

ORIGINAL RESEARCH ARTICLE

MORPHOMETRY OF DISTAL RADIUS – A RADIOGRAPHIC STUDY IN NEPALESE POPULATION

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**ABSTRACT**

**Background:** Distal radius fractures are common injuries. The outcome of the fractures depends upon the post reduction morphometric parameters. This study was aimed to assess the normal morphometric parameters of distal radius in Nepalese population.

**Methods:** This was a prospective cross-sectional study of morphometric measurements of 150 distal radius on x rays of wrist joints of patients presenting to department of orthopedics at CMCTH from October 2020 to September 2021. Radial height, Radial inclination, Palmer tilt, Ulnar variance and Radial width in posteroanterior (PA) and lateral views were measured. The data obtained was analyzed to see the difference according to age, sex, side, dominance and ethnicity.

**Results:** The mean values of Radial height, Radial inclination, Palmer tilt, Ulnar variance and Radial width posteroanterior and lateral were 11.75±0.94mm, 22.75±1.50 degrees, 10.51±1.04 degrees, -0.51 to +1.15 mm, 27.05±1.16 mm and 18.7±1.12 mm respectively.

**Conclusions:** The distal radius morphometry of Nepalese population is comparable to other national, regional and western similar studies. There were no any statistically significant differences of all the morphometric parameters of distal radius according to age, sex, side, dominance and ethnicity except Radial inclination, according to ethnicity; and Radial width, according to ethnicity and dominance.

**INTRODUCTION**

The morphometric measurements of the distal radius are important for reduction of the displaced distal radius fracture, prosthesis design and wrist biomechanics.<sup>1</sup> The parameters are Radial height (RH), Radial inclination (RI), Palmer tilt (PT), Ulnar variance (UV) and maximum Radial width in posteroanterior (RWPA) and lateral (RWL) views. Various studies have established the relation between these parameters and functional outcome following fracture reduction.<sup>2,3</sup> Reduction in Palmer tilt resulted in increased stress on ulna.<sup>4</sup> Radial shortening and altered Radial inclination also have been found to cause significant alteration in the kinematics of wrist joint, and grip strength. Dorsal angulation, initial length of radius and other measurements affects the pronation and supination.<sup>5</sup> Further, negative Ulnar variance has been found to be associated with Kienbock's disease as this increases the loading along the capitate-lunate-radius axis; though the causal relationship hasn't been established as the disease is also commonly seen among neutral and positive Ulnar variance.<sup>6</sup>

Distal radius fracture are common, comprising 25% of pediatric

fractures and 18% of elderly fractures.<sup>7</sup> Different modalities of treatment have been established for distal radius fractures like closed reduction and cast, K wire fixation, plating, External fixation. Their classification, treatment modalities and acceptability of post reduction status are based on parameters measured on x rays.<sup>8</sup> The aim of the fracture reduction being anatomical alignment with restoration of full painless motion; the knowledge of the normal morphological values of the distal radius is critical. We don't have adequate similar studies done in our population to guide treatment for our patients. Moreover, studies have established that, the morphometry of the distal radius varies with ethnicity as well.<sup>9</sup> There are very limited studies that have discussed about the distal radial width.

The aim of this study was to evaluate the different morphological parameters of the distal radius in our population and find out their association with age, sex, side, dominance and ethnicity.

**METHODS**

This was a prospective cross-sectional study done at

Department of Orthopedics of Chitwan Medical College and teaching Hospital from October 2020 to September 2021.

A total of 155 patients were included according to convenient quota sampling. Patients giving informed consent, with x-rays of wrists, true views posteroanterior and lateral were included in the study. Five patients were excluded due to rotation of the views. Magnification correction was done for all the radiographs and reviewed by two authors and mean value was obtained. Skeletally immature, history of previous fracture in the same wrist, presence of fracture and those not giving informed consent were excluded from the study. The parameters studied were Radial Inclination, Radial Height, Palmer Tilt, Ulnar variance and Radial Width in posteroanterior and lateral view.

