

The importance of the ossification centre morphology in the left hand-wrist bones for age evaluation

Catalin Dogaroiu^{1,2}, Corneliu Octavian Capatina², Elena Viorica Gherghe^{2,*}, Marian Avramoiu³

Abstract: Determining the chronological age by assessing only the presence of ossification centres and the degree of epiphyseal union observed in the left hand-wrist X-rays could lead to important chronological age underestimation or overestimation.

This article presents 4 such cases, emphasizing the importance of assessing the morphology of hand bone elements in addition to their presence in order to increase the accuracy of the chronological age evaluation.

Key Words: chronological age evaluation, left hand-wrist X-ray, presence of ossification centres, morphology of ossification centres.

Greulich & Pyle (GP) atlas is one of the most popular method to assess subadult skeletal age [1,2], which shows a good correlation with the chronological age [3,4,5]. The principle of this fast and simple method consists in comparing a given hand radiograph with a series of reference radiographs from boys and girls of certain age groups and selecting the nearest match [6].

This article underlines the fact that the evaluation of the chronological age based solely on the presence of ossification centres, without assessing their morphology and that of hand bones, can lead to erroneous estimation (either overestimation or underestimation) which go beyond the standard deviation of 0.6 and 1.1 years identified by Greulich & Pyle [7].

Four cases were selected from a study group of 388 children ranging in age from 1 to 9 years old, examined at the "Mina Minovici" National Institute of Legal

Medicine, Department of Medico-Legal Identification. The age evaluation in these cases using only the presence of ossification centers in the left hand would have led to an overestimation of up to 1 year and 9 months and to an underestimation of up to 2 years and 10 months.

The chronological age of the 4 children was known from the maternity hospital certificate which was made available to us either by parents or social workers. The Romanian legislation requires a medico-legal examination in order to determine the age in case the person does not have an official birth certificate or the person who has committed a crime has to be prosecuted as an adult or a minor.

To determine the age, the following elements showed on the left hand X-ray were assessed:

1. The presence of ossification centres (the distal epiphysis of the radius and ulna, the carpal bones (scaphoid, lunate, triquetrum, trapezium, trapezoid,

1) "Carol Davila" University of Medicine and Pharmacy, School of Medicine, Department of Forensic Pathology and Bioethics, Bucharest

2) "Mina Minovici" National Institute of Legal Medicine, sos. Vitan Barzesti 9, sector 4, Bucharest, Romania

* Corresponding author: MD, Email: gherghe_elenal986@yahoo.com

3) Medico-Legal Laboratory Rm. Valcea, Romania

capitate, hamate), the base of the 1st metacarpal, the head of the 2nd – 5th metacarpals and the base of the phalanges).

2. The morphological traits of the centres mentioned above.

Case 1 – Boy, chronological age 1 year 2 months and 29 days



Figure 1. Boy, chronological age 1 year 2 months and 29 days.

The ossification centres identified are those for the distal radial epiphysis, capitate, hamate, triquetrum, lunate, epiphyses of the proximal 2nd and 3rd phalanges and 1st distal phalanx.

Based only on the carpal bone ossification, the estimated skeletal age should be 3 years - 3½ years. For a more accurate evaluation of the biological age, not only the absence of the 2nd, 3rd and 4th metacarpal head ossification centres (which develop after the age of 1½ years) should be considered, but also the morphology of hand bones and ossification centres. This morphology is suggestive of the 1 year – 1 year and 3 months age group [8, 9]:

- the centre of ossification for the distal radial epiphysis is small and oval-shaped (the wedge-shape of this ossification centre develops at around 2.8 years of age);

- the capitate and hamate are closer, they are no longer round-shaped and their reciprocal facets have begun to flatten;

- the hamate facet of the 2nd metacarpal base is

slightly flattened;

- the medial and lateral parts of the distal ends of the 3rd and 4th proximal phalanges are slightly flattened.

Case 2 – Boy, chronological age 4 years 3 months and 26 days



Figure 2. Boy, chronological age 4 years 3 months and 26 days.

If we estimate the age only on the presence of ossification centres (all ossification centres are present, except the ossification centre of the distal ulnar epiphysis), the biological age could be between 6 and 7 years. However, an accurate age estimation should consider the absence of the distal ulnar epiphysis ossification centre, characteristic for 0 - 5 years old children, and especially the morphology of ossification centres and hand bones [8, 9]:

- the distal radial epiphysis is wedge-shaped and one can notice the volar and dorsal surfaces which appear after 4 years of age;

- the absence of the reciprocal convexity and concavity of the hamate and capitate respectively, which appear around 6 years of age;

- the long axis of the triquetrum can be distinguished at around 4½ years of age;

- the surface of the proximal end of the 2nd metacarpal which will articulate with the trapezoid is

slightly concave and the 4th and 5th metacarpal bases begin to slightly overlap; these changes appear around 4½ - 5 years of age;

- the ossification centres of the epiphyses of the 2nd - 5th metacarpals are slightly flattened at their medial aspects and rounded distally (normal at around 4½ years of age);

- the epiphyses of the proximal phalanges are not as wide as their shafts;

- the articular surfaces of the 2nd and 3rd proximal phalanges are slightly concave and their corresponding epiphyses are wedge-shaped, tapering toward their medial aspects (normal at around 4 years of age);

- the proximal epiphyses of the middle phalanges are wider than half of their shafts at around 4½ years of age.

