Age Estimation from Radiological Study of Epiphyseal Fusion Around Wrist Joint in Male Population of North East Madhya Pradesh

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Abstract

Apart from identification, determination of age is required in various civil and criminal cases. Age estimation by observing appearance and fusion of ossification centres is most accurate and reliable method which is implemented universally. However, it is not possible to establish a uniform standard for age estimation from appearance and fusion of ossification centres for whole India as there is disparity in the timing of appearance and fusion of ossification centres in Indian population due to various factors. Hence, this descriptive observational study was conducted to estimate average age of fusion of ossification centres at lower end of radius and ulna in male population of North East Madhya Pradesh. Total 80 cases in the age group of 12 to 20 years attending the OPD of this tertiary care centre were included in the study. X-rays of both wrists were taken in anteroposterior view at Dept. of Radiology after taking written informed witnessed consent from parents and legal guardians of patients and examined in Dept. of Forensic Medicine.

Age of fusion of lower end of radius and ulna is found to be 17-18 years in males of North East Madhya Pradesh.

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

Introduction

Identification is the determination of individuality of person based on certain physical characteristics.[1] Age determination is one of the essential factor in establishing exact identity of a living individual. Apart from identification , determination of age is required for civil purposes like employment, consent for marriage, immigration, attainment of majority, competitive sports law suit and criminal purposes like rape, kidnapping, criminal responsibility, prostitution and judicial punishment.[2]Age estimation in the living becomes more important in developing countries where birth records are often not well maintained. Age estimation by observing appearance and fusion of ossification centres is most accurate and reliable method which is implemented universally.[3] Ossification is a continuous process. Some of the bones are cartilaginous and some are membranous in origin. Ossification imparts terminal

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shape and texture to them. Changes in ossification of bones occur in predictable order and hence, they are taken into account while estimating the age of a person.[4]

There is disparity in the timing of appearance and fusion of ossification centres of the bones in Indian population. This disparity is mainly due to various factors like racial, hereditary, climatic, and nutritional. Due to these variations, it is not possible to establish a uniform standard for age estimation from appearance and fusion of ossification centres for whole India.[5] Hence, this study was conducted to formulate references in future to estimate the age of males from radiological examination of wrist joint in North east Madhya Pradesh which will be helpful in civil and criminal cases.

Aims and Objectives

To estimate average age of fusion of ossification centres at lower end of radius and ulna in male population of North East Madhya Pradesh.

Material and Methods

This descriptive observational study was conducted in Dept. of Forensic Medicine of this tertiary care centre from October 2019 to October 2020 after obtaining approval from Institutional Ethics Committee. Total 80 males in the age group of 12 to 20 years attending the OPD of this tertiary care centre were included in the study. Cases were equally divided into 8 groups as 12-13, 13-14, 14-15,15-16,16-17,17-18,18-19 and 19-20 according to their age in years where upper limit indicates the completed age and lower limit indicates non completed age. Cases with nutritional, endocrinal and developmental disorders affecting skeletal maturity, cases showing physical deformities and fractures of radius and ulna and those in which birth date is not known or date of birth is not supported by valid proof like birth certificate etc. were excluded from the study. Written informed consent was taken from parents or legal guardians of participants. X-rays of both wrists were taken in anteroposterior view at Dept. of Radiology of this tertiary care centre and examined in Dept. of Forensic Medicine. Process of fusion of epiphysis with metaphysis was divided in five stages based on classification by Sangma W et al[6]

Stage 1:Non union–When the epiphysial cartilage does not begin to decrease in thickness. **(Figure No.1)**

Stage 2: Commence of union – when the thickness of epiphysial cartilage is found to be reduced appreciably (1/4th united). **(Figure No.2)**

Stage 3: Incomplete union – when the epiphysis has begun to fuse with shaft and complete union is well underway (1/2 united). **(Figure No.3)**

Stage 4: Complete union – when the epiphysial cartilage is bony in architecture and its density indistinguishable from the epiphysis and diaphysis in its neighbourhood but an epiphysial line called epiphysial scar can still be distinguished. (3/4 united)**(Figure No.4)**

Stage 5: Complete union – with absence of epiphysial scar. **(Figure No.5)**

The youngest age group where there is complete fusion of epiphysis and diaphysis at distal end of radius in 100% cases is taken as criteria for generalization.

