

Radiographic measurements of the distal radius in Pakistani population

Shams ur Rehman, Waqar Alam, Muhammad Siraj, Malik Javed Iqbal, Saeed Ahmed

Received:

13th January 2015

Accepted:

6th October 2015

Abstract

Background: Distal radius radiographic anatomy (radial inclination, palmar tilt, radial height, and ulnar variance) is an important parameter in the evaluation and treatment of distal radius fractures in which anatomical alignment must be corrected. If distal radial anatomy is not properly restored in patients with wrist trauma, function of the hand may remain poor even after healing. Currently, treatment of distal radius fractures in Pakistan is still based on radiographic parameters of western population or from the contralateral side. The aim of this study is to determine distal radius radiographic measurements of Pakistani population and to compare between male and female gender.

Methods: Distal radius radiographic parameters were measured from 400 plain X-ray of wrist in AP and lateral projection. Samples were taken consecutively from patients with distal radius fracture of unilateral wrist, presenting to the Department of Orthopedics Khalifa Gul Nawaz Teaching Hospital, Bannu from 1st January 2013 to 1st October 2013. Radial inclination, palmar tilt, radial height, and ulnar variance was measured. Data were recorded using tables and grouped between male and female, statistical analysis was performed using Mann-Whitney test.

Results: From 400 plain X-ray evaluated, there were 300 males and 100 females with the mean age of 25.5 years old (20-50). The mean of radial inclination was $23.99 \pm 3.75^\circ$, palmar tilt $13.76 \pm 4.36^\circ$, radial height 11.31 ± 1.66 mm, and ulnar variance -0.45 ± 2.03 mm. There was statistically significant difference between male and female.

Conclusion: Distal radius radiographic anatomy of Pakistani population may provide valuable data for the treatment of distal radius fractures. The use of contralateral side as reference should be reconsidered.

Keywords: radiographic anatomy, palmar tilt, radial height, radial inclination, ulnar variance

Khalifa Gul Nawaz
Teaching Hospital,
Bannu Medical College
Bannu.

SUr Rehman
W Alam
M Siraj
MJ Iqbal
S Ahmed

Correspondence:

Dr Shams ur Rehman
Assistant professor
Orthopaedic
Khalifa Gul Nawaz
Teaching Hospital Bannu,
Bannu Medical College
Bannu.
Cell no: 0333-9242276
email: drshamswazir_80@
yahoo.com

Introduction:

The relationship of radiographic morphology of distal radius with wrist biomechanics has been studied in various literatures. Four important parameters of the distal radius are radial inclination, palmar tilt, radial height, and ulnar variance. If distal radial anatomy is not properly restored in patients with wrist trauma, function of the hand may remain poor even after healing. In 1987, Short, et al conducted experiments on cadavers and expressed the importance of anatomic correction of palmar tilt¹. Laboratory studies by Short et al. and Pogue et al. showed

that 20 to 30 degrees of dorsal tilt altered the force distribution across the radiocarpal joint². Decrease in palmar tilt resulted in an increased burden of ulna. Load pressure distribution on the joint surface of distal radius and ulna will also be more concentrated with increasing dorsal angulation. Changes due to the reduced value of radial inclination and radial height have also been reported by several studies. Stockley and Porter noted that dorsal angulation of more than 20 degrees and radial inclination of less than 10 degrees caused a loss of grip strength^{2,3}. Zemel found that more than 10 degrees of

dorsal tilt led to decreased wrist flexion, and 6 mm of radial shortening caused dysfunction of the distal radioulnar joint^{2,4}.

Negative ulnar variance is one of the predisposing factors of Kienbock's disease. In 1984, in a biomechanical study on cadavers, Palmer and Werner concluded that axial force through the wrist was borne by radiocarpal joint 82% and ulnocarpal joint 18%. Positive ulnar variance of 2.5 mm resulted in increased loading on ulnocarpal joint up to 42%. Conversely negative ulnar variance will decrease compression loads borne by ulnocarpal joint up to 4.3%^{1,5}.

