

**SHORT COMMUNICATION**

# Evaluation of Normal Ranges of Wrist Radiologic Indexes in Mashhad Population

Tohid Vaezi, MD; Golnaz Ghayyem Hassankhani, MD; Mohammad H. Ebrahimzadeh, MD; Ali Moradi, MD

Research performed at Orthopedic Research Center, Ghaem Hospital, Mashhad University of Medical Sciences, Mashhad, Iran

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**Abstract**

Hand and wrist radiographic indexes such as radial inclination, ulnar variance, carpal height ratio, and radial tilt play an important role in the diagnosis and management of medical disorders, so they should be modified regarding the population and race difference. This study aims to compare the normal radiologic wrist indexes in Mashhad population with other existing databases and define some of the factors that may influence the normal radiographic indexes.

A total of 100 healthy participants were enrolled in this prospective cross-sectional study. After performing PA and lateral wrist radiographs, all radiological indexes including the wrist height; 1st and 3rd metacarpal length; ulnar variance; radial tilt and radial inclination; radiolunate, capitulate, and scapholunate angle; capitate and scaphoid length; lunate and wrist width; and lunate diameter were measured.

Significant differences were found between the two genders in the 1st and 3rd metacarpal length ( $P < 0.001$  and  $P < 0.001$  respectively), wrist height ( $P < 0.001$ ), radial tilt ( $P = 0.027$ ), radiolunate angle ( $P = 0.001$ ), capitate and scaphoid length ( $P < 0.001$  and  $P < 0.001$  respectively), lunate and wrist width ( $P < 0.001$  and  $P < 0.001$  respectively), lunate length ( $P = 0.003$ ), and lunate diameter ( $P < 0.001$ ). A significant linear correlation was found between ulnar variance ( $P = 0.003$ ), scapholunate angle ( $P = 0.016$ ), and wrist ratio ( $P = 0.011$ ) with age.

According to our findings, using population specific wrist and hand indexes is recommended to diagnose and follow up upper extremities conditions.

**Keywords:** Normal ranges, Radiologic indexes, Wrist

**Introduction**

Plain radiographs have been known as the most common tools to recognize the wrist pathologic disorders (1). For instance, radial inclination, ulnar variance, and radial tilt have been used either to diagnose the stability of distal radius fracture or to evaluate the effectiveness of reduction (1, 2). Also, ulnar variance is a red flag for wrist disorders such as Kienbock's disease, ulnar abutment, and radioulnar impingement syndrome (3). Radial inclination and palmar tilt are used to assess the outcomes of distal radial fractures (3). Carpal height ratio and scapholunate

angle determine wrist collapse and instabilities as a result of rheumatoid arthritis or avascular necrosis of lunate called Kienbock's disease (4).

Anatomical variations of the wrist have been found among different genders and races and it is a need to define the normal ranges in each area (5). This anatomical dissimilarity leads to variability in present normal databases (4).

The current study aims to compare the normal wrist indexes in Mashhad population with other existing databases and discover some factors that may influence

**Corresponding Author:** Ali Moradi, Orthopedic Research Center, Ghaem Hospital, Mashhad University of Medical Sciences, Mashhad, Iran  
Email: Moradial@mums.ac.ir



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radiographic normal indexes.

### Materials and Methods

A total of 100 healthy participants were enrolled in this prospective cross-sectional study conducted in 3 hand clinics in Mashhad, after ethical board approval. According to a previous study and considering  $\alpha=0.05$  and 80% power the sample size was calculated as 100 participants (2). The Participants were chosen from the patients' relatives who have been referred to our clinics. Healthy participants were asked to take standard posteroanterior (PA) and lateral wrist radiographs. The exclusion criteria included age under 18, anatomical deformity of upper extremities and any history of wrist fractures.

The wrist PA views were taken by placing the beam vertically to radius styloid with the shoulder abducted and the elbow flexed both at  $90^{\circ}$ . For the lateral view, the wrist was flexed and abducted while it was in neutral position. DICOM viewer was used to measure the radiological indexes. All length measurements were performed and recorded in millimeters and the angles were measured in degrees. Radiological wrist indexes including first and third metacarpal length, wrist height, ulnar variance, radial tilt, radial inclination, radiolunate angle, capitulate angle, scapholunate angle, capitate and scaphoid length, lunate and wrist width and lunate diameter were measured as follow:

Youm Carpal height ratio is calculated by dividing the carpal height by the length of the third metacarpal (6).

The wrist ratio is calculated by dividing the AP wrist width by the ML wrist width.

The 3rd metacarpal length is the interval between distal and proximal articular surfaces [Figure 1A].

