Original Research Article

A Cross-sectional Radiological Study of Ossification at Lower End of Ulna and Tip of Olecranon among Children and Adolescents coming to Forensic Medicine Department, Medical College, Kolkata, for Age Estimation

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Abstract

Objectives*:* To study radiologically the ossification status of lower end of ulna and tip of olecranon and compare with Galstaun chart and other standard charts.

Material and Methods: A record based cross sectional study was performed in the department of Forensic and State Medicine, Medical College Kolkata for one month, on children and adolescent coming to the department for age estimation over a span of past one year. Their chronological age was noted from birth certificates. The X-Ray plates was looked for appearance and fusion of lower end of ulna and tip of olecranon and compared with Galstaun chart and other standard charts.

Results: The records of 199 subjects (Male-142. Female-57) were examined, who belong to the age group of 7yrs to 19yrs. After observing the appearance and fusion from X-Ray plates and comparing them with Galstaun chart it was seen that maximum deviation from mean age occurred in appearance of lower end of ulna. Appearance of tip of olecranon also had a wide deviation. Males were found to have more variations than females.

Keywords: *Age estimation, Radiological study, ossification, children, adolescent.*

Introduction

Age estimation is one of the regular assignments in clinical forensic medicine. As illiteracy is a major drawback in India, many citizens are unaware of the importance of registration of birth and death. Even if there is registration, there is often lack of maintenance of records. That's why forensic age estimation becomes important in certain civil and criminal issues. Though there are many methods of age estimation, namely physical (general development), dental (eruption of teeth and root calcification sometimes aided by Gustafson's method) etc., radiological estimation by observation of time related appearance and fusion of different secondary ossification centers, is the commonest method used. It is reliable upto 22-25 years of age only, as mentioned by most of the authors.[1] Age, for the appearance of ossification centers, is relatively constant with minor variations. There are many factors which influence the appearance and fusion of bony centers like climatic, economic, hereditary, dietetic, geographical and some other unknown factors.[1]

The Indian population differs from the western population in different anthropological traits. Studies done on this subject in India are inadequate. Galstaun in 1930 and 1937 has done a study on Bengali population. The Galstaun chart is the most widely used chart of its kind for comparison, in most parts of West Bengal. According to this chart the age of appearance of ossification centre for lower end of ulna in male is 10 to 11 yrs and in females is 8 to 10 yrs; and the age of fusion for the same in males is 18 yrs and in females is 17 yrs respectively. Similarly the age of appearance of ossification centre for tip of olecranon in males is 11 to13 yrs and for females is 9 to 12 yrs and age of fusion for males is 17 yrs and for females is 15 yrs respectively. [3]

Likewise Bajaj studied on Delhi population in 1967, Pilai in Madras in 1936, Basu & Basu on Bengalis in 1938, Agarwal & Pathak on Punjabis in 1957 etc. [2] Most of the data for those studies were collected using traditional X-Ray. The present study focuses on observation of status of ossification of secondary ossification centers using digital x-ray and applying traditional comparison method. Determination of the age of an individual from the observation of appearance and fusion of the secondary ossification centers is legally and medico-legally accepted in India. The present study was carried out by observing the epiphyseal appearance and union at the lower end of ulna and tip of olecranon. This study was carried out in subjects (children and adolescents) who attended forensic medicine department of Medical College, Kolkata for estimation of age in civil matters (recruitment in age-category sports).

Aims and Objectives

1. To study the radiological appearance and fusion of secondary ossification centers in lower end of ulna and tip of olecranon

2. To assess whether there is any significant difference between the radiological bone age of today's population with that of standard charts (Galstaun)

3. To find out the gender wise disparity if any

4. To compare the results with other studies done in India

Material and Methods

Study type (Design) – Record based cross-sectional study (Descriptive)

Study period – 1 month (15th December 2019 to 15th January 2020)

Study population- All the children and adolescent from native Bengali population who came to the Upgraded Department of Forensic and State Medicine of Medical College, Kolkata for determination of age.

Place of study – Upgraded Department of Forensic and State Medicine, Medical College, Kolkata

Sample size – 199; Male-142, Female-57

Inclusion criteria-

1. All the children and adolescent from native Bengali population residing at sub- urban areas of Kolkata, who came to the forensic and state medicine department of Medical College Kolkata for age determination for the purpose of recruitment in age category sports

2. Sex- all inclusive

3. Age – all inclusive

4. Must have age proof in the form of birth certificate and mothers hospital discharge certificate

5. Must have residential proof in the form of residential certificate

Exclusion criteria –

1. Individuals having skeletal or craniofacial deformity.

2. Individuals suffering from hormonal disorders affecting growth and development.

3. Individuals suffering from malnutrition and other nutritional disorders affecting growth and development

Study tools :

1. Digital skiagram showing antero-posterior view of wrist joint and antero-posterior and lateral view of elbow joint of non-dominant hand.

