Sarhan MY, Altamimi AA, Gharaibeh MA, et al. Evaluation of Normal Ranges of Wrist Radiologic Indexes in Jordanian Population. *Orthopedic Reviews*. 2024;16.
doi:10.52965/001c.120049

General

Evaluation of Normal Ranges of Wrist Radiologic Indexes in Jordanian Population

Mohammed Y. Sarhan[1], Anas AR Altamimi[2], Monther A Gharaibeh[3], Alaa Akel[4], Muntaser Abu Shokor[5], Omar Alshiekh Salem[6], Basel Balbisi[2], Mohammad Abu-Jeyyab[7]

[1] Department of special surgery, faculty of medicin, Hashemite University, [2] Department of special surgery, faculty of medicine, Hashemite University, [3] Department of special surgery, faculty of medicine , Hashemite University, [4] epartment of special surgery, faculty of medicine, Mutah University, [5] The Specialty hospital Amman, [6] East Sussex Healthcare NHS Trust, [7] School of Medicine, Mutah University

Keywords: wrist, Xray, index

https://doi.org/10.52965/001c.120049

Orthopedic Reviews

Vol. 16, 2024

Background

The wrist is a complex joint that plays a role in several everyday tasks. Various radiological indices have been created to assess the alignment and structure of the wrist using standard X-ray images. Nevertheless, these indicators may differ based on variables such as age, gender, ethnicity, handedness, and wrist position. This research aimed to assess the radiological indices of the wrist in a group of healthy people from Jordan and investigate the impact of age and gender on these indices.

Methods

We obtained data from a sample of 385 patients who presented at our hospital with minor non-specific wrist pain and satisfied the specified criteria for inclusion. We conducted measurements of radial inclination, radial height, volar tilt, ulnar variance, and carpal height ratio using both anteroposterior and lateral views of the wrist. We used linear regression and independent sample t-test to examine the correlation between age, gender, and radiological indicators. The reliability of the measurements was assessed using the intraclass correlation coefficient (ICC).

Results

Our study revealed a negative correlation between age and carpal height ratio ($r = -0.13$, $p = 0.03$). However, no significant gender differences were seen in any of the radiological indices ($p > 0.05$). Our findings indicate that ulnar variance had the greatest level of reliability across observers, with an intra-observer intraclass correlation coefficient (ICC) of 0.95 and an inter-observer ICC of 0.8. Conversely, volar tilt exhibited the lowest inter-observer reliability, with an ICC of 0.1.

Our results provide a valuable point of reference for the wrist morphology and alignment in the Jordanian population. Our suggestion is that the carpal height ratio might indicate alterations in the wrist joint due to aging, whereas ulnar variation may serve as a dependable indicator of wrist alignment. We suggest doing more research to investigate the biological and anatomical factors behind these results and to compare them with other demographic groups.

INTRODUCTION

The wrist is a complex joint that consists of eight carpal bones and their articulations with the radius, ulna, and metacarpals. The wrist plays a vital role in various activities of daily living, such as grasping, writing, typing, and playing sports. Therefore, understanding the normal anatomy and morphology of the wrist is essential for diagnosing and treating various wrist disorders, such as fractures, osteonecrosis, arthritis, and carpal instability.[1]

One of the most common methods for assessing wrist anatomy is plain radiography, which is a simple, inexpensive, and widely available imaging technique. Plain radiographs can provide valuable information about the shape, size, position, and alignment of the carpal bones and their relationships with the adjacent bones.[1]However, plain radiography also has some limitations, such as projection errors, magnification errors, and interobserver variability.[2] To overcome these limitations, several radiological indices have been developed to quantify the wrist morphology using measurements of distances and angles from specific

landmarks on the radiographs. These indices can help to characterize the normal wrist architecture and evaluate the deviations from normality in different wrist diseases.[1] Some examples of these indices are radial inclination, radial tilt, radial height, ulnar variance, carpal height ratio, ulnar-carpal ratio, and radial-carpal ratio.[2,3]

However, these indices may also vary depending on several factors, such as age, gender, ethnicity, handedness, and wrist position. Therefore, it is important to establish the normal values and ranges of these indices for different populations and compare them with the values obtained from patients with wrist disorders.[2,4]

To getting precise and dependable measurements of these indices, it is essential to position the patient correctly for certain perspectives. Various perspectives, such as posteroanterior, lateral, oblique, and scaphoid, might unveil distinct facets of the wrist's anatomy and disease.[5] Incorrect placement might result in inaccuracies in the measurements and misrepresentation of the findings.[6] Consequently, we adhered to the established protocols for wrist radiography and verified that the patients were appropriately positioned for each perspective.

