

## Estimation of Age from Appearance of Carpal Bones in X-Ray Hand: A Cross-Sectional Study in Purvanchal Region U.P., India

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### Abstract

**Introduction:** Estimation of age from radiological examination of wrist joint for appearance of carpal bones is a practically feasible method in the field of medical and legal professions. Variations have been seen in various geographic regions therefore the aim of this study is to determine relationship between age and appearance of ossification centers of carpal bones in the population of Purvanchal Region. **Objectives:** The primary objective of this study was to assess the skeletal maturity at wrist joint for known chronological age. **Material and methods:** This is a cross-sectional study. The study population consisted of children 0 to 15 years coming to Paediatrics OPD of Government Medical College, Azamgarh, from October 2018 to April 2019. Only subjects with known date of birth and apparently healthy individuals were included in the study. The study comprised of a total 289 subjects in age group 0 to 15 from Purvanchal region. **Results:** This study shows that mean age and standard deviation of appearance of ossification centers of various carpal bones are as follows: capitate and hamate (2.03±1.16 months), triquetrum (34.05±22.8 months), lunate (44.14±21.63 months), trapezium and trapezoid (73.44±24.13 months), scaphoid (73.44±24.14 months) and pisiform (124.84± 23.04 months). There is statistically significant difference in age of appearance of triquetrum, scaphoid, trapezium and trapezoid in males and females, triquetrum being late to appear in females. **Conclusion:** Variation in age of appearance of carpal bones has been noted in present study from studies in other regions of India and abroad.

**Keywords:** Ossification centers; carpal bone; age estimation; Purvanchal Region; radiological; wrist joint.

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### Introduction

Estimation of age of individuals living or dead from appearance of ossification centers is a reasonable scientific method and practically feasible fact in the field of medical and legal professions[1]. One of the principal means which enable one to form fairly accurate opinion about the age in early years is ossification of bones[2]. Doctors are called upon in the court of law to give expert opinion about age of a person. Besides this forensic experts face challenge in commenting on age of bones in mutilated skeletal remains. Therefore estimation of age presents a task of considerable importance from the view point of administration of justice[3,4]. In legal practice punishment depends upon criminal responsibility, that depends chiefly on the age of a person to considerable extent[5]. Important ages from the point of view of criminal responsibility are 0-1 year, 5 years, 7 years, 7-12 years and 18 years. Age group 0-1 year is related to infanticide under Sec. 315 IPC. Under Sec. 82 IPC nothing is an offence which is done by a child under 7 years of age. Under Railways Act 1890 a child below 7 years is liable to punishment if it does anything maliciously to wreck or attempt to wreck a train, to hurt or attempt to hurt a person travelling by railways or to endanger the safety of the persons travelling by railways. However, a child below 5 years is not punishable. Under Sec.83 IPC children between 7 and 12 years of age are held responsible if the court is satisfied that he or she has attained sufficient degree of maturity of understanding to judge the

nature of consequences of their acts on that occasion. The age of 10 years is related to kidnapping. For consent important ages are 12 years and 18 years. It cannot be reasonably expected to formulate a uniform standard for determination of age from appearance of ossification centers because of variations in the climatic, dietetic, hereditary and other factors affecting the people of different states in India[6]. According to best of my knowledge appearance of carpal bones at wrist joint for estimation of age has not been closely investigated by forensic experts in the region of Purvanchal in eastern U.P. Therefore the present study was conducted with an objective to analyze and ascertain the age of appearance of ossification centers at wrist joint.

#### Aims and objectives

1. To assess the skeletal maturity at wrist joint for known chronological age.
2. Comparison with other studies at wrist joint.
3. To evaluate sex related variation and its correlation with age.
4. To know variation if any and exception of appearance of centers of ossification.
5. To evaluate the medicolegal aspects of different ages.
6. To suggest any additional radiological investigation to aid and to reduce range in age.

#### Material and Methods

The present cross-sectional study was planned and executed at Department of Forensic Medicine, Government Medical College, Azamgarh. The study population consisted of children 0 to 15 years coming to Paediatrics OPD of Government Medical College, Azamgarh, from October 2018 to April 2019. Only subjects with known date of birth and apparently healthy individuals were included in the study. Individuals with any chronic illness, short stature,

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deformity, severe malnutrition- weight age less than 60%, endocrine disorders, malformations, chronic drug intake- antiepileptic, steroid etc were excluded from the survey.

The study comprised of a total 289 subjects in age group 0 to 15 from Purvanchal region. The sample was divided into 14 groups each of 12 months interval (Table 1).

