Measurements of carpal bone angles on lateral wrist radiographs

Measurements of carpal bone angles on lateral wrist radiographs can be of assistance in the diagnostic evaluation of wrist malalignment. A series of 75 normal wrists was examined by use of a standardized radiographic technique. The normal carpal bone angles were determined using the bone axes with the least observer variability (mean and range): radiolunate, −1.02 (−10 to 12), radioscaphoid, 51.80 (35 to 65), and scapholunate, 50.77 (36 to 66). Normal mean values and ranges for intercarpal bone angles may be of assistance in the diagnostic evaluation of ligamentous injury to the wrist. (J HAND SURG 1991;16A:888-93.)

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Lateral radiographs are important when evaluating the congruity of the carpus. The intercarpal bony congruence is the key to diagnosis of many wrist injuries. Classification of wrist malalignments requires a standardized radiographic examination.[1, 2] Consistent and comparable projections can be facilitated by using a device controlling the wrist position in all directions during radiographic examination.[3] To ensure uniformity when reporting results, the lateral radiographs should always be obtained in the same position, preferably zero position.[2] When measuring the intercarpal bone angles the use of axes with the least observer variability is recommended.[4] No difference can be certified between the right and left uninjured wrist in the same person.[4, 5] Several authors have described the normal

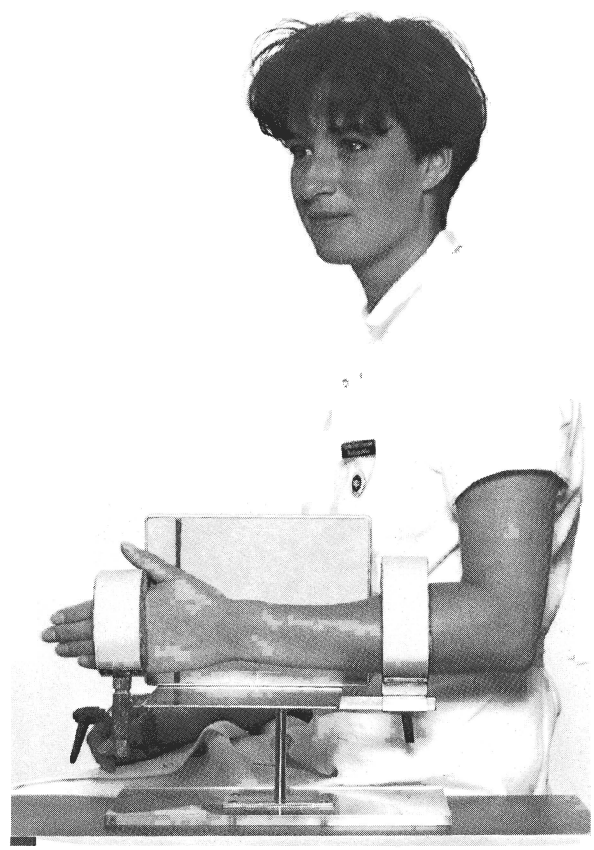

Fig. 1. The stabilizing device shown with cassette prepared for posteroanterior projection. (From Larsen CF, Stigsby B, Mathiesen FK, Lindequist S. Acta Radiol 1990;31(5).

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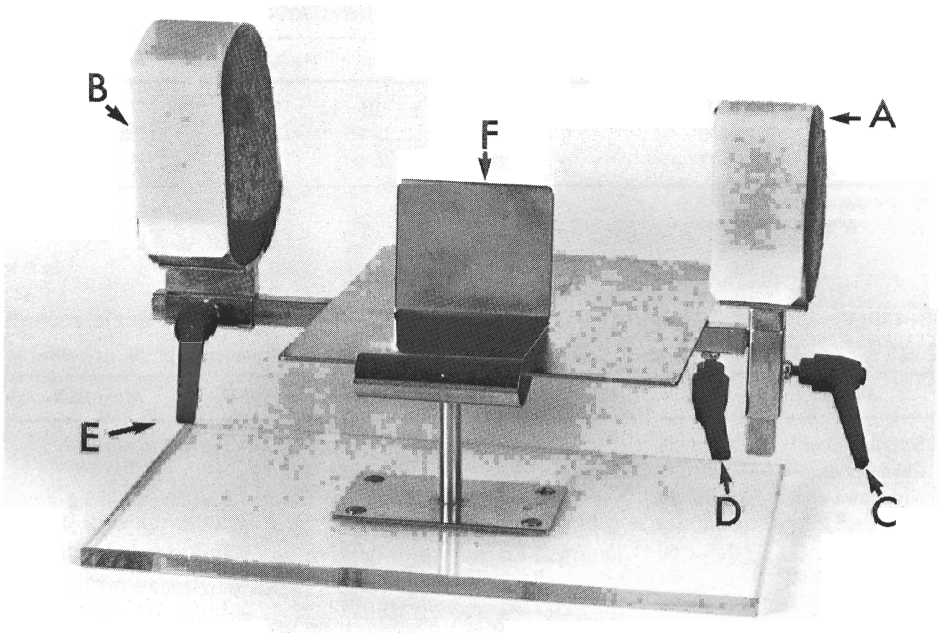