Data analysis was done in computer using SPSS software.

Observations and Results

Table No. 1 showing distribution of cases according to age groups

Age group (Years)	No.
12-13	10
13-14	10
14-15	10
15-16	10
16-17	10
17-18	10
18-19	10
19-20	10
Total	80

Table No. 2 showing distribution of cases according to stages of fusion of lower end of radius

Age	Stages of fusion of lower end of radius in males					Total
	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	
12-13	9	1	0	0	0	10
13-14	0	9	1	0	0	10
14-15	0	1	9	0	0	10
15-16	0	2	8	0	0	10
16-17	0	1	6	2	1	10
17-18	0	0	0	7	3	10
18-19	0	0	0	3	7	10
19-20	0	0	0	2	8	10

It is evident from table no.2 that complete fusion at distal end of radius is seen in 30% of cases in age group 16-17 years and 100% of cases in age group 17-18 years,18 -19 and 19-20 years. The youngest age group where there is complete fusion of epiphysis and diaphysis at distal end of radius in 100% cases is taken as criteria for generalization. Hence, it can be interpreted as distal end of radius fuses completely at 17-18 years in males of North East Madhya Pradesh.

Table No. 3 showing distribution of cases according to stages of fusion of lower end of ulna

Age	Stages of fusion of lower end of ulna in males					Total
	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	
12-13	9	1	0	0	0	10
13-14	0	9	1	0	0	10
14-15	0	1	9	0	0	10
15-16	0	3	7	0	0	10
16-17	0	1	7	1	1	10
17-18	0	0	0	5	5	10
18-19	0	0	0	3	7	10
19-20	0	0	0	0	10	10

It is evident from table no.3 that fusion of distal end of ulna is seen in 20% of cases in age group 16-17 years and 100% of cases in age group 17-18 years,18 -19 and 19-20 years. The youngest age group where there is complete fusion of epiphysis and diaphysis at distal end of ulna in 100% cases is taken as criteria for generalization. Hence, it can be interpreted as distal end of ulna fuses completely at 17-18 years in males of North East Madhya Pradesh.

Table No.4 showing comparison of the age of fusion of lower end of radius and ulna estimated by various studies in India with the present study.

Study	Population studied	Age of fusion of lower end of radius	Age of fusion of lower end of ulna
Hapeworth12 (1929)	Punjabis	16-17	16-17
Lall R and Nat BS13 (1934)	Uttar Pradesh	19	19
M.J. Pilliai14 (1936)	South India	18 years	18 years
Galstaun15 (1937)	Bengal	18 years	18.5 years
Loomba16 (1958)	Uttar Pradesh	20-21	Beyond 18
Mehta17 (1963)	Mumbai	18-19	18-19
Das R et al18 (1965)	Punjab	Beyond 18	Beyond 18
Saksena and Vyas19 (1969)	Madhya Pradesh	19-20	19-20
Gupta SMD et al20 (1974)	Uttar Pradesh	20-21	20-21

Cont... **Table No.4 showing comparison of the age of fusion of lower end of radius and ulna estimated by various studies in India with the present study.**

