Rotational Shift of Proximal Carpal Row and it's Correlation with Global Wrist Joint Laxity

Ashish Agarwal[1], Varun Agarwal[2]

ABSTRACT

Introduction: As the wrist moves to ulnar deviation, the proximal carpal row undergoes radial translation, dorsal rotation and supination. Similarly, the radial deviation involves ulnar translation of the proximal carpal row, its volar rotation and pronation. These combined movements of the proximal carpal row are called rotational shift of the carpus. Study aimed to quantify the rotational shift of the proximal carpal row during ulnar or radial deviation of the wrist.

Material and methods: The proposed study was a prospective study conducted in the Department of Orthopedics, RMCH, Bareilly, UP comprising 100 healthy volunteers with equal sex ration who never had any symptoms pertaining to their wrist joint. PA and lateral radiograph were obtained in full radial and ulnar deviation. A custom-made positioning device was used to ensure proper placement of the hand and wrist during the examination.

Results: In the present study, we observed that the radioscaphoid angle in radiation deviation varied from 50 to 85 degree with mean of 68.96 degree. Radioulnate angle in radial deviation varied from -2 to 45 degree with mean of 17.79 degree. Radioscaphoid angle in ulnar deviation varied from 10 to 70 degree with mean of 39.97 degree. Radioulnate angle in ulnar deviation varied from -3 to -38 degree with mean of -17.15 degree.

Conclusion: Within the limitations of the present study, it can be concluded that the ulnar deviation of the wrist is seen to cause radial translation ad dorsal rotation of the proximal carpal row. Similarly, the radial deviation was seen to cause ulnar translation and volar rotation of the proximal carpal row.

Keywords: Proximal Carpal Row, Global Wrist Joint Laxity

INTRODUCTION

As the wrist moves to ulnar deviation, the proximal carpal row undergoes radial translation, dorsal rotation and supination. Similarly, the radial deviation involves ulnar translation of the proximal carpal row, its volar rotation and pronation. These combined movements of the proximal carpal row are called roatational shift of the carpus. Various studies have qualified the three components of the rotational shift of the carpus but with large variability. The wrist joint laxity and the scaphoid's mobility pattern during RUD of the wrist are reported to show strong inverse correlation although the joint laxity failed to show any correlation with the lunate's mobility pattern. Interestingly the same study reported significant correlation between movements of the scaphoid and the lunate during RUD of the wrist. It is to be noted that these studies measure the flexion extension movements of the scaphoid and the lunate on the postero-anterior radiographs of the wrist while the results would surely be more reliable if the flexion extension movements were quantified on sagittal images. The present study was proposed to quantify the rotational shift of the proximal carpal row during ulnar or radial deviation of the wrist.

MATERIAL AND METHODS

The proposed study was a prospective study conducted in the Department of Orthopedics, RMCH, Bareilly, UP, between January 2019 to March 2019, comprising 100 healthy volunteers with equal sex ration who never had any symptoms pertaining to their wrist joint. An informed written consent was obtained. Standard posterolateral and true lateral radiograph of wrist were made to exclude any radiological abnormality. PA and lateral radiograph were obtained in full radial and ulnar deviation. A custom-made positioning device was used to ensure proper placement of the hand and wrist during the examination.

Inclusion criteria
100 healthy volunteers between age group 20 to 40 years with equal sex ratio

Exclusion criteria
1. Past history of wrist injury.
2. Heavy manual labour.
3. Systemic collagen vascular disease.

Global wrist laxity was determined by measuring hyper mobility of the thumb column and measuring maximum passive flexion and extension of the wrist. Lunate's sagittal axis was drawn as a line perpendicular to the line tangential to its two poles. Radiolunate angle (RLA) is measured as the angle between the lunate sagittal axis and the line along the long axis of the radius. Similar measurement drawn on the lateral radiographs repeated in the ulnar and radial deviation is termed as RLA-U and RLA-R respectively. The lunate flexion index (LFI) is calculated as the difference between
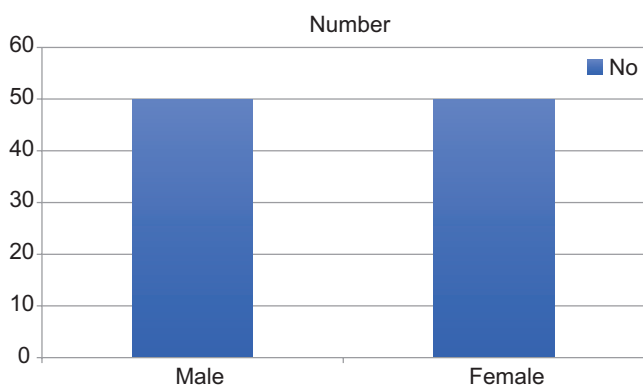
RLA-U and RLA-R expressed as a percentage of the RLA –U. Radio-ulnar translation of the scaphoid and the lunate were measured on antero-posterior radiographs with wrist in ulnar and deviation. Various references points for the radius, scaphoid and ulnar were drawn as vertical lines from the tip of the radial styloid, the most ulnar point on the lunate respectively. The statistical analysis of the data was done using SPSS version 11.0 for windows. Pearson's correlation coefficient was used for checking the relationship between various indices. A p-value of 0.05 and lesser was defined to be statistical significant.

