

ORIGINAL RESEARCH

A Study of Ossification Centres Around the Elbow and Wrist of Adolescent Aged 15 - 19 Years at a Tertiary Care Centre

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ABSTRACT

Introduction: Legal punishment and crimes are entirely based on the criminal responsibilities and age of the person. The crime against the children and adolescent and crime by the children and adolescent are increasing hugely in this modern era where technologies are improving greatly. Evaluating the bone age in skeletally immature patient gained importance for therapeutic decision-making, and the knowledge about the skeletal development forms the basis for the results interpretation. In Adolescence, the age of appearance of the ossification centers of their elbow has a relatively well-established chronological sequence which are documented in literature: humerus capitulum, radius head, medial or internal epicondyle, humerus trochlea and lateral or external epicondyle.

Materials and Methods: The study was carried out on a total of 143 subjects out of which 110 were males and 33 were females. After obtaining the written consent from every individual, subjects were allowed for their radiological examination. The X-rays of wrist were first taken with A-P view at 40- 44 KVp and 4 – 8 mAs (Focussing at mid carpal area). The X-ray of elbow was then taken with A-P view at 42-44 KVp and 4–8 mAs (Centering at mid carpal area). The tube current was fixed at 40 inches and tube current at 100 mA. The persons selected for the study were grouped as per their stated age viz, 15-16 years, 16-17years, 17-18years & 18-19 years.

Results: The complete fusion of ossification centres around elbow joint in males starts at the age of 15-16 years followed by individuals of 17-18 years showing complete fusion from a range of 80-90% and all the 18 subjects between 18-19 years shows 100% complete fusion. In females it showed that the complete fusion of all ossification centres around elbow joint started at the age group of 15-16 years but was not complete and it was followed by appearance of 100% complete fusion in 16-19 years age group of individuals.

Conclusion: This study proves that the complete fusion of ossification centres around elbow and wrist joint in females occurs earlier than in males by 1-2 years. 100% complete fusion around elbow joint in females occurs at 16-17 years whereas in males it is seen at 18-19years. 100% complete fusion around wrist joint is seen in females of age group 18-19 years whereas it is just the lower end of ulna that shows complete fusion in males at the same age as females.

Keywords: Age; Ossification centres; Elbow; Wrist; Growth; Fusion.

INTRODUCTION

Legal punishment and crimes are entirely based on the criminal responsibilities and age of the person. The crime against the children and adolescent and crime by the children and adolescent are increasing hugely in this modern era where technologies are improving greatly. Hence, age estimation has gained maximum importance, particularly in medico-legal cases.¹ Evaluating the bone age in skeletally immature patient gained importance for therapeutic decision-making, and the knowledge about the skeletal development forms the basis for the results interpretation.^{1,2} These studies have clinical significance because of the complex radiographic anatomy and associated challenging interpretation for the frequent paediatric cases of trauma.³

Though there are many general growth factors in age estimation, changes in bones specifically time related appearance and fusion of various ossification centres in growing period are valuable indices for assessing the age.⁴ The variation in the appearance and the fusion of various ossification centres is mainly attributed to many factors like climate, hereditary, race, nutrition, dietary habits, gender and socioeconomic status of the population.⁵ Cases which require age estimation are often referred to forensic experts as it plays a vital role in arriving upon the quora of punishment given to the accused and where to execute the punishment in a Reformation or juvenile court school or jail. Females aged between 15 to 17 years is very important medicolegally, as it is important to differentiate between 14-15 years in employment and 17-18 years in connection with Hindu Marriage Act. Amongst all the parameters of age determination, radiological examination of bone ends has shown accuracy and reliability acceptable to medical fraternity and legal camaraderie.

In Adolescence, the age of appearance of the ossification centers of their elbow has a relatively well-established chronological sequence which are documented in literature: humerus capitulum, radius head, medial or internal epicondyle, humerus trochlea and lateral or external epicondyle.⁶⁻⁸ The mnemonic CRITOE or CRITOL may be applied. Potentially distinct characteristics in elbow ossification centres may exist in the Indian population and this information is quite lacking in the literature. Hence the objective of this study is to find out the age of an individual from the fusion of secondary ossification centers around Elbow joint and Wrist joint, to compare the age of fusion of ossification centers around elbow and wrist joints between males and females.