Wrist height in PA radiograph is the interval between bases of the third metacarpus to the intersection between the distal articular surface of radius along with the 3rd metacarpus alignment [Figure 1B].

First metacarpal length in PA radiograph is the interval between the distal and proximal articular surfaces in millimeters [Figure 1C].

Ulnar variance is the distance between the distal articular surfaces of ulnar and radius which may be considered as neutral, positive or negative variance [Figure 2] (3).

Radial tilt is the angle between volar and dorsal articular ends of distal radius drawn perpendicularly to the longitudinal axes of the radius bone in lateral view [Figure 3] (2).

Radial inclination is the angle between the line drawn perpendicular to the longitudinal axis of the radius and another line from radial styloid to ulnar aspect of distal radius in PA radiograph (1) [Figure 4].

Radiolunate angle is the angle between the longitudinal axes of radius and lunate in lateral view [Figure 5] (7).

Capitolunate angle is the angle between the longitudinal axis of capitate to the axis of lunate in lateral view [Figure 6] (7).

Scapholunate angle is the angle between longitudinal axes

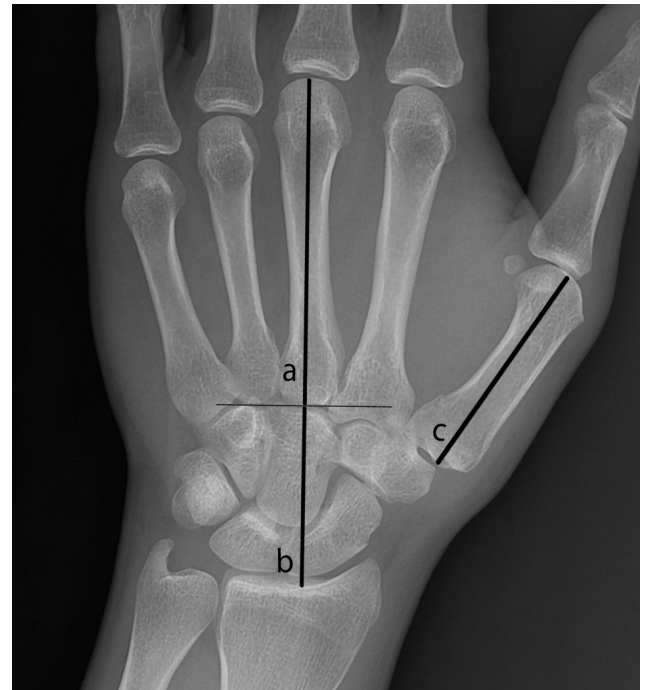


Figure 1. (A) Third metacarpal length. (B) Wrist height. (C) First metacarpal length.



Figure 2. Ulnar variance.

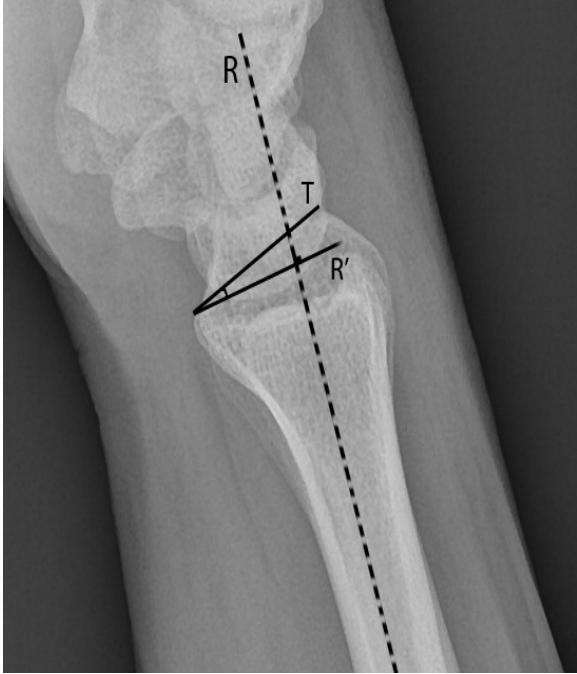


Figure 3. Radial tilt.