Fig. 2. The stabilizing device. *A*, Finger support (changeable foam rubber shell, which can be adjusted to the size of the hand); *B*, forearm support (changeable foam rubber shell, which can be adjusted to the size of the forearm); *C*, height-adjustment screw; *D*, angulation-adjustment screw; *E*, length-adjustment screw; *F*, cassette support. (From Larsen CF, Stigsby B, Mathiesen FK, Lindequist S. Radiographic examination of the wrist. Acta Radiol 1990;31(5).

angular relationships. However, the range of the angles in normals varies considerably.[4-12] Differences in the positioning and radiographic technique, as well as differences in definitions of axes used for measurements, might explain some of the variation.[13] No one seemed to control radial or ulnar deviation, and it has been shown[3] that radial or ulnar deviation changes the alignment of the carpal bones. An ethnic variation is possible but has not yet been reported.

The aim of this study was to establish the normal values of the various intercarpal angles with use of a standardized radiographic method.

Material and methods

A series of 75 consecutive patients aged 18 years and older, with unilateral wrist trauma, were selected for measurements. All patients had closed epiphysial plates and no history or radiological evidence of previous injury or infection of the hand, forearm, or elbow. None of the patients had any general affection of the skeleton (e.g., metabolic disease).

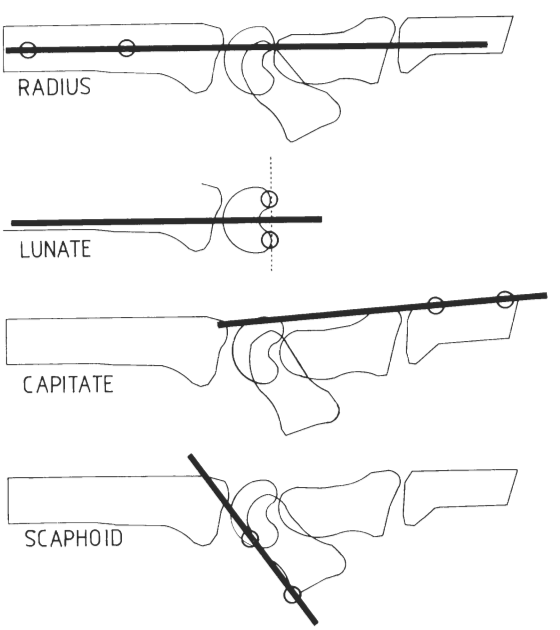

Fig. 3. Bone axes (refer to definition in text).

Table I. Carpal angles in lateral radiographs in neutral position of the wrist in 75 normal wrists

Angle	*Mean (M)*	*SD*	*Range*	*M − 2SD*	*M + 2SD*
Radiolunate*	−1.02	5.34	(−10)−12	−11.71	9.65
Radioscaphoid‡	51.80	6.41	35-65	38.98	64.62
Scapholunate	50.77	6.72	36-66	37.33	64.21

*Same measurements as the capitate-lunate angle.
‡Same measurements as the capitate-scaphoid angle.

Table II. Mean, range, standard deviation (SD) and mean + / −2 SD of each carpal angle according to various authors