**Table 1: Age distribution of patients studied**

Age in months	No. of Patients	%
0-12 months	36	12.4
13-24 months	39	13.4
25-36 months	20	6.9
37-48 months	24	8.3
49-60 months	22	7.6
61-72 months	28	9.6
73-84 months	10	3.4
85-96 months	18	6.2
97-108 months	11	3.8
109-120 months	13	4.4
121-132 months	8	2.7
133-144 months	18	6.2
145-156 months	21	7.2
>156 months	21	7.2
Total	289	100.0

X ray of left hand in AP view was taken. The information regarding particulars of the subjects and findings were recorded in a specially designed proforma.

**Statistical software:** The statistical software namely SPSS 22.0 and R environment ver.3.2.2 were used for analysis of data and Microsoft word and Excel have been used to generate tables. Student t test has been applied for p value. Kaplan Meier Function was applied to calculate 95% Confidence Interval (CI).

**Results and discussions**

The study has been conducted on 289 healthy individuals aged between 0 to 15 years of which 167 (57.7%) were males and 122 (42.2%) were females (Table 2).

**Table 2: Gender distribution of patients studied**

Gender	No. of Patients	%
Female	122	42.2
Male	167	57.7
Total	289	100.0

Table 3, 4 & 5 show percentages of individuals showing appearance of carpal bones in different age groups in males and females combined, males and females respectively.

**Table 3: Incidence appearance of ossification according to different age groups (male and female)**

Age in months	OSSIFICATION								Total
	Scaphoid	Lunate	Triquetral	Pisiform	Trapezium	Trapazoid	Capitate	Hamate	
0-6M	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)	12(70.6%)	11(64.7%)	17
7-12M	0(0%)	0(0%)	4(21%)	0(0%)	0(0%)	0(0%)	19(100%)	19(100%)	19
13-24M	0(0%)	2(5%)	12(30.7%)	0(0%)	0(0%)	0(0%)	39(100%)	39(100%)	39
25-36M	0(0%)	3(15%)	9(45%)	0(0%)	0(0%)	0(0%)	20(100%)	20(100%)	20
37-48M	1(4.2%)	7(29.2%)	19(79.2%)	0(0%)	1(4.2%)	1(4.2%)	24(100%)	24(100%)	24
49-60M	3(13.6%)	15(68.2%)	19(86.4%)	0(0%)	4(18.2%)	4(18.2%)	22(100%)	22(100%)	22
61-72M	15(53.6%)	20(71.4%)	28(100%)	0(0%)	10(35.7%)	10(35.7%)	28(100%)	28(100%)	28
73-84M	3(30%)	10(100%)	10(100%)	0(0%)	6(60%)	6(60%)	10(100%)	10(100%)	10
85-96M	14(77.7%)	17(94.4%)	17(94.4%)	2(11.1%)	10(55.6%)	10(55.6%)	18(100%)	18(100%)	18
97-108M	10(90.9%)	11(100%)	11(100%)	3(27.3%)	10(90.9%)	10(90.9%)	11(100%)	11(100%)	11
109-120M	13(100%)	13(100%)	13(100%)	2(15.4%)	13(100%)	13(100%)	13(100%)	13(100%)	13
121-132M	8(100%)	8(100%)	8(100%)	4(50%)	8(100%)	8(100%)	8(100%)	8(100%)	8
133-144M	18(100%)	18(100%)	18(100%)	11(61.1%)	18(100%)	18(100%)	18(100%)	18(100%)	18
145-156M	21(100%)	21(100%)	21(100%)	20(95.2%)	21(100%)	21(100%)	21(100%)	21(100%)	21
156M & above	21(100%)	21(100%)	21(100%)	21(100%)	21(100%)	21(100%)	21(100%)	21(100%)	21

**Table 4: Incidence appearance of ossification center according to different age groups (male)**

Age in months	OSSIFICATION								Total
	Scaphoid	Lunate	Triquetral	Pisiform	Trapezium	Trapazoid	Capitate	Hamate	
0-12 M	0(0%)	0(0%)	2(8%)	0(0%)	0(0%)	0(0%)	21(84%)	20(80%)	25
13-24M	0(0%)	1(4.3%)	5(21.7%)	0(0%)	0(0%)	0(0%)	23(100%)	23(100%)	23
25-36M	0(0%)	2(18.2%)	4(36.4%)	0(0%)	0(0%)	0(0%)	11(100%)	11(100%)	11
37-48M	0(0%)	2(18.2%)	6(54.5%)	0(0%)	0(0%)	0(0%)	11(100%)	11(100%)	11
49-60M	1(8.3%)	8(66.7%)	10(83.3%)	0(0%)	1(8.3%)	2(16.7%)	12(100%)	12(100%)	12
61-72M	5(35.7%)	7(50%)	14(100%)	0(0%)	3(21.4%)	5(35.7%)	14(100%)	14(100%)	14
73-84M	2(33.3%)	6(100%)	6(100%)	0(0%)	2(33.3%)	3(50%)	6(100%)	6(100%)	6
85-96M	10(76.9%)	12(92.3%)	12(92.3%)	0(0%)	6(46.2%)	6(46.2%)	13(100%)	13(100%)	13
97-108M	3(75%)	4(100%)	4(100%)	0(0%)	3(75%)	4(100%)	4(100%)	4(100%)	4
109-120M	10(100%)	10(100%)	10(100%)	1(10%)	10(100%)	10(100%)	10(100%)	10(100%)	10
121-132M	6(100%)	6(100%)	6(100%)	2(33.3%)	6(100%)	6(100%)	6(100%)	6(100%)	6
133-144M	12(100%)	12(100%)	12(100%)	6(50%)	12(100%)	12(100%)	12(100%)	12(100%)	12
145-156M	11(100%)	11(100%)	11(100%)	10(90.9%)	11(100%)	11(100%)	11(100%)	11(100%)	11
156M & above	9(100%)	9(100%)	9(100%)	9(100%)	9(100%)	9(100%)	9(100%)	9(100%)	9