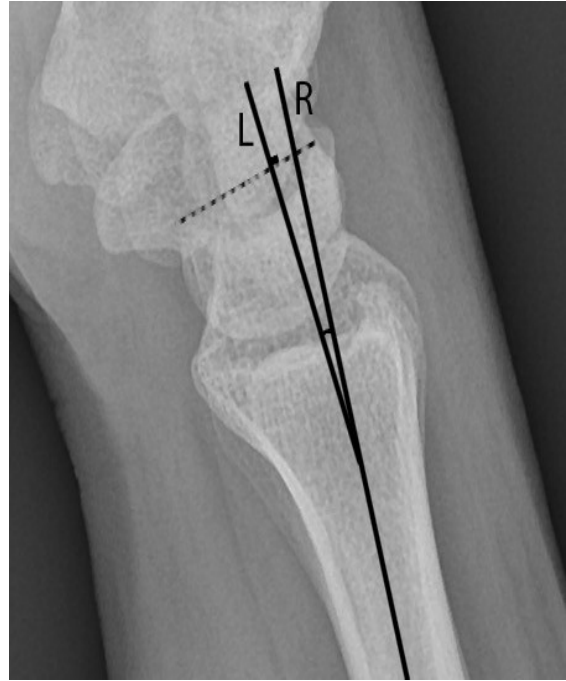


Figure 5. Radiolunate angle.



Figure 4. Radial inclination.



Figure 6. Capitulate angle.

of lunate and scaphoid (tangential line from the dorsum of scaphoid) in the lateral radiograph [Figure 7] (7).

Scaphoid length is the interval between the distal and proximal poles of scaphoid in millimeters in wrist PA

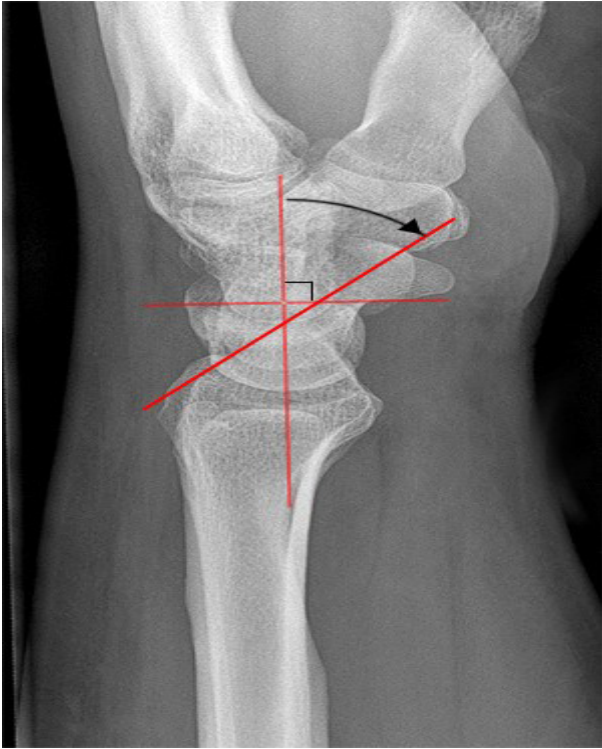


Figure 7. Scapholunate angle.



Figure 8. (S) Scaphoid length. (C) Capitate length. (L) Lunate width. (W) Wrist width.

radiographs [Figure 8S].

Capitate length is the distance between the distal and proximal poles of the capitate [Figure 8C].

Lunate width is the maximum diameter of the lunate prolonged to radius alignment in wrist AP radiographs [Figure 8L].

Wrist width is the distances between the ulnar side articular corners of the 5<sup>th</sup> metacarpus to the radial corner of the 2<sup>nd</sup> metacarpus in PA view [Figure 8W].

Lunate diameter is the maximum lunate diameter which is parallel with the radius bone in lateral view [Figure 9].

The data were analyzed by SPSS version 16.0 (SPSS Inc., Chicago IL) and a  $P > 0.05$  was considered as statistically significant. Leven's test, T- test and Pearson's correlation were used to analyze the data and to investigate the relationship between the variables.

### Results

A total of 100 participants were enrolled in this study, 47 were women and 53 were men. Also, 61 participants were right-handed and 39 were left-handed. The mean age of the participants was  $38.1 \pm 14.7$  years with the minimum of 18 and the maximum of 85 years old [Table 1].

Normal wrist indexes among different genders are shown in Table 2.

Regarding gender, statically significant differences



Figure 9. Lunate diameter.

was measured in first and third metacarpal length,

**Table 1. Demographic characteristics of participants (N=100)**

<b>Age (Mean, SD)</b>		38.1 (14.7)
<b>Gender (N%)</b>	Female	47 (47)
	Male	53 (53)
<b>Dominant hand (N%)</b>	Right	61 (61)
	Left	39 (39)

wrist height, radial tilt, radiolunate angle, capitate and scaphoid length, lunate and wrist width, lunate length and Lunate diameter [Table 3].

A significant linear correlation was measured between the ulnar variance, scapholunate angle, wrist width and wrist ratio with age [Table 4].

