Skeletal Age of Individual Bones

Distal End of Radius	8 yr. 2 mo.	Proximal Phalanx I	8 yr. 0 mo.
Distal End of Ulna	8 yr. 6 mo.	Proximal Phalanx II	8 yr. 0 mo.
		Proximal Phalanx III	8 yr. 0 mo.
Capitate	8 yr. 0 mo.	Proximal Phalanx IV	8 yr. 0 mo.
Hamate	8 yr. 0 mo.	Proximal Phalanx V	8 yr. 0 mo.
Triquetral	8 yr. 0 mo.		
Lunate	8 yr. 8 mo.	Middle Phalanx II	7 yr. 10 mo.
Scaphoid	8 yr. 2 mo.	Middle Phalanx III	7 yr. 10 mo.
Trapezium	8 yr. 2 mo.	Middle Phalanx IV	7 yr. 10 mo.
Trapezoid	8 yr. 2 mo.	Middle Phalanx V	7 yr. 8 mo.
Metacarpal I	8 yr. 0 mo.	Distal Phalanx I	8 yr. 0 mo.
Metacarpal II	8 yr. 0 mo.	Distal Phalanx II	8 yr. 0 mo.
Metacarpal III	8 yr. 0 mo.	Distal Phalanx III	8 yr. 0 mo.
Metacarpal IV	8 yr. 0 mo.	Distal Phalanx IV	8 yr. 0 mo.
Metacarpal V	8 yr. 0 mo.	Distal Phalanx V	8 yr. 0 mo.

Pisiform	*
Adductor Sesamoid of Thumb	*
Flexor Sesamoid of Thumb	*

* These centers are still cartilaginous at this stage of development.

The white lines adjacent to the metacarpal surface of the hamate, capitate, and trapezoid mark a part of their respective volar margins. These markings become more distinct and complete in subsequent standards. As the scaphoid has elongated, its capitate surface has become somewhat less convex.

The concavity in the base of the second metacarpal adjacent to the trapezoid has become more pronounced. The ulnar portion of the base has begun to extend toward the capitate, with which it will later articulate. The oblique view of the first metacarpal, which the ordinary hand-film provides, permits the observation that the epiphysis of this bone reaches the palmar or volar margin of the shaft before it grows far enough dorsally to be aligned with the dorsal margin of the shaft. The proximal epiphysis of the thumb also appears in the oblique view to be the same width as its shaft.

The epiphyses of the distal phalanges of the second, third, fourth, and fifth fingers are now as wide as their shafts. All middle phalangeal epiphyses and the epiphyses of the distal phalanges of the second and third fingers have shaped further to the contours of the trochlear surfaces of the phalanges with which they articulate.

Skeletal Age of Individual Bones

Distal End of Radius	9 yr. 2 mo.	Proximal Phalanx I	9 yr. 0 mo.
Distal End of Ulna	9 yr. 3 mo.	Proximal Phalanx II	9 yr. 0 mo.
		Proximal Phalanx III	9 yr. 0 mo.
Capitate	9 yr. 0 mo.	Proximal Phalanx IV	9 yr. 0 mo.
Hamate	9 yr. 0 mo.	Proximal Phalanx V	9 yr. 0 mo.
Triquetral	9 yr. 0 mo.		
Lunate	9 yr. 6 mo.	Middle Phalanx II	8 yr. 9 mo.
Scaphoid	9 yr. 0 mo.	Middle Phalanx III	8 yr. 9 mo.
Trapezium	9 yr. 0 mo.	Middle Phalanx IV	8 yr. 9 mo.
Trapezoid	9 yr. 0 mo.	Middle Phalanx V	8 yr. 6 mo.
Metacarpal I	9 yr. 0 mo.	Distal Phalanx I	9 yr. 0 mo.
Metacarpal II	9 yr. 0 mo.	Distal Phalanx II	9 yr. 0 mo.
Metacarpal III	9 yr. 0 mo.	Distal Phalanx III	9 yr. 0 mo.
Metacarpal IV	9 yr. 0 mo.	Distal Phalanx IV	9 yr. 0 mo.
Metacarpal V	9 yr. 0 mo.	Distal Phalanx V	9 yr. 0 mo.

Pisiform	*
Adductor Sesamoid of Thumb	*
Flexor Sesamoid of Thumb	*

* These centers are still cartilaginous at this stage of development.