Angle	*Authors*	*n*	*Mean*	*Range*	*SD*	*M − 2SD*	*M + 2SD*
RL	Sarrafian et al.[8]	55		(−31)−?			
	Chaise et al.[10]	50		(−30)−15			
	Nishikawa et al.[6]	50	10		7.6	−5.2	25.2
	Imamura[11]	40	−7.4		3.3	−14.2	−0.8
	Yamada[12]	60	4.5	(−15)−27	9.1	−13.7	22.7
	Nakamura et al.[5]	84	10	(−22)−6	8	−26	4
	Larsen et al.	75	−1.02	(−10)−12	5.3	−11.7	9.65
RS	Sarrafian et al.[8]	55	58	33-73			
	Chaise et al.[10]	50	50	30-75			
	Nishikawa et al.[6]	84	66		6.1	53.8	78.2
	Imamura[11]	40	66.6		5.1	56.4	76.8
	Yamada[12]	60	54.5	37-69	6.6	41.3	67.7
	Nakamura et al.[5]	84	66	54-78	6	54	78
	Larsen et al.	75	51.8	35-65	6.4	39	64.6
RC	Sarrafian et al.[8]	55		(−5)−20			
	Chaise et al.[10]	50		(−5)−20			
	Nishikawa et al.[6]	50	2.6		5.9	−9.2	14.4
	Yamada[12]	60					
SC	Sarrafian et al.[8]	55	63	41-83			
	Chaise et al.[10]	50	60	35-85			
	Imamura[11]	40	65.8		4.1	57.6	74
	Yamada[12]	60					
SL	Linscheid et al.[7]	n.s.	46	30-60			
	Sarrafian et al.[8]	55	51	28-101			
	Gilula and Weeks[9]	n.s.		30-60			
	Chaise et al.[10]	50	50	30-80			
	Imamura[11]	40	56		3.5	49	63
	Yamada[12]	60	50	30-67	8.2	33.6	66.4
	Nakamura et al.[5]	84	56	42-70	7	42	70
	Larsen et al.	75	50.8	36-66	6.7	37.3	64.2
CL	Sarrafian et al.[8]	55					
	Gilula and Weeks[9]	n.s.		0-30			
	Imamura[11]	40	7.4		3.3	0.8	14
	Yamada[12]	60	−4.5		9.1	−22.7	13.7
	Nakamura et al.[5]	84	−10		8	−26	4

From each patient radiographs in posteroanterior (PA) and lateral view were taken of both wrists using a device[3] (Figs. 1 and 2). The lateral radiographs were obtained in zero position[1] and without stress; the arm adducted against the trunk; the elbow flexed 90 degrees; the forearm in neutral rotation (no supination or pronation) and the wrist in neutral position (no radial or ulnar deviation, and no extension or flexion).

The device allowed multidirectional positioning of the wrist using adjustment screws. Without moving the wrist, PA and lateral radiographs were taken. If radiographs in one or both views were incorrect the position

Table III. The use of definitions of the axes of carpal bones according to various authors

Authors	*Radius*	*Scaphoid*	*Lunate*	*Capitate*
Linscheid et al.[7]	R1	S1	L1	C1
Sarrafian et al.[8]	R1	S1	L1	C1
Gilula and Weeks[9]	R1	S1/S2	L1	C1
Chaise et al.[10]	R1	S1	L1	C1
Imamura[11]	R2	S1	L1	C2
Yamada[12]	R2	S2	L1	C2
Nakamura et al.[5]	R2	S1	L1	C2
Larsen et al.	R1	S2	L1	C2

R1, The line through the center of the medulla at 2 and 5 cm proximally to the radio-carpal joint; R2, the tangent of the dorsal margin of radius more than 3 cm from the distal articular surface; L1, the line perpendicular to the tangent of the two distal poles; S1, the line through the proximal and distal poles; S2, the tangent of the palmar proximal and distal convexities; C1, the line through the proximal and distal poles; C2, the tangent of the dorsal margin of the diaphysis of the third metacarpal bone (substitute axis).

could be adjusted and the examination repeated. In the lateral view the ulna and the radius must overlap and the ulna styloid should be exactly in the center of the ulnar head to ensure that no pronation or supination is present. Furthermore, the long axis of the radius and the third metacarpal bones must be colinear ensuring that no extension or flexion is present. In the PA view the long axis of the radius and the third metacarpal bone must be colinear to ensure that no radial or ulnar deviation is present.

The radiological measurements of intercarpal bone angles in lateral projection of the wrist were assessed by use of the following definitions of axes (Fig. 3):

Radius: The line through the center of the medulla at 2 and 5 cm proximal to the radiocarpal joint.

Lunate: The line perpendicular to the tangent of the two distal poles.

Scaphoid: The tangent of the palmar proximal and distal convexities.

Capitate: The tangent of the dorsal margin of the diaphysis of the third metacarpal bone (substitute axis).

Results

The results of carpal angle determination in the normal wrists are shown in Table I. The SD of the angular measurements vary from 4.31 degrees (radiocapitate angle) to 6.72 degrees (scapholunate angle). Range and mean values +/−2SD demonstrate the variation.