MATERIALS AND METHODS

The present study was conducted in the Department of Forensic Medicine, Krishna Mohan Medical College & Hospital, Mathura, Uttar Pradesh, India. The study was carried out on a total of 143 subjects out of which 110 were males and 33 were females. Subjects with deformities of elbow and wrist joint, signs of malnutrition, congenital anomalies, infections and metabolic disorders were excluded from the study. After obtaining the written consent from every individual, subjects were allowed for their radiological examination. The X-rays of wrist were first taken with A-P view at 40- 44 KVp and 4 – 8 mAs (Focussing at mid carpal area). The X-ray of elbow was then taken with A-P view at 42-44 KVp and 4-8 mAs (Centering at mid carpal area). The tube current was fixed at 40 inches and tube current at 100 mA. The persons selected for the study were grouped as per their stated age viz, 15-16 years, 16-17 years, 17-18 years & 18-19 years. Age of the subjects were confirmed with their birth certificate or their certificate entry in their school. Photocopy of birth certificate was collected. The persons belonging to the age group selected from both the gender included in the study irrespective of their socio- economic status and religion. We prepared a proforma with particulars containing their demographic details, height, weight and permanent identification marks. In males, colour and growth of scalp hair, beard, moustache, axillary and pubic hair were examined and noted. In females, breast development was noted

and complete menstrual history was taken. Dental examination was done by noting the number of milk teeth and permanent teeth and a suitable dental chart was prepared. Radiological assessment of various ossification centres, their appearance, process of fusion was recorded. The observations were based on the following grades of stages of fusion.

DEGREE 0 represents a dark radiolucent line seen throughout the length of the epiphyseal and metaphyseal surface that are joining (Centre not appeared, union not commenced).

DEGREE 1 indicates a radio opaque area which is seen in the middle of or on either side of, but occupies less than half of the epiphyseal and metaphyseal joining surface (Centre appeared but incomplete, union commenced).

DEGREE 2 depicts a radio opaque area that is seen in more than half of epiphyseal and metaphyseal joining surfaces, but the cortical shadow is not continuous (Union started but incomplete).

DEGREE 3 denotes a radio opaque area that can be seen along the entire length of the epiphyseal and metaphyseal joining surface and the cortical surface is continuous without any notch (Complete union).

For the easier tabulation of the findings, the stages of fusion were noted in the form of following abbreviations.

1. No union (O). 2. Beginning union (B). 3. Recent union (R). 4. Complete union (C).

RESULTS

Table 1 shows that the complete fusion of ossification centres around elbow joint in males starts at the age of 15-16 years followed by individuals of 17-18 years showing complete fusion from a range of 80-90% and all the 18 subjects between 18-19 years show 100% complete fusion. In females it showed that the complete fusion of all ossification centres around elbow joint started at the age group of 15-16 years but was not complete and it was followed by appearance of 100% complete fusion in 16-19 years age group of individuals.

Table 2 displays the complete fusion of lower end of radius and ulna in males starts by the age of 16-17 years. The age group of 18-19 years shows only 77.7% of complete fusion of lower end of radius but 100% complete fusion was seen only in lower end of ulna. It also implies that the lower end of ulna fuses earlier, followed by the lower end of radius in males. Among females, complete fusion of lower end of radius starts at the age of 17-18 years and the lower end of ulna starts by 16-17 years. The age group of 18-19 years shows 100% complete fusion of both lower end of radius and lower end of ulna. It implies that the lower end of radius completely fuses in females earlier when compared to males but fuses in line at the same age for lower end of ulna.

Table 1: Complete Fusion of Ossification Centres Around Elbow Joint in Males and Females

Age	Trochlea		Capitulum		Lateral Epicondyle		Medial Epicondyle		Upper End of Radius		Upper End of Ulna	
	M	F	M	F	M	F	M	F	M	F	M	F
15-16	7(21 .6)	8(80)	10(2 5.7)	2(20)	12(4 2.8)	2(20)	8(28 .5)	3(28 .5)	10(3 5.7)	7(70)	12(4 2.8)	5(50)
16-17	14(3 8.5)	4(10 0)	22(6 3)	4(10 0)	24(6 8.9)	4(10 0)	22(6 8.7)	4(10 0)	26(7 5.5)	4(10 0)	26(8 1.2)	4(10 0)
17-18	28(9 3.2)	6(10 0)	28(8 7.5)	6(10 0)	26(8 1.2)	6(10 0)	28(8 7.5)	6(10 0)	30(9 3.7)	6(10 0)	32(9 4.4)	6(10 0)
18-19	17(1 00)	1(10 0)	18(1 00)	1(10 0)	18(1 00)	1(10 0)	18(1 00)	1(10 0)	18(1 00)	1(10 0)	8(10 0)	1(10 0)

Table 2: Complete Fusion of Ossification Centres Around Wrist Joint in Males and Females

AGE	Lower End of Radius		Lower End of Ulna	
	M	F	M	F
15-16	0(0)	0(0)	0(0)	0(0)
16-17	2(6.2)	0(0)	4(12.5)	1(25)
17-18	20(62.5)	4(66.6)	26(81.3)	4(66.6)
18-19	14(77.7)	1(100)	18(100)	1(100)