The epiphysis of the ulna has widened and thickened to form a bony plate, the exact shape of which varies in different children. Its radial margin is usually thinner than its ulnar margin and a slight indentation is sometimes visible on its distal surface. The central portion of its epiphysial cartilage plate has now attained its definitive thickness, i.e., it is now as thin as it will become until the epiphysis begins to fuse with its shaft. Its styloid process is beginning to appear.

The two metacarpal articular surfaces of the capitate are beginning to differentiate. That portion of the distal margin of the hamate which will later articulate with the base of the fifth metacarpal can now be seen as a small but distinct projection. A process of the trapezium is beginning to project from its distal surface toward the base of the second metacarpal. It will become more distinct as development proceeds. The spaces between the scaphoid, trapezoid, and trapezium and that between the scaphoid and lunate remain wide. It should be remembered that, at birth, the various carpal units are completely cartilaginous and in reasonably close apposition to each other. What is depicted in this series of films is the form of the osseous centers which develop within the substance of the cartilaginous carpal units. The spaces just referred to are a measure of the extent to which the replacement of the cartilage by bone is as yet incomplete.

The distal ends of the shafts of the second and third proximal phalanges have become slightly concave as their trochlear surfaces begin to differentiate.

Skeletal Age of Individual Bones

Distal End of Radius	10 yr. 2 mo.	Proximal Phalanx I	10 yr. 0 mo.
Distal End of Ulna	10 yr. 2 mo.	Proximal Phalanx II	10 yr. 0 mo.
		Proximal Phalanx III	10 yr. 0 mo.
Capitate	10 yr. 0 mo.	Proximal Phalanx IV	10 yr. 0 mo.
Hamate	10 yr. 0 mo.	Proximal Phalanx V	10 yr. 0 mo.
Triquetral	10 yr. 0 mo.		
Lunate	10 yr. 3 mo.	Middle Phalanx II	9 yr. 6 mo.
Scaphoid	10 yr. 0 mo.	Middle Phalanx III	9 yr. 6 mo.
Trapezium	10 yr. 0 mo.	Middle Phalanx IV	9 yr. 6 mo.
Trapezoid	10 yr. 0 mo.	Middle Phalanx V	9 yr. 5 mo.
Metacarpal I	10 yr. 0 mo.	Distal Phalanx I	10 yr. 0 mo.
Metacarpal II	10 yr. 0 mo.	Distal Phalanx II	10 yr. 0 mo.
Metacarpal III	10 yr. 0 mo.	Distal Phalanx III	10 yr. 0 mo.
Metacarpal IV	10 yr. 0 mo.	Distal Phalanx IV	10 yr. 0 mo.
Metacarpal V	10 yr. 0 mo.	Distal Phalanx V	10 yr. 0 mo.

Pisiform	10 yr. 0 mo
Adductor Sesamoid of Thumb	*
Flexor Sesamoid of Thumb	*

* These centers are still cartilaginous at this stage of development.

A part of the outline of the volar margin of the capitate surface of the scaphoid can now be seen as a rather heavy white line. A slight indentation has appeared in the distal surface of the trapezium in the area of its future articulation with the first metacarpal. Its scaphoid surface has begun to flatten. A similar but less marked flattening is visible in the surface of the trapezoid which is adjacent to the scaphoid. Ossification has begun in the pisiform, the irregularly circular outline of which can be seen indistinctly through the triquetral.

The epiphysis of the first metacarpal has a slight indentation on its future articular surface. The radial tip of this epiphysis has not yet reached the corresponding margin of its shaft.

The more proximal part of the articular surface of the distal phalanx of the thumb is now slightly concave. The proximal phalanges of the second, third, fourth, and fifth fingers are not yet as wide as their shafts. The epiphyses of the middle phalanges have thickened central portions, angular proximal surfaces, and relatively flattened distal margins. The epiphyses of the distal phalanges of the second to fifth fingers are all wider than their shafts.