In this study, we aimed to measure the radiological indices of the wrist in a sample of healthy Jordanian adults using plain radiographs and to analyze the effects of age and gender on these indices. We also compared our results with those reported in previous studies from different countries and regions. We hope that our findings will contribute to the existing knowledge of wrist morphology and provide a useful reference for clinicians who deal with wrist diseases in the Jordanian population.

MATERIALS AND METHODS

The study protocol of this study received ethics approval from our local ethics committee. We followed convenience sampling to collect our data. We studied all distal radius x-rays of patients who visited our hospital complaining of mild nonspecific wrist pain. Exclusion criteria included patients with previous fracture around the wrist, patients with undiagnosed new trauma to the wrist, patients who received a soft tissue surgery involving the ligaments around the wrist, patients with diagnosed inflammatory arthritis, and patients with incomplete or improper x-rays.

RADIOGRAPHIC ASSESSMENT

Proper anteroposterior (AP) and lateral views for the wrist of 385 patients were included for measurements. On the lateral view, we measured volar tilt. Radiological indices calculated on the AP view were radial inclination, radial height, ulnar variance, and carpal height ratio.

Volar tilt was measured as the angle between a tangential line connecting both volar and dorsal rims of the lunate fossa in relation to a line perpendicular to the radial shaft axis. Measures with dorsal rather than volar tilt were recorded in negative valuesThe radial inclination angle was measured between a reference line perpendicular to the radial shaft axis to a line representing the distal radius articular surface The distance in millimeters (mm), between two lines drawn perpendicular to the long axis of the radius on the AP projection from the apex of the radial styloid and level of the ulnar aspect of the articular surface, was noted as the radial height. The ulnar variance was recorded in (mm) as the distance between two tangential lines representing the distal articular surface of the radius and ulna. Values were recorded in a negative sign for patients with negative ulnar variance and in a positive sign for patients with positive ulnar variance. There was some deviated bad inter-observer variability due to the difficulty of its measurements (the overlapping between the ulna and radius)

We used the method of Youm to calculate the carpal height ratio. Carpal height was considered the distance between the base of the third metacarpal and the point of intersection of the metacarpal axis with the radiocarpal joint. The resulting value was divided by the length of the third metacarpal.

All radiographic measures were performed by an orthopedic specialist using a DICOM viewer software. We need to do the interobserver variability so we need specialists: an Orthopedic resident PGY5 , and a general physician who's well trained for measuring the distal radius indexes.

RELIABILITY

For the assessment of intra-observer reliability, the x-rays of 75 randomly selected patients were assessed a second time by the specialist reader with a minimum of four weeks of interval between the readings. A second independent reader was asked to perform the same indices measurements for the previously randomly selected images for the assessment of inter-observer reliability.

STATISTICAL ANALYSIS

IBM SPSS 22 was used to perform statistical analysis for this study. Descriptive statistics including mean, standard deviation, and range were recorded for patients demographics and measured radiological indices. A linear regression model with Pearson's correlation coefficient was used to study the relation between carpal height ratio and ulnar variance, the age of the patient, and all measured indices. An Independent sample t-test was used to compare radiological indices between different genders. For reliability analysis, ICC was used to measure inter and intra-observer reliability. A significant level was set at $p < 0.05$.

RESULTS

Patients demographics are shown in Table 1.

RADIOGRAPHIC INDICES

Measurements from 385 X-rays of normal wrists (men and women), were used to determine normal indices and ratios among the Jordanian population. The mean radial inclination was 21.9 degrees (Range 15-32.7 degrees), with a mean radial height of 12.6 mm (Range 8.4-18.9) and a mean volar tilt of 9.9 degrees. Ulnar variance ranged from -5.8 mm

Table 1. Patients demographics

Demographics	
Age (Mean/SD)	41.5 (14.6)
Gender	F: 138 M:247
Side	Left: 202 Right:183

Table 2.

Indices	Mean	SD	Range
Radial inclination	21.9	2.3	15-32.7
Radial height (mm)	12.6	1.7	8.4-18.9
Volar tilt	9.9	1.9	1.05-15.3
Ulnar variance (mm)	-0.3	2.0	-5.8-4.1
Carpal height ratio	0.5	0.06	0.4-1.5

Table 3. Effect of age on radiological indices

	Pearsons R	P value
Radial inclination	-0.04	0.5
Radial height (mm)	-0.09	0.1
Volar tilt	-0.05	0.4
Ulnar variance (mm)	0.07	0.2
Carpal height ratio	-0.13	0.03

Table 4. Gender-related comparison of different radiographic measures

	Male	Female	P value
Radial inclination	21.9 (2.3)	21.7 (2.3)	0.5
Radial height (mm)	13.1 (1.7)	11.9 (1.4)	0.1
Volar tilt	9.8 (1.9)	10.0 (1.9)	0.9
Ulnar variance (mm)	-0.31 (2.0)	-0.38 (2.2)	0.4
Carpal height ratio	0.53 (0.04)	0.52 (0.09)	0.3

(negative ulnar variance) to 4.1 mm, with a mean of 9.9 mm. The mean of the calculated carpal height ratio using the method of Youm was 0.5 (Range 0.4-1.5).