**Table 5: Incidence appearance of ossification center according to different age groups (Female)**

Age in months	OSSIFICATION								Total
	Scaphoid	Lunate	Triquetral	Pisiform	Trapezium	Trapazoid	Capitate	Hamate	
0-12 M	0(0%)	0(0%)	2(18.2%)	0(0%)	0(0%)	0(0%)	10(90.9%)	10(90.9%)	11
13-24M	0(0%)	1(6.3%)	7(43.7%)	0(0%)	0(0%)	0(0%)	16(100%)	16(100%)	16
25-36M	0(0%)	1(11.1%)	5(55.6%)	0(0%)	0(0%)	0(0%)	9(100%)	9(100%)	9
37-48M	1(7.7%)	5(38.5%)	13(100%)	0(0%)	1(7.7%)	2(15.4%)	13(100%)	13(100%)	13
49-60M	2(20%)	7(70%)	9(90%)	0(0%)	3(30%)	5(50%)	10(100%)	10(100%)	10
61-72M	10(71.4%)	13(92.9%)	14(100%)	0(0%)	7(50%)	10(71.4%)	14(100%)	14(100%)	14
73-84M	1(25%)	4(100%)	4(100%)	0(0%)	4(100%)	2(50%)	4(100%)	4(100%)	4
85-96M	4(80%)	5(100%)	5(100%)	2(40%)	4(80%)	4(80%)	5(100%)	5(100%)	5
97-108M	7(100%)	7(100%)	7(100%)	3(42.9%)	7(100%)	7(100%)	7(100%)	7(100%)	7
109-120M	3(100%)	3(100%)	3(100%)	1(33.3%)	3(100%)	3(100%)	3(100%)	3(100%)	3
121-132M	2(100%)	2(100%)	2(100%)	2(100%)	2(100%)	2(100%)	2(100%)	2(100%)	2
133-144M	6(100%)	6(100%)	6(100%)	5(83.3%)	6(100%)	6(100%)	6(100%)	6(100%)	6
145-156M	10(100%)	10(100%)	10(100%)	10(100%)	10(100%)	10(100%)	10(100%)	10(100%)	10
156M & above	12(100%)	12(100%)	12(100%)	12(100%)	12(100%)	12(100%)	12(100%)	12(100%)	12

Table 6 shows mean age and standard deviation of ossification of different carpal bones in males, females and combined. It also shows 95% Confidence Interval (CI) using Kaplan Meier Function.

**Table 6: Comparison of mean age according to gender of population studied**

Carpal bone	Mean Age in Months (Ossification appeared)			P value	Kaplan Meier function	
	Male	Female	Total		Mean Age(months)	95% CI
Scaphoid	76.66±24.81	69.36±22.82	73.44±24.14	0.094+	73.71	69.48-77.94
Lunate	43.14±21.89	45.29±21.43	44.14±21.63	0.553	43.81	40.32-47.31
Triquetral	31.12±22.66	37.87±22.57	34.05±22.80	0.056+	33.72	30.33-37.09
Pisiform	123.80±22.64	126.78±23.98	124.84±23.04	0.563	124.96	120.12-129.73
Trapezium	76.66±24.81	69.36±22.82	73.44±24.13	0.094+	73.71	69.48-77.94
Trapazoid	76.66±24.81	69.36±22.82	73.44±24.13	0.094+	73.71	69.48-77.94
Capitate	2.14±1.30	1.67±0.58	2.03±1.16	0.559	2.03	1.37-2.68
Hamate	2.14±1.30	1.67±0.58	2.03±1.16	0.559	2.03	1.37-2.68

In this study the mean age of appearance of capitate and hamate is 2.03±1.16 months (Fig 1) which is in accordance with Hasan and Narayan (1963)[7] However Galstaun (1937)[8] reported later appearance of Hamate at 10-11 months. Paterson (1929)[9] and Flecker (1942)[10]reported appearance of capitate and hamate at 6 months.