Skeletal Age of Individual Bones

Distal End of Radius	11 yr. 0 mo.	Proximal Phalanx I	11 yr. 0 mo.
Distal End of Ulna	11 yr. 0 mo.	Proximal Phalanx II	11 yr. 0 mo.
		Proximal Phalanx III	11 yr. 0 mo.
Capitate	11 yr. 0 mo.	Proximal Phalanx IV	11 yr. 0 mo.
Hamate	11 yr. 0 mo.	Proximal Phalanx V	11 yr. 0 mo.
Triquetral	11 yr. 0 mo.		
Lunate	11 yr. 0 mo.	Middle Phalanx II	10 yr. 6 mo.
Scaphoid	11 yr. 0 mo.	Middle Phalanx III	10 yr. 6 mo.
Trapezium	11 yr. 0 mo.	Middle Phalanx IV	10 yr. 4 mo.
Trapezoid	11 yr. 0 mo.	Middle Phalanx V	10 yr. 4 mo.
Metacarpal I	11 yr. 0 mo.	Distal Phalanx I	11 yr. 0 mo.
Metacarpal II	11 yr. 0 mo.	Distal Phalanx II	11 yr. 0 mo.
Metacarpal III	11 yr. 0 mo.	Distal Phalanx III	11 yr. 0 mo.
Metacarpal IV	11 yr. 0 mo.	Distal Phalanx IV	11 yr. 0 mo.
Metacarpal V	11 yr. 0 mo.	Distal Phalanx V	11 yr. 0 mo.

Pisiform	11 yr. 0 mo.
Adductor Sesamoid of Thumb	*
Flexor Sesamoid of Thumb	*

* These centers are still cartilaginous at this stage of development.

The volar and dorsal margins of the surface of the hamate which will articulate with the fourth metacarpal can now be seen. The distal tip of the hamulus of the hamate is just becoming discernible. The future scaphoid and radial articular surfaces of the lunate now are beginning to be defined. The articular facets of the distal row of carpals, particularly those of the capitate, have become progressively more sharply delimited. The distal margin of the scaphoid is now somewhat flattened and its capitate articular surface distinctly concave. The pisiform is now more distinct than in the preceding standard, its shadow being visible through and between the hamate and triquetral.

The faint white lines which are more distinct along the ulnar and proximal margins of the epiphysis of the second metacarpal outline a portion of the volar surface of that epiphysis. The process of reciprocal shaping of the proximal surface of this epiphysis to its shaft is slightly farther advanced than the same process in the other metacarpals.

The epiphysis of the proximal phalanx of the second finger is now as wide as its shaft. The epiphyses of the distal phalanges of the second, third, fourth, and fifth fingers are beginning to conform in shape to that of the trochlear surfaces of their respective middle phalanges. This process is farthest advanced in the third finger. The epiphysis of the proximal phalanx of the thumb now extends farther medially (toward the volar surface) than does the corresponding border of its shaft.

Reciprocal shaping has progressed in all the carpals and epiphyses according to their contours in the preceding standard.

SKELETAL AGE: 11 YEARS AND 6 MONTHS

Skeletal Age of Individual Bones

Distal End of Radius	11 yr. 6 mo.	Proximal Phalanx I	11 yr. 6 mo.
Distal End of Ulna	11 yr. 6 mo.	Proximal Phalanx II	11 yr. 6 mo.
		Proximal Phalanx III	11 yr. 6 mo.
Capitate	11 yr. 6 mo.	Proximal Phalanx IV	11 yr. 6 mo.
Hamate	11 yr. 6 mo.	Proximal Phalanx V	11 yr. 6 mo.
Triquetral	11 yr. 6 mo.		
Lunate	11 yr. 6 mo.	Middle Phalanx II	11 yr. 3 mo.
Scaphoid	11 yr. 6 mo.	Middle Phalanx III	11 yr. 3 mo.
Trapezium	11 yr. 6 mo.	Middle Phalanx IV	11 yr. 3 mo.
Trapezoid	11 yr. 6 mo.	Middle Phalanx V	11 yr. 2 mo.
Metacarpal I	11 yr. 6 mo.	Distal Phalanx I	11 yr. 6 mo.
Metacarpal II	11 yr. 6 mo.	Distal Phalanx II	11 yr. 6 mo.
Metacarpal III	11 yr. 6 mo.	Distal Phalanx III	11 yr. 6 mo.
Metacarpal IV	11 yr. 6 mo.	Distal Phalanx IV	11 yr. 6 mo.
Metacarpal V	11 yr. 6 mo.	Distal Phalanx V	11 yr. 6 mo.

Pisiform	11 yr. 6 mo.
Adductor Sesamoid of Thumb	*
Flexor Sesamoid of Thumb	*

* These centers are still cartilaginous at this stage of development.

The developing styloid process of the radial epiphysis has become more distinct and the white line immediately adjacent to the cartilage plate, which marks a part of its volar margin, now extends farther laterally.