### Discussion

Several imaging studies using the landmarks on PA

**Table 2. Normal wrist indexes in different genders**

Variable	Mean			Maximum			Minimum		
	Total (SD)	Male	Female	Total	Male	Female	Total	Male	Female
Wrist height (Mean, SD)	37.1 (3.75)	39.6	34.3	45.5	45.5	39.2	29.3	33.7	29.3
Wrist width (Mean, SD)	46.7 (4.77)	50.3	42.7	58.6	58.6	49.1	38.1	41.2	38.1
Ulnar variance (Mean, SD)	1.15 (2.54)	0.94	1.38	7.00	7.00	5.50	-4.50	-4.50	-3.00
First metacarpal length (Mean, SD)	49.7 (3.95)	52.0	47.0	61.0	61.0	54.5	42.9	44.8	42.9
Third metacarpal length (Mean, SD)	70.1 (5.55)	73.4	66.4	84.3	84.3	73.5	60.5	60.5	60.5
Scaphoid length (Mean, SD)	23.1 (3.57)	25.5	20.5	30.1	30.1	25.5	15.7	18.4	15.7
Capitate length (Mean, SD)	23.8 (2.39)	25.5	21.9	28.6	28.6	25.0	18.2	21.7	18.2
Lunate width (Mean, SD)	10.9 (1.51)	11.6	10.2	14.8	14.8	12.2	7.00	8.10	7.00
Lunate diameter (Mean, SD)	9.63 (1.25)	10.3	8.86	12.4	12.4	11.1	6.50	7.00	6.50
Radial inclination (Mean, SD)	24.5 (3.23)	24.3	24.7	33.0	31.7	33.0	17.3	17.3	18.0
Radial tilt (Mean, SD)	10.2 (5.17)	9.15	11.4	22.5	22.5	20.3	0.00	0.00	1.00
Radiolunate angle (Mean, SD)	3.31 (9.02)	0.651	6.31	22.5	16.6	22.5	-17.0	-17.0	-16.0
Capitolunate angle (Mean, SD)	18.3 (6.99)	18.7	17.8	34.2	34.2	32.6	0.00	5.50	0.00
Scapholunate angle (Mean, SD)	52.5 (8.92)	53.4	51.5	72.0	72.0	70.9	32.3	37.2	32.3

and lateral radiographs have already been provided to measure the bony structures (1). Normal wrist indexes can be useful to follow up hand pathologies by comparing indexes before and after the treatment (8). Race, age, and gender differences have been recommended to be considered in radiograph analysis since they affect the accuracy of the diagnose (1, 9).

Like every other study, our study had some limitations. One of the limitation was the risk of inaccurate measuring owing to operator related technique for performing radiographs. The second limitation was that we used patients' healthy relative which may not really be representative of the normal Iranian population. Finally, we had to reduce the number of participants to the minimum calculated number which was 100 due to the limited time and budget.

The fact that age and gender influence hand indexes such as ulnar variance, third metacarpal length, and radial inclination have been previously proven in Mexicans, Egyptians and Taiwanese populations (1, 9, 10). Also, differences in the carpal height, carpal-ulnar distance

and the 3rd metacarpal length among various ages have already been reported (11). As our data shows the ulnar variance was correlated with age, which implies it as a cause of ulnocarpal impingement syndrome (12). Moreover, normal aging was in combination with degenerative changes (1). In contrast with the results of our study, a previous study has reported variations in ulnar variance between males and females (1). Despite the ulnar variance, the other length related indexes were significantly shorter in women implying that men wrist are wider.

Our findings were similar in a number of ways to the results of a previous study by Jafari et al. In agreement with our study, they revealed no significant differences in radial tilt and scapholunate angle due to age and sex, as well as in ulnar variance and radial tilt regarding sex and age, respectively. Also, Wrist height, 3<sup>rd</sup> metacarpal length, lunate width, and capitate length found to be statistically different considering gender [Table 5] (2).