Radial inclination (RI) is measured in PA view and is the angle between a line joining the tip of the radial styloid process to the distal most part of the DRUJ and a line perpendicular to the radial shaft. Radial height (RH) is the vertical distance in millimeters in PA view, between parallel lines perpendicular to the radial axis, one at the distal most part of head of ulna and another at the radial styloid. Palmer tilt (PT) is the angle in lateral view between a line perpendicular to the long axis of radius and the line joining the volar and dorsal rims of the distal radius.<sup>10</sup> Statistical analysis was done using SPSS version 20 comparing the means with significance set at  $p < 0.005$ .



Figure 1: Radial Height (RH), Radial Inclination (RI) and Palmer Tilt (PT)<sup>(10)</sup>

## RESULTS

The mean age of the sample (n=150) was 37.57±13.79 years. Among those, 36% (54) were less than 30 years, 57.33% (86) were 31-60 years and only 6.66% (10) were above 61 years.

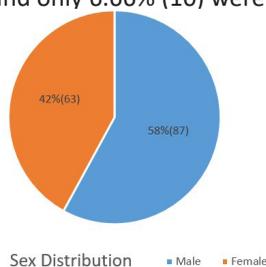


Figure 2: Sex distributions of our patients

Males were 58% (87) and females were 42% (63) (Figure 2). Left side involvement was 50.7% (76) almost equal with right

side 49.3% (74). Of all the samples, 86% (129) were right hand dominant while rest 14% (21) were left hand dominant. As per the broad ethnicity of Nepal,<sup>11</sup> most of our patients belonged to Khas ethnicity 35.3% (53), while Madhesi were 24% (36), Newar were 21.3% (32) and Hill (Adibasi/Janajati) were 19.3% (29) (Table 1).

Table 1: Frequency distribution of our sample population according to ethnicity

Ethnicity	Frequency (%)
Khas	35.3% (53)
Madhesi	24% (36)
Newar	21.3% (32)
Hill (Adibasi/Janajati)	19.3% (29)

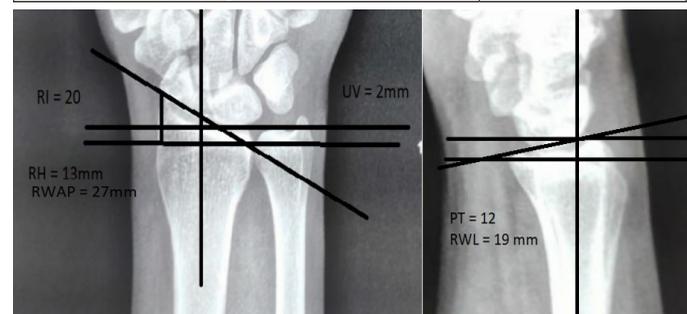


Figure 3: Measurements of our sample case

The overall population mean values are shown in the table 2.

Table 2: Overall mean values of the dependent variables

Variables	Mean values	95% CI
Radial Height (mm)	11.75±0.94	11.60 – 11.90
Radial Inclination(degrees)	22.75±1.50	22.5 – 23.00
Palmer Tilt (degrees)	10.51±1.04	10.35 – 10.68
Ulnar Variance (mm)	-0.51±1.15	-0.69 – -0.32
Radial Width PA (mm)	27.05±1.16	26.86 – 27.24
Radial Width Lateral (mm)	18.7±1.12	18.52 – 18.88

The mean values of all the variables as per age group, sex, side, dominance and ethnicity are tabulated as below (Table 3).

There was statistically significant difference in the Radial width diameter in lateral (RWL) view when adjusted to same dominant side and injured side ( $p=0.04$ ). Otherwise, there was no any statistical significant difference in mean.

More than half of our patients 56.7% (85) had negative Ulnar variances, 24.7% (37) had neutral variance and 18.7% (28) had positive Ulnar variance (Figure 4).

