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A RADIOLOGICAL STUDY: AGE ESTIMATION BY MEASUREMENT OF EPIPHYSIS OF LOWER END OF RADIUS AND ULNA BONE

Ravindra Kumar[1], Vimal Modi[2]

1.PhD Scholar, Department of Anatomy, Index Medical College, Hospital and Research Centre, Malwanchal University, Indore (M.P),
2.Professor, Department of Anatomy, Index Medical College, Hospital and Research Centre, Malwanchal University, Indore (M.P),

Abstract

INTRODUCTION: It is not possible to enunciate a hard and fast rule for age determination from this union for the whole India because India is composed of areas which differ in climatic, dietetic and disease factors which affect skeletal growth. The present a radiological study was carried out age estimation by measurement of carpal and epiphyses of Radius and ulna. AIM AND OBJECTIVE: To estimate average age of fusion of ossification centres at lower end of radius, ulna and carpal bones in population of North Indian population. To estimate average age of fusion of ossification centres at lower end of radius and ulna in male population. METHOD AND MATERIALS: This hospital-based study was conducted in Department of Anatomy and Department of Radio diagnosis, Index Medical College, Hospital and Research Centre Indore MP, India. The subjects were explained about the procedure and written informed consent was taken. The detailed physical examination was done and data regarding patient's particulars like age, sex, clinical history etc. was taken on pre designed proforma. The radiography in the form of X-rays and USG was done. The ultra-sonographic scan of individual subject was evaluated with respect to the stage of epiphyseal ossification followed by evaluation of radiographic grade. RESULT: Shows the association of male age with stages of fusion of lower end of radius in males and it was found that as the age increases the stage of fusion also increases (i.e., at 10-12 years 15.8% males were having grade I lower end of radius whereas at 18.1-20 years of 100.0% were having grade3 fusion of lower end of radius. CONCLUSION: The age increases the stage of fusion also increases (i.e., at 10-12 years 15.8% males were having grade I lower end of radius whereas at 18.1-20 years of 100.0% were having grade3 fusion of lower end of radius. The age increases the stage of fusion also increases (i.e., at 10-12 years 23.8% females were having grade I lower end of radius whereas at 18.1-20 years of 100.0% were having grade 3 fusion of lower end of radius.

Keywords- Age estimation, X-rays, Ossification, Radius, Ulna

INTRODUCTION

Skeletal age reflects the maturity of an individual, and skeletal age assessment is commonly used to judge the actual age of a person. Aside from dental eruption, of particular importance for age determination in young children is the development of wrist bones.[1] 4 Carpal bones are useful in determining the skeletal age of individuals and assessing their growth status. This is particularly of great importance for pediatricians to diagnose metabolic or endocrine disorders. Medico-legally, it is necessary to estimate the bone age in case no birth certificate has been issued.[2,3]

Standard anatomy literature describes a specific pattern of development of carpal bones. The first bones to ossify are the capitate and hamate, and this occurs during the first year of life. The triquetral is next to appear arising during the third year of life and the lunate appears on the fourth year of life. The scaphoid develops in the fifth year, and the trapezium and trapezoid appear in the sixth year. The last one to appear is the pisiform, which occurs in the twelfth year of life. Other literature describes a much earlier ossification of pisiform, that is, in the

ninth year of life.[4,5] In general, the ossification of carpal bones and other bones of the hand occurs earlier in females than in males.

Variations occur among populations with regard to the time of appearance of ossification centres in different bones of the hand and wrist. The literature has documentations for the specific time of appearance of bones for some population types, including American Caucasian, Indian, Pakistani, Nigerian, Sudanese, and Western Australian.[6,7,8,9,10,11,12]

The Indian population differs widely from the western population in hereditary, dietary, socioeconomic and ethnic factors. Studies done in India are few. Galstaun, in 1930 and 1937 has done a study in Bengali population. Bajaj in 1967 has done a study in Delhi. Other studies done in India are Pillai (Madarasis) in 1936, Hepworth (Punjabis) in 1929, Basu and Basu (Bengalis) in 1938, Kalpesh shah in 1991 and G. J. Patel in 2009 (in Gujaratis), which are all based on the fusion of ossification centres.[13,14,15,16,17,18,19,20]

