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Skeletal Development of the Hand and Wrist

A Radiographic Atlas and Digital Bone Age Companion

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Table 1: Brush data—Boys: The variability of skeletal age of boys in the Brush Foundation Study

Chronological Age	Number of Hand Radiographs	Mean Skeletal Age (Months)	Optional Adjustment to Chronological Age (months)	Standard Deviation for Skeletal Age (Months)
3 months	121	3.01	0.01	0.69
6 months	129	6.09	0.09	1.13
9 months	137	9.56	0.56	1.43
12 months	130	12.74	0.74	1.97
18 months	106	19.36	1.36	3.52
2 years	105	25.97	I.97	3.92
2.5 years	107	32.40	2.40	4.52
3 years	127	38.21	2.21	5.08
3.5 years	138	43.89	1.89	5.40
4 years	170	49.04	I.04	6.66
4.5 years	176	56.00	2.00	8.36
5 years	191	62.43	2.43	8.79
6 years	186	75.46	3.46	9.17
7 years	182	88.20	4.20	8.91
8 years	168	101.38	5.38	9.10
9 years	160	113.90	5.90	9.00
10 years	177	125.68	5.68	9.79
11 years	154	137.32	5.32	10.09
12 years	165	148.82	4.82	10.38
13 years	175	158.39	2.39	10.44
14 years	163	170.02	2.02	10.72
15 years	124	182.72	2.72	11.32
16 years	99	195.32	3.32	12.86
17 years	68	206.21	2.21	13.05

Modified from: Greulich WW, Pyle SI. Radiographic Atlas of Skeletal Development of the Hand and Wrist, 2nd ed. Stanford, CA: Stanford University Press and London, UK: Oxford University Press, 1959.

Chronological Age	Number of Hand Radiographs	Mean Skeletal Age (months)	Optional Adjustment to Chronological Age (months)	Standard Deviation for Skeletal Age (months)
3 months	108	3.02	0.02	0.72
6 months	121	6.04	0.04	1.16
9 months	122	9.05	0.05	1.36
12 months	117	12.04	0.04	I.77
18 months	93	18.22	0.22	3.49
2 years	IOI	24.16	0.16	4.64
2.5 years	98	30.96	0.96	5.37
3 years	133	36.63	0.63	5.97
3.5 years	131	43.50	1.5	7.48
4 years	154	50.14	2.14	8.98
4.5 years	152	60.06	6.06	10.73
5 years	167	66.21	6.21	11.65
6 years	191	78.50	6.5	10.23
7 years	200	89.30	5.3	9.64
8 years	201	100.66	4.66	10.23
9 years	195	113.86	5.86	10.74
10 years	206	125.66	5.66	11.73
11 years	203	137.87	5.87	11.94
12 years	198	149.62	5.62	10.24
13 years	179	162.28	6.28	10.67
14 years	170	174.25	6.25	11.30
15 years	117	183.62	3.62	9.23
16 years	64	189.44	-2.56	7.31

 Table 2:

 Brush data—Girls: The variability of skeletal age of girls in the Brush Foundation Study

Modified from: Greulich WW, Pyle SI. Radiographic Atlas of Skeletal Development of the Hand and Wrist, 2nd ed. Stanford, CA: Stanford University Press, 1959.

Table 3:

Stuart data—Boys (Less commonly used than the Brush Foundation Study data); means and standard deviations for skeletal age of the hand and wrist

Chronological Age	Number of Hand Radiographs	Mean Skeletal Age (months)	Optional Adjustment to Chronological Age (months)	Standard Deviation for Skeletal Age (months)
12 months	66	12.7	0.7	2. I
18 months	67	17.5	-0.5	2.7
2 years	67	22.6	-1.4	4.0
2.5 years	67	28.1	-1.9	5.4
3 years	67	33.8	-2.2	6.0
3.5 years	67	39.5	-2.5	6.6
4 years	65	44.8	-3.2	7.0
4.5 years	64	50.3	-3.7	7.8
5 years	64	56.2	-3.8	8.4
5.5 years	64	62.4	-3.6	9.1
6 years	66	68.4	-3.6	9.3
7 years	66	80.6	-3.4	10.1
8 years	63	92.5	-3.5	10.8
9 years	63	104.9	-3.I	II.0
10 years	63	118.0	-2	11.4
11 years	65	132.1	0.1	10.5
12 years	64	144.5	0.5	10.4
13 years	66	156.4	0.4	11.1
14 years	65	168.5	0.5	12.0
15 years	65	180.7	0.7	14.2
16 years	65	193.0	Ι	15.1
17 years	60	206.0	2	15.4

Modified from: Greulich WW, Pyle SI. Radiographic Atlas of Skeletal Development of the Hand and Wrist, 2nd ed. Stanford, CA: Stanford University Press and London, UK: Oxford University Press, 1959.