2. View box

3. Standard charts (of radiological appearance and ossification of secondary ossification centers)

4. Technical features of digital X-ray machine-generator of 80 KW (kilowatt) power, collimator with focal spot size of 0.6mm, anode heat capacity of 300 KHU (Kilo Heat Unit where 1 Joule =1.4 HU), ceiling suspended tube with movements in all direction, x-ray table having a weight bearing capacity of 200 kg, digital detector with a spatial resolution of 2.5 lines pair/ millimeter, high speed processor of 32 bit and an image storage disc of 70 gigabyte.

Study technique :

All cases recorded during the last one year from the study period were considered for study after observing the inclusion and exclusion criteria. Digital

x-ray of wrist and elbow joint of non dominant side were taken for observation. Records of preliminary physical examination were looked for to exclude any apparent growth retardation, malnutrition and other exclusion criteria. The x-ray plates were examined for the appearance and fusion of secondary centers of ossification in respect to lower end of ulna and tip of olecranon and compared with the Galstaun chart for known chronological age.[3] The age was estimated using the conventional comparison method. As a convention and regular practice in the department of Forensic and State Medicine, Medical College Kolkata each and every x-ray plate was interpreted by a team of four members comprising of one senior faculty, one junior faculty and two residents. This method was applied to minimize interobserver variation as collective decision (consensus) of the team was taken into account for interpretation. So the data in the record was actually an interpretation by a team of forensic experts. Moreover, each and every plate was re-examined by the authors. However no statistical analysis was done to measure the interobserver variation and this is mentioned in the limitation of study. For appearance, "just appeared" was also taken into account and for fusion, "complete fusion" was taken into consideration. The results were then statistically evaluated after tabulating the collected data in excel-sheet.

Consent for the study:

As it is a record based study on subjects coming for age estimation in relation to qualification in age category sports, no separate consent was taken, as consent was given during medical examination for using the data for academic purposes in the future.

Review of Literature

There appears to be limited number of studies in India related to age estimation using routine x-rays and quite fewer in West Bengal. Age estimation, being an important aid in legal matters, demands accuracy and so it becomes pertinent to follow the latest data related to a particular population. But unfortunately in most of the set ups age old data chart is still in use.

In one of the studies which was carried out on 104 subjects, 54 males and 50 females, in the age group of 15-21 yrs, in B.J Medical College, Ahmedabad in 2009, using x-rays of lower end of radius and ulna, it was seen that completion of epiphyseal fusion in lower end of ulna of both hands in males is 19 to 20 yrs and for females is 18 to 19 yrs. [4]

Another study done in the department of forensic medicine of Surat Medical College, using x-rays of lower end of radius and ulna, among 218 cases of age group of 14 to 21 yrs, was of the conclusion that fusion of lower end of ulna started at 14 to 15 yrs and completed at 19 yrs in female and 21 yrs in male. [2]

In a study on epiphyseal union at elbow and wrist joints in the radiology department of King George Hospital, Lucknow among Indian females of age group 10 to 18 yrs, showed that the results were about at least 2 years ahead of the figures given in most of the textbooks. [5]

Department of Anatomy of Government Medical College, Nagpur carried out a study on ages of epiphyseal union around wrist joint among 80 subjects (44 girls and 36 boys) of age group of 13 to 23 years; lower end of ulna was found to be completely fused at 19 to 20 years in both males and females.[6]

A radiological study of epiphyseal union of distal end of radius and ulna in subjects of age group 16 to 22 yrs was carried out on 100 healthy medical students (50 males &50 females) of Dr. S.N. Medical College, Jodhpur (Rajasthan). In the same study average age for complete epiphyseal fusion of lower end of ulna for males is 19 to 20 years and for females is 18 to 19 yrs.[7]

In a prospective cross sectional hospital based study, conducted in Sudan, with data collected from 5 hospitals; Khartoum, Khartoum North, Omdurman, Police, and Um badda, 57 (Fifty seven) AP and Lateral plane elbow x- rays were taken for healthy Sudanese children (40 Males and 17 Females), aged 13 to 23 years. In this study, the films of the 1st group (at average of 14 years) only 20% of them showed closed olecanon process. In the 2nd group (at average of 17 years) 66.7% showed closed olecranon process. All children above 19 yrs (3rd group) had closed physis. The female physeal fusion precedes the male in one of all the 6 centers.[8]

The discrepancies in so many studies have heightened the need for a digital skiagram based study

to focus on the need of a region based data for age estimation using x-ray plates.

