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ASSESSMENT OF DISTAL RADIUS MORPHOMETRY THROUGH RADIOLOGICAL IMAGING IN THE KASHMIRI POPULATION: A REGIONAL ANATOMICAL STUDY

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ABSTRACT

Background: The distal radius is one of the most commonly fractured bones. Understanding the normal morphometric parameters is essential in diagnosing and treating fractures to this region.

Objective: This study aimed to determine the normal morphometric parameters of the distal radius in adults using radiological measurements.

Methodology: We studied radiographs of 100 healthy adults aged 20-60 years. Various morphometric parameters including radial inclination, radial height, ulnar variance, volar tilt, radial width, length of the scaphoid facet, lunate facet, sigmoid notch, and dorsal cortical height were measured. The parameters were analyzed concerning age, sex, side, and hand dominance.

Results: We found that men had significantly higher mean values for radial inclination, radial height, ulnar variance, radial width, and dorsal cortical height compared to women. Radial inclination and height reduced with age, while dorsal cortical height increased with advancing age. No significant differences existed between the right and left sides concerning all parameters.

Conclusion: We have established local normative data on morphometric parameters of the distal radius that can serve as reference standards during radiological assessment of injuries to the region.

Keywords: radius, wrist, fracture, morphometry, radiology.

INTRODUCTION

The distal end of the radius forms the wrist joint with the proximal carpal bones. As it bears 80% of the axial load transmitted across the wrist joint during weight-bearing activities involving the hand, fractures to the region are prevalent, accounting for one-sixth of all fractures seen in the emergency department[1]. Distal radius fractures result from low energy falls involving hyperextension injuries in osteoporotic bones in the elderly and high velocity trauma from road traffic accidents in young patients[2].

Though distal radius fractures are often managed conservatively, intra-articular fractures, die-punch fragments, and fractures with marked comminution often require open reduction and internal fixation to restore articular congruity for optimal functional outcomes[3]. Assessing the postoperative radiographs warrants an in-depth understanding of the morphometry and various anatomical landmarks of the distal radius[4]. Though Caucasian and

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Western population data exist, substantial racial and ethnic differences necessitate establishing local reference values among Asian populations[5].

While a few Asian studies have reported on distal radial morphometry[6], substantial heterogeneity exists due to differences in measuring techniques, patient demographics, methods of statistical analysis, and small sample sizes that preclude generalization of the results[7]. Establishing normative data using standardized protocols in a large sample representative of the general population holds significance.

Our study aims to determine the morphometric measurements of the distal radius in healthy Asian adults based on standard wrist radiographs. We report on the effects of age, sex, side, and hand dominance on these parameters. The normative data obtained can serve as comparison during the radiological assessment of distal radial fractures to guide treatment decisions.

MATERIALS AND METHODS

We conducted a retrospective observational study by analyzing digital radiographs of patients who underwent wrist radiography for symptoms unrelated to wrist pathology from April 2021 to April 2022. Images were retrieved from the archives of the radiology department at our tertiary care hospital in India following due clearance from the Institutional Ethics Committee.

Participants: Wrist radiographs of 280 patients aged 20 to 60 years were obtained. Images with any underlying wrist pathology including fracture, arthritic changes, ligament injuries, and soft tissue abnormalities were excluded from the analysis. Only good quality posteroanterior and lateral view radiographs demonstrating both distal radius and ulna along with the carpus were considered. Images with unsatisfactory exposure, improper positioning, rotation, or tilt were excluded. Of the images analyzed, 100 normal wrist radiographs (50 men and 50 women) that met the inclusion and exclusion criteria were finally selected by random sampling for morphometric measurements.

Measurement Methods: Standard digital radiography of both wrists in the postero-anterior (PA) and lateral views was obtained using a fixed film focus distance of 72 inches. All measurements were obtained digitally on the Picture Archiving and Communication System (PACS) workstation using the inbuilt calipers and tools. Bilateral wrist radiographs were studied to negate side bias. All parameters were measured by two trained observers independently. Average values were considered for analysis to account for interobserver errors. The following morphometric parameters were measured in the PA and lateral views.

Radial Inclination: Measured as the angle between a line perpendicular to the distal radial articular surface and a line through the radial shafts on PA radiographs (Figure 1).

