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RADIOGRAPHY OF THE WRIST

A new device for standardized radiographs

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Abstract

A number of methods exist for determination of carpal bone angles on lateral wrist radiographs. However, there is no general or precise definition of the angles measured. In this study the positioning of the wrist is emphasized and a device used to obtain standardized radiographs is presented. An analysis of variance of two series of patients revealed no radiological difference between the contralateral wrists in the same person. We conclude that the asymptomatic wrist can be used as normal reference in the assessment of carpal bone angles in the pathological wrist and a difference between the carpal bone angles in the two wrists in the same person exceeding 5° can be considered significant.

Key words: Wrist, radiography; technique.

A standardized method for obtaining wrist radiographs is necessary to ensure correct positioning and reproducibility (2, 13). Consistent and comparable projections can be facilitated by using a device to stabilize and control the position of the wrist in the desired position (12). The device described by MICKS (11) and the method reported by MEYREUIS et al. (10) do not control the position of the wrist in the postero-anterior plane allowing radial or ulnar deviation in the wrist during the lateral radiographic examination. The device used by NAKAMURA et al. (12) allowed flexion and extension only, thus controlling movements in all other directions. Ulnar deviation was prevented by the floor of the support. However, differences in the hypothenar muscle mass might cause either radial or ulnar deviation.

The present investigation had three purposes: 1) to construct a device controlling the wrist position in all directions during radiographic examination; 2) to measure the radiographic changes in carpal bone angles in various wrist positions; 3) to establish whether the healthy contralateral wrist can be used as normal reference in the radiographic assessment of carpal bone angles in the pathological wrist.

Material and Methods

Radiographic examination of a specimen. A 42-year-old male, who had his arm amputated in an occupational accident (reimplantation was not possible). The arm was used for the study of radiographic changes in carpal bone angles at various positions of the wrist. The specimen was placed in a specially constructed device (Fig. 1). The device allowed multidirectional positioning of the wrist using adjustment screws. Without moving the wrist, postero-anterior and lateral radiographs were obtained (Fig. 2). If the radiographs in one or both views were incorrect, the position of the wrist was adjusted and the examination repeated.

The specimen was positioned in a modified zero position (13) (forearm in neutral rotation, and the wrist in neutral position). Subsequently radiographs were taken with the wrist deviating from zero position in pronation and supination of the forearm, and radial and ulnar deviation of the wrist.

Radiographic examination of two series of patients. Two series of patients (A and B) were included to establish if the healthy contralateral wrist could be used as normal reference in the radiographic assessment of changes in carpal bone angles in the pathological wrist: A) 23 patients with contralateral wrist trauma. Radiographic carpal bone angles were measured twice with a 2-week interval by one observer (C. F. L.) to calculate intra-observer variability (9). B) 10 healthy persons. Radiographic carpal bone angles were assessed bilaterally (in random order to prevent incidental knowledge bias) by one observer (C. F. L.) to determine the radiographic side difference in carpal bone angles.

Both series A and B fulfilled the following. *Inclusion criteria:* age 18 years and above, and closed epiphysial

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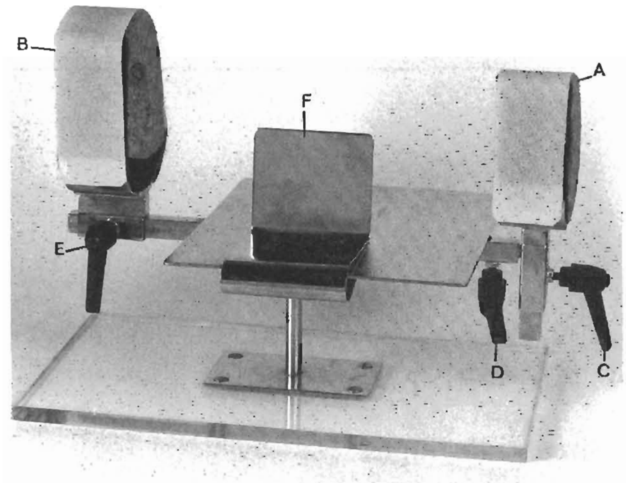
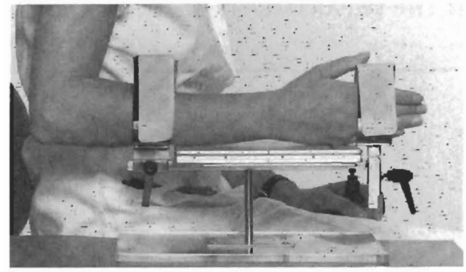