Radiographic anatomy of distal radius is a very important component to be considered in the evaluation and treatment of injuries involving the wrist joint. Distal radial fractures are among the most common fractures of the upper extremity and represent approximately 1/6th of all fractures treated in emergency department^{6,7}. Thus, an understanding of the normal value of distal radius morphometry becomes very important in the management of distal radius fractures in order to maintain anatomical alignment⁸.

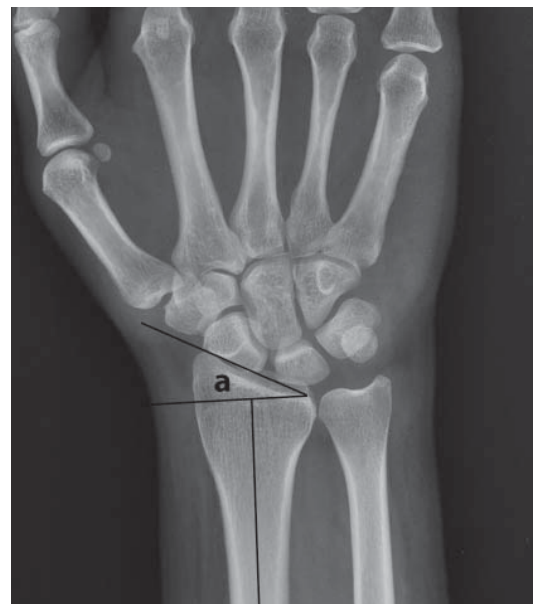
So far in daily practice we use normal value of distal radius radiographic parameters from western literature as a reference for the evaluation of acceptable value of post reduction distal radius anatomy. Gartland, Graham and Hastings developed radiographic criteria for the acceptable healing of distal radial fractures^{2,9,10}. The aim of this study is to determine distal radius radiological parameters of Pakistani population. This study also sought to compare the radiological parameters of distal radius between male and female subjects, because some researchers have claimed that there is difference in the values of the distal radius morphology based on gender¹¹.

This study provides a preliminary data for further analytical or experimental research. The result may also become the reference for the evaluation and treatment of distal radius fracture and injury in Pakistani population.

Methods:

In this study, we performed evaluation of primary data from the normal healthy wrists of patients presenting to the Department of Orthopedics Khalifa Gul Nawaz Teaching Hospital, Bannu with distal radius fractures from 1st January 2013 to 1st October 2013. We selected this sample data because it has been suggested by many authors in the literature to use morphometry data of the healthy side as individual reference value for the treatment of distal radius injury because it was more suitable compared to population data¹¹. For this study we selected 400 subjects, both male and female with the age range of 20-50 years, as sample. True anteroposterior and lateral x ray was taken after subjects signed the consent for research. Subjects with previous history of trauma, fracture or deformity to the healthy wrist were excluded from the study. There data was collected with the help of a proforma which is constructed using the four distal radial parameters (Radial inclination, Palmer tilt, Radial height, and Ulnar variance).

The radial inclination was measured as the angle between a line joining the tip of the radial styloid and the ulnar corner of the articular surface at the distal end of the radius and a line drawn perpendicular to the long axis of the radius^{1,2,10,11}. (figure 1)



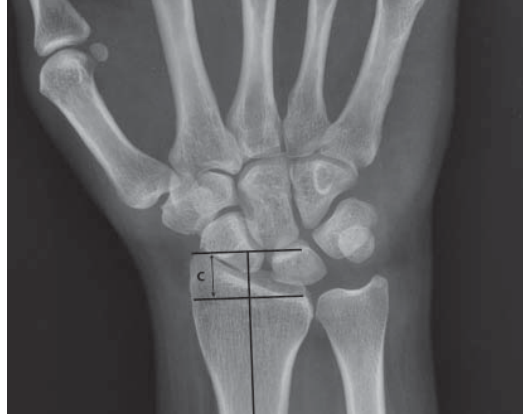
On lateral view the angle created between the articular surface of the distal radius and a line perpendicular to the long axis of the radius denoted the palmar tilt^{1,2,10,11}. (figure 2)



variance is when the horizontal line at the base of ulnar styloid process is more proximal than the horizontal line at the base of lunate fossa.