As the radius and the capitate are defined as colinear, the radiocapitate angle was zero degrees. Thus the angles between the capitate and the lunate and the scaphoid measured the same as the angles between these bones and the radius.

The mean radio-lunate angle was also close to colinearity with the radius (−1.02 degrees), and the range −10 degrees to 12 degrees. The mean scapho-lunate angle was 50.77 (range, 36 to 66 degrees), and the mean radio-scaphoid angle 51.8 degrees (range, 35 to 65 degrees).

Discussion

Positioning of the arm, use of a device as support, and evaluation using well-defined carpal bone axes are important factors. Hardy and associates[14] showed that the radiographic examination of the wrist should be done with standardized wrist positioning. Several methods of positioning the upper extremity during radiographic examination have been reported.[13] Few authors reporting studies of radiography of the wrist joint have stated the position of the arm during their examinations.[6, 12]

In previous studies different radiographic techniques have been used (Table II). Linscheid et al.[7] stated that the scapho-lunate angle averages 46 degrees and ranges from 30 degrees to 60 degrees in normal wrists. Gilula and Weeks[9] proposed the same range of the scapholunate angle. They also added a range from 0 degrees to 30 degrees for the luno-capitate angle. However, no description of radiographic technique or material was given. In the work of Sarrafian et al.[8] detailed measurements of intercarpal bone angles were reported. The method described controlled for flexion/extension, but ulnar/radial deviation and/or pronation/supination could not be controlled. Also this work included wrists of persons as young as 14 years of age. A series of 50 normal wrists was analyzed by Chaise and associates[10] using a method described by Meyreuis.[15] In this study as well as in later studies,[5-6, 11-12] the position of the wrist was controlled with a device. However, none of the studies used methods controlling ulnar/radial deviation. Ulnar or radial deviation can not be controlled alone by placing the ulnar border firmly on the table or film cassette, as differences in the hypothenar musclemass might cause either ulnar or radial deviation. If

Table IV. Description of radiographic techniques used by various authors

	Description of technique			
		Controlling position for:		
Authors	*Use of device*	*Ulnar/radial deviation*	*Flexion/extension*	*Supination/pronation*
Linscheid et al.[7]	None			
Sarrafian et al.[8]	+	−	+	+
Gilula and Weeks[9]	None			
Chaise et al.[10]	+	−	+	+
Nishikawa et al.[6]	+	−	+	+
Imamura[11]	+	−	+	+
Yamada[12]	+	−	+	+
Nakamura et al.[5]	+	−	+	+
Larsen et al.	+	+	+	+

+, Yes; −, no.

lateral radiographs are to be used for measurements of intercarpal bone angles, the wrist must be stabilized with a support, and the position of the wrist in the two remaining planes controlled. Our results are not significantly different from previous studies using standardized radiographic technique except for the ranges that are narrower, indicating that controlling for ulnar/radial deviation might be of minor importance if the remaining planes are controlled.

We have previously shown the importance of the use of well-defined carpal axes with the least observer variability.[4, 13] Previous authors have used different definitions of carpal bones axes (Table III). On the basis of the intraobserver variation Larsen et al.[4] calculated a minimal recognizable difference (MRD = 2 × SD of difference) for different combinations of carpal bone axes. Three different methods have been used: the tangential, the axial, and a combination of tangential and axial measurements. The MRD was 3.60 degrees to 9.32 degrees depending on the axes used. The angles defined from the axes recommended in the present study resulted in the least observer variability and an MRD of 3.60 degrees to 4.84 degrees. The various methods used for measuring the carpal angles might explain differences in mean values and ranges reported.

The standard radiographic examination of the wrist consists of posteroanterior radiographs, lateral, and oblique views. Whenever ligamentous injury is suspected, additional projections should be obtained.[2] The lateral radiographs must be examined carefully to reveal any disturbance in the colinearity along the radiocapitate axis and/or intercarpal malalignment. It is important to remember that these radiographs demonstrate "static" malalignments only, while motion or stress views are necessary to demonstrate "dynamic" malalignment. In previous studies,[3, 6] it has been shown that the asymptomatic wrist may be used to establish the normal intercarpal alignment. A difference between the carpal bone angles in the two wrists in the same person exceeding 5 degrees can be considered significant.[4] However, this is only true if standardized radiographs are obtained. Normal mean values and ranges for intercarpal bone angles may be of assistance in the diagnostic evaluation of ligamentous injury to the wrist.

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