Abstract:
Background: Distal end of radius fracture is a common fracture due to fall on outstretched hand (15 per 100 fracture patients). Reduction of this fracture is generally assessed by four morphometric measurements of the distal radius. These are radial height, radial inclination, ulnar variance and palmar tilt. These morphometric measurements also play important role in radio carpal, radio-ulnar pathologies and wrist osteotomies. These measurements are calculated intra-operatively or postoperatively on a radiograph or a image intensifier image. We aimed to calculate mean radiographic measurements of all 4 parameters in Indian population.

Materials and methods: This is retrospective, unicentric, observational, analytic study. We studied 212 normal wrist posteroanterior and lateral radiographs from our hospital radiology data, and calculated these 4 morphometric measurements using default workstation (AGFA) in computer console. The data entered in Microsoft Excel sheet and Standard calculations were done. Mean measurement values were analyzed statistically between the groups.

Results: The average radial height is 12.09mm(+1.52mm) with range from 9.1mm to 16.7mm, radial inclination is 25.77 degree(+2.91 degree) range from 21degree-33degree, ulnar variance -1.16mm(+1.48mm) range from -4.9mm to 2.1mm is and palmar tilt is 11.58degree(+2.37degree) range from 4degree to 17degree.

Conclusion: These can be used as a reference measurement for treating the fracture distal radius in Indian population. Radial inclination is higher in our data, Ulnar variance is more towards negative ulnar variance. Palmer tilt and radial height are comparable to the western population.

Keywords: Morphometry, radiography, workstation, Radius fractures.
Introduction

Distal radius fracture is the most common osteoporotic metaphyseal fracture and also common due to fall on outstretched hand in young population. Incidence of this fracture is almost 18.9 per 10000 person years or higher\(^1\). Fracture reduction is assessed by measuring the morphometric measurements of the distal radius on radiographs. Radio carpal relationship is also affected by these morphometric parameters. Other conditions like osteotomies of the distal radius or pathology of distal radius ulna joint (dislocation) are also assessed based on these important morphometric measurements.

These parameters are namely radial height, radial inclination, ulnar variance and palmar tilt. The relationship of the wrist kinematics, functional outcome and these parameters after reduction of fracture is well known\(^2\). Reduced radial height and increased radial inclination and dorsal tilt has significantly changed wrist kinematics and reduced the grip strength\(^3\) and wrist pronation-supination\(^4,5,6\). There is a racial variation in all of these measurements\(^7\). Literature shows the use of a anteroposterior, postero-anterior, and lateral radiographs to calculate and determine the mean morphometric measurements with few variations. Cadaveric studies have also given the morphometric measurements of these parameters accurately\(^8\). But using radiographs to calculate morphometry makes these measurements more surgeon friendly as these can be compared intra-operatively to achieve acceptable distal radius alignment\(^9,10\) and postoperatively to assess the reduction in acceptable limits.

Aims:

The aim of this study is to determine the mean morphometric parameters of the distal radius bone on a true sized, normal, adult postero-anterior and lateral radiographs from our department of radiology database. Compare them within groups of gender and side. Tabulate them to assess that with OTA (Orthopedic Trauma Association) criteria for acceptable reduction of distal radius fractures.

Materials and methods

Total of 212 posteroanterior (PA) and lateral radiographs of adults (mature skeleton) were selected from Department Of Radiology of our Hospital database. This is a retrospective, unicentric, observational study where most of the Radiographs were from the month of September,October, November 2017. Wrist radiographs are taken in our department focused from 100 Centimeter and the receiver/ cassette is kept on the table and hand rested on the cassette kept on table. But the radiographs had to be adjusted for the magnification on the AGFA Healthcare workstation to 100% size (true size). This is a computer workstations in which we can access the radiographs and draw lines and angles on computer. The workstation immediately gives measurement of length in millimeter or centimeter and angle in degrees. This data of length and angles was entered in data collection form by one observer only.

Inclusion criteria

Wrist radiographs were selected from true PA criteria. These criteria are- ulnar styloid process starting from the medial ulnar cortex of ulna bone, distal radius ulna joint has no or minimal overlap and metacarpal bases have no or minimal overlap. Similarly true lateral view is selected on criteria-ulnar styloid lying on dorsal side of radiograph, Pisiform bone lies between the distal pole of Scaphoid and distal pole of Capitate bone. Only wrist radiographs reported normal were included.

Exclusion Criteria

The radiographs not having above criteria were not included in study. Those with fracture anywhere on the wrist or forearm bone, arthritis of wrist or surrounding joint, lesion in the bone (like osteochondroma or joint like osteoarthritis, rheumatoid arthritis) were not included in this study. Those radiographs having true PA criteria but no true lateral criteria or vice versa were rejected.

Measurements

Measurements were done on the workstation named AGFA (which is a default in our radiology department) by one observer only. Radial height, radial inclination, ulnar variance and palmar tilt are calculated and entered in the Microsoft Excel sheet for further calculations. We used freely available Open Epi to do statistical analysis. We compared the mean values in males and females as well as in right and left wrist radiographs statistically.