Radial length was measured from the PA radiograph; this is the distance between two perpendiculars to the long axis of the radius, one drawn at the tip of the radial Styloid process and one drawn at the distal articular surface of the ulna^{1,2,10,11}. (figure 3)



Results were compared between male and female gender, and also compared to OTA reference value. Because data distribution was not normal, statistical analysis was done using Mann-Whitney test in SPSS statistical software for Windows version 17.

Results:

300 subjects (200 male and 100 female) were studied in this research with mean age 25.50 years old (range 20-50).

The mean of radial inclination was $23.99 \pm 3.75^\circ$, palmar tilt $13.76 \pm 4.36^\circ$, radial height 11.31 ± 1.66 mm, and ulnar variance -0.45 ± 2.03 mm (Table 1). There were also statistically significant differences between radial inclination, palmar tilt, radial height, and ulnar variance between male and female gender (Table 2). Male subjects tend to have negative ulnar variance and female subjects tend to have positive ulnar variance (Table 2).

Ulnar variance is the 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 distal radius evaluated from true AP projection of the wrist^{1,2,10,11}. (figure 4)

Positive ulnar variance is when the horizontal line at the base of ulnar styloid process is more distal than the horizontal line at the base of lunate fossa (Figure 4). Conversely, negative ulnar

Table 1. Distribution of radial inclination, palmar tilt, radial height, and ulnar variance from 400 subjects

Parameter	Mean ± SD
Radial inclination	$23.99 \pm 3.75^\circ$
Palmar tilt	$13.76 \pm 4.36^\circ$
Radial height	11.31 ± 1.66 mm
Ulnar variance	-0.45 ± 2.03 mm

Table 2. Distribution of radial inclination, palmar tilt, radial height, and ulnar variance between male and female subjects:

Parameter	Median (range)		P*
	Male	Female	
Radial inclination	25° (15°-35°)	22° (12°-29°)	0.005
Palmar tilt	14° (1°-30°)	15° (4°-26°)	0.017
Radial height (mm)	11(7-15.5)	12 (8-16)	0.006
Ulnar variance (mm)	-1(-5-3)	1 (0-5)	0.005

Discussion:

The relationship between radiological anatomy and biomechanic of distal radius has been studied extensively in many literatures. Radiocarpal articular congruity remains the most clinically significant radiographic parameter regarding both functional outcome and future degenerative changes. The threshold for acceptable amounts of radiographic congruity remains somewhat controversial. Clinical studies have implicated the loss of the normal 11 to 12 degrees of palmar tilt as having a significant effect on functional outcome. Gartland and Werley concluded that residual dorsal tilt has a more direct effect on outcome than residual radial deviation, radial shortening, or loss of integrity of the radioulnar joint^{12,13}. In a retrospective review, Kopylov found that loss of as little as 12 degrees from the normal tilt resulted in an 80% increased risk of radiographically apparent arthritis¹⁴. McQueen examined 30 patients with extra-articular fractures and found that loss of 12 degrees or more of the normal palmar tilt resulted in functional impairment when compared with fractures that healed at neutral or with a positive palmar tilt^{13,15}. Porter felt that loss of function did not occur until at least 20 degrees of palmar tilt was lost³. The reason for the loss of function is probably multifactorial; however, cadaveric data have provided some potential explanations. The changes in palmar tilt affect not only radiocarpal mechanics, but also radioulnar mechanics. Short et al found that as little as a 10-degree loss of palmar tilt causes the area of maximum

load on the radius to become more concentrated and to shift dorsally. This change in load concentration may explain the clinical findings relating dorsal tilt to radiographically apparent degenerative changes at long-term follow-up^{1,13}. In addition, the change in palmar tilt increases the tension on the palmar and dorsal radioulnar ligaments resulting in an increased load required for forearm rotation^{13,16}. Collapse of the radial metaphysis results in radioulnar incongruity¹³. (Adams found that shortening of the radius may result in significant distortion of TFCC and may cause major changes in kinematics of the wrist, while the effect on radial inclination and dorsal angulation is not so significant¹⁷).