Fig. 1. The stabilizing device. (A) Finger support (changeable foam rubber shell, which can be adjusted to the size of the hand. (B) Forearm support (changeable foam rubber shell, which can be adjusted to the size of the forearm. (C) Height adjustment screw. (D) Angulation adjustment screw. (E) Length adjustment screw. (F) Cassette support.



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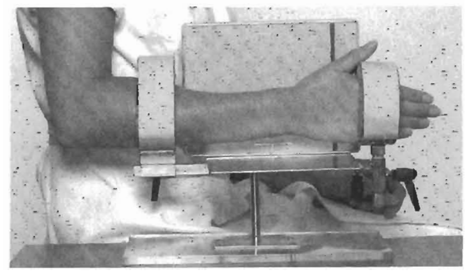

b

Fig. 2. The stabilizing device shown with cassette prepared for a) lateral projection, and b) for postero-anterior projection.

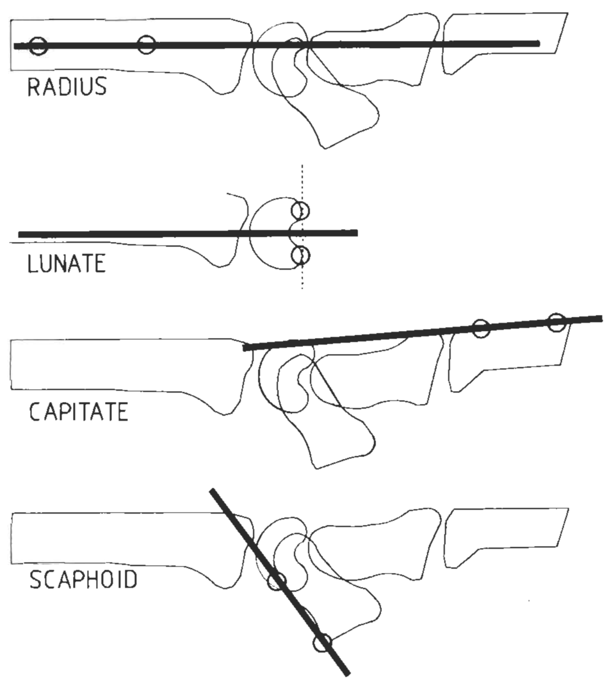

Fig. 3. Definitions of the bone axes (refer to text).

plates. *Exclusion criteria:* history or radiologic evidence of previous injury or infection of the hand, forearm, or elbow (for series A only the uninjured side); general affection of the skeleton (e.g. metabolic disease); over- or underexposure of radiograph; skew projection; less than 7 cm of radius on radiograph, and less than 2/3 of third metacarpal bone on radiograph.

Definition of zero position. The arm is adducted against the trunk; the elbow flexed 90°; the forearm in neutral rotation (no supination or pronation), and the wrist in neutral position (no radial or ulnar deviation, and no flexion or extension) (13).

Securing zero position in the wrist radiographs. In the lateral view the ulna and the radius must overlap and the ulna styloid must 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 bone must be colinear, ensuring that no flexion or extension is present. In the postero-anterior view the long axis of the radius and the third metacarpal bone must be colinear, ensuring the absence of radial or ulnar deviation.