RESULTS

There were 50 males and 50 females (graph 1) The radioscaphoid angle in radiation deviation varied from 50 to 85 degree with mean of 68.96 degree, its showing there were 6 cases ngle between 50-54 degree, 7 cases with 55-59 degree, 12 cases between 60-64 degree, 20 cases 65-69 degree 23 cases 70-74 degree and maximum 23 cases 75-
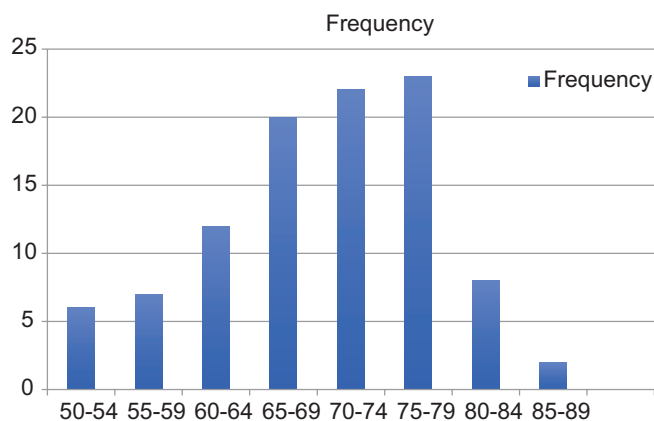

Graph-2: Radioscaphoid angle in radial deviation

79 degreeand minimum 2 cases in between 85-89 degree of agmggle. (graph 2) Radioulnate angle in radial deviation varied from -2 to 45 degree with mean of 17.79 degree, maximum angle deviation found in 16-20 degree in 30 csubjects and minimum ranging between -4 to 0degree in one subject (table 1). Radioscaphoid angle in ulnar deviation varied from 10 to 70 degree with mean of 39.97 degree. Radioulnate angle in ulnar deviation varied from -3 to -38 degree with mean of -17.15 degree. Which was maximum in 31 cases in between 11-15 degree and minimum in 2 cases in between 36-40 degree (table 2)

DISCUSSION

In the present study, we observed that the radioscaphoid angle in radiation deviation varied from 50 to 85 degree with mean of 68.96 degree. Radioulnate angle in radial deviation varied from -2 to 45 degree with mean of 17.79 degree. Radioscaphoid angle in ulnar deviation varied from 10 to 70 degree with mean of 39.97 degree. Radioulnate angle in ulnar deviation varied from -3 to -38 degree with mean of -17.15 degree. The results were compared with previous studies. Stoesser H et al determined the kinematics of the scaphoid, lunate, and capitate during unconstrained simulated wrist flexion/extension and to examine the effect of motion direction on the contribution of each bone. Seven cadaveric upper extremities were tested in a passive wrist simulator with 10N tone loads applied to the wrist flexors/extensors. Scaphoid, lunate, and capitate kinematics were captured using optical tracking and analyzed with respect to the radius. Scaphoid and lunate motion correlated linearly with wrist motion. In extension, the scaphoid and lunate extended $83 \pm 19\%$ and $37 \pm 18\%$ relative to total wrist extension, respectively. In flexion, the scaphoid and lunate flexed $95 \pm 20\%$ and $70 \pm 12\%$ relative to total wrist flexion, respectively. The lunate rotated $46 \pm 25\%$ less than the capitate and $35 \pm 31\%$ less than the scaphoid. The intercarpal motion between the scaphoid and lunate was $25 \pm 17\%$ of wrist flexion. They concluded that the scaphoid, lunate, and capitate move synergistically throughout planar wrist motion. The scaphoid and lunate contributed at a greater degree during flexion, suggesting that the radiocarpal joint plays a more critical role in wrist flexion.[7] Rainbow MJ et al determined motion of the carpus during extremes of wrist