Clinical studies have also indicated a strong correlation between radial length and loss of strength. McQueen found that more than 2 mm of radial shortening resulted in symptomatic loss of strength^{13,18}. Jenkins found that not only was shortening of more than 4 mm associated with loss of strength, but it also correlated with pain^{13,19}.

Cadaver data indicate that the carpus shifts ulnarly in response to loss of radial inclination, thereby resulting in increased load on the triangular fibrocartilage complex (TFCC) and the ulna. This effect is not as severe as other deformities, but clinical studies show a correlation between decreased radial inclination and decreased grip strength^{13,19}. In addition, long-term follow-up indicates that this increases the risk of degenerative changes by 90%¹⁴.

Palmer and Werner in a biomechanics study on cadaver found that axial force on distal radius was transmitted 82% through radiocarpal joint and 18% through ulnocarpal joint⁵. Positive ulnar variance of 2.5 mm resulted in increased loading on ulnocarpal joint up to 42%. Meanwhile, negative ulnar variance decreased compression loads on ulnocarpal joint up to 4.3%¹⁻⁵. This was in accordance with the research performed by De Smet, et al which found that negative ulnar variance was associated with Kienbock's disease (avascular necrosis of the lunate), avascular necrosis of scaphoid, and scapholunate dissociation.

tion²⁰. Conversely positive ulnar variance would result in excessive loading on ulnar compartment that may cause triangular fibrocartilage complex (TFCC) degeneration and perforation as well as degenerative changes on carpal bone cartilage²⁰. Morphometric descriptions of distal radius as proposed by Gartland, et al is one reference adopted by most orthopaedic surgeon today including in Indonesia as a standard value in the evaluation and management of distal radius fractures. In his research, he found that the result of 60 cases (31.7%) was clinically unsatisfactory due to changes in palmar tilt, and the effect of decreased radial inclination was not clinically significant^{12,22}.

Altissimi, et al in a long-term evaluation of 297 cases of conservative distal radius fracture management found that clinically unsatisfactory result was obtained if radial inclination was less than 5°, palmar tilt more than 15°, and ulnar variance more than 5 mm²¹. Hollevoet, et al suggested using the contralateral side (healthy side) as an individual reference parameter which was more similar compared to values obtained from population data^{11,22}.

Conclusion:

we conclude on the above facts that it is very important to restore the alignment of distal radius to the normal value. Until now most of clinicians in Pakistan are still using parameters from western literature as reference. It is not wise because the results obtained here was quite different from western literature (Table 3).

Table 3. Comparison between distal radius morphometry in this study (combined right and left side) and reference value from The Orthopaedic Trauma Association (Gartland et al, 1951)

Parameter	Results of this study	OTA reference value ⁹
Radial inclination	23.99 ± 3.75° (20.24-27.74)°	13°-30°
Palmar tilt	13.76 ± 4.36° (9.40-18.12)°	1°-21°
Radial height (mm)	11.31 ± 1.66 (9.65-12.97)	11-13
Ulnar variance (mm)	-0.45 ± 2.03	Neutral

(-2.45-1.58)

From this study, it was known that the mean value of distal radius morphometry in Pakistani population are; radial inclination 23.99 ± 3.75°, palmar tilt 13.76 ± 4.36°, radial height 11.31 ± 1.66 mm, and ulnar variance -0.45 ± 2.03 mm. There were statistically significant differences of those values between male and female. Mean radial inclination was greater in males, but the mean of palmar tilt, radial height, and ulnar variance was greater in female. Ulnar variance tends to be negative in male and positive in female.

Role and contribution of authors:

Dr Shams ur Rehman, Assistant Professor Orthopedics, Khalifa Gul Nawaz Teaching Hospital, Bannu, initial writing up the article and collection of data.

Dr Waqar Alam, collection of data, references and discussion writing

Dr Muhammad Siraj, collection of references

Dr Malik Javed Iqbal, interpretation of data, result and discussion writing

Dr Saeed Ahmed, statistical analysis

All the Co Authors mentioned have contributed in writing this article by collecting data and composing.