Good correlation between skeletal age and calendar age is used for forensic purposes, especially for personal identification. This problem is of particular significance in the Indian community, as a result of the large number of illegal immigrants without documents where age is unknown or unclear. Determination of the age of an individual from the appearance and the fusion of the ossification centres is a well-accepted fact in the field of medical and legal professions. Carpal and Epiphysis of bones unites during age periods which are remarkably constant for a particular epiphysis. The determination of age presents a task of considerable importance from the view-point of the administration of justice. It is not possible to enunciate a hard and fast rule for age determination from this union for the whole India because India is composed of areas which differ in climatic, dietetic and disease factors which affect skeletal growth. The present a radiological study was carried out age estimation by measurement of carpal and epiphyses of Radius and ulna.

MATERIAL & METHODS

This cross-sectional study was conducted in the Department of Anatomy with collaboration of department of Radio diagnosis, Index Medical College, Hospital and Research Centre Indore MP, India from January 2021 to December 2022 after approval of Institutional Ethical committee. The study population included 300 patients (150 males and 150 females) of 6 to 20 years of age who was required the age estimation based on radiography according to measurement of carpal & epiphyses of Radius and ulna and compared it by their original age.

Study design: A cross-sectional study

Study subjects: The subjects free from any physical disability involving upper limbs was included in the study.

Study location: This hospital-based study was conducted in Department of Anatomy and Department of Radio diagnosis, Index Medical College, Hospital and Research Centre Indore MP, India.

Study Duration: January 2021 to December 2022 (24 months).

Sample Size: 300 patients

Finally in this study, was including 300 women. Sample size was estimated using software Power analysis and sample size, version 8 (PASS-2008).

Inclusion criteria:

- Subjects aged 6-20 years with age proof
- Both male and female.

Exclusion criteria: Patients excluded with-

- Subjects having age less than 6 years and more than 20 years
- Subjects showing any sign of disease affecting skeletal maturation.
- Subjects with history or any stigmata of previous fractures of bones (of and around the pelvis).
- Subjects with nutritional, endocrine disorders, chronic infections etc.

Study tool/ Patient's data acquisition

- Predesigned proforma
- Consent form
- Ultrasonic equipment for sonography
- X-ray machine (DR 100e Mobile X Ray System, Brand-Agfa Healthcare)

Procedure methodology:

The subjects were explained about the procedure and written informed consent was taken. The detailed physical examination was done and data regarding patient's particulars like age, sex, clinical history etc. was taken on pre designed proforma.

The radiography in the form of X-rays and USG was done. The ultra-sonographic scan of individual subject was evaluated with respect to the stage of epiphyseal ossification followed by evaluation of radiographic grade.

Ultrasonological and clinical examination: Each subject was examined ultrasonologically for wrist joint of both limb in the Department of Radiology and subsequently, the ultra-sonogram was studied in detail by the radiologist with respect to fusion of various ossification centres. The ultra sonography was done by ultra sonographic machine. (**Ultrasound Color Doppler System, *Model*: DCU-12)**

1. Radiographic positioning of the parts: Anteroposterior position of the wrist joint of right hand was used. The radiographers were advised to take care that lower end of ulna and radius should be viewed in the film of wrist joint in order to visualize clearly all the ossification centres.

2. Radiographic factors: The skiagrams of elbow joint of right hand was taken in film of 8-10 mA/Sec at 45 to 55 k. v. The Hindustan photo film screen sensitive films of 15”x10” for pelvis and 10”x8” for hand was used by optimum processing method.

Statistical Analysis

Data was analysed using Statistical Package for Social Sciences, version 20 (SPSS Inc., Chicago, IL). Results for continuous variables was presented as mean ± standard deviation, whereas results for categorical variables was presented as frequency/number (percentage). Risser’s score was also used for comparison of Xray and USG findings. Inter class correlation was done on the basis on Wilcoxon Signed Ranks Test. The level $P < 0.05$ was considered as the cutoff value or significance.

RESULT

This prospective study was carried out in the Department of Anatomy with collaboration of department of Radio diagnosis, Index Medical College, Hospital and Research Centre Indore MP. Patients of 6-20 years of age were included. Relevant data about patient’s name, age, sex and clinical history were noted.

