Radiographic Study of Distal Radius Parameters in Patients Visiting Tertiary Care Hospital

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Citation

Shrestha S, Mansur DI, Shrestha R, Karki S, Maskey S, Malla M, et al. Radiographic Study of Distal Radius Parameters in Patients Visiting Tertiary Care Hospital. *Kathmandu Univ Med J.* 2022;78(3):136-40.

ABSTRACT

Background

The important morphological parameters of distal radius namely palmar tilt, radial inclination, radial height and ulnar variance are consequential in the evaluation and management of the distal radius fracture, distal radius plate design and kinesiology. Correction of these parameters in anatomical alignment is important to restore the normal biomechanics of the wrist joint.

Objective

To ascertain the distal radius parameters in the patients attending tertiary care hospital with regard to gender and age.

Method

The wrist radiographs (postero-anterior and lateral views) of 125 patients, from 16 to above 60 years of age were used to determine the four parameters of distal radius. The subjects were divided into gender and three different age groups (16-36 years, 37-57 years and > 57 years). Independent t-test and ANOVA test was used for statistical analysis with level of significance set at $p \leq 0.05$.

Result

The mean palmar tilt was 15.69 ± 4.84° (p-value = 0.40). The mean radial inclination was 22.58 ± 2.82° (p-value = 0.88). The mean value of radial height was 10.31 ± 1.59 mm (p-value= 0.001). Positive ulnar variance were recorded in maximum of subjects (46.40%) and the least was neutral (16.80%).

Conclusion

The distal radius parameters of our population were similar to the Orthopedic Trauma Association standard reference value. And there was significant difference in radial height between males and females.

KEY WORDS

Distal radius, Palmar tilt, Radial height, Radial inclination, Ulnar variance

INTRODUCTION

Radius is a lateral bone of forearm which alone assisted by the articular disc of inferior radio-ulnar joint, enters in the formation of wrist joint.[1] Among the upper extremity injuries, distal radius fractures (DRF) are common injuries that are treated by a variety of methods.[2] The distal radius includes the four important morphological parameters: palmar tilt (PT), radial inclination (RI), radial height (RH), and ulnar variance (UV) which are consequential in management of DRF, distal radius plate design and kinesiology.[3,4]

The pressure distribution in the ulnar and radial articular surfaces changes in position and become more concentrated with increased PT.[4,5] Several researches recorded quite different value of it from the western literature.[6,7] Decreased RH and RI causes disturbance in kinematics and the anatomical configuration of triangular fibrocartilage complex (TFCC).[8,9] Various researcher found the RI and RH were closer to the most commonly used Orthopedic Trauma Association (OTA) reference value (23° and 12 mm respectively).[10-13] Aforesaid parameters along with altered PT has substantial influence in the kinesiology and the grip strength of wrist joint.[14,15] UV is now commonly used in treatment of Kienbock's disease and degenerative perforations of TFCC. The radioulnar joint creates 82% of the axial force to the wrist joint and 88% load to the ulnocarpal joint.[16,17] A positive and negative UV increase load of ulnocarpal joint up to 42% and decrease up to 4.3%.[4,16-19] Its neutral OTA reference value differs with the various studies.[20]

A central issue of the relationship between the anatomical and functional result among the chronicle of evaluation and treatment of injuries involving the wrist joint. Hence, an understanding of normal parameters of distal radius becomes very significant in DRF management for maintaining anatomical alignment.[2,18,19] Western findings are being used by the Nepalese clinical practitioner as reference value due to the absence of local database. This study may provide a prelude data for further analytical or experimental research and may be used as preliminary data for the evaluation and treatment of distal radius injuries.

METHODS

A single hospital-based observational cross-sectional study was carried out in the department of Anatomy. The data was collected from Department of Orthopedics and Department of Radio-diagnosis, Dhulikhel Hospital, Kathmandu University Hospital from November 2019 to April 2020. This study was approved by the Institutional Review Committee of Kathmandu University School of Medical Sciences. Wrist radiographs of 125 individuals from 16 years of age and above who presented with the wrist related complaints in the outpatient department of Orthopedics were evaluated. Only true postero-anterior and lateral views of consecutive wrist radiographs using standard protocol were used. Radiographs of individual's age below 16 years or showing any irregularities due to structural deformity, distal end radius injuries, mal-union, non-union and pathological conditions (eg. arthritis) were excluded. Palmar tilt was measured on the lateral view radiograph and remaining parameters were measured on postero-anterior view radiographs. All parameters were measured using Medsynaptic Pac software.

