

Original Research Article

Comparative Study of Various Human Ossification Centers From 10 Years to 20 Years of Age

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Abstract

Introduction: The appearance and fusion of different ossification centers has a sequence. The process of union of epiphysis and diaphysis is called fusion and the fusion is a process, not an event. This study is an attempt to compare various human ossification centers radiologically in both males and females for estimation of age.

Materials and Methods: This is a retrospective study based on the radiological findings from the cases referred to the Dept of forensic medicine, Rangaraya medical college, Kakinada. X-rays of shoulder, elbow, wrist and pelvis are utilized for this study. Age range of cases we studied was 10-20yrs of age. Ossification centers for upper end of humerus, medial epicondyle, upper end of radius, lower end of ulna, lower end of radius, pisiform, base of first metacarpal, iliac crest, femur head and greater trochanter were studied in relation to each other. The ossification process is divided into 7 progressive stages (0-6) based on the stage of appearance and fusion of the ossification centers. Master charts were prepared for boys and girls separately and analyzed.

Results and Conclusion: Radiological findings of shoulder, elbow, wrist and pelvis from a total of 109 belonging to the females and 40 belonging to the males were studied and a point score taking Gray's anatomy as standard and making correction for Indians is given to the 10 ossification centers studied. It is found that with increasing age the point score is increasing. It is found that the point score in females is higher than in males at a given age in majority of cases indicating ossification process concluding early in females than in males.

Key words: Ossification centers, radiological examination, Point score, Ossification process.

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Introduction

Age estimation is an important part in medico legal work and is a part of clinical forensic medicine. Age estimation is required in cases of sexual offences, kidnapping, and child labor etc. to name a few.

The procedure of age estimation involves physical examination, dental examination and radiological examination from birth to attainment of adulthood. Age estimation depends on the study of the growth, eruption of temporary and permanent teeth and development of secondary sexual characters until the adolescence ⁽¹⁾. The radiological study of ossification is appearance and fusion of various ossification centers in selected bones play an important role in age estimation up to about 21 yrs.

Aim of the Study:

To study and compare appearance & fusion of various human ossification centers radiologically in both boys and girls and to evaluate sex related variation & its correlation with age.

Material and Methods

This is a retrospective analytical study based on the cases referred to the Department of Forensic medicine, Rangaraya medical college, Kakinada. Present study is limited to the ossification landmarks in select regions in the age group of 10-20 yrs. X-rays of shoulder, elbow, wrist and pelvis are utilized for this study. The estimation of age is done based on the data given in Gray's anatomy regarding the chronology of ossification of human bones ⁽²⁾.

The ossification process is divided into 7 progressive stages (0-6) which are as listed below:

Stage 0 - ossification centre not appeared.

Stage 1 - ossification centre just appeared (like a white spot).

Stage 2 -expansion of ossification centre (epiphysis) up to half of full extent.

Stage 3 -expansion of ossification to the full extent.

Stage 4 -narrowing of gap between epiphysis and

diaphysis.

Stage 5 -complete union of epiphysis and diaphysis with dense white line.

Stage 6 -complete union of epiphysis and diaphysis without any white line.

The reference is made to the study done by Darmesh S. Patel et al, who studied 'Epiphyseal fusion at lower end of radius and ulna valuable tool for age determination, original research paper' and classified fusion process into 4 stages.⁽³⁾

1. NON UNION: a dark black radiolucent line seen between the area of diaphysis and epiphysis. This stage is labeled as STAGE-0

2. UNION IN PROGRESS: Gap between diaphysis and epiphysis begins to decrease but complete union does not occur. This stage is labeled as STAGE+

3. COMPLETE UNION WITH WHITE DENSE LINE: Union between diaphysis and epiphysis completed but white dense line still visible at diaphysio-epiphyseal junction. This stage is labeled as STAGE++

4. COMPLETE UNION WITHOUT-ANT DENSE WHITE LINE: Union between diaphysis and epiphysis and no white dense line visible at diaphysio-epiphyseal junction. This stage labeled as STAGE+++

The published stages of fusion mentioned-above are adopted in the present study. In addition, the process of appearance of an ossification centre is divided into 3 stages. An integration of both these resulted in a comprehensive staging ranging from stage 0-6. Each stage is given a corresponding point score as follows:

S.No	STAGE	POINT SCORE
1	0	0
2	1	1
3	2	2
4	3	3
5	4	4
6	5	5
7	6	6

Observations & Discussion

The average point score in 11 year girls is 30.0 and the average point score in 11 year boys is 29.0, indicating that ossification in girls is advanced than in boys. Lewis and Garn noted that in the appearance of 36 ossification centers, girls were advanced over boys by about 25%. The difference was about 19% in the timing of knee ossification. Data summarized by Krogman ⁽⁶⁾ and Stewart ⁽¹³⁾ show that union of most epiphyses occurs in females about one to two years earlier than in males. The youngest boys noted with this centre were aged 7 and the youngest girl 8 years

and 6 months. It was present in half of the girls at the age of 9 and the majority of boys at 11. The oldest girl in whom it was not present was aged 10 and the oldest boy 14 years and 7 months. Pryor found the centre present in a girl aged 7 years and 7 months, but absent in another girl aged 10 years and 7 months. The percentages at each age are compared with the figures given by Paterson, the latter appearing to be a rough estimate only. In females, it was present in all of 40 instances at the ages 11 to 14, i.e., 100 per cent. Thus, in this series, this bone was rather more frequently demonstrable than is estimated by Paterson. ⁽⁷⁾

Table1: Head of femur fused and iliac crest in process of fusion (Males)

S.no	ID No	SEX	SHOULDER	ELBOW		WRIST				PELVIS			RESULT
			UH	ME	UR	LU	LR	P	MC1	IC	FH	GT	
1.	M24	M	4	5	6	4	4	3	5	4	5	4	44
2.	M25	M	4	5	5	4	4	3	5	4	6	6	46
3.	M26	M	4	4	5	4	4	3	5	4	5	5	43
4.	M27	M	4	5	6	4	4	3	5	4	6	6	47
5.	M28	M	4	6	6	5	5	3	6	5	6	6	52
6.	M29	M	5	6	6	6	6	3	6	5	6	6	55
7.	M31	M	5	6	6	4	4	3	6	5	5	4	48
8.	M32	M	6	6	6	6	5	3	6	4	6	6	54
9.	M33	M	6	6	6	6	6	3	6	5	6	6	56

Cont... Table1: Head of femur fused and iliac crest in process of fusion (Males)

10	M34	M	5	6	6	6	5	3	6	5	6	6	54
11	M35	M	5	6	6	6	6	3	6	5	6	6	55
12	M36	M	6	6	6	6	6	3	6	5	6	6	56
13	M37	M	6	6	6	6	5	3	6	5	6	6	55
14	M38	M	5	6	6	6	6	3	6	5	6	6	55
15	M39	M	6	6	6	6	5	3	6	5	6	6	55
Average													51.7

Abbreviations

UH upper end of humerus

P pisiform

ME medial epicondyle

MC1 first metacarpal

UR upper end of radius

IC iliac crest

LU lower end of ulna

FH head of femur

LR lower end of radius

GT greater trochanter

M male

F Female

The average point score in 14 year girls is 42.0 and the average point score in 14 year boys is 40.0, indicating that ossification in girls is advanced than in boys. The youngest subjects in whom these epiphyses were present were a girl aged 14 and a boy aged 15, where it was present on each side in each case. In females the majority of epiphyses appear at the age of 14 and in males at 16 years of age, but the maximum incidence is at 15 and 16 in girls and 18 in young men. Epiphyses were found present in females on both sides at the age of 21, and in the male at the age of 21 years and 7 months.

The average point score in 15 year girls is 44.6 and the average point score in 15 year boys is 44.2, (considering medial epicondyle stage 5) indicating that ossification in girls is advanced than in boys. The medial epicondyle, unlike the lateral, is quite separate from the other centers at the lower end of the

humerus and fuses directly and independently with the diaphysis. The earliest age this has been noted is 3 years and 10 months in a female and 5 years and 9 months in the male. None of 23 boys and 7 girls aged 3 and 4 showed this epiphysis. The centre was found in most girls at the age of 5 and in most boys at 6 years of age. Its absence was noted in a girl aged 6 and a boy aged 7. The youngest girls where the medial epicondyle was found fused with the diaphysis were aged 10, the youngest boys 12, in one case being present on the right although fused on the left side. In one half of the girls union had taken place at the age of 14 and in one half of the boys at 16. The fusion of medial epicondyle was observed in nearly half (45.45%) of the cases at age of 13 years. In 86% of cases it fuses at 14 yrs, 97% at 15 yrs and in all cases of 16 & 17years. ⁽¹⁸⁻²³⁾

