



Estimation of Age from Appearance of Carpal Bones in X-Ray Hand: A Cross-Sectional Study in North Indian Population

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ABSTRACT

INTRODUCTION: There are eight carpal bones in the adult human wrist, arranged in two rows between the metacarpals and the distal radius and ulna. The proximal row includes the scaphoid, lunate, triquetral and pisiform. The trapezium, trapezoid, capitate and hamate form the distal row. The scaphoid is positioned between the radius and trapezium at the base of the thumb; it is the most lateral and proximal carpal. The scaphoid is characterised by a major concave surface for the head of the capitate, adjacent to the blunt tail-like tubercle, as well as a major convex surface for articulation with the distal end of the radius. Medial to the scaphoid is the lunate, which on its proximal surface has a convex facet that articulates with the radius, and on the distal surface has a concave surface for articulation with the capitate. **AIM AND OBJECTIVE:** To estimate average age by ossification carpal bones in male population. To estimate average age by ossification of carpal bones in female population. **METHOD AND MATERIALS:** This hospital-based study was conducted in Department of Anatomy and Department of Radio diagnosis, Index Medical College, Hospital and Research Centre Indore MP, India. The subjects were explained about the procedure and written informed consent was taken. The detailed physical examination was done and data regarding patient's particulars like age, sex, clinical history etc. was taken on pre designed proforma. The radiography in the form of X-rays and USG was done. The ultra-sonographic scan of individual subject was evaluated with respect to the stage of epiphyseal ossification followed by evaluation of radiographic grade. **RESULT:** shows the percentage of presence of carpal bones in each age group (years) of female gender and it was found that maximum bone was present in all the cases before reaching 6 years of age except lunate in 85.7% scaphoid 76.2% cases noted, trapezium in 71.4%, Trapezoid in 57.1% and pisiform appearing in 33.3% cases in 6-8 years, and 100.0% noted in 10.1-12 years age groups. **CONCLUSION:** Maximum bone was present in all the male cases before reaching 6 years of age except scaphoid 68.2% cases noted, trapezium in 77.3%, trapezoid in 63.6% and pisiform appearing in 33.3% cases in 8.1-10 years, and 100.0% noted in 14.1-16 years age groups.

Keywords: Ossification centers; carpal bone; age estimation; north Indian population; radiological; wrist joint

INTRODUCTION

The Carpals: There are eight carpal bones in the adult human wrist, arranged in two rows between the metacarpals and the distal radius and ulna. The proximal row includes the scaphoid, lunate, triquetral and pisiform. The trapezium, trapezoid, capitate and hamate form the distal row. The scaphoid is positioned between the radius and trapezium at the base of the thumb; it is the most lateral and proximal carpal. The scaphoid is characterised by a major concave surface for the head of the capitate, adjacent to the blunt tail-like tubercle, as well as a major convex surface for articulation with the distal end of the radius. Medial to the scaphoid is the lunate, which on its proximal surface has a convex facet that articulates with the radius, and on the distal surface has a concave surface for articulation with the capitate.

The triquetral has three distinct articular surfaces for the hamate, lunate and pisiform. The articular surface for the pisiform is a single circular elevated facet, on the medial surface of the bone. The hamate facet is distal to the lateral lunate facet, although the two are continuous. The pisiform is the smallest of the carpals; it is technically a sesamoid bone because it develops within a tendon. The pisiform is pea-shaped with a flattened articular surface for the triquetral. The trapezium is the most lateral carpal of the distal row, situated at the base of the metacarpal I. It is irregularly shaped with a large saddle shaped articular surface for metacarpal I. The trapezium also articulates with metacarpal II and the scaphoid. The trapezoid is the smallest carpal of the distal row and is roughly shaped like a boot. It articulates with the trapezium, the scaphoid, the capitate and metacarpal II. The capitate has a rounded proximal head and a square shaped distal end which articulates with metacarpals II and III (and occasionally IV). The hamate is the large triangular shaped carpal that articulates with the capitate, the triquetral and the lunate, and the bases of the metacarpals IV and V. The hamate has a hook-shaped projection (hamulus) on the palmar surface which is an attachment point for a fibrous band through which the flexor tendons of the wrist pass.^{1,2}