Table No.1: Age of fusion in years of epiphyses of distal end of radius

Age Group (years)	Male (n=150)	With Epiphyseal Fusion	Female (n=150)	With Epiphyseal Fusion
6-8	22 (14.7%)	0 (0.0%)	21 (14.0%)	0 (0.0%)
8.1-10	21 (14.0%)	0 (0.0%)	22 (14.7%)	0 (0.0%)
10-12	19 (12.7%)	0 (0.0%)	21 (14.0%)	0 (0.0%)
12.1-14	19 (12.7%)	0 (0.0%)	26 (17.3%)	15 (57.7%)
14.1-16	24 (16.0%)	11 (45.8%)	21 (14.0%)	16 (76.2%)
16.1-18	23 (15.3%)	19 (82.6%)	19 (12.7%)	17 (89.5%)
18.1-20	22 (14.7%)	22 (100.0%)	20 (13.3%)	20 (100.0%)

The following table shows the association of age with gender and with epiphyseal fusion of distal end of radius and it was found that the epiphyseal fusion in males were start after the age 14.1-16 years group while in female it was started in 12.1-14 rears age group.

Table No. 2: showing distribution of cases according to Degrees of fusion of lower end of radius in male

Age Group (years)	Male (n=150)	Degrees of fusion of lower end of radius in males			
		Degree 0	Degree 1	Degree 2	Degree 3
6-8	22	22 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
8.1-10	21	21 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
10-12	19	16 (84.2%)	2 (15.8%)	0 (0.0%)	0 (0.0%)
12.1-14	19	5 (26.3%)	10 (52.6%)	4 (21.1%)	0 (0.0%)
14.1-16	24	0 (0.0%)	6 (25.0%)	18 (75.0%)	0 (0.0%)
16.1-18	23	0 (0.0%)	0 (0.0%)	8 (24.8%)	15 (75.2%)
18.1-20	22	0 (0.0%)	0 (0.0%)	0 (0.0%)	22 (100.0%)

The following table shows the association of male age with stages of fusion of lower end of radius in males and it was found that as the age increases the stage of fusion also increases (i.e., at 10-12 years 15.8% males were having grade I lower end of radius whereas at 18.1-20 years of 100.0% were having grade3 fusion of lower end of radius.

Table No. 3: showing distribution of cases according to Degrees of fusion of lower end of radius in female

Age Group (years)	Female (n=150)	Degrees of fusion of lower end of radius in females			
		Degree 0	Degree 1	Degree 2	Degree 3
6-8	21	21 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
8.1-10	22	22 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
10-12	21	16 (76.2%)	5 (23.8%)	0 (0.0%)	0 (0.0%)
12.1-14	26	2 (7.7%)	19 (73.1%)	5 (19.2%)	0 (0.0%)
14.1-16	21	0 (0.0%)	4 (21.1%)	14 (66.7%)	3 (14.3%)
16.1-18	19	0 (0.0%)	0 (0.0%)	4 (21.1%)	15 (78.9%)
18.1-20	20	0 (0.0%)	0 (0.0%)	0 (0.0%)	20 (100.0%)

The following table shows the association of female age with stages of fusion of lower end of radius in females and it was found that as the age increases the stage of fusion also increases (i.e., at 10-12 years 23.8% females were having grade I lower end of radius whereas at 18.1-20 years of 100.0% were having grade 3 fusion of lower end of radius.

Table No.4: Age of fusion in years of distal epiphyses of Ulna in male and female

Age Group (years)	Total Male (n=150)	With Epiphyseal Fusion	Total Female (n=150)	With Epiphyseal Fusion
6-8	22 (14.7%)	0 (0.0%)	21 (14.0%)	0 (0.0%)
8.1-10	21 (14.0%)	0 (0.0%)	22 (14.7%)	0 (0.0%)
10-12	19 (12.7%)	0 (0.0%)	21 (14.0%)	0 (0.0%)
12.1-14	19 (12.7%)	0 (0.0%)	26 (17.3%)	0 (0.0%)
14.1-16	24 (16.0%)	5 (20.8%)	21 (14.0%)	12 (57.1%)
16.1-18	23 (15.3%)	15 (65.2%)	19 (12.7%)	17 (89.5%)
18.1-20	22 (14.7%)	22 (100.0%)	20 (13.3%)	20 (100.0%)

The following table shows the association of age with gender and with epiphyseal fusion of distal epiphyses of Ulna and it was found that the epiphyseal fusion in males were start in the age 14.1-16 years group was 5 (20.8%) children; while in female it was started in 14.1-16 years age group it was noted in 57.1% children.