Fig 1: X-ray hand AP view wrist joint of a month old female showing ossification of capitate and hamate



Fig 2: X-ray hand AP view wrist joint of a 1 year and 3 months old female showing ossification of capitate, hamate and triquetrum



Fig 3: X-ray hand AP view wrist joint of a 2 years and 8 months old male showing ossification of capitate, hamate, triquetrum and lower end of radius



Fig 4: X-ray hand AP view wrist joint of a 3 years 3 months old male showing ossification of capitate, hamate, triquetrum and lunate and lower end of radius



Fig 5: X-ray hand AP view wrist joint of a 5 years 11 months old female showing ossification of capitate, hamate, triquetrum, lunate, trapezoid and scaphoid and lower end of radius



Fig 6: X-ray hand AP view wrist joint of a 6 years old female showing ossification of capitate, hamate, triquetrum, lunate, trapezium, trapezoid and scaphoid and lower end of radius



**Fig 7: X-ray hand AP view wrist joint of a 7 years and 8 months old female showing ossification of capitae, hamate, triquetral, lunate, scaphoid, trapezium, trapezoid, pisiform, lower end of radius and lower end of ulna**

In our study mean age of appearance of triquetral is 34.05±22.80 months (Fig 2,3) which is in accordance with Paterson (1929)[9]and Galstaun (1937)[8]. Flecker (1942)[10] and Hasan and Narayan (1963)[7] reported a slight delay in it appearance. Mean age of appearance of lunate is 45.14±21.63 months (Fig 4) in our study which is in accordance with Paterson (1929)[9]and Flecker (1942) [10]. Galstaun (1937)[8]and Hasan and Narayan(1963)[7] reported later appearance of lunate at 5 and 6 years respectively. Trapezium, trapezoid and scaphoid appeared at 73.44±24.13 months (Fig 5,6) in this study which is similar to Galstaun(1937)[8] and Hasan and Narayan (1963)[7]. Paterson (1927)[9]reported earlier appearance of trapezium and trapezoid at 4-5 years in girls. Pisiform appeared at 124.84±23.04 months (Fig 7) in present study which is in accordance with Paterson (1929)[9] and

Flecker(1937)[10]. The age of appearance of pisiform is reported to be slightly higher in Gaulstan(1937)[8] and Hasan and Narayan (1963)[7] studies.

In this study it has been found that there is statistically significant difference in age of appearance of triquetral, scaphoid, trapezium and trapezoid in males and females, triquetral being late to appear in females. Scaphoid, trapezium and trapezoid appeared early in females. There is no statistically significant difference in age of appearance in case of capitae, hamate, lunate and pisiform as far as gender is concerned. These findings are similar to that in Galstaun (1937)[8] and Hasan and Narayan (1963)[7] except pisiform that appeared late in males in these studies (table 7).

**Table 7: Comparison of Various Studies**

Studies	Sex	Capitate	Hamate	Triquetral	Lunate	Trapezium	Trapezoid	Scaphoid	Pisiform
Paterson (1929) England	M	6m	6m	3-4y	4-5y	6y	6y	6y	12-14y
	F	6m	6m	2-3y	3-4y	4-5y	4-5y	6y	9-10y
Flecker (1942) Australia	M	6m	10-11m	4y	4y	5y	6y	6y	11y
	F	6m	10-11m	3-4y	3y	5y	6y	4y	10y
Galstaun (1937) Bengal	M	6m	8-14m	3-4y	5y	7y	4-7y	7-11y	12-17y
	F	6m	8-14m	2-3y	5y	5-6y	5-6	6y	9-12y
Hasan & Narayan (1963) UP	M	<6m	<6m	5y	6y	8y	7y	7y	13y
	F	<6m	<6m	3y	6y	6y	6y	7y	11y
Present Study	M	2.14m	2.14m	2y7m	3y 7m	6y 4m	6y 4m	6y 4m	10y 3m
	F	1.67m	1.67m	3y1m	3y 9m	5y 9m	5y 9m	5y 9m	10y 6m

**Conclusion**

Variation in age of appearance of carpal bones has been noted in present study from studies in other regions of India and abroad. Therefore, such kinds of studies are recommended to be conducted in different regions at large scale through large projects so that a standardized value may be derived for a particular population in the country. Fully automatic bone age assessment may be done by Computer Aided Diagnosis (CAD) method, providing more accurate results.

High resolution MRI, examining microcomponents of carpal bones, is another method that may be used for more precise estimation of age.

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