Table	4:

Stuart data—Girls (Less commonly used than the Brush Foundation Study data); means and standard deviations for skeletal age of the hand and wrist

Chronological Age	Number of Hand Radiographs	Mean Skeletal Age (months)	Optional Adjustment to Chronological Age (months)	Standard Deviation for Skeletal Age (months)
12 months	65	12.7	0.7	2.7
18 months	66	18.4	0.4	3.4
2 years	66	23.7	-0.3	4.0
2.5 years	65	29.0	- I	4.8
3 years	66	34.5	-1.5	5.6
3.5 years	66	40.6	-1.4	6.5
4 years	67	46.4	-1.6	7.2
4.5 years	67	52.3	-1.7	8.0
5 years	67	58.1	-1.9	8.6
5.5 years	67	63.9	-2.I	8.9
6 years	67	70.4	-1.6	9.0
7 years	67	82.0	-2	8.3
8 years	67	94.0	-2	8.8
9 years	67	105.9	-2.I	9.3
10 years	66	119.0	-I	10.8
11 years	66	132.9	0.9	12.3
12 years	66	147.2	3.2	14.0
13 years	66	160.3	4.3	14.6
14 years	63	172.4	4.4	12.6
15 years	61	184.3	4.3	II.2

Modified from: Greulich WW, Pyle SI. *Radiographic Atlas of Skeletal Development of the Hand and Wrist, 2nd ed.* Stanford, CA: Stanford University Press and London, UK: Oxford University Press, 1959.

Male Standards

Skeletal Age: Newborn (term)



Skeletal Age: Newborn (term)



Skeletal Age: 3 Months



Skeletal Age: 3 Months



Skeletal Age: 6 Months



Skeletal Age: 6 Months



Skeletal Age: 9 Months



Skeletal Age: 9 Months





Skeletal Age: 1 Year



Skeletal Age: I Year and 3 Months



Skeletal Age: 1 Year and 3 Months





Skeletal Age: I Year and 6 Months

Skeletal Age: 2 Years

Skeletal Age: 2 Years

Skeletal Age: 2 Years and 8 Months

Skeletal Age: 3 Years

Skeletal Age: 3 Years

Skeletal Age: 3 Years and 6 Months

Skeletal Age: 3 Years and 6 Months

Skeletal Age: 4 Years

Skeletal Age: 4 Years

Skeletal Age: 4 Years and 6 Months

Skeletal Age: 5 Years

Skeletal Age: 5 Years

Skeletal Age: 6 Years

Skeletal Age: 6 Years



Skeletal Age: 7 Years



Skeletal Age: 7 Years



Skeletal Age: 8 Years

The epiphyses of the distal phalanges are as wide as their shafts

The ulnar margin of the 2nd metacarpal is now more pronounced where it will articulate with the capitate

White lines are now evident at the metacarpal surfaces of the hamate, capitate, and trapezoid, denoting their volar surfaces; these become more pronounced with later standards

The scaphoid has elongated with less convexity of its capitate surface All middle phalangeal epiphyses as well as the 2nd and 3rd distal phalangeal epiphyses are thicker centrally as they contour to the trochlear surfaces of their respective proximal phalanges

The 2nd metacarpal concavity adjacent to the trapezoid is now pronounced

The 1st metacarpal epiphysis reaches the volar-ulnar margin of its shaft before the dorsal-radial margin

Skeletal Age: 8 Years



Skeletal Age: 9 Years



Skeletal Age: 9 Years



Skeletal Age: 10 Years



Skeletal Age: 10 Years



Skeletal Age: 11 Years

The epiphyses of the 2nd – 5th distal phalanges have started to contour to the trochlear surfaces of the middle phalanges Overall continued enlargement and progressive reciprocal shaping of the carpal bones