Results

Out of 250 recorded subjects, 199 were included keeping in mind the inclusion criteria, in which 142 were males and 57 females. There are variations in appearance of lower end of Ulna in both males (Table I) (Fig. 2) and females (Table II) where there are frequencies of appearances below the given age range by standard charts. Similarly the fusion for lower end of Ulna occurred before the stipulated age range of standard charts in males (Table III). But in all females the fusion of lower end of ulna occurred by 17 yrs.

Frequency of tip of olecranon appearance in males (Table IV) and females (Table V) (Fig.1) also showed variations from Galstaun chart. Similarly the secondary centers for tip of olecranon showed earlier fusion than the standard age according to Galstaun in both males (Table VI) and females (Table VII). The comparison of radiological bone age of this study with that of Galstaun chart (Table VIII) for both the secondary centers of ossification clearly depicts the variations. The percentage for conformation in appearance of the ossification centers in both males and females (Table IX) with Galstaun chart showed that the female age ranges have less variations than males, however, the percentage for conformation in fusion with the Galstaun chart showed a mixed variation. A comparison with other charts followed in India (Table X) heightens the need for updating the standard charts.

Table no I: Frequency of lower end of Ulna appearance in males (n = 142)

Age	Status	Number	Percentage
<10 y	Appeared	37	26.1
10-11 y	Appeared	105	73.9
>11 y	Not appeared	0	0

Table no II: Frequency of lower end of Ulna appearance in females (n = 57)

Age	Status	Numbers	Percentage
<8 y	Appeared	2	3.5
8-10 y	Appeared	55	96.5
>10 y	Not appeared	0	0

Table no III: Frequency of tip of Olecranon appearance in males (n=142)

Age	Status	Numbers	Percentage
<11 y	Appeared	28	19.7
11-13 y	Appeared	114	80.3
>13 y	Not appeared	0	0

Table no IV: Frequency of tip of Olecranon appearance in females (n=57)

Age	Status	Number	Percentage
<9 y	Appeared	4	7.0
9-12 y	Appeared	53	93
>12 y	Not appeared	0	0

Table no V: Radiological bone age in our study compared to standard Galstaun chart

Secondary centers of ossification	Age range of our study(y – years)	Galstaun's age range (y-years)	Gender M –male F -female	Status
Lower end of ulna	8 -11 y	10-11 y	M	Appearance
Lower end of ulna	7-10 y	8-10 y	F	Appearance
Tip of olecranon	9-13 y	11-13 y	M	Appearance
Tip of olecranon	7-12 y	9-12 y	F	Appearance
Lower end of ulna	17-18 y	18 y	M	Fusion
Lower end of ulna	17 y	17 y	F	Fusion
Tip of olecranon	15-17 y	17 y	M	Fusion
Tip of olecranon	14-15 y	15 y	F	Fusion

Table no VI: Comparison with other standard charts of India

Studies	Lower end of ulna				Tip of olecranon			
	Male		Female		Male		Female	
	A	F	A	F	A	F	A	F
Hepworth	-	16-17	-	16-17	-	-	-	-
Lall R & Nat B S	-	19	-	19	-	-	-	-
Pillai	-	18	-	18	-	-	-	-
Basu&Basu	-	16-17	-	16-17	-	-	-	-
Mittal	-	17-18	-	16-17	-	-	-	-
Our study	8-11 y	17-18 y	7-10 y	17 y	9-13 y	15-17 y	7-12 y	14-15 y

Discussion

There are limited number of studies in India related to age estimation using routine x-rays and quite fewer in West Bengal. As Age estimation is an important aid in legal matters, it becomes pertinent to follow the latest data related to a particular population. But unfortunately in most of the set ups age old data chart is still in use.

In the present study, total number of subjects taken into consideration from the records were 199 (n= 199), out of which 142 were males and 57 were females. The results for appearance of lower end of ulna in males showed that for 26.1% of male subjects the appearance occurred before 10 years whereas in Galstaun chart, which is followed in West Bengal the age for appearance of secondary ossification centre of lower end of ulna is 10 to 11 years[3]. But in females, 3.5% of the subjects showed appearance before 8 years, the age of appearance of lower end of Ulna according to Galstaun being 8 to 10 years. The fusion of lower end of Ulna in males in 99.3% of cases occurred at 18 years which is in accordance with the Galstaun's age range and in females all showed fusion by 17 years of age which is at par with the Galstaun chart.