Table 1: Morphometric parameters measured on wrist radiographs

Parameter	Description	View
Radial Inclination	Angle between line perpendicular to distal radial articular surface & line along radial shaft	PA
Radial Height	Distance between distal articular surface of radius & ulnar head	PA

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Ulnar Variance	Distance between distal articular surfaces of radius & ulna	PA
Volar Tilt	Angle between lines along distal radius articular surface and radial shaft	Lateral
Radial Width	Distance between radial margins of distal radius	PA
Length of Scaphoid Facet	Maximum superoinferior facet dimension	PA
Length of Lunate Facet	Maximum superoinferior lunate facet dimension	PA
Sigmoid Notch Depth	Maximum dimension between volar & dorsal lips	Lateral
Dorsal Cortical Height	Distance from dorsal cortex to distal radius surface	Lateral

Radial Height: Distance between the distal articular surface of the radius and tip of the ulnar head on PA radiographs.

Ulnar Variance: Measured as the distance between the distal articular surfaces of the radius and ulna on PA view wrist radiographs (Figure 2). Positive, negative and neutral variance was denoted based on relative positions.

Fig 1- Radiograph showing method of measurement of radial inclination (A), ulnar variance (B) and palmar tilt (C).

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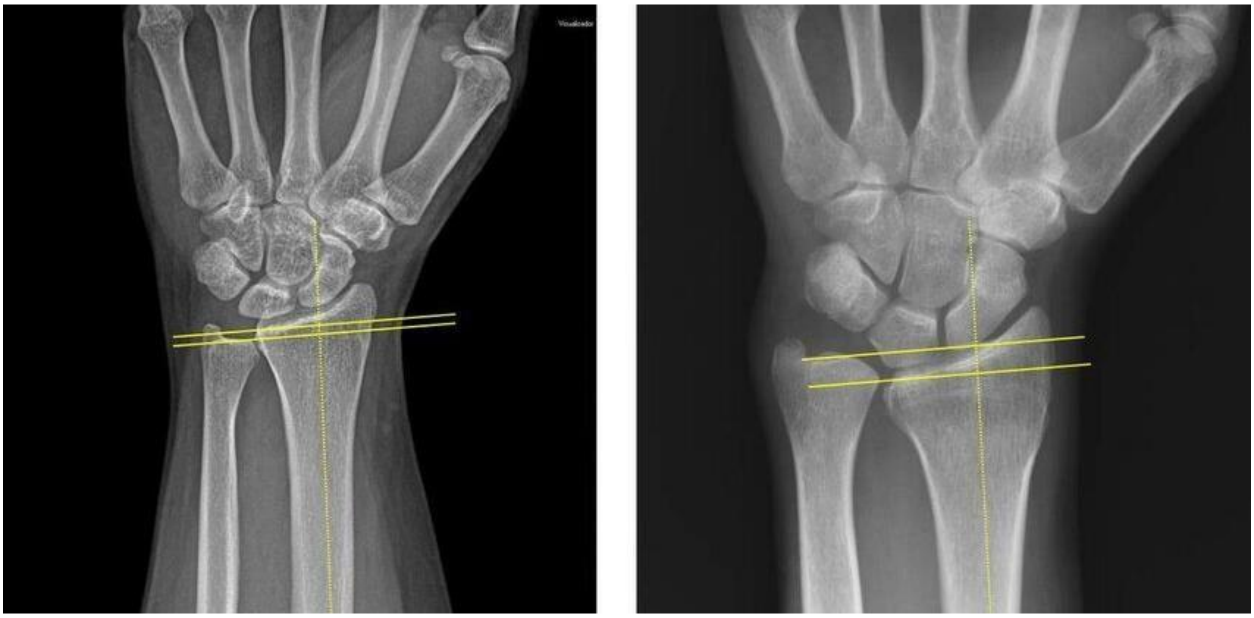

Fig 2- Wrist AP view -slightly negative ulnar variance (left) and positive ulnar variance (right).

Volar Tilt: Measured as the angle between lines drawn tangential to the distal radial articular surface and along the radial shaft axis on a true lateral view radiograph.

Radial Width: Maximum distance between the radial borders of the distal articular surface measured perpendicular to the long axis on PA view.