In the assessment of the relation of age with measured radiological indices, the carpal height ratio showed a statistically significant negative but weak correlation to the increasing age of the patients. All other indices had a weak and statistically insignificant correlation to the age of the patient. (Table 3)

A comparison of the different radiographic measures between males and females did not show any statistically significant difference between the two groups. (Table 4)

RELIABILITY OF RADIOGRAPHIC MEASUREMENTS:

In the analysis of X-ray measurement reliability, we followed the guidelines of selecting the intraclass correlation coefficient (ICC) reported by Koo et al. Randomly selected X-rays of 75 patients (two views) were used to perform reliability measures.

For intra-observer reliability, (ICC two-way mixed effect, absolute agreement), a single measurement model was calculated. Ulnar variance had the best intra-observer reliability (ICC = 0.95). All the other indices had moderate to excellent intra-observer reliability.

inter-observer reliability, ICC two-way mixed effect, absolute agreement, and a single measurement model were calculated. The same trend has been noticed as ulnar variance had a good inter-observer reliability (ICC=0.8) and

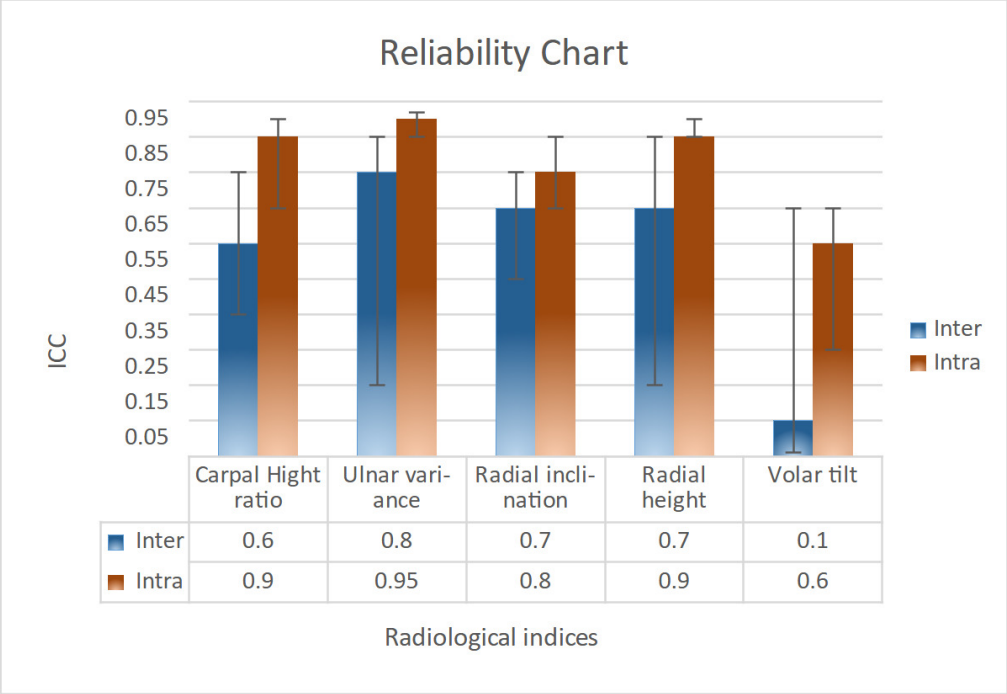

Figure. inter-observer and intra-observer reliability of reading different radiographic measures.

volar tilt had a poor reliability (ICC= 0.1). Results are reported in the figure.

DISCUSSION

The most common method for assessing the bone components of the wrist is plain radiography.[5]Carpal indices were created using distances and angles determined from bone landmarks on lateral and posteroanterior (PA) radiographs to characterize normal wrist architecture and evaluate anomalies. More and more, it is thought that morphological differences in the wrist structures might contribute to disorders with the wrist.[6] .Changes in radiographic carpal bone measures can be used to track the evolution of degenerative disease, carpal instability, osteonecrosis, and osteoarthrosis.[3] The position of the wrist, forearm, and arm, as well as the orientation of the X-ray beam, have all been proven to alter the appearance and placement of the osseous landmarks, and hence the measurements.[7,8]

These indices are employed in the detection and therapy of wrist disorders. Examples of measurements that may be used to diagnose and assess distal radius fractures include radial inclination, radial tilt, radial height, and ulnar variance.[9] Also, lunate osteonecrosis and osteoarthritis carpal collapse may be evaluated using the carpal height ratio. Moreover, the ulnar-carpal ratio and radial-carpal ratio can show us carpal translocation and misalignment, which are symptoms of wrist arthritis.[10,11] Physicians have been able to identify small angulations and aberrant bone and joint connections using precise measurements from X-rays. However, the normal side does not give a better reference than normal values acquired from databases due to the variability between the right and left wrist, radial inclination and radial tilt of the distal radius, and ulnar variance.[12]

Our study revealed that there is a negative correlation between carpal height ratio and age. However, there is no relationship between age and other radiological indices.