The age of appearance of tip of olecranon in 19.7% of males occurred below 11 years of age and in the rest it appeared at 11 to 13 years of age which is the age range mentioned in Galstaun chart and in 7.0% of females the appearance occurred below 9 years, the age according to the galstaun chart being 9-12 years. In 5.6% of males, the tip of olecranon was found to have fused below 17 years and in the rest 94.4% it fused at 17 years in accordance with Galstaun chart and in 12.3% of females the fusion occurred below 15 years and in the rest 87.7 % the fusion was at par with the Galstaun chart that is at 15 years of age.

Hepworth et al. in his study found the age for lower end of ulna fusion in males and females to be 16-17 years which is similar with the results of study by Basu & Basu, which is almost consistent with the results of our study. However Pillai stated that the age for fusion of lower end of ulna in both males and females is 18 years.[2]

In results of the studies which were carried out in B.J Medical College, Ahmedabad (2009), Department of forensic medicine of Surat Medical College, Department of Anatomy of Government Medical College, Nagpur, Radiology department of King George Hospital, Lucknow and Dr. S.N. Medical College, Jodhpur (Rajasthan), are inconsistent with our study results. The discrepancies in so many studies demands the need for a digital skiagram based study to focus on the need of a region based data for age estimation using X-Ray plates.

Conclusion

The appearance of lower end of ulna and tip of olecranon in both males and females vary significantly from GALSTAUN CHART as well as from other studies. The fusion of the lower end of ulna and tip of olecranon in both males and females is almost in accordance with other studies. The variation can be due to the factors affecting the ossification like geographical, environmental, hereditary factors etc. The uniqueness of the finding of the study lies in the fact that it is one of the very few studies to include tip of olecranon on native Bengali population and in our study fusion was less variable than the appearance, which is quite contrary to the general rule.

Limitations:

1. The other factors affecting bone age were not taken into consideration like geographical, genetic, nutritional factors etc.

2. Larger sample size is preferable in further studies

3. A certain amount of children from a locality might not represent the whole population of said age group of that community.

4. There might be considerable interobserver variation in the interpretation of x-rays in such type of observational studies. Every effort was made to minimize interobserver variation while designing the study, through the process of collective observation (i.e. consensus) by a group of forensic experts and re-examination by the authors. However, the interobserver variation was not measurable. Still some amount of interobserver variations cannot be ruled out.

5. Further study regarding different stages of fusion is preferable

Recommendations:

· To formulate separate standards of ossification for geographically distinct regions

· To carry out further studies on a larger sample size

· To update the age old standard charts

Conflict of Interest: Nil

Source of Funding: The study was conducted within the set-up of a state government medical college with the help of self funding when and where required.

Ethical Clearance: Ethical clearance and approval taken from the Institutional Ethics Committee of Medical College, Kolkata.

References

1. Raichandani L, Maharshi A, Raichandani S, Kataria K S, Raichandani K , Choudhary A. Radiological study of epiphyseal union of the distal end of radius and ulna with the shaft of the left hand in age group 16-22 years in western Rajasthan population. International journal of applied research. 2017; 3(4): 08-12
2. Rajdev B M, Gajera C N, Rajdev S B, Govekar G P, Tailor C I, Chandegara P V. Age of fusion of epiphysis at distal end of radius and ulna : Int J Int Med Res. 2014; 1(2); 5-11
3. Santanu. Galstaun's chart. Available from : https://www.scribd.com/doc/173414021/Galstaun-s-chart. [last accessed on 14-11-19]
4. Patel D S, Agarwal H , Shah J V. Epiphyseal Fusion at Lower End of Radius and Ulna Valuable Tool for Age Determination : J Indian Acad Forensic Med. April-June 2011; 33(2): 125-129
5. Lall R B R, R. S. Townsend. Ages of epiphysial union at the elbow and wrist joints amongst indian girls: The Indian Medical Gazette. Oct 1939; 614-616.
6. Nemade K S, Kamdi N Y, Parchand M P. Ages of epiphyseal union around wrist joint - a radiological study: J . Anat. Soc. India. 2010; 59(2) : 205-210
7. Sharma Y. Roentgenologic prospective study of epiphyseal union around elbow and wrist joint and pelvis in boys and girls of Mewar region of Rajasthan. Submitted to the University of Rajasthan, Jaipur, 1994; 19 (1); 4-8
8. Mohamedahmed Alwahbany S A, Ahmed T O, Hussien A D. Radiological assessment of closure time of around elbow secondary ossification centers, in Khartoum hospital, Khartoum north hospital, Omdurman hospital, police hospital, and Umbadda hospital, in Khartoum, Sudan: International Journal of Orthopaedics Sciences 2017; 3(2): 806-812