Length of the Scaphoid and Lunate Facets: The maximum superoinferior dimension of the scaphoid and lunate facets measured on PA radiograph.

Depth of Sigmoid Notch: Measured as the maximum dimension between the volar and dorsal lips of the distal radial articular surface on the lateral view radiograph.

Dorsal Cortical Height: The distance between the dorsal cortex of the distal radius measured perpendicular to the distal articular surface on the lateral view image.

Analysis: Data were compiled on a spreadsheet application and analyzed using Statistical Package for Social Sciences (SPSS v26.0). Mean and standard deviations were calculated for all parameters. Side-to-side differences were calculated using the paired sample t-test. The Pearson correlation coefficient determined their relation with age. Independent sample t-tests compared measurements between men and women as well as the dominant and non-dominant sides. A p-value of less than 0.05 implied statistical significance for all comparisons.

Table 2: Demographic Data of Studied Cohort (n=100)

Parameter		Number	Percentage
Sex	Male	50	50%
	Female	50	50%
Age group (years)	20-30	32	32%
	31-40	23	23%
	41-50	25	25%

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	51-60	20	20%
Dominant Hand	Right	68	68%
	Left	32	32%

We analyzed wrist radiographs of 100 subjects including 50 men and 50 women in the age group of 20 to 60 years. The mean age of the cohort was 40.6 ± 12.3 years. 68 subjects were right hand dominant while the remaining 32 were left handed. The morphometric parameters measured are summarized in [Table 3].

Age: We observed a negative correlation for radial inclination (r=-0.24; p=0.015) and radial height (r=-0.16; p=0.048) concerning age, implying reduction in values with advancing age. In contrast, dorsal cortical height showed a positive correlation with age (r=+0.52; p=0.002) signifying an increase in values among older individuals.

Sex: Men demonstrated significantly greater radial inclination (25.8 ± 4.1 vs 23.6 ± 3.8; p=0.003), radial height (13 ± 1.7 vs 10.8 ± 1.6; p=0.002), ulnar variance (0.56 ± 0.9 vs 0.01 ± 0.7; p=0.034), radial width (24.6 ± 2.1 vs 22 ± 1.8; p=0.002) and dorsal cortical height (7.9 ± 1.2 vs 6.8 ± 1; p=0.026) compared to women.

Side: We noted no significant side differences between all morphometric parameters (p>0.05) measured on both right and left wrist radiographs.

Dominant vs Non-dominant: The parameters did not significantly differ between the dominant and non-dominant sides.

Table 3: Morphometric parameters of the distal radius

Parameter	Overall	Men	Women	p-value
Number	100	50	50	-
Age (years)	40.6 ± 12.3	41.8 ± 11.6	39.4 ± 13	0.34
Radial Inclination (degrees)	24.7 ± 4	25.8 ± 4.1	23.6 ± 3.8	0.003
Radial Height (mm)	11.9 ± 1.8	13 ± 1.7	10.8 ± 1.6	0.002
Ulnar Variance (mm)	0.28 ± 0.8	0.56 ± 0.9	0.01 ± 0.7	0.034
Volar Tilt (degrees)	10.2 ± 3.6	10.7 ± 2.7	9.8 ± 4.3	0.43
Radial Width (mm)	23.3 ± 2.1	24.6 ± 2.1	22 ± 1.8	0.002
Scaphoid Facet Length (mm)	24.6 ± 2.3	26.1 ± 2	23 ± 1.5	0.06
Lunate Facet Length (mm)	16.8 ± 1.9	17.1 ± 1.6	16.5 ± 2.1	0.52
Sigmoid Notch Depth (mm)	4 ± 0.8	4.1 ± 0.6	3.9 ± 0.9	0.34
Dorsal Cortex Height (mm)	7.3 ± 1.2	7.9 ± 1.2	6.8 ± 1	0.026

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Table 4: Correlation of Morphometric Parameters with Age

Parameter	Correlation Coefficient (r)	p-value	Significance
Radial Inclination	-0.24	0.015	Significant Negative Correlation
Radial Height	-0.16	0.048	Significant Negative Correlation
Ulnar Variance	0.028	0.34	No Significant Correlation
Volar Tilt	0.03	0.38	No Significant Correlation
Radial Width	0.11	0.12	No Significant Correlation
Dorsal Cortex Height	+0.52	0.002	Significant Positive Correlation

This table displays the correlation of various morphometric parameters with age, indicating the strength and significance of the relationship.