Development of the Carpals: Unlike other bones of the hand-wrist, the carpals do not develop epiphyses.^{4,6} Scheuer and Black⁴ (2004) note that with the exception of the pisiform, the sequence of appearance of the carpals is circular, starting with the capitate, proceeding counter-clockwise (in anatomical position) and ending with the trapezium and trapezoid. The capitate is the first carpal to ossify, typically appearing between 2 to 3 months postnatal in

females, and 3 to 4 months in males. The primary centre for the capitate can sometimes be present at birth. The hamate ossifies next; it develops articular surfaces as it changes in size and shape from a small roughened nodule to an inverted triangle.³ By 11 to 14 years of age the hamulus is radiographically identifiable.^{7,8} The triquetral has a highly variable onset of ossification, developing in the first year for some individuals, and the second or third for others.⁵ The lunate develops recognisable articular surfaces for the scaphoid and the triquetral after 4 to 5 years of age. **Error! Bookmark not defined.** The ossification centres appear concurrently for the trapezium and trapezoid at approximately 4 to 5 years of age.⁴ The scaphoid forms a distinct 'tear-drop' shape at 7 to 8 years of age.⁴ The pisiform is the last carpal to commence ossification at approximately 8 to 10 years of age.⁴

METHOD AND MATERIALS

This cross-sectional study was conducted in the Department of Anatomy with collaboration of department of Radio diagnosis, Index Medical College, Hospital and Research Centre Indore MP, India from January 2021 to December 2022 after approval of Institutional Ethical committee. The study population included 300 patients (150 males and 150 females) of 6 to 20 years of age who was required the age estimation based on radiography according to measurement of carpal & epiphyses of Radius and ulna and compared it by their original age.

Study design: A cross-sectional study

Study subjects: The subjects free from any physical disability involving upper limbs was included in the study.

Study location: This hospital-based study was conducted in Department of Anatomy and Department of Radio diagnosis, Index Medical College, Hospital and Research Centre Indore MP, India.

Study Duration: January 2021 to December 2022 (24 months).

Sample Size: 300 patients

Finally in this study, was including 300 women. Sample size was estimated using software Power analysis and sample size, version 8 (PASS-2008).

Inclusion criteria:

- Subjects aged 6-20 years with age proof
- Both male and female.

Exclusion criteria: Patients excluded with-

- Subjects having age less than 6 years and more than 20 years
- Subjects showing any sign of disease affecting skeletal maturation.
- Subjects with history or any stigmata of previous fractures of bones (of and around the pelvis).
- Subjects with nutritional, endocrine disorders, chronic infections etc.

Study tool/ Patient's data acquisition

- Predesigned proforma
- Consent form
- Ultrasonic equipment for sonography
- X-ray machine (DR 100e Mobile X Ray System, Brand-Agfa Healthcare)

Procedure methodology:

The subjects were explained about the procedure and written informed consent was taken. The detailed physical examination was done and data regarding patient's particulars like age, sex, clinical history etc. was taken on pre designed proforma.

The radiography in the form of X-rays and USG was done. The ultra-sonographic scan of individual subject was evaluated with respect to the stage of epiphyseal ossification followed by evaluation of radiographic grade.

Ultrasonological and clinical examination: Each subject was examined ultrasonologically for wrist joint of both limb in the Department of Radiology and subsequently, the ultra-sonogram was studied in detail by the radiologist with respect to fusion of various ossification centres. The ultra sonography was done by ultra sonographic machine. (**Ultrasound Color Doppler System, Model: DCU-12**)

1. Radiographic positioning of the parts: Anteroposterior position of the wrist joint of right hand was used. The radiographers were advised to take care that lower end of ulna and radius should be viewed in the film of wrist joint in order to visualize clearly all the ossification centres.

2. Radiographic factors: The skiagrams of elbow joint of right hand was taken in film of 8-10 mA/Sec at 45 to 55 k. v. The Hindustan photo film screen sensitive films of 15"x10" for pelvis and 10"x8" for hand was used by optimum processing method.

Statistical Analysis: Data was analysed using Statistical Package for Social Sciences, version 20 (SPSS Inc., Chicago, IL). Results for continuous variables was presented as mean \pm standard deviation, whereas results for categorical variables was presented as frequency/number (percentage). Risser's score was also used for comparison of Xray and USG findings. Inter class correlation was done on the basis on Wilcoxon Signed Ranks Test. The level $P < 0.05$ was considered as the cutoff value or significance.