• Palmar tilt (Figure 1): An angle formed by horizontal line perpendicular to the axis of radius at the level of radial styloid process tangential line connecting dorsal and palmar edge of the articular surface of distal end radius.

Figure 1. Palmar tilt

Figure 2. Radial inclination

• Radial inclination (Figure 2): An angle formed by horizontal line perpendicular to the axis of radius at the level of lunate fossa with tangential line connecting the styloid process of radius and ulnar side of distal radius.

• Radial height (Figure 3): A distance from horizontal line perpendicular to the axis of radius at the level of lunate fossa or the lowest part of distal radius to the horizontal line perpendicular to the axis of radius at the level of radial styloid process.

Figure 3. Radial height

Figure 4. Ulnar variance

• Ulnar variance (Figure 4): A distance measured from horizontal line perpendicular to the axis of ulna at the level of the base of ulnar styloid process to the horizontal line perpendicular to the axis of radius at the level of lunate fossa or the most proximal part of the distal radius. The values of ulnar variance are designated as neutral or positive or negative.

- Neutral UV= if there is no distance between these 2 lines (0mm).

- Positive UV = if the ulnar tangent is distal to the radial tangent.

- Negative UV = if the ulnar tangent is proximal to the radial tangent.

• Thereafter, the data was entered in MS Excel and analyzed by using SPSS version 23.0. Descriptive analysis was done for distribution of gender and mean age. Independent t-test were used for mean and standard deviation of parameters and comparison was carried out using Chi-square test and ANOVA test with the level of significance set for the $p \leq 0.05$. Data were analyzed as a whole population and grouped between male and female gender, three different age groups(16-36 years, 37-57 years and > 57 years), and also compared to OTA reference value.[4,6]

RESULTS

A total of 125 plain radiographs of the wrist joint were analyzed in this study. There were 69 male (55.20%) and 56 female (44.80%) patients. The mean age of the study population was 35.35 ± 15.53 and the age ranged from 16 to 86 years. However, palmar tilt was observed in only 120 radiographs (lateral view) because of rotation and improper positioning of forearm.

The palmar tilt averaged 15.69 ± 4.84° and radial inclination was 22.58 ± 2.82° with insignificant difference in between genders. However, the mean radial height was 10.31 ± 1.59 mm with significant difference in between genders. Ulnar variance was positive in maximum of subjects (46.40%) and least (16.80%) were neutral with insignificant differences in between genders (Table 1). All the parameters showed insignificant difference in different age groups. Highest value of palmar tilt was recorded in age group 37 - 57 years whereas radial inclination and radial height were in > 57 years and 16 - 36 years respectively (Table 2).

Table 1. Distribution of palmar tilt, radial inclination, radial height and ulnar variance according to gender.

Parameters	n	Mean ± Standard deviation			p-value
		Total	Male	Female	
Palmar Tilt (°)	120	15.69 ± 4.84	15.34 ± 5.08	16.10 ± 4.55	0.40
Radial inclintion(°)	125	22.58 ± 2.82	22.62 ± 2.68	22.54 ± 2.99	0.88
Radial height(mm)	125	10.31 ± 1.59	10.86 ± 1.43	9.62 ± 1.51	0.000
Ulnar variance					
Positive		58 (46.40%)	29	29	
Neutral	125	21 (16.80%)	14	7	0.41
Negative		46 (36.80%)	26	20	

Table 2. Distribution of palmar tilt, radial inclination, radial height and ulnar variance according to age group.