Methods of measuring carpal bone angles. The methods with the least observer variability have been presented previously (9). These angles are defined from the carpal bone axes (Fig. 3): Radius: the line through the center of the medulla at 2 and 5 cm proximal to the radio-carpal joint. Lunate: the line perpendicular to the tangent of the two distal poles. Scaphoid: the tangent of the volar proximal and distal convexities. Capitate: the tangent of the dorsal margin of the diaphysis of the third metacarpal bone (substitute axis).

Statistics. The *intra-observer* variation was calculated from the sum of squares of differences between the first and second unilateral assessment in series A.

From series B the combined *intra-observer, radiographic,* and *anatomic* variation was calculated from the sum of squares of differences between the assessments of the two sides. The 20 radiographs in series B were assessed in random order to avoid incidental knowledge bias. A *variance ratio test* (F-test) was used to determine if the variation in the assessment of series B was higher than in series A (a difference would be due to either radiographic or anatom-

Table 1

Carpal bone angles on lateral radiographs at various wrist positions in one specimen

Wrist position	RS	RL
Neutral	60	−8
Pronation		
5°	55	−4
10°	52	−3
Supination		
5°	49	1
10°	45	4
Radial deviation		
5°	62	−8
10°	65	−8
max. radial deviation	68	−10
Ulnar deviation		
5°	52	−5
10°	44	−3
15°	32	−1
max. ulnar deviation	28	−1

RS = radio-scaphoid angle. RL = radio-lunate angle.

Table 2

Radio-scaphoid angles on lateral radiographs measured in contralateral wrists in 10 healthy persons

Patient no.	R	L	D	D^2
1	53	51	2	4
2	62	61	1	1
3	50	52	−2	4
4	52	54	−2	4
5	52	50	2	4
6	61	61	0	0
7	47	48	−1	1
8	49	52	−3	9
9	55	55	0	0
10	62	60	2	4
ΣD^2				31
df				10
Variance $= \Sigma D^2/df = 31/10 =$				3.1

R = right. L = Left. D = difference (R-L). df = degrees of freedom.

Table 3

Radio-lunate angles on lateral radiographs measured in contralateral wrists in 10 healthy persons

Patient No.	R	L	D	D^2
1	−10	−7	−3	9
2	3	4	−1	1
3	0	0	0	0
4	0	0	0	0
5	4	3	1	1
6	−4	−1	−3	9
7	5	3	2	4
8	−5	−2	−3	9
9	5	4	1	1
10	−4	−4	0	0
ΣD^2				34
df				10
Variance $= \Sigma D^2/df = 34/10 =$				3.4

R = right. L = Left. D = difference (R-L). df = degrees of freedom.

Table 4

Intra-observer variation in measurements of the radio-scaphoid and radio-lunate angles on unilateral radiographs of 23 normal wrists

Patient No.	RS A1	A2	D	D^2	RL A1	A2	D	D^2
1	50	51	−1	1	−6	−6	0	0
2	51	51	0	0	4	4	0	0
3	50	52	−2	4	−3	−3	0	0
4	50	50	0	0	4	5	−1	0
5	48	49	−1	1	−1	−3	2	4
6	62	60	2	4	4	0	4	16
7	47	48	−1	1	5	4	1	1
8	42	43	−1	1	2	3	−1	1
9	53	53	0	0	3	2	1	1
10	52	53	−1	1	−7	−10	3	9
11	54	56	−2	4	−3	2	−1	1
12	60	61	−1	1	−4	−6	−2	4
13	46	49	−3	9	2	0	2	4
14	51	51	0	0	−4	−3	−1	1
15	46	47	−1	1	−7	−8	1	1
16	46	47	−1	1	12	10	2	4
17	46	48	−2	4	2	2	0	0
18	45	46	−1	1	0	3	−3	9
19	47	48	−1	1	4	5	−1	1
20	46	47	−1	1	−5	0	−5	25
21	54	54	0	0	−5	−5	0	0
22	55	55	0	0	−4	−5	1	1
23	50	50	0	0	2	2	0	0
ΣD^2				36				84
df				23				23
Variance $= \Sigma D^2/df =$				1.57				3.65

RS = radio-scaphoid angle. RL = radio-lunate angle. A1 = 1st assessment. A2 = 2nd assessment. D = difference (A1-A2). df = degrees of freedom.

ical side differences since the observer remained the same). A 95 percent significance level was chosen.