Radial height is calculated by the distance between two lines; one line perpendicular to long axis of radius (anatomic axis) bone passing through the tip of radial styloid and second line similar to first, passing through lunate fossa margin of the radius bone. (Fig.1)
Radial inclination angle is calculated by angle between two lines; one joining tip of radial styloid and ulnar corner of lunate fossa and other line perpendicular to long axis of the radius. The small angle out of two is radial inclination angle. (Fig.2)

Ulnar variance is calculated by measuring distance between 2 lines drawn; one through the highest point of ulnar corner of lunate fossa and other passing through highest point of distal articular surface both parallel to each other.

Palmar tilt is calculated by angle formed between 2 lines; one through dorsal and volar prominences of distal articular surface of radius and other line perpendicular to long axis of the radius bone on a true lateral radiograph. The small angles is taken as palmer tilt angle. (Fig.3)

Results

Table 1 shows the result of this study.

212 (Two Hundred And Twelve) Radiographs were studied, 139 labelled right and 73 labelled Left. Mean radial height is 12.09mm (+-1.52mm)[9.10mm to 1.67mm], mean Radial inclination is 25.77 degree (+-2.91 degree)[21 to 33 degrees], mean ulnar variance is -1.16mm (+-1.48mm) [-4.9mm to 2.1mm], mean palmar tilt is 11.58degree (+-2.37degree)[4 to 17 degrees].

Mean Radial height in male is 12.4mm (+-1.5mm) which was statistically more (P value<0.001) than that in females 11.03mm (+-1.19mm). Mean Radial height in right wrist is 12.3mm (+-1.6mm) which was statistically more (P value=0.01) than that in left wrist 11.7mm (+-1.62mm).

Mean Radial inclination angle in male is 26.02 degrees (+-3.02degree) which is statistically more (P value=0.005) than that in females 24.87 degree (+-2.21degree). Mean Radial inclination angle in right wrist is 26.09 degrees (+-2.9degree) which is statistically more (P value=0.027) than that in left wrist 25.16 degree (+-2.8degree).

Mean ulnar variance in male is -1.33mm (+-1.43mm) which was statistically low (P value=0.004) than that in females -0.56mm (+-1.57mm). While mean ulnar variance does not vary significantly on right or left side. 46 radiographs have neutral ulnar variance.

Mean palmar tilt angle in male is 11.3 degrees (+-2.15degree) which is statisticallyless (P value=0.001) than that in females 12.67degree (+-2.87degree). Mean palmar tilt angle in left wrist is 11.07 degrees(+2.19degree) which is statistically less (P value=0.02) than that in right wrist 11.86 degree (+-2.43degree).

Spearman’s correlation test shows that radial height is positively correlated to radial inclination (p value = 0.000) but is negatively correlated to ulnar variance (p value = 0.005) and palmar tilt (p value=0.162).

Table 1. Results Of our study; the mean values of all 4 morphometric parameters.

<table>
<thead>
<tr>
<th>n = 212 Radiographs</th>
<th>Mean (+_SD)</th>
<th>Mean Male (n=167)</th>
<th>Mean Female (n=45)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radial Height (mm)</td>
<td>12.1 (+_1.5)</td>
<td>12.4 (+_1.5)</td>
<td>11.0 (+_1.1)</td>
</tr>
<tr>
<td>Radial Inclination (degree)</td>
<td>25.77 (+_2.91)</td>
<td>26.02 (+_3.02)</td>
<td>24.87 (+_2.21)</td>
</tr>
<tr>
<td>Ulnar Variance(mm)</td>
<td>-1.167 (+_1.489)</td>
<td>-1.328 (1.427)</td>
<td>-0.5644 (1.573)</td>
</tr>
<tr>
<td>Palmar Tilt (degree)</td>
<td>11.59 (+_2.38)</td>
<td>11.3 (+_2.15)</td>
<td>12.67 (+_2.87)</td>
</tr>
</tbody>
</table>

“n” total number in the group, mm= millimeters.
Discussion

Reduction of distal radius fracture is assessed by the anatomically restoring morphometric measurements\textsuperscript{11}. Intraoperatively orthopedic surgeon use the guidelines given by Gartland and Werley\textsuperscript{12}. Also most of the other criteria (for acceptability of reduction of distal radius fracture) followed are laid by western literature\textsuperscript{7,12,13,14}. While study of the Chan et al. showed that there is significant difference in the morphometric measurements in 2 races that is in Chinese and Malaysian population\textsuperscript{7}. Mishra PK\textsuperscript{15} studied parameters in PA and lateral radiographs to find no statistical difference between measurements in Indian and Western population.