As compared with Standard 20, the carpals are now somewhat larger, the spaces between them have become further reduced, and there has been an increase in the degree of reciprocal shaping of the individual bones to each other, to the bases of the metacarpals, and to the radial and ulnar epiphyses. The capitate surface of the scaphoid now slightly overlaps the adjacent portion of the capitate. The volar margin of the lunate in the preceding standard can be seen as a heavy white line. This line has now expanded centrally to form a blunt protuberance which is directed toward the capitate.

Skeletal Age of Individual Bones

Distal End of Radius	12 yr. 6 mo.	Proximal Phalanx I	12 yr. 6 mo.
Distal End of Ulna	12 yr. 6 mo.	Proximal Phalanx II	12 yr. 6 mo.
		Proximal Phalanx III	12 yr. 6 mo.
Capitate	12 yr. 6 mo.	Proximal Phalanx IV	12 yr. 6 mo.
Hamate	12 yr. 6 mo.	Proximal Phalanx V	12 yr. 6 mo.
Triquetral	12 yr. 6 mo.		
Lunate	12 yr. 6 mo.	Middle Phalanx II	12 yr. 3 mo.
Scaphoid	12 yr. 6 mo.	Middle Phalanx III	12 yr. 3 mo.
Trapezium	12 yr. 6 mo.	Middle Phalanx IV	12 yr. 3 mo.
Trapezoid	12 yr. 6 mo.	Middle Phalanx V	12 yr. 3 mo.
Metacarpal I	12 yr. 6 mo.	Distal Phalanx I	12 yr. 6 mo.
Metacarpal II	12 yr. 6 mo.	Distal Phalanx II	12 yr. 6 mo.
Metacarpal III	12 yr. 6 mo.	Distal Phalanx III	12 yr. 6 mo.
Metacarpal IV	12 yr. 6 mo.	Distal Phalanx IV	12 yr. 6 mo.
Metacarpal V	12 yr. 6 mo.	Distal Phalanx V	12 yr. 6 mo.

Pisiform	12 yr. 6 mo.
Adductor Sesamoid of Thumb	*
Flexor Sesamoid of Thumb	*

* These centers are still cartilaginous at this stage of development.

Since the preceding standard, the carpals have enlarged, their articular surfaces have become more distinct, and the spaces between them have been further reduced. This differentiation has progressed farther in the distal than in the proximal row of carpals and is most marked in the carpal-metacarpal area.

The outline of the hook of the hamate is now visible. The volar and dorsal margins of the triquetral are becoming distinguishable on the side adjacent to the hamate. A dorsal extension of the capitate articular surface of the scaphoid has appeared, since the preceding standard. It can best be seen immediately medial to the white line formed by the volar margin of the scaphoid.

The base of the second metacarpal has adjusted further to the shape of the adjacent surfaces of the trapezoid. This has been a slow process, which was already under way in Standard 21. The nature of the change can best be appreciated by comparing Standards 20 and 22. Parts of the volar margins of the epiphyses of the third, fourth, and fifth metacarpals are now distinguishable as fine to heavy white linear markings along the sides or proximal margins of those epiphyses. Reciprocal shaping has progressed in the adjacent surfaces of the metacarpal epiphyses and their shafts.

The epiphyses of the proximal phalanges of the third, fourth, and fifth fingers and of the middle phalanges of the second and third fingers are now as wide as their shafts.

The lateral (radial) side of the epiphysis of the distal phalanx of the third finger ends in a tip which is bending distally. This is an early stage of a process which will result in the capping of the shaft by its epiphysis.

Skeletal Age of Individual Bones

The skeletal age assigned to each bone in this standard is 13 years.

The radial epiphysis and the epiphyses of the second to fifth metacarpals are now as wide as the adjacent margins of their shafts.

The ossification center of the sesamoid in the tendon of the adductor pollicis is now visible, just medial to the head of the first metacarpal.

The epiphyses of the proximal phalanges of the second, third, fourth, and fifth fingers have increased somewhat in thickness and their radial margins end in distally directed tips. The epiphysis of the middle phalanx of the fifth finger is now as wide as its shaft. The tips of the epiphyses of the distal phalanges of the second to fifth fingers are bent slightly distally and the distal ends of the corresponding middle phalanges are now slightly concave.

Note: This film is of the hand of a different boy from the one in the preceding standard.

Skeletal Age of Individual Bones

The skeletal age assigned to each bone in this standard is 13 years 6 months.

The proximal margins of the radial and ulnar epiphyses have adjusted further to the shape of the adjacent surface of their shafts. The ulnar articular surface of the radius is now flattened. Reciprocal shaping is under way in the radioulnar joint.