The epiphysis of the 2nd proximal phalanx is now as wide as its metaphysis

The ulnar volar margin of the epiphysis of the 1st metacarpal now extends beyond the margin of the metaphysis

> The distal scaphoid has flattened and its capitate surface is distinctly concave

The scaphoid and radial facets of the lunate are becoming defined

The volar and dorsal surfaces of the hamate are now discernible at the articulation with the 4th metacarpal base

The pisiform is better defined

The ulnar epiphysis has matured

Skeletal Age: 11 Years





Skeletal Age: 11 Years and 6 Months



Skeletal Age: 11 Years and 6 Months



Skeletal Age: 12 Years and 6 Months



Skeletal Age: 12 Years and 6 Months





Skeletal Age: 13 Years





Skeletal Age: 13 Years and 6 Months



Skeletal Age: 14 Years

All epiphyses of the 2nd - 5th digits, including those of the distal phalanges, have begun to cap their shafts. In the proximal phalanges, capping is more evident on the radial side

The cartilaginous growth plates of the metacarpals are now uniformly narrow. Some portions of the osseous margins around them have become less distinct

The radial epiphysis has begun to cap its shaft (that is, its margins point proximally)

Skeletal Age: 14 Years



Skeletal Age: 15 Years



Skeletal Age: 15 Years



Skeletal Age: 15 Years and 6 Months



Skeletal Age: 15 Years and 6 Months



Skeletal Age: 16 Years



Skeletal Age: 16 Years



Skeletal Age: 17 Years



Skeletal Age: 17 Years



Skeletal Age: 18 Years

Vertical white lines on the $2^{nd} - 5^{th}$ metacarpal heads outline portions of their volar surfaces. Prior to fusion, these lines are interrupted by the growth plates as in the 13-Year, 6-Month Male Standard. These lines become continuous with the shaft as fusion occurs. This is usually more advanced on the ulnar side.

> All of the epiphyses except that of the radius have fully completed fusion with their respective shafts. This process is nearly complete in the radius.

Skeletal Age: 18 Years





Skeletal Age: 19 Years

The epiphyseal line of the radius is now only faintly seen. It may disappear completely or persist into adulthood.

The radial epiphysis is now completely fused with its shaft, completing skeletal maturation of the hand and wrist.

Skeletal Age: 19 Years



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Female Standards

Female

Skeletal Age: Newborn (term)


Skeletal Age: Newborn (term)



Skeletal Age: 3 Months



Skeletal Age: 3 Months



Skeletal Age: 6 Months



Skeletal Age: 6 Months



Skeletal Age: 9 Months



Skeletal Age: 9 Months



Skeletal Age: I Year



Skeletal Age: 1 Year



Skeletal Age: I Year and 3 Months



Skeletal Age: I Year and 3 Months



Skeletal Age: I Year and 6 Months



Skeletal Age: I Year and 6 Months



Skeletal Age: 2 Years



Skeletal Age: 2 Years





Skeletal Age: 2 Years and 6 Months



Skeletal Age: 3 Years



Skeletal Age: 3 Years



Skeletal Age: 3 Years and 6 Months



Skeletal Age: 3 Years and 6 Months



Skeletal Age: 4 Years and 2 Months



Skeletal Age: 4 Years and 2 Months



Skeletal Age: 5 Years



Skeletal Age: 5 Years



Skeletal Age: 5 Years and 9 Months



Skeletal Age: 5 Years and 9 Months



Skeletal Age: 6 Years and 10 Months



Skeletal Age: 6 Years and 10 Months



Skeletal Age: 7 Years and 10 Months



Skeletal Age: 7 Years and 10 Months





Skeletal Age: 8 Years and 10 Months



Skeletal Age: 10 Years



Skeletal Age: 10 Years



Skeletal Age: 11 Years


Skeletal Age: 11 Years



Skeletal Age: 12 Years



Skeletal Age: 12 Years



Skeletal Age: 13 Years



Skeletal Age: 13 Years



Skeletal Age: 13 Years and 6 Months



Skeletal Age: 13 Years and 6 Months





Skeletal Age: 14 Years



Skeletal Age: 15 Years



Skeletal Age: 15 Years



Skeletal Age: 16 Years



Skeletal Age: 16 Years



Skeletal Age: 17 Years



Skeletal Age: 17 Years



Skeletal Age: 18 Years



Skeletal Age: 18 Years