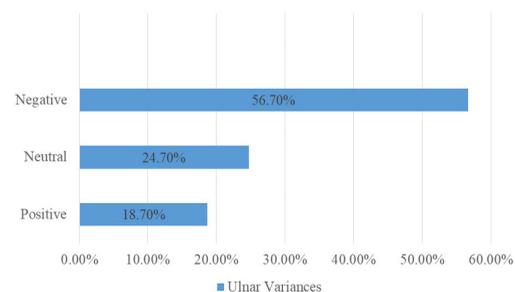


Figure 4: Ulnar variance patterns of our population

**Table 3: Independent and dependent variables mean values**

Variables		RI (degree)	RH (mm)	PT (degree)	UV (mm)	RW PA (mm)	RW L (mm)
Age(years)	<30	22.72±1.63	11.61±0.99	10.54±1.17	-0.65±1.15	27.02±1.18	18.81±0.97
	31-60	22.74±1.44	11.81±0.92	10.51±0.99	-0.40±1.16	27.10±1.17	18.64±1.20
	>61	22.90±1.37	12.00±0.81	10.40±0.69	-0.7±1.05	27.05±1.16	18.60±0.96
	P value	0.95	0.32	0.93	0.38	0.71	0.64
Sex	Male	22.76±1.5	11.70±0.85	10.43±0.92	-0.45±1.14	27.03±1.09	18.67±1.00
	Female	22.75±1.5	11.83±1.07	10.63±1.18	-0.59±1.15	27.08±1.27	18.75±1.28
	P value	0.96	0.43	0.22	0.46	0.81	0.67
Side	Left	22.63±1.60	11.75±1.04	10.51±1.18	-0.54±1.10	26.96±1.19	18.70±1.22
	Right	22.88±1.39	11.76±0.84	10.51±0.88	-0.47±1.20	27.15±1.14	18.70±1.03
	P value	0.31	0.96	0.99	0.72	0.32	0.97
Dominance (same) (n=87)	Left	22.56±1.45	11.75±1.06	10.38±1.14	-0.50±1.41	27.44±1.26	18.79±1.02
	Right	22.85±1.38	11.75±0.84	10.52±0.90	-0.55±1.16	27.08±1.14	18.69±1.05
	P value	0.48	0.98	0.58	0.88	0.27	0.04
Ethnicity	Khas	22.66±1.68	11.77±0.91	10.72±1.26	-0.32±1.22	26.72±1.11	18.49±1.23
	Hill (A/J)	22.14±1.66	11.41±0.94	10.14±0.98	0.83±0.92	26.69±0.96	18.66±1.07
	Madhesi	23.03±1.13	11.78±1.07	10.44±0.87	0.75±0.87	27.42±1.13	18.92±1.10
	Newar	23.16±1.24	12.00±0.8	10.59±0.79	0.25±1.39	27.53±1.21	18.84±0.98
	P value	0.31	0.11	0.10	0.07	0.001	0.29

**DISCUSSION**

The biomechanics of wrist joint is invariably affected by the morphometry of the distal radius. In the cadaveric study done by Short et al,<sup>4</sup> increase in dorsal angulation increased the loading on Ulna. Pogue et al<sup>12</sup> showed that radial shortening of 2 mm significantly increased contact area in lunate fossa. Similarly, decrease in RI shifted load distribution from Scaphoid fossa to more on Lunate fossa. Werner et al<sup>13</sup> found weak correlation between increase in load transmission through the Ulna and positive ulnar variance. Also, distortion of the

Triangular Fibrocartilage Complex (TFCC) was more associated with radial shortening as shown by Adams et al.<sup>14</sup> Significantly higher unsatisfactory results were seen with conservative treatment of distal radius fractures when radial deviation was <5 degree, volar tilt >15 degree and radioulnar index was higher than 5mm compared to normal side.<sup>3</sup> Increase in dorsal tilt was found to be associated with mid carpal instability.<sup>15</sup> Articular reconstruction should be within 2 mm of gap or step off, within 2 mm of normal length and normal carpal alignment for optimal outcome of distal radius fractures.<sup>16</sup>

**Table 4: Comparison of our findings with other studies**

Studies	RI (Degree)	RH (mm)	PT Degrees)	UV (mm)	RWAP (mm)	RWLAT (mm)
Ours	22.75±1.50	11.75±0.94	10.51±1.04	-0.51±1.15	27.05±1.16	18.7±1.12
Kandel et al <sup>21</sup>	23.62	10.9	9.72		28.5	18.8
Chan et al <sup>9</sup>	25.1±3.42		12.6±3.55	-0.1±1.31		
Nekanti et al <sup>18</sup>	21.58±3.35	8.8±2.6	11.36±3.16			
Hadi et al <sup>17</sup>	23.99±3.75	11.31±1.66	13.76±4.36	-0.45±2.03		
Bhat et al	21-33	9.1-16.7	4-17	-2.1 to +4.9		
Palmer et al <sup>13</sup>	30		6	0.1±1.4		
Altissimi et al <sup>3</sup>	16-28		0-18	-2.5 to +3.1		
AO/OTA	13-30	11-13	1-21			