Kothari21 (1974)	Marwar	19-20	19-20
Prasad RS et al22 (1976)	Bihar	17-18	17-18
Banerjee and Agrawal23 (1998)	Uttar Pradesh	19-20	19-20
Nemade et al24 (2010)	Maharashtra	20-21	19-20
Bhise et al25 (2011)	Mumbai	17-18	18-19
Patel et al 26(2011)	Gujrat	19-20	19-20
Kadam and Vishwanathan27 (2012)	Davangiri	18-19	15-16
Wankhade et al28 (2013)	Maharashtra	16-20	16-20
Vaishnawa et al29 (2013)	Jodhpur,Rajsthan	17-18	19-20
Hassan2 (2015)	Kashmir	18-19	18-19
Shanmugasundaram et al30 (2015)	Tamilnadu	17	17
Krishnamoorthy et al31 (2016)	Khammam	18-19	17-18
Leena et al32 (2017)	Rajsthan	18-19	19-20
Dere et al33 (2018)	Mumbai	18-19	18-19
Present study(2020)	Madhya Pradesh	17-18	17-18

Table No.5 showing comparison of the age of fusion of lower end of radius and ulna given by various studies in foreign countries with the present study.

Study	Population studied	Age of fusion of lower end of radius	Age of fusion of lower end of ulna
Pryor[34] (1923)	American	19	19
Paterson[35] (1929)	English	21	21
Sidhom and Derry[36] (1931)	Egyptian	19-20	19-20
Ledger and Wassom[37] (1941)	Pakistan	Beyond 20 years	18-19 years
Flecker[38] (1942)	Australian	19 years	19 years
Brash[39] (1953)	European	21	21
Breathnach[40] (1958)	European	19	19
Greulich and Pyle[41] (1959)	American	Beyond 18	18
Gray[42] (1995)	European	19	18
Al-Qtaitat[43] (2010)	Jordanian	20-21	20-21
Davies and Parsons[44]	-	19-20	20
Present study(2020)	Madhya Pradesh	17-18	17-18

Figure 1- X-ray AP view of wrist of 12 years male showing stage 1 of ossification of radius (Non-union)

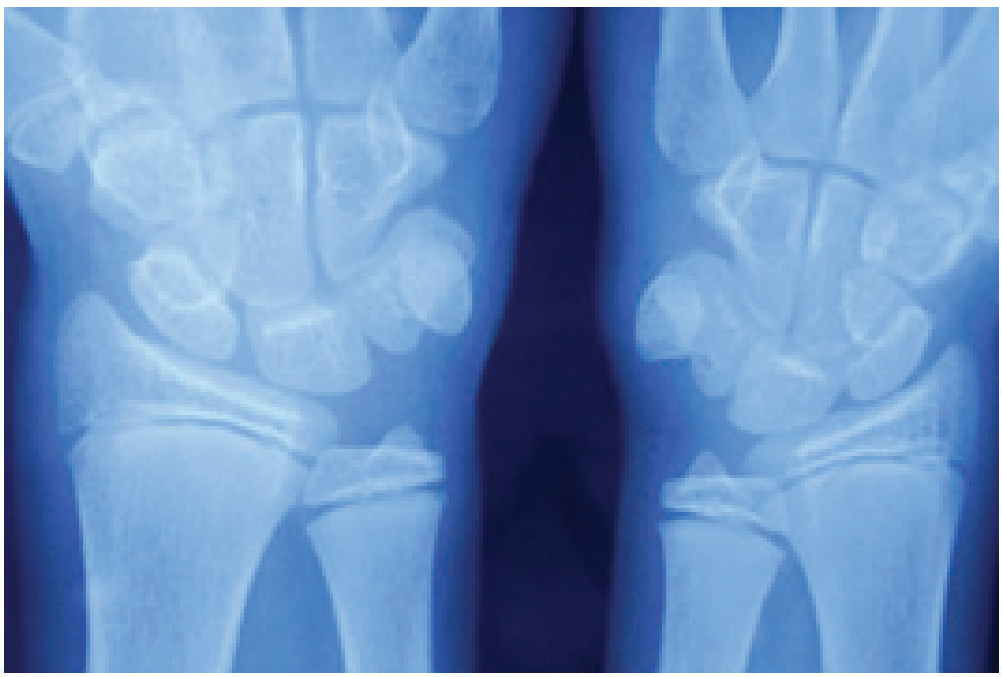

Figure 2- X-ray AP view of wrist of 13 years male showing stag 2 of ossification of radius (Commence of union)