Conflict of Interest: none

References:

- Short WH, Palmer AK, Werner FW, Murphy DJ. A biomechanical study of distal radius fractures. *J Hand Surg Am.* 1987;12(4):529-34.
- Crenshaw AH, Perez EA. Fractures of the shoulder, arm and forearm. In: Canale ST, Beaty JS. *Campbell's operative orthopaedics.* 11th ed. Philadelphia. Mosby 2008;3441-53.
- Porter M, Stockley I. Fractures of the distal radius. *ClinOrthopaedRel Res* 1987;220:241-252.
- Zemel, 1987. Zemel NP: The prevention and treatment of complications from fractures of the distal radius and ulna. *Hand Clin* 1987; 3:1.
- Palmer AK, Werner FW. Biomechanics of the distal radioulnar joint. *ClinOrthopRelat Res.* 1984;187:26-35.
- Koval KJ, Zuckerman JD. *Handbook of fractures.* 3rd ed. Lippincott Williams & Wilkins 2006; 226-36.
- Gupta DK, Kumar G. Ulnocarpal stabilization in the management of comminuted fractures distal end radius. *Indian J Orthop* 2009;43(1): 55-61.

8. Sandjaja G. Gambarannilai rata-rata aksissudut radius distal normal padapengujung di RSCM [thesis]. Mount Pleasant (MI): Universitas Indonesia; 1993. Indonesian.
9. Gartland JJ, Werley CW. Evaluation of healed colles' fractures. *J Bone Joint Surg Am.* 1951;33A(4):895-907.
10. Graham, 1997. Graham TJ: Surgical correction of malunited fractures of the distal radius. *J Am AcadOrthopSurg* 1997; 5:270.
11. Hollevoet N, van Maele G, van Seymortier P, Verdonk R. Comparison of palmar tilt, radial inclination, and ulnar variance in right and left wrists. *J Hand SurgBr.* 2000;25(5):431-3.
12. Gartland J, Werley C. Evaluation of healed Colles' fractures. *J Bone Joint Surg* 1951;33(4):895-907.
13. Ruch DS. Fractures of the distal radius and ulna. In: Bucholz RW, Heckman JD, Court-Brown CM, eds. *Rockwood and Green's fractures in adults.* 6th ed. Philadelphia: Lippincott Williams and Wilkins 2006;909-64.
14. Kopylov P, Johnell O, Redlund-Johnell I, et al. Fractures of the distal end of the radius in young adults: a 30-year follow-up. *J Hand Surg* 1993;18(1):45-49
15. McQueen M, Caspers J. Colles' fracture: does the anatomical result affect the final function? *J Bone Joint Surg* 1988;70(4):649-651.
16. Kihara H, Palmer AK, Werner F, et al. The effect of dorsally angulated distal radius fractures on distal radiolunar joint congruency and forearm rotation. *J Hand Surg* 1996;21:40-47.
17. Adams BD. Effects of radial deformity on distal radiolunar joint mechanics. *J Hand Surg Am.* 1993;18(3):492-8.
18. McQueen MM, Hajducka C, Court-Brown C. Redisplaced unstable fractures of the distal radius: a randomised, prospective study of bridging versus non-bridging external fixation. *J Bone Joint Surg* 1996;78(3):404-409.
19. Jenkins NH, Mintowt-Czyz WJ. Mal-union and dysfunction in Colles' fracture. *J Hand Surg Br* 1988;13:291-293.
20. De Smet L. Ulnar variance: facts and fiction review article. *ActaOrthop Belg.* 1994;60(1):1-9.
21. Altissimi M, Attenucci R, Fiacca C, Mancini GB. Long term results of conservative treatment of fractures of the distal radius. *ClinOrthopRelat Res.* 1986;206:202-10.
22. Franco-Valencia M, Torres-González R, Fuentes-Figueroa S. [Radiographic measurements of the wrist in healthy Mexicans] *Cir Cir.* 2006 Sep-Oct;74(5):335-42.