On the controversy, neither age nor gender affected

**Table 3. The correlation between wrist normal indexes and gender**

Variables		Mean	Standard deviation	95% Confidence Interval		P value
				Lower Bound	Upper Bound	
Third metacarpal length (Mean, SD)	Male	73.4	4.93	5.19	8.65	<i>P</i> <0.001
	Female	66.4	3.58			
Wrist height (Mean, SD)	Male	39.6	2.77	4.28	6.38	<i>P</i> <0.001
	Female	34.3	2.51			
Ulnar variance (Mean, SD)	Male	0.94	2.77	-1.46	0.569	0.387
	Female	1.38	2.26			
Radial inclination (Mean, SD)	Male	24.3	3.18	-1.64	0.937	0.591
	Female	24.7	3.3			
Radial tilt (Mean, SD)	Male	9.15	4.93	-4.3	-0.255	0.027
	Female	11.4	5.21			
Radiolunate angle (Mean, SD)	Male	0.651	8.27	-9.08	-2.24	0.001
	Female	6.31	8.94			
Capitolunate angle (Mean, SD)	Male	18.7	6.66	-1.83	3.74	0.497
	Female	17.8	7.38			
Scapholunate angle (Mean, SD)	Male	53.4	8.48	-1.62	5.47	0.284
	Female	51.5	9.39			
First metacarpal length (Mean, SD)	Male	52	3.27	3.76	6.21	<i>P</i> <0.001
	Female	47.1	2.84			
Scaphoid length (Mean, SD)	Male	25.5	2.88	4	5.99	<i>P</i> <0.001
	Female	20.5	2.12			
Capitate length (Mean, SD)	Male	25.5	1.61	3.01	4.25	<i>P</i> <0.001
	Female	21.9	1.48			
Lunate width (Mean, SD)	Male	11.6	1.42	0.9	1.96	<i>P</i> <0.001
	Female	10.2	1.22			
Wrist width (Mean, SD)	Male	50.3	3.03	6.43	8.73	<i>P</i> <0.001
	Female	42.7	2.72			
Lunate diameter (Mean, SD)	Male	10.3	1.08	1.04	1.85	<i>P</i> <0.001
	Female	8.86	0.595			

wrist radiographic indexes in Foteva et al study (13).

One important distinction between Jafari et al. and our study is that no significant differences were found in wrist height, 3<sup>rd</sup> metacarpal length, lunate width and capitate length considering age. Also, carpal height ratio was not statically significant due to age and gender in Jafari et al. study; however, in our study wrist height was significantly higher in females and found to decrease by aging (2).

Finally, it is a common knowledge that radiographic instruments can be used to perform new orthopedic studies, make orthopedic implants and diagnose

pathologic disorders such as carpal collapse caused by osteonecrosis or osteoarthritis, radius fracture and its prognosis, ligament injuries, and make the most effective decisions to perform surgical procedures (2, 3, 8, 14).

Our study evaluates the relationship between age and sex with normal radiographic indexes of wrist among the Iranian population. Different types of studies like ours are useful to obtain normal radiographic values of hand and wrist regarding morphological differences among various races. We recommend that every population should use its database as a normal reference, owing to differences have been found in our

Table 4. The correlation between wrist normal indexes and age		
Variable	Pearson correlation	P value
Third metacarpal length	- 0.030	0.770
Wrist height	0.168	0.094
Ulnar variance	0.300	0.003
Radial inclination	- 0.005	0.623
Radial tilt	- 0.400	0.970
Radiolunate angle	- 0.790	0.433
Capitolunate angle	- 0.350	0.732
Scapholunate angle	0.239	0.016
First metacarpal length	- 0.630	0.533
Scaphoid length	0.108	0.287
Capitate length	0.137	0.175
Lunate width	0.059	0.561
Wrist width	0.193	0.054
Lunate diameter	0.030	0.767
Wrist ratio	- 0.253	0.011

Table 5. Comparison between our study and Jafari study

Variables	Differences in the wrist Radiographic measurements between ages in Jafari study	Differences in the wrist Radiographic measurements between ages in Our study	Differences in wrist Radiographic measurements between men and women in Jafari study	Differences in wrist Radiographic measurements between men and women in our study
Ulnar variance	$P>0.05$	0.003	$P>0.05$	$P>0.05$
Radial inclination	$P>0.05$	$P>0.05$	$P>0.05$	$P>0.05$
Wrist height	0.0001	$P>0.05$	0.0001	$P<0.001$
Third metacarpal length	0.0001	$P>0.05$	0.0001	$P<0.001$
Lunate width	0.0001	$P>0.05$	0.0001	$P<0.001$
Capitate length	0.0001	$P>0.05$	0.0001	$P<0.001$
Radial tilt	$P>0.05$	$P>0.05$	$P>0.05$	0.027
Scapholunate angle	$P>0.05$	$P>0.05$	$P>0.05$	$P>0.05$
Carpal height ratio	$P>0.05$	0.011	$P>0.05$	0.002

study.

An informed consent was obtained from the study participants.

The authors declare no conflicts of interest concerning the materials or methods used in this study or the findings specified in this paper.

Tohid Vaezi MD

Golnaz Ghayyem Hassankhani MD

Mohammad H. Ebrahimzadeh MD

Ali Moradi MD

Orthopedic Research Center, Ghaem Hospital, Mashhad University of Medical Sciences, Mashhad, Iran

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