The complete outline of the hamulus of the hamate can now be seen distinctly. This scaphoid is more elongated than that in Standard 23; there the scaphoid is shorter and has a flatter and wider distal end than the bone in this standard. These are two contrasting and commonly occurring types of scaphoids. A comparable difference in shape is seen also in the lunates and triquetrals of these two standards. At this stage of development, the distal end of the scaphoid flattens further and increases in size. The white marking on the external margin of a portion of the outline of the tubercle of the scaphoid, traces of which can be seen in earlier standards, indicates the approximate distal limit of its radial articular surface. The surface of the trapezium which articulates with the first metacarpal has become more concave, and the proximal borders of its dorsal and volar surfaces are now readily distinguishable. The articular surfaces of the trapezoid are now well differentiated.

The epiphyses of all of the metacarpals are now clearly as wide as their shafts, and these adjacent margins conform closely in shape.

All of the proximal epiphyses have begun to cap their shafts. The process has advanced farthest in the thumb and in the fifth, fourth, and third fingers. It is more pronounced in the volar than in the dorsal side of the epiphysis of the thumb, and on the radial than on the ulnar side of the epiphyses of the fingers.

Skeletal Age of Individual Bones

The skeletal age assigned to each bone in this standard is 14 years.

The epiphysis of the radius and the epiphyses of all phalanges of the second, third, fourth, and fifth fingers have now begun to cap their shafts. In the proximal phalanges the capping is more clearly visible on the radial than on the ulnar sides of the epiphyses.

The sides of the epiphyses of the second to the fifth metacarpals are now aligned closely with the sides of their shafts. The growth cartilage plates are uniformly narrow and some portions of the epiphysial-shaft spaces are fuzzy, indicating that the late pre-fusion stage has been reached.

The extent to which the individual bones in this standard have attained their early adult form can be appreciated by comparing them with those of the same boy at age 18 years as shown in Standard 29.

Skeletal Age of Individual Bones

The skeletal age assigned to each bone in this standard is 15 years.

The epiphysis of the radius has capped its shaft. The epiphysis of the ulna is now as wide as its shaft and follows its contour closely. The spaces which separated the radial and ulnar epiphyses from their shafts in the preceding standard have been somewhat reduced.

All carpals have now attained their early adult shape.

Fusion is under way in the epiphyses of all distal phalanges. It is farthest advanced in the thumb and third finger and least advanced in the fifth. Beginning of fusion is apparent, also, in the dorsal third of the first metacarpal.

Skeletal Age of Individual Bones

The skeletal age assigned to each bone in this standard is 15 years and 6 months.

A part of the outline of the tubercle of the scaphoid can now be seen.

The flexor sesamoid can now be seen through the head of the first metacarpal, immediately lateral to the adductor sesamoid. It begins to ossify shortly after the adductor sesamoid and is clearly visible in the original film of Standard 24.

The epiphysis of the first metacarpal has recently fused with its shaft. The epiphyses of the other metacarpals are about to begin their fusion.

Fusion has recently been completed in all of the distal phalanges.

This standard illustrates the stage of skeletal development usually attained by boys at the time of puberty.

This is the same stage of skeletal development which in girls is usually attained at about the time of their menarche.

Skeletal Age of Individual Bones

The skeletal age assigned to each bone in this standard is 16 years.

The epiphyses of the second, third, fourth, and fifth metacarpals have begun to fuse with their shafts.

Epiphysial-diaphysial fusion is well advanced in all the proximal phalanges and in the middle phalanges of the second and fifth fingers. It has also begun in the middle phalanges of the third and fourth fingers.

An accessory sesamoid bone is present over the volar surface of the distal end of the proximal phalanx of the thumb and the heads of the second and fifth metacarpals. Other accessory sesamoids are occasionally present. If these accessory sesamoids are going to develop they are usually visible radiographically at this stage.

Skeletal Age of Individual Bones

The skeletal age assigned to each bone in this standard is 17 years.

The thickness of the growth cartilage of the radius has become reduced preparatory to epiphysial-diaphysial fusion. Fusion has already begun in the ulna.

The epiphyses of the second, third, fourth, and fifth metacarpals have recently fused with their shafts.

With the recent completion of fusion in the middle phalanges of the third and fourth fingers, all of the phalangeal epiphyses have now fused with their shafts.

With the fusion of an epiphysis with its shaft, the epiphysial cartilage plate which previously has separated them is, of course, eliminated, and the radiolucent line or area which represents the cartilage plate in the radiograph disappears.