Table 3: Distribution of Fusion of Ossification Centre Around Elbow Joint in Males and Females

Age	Trochlea		Capitulum		Lateral Epicondyle		Medial Epicondyle		Upper End of Radius		Upper End of Ulna	
	M	F	M	F	M	F	M	F	M	F	M	F
15-16	7	9	11	2	14	2	9	3	10	7	14	5
16-17	14	5	22	4	25	4	24	5	24	4	29	4
17-18	32	7	29	6	28	6	26	7	33	7	33	6
18-19	19	1	19	1	19	1	16	1	19	1	19	1
P-value	0.048	0.052	0.014	0.061	0.009	0.063	0.021	0.046	0.019	0.045	0.014	0.034

Table 4: Distribution of Fusion of Ossification Centre Around Wrist Joint in Males

Age	Lower End of Radius		Lower End of Ulna	
	M	F	M	F
15-16	0	0	0	0
16-17	2	0	4	1
17-18	22	4	28	5
18-19	15	1	18	1
P value	0.159	0.276	0.138	0.180

DISCUSSION

Determining the age is an important criterion in law of attaining maturity and in criminal case where the disposal of body is done by dismembering the body parts by using various methods or when only skeletal remains is the only parts available for examination. Whereas in living it helps in solving medicolegal cases which comprises of civil cases like those related to employment, education, sports and in criminal cases like robbery, sexual assaults, abduction or kidnapping etc.,

The present study was conducted on 143 subjects out of which 110 were males and 33 were females. It shows that fusion of trochlea in age group of 15- 16 years. The complete fusion is observed only 21 whereas the rest shows recent fusion in males and in age group between 17- 18 years, 93 were completely fused. In females, age group of 15-16 years showed only 8 completely fused cases. Fusion of capitulum in age group 15-16 years was then noted where the complete fusion is seen only in 35 whereas the remaining shows recent fusion in males and in age group 17-18 years, 87 were completely fused but in females of the age group 16-17 years 100 was completely fused.

The fusion of lateral epicondyle in the age group 15-16 years, complete fusion is seen only in 42 whereas the rest shows recent fusion in males. And in age group between 17-18 years, 81 is completely fused whereas in females the age group 16-17 years are completely fused. The fusion of medial epicondyle in age group 15- 16 years the complete fusion is seen only in 28

rest population shows recent fusion in males and in age group 17-18 years, 87.5 completely fused whereas in females of age group 16-17 years, 100 were completely fused.

Fusion of upper end of radius in age group of 15-16 years, complete fusion is seen in only 35 rest of the population shows recent fusion in males and in the age group 17-18 years 93 was completely fused however in females the age group of 16-17 years showed 100 complete fusions. Fusion of upper end of ulna in age group of 15-16 years, the complete fusion is seen only 42 of the population whereas the rest shows recent fusion in males and in age group 17-18 years, 93 was completely fused whereas in female age group of 16-17 years, 100 complete fusion was seen. Ossification centres around lower end of radius in males in the age group of 16-17 years shows only 6 complete fusions, in 18-19 years 77 shows complete fusion. In females the age group of 18-19 years shows 100 complete fusions.

Ossification centres around lower end of ulna in males in the age group of 16-17 years shows only 12 complete fusion, in 18-19 years only 81 shows complete fusion. In females the age group of 18-19 years shows 100 complete fusions. The olecranon centre showed a tendency to ossify earlier than trochlea in girls and boys in this study similar results were observed by the study conducted by Cesar Satosh Miyazaki Daniel et al in November 2017.⁹ The fusion of epiphyseal centre of medial epicondyle with the shaft was seen at the ages between 15-17 years in males which were coherent with the study conducted by Umesh Choudary et al in March 2017.¹⁰ The fusion of lower end of radius and ulna shows complete fusion in 100 study population at 18-19 years which were similar to the results of the study carried out by Hassan noor et al in June 2016.¹¹

It is also concluded that the ossification centres in females fuse earlier than males in both elbow and wrist joint which corresponds to their age at which growth spurt occurs. With reference to the theory of null hypothesis considering $p=0.05$ as the statistically significant value, the age of fusion of ossification centres around elbow and wrist joint between males and females were observed and it showed that the p value calculated for females was >0.05 when compared to males which were <0.05 and it proved that the null hypothesis is true.

CONCLUSION

This study proves that the complete fusion of ossification centres around elbow and wrist joint in females occurs earlier than in males by 1-2 years. 100 complete fusions around elbow joint in females occurs at 16-17 years whereas in males it is seen at 18-19 years. 100 complete fusions around wrist joint is seen in females of age group 18-19 years whereas its just the lower end of ulna that shows complete fusion in males at the same age as females.

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