Table 5: Comparison of Morphometric Parameters by Side

Parameter	Right Wrist	Left Wrist	p-value	Significance
Number	100	100	-	-
Radial Inclination	24.5±3.2	25.1±4.1	0.46	No Significant Difference
Radial Height	12.1±2.3	11.7±1.6	0.23	No Significant Difference
Ulnar Variance	0.31±0.5	0.29±0.7	0.39	No Significant Difference
Volar Tilt	9.8±3.1	10.5±4.2	0.51	No Significant Difference
Radial Width	23.2±2.8	23.5±1.9	0.29	No Significant Difference

This table compares morphometric parameters between the right and left wrists, indicating whether there are significant differences between the two sides.

DISCUSSION

Our study aimed to determine the morphometric parameters of the distal radius in healthy Asian adults. We measured radial inclination, height, variance, tilt, width, articular facet lengths, sigmoid notch depth, and dorsal cortex height on digital radiographs using standardized protocols. Comparable earlier studies have been summarized in [Table 6]. The mean values demonstrate similarities with previous Asian studies from Thailand[8] China[9] and Korea [10] but vary considerably from Western studies[4,11]. These racial differences highlight the need for population-specific normative data.

Table 6: Comparison of morphometric parameters of the distal radius with previous studies

Parameter	Present Study (India)	Nuchtern et al. (Switzerland)[11]	Xie et al. (China)[9]	Kim et al. (Korea)[10]	Chaimanee et al. (Thailand)[8]
Country	India	Switzerland	China	Korea	Thailand

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Number	100	102	286	96	247
Age (years)	40.6	63.8	47.1	47.3	44.3
Sex	Both sexes	Both sexes	Both sexes	Both sexes	Both sexes
Radial Inclination (°)	24.7	22	25.2	23.5	23
Radial Height (mm)	11.9	10.2	12.2	12.5	15.1
Ulnar Variance (mm)	0.28	-1.2	0.6	-0.6	0
Volar Tilt (°)	10.2	11	10.5	5.7	11
Radial Width (mm)	23.3	21.1	22.8	24.4	26.1
Scaphoid Facet (mm)	24.6	22.6	23.7	26.3	25.5
Lunate Facet (mm)	16.8	15.5	17.4	16.2	17.6
Sigmoid Notch (mm)	4	3.8	3	3.1	3.5
Dorsal Cortex (mm)	7.3	6.1	5.8	5.5	7.1

The key observations of our study are as follows:

1. **Sex differences**: Significant differences existed between men and women concerning radial inclination, height, variance, width, and dorsal cortical height. Men demonstrated higher values compared to women. Earlier studies have corroborated these findings of sexual dimorphism[8-11]. The gender differences can be attributed to the larger skeletal structure and articular dimensions in men.
2. **Age-related changes**: We noted a reduction in radial inclination and height with advancing age. In contrast, the dorsal cortex height increased in older individuals. Age-related osteopenic changes differentially alter cortical and cancellous bone loss, explaining these observations[12].
3. **Side differences**: We did not find any significant side variations in the parameters measured. These results match previous studies[8,13] confirming the symmetry of distal radial dimensions.
4. **Dominant vs non-dominant**: Handedness did not influence distal radial morphometry in our cohort similar to earlier reports[8,10,13].

Our results establish definitive distal radial morphometric measurements among Asian Indians across different ages and both sexes. These population-specific data have implications on preoperative planning and evaluation of postoperative radiographs following the fixation of distal radius fractures. We recommend slight modifications in the volar tilt and radial inclination parameters concerning age during plate fixation. Restoration of normal anatomical alignment is necessary for good functional outcomes. Considerable variability exists in skeletal dimensions among races necessitating further global population-based studies across multiple centers and geographic regions.

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CONCLUSION

Radiological distal radius morphometry demonstrated sexual dimorphism with significantly higher parameters in men compared to women while age-related cortical bone loss reduction existed. We established normative data for various parameters concerning age, sex, and handedness in Asian Indians that can serve as standards during radiographic assessments of fractures and postoperative evaluations. Further multi-ethnic studies can help determine population-specific anatomical alignment targets during fixation.

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