The average point score in 16 year girls is 47.0 and the average point score in 16 year boys is 44.6, indicating that ossification in girls is advanced than in boys. Following the trend of observation of fusion of ossification centers at early age, contrary to what is mentioned in literatures pertaining to Indian population, head of femur was found fused in two-third of the cases at very early age of 14 years. At 15 years it was found in 58% of cases and at 16 years in 65.5% of cases. In the prescribed age of fusion, i.e.

at 17-18 years it was observed to be fused in 86% of cases and not in hundred percent.⁽¹⁷⁻²²⁾ The youngest to fuse in each sex were girls aged 14 and a boy of 14, in the former instances on both sides. At the age of 14 the great majority had fused in girls, but not until the age of 17 in males had the majority united. This is much earlier than the dates given by Paterson, namely 17 for females and 18 for males. The oldest subjects with unfused epiphyses were 16 years and 10 months in a female and 20 years and 2 months in a male⁽⁶⁾

Table2: ossification landmarks of different ossification centers.

S.No	Ossification landmark	Grays Anatomy (Age in years)	Adjusted value for Indians (Age in years)		Average point score (Age in years)	
			Male	Female	Male	Female
1	Upper End Of Humerus recent fusion	18-19	18	17	53.4	52.8
2	Upper End Of Radius recent fusion	16-17	16	15	41.8	39.5
3	Lower End Of Ulna recent fusion	17-18	17	16	52.0	52.0
4	Lower End Of Radius recent fusion	18-19	18	17	52.8	53.0
5	Femur Head recent fusion	17-18	17	16	40.7	42.3
6	Ossification around elbow complete and UH not fused	16-17 to 18-19	17	16	49.5	47.6
7	Ossification around elbow complete and LU not fused	16-17 to 17-18	16	15	47.5	45.6
8	Ossification around elbow complete and LR not fused	16-17 to 18-19	17	16	48.0	45.3
9	UH not fused and LU fused	17-18 to 18-19	17	16	52.0	50.4
10	UH not fused and FH fused	17-18 to 18-19	17	16	41.4	45.0
11	UH and LR stage 5	18-19	18	17	54	53.3

The average point score in 17 year girls is 53.0 and the average point score in 17 year boys is 47.3, , indicating that ossification in girls is advanced than in boys. The age of fusion of the combined epiphysis for the head and greater tubercle with the diaphysis seems fairly constant. The earliest fusion was at the age of 16 years and 8 months on both sides in a female, and 16 in a boy, the latest 18 in a female and 19 years and 2 months in the male. In none of 20 subjects aged 15 (16 boys and 4 girls) were these epiphyses fused, nor were any epiphyses noted in 30 others (including 14

males and 11 females) aged 20. The majority were fused at the age of 17 in females and 19 in males. Union was constantly found at 19 in females and 20 in males, which does not at all correspond to the various ages, 20 to 25 given by numerous anatomists, and they differ from those given by Paterson, namely 18 for females and 21 for males. It was observed that it was fused at the age of 14 yrs in 13% of cases, 11.4% at 15 yrs, 20% at 16 yrs, 36% at 17 yrs, 43% at 18 yrs, 80% at 19 yrs and 33% at 20 yrs of age. ⁽¹⁷⁻²³⁾



Figure 1- RADIOGRAPH SHOWING UPPER END OF HUMERUS IN STAGE 3



Figure 2- RADIOGRAPH SHOWING UPPER END OF HUMERUS IN STAGE 4



Figure 3-RADIOGRAPH SHOWING UPPER END OF HUMERUS IN STAGE 5



Figure 4-RADIOGRAPH SHOWING UPPER END OF HUMERUS IN STAGE 6

Conclusion

In this study, it is attempted to calculate point score taking Gray's anatomy as standard and making correction for Indians. Point score is noted for various ossification centers. An attempt is made to find correlation between point score and age. It is found that with increasing age the point score is increasing. It is found that the point score in girls is higher than boys at a given age in majority of cases indicating ossification process concluding early in girls than in boys.

The study reveals that girls are 1 year ahead of boys in ossification. For example average point score of 15 year girls is equal to 16 year boys (44.6), the average point score of 16 year girls is (47) nearly equal to average point score of 17 year boys (47.3) and the average point score of 17 year girls is (53) equal to average point score of 18 year boys (53.1). It is suggested that further work may be done with a greater sample size to find out the correlation between point score and the age of an individual.

Ethical Clearance: There were no ethical issues involved as the study was analytical and did not violate any ethical principles.

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Conflict of Interest: Nil

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