RESULT

This prospective study was conducted in the Department of Anatomy at Index Medical College, Hospital and Research Centre Indore MP, in cooperation with the Department of Radiodiagnosis. Patients ranged in age from 6 to 20. Information pertinent to the patient's name, age, sex, and medical history was recorded.

Table No. 1: Percentage of presence of carpal bones in each age group (years) of male gender.

| Presence of carpal bones | Age Group (years) | | | | | | |
|--------------------------|-------------------|---------------|--------------|----------------|----------------|----------------|----------------|
| | 6-8 (n=22) | 8.1-10 (n=21) | 10-12 (n=19) | 12.1-14 (n=19) | 14.1-16 (n=24) | 16.1-18 (n=23) | 18.1-20 (n=22) |
| Capitate | 22 (100.0%) | 21 (100.0%) | 19 (100.0%) | 19 (100.0%) | 24 (100.0%) | 23 (100.0%) | 22 (100.0%) |
| Hamate | 22 (100.0%) | 21 (100.0%) | 19 (100.0%) | 19 (100.0%) | 24 (100.0%) | 23 (100.0%) | 22 (100.0%) |
| Triquetral | 22 (100.0%) | 21 (100.0%) | 19 (100.0%) | 19 (100.0%) | 24 (100.0%) | 23 (100.0%) | 22 (100.0%) |
| Lunate | 22 (100.0%) | 21 (100.0%) | 19 (100.0%) | 19 (100.0%) | 24 (100.0%) | 23 (100.0%) | 22 (100.0%) |
| Scaphoid | 15 (68.2%) | 19 (90.5%) | 19 (100.0%) | 19 (100.0%) | 24 (100.0%) | 23 (100.0%) | 22 (100.0%) |
| Trapezium | 17 (77.3%) | 20 (95.2%) | 19 (100.0%) | 19 (100.0%) | 24 (100.0%) | 23 (100.0%) | 22 (100.0%) |
| Trapezoid | 14 (63.6%) | 18 (85.7%) | 19 (100.0%) | 19 (100.0%) | 24 (100.0%) | 23 (100.0%) | 22 (100.0%) |
| Pisiform | 0 (0.0%) | 7 (33.3%) | 14 (73.7%) | 18 (94.7%) | 24 (100.0%) | 23 (100.0%) | 22 (100.0%) |

The above table shows the percentage of presence of carpal bones in each age group (years) of male gender and it was found that maximum bone was present in all the cases before reaching 6 years of age except scaphoid 68.2% cases noted, trapezium in 77.3%, trapezoid in 63.6% and pisiform appearing in 33.3% cases in 8.1-10 years, and 100.0% noted in 14.1-16 years age groups.

Table No. 2: Percentage of presence of carpal bones in each age group (years) of female gender.

| Presence of carpal bones | Age Group (years) | | | | | | |
|--------------------------|-------------------|---------------|----------------|----------------|----------------|----------------|----------------|
| | 6-8 (n=21) | 8.1-10 (n=22) | 10.1-12 (n=21) | 12.1-14 (n=26) | 14.1-16 (n=21) | 16.1-18 (n=19) | 18.1-20 (n=20) |
| Capitate | 21 (100.0%) | 22 (100.0%) | 21 (100.0%) | 26 (100.0%) | 21 (100.0%) | 19 (100.0%) | 20 (100.0%) |
| Hamate | 21 (100.0%) | 22 (100.0%) | 21 (100.0%) | 26 (100.0%) | 21 (100.0%) | 19 (100.0%) | 20 (100.0%) |
| Triquetral | 21 (100.0%) | 22 (100.0%) | 21 (100.0%) | 26 (100.0%) | 21 (100.0%) | 19 (100.0%) | 20 (100.0%) |
| Lunate | 18 (85.7%) | 22 (100.0%) | 21 (100.0%) | 26 (100.0%) | 21 (100.0%) | 19 (100.0%) | 20 (100.0%) |
| Scaphoid | 16 (76.2%) | 22 (100.0%) | 21 (100.0%) | 26 (100.0%) | 21 (100.0%) | 19 (100.0%) | 20 (100.0%) |
| Trapezium | 15 (71.4%) | 22 (100.0%) | 21 (100.0%) | 26 (100.0%) | 21 (100.0%) | 19 (100.0%) | 20 (100.0%) |
| Trapezoid | 12 (57.1%) | 19 (86.4%) | 21 (100.0%) | 26 (100.0%) | 21 (100.0%) | 19 (100.0%) | 20 (100.0%) |
| Pisiform | 7 (33.3%) | 14 (63.6%) | 21 (100.0%) | 26 (100.0%) | 21 (100.0%) | 19 (100.0%) | 20 (100.0%) |