In our study, the mean RI was 22.75±1.50 degrees. There was no statistical difference in mean RI when compared with age groups (<30, 31-60, >61), sex (male/female), side and dominance (left/right). However, variations of RI among different ethnicity is statistically different (P=0.03). Newar ethnicity had the greatest RI (23.16±1.24) while Hill (Adibasi/janajati) had 22.14±1.66. RI slightly increased with age. Compared to other studies, we had slightly small RI in our population. This could be attributed to short stature and bone of average Nepali population which needs further study.

The mean RH in our study was 11.75±0.94mm. When compared between different age groups, sex, side, dominance and ethnicity, there was no any statistically significant difference. Highest RH was observed among Newar ethnicity. Our findings are comparable to Hadi et al,<sup>17</sup> where he observed mean RH of 11.36±1.66 mm. Nekkanti et al<sup>18</sup> found small RH of 8.80±2.6mm in the south indian population. Our RH was slightly greater on both left and right side compared to Gupta et al.<sup>19</sup>

The mean PT in our study was 10.51±1.04 degrees. Though no

any statistical significance was observed in PT in different age groups, side, sex, dominance and ethnicity; this was slightly greater in young age group (<30 years) and in Khas ethnicity. Our observation is in consistence with findings of Nekkanti et al and OTA, while ours PT is slightly smaller than Chan et al (13.0±3.57)<sup>9</sup> but is greater than Werner et al ie 6mm.<sup>13</sup> The mean Ulnar variance was -ve in 56.7% (85) of our population, while 24.7% (37) had neutral variance and 18.7% (28) positive UV. There was no any statistically significant difference in UV, when compared among different age groups, sex, side, dominance and ethnicity. The mean UV was found to be positive in Newar and Madhesi ethnicity while it was negative in all others. Our observation differs with Chan et al<sup>9</sup>, where he found statistically significant difference in UV among Malays and Chinese ethnicities. Studies have shown that, negative UV is associated with Keinbock's disease while positive UV is associated with Triangular Fibrocartilage Complex (TFCC) tear.<sup>20</sup>

The Radial width (RW) parameter had been poorly studied radiologically. The mean RW in our study AP view was 27.05±1.16 mm and in Lateral view was 18.7±1.12. This finding is similar to the study done by Kandel et al.<sup>21</sup> In their cadaveric study of dry radii, the mean transverse diameter was 28.50±2.6 mm while the anteroposterior diameter was 18.8mm±1.4mm. Similarly, Prithiskumar et al<sup>1</sup> found the mean transverse diameter on left radius 26.7±2.20mm, right radius 26.30±2.40 mm and the AP diameter on left was 17.80mm and right radius was 17.5±1.70mm. We observed statistically significant difference of RW in PA view among different ethnicity (p=0.001) and also of RW in lateral view in dominance of left and right (p=0.01). Due to the small sample size, the statistical difference

observed may not have clinical significance which may need further study. In the study of morphometry and racial variance by Chan et al,<sup>9</sup> RI and PT was highest in Indian patients. Indian and Malay patients had positive UV but Chinese had negative UV; unlike in our study, where there was no any variations in ethnicity.

This study provided our own data of morphological parameters of distal radius of our population. The values of these parameters are of paramount importance in achieving optimal functional outcome as shown by various studies. Our data can be used for further larger study.

## CONCLUSION

The morphometry of the distal radius of Nepalese population are comparable with the reports of national, regional as well as western studies. No any statistically significant differences were observed in most of the morphological parameters according to age, sex, side, dominance and ethnicity. Radial inclination, which has significant difference according to ethnicity. Similarly, there is also statistically significant difference in Radial Width according to ethnicity and dominance.

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**CONFLICT OF INTEREST:** None

**FINANCIAL DISCLOSURE:** None

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