Cadaveric studies by Johnson and sobzo has doubted measuring morphometric parameters by radiographs as 5 degree rotation in forearm can decrease the palmar tilt by 1.6degree\textsuperscript{8}. Studies of Cadaveric population can not be applied clinically to patients directly as population is generically older that clinical population and also cadavers are not screened for diseased bone like presence of previous fractures, healed fractures or pathology like tumor in bone. Also not all patients with distal radius fractures require open reduction where morphometry can be calculated. Orthopedic surgeon assess the reduction morphometry (even in open reduction surgery) by fluoroscopy/ image intensifier image only.

Hence radiography is the only available tool in orthopedist hand to calculate these parameters intraoperatively and post operatively and is widely used. Views usually taken are PA\textsuperscript{16,17} and lateral view. Also PA view shows less bone overlap and calculation of these parameters becomes easy. PA radiograph is easy to take even in painful wrist than AP view because of supination force in AP wrist radiograph. Also the study by Pennock et al shows that Supination of forearm significantly increase the apparent morphometric measurements of DER\textsuperscript{18}.

In our study we included radiographs purely on true PA and true Lateral view criteria mentioned above.

From above discussion it can be concluded that knowing the normal values of distal radius morphometry is very Important in treating distal radius fractures.

Table 2 compares the difference between our study and western studies.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Our study</th>
<th>Gartland and Werley, 1951\textsuperscript{12}</th>
<th>Altissimi et al, 1986\textsuperscript{19}</th>
<th>Schuind et al, 1992\textsuperscript{20}</th>
<th>Werner et al,1992 (cadaveric)\textsuperscript{21}</th>
<th>Nakamura et al,1991\textsuperscript{22}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palmar tilt (degree)</td>
<td>11.59 (+2.38)[4-17]</td>
<td>11[1-21]</td>
<td>0-18</td>
<td>Not reported</td>
<td>6</td>
<td>Not reported</td>
</tr>
<tr>
<td>Ulnar variance (mm)</td>
<td>-1.167 (+1.489)[-4.9 to 2.1]</td>
<td>Not reported</td>
<td>-2.5to + 3.1mm</td>
<td>-4.2 to 2.3mm</td>
<td>-0.1mm ± 1.4mm</td>
<td>0.20 ± 1.39mm</td>
</tr>
</tbody>
</table>

In our study mean value of radial inclination was 25.77 degrees which is in reference range of Altissimi et al, 1986(16-28 degrees) and is less than that of Indian population(27degree) from Malaysia\textsuperscript{7}.

In our study Radial height was 12.1mm which falls in OTA reference value but range(9.1mm-16.7mm) is much less than Mishra PK\textsuperscript{15} (7.1mm-30.4mm).Table3.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Our study</th>
<th>Mishra PK\textsuperscript{15}</th>
<th>OTA reference value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radial inclination (degree)</td>
<td>21-33</td>
<td>11.3-42.1</td>
<td>13-30</td>
</tr>
<tr>
<td>Palmer tilt (degree)</td>
<td>4-17</td>
<td>1-16.9</td>
<td>1-21</td>
</tr>
<tr>
<td>Radial height (mm)</td>
<td>9.1-16.7</td>
<td>7.1-30.4</td>
<td>11-13</td>
</tr>
<tr>
<td>Ulnar variance (mm)</td>
<td>-4.9 to 2.1</td>
<td>-2.4 to 4.1</td>
<td>Neutral</td>
</tr>
</tbody>
</table>
In our study 46 radiographs have neutral ulnar variance which is OTA references value but mean Ulnar variance is negative (-1.167mm). While Mishra PK\textsuperscript{15} in Indian population had positive ulnar variance 0.66mm±2.46mm.

In our study there was a statistically significant difference of mean values in gender with respect to all four morphometric measurements (Table1); while in Mishra PK\textsuperscript{15} study, only the radial height showed the statistical difference (gender specific), while the other parameters were statistically insignificant.

In our study there was a statistically significant difference of mean values in right and left wrist with respect to morphometric measurements except ulnar variance; while in Mishra PK\textsuperscript{15} study, no significant difference was found in any of the 4 parameters.

Limits of our study are - wide range of age, pure radiographic criteria for selection and retrospective study.

While the strength of the study is that the radiographic criteria was applied strictly to include only true PA and Lateral view radiographs\textsuperscript{25}.

Radial inclination was higher in our study as compared to previous studies. Ulnar variance was on negative side , while previous study shows it is neutral. though these can not be compared to previous studies statistically.

**Conclusion**

We have set the normal values in true PA and lateral wrist radiographs and these can be used as a reference values in Indian population. In our study we conclude that ulnar variance is negative in most of the Indian population and shall be considered normal. Rest of the morphometric values like radial height and radial inclination angle, palmar tilt are comparable to western literature.

**References**

15. Mishra PK, Nagar M, Gaur SC, Gupta A. Morphometry of distal end radius in the Indian population: A radiological study Morphometry of distal end radius in


22. Sandjaja G. Overview The average value of the distal radius angle normal access to the visitors at the RSCM[Thesis]. Mount Pleasant, MI: Universitas Indonesia; 1993.