Basu & Basu (1938)<sup>4</sup> in Bengalis, Lal & Townsend (1939)<sup>5</sup> in Uttar Pradesh, Nemade K et al (2007)<sup>8</sup> in Vidarbha & Ledger & Wasson (1941)<sup>10</sup> in Pakistani population.

**Medial epicondyle:** The observations of present study for males, matches with work of MJS Pillai (1936)<sup>2</sup> in South Indians, Galstaun (1937)<sup>3</sup> in Bengalis, Nemade K et al (2007)<sup>8</sup> in Vidarbha & Ledger & Wasson (1941)<sup>10</sup> in Pakistani population. For females, the observations match with the findings of MJS Pillai (1936)<sup>2</sup> in South Indians, Gupta et al (1974)<sup>6</sup> in Uttar Pradesh, Sahni & Jit (1995)<sup>7</sup> in Punjabis, Nemade K et al (2007)<sup>8</sup> in Vidarbha & Ledger & Wasson (1941)<sup>10</sup> in Pakistani population.

**Radial head:** The observations of present study for males, matches with work of Lal & Nat (1934)<sup>1</sup> in Uttar Pradesh, MJS Pillai (1936)<sup>2</sup> in South Indians, Galstaun (1937)<sup>3</sup> in Bengalis, Gupta et al (1974)<sup>6</sup> in Uttar Pradesh, Nemade K et al (2007)<sup>8</sup> in Vidarbha, Ledger & Wasson (1941)<sup>10</sup> in Pakistani population, Frazer (1958)<sup>11</sup> in Europeans & Gray (1995)<sup>12</sup> in Europeans. For females, the observations match with the findings of Galstaun (1937)<sup>3</sup> in Bengalis, Lal & Townsend (1939)<sup>5</sup> in Uttar Pradesh, Sahni & Jit (1995)<sup>7</sup> in Punjabis, Nemade K et al (2007)<sup>8</sup> in Vidarbha, Ledger & Wasson (1941)<sup>10</sup> in Pakistani population & Frazer (1958)<sup>11</sup> in Europeans.

**Ulnar Olecranon:** The observations of present study for both males & female, matches with work of Galstaun (1937)<sup>3</sup> in Bengalis.

### Summary and Conclusions

9. This study was conducted exclusively on the young indigenous population of Chhattisgarh region.

10. The epiphyseal union of bones at right elbow joint in males is completed in all instances (100%) at the age of 16-20 years.

11. The epiphyseal union of bones at right elbow joint in females is completed in all instances (100%) at the age of 15-20 years.

12. As the sample size is limited, further studies are necessary. Region wise studies should be conducted for

better correlation and comparison.

13. Due to changing lifestyle pattern, dietary, climatic, behavioral factors, age of ossification is changing as mentioned in the available literature. So as to evaluate these changes, studies are recommended in every region of India at regular time period for academic and judicial interest.

14. The opinion about age should be given always in the range. From this study it can be concluded that the opinion about age can be given in a range having margin of error of 1-2 years.

15. Radiological interpretations are observer dependent so the set standards should be considered under expert guidance to arrive at conclusion in such radiological studies.

16. For estimation of age, relevant joints should be radiologically examined for different centres and opinion should be arrived considering the status of multiple centres.

**Ethical Clearance-** Taken from institutional ethical committee.

**Source of Funding-** Self.

**Conflict of Interest-** Nil.

### References

1. Lal R. and Nat B.S. Ages of epiphyseal union at the elbow and wrist joints amongst Indians. Indian J. Med. Res. 1934; 21: 683-689.
2. M. J.S. Pillai. The study of epiphyseal union for determining the age of South Indians. Indian J. Med. Res. 1936; 23: 1015-1017, 1936.
3. Galstaun G. Some notes on the union of epiphyses in Indian girls. Indian Med. Gaz. 1930; 65:191-19
4. Basu S.K. and Basu S. The age-order of epiphyseal union in Bengalee girls (a preliminary study). J. Indian M.A. 1938; 571-578.
5. Lal R. and Townsend R.S. Ages of epiphyseal union at the elbow and wrist joints amongst Indian Girls. Indian Med. Gaz. 1939 Oct.: 614-615.
6. Gupta et. al. A roentgenologic study of epiphyseal union around elbow, wrist and knee joints and pelvis in Boys and Girls of Uttar Pradesh. J. Indian M.A. 1974; 62: 10- 12.
7. Sahni D. and Jit I. Time of fusion of epiphyses

- at the elbow and wrist joints in girls of northwest India. *Forensic Sci Int.* 1995; 74(1-2): 47-55.
8. Nemade K, Kamdi N et al. The Age Order of Epiphyseal Union around Elbow Joint - A Radiological Study in Vidarbha. *International Journal of Recent Trends in Science And Technology*, 2014; 10(2): 251-255.
  9. Sidhom G. and Derry D.E. Dates of union of some epiphyses in Egyptian from X-ray photographs. *J. Anat* 1931; 65: 196-211.
  10. Ledger L.K. and Wasson T.C. Ages of epiphyseal union at the elbow and wrist joints amongst 238 children in North-West Frontier Province. *Ind. Med. Gaz.* 1941; 76: 81.
  11. Breathnach A.S. Editor of Frazer's Anatomy of human 5<sup>th</sup> ed. London: J.A. Churchill Ltd: page no. 77, 87, 118, 127, 142, 1958.
  12. Bannister L.H. Editor of Gray's Anatomy Descriptive and applied 38<sup>th</sup> Ed. 1995; Page no. 626, 636, 639, 669, 684, 697, 711.
  13. Davies D.A. and Parsons P.G. Age order of appearance and union of the normal epiphyses as seen by X-rays. *J. Anat* 62 1927; 58-71.
  14. Paterson R.S. Radiological investigation of the epiphyses of the long bones. *J. Anat* 1929; 64: 28-46.
  15. Pryor J.W. Differences in the time of development of the centres of ossification in the male and female skeleton. *Anat. Rec.* 1923; 25: 252-273.
  16. 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. Anthrop.* 1933; 8: 401-41.
  17. Jit I, Kulkarni M. Time of appearance and fusion of epiphysis at medical end of clavicle. *Indian J Med Res* .1976 May; 64(5):773-82