Also, our study showed that there is no difference between males and females in all radiological indices. We also found that ulnar variance had the best intra-observer and inter-observer reliability, while volar tilt had the worst inter-observer reliability.

In terms of the gender of patients, Jafari et al showed no difference between the gender of the patient and radiological indices.[9] On the other hand, Mona et al showed there is a statistically significance difference between gender and radiological indices[6]

Our research, like all others, had certain limitations. One of the constraints was the risk of incorrect measurement due to operator-related radiograph-taking approaches. The second drawback was that we selected healthy relatives of patients, who may not be representative of the general Jordanian population.

The data obtained from radiological indices has important clinical implications. We can increase diagnosis accuracy and adjust treatment techniques more effectively by better understanding wrist anatomy and its variability. Combining radiological data with various diagnostic modalities may give a more thorough view of wrist health as medical imaging technology progresses.

Finally, radiological indices obtained from plain radiographs are quite useful for evaluating wrist morphology and diagnosing different wrist diseases. These measures give doctors critical information about wrist health, especially in situations of fractures, osteonecrosis, and arthritis. The discovery of a negative association between carpal height ratio and age in our study, as well as the investigation of gender-related variances, provides vital knowledge

to the area. The literature's conflicting results about gender differences highlight the need for more study to completely understand the delicate linkages between wrist morphology, gender, and associated illnesses.

Submitted: August 27, 2023 EST, Accepted: March 24, 2024 EST

REFERENCES

1. Kamal RN, Starr A, Akelman E. Carpal kinematics and kinetics. *J Hand Surg Am*. 2016;41(10):1011-1018. doi:10.1016/j.jhsa.2016.07.105

2. Crisco JJ, Wolfe SW, Neu CP, Pike S. Advances in the in vivo measurement of carpal kinematics. *Orthopedic Clinics of North America*. 2001;32(2):219-231. doi:10.1016/S0030-5898(05)70244-3

3. Eschweiler J, Radermacher K, Nick HE, et al. Anatomy, biomechanics, and loads of the wrist joint. *Life (Basel)*. 2022;12(2):188. doi:10.3390/life12020188

4. Eschweiler J, Allmendinger F, Stromps JP, et al. Biomechanical modelling of the wrist joint. *Z Orthop Unfall*. 2014;152(2):161-169. doi:10.1055/s-0034-1368246

5. Robertson C, Neu CP, Haddad R, et al. The sensitivity of carpal bone indices to rotational malpositioning. *J Hand Surg Am*. 2002;27(3):435-442. doi:10.1053/jhsu.2002.31732

6. Mohammed Ali MH. A normal data-base of posteroanterior radiographic measurements of the wrist in healthy Egyptians. *Surg Radiol Anat*. 2009;31(9):665-674. doi:10.1007/s00276-009-0500-4

7. Wang YC, Tseng YC, Chang HY, et al. Gender differences in carpal height ratio in a taiwanese population. *J Hand Surg Am*. 2010;35(2):252-255. doi:10.1016/j.jhsa.2009.11.010

8. Foteva M, Poposka A. Kinematic radiographic measurements of the wrist in the healthy population in the Republic of Macedonia. *Prilozi*. 2010;31(2):83-93.

9. Jafari D, Taheri H, Shariatzade H, et al. Radiographic indices in one hundred fifty normal Iranian wrists. *Med J Islam Repub Iran*. 2012;26(3):132-139.

10. Feipel V, Rinnen D, Rooze M. Postero-anterior radiography of the wrist. Normal database of carpal measurements. *Surg Radiol Anat*. 1998;20(3):221-226. doi:10.1007/BF01628899

11. Roh YH, Lee BK, Baek GH, et al. Reliability and validity of carpal alignment measurements in evaluating deformities of scaphoid fractures. *Arch Orthop Trauma Surg*. 2014;134(6):887-893. doi:10.1007/s00402-014-1998-4

12. Schuind F, Alemzadeh S, Stallenberg B, Burny F. Does the normal contralateral wrist provide the best reference for X-ray film measurements of the pathologic wrist? *J Hand Surg Am*. 1996;21(1):24-30. doi:10.1016/s0363-5023(96)80150-x