The study was conducted in accordance with the Helsinki II declaration, where all patients must give informed consent.

Results

In neutral position the carpal bones were easy to identify and tracings could be made without problems. Even a 10° supination or a 10° pronation distorted the appearance of the carpal bones (Table 1). As a consequence it was difficult to identify the bones resulting in less accurate tracings. In pronation the radio-scaphoid angle decreased. However, the scapho-lunate angle remained unchanged. When supinating the wrist the radio-scaphoid angle decreased. In radial deviation the scaphoid and the lunate rotated into flexion, resulting in an increase of the radio-scaphoid and radio-lunate angles. In ulnar deviation both the radio-scaphoid and the radio-lunate angles decreased as the scaphoid and the lunate rotated into dorsiflexion. The results of the study carried out to determine differences between carpal bone angles in the contralateral wrists of the same person are given in Tables 2 and 3. The largest difference revealed between the right and left wrist in the same person was 3°.

The variance of the radio-scaphoid angle and the radio-lunate angle measured on radiographs from both wrists was respectively 3.1 and 3.4. In the series of 23 normal wrists measured twice by the same observer the variance for the same two carpal bone angles was 1.57 and 3.65 (Table 4).

Variance ratio tests showing no significant difference between the variance in the two series of patients indicate the absence of clinically important radiological or anatomical side differences.

Discussion

In this study the importance of correct positioning of the wrist for determining carpal bone angles is demonstrated. Imamura (3) reported similar observations. Varying positions of the carpal bones in different movements of the wrist have been discussed in detail (4–8). The changes of intercarpal angles occurring when the lateral wrist radiographs are obtained in supination or pronation are important. However, the error is easily detected as the radius and the ulna are not overlapping. The significant changes of intercarpal angles during ulnar deviation are more important because it is difficult to control radial-ulnar abduction in lateral radiographs.

The device allowed adjustment of the wrist position in all three planes. It has proven suitable and accurate for radiographic wrist examinations. However, it seemed that only well mobilized and cooperating patients could be examined in this way. Patients in bed as well as patients with painful fractures or dislocations cannot be examined by this method. Despite the simplicity of the device some training is necessary to obtain adequate radiographs. Radiological examination using a device is more time consuming than examination without extra equipment. If, however, lateral radiographs are to be used for measurements of carpal bone angles, the wrist must be supported and the position in the remaining planes controlled.

A number of measuring methods have been designed for evaluating carpal bone angles on lateral radiographs. Nakamura et al. (12) stated that only a difference of more than 10° between the contralateral bone angles should be considered of diagnostic significance. Their study was based on 25 patients with bilateral wrist measurements and an SD of 5 to 6°. No calculations of a possible statistical difference were reported.

Garcia-Elias et al. (1) showed that any determination of intercarpal angles using a goniometer has an SD of 5.2° of observer variation. They reported an even higher interobserver variation when the method was used for exact quantification of carpal motion.

Larsen et al. (9) recommended the use of a set of definitions of bone axes securing the least observer variability. Using this method a difference between the carpal bone angles on lateral radiographs in the wrists of the same person exceeding 5° can be considered significant. In the present study we found no significant difference between the two wrists in the same person.

We conclude that the contralateral healthy wrist can be used as a normal reference in the radiographic assessment of carpal bone angles in the pathological wrist.

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