The above table shows the percentage of presence of carpal bones in each age group (years) of female gender and it was found that maximum bone was present in all the cases before reaching 6 years of age except lunate in 85.7% scaphoid 76.2% cases noted, trapezium in 71.4%, Trapezoid in 57.1% and pisiform appearing in 33.3% cases in 6-8 years, and 100.0% noted in 10.1-12 years age groups.

DISCUSSION

The present cross-sectional investigation was approved by the institutional ethical council and carried out from January 2021 to December 2022 in the anatomy department of Index Medical College, Hospital and Research Center Indore MP, India, in cooperation with the radiodiagnosis department. 300 patients, 150 of whom were male and 150 of whom were female, between the ages of 6 and 20 were included in the study population. They were enrolled for the purpose of estimating their age using radiography, which measured the carpal and epiphyses of the radius and ulna, and compared that age to their initial age.

Our study noted that the maximum bone was present in all the cases before reaching 6 years of age in male and female both gender except scaphoid 68.2% cases noted, trapezium in 77.3%, trapezoid in 63.6% and pisiform appearing in 33.3% cases in 8.1-10 years, and 100.0% noted in 14.1-16 years age groups in males. But lunate in 85.7% scaphoid 76.2% cases noted, trapezium in 71.4%, Trapezoid in 57.1% and pisiform appearing in 33.3% cases in 6-8 years, and 100.0% noted in 10.1-12 years age groups in females. 68.2% cases of male gender were found develop distal epiphyses (DE) of ulna in age group 6-8 years and rest cases after that. And in female gender it was found that all the females were detected with Presence of /distal epiphyses (DE) of radius and ulna before reaching 8 years of age. In a similar study **Wankhade PA et al⁹** reported that the Scaphoid, Lunet, Triquetral, Trapezium, capitate, Hamate appeared in 1 (2%), 5 (10%), 8(16%), 1(2%), 9(18%), 9(18%) respectively in < 1-5 age group. Pisiform and Trapezoid appeared in 6(12%), 13(26%) respectively in 6-10 age group. In another study **Kiran UB et al¹⁰** reported the capitate and hamate carpals ossified during the first year of life in children of both sexes. Triquetral and lunate appeared at 3 - 4 years, trapezium, trapezoid and scaphoid carpals appeared between 5 and 8 years. Pisiform appeared at 9 years of age in females and at 13 years in males. **Al-Khater KM et al¹¹** reported that the e first bones at the wrist region to appear in Saudi children are the capitate, hamate, and distal epiphysis of the radius, and these appear during the first year of life. The other bones develop subsequently at yearly intervals, and the last one to appear is the pisiform, which arises at the end of the first decade of life. **Majeedi IF et al¹²** reported the 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), triquetral (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 triquetral, scaphoid, trapezium and trapezoid in males and females, triquetral being late to appear in females.

CONCLUSION

- ❖ Maximum bone was present in all the male cases before reaching 6 years of age except scaphoid 68.2% cases noted, trapezium in 77.3%, trapezoid in 63.6% and pisiform appearing in 33.3% cases in 8.1-10 years, and 100.0% noted in 14.1-16 years age groups.
- ❖ The maximum bone was present in all the female cases before reaching 6 years of age except lunate in 85.7% scaphoid 76.2% cases noted, trapezium in 71.4%, Trapezoid in 57.1% and pisiform appearing in 33.3% cases in 6-8 years, and 100.0% noted in 10.1-12 years age groups.
- ❖ 68.2% cases of male gender were found develop distal epiphyses (DE) of ulna in age group 6-8 years and rest cases after that.
- ❖ In female gender it was found that all the females were detected with Presence of /distal epiphyses (DE) of radius and ulna before reaching 8 years of age.

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