Parameters	16-36 years	37-57 years	>57 years	p-value
Palmar Tilt (°)	15.68 ± 4.97	16.40 ± 4.31	14.07 ± 5.26	0.35
Radial inclination (°)	22.77 ± 2.59	22.66 ± 3.12	31.45 ± 3.23	0.25
Radial height (mm)	10.34 ± 1.54	10.33 ± 1.85	10.12 ± 1.28	0.89
Ulnar variance				
Positive	31	18	9	
Neutral	13	5	3	0.39
Negative	33	10	3	

DISCUSSION

Classically, in the clinical practice, orthopedic surgeons have been treating distal radius fractures with the reference values of Gartland and Werley.[20] However, the morphometry of distal radius vary from country to country, race, ethnic background and physical build of the individual. Many researchers have reported the relationship between morphometry and biomechanics of distal radius. Mishra et al. reported a statistically significant difference in the palmar tilt, radial inclination, radial height, and ulnar variance between the male and female subjects of the Indian population.[3] Ulnar variance was statistically variable in the Chinese and Malaysian population.[6] However, Gelberman et al. established that negative ulnar variance was commonly observed in Whites and was more susceptible to suffer from Kienbock's disease.[16]

Using the radiography as a tool for evaluating the morphometry measurements of the distal radius have been condemned by few researchers. Johnson and Sazbo found that the palmar tilt is affected by the rotation. On that account, the 5°of rotation produces the 1.6° of alteration in the palmer tilt in a lateral view radiograph.[21] The effect of forearm rotation over the radial inclination, radial height and palmar tilt was shown in the study of Pennock et al. which found that supination increases the apparent measurements while pronation decreases it significantly.[22] Therefore, in the course of the present study the positioning of the forearm was tried to keep in neutral rotation to neutralize the effect of supination and pronation.

In this study, the palmar tilt was 15.69 ± 4.84° which is within the western standard reference value by OTA (Table 3).[11,20] In the various studies of Indian population, the mean palmar tilt ranged from as 9.7 ± 0.14° to 11.07 ± 3.16° (Table 4).[3,4,13] However, the palmar tilt of our population was more similar to the palmar tilt in the Malaysian population (12.6 ± 3.55°) and the Indonesian population 13.76 ± 4.36°(Table 4).[6,10]

Table 3. Comparison between our study and Orthopedic Trauma Association (OTA).

Parameters	Present study	OTA References value
Palmar Tilt (°)	15.69 ± 4.84	1-21
Radial inclination (°)	22.58 ± 2.82	13-30
Radial height (mm)	10.31 ± 1.59	11-13
Ulnar variance	Positive	Neutral

Table 4. Comparison between our study and earlier reported studies.

Parameters	Palmar Tilt (°)	Radial inclination (°)	Radial height (mm)	Ulnar variance
Present study	15.69 ± 4.84	22.58 ± 2.82	10.31 ± 1.59	Positive
Mishra et al.[3]	10.07±5.28 Rt: 10.48±5.16 Lt: 9.30±5.24	23.27±7.42 Rt: 23.18±7.84 Lt: 23.42±6.72	11.31±4.9 Rt: 11.27±3.62 Lt: 11.36±6.76	0.66±2.46 Rt: 0.77±2.54 Lt: 0.47±2.34
Nekkanti et al.[4]	11.36±3.16	21.58±3.35	8.8±2.5	Neutral
Chan et al.[6]	13.0±3.57	27±3.18	Not reported	0.13±0.70
Syaiful et al.[7]	13.76±4.36 Rt: 14(2-25) Lt: 15(1-30)	23.99±3.75 Rt: 24 (12-35) Lt: 25(15-30)	11.31±1.66 Rt: 11(7-15) Lt: 11(7-15)	-0.45±2.03 Rt: -1(-5-5) Lt: 0(-5-5)
Schuind et al.[10]	Not reported	24(19-29)	Not reported	-4.2±2.3
Altissimi et al.[11]	0-18	16-28	Not reported	-2.5±3.1
Gupta et al.[12]	Not reported	Total: 25.05 Rt: 25.6, Lt: 24.0	Rt: 9.7±0.14 Lt: 10±0.13	Not reported
Prisithkumar et al.[13]	Rt: 9.7±0.14 Lt: 10±0.13	Rt: 22.1±2.9 Lt: 21.8±2.5	Rt: 10.8±1.5 Lt: 11±1.5	Not reported