Taking into account the absence of the distal ulnar epiphysis as well as the morphology of the ossification centres, one can estimate the person's age as being 4 - 4½ years old.

Case 3. Boy, chronological age 3 years 6 months and 11 days



Figure 3. Boy, chronological age 3 years 6 months and 11 days.

The estimated skeletal age based only on the presence of ossification centres (distal radial epiphysis, capitate, hamate, epiphyses of the 2nd and 3rd metacarpals, 2nd and 3rd proximal phalanges, 2nd - 4th middle phalanges

and 1st, 3rd and 4th distal phalanges) could be 1½ - 2 years of age. Considering the morphology of the ossification centres, the following characteristics are present [8, 9]:

- the capitate and hamate are larger and closer together;

- the trapezoid facet of the base of the 2nd metacarpal has begun to flatten, which could indicate 3½ years of age.

- at the proximal end of the 2nd metacarpal, the trapezoid and capitate facets make a wide angle at around 3½ years of age;

- for the 3 - 3½ years of age, the epiphyses of the proximal phalanges ossification centres are disc-shaped and the one of the 2nd proximal phalanx is mildly wedge-shaped, tapering toward the medial aspect.

The morphology of the ossification centres may be found in the group of 3 - 3½ years of age, although the ossification centres for the lunate, triquetrum, most of the phalanges and metacarpal epiphyses are absent.

Case 4. Girl, chronological age 4 years old

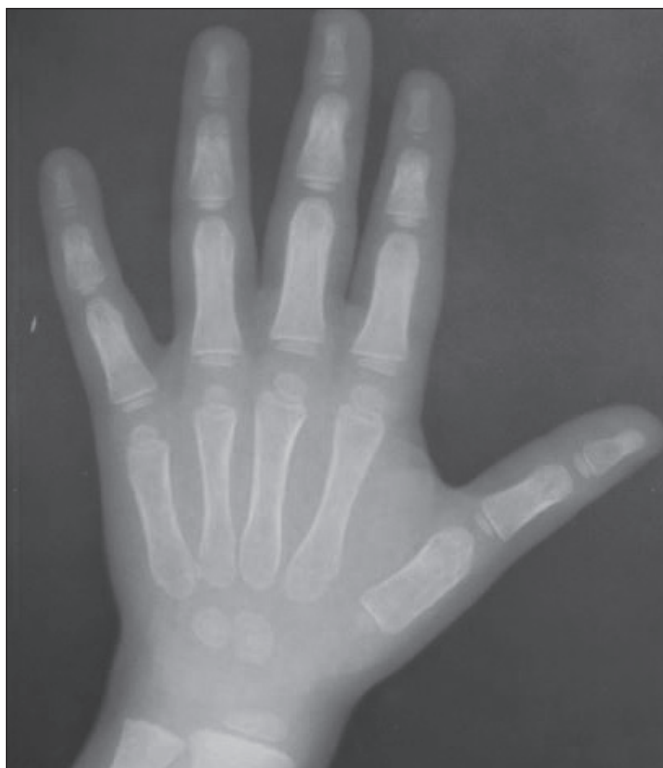


Figure 4. Girl, chronological age 4 years old.

Taking into consideration solely the presence of the ossification centres (distal radial epiphysis, capitate, hamate, epiphyses of the 1st - 5th metacarpals, the bases of the 1st - 5th proximal and distal phalanges, epiphyses of the 2nd - 5th middle phalanges) the biological age could be 2 - 2½ years. But the morphology of the ossification centres is specific to 3½ - 4½ years of age [8, 9]:

- the hamate and capitate reciprocal facets are slightly flattened;

- the ossification centres of the epiphyses of the

2nd – 5th metacarpals are slightly flattened at their medial aspects and rounded distally, around 4½ years of age;

-the 4th and 5th metacarpal bases begin to slightly overlap at around 4½ years of age;

-the ossification centres of the epiphyses of the 2nd – 5th proximal phalanges are not yet as wide as their corresponding shafts;

-the articular surface of the 2nd proximal phalanx is slightly concave;

-the epiphyses of 2nd and 3rd proximal phalanges are mildly wedge-shaped, tapering toward their medial aspects;

-the epiphyses of the proximal phalanges have relatively smooth margins;

-the proximal epiphyses of the middle phalanges are not all wider than half of their shafts, before 4½ years of age.

Radiographic Atlas of Skeletal Development of the Hand and Wrist by Greulich and Pyle just by observing the presence or absence of ossification centres in the left hand-wrist bones could lead to results which are very different from the actual chronological age of individuals; in practice there are often cases where the number of centres is very different from the standard of a certain group age which appears in the atlas mentioned above.

In order to accurately estimate the chronological age, it is important to take into consideration the morphology of the ossification centres as well, as it reflects the chronological age better than the number of centres do (a larger or a smaller number of ossification centres indicates an age younger or older than the real age).

When the number of ossification centres is larger than the number given by Greulich & Pyle's standards, their morphology will not present the characteristics of the age group in question. Instead, the ossification centres will present a mixed morphology, characteristic of the groups between the biological and the chronological age.

CONCLUSIONS

Estimating the biological age according to the

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