Table No. 5: showing distribution of cases according to Degrees of fusion of lower end of ulna in female

Age Group (years)	Male (n=150)	Degrees of fusion of lower end of ulna in males			
		Degree 0	Degree 1	Degree 2	Degree 3
6-8	22	22 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
8.1-10	21	22 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
10-12	19	17 (89.5%)	2 (10.5%)	0 (0.0%)	0 (0.0%)
12.1-14	19	7 (36.8%)	9 (47.4%)	3 (15.8%)	0 (0.0%)
14.1-16	24	0 (0.0%)	9 (37.5%)	15 (62.5%)	0 (0.0%)
16.1-18	23	0 (0.0%)	0 (0.0%)	10 (43.5%)	13 (56.5%)
18.1-20	22	0 (0.0%)	0 (0.0%)	0 (0.0%)	22 (100.0%)

The following table shows the association of female age with stages of fusion of lower end of ulna in males and it was found that as the age increases the stage of fusion of lower end of ulna also increases (i.e., at 10-12 years

10.5% males were having grade 1 lower end of ulna whereas at 18.1-20 years of 100.0% were having grade 3 fusion of lower end of ulna.

Table No. 6: showing distribution of cases according to Degrees of fusion of lower end of ulna

Age Group (years)	Female (n=150)	Degrees of fusion of lower end of ulna in females			
		Degree 0	Degree 1	Degree 2	Degree 3
6-8	21	21 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
8.1-10	22	22 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
10.1-12	21	16 (76.2%)	5 (23.8%)	0 (0.0%)	0 (0.0%)
12.1-14	26	3 (11.5%)	17 (65.4%)	6 (23.1%)	0 (0.0%)
14.1-16	21	0 (0.0%)	6 (28.6%)	13 (61.9%)	2 (9.5%)
16.1-18	19	0 (0.0%)	0 (0.0%)	7 (36.8%)	12 (63.2%)
18.1-20	20	0 (0.0%)	0 (0.0%)	0 (0.0%)	20 (100.0%)

The following table shows the association of female age with stages of fusion of lower end of ulna in females and it was found that as the age increases the stage of fusion of lower end of ulna also increases (i.e., at 10-12 years 23.8% males were having grade 1 lower end of ulna whereas at 18.1-20 years of 100.0% were having grade 3 fusion of lower end of ulna.

DISCUSSION

The present cross-sectional study was conducted in the Department of Anatomy with collaboration of department of Radio diagnosis, Index Medical College, Hospital and Research Centre Indore MP, India from January 2021 to December 2022 after approval of Institutional Ethical committee. The study population included 300 patients (150 males and 150 females) of 6 to 20 years of age who were enrolled for age estimation based on radiography according to measurement of carpal & epiphyses of Radius and ulna and compared it by their original age. Subjects having age less than 6 years and more than 20 years, showing any sign of disease affecting skeletal maturation, with history or any stigmata of previous fractures of bones and with nutritional, endocrine disorders, chronic infections etc. were excluded from the study. The radiography in the form of X-rays and USG was done. The ultra-sonographic scan of individual subject was evaluated with respect to the stage of epiphyseal ossification

followed by evaluation of radiographic grade. **Srinivasulu K et al,[21] Khartade HK et al,[22] Patel DS et al,[23] Wankhade PA et al[24]** and **Kiran UB et al[25]** also opted similar methodology in their respective study.