Figure 3- X-ray AP view of wrist of 15 years male showing stage 3 of ossification of radius (Incomplete union)

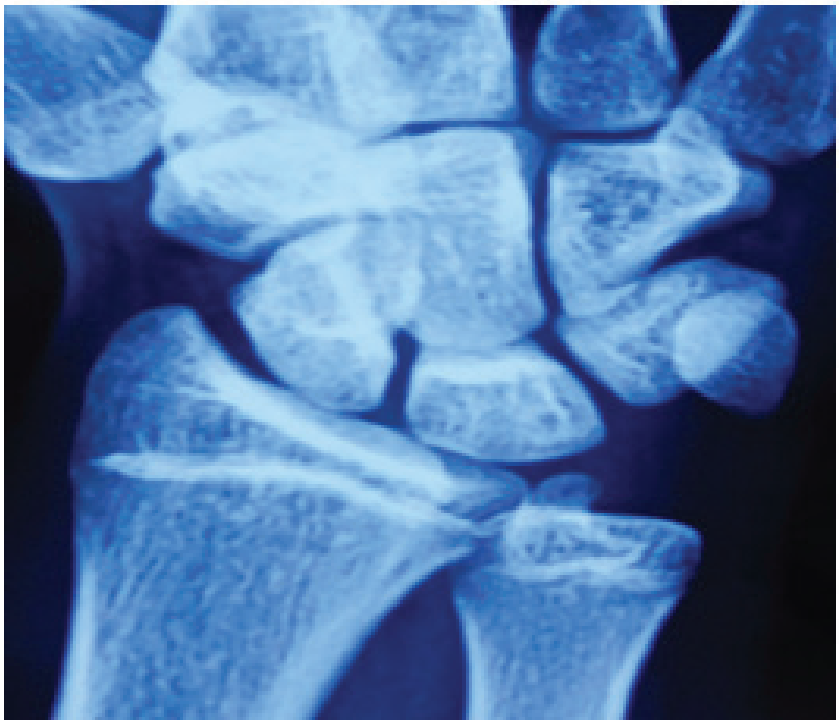

Figure 4- X-ray AP view of wrist of 17 years male showing stage 4 of ossification of radius (Complete union with epiphyseal scar)

Figure 5 - X-ray AP view of wrist of 18 years male showing stage 5 of ossification of radius (Complete union with disappearance of epiphyseal scar)

Discussion

The cardinal principle of age estimation techniques in juveniles is that the skeleton is continuously growing slowly until the adult age is reached.[7] Fusion of centres of ossification occur during age periods which are remarkably persistent for a particular bone. As per recommendations of the study group on Forensic Age Diagnostics, procedure for estimation of age should consist of a physical examination including measurements of height and weight, determining degree of sexual maturation by Tanner staging, dental examination and radiological examination.[8] Ideally, a longitudinal study assessing the fusion of epiphysis with diaphysis will predict more accurately the age of epiphyseal union. However, this is not ethically possible owing to the health risks to participants caused by repeated radiological examinations. A cross-sectional study involving large number of individuals in each age group will resolve this problem. Typical long bones develop by primary and secondary centres. Initially, the centre is small, round and pinhead sized. It grows peripherally and gradually takes up the osteological details of bony part. This is possible due to complex but dependable system by which the osseous framework of the body develops, grows and matures.[9] Radiologically, primary and secondary centres become apparent as white spots. As bone grows, this white area increase in size and only black plate remains between primary and secondary centres termed as growth plate. It is a layer of hyaline cartilage that remains between epiphysis and diaphysis. Complete disappearance of the epiphyseal plate is termed as fusion.[10] Fusion is not an event but it

is a process. Epiphyseal scar is a radiopaque line visible at the junction of epiphysis and metaphysis which represents union. It was interpreted as complete fusion in present study. Union of epiphysis is seen about 6 months earlier radiologically than anatomically.[11] In present study, we observed various stages of fusion of epiphysis with diaphysis giving particular importance to last two stages that is stage 4 and 5 as they are having higher practical utility forensically.