The radial inclination was 22.58 ± 2.82° in the study which agrees the OTA criteria reference and also similar to various western researches (Table 3).[10,11,20] The radial inclination in our population was more alike to the Indian population but slightly variant to the Indonesian and the Malaysian (Table 4).[3,4,6,10,12,13]

OTA reference value of the radial height is 11 to 13 mm (Table 3) and this study recorded 10.31 ± 1.59 mm which was statistically significant at $p < 0.05$.[20] The radial height was close to the Indian and Indonesian population; however, a study done on dry radius bone showed a slight decrease radial height (Table 4).[3,4,10,12,13]

The above findings could presumably mean that orthopedic surgeons tend to over distract the distal radius during treatments in order to meet the required acceptable radiographic criteria, which could lead to suboptimal functional outcome of these injuries in terms of hand grip and range of movements of the distal radius.

A positive ulnar variance in 46.40% of the total subjects, a negative in 36.80% and neutral in 16.80% were observed in this study which is contrary to the neutral ulnar variance referred by the OTA (Table 1 and 3).[20] In the studies of the Indian population, Mishra et al. observed a positive ulnar variance whereas a neutral ulnar variance was reported by Nekkanti et al.[3,4] A negative ulnar variance was observed in the Malaysian and Indonesian population.[6,7] However, in the present study higher tendency was positive ulnar variance (Table 4).

Most researches did not report any significant statistical difference in the parameters of distal radius between right and left of the same patient and very few discussed according to the gender and age distribution. In this study, only the radial height showed a statistical difference between genders whereas remained constant with the different age group. The palmar tilt decreased and radial inclination increased with growing age. Negative ulnar variance was highly encountered in 16-36 years age group. The parameters in the study were not compared between the right and left side because the few authors never agree to use the present population as a reference parameter. In the study of Hollevoet et al., variability of the left-right differences was compared with the variability of the whole group and was significantly less for radial inclination, ulnar variance, and palmar tilt; hence, suggested that contra-lateral wrist is the best parameter as a reference value for an individual for distal radius management, rather than population data.[23]

About 8-15% among all the fractures of the upper limb prevails with distal radius fracture.[24,25] In 1951, Gartland and Werley described the earliest effect on the malunited distal radius fractures, which is used widely to assess the functional outcome of distal radius fracture treatment.[20] Their study revealed that 31.7% of cases had unsatisfactory results because the palmar tilt was not corrected and published that loss of the radial inclination had no appreciable effect on the final functional outcome.[20] In 1984, Altissimi et al. observed unsatisfactory results after conservatively treated distal radius fractures were associated with a radial deviation of < 5° and palmar tilt >12°.[11] Moreover, mid carpal instability could result from increased palmar tilt.[26] A non anatomical reduction of the fracture could lead to a poor grip strength.[27,28] Werner et al. investigated the effects of varying degrees of ulnar variance on the load transmission through the ulnarhead and found only a weak correlation between positive ulnar variance and increased load transmission through theulna.[8]

From the above attestation, it is obvious that it is important to restore the anatomical alignment of distal radius for normal functional movement in event of a fracture. Some factors cannot be controlled in the comparison such as position of forearm rotation to significantly alter ulnar variance as showed by Jung et al. study.[29] Moreover, age and gender alter the ulnar variance.[30]

Limitations of the study are that it was a single center study (single observer) with the smaller population with unequal distribution of gender, side, and ethnic as well as race that may affect the comparison of values. The study fails to include large sample size of different geographical regions of Nepal. Therefore, the further observational studies involving the multiple examiners are needed for the homogeneity.

CONCLUSION

The distal radius parameters of our population were comparable to OTA reference value. Radial height was significantly different between male and female population. There was no significant difference between genders in regard to radial inclination, radial height and ulnar variance. Moreover, there holds insignificant difference in all the parameters of distal parameters between different age groups of the population. This data may provide a perception of the parameters of distal radius in the Nepalese population. Knowledge of normal values and variations of morphometry is important for any racial or local population group and this may accommodate the orthopedic surgeons to be more efficient and meticulous in the treatment of common fractures.

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