In our study the epiphyseal fusion in males were start after the age 14.1-16 years group while in female it was started in 12.1-14 rears age group in case of radius. But in case of ulna epiphyseal fusion in males were start in the age 14.1-16 years group was 5 (20.8%) children; while in female it was started in 14.1-16 years age group it was noted in 57.1% children. **Rajdev BM et al[26]** reported that the fusion in the lower end of Radius started in the age group of 14-15yrs which is completed at 20 to 21 years, while fusion in the lower end of Ulna started in the age group of 14-15yrs which is completed at 19 to 21 years. **Al-Qtaitat A et al[27]** reported that the complete union of lower end of ulna is seen at 20-21 years. Females were consistently developing epiphyseal union at a younger age than their male counterparts, with a two years difference. **Hassan N et al[28]** reported the completion of epiphyseal fusion in lower end of radius in 100% males was noticed at 18–19 years and for 100% females, it was noticed at 17–18 years. The starting up of epiphyseal fusion in lower end of ulna in males was observed at 14–15 years in 10% of the male population and for females, it was observed at 13–14 years in 10% of the female population. The completion of epiphyseal fusion in lower end of ulna in 100% males was noticed at 18–19 years and for 100% females, it was noticed at 17–18 years. **Beryl S. Ominde et al[29]** reported that the distal radius fused completely at 18–19 and 17–18 years, distal ulna at 19–20 and 18–19, medial epicondyle fused at 17–18 and 16–17 years, head of radius at 16–17, and 15–16 years for males and females respectively. **Khartade HK et al[22]** reported that the age of fusion of lower end of radius and ulna is found to be 17-18 years in males of North East Madhya Pradesh. **Srinivasulu K et al[21]** reported that the ossification of lower end of radius completed at 17 to 18 years in females and 19 to 20 years in males, whereas ossification center of lower end of ulna ossified one year earlier than radius, it ossifies at 16 to 17 years in females and 18 to 19 years in males.

In this study we noted that the age increases the stage of fusion also increases (i.e., at 10-12 years 15.8% males were having grade I lower end of radius whereas at 18.1-20 years of 100.0% were having grade3 fusion of lower end of radius. The age increases the stage of fusion also increases (i.e., at 10-12 years 23.8% females were having grade I lower end of radius whereas at 18.1-20 years of 100.0% were having grade 3 fusion of lower end of radius. The age increases the stage of fusion of lower end of ulna also increases (i.e., at 10-12 years 10.5% males were having grade 1 lower end of ulna whereas at 18.1-20 years of 100.0% were having grade 3 fusion of lower end of ulna. The age increases the stage of fusion of lower end of ulna also increases (i.e., at 10-12 years 23.8% males were having grade 1 lower end of ulna whereas at 18.1-20 years of 100.0% were having grade 3

fusion of lower end of ulna. Our findings were comparable to a similar study **Patel DS et al**[23] they also reported that the females show early age of fusion as compared to male but this difference is less than one year. In another study **Rao BS & Khan MI**[30] also reported that the mean ages at ossification for stage I in males were found to be 12.90 years. At stage II they found the mean age of 15.18 years. In stage III they noted the mean age of 16.15 years and stage IV the mean age value at all ossification centres was 19.18 years. Similarly for females the mean values of all ossification centres at the stage I estimated the age of 14.12 years. In stage II the mean age estimated was 15.27 years and stage III the mean age estimated was 16.29 years and stage IV mean age estimated was 17.96 years.

CONCLUSION

- The epiphyseal fusion in males were start after the age 14.1-16 years group while in female it was started in 12.1-14 rears age group.
- The age increases the stage of fusion also increases (i.e., at 10-12 years 15.8% males were having grade I lower end of radius whereas at 18.1-20 years of 100.0% were having grade3 fusion of lower end of radius.
- The age increases the stage of fusion also increases (i.e., at 10-12 years 23.8% females were having grade I lower end of radius whereas at 18.1-20 years of 100.0% were having grade 3 fusion of lower end of radius.
- The epiphyseal fusion in males were start in the age 14.1-16 years group was 5 (20.8%) children; while in female it was started in 14.1-16 years age group it was noted in 57.1% children.
- The age increases the stage of fusion of lower end of ulna also increases (i.e., at 10-12 years 10.5% males were having grade 1 lower end of ulna whereas at 18.1-20 years of 100.0% were having grade 3 fusion of lower end of ulna.
- The age increases the stage of fusion of lower end of ulna also increases (i.e., at 10-12 years 23.8% males were having grade 1 lower end of ulna whereas at 18.1-20 years of 100.0% were having grade 3 fusion of lower end of ulna.

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