We observed fusion of lower end of radius in 17-18 years. Similar to our findings, Pillai MJ[14], Gaulstaun[15], Prasad RS et al[22], Bhise et al[25], Vaishnawa et al[29], Shanmugasundaram et al[30], and Wankhade et al[28] also observed fusion of lower end of radius in the same age group. Hapeworth[12] observed fusion of lower end of radius in earlier age group i.e.16-17 years in a study conducted on Punjabi population. Lall R and Nat BS[13], Loomba[16], Mehta[17], Das et al[18], Saksena and Vyas[19], Gupta SMD et al[20], Kothari[21], Banerjee and Agrawal[23], Nemade et al[24], Patel et al[26], Kadam and Vishwanathan[27] , Hassan et al[2], Krishnamoorthy et al[31], Leena et al[32] and Dere et al[33] noted fusion of lower end of radius in higher age groups. Also, all studies conducted on American population by Pryor[34] and Greulich and Pyle[41], European population by Brash[39], Breathnach[40] and Gray[42], Australian population by Flecker[38], English population by Paterson[35], Jordanian population by Al-Qtaitat[43],Egyptian population by Sidhom and Derry[36] and Pakistani population by Ledger and Wassom[37] showed that fusion of lower end of radius occurred in higher age groups than present study. (Table No.5)

We observed fusion of lower end of ulna in 17-18 years. Findings of present study are consistent with that of studies by Pillai MJ[14], Gaulstaun[15], Prasad RS et al[22], Shanmugasundaram et al[30], Krishnamoorthy et al[31] and Wankhade et al[28] who also observed fusion of lower end of ulna in the same age group. Hapeworth[12] observed fusion of lower end of ulna in earlier age group i.e.16-17 years. Lall R and Nat BS[13], Loomba[16], Mehta[17], Das et al[18], Saksena and Vyas[19], Gupta SMD et al[20], Kothari[21], Banerjee and Agrawal[23], Nemade et al[24], Patel et al[26], Kadam and Vishwanathan[27] , Hassan et al[2], Krishnamoorthy et al[31], Leena et al[32] , Dere et al[33], Bhise et al[25] and Vaishnawa et al[29] noted fusion of lower end of ulna in higher age groups. Also, studies conducted on American population by Pryor[34] and Greulich and Pyle[41], European population by Brash[39], Breathnach[40] and Gray[42], Australian population by Flecker[38], English population by Paterson[35], Jordanian population by Al-Qtaitat[43],Egyptian population by Sidhom and Derry[36] and Pakistani population by Ledger and Wassom[37] showed that fusion of lower end of ulna occurred in higher age groups than present study.

Differences in fusion of lower end of radius and ulna may be due to climatic, hereditery, racial, and nutritional factors.

Conclusion

Age of fusion of lower end of radius and ulna is found to be 17-18 years in males of North East Madhya Pradesh. It can also be concluded that age of fusion of lower end of radius and ulna is highly variable in populations of different countries and population of different regions of same country. Hence, standard data for one population may not be applicable to other population and every region must have their own standard set of data for comparison for accurate age estimation. Small sample size in each age group is a limitation of present study and authors recommend that further studies should be conducted by taking larger sample size for each group for more reliable results and higher applicability of results to population of North East Madhya Pradesh.

Ethical Clearance - Necessary ethical clearance has been taken from Institutional Ethics Committee.

Source of Funding- Self

Conflict of Interest- None

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