Graph-1: Gender-wise distribution

Angle deviation	Frequency
-4 – 0	1
1-5	2
6-10	11
11 – 15	21
16 – 20	30
21 – 25	18
26 – 30	3
21 – 25	4
26 – 30	3
31- 35	5
41 – 45	2
Table-1: Frequency of angle deviation	

Angle deviation	Frequency
1-5	5
6-10	16
11-15	31
16-20	23
21-25	13
26-30	4
31-35	6
36-40	2
Table-2: Radioulnate angle in ulnar deviation	

flexion and extension. Computed tomography scans of 12 healthy wrists were obtained in neutral-grip, extreme loaded flexion, and extreme loaded extension. Three-dimensional bone surfaces and 6-degree-of-freedom kinematics were obtained for the radius and carpal bones. The flexion and extension rotation from neutral-grip to extreme flexion and extreme extension of the scaphoid and lunate was expressed as a percentage of capitate flexion and extension and then compared to previous studies of active wrist flexion and extension. Finally, joint space metrics at the radiocarpal and midcarpal joints were used to describe arthrokinematics. In extreme flexion, the scaphoid and lunate flexed 70% and 46% of the amount the capitate flexed, respectively. In extreme extension, the scaphoid extended 74% and the lunate extended 42% of the amount the capitates extended, respectively. The third metacarpal extended 4° farther than the capitate in extreme extension. The joint contact area decreased at the radiocarpal joint during extreme flexion. The radioscaphoid joint contact center moved onto the radial styloid and volar ridge of the radius in extreme flexion from a more proximal and ulnar location in neutral. They concluded that the contributions of the scaphoid and lunate to capitate rotation were approximately 25% less in extreme extension compared to wrist motion through an active range of motion. More than half the motion of the carpus when the wrist was loaded in extension occurred at the midcarpal joint.[8]

Seradge H et al studied 11 fresh-frozen cadaver specimens to quantify the contribution of the scapho-lunate and luno-triquetral joints to global wrist motion were. The carpus was labeled with metallic markers and the joints were selectively transfixed with wires. The wrist was allowed to follow its natural radial and ulnar deviation during flexion and extension, extension and flexion during radial and ulnar deviation, respectively. The data was collected by means of radiography, goniometric measurement, and computer analysis. The proximal carpal row (the intercalated segment) although anatomically represented as a row, presented through its two intersegmental joints, a definite segmental behavior. Each intersegmental joint of the proximal carpal row influenced global wrist motion in all directions but to a different degree for each plane of motion. The segmental joints within the intercalated segment collectively govern 40% of the wrist flexion, 33% of extension, and 10% of ulnar deviation. The scaphoid through its scapho-lunate link exerts a governing effect on total intersegmental proximal carpal row contribution to the global wrist motion.[9]

Green and O'Brien provided a classification for carpal dislocations; however, that schema does not specifically address the injury seen in our case. The Mayo classification of carpal instability divides instability into carpal instability dissociative, carpal instability non-dissociative, carpal instability complex and the adaptive carpal changes, following malunion or nonunion of the distal radius. The complex carpal dislocation reported here represents a combined radio-carpal–mid-carpal instability non-dissociative pattern, as the ligamentous disruption occurs between the distal radius and the proximal carpal row and also between the proximal and distal carpal rows. These injuries are considered exceedingly rare. A review of the literature reveals that isolated cases of unusual complex carpal dislocations have been reported, however, owing to their rarity they are few in number.[10-14] Camus EJ et al attempted to understand the organization and the composition of the functional units of the carpus. They took radiographs of 40 normal right wrists in radial and ulnar deviation and measured the displacement in the coronal plane of each carpal bone except the pisiform. They measured the angular movements of each carpal bone compared to a vertical axis passing through the geometric centre of the carpus. This axis is parallel to the radial axis which is defined as the line joining the midpoints of the radius at 2 and 5 cm proximal to the radial articular surface. They studied the movement of each row and each column. Recorded angular movements were the followings: scaphoid 26 degrees, lunate 28 degrees, triquetrum 29 degrees, trapezium 44 degrees, trapezoid 50 degrees, capitate 50 degrees, hamate 56 degrees. Average angular movement within the first row is 27 degrees, within the second row is 50 degrees. Average angular movement within the radial column is 38 degrees, middle column is 39 degrees, ulnar column is 42 degrees. They concluded that the amplitude of movement is similar for the bones of each row, and different for the bones of each column. The bones of each row tend to move together and can alone account for all movements of the wrist. The movements measured between each column are torsional intrarow movements, allowing congruence between the two rows and the glenoid surface of the radius. The scaphoid movements are superposable with those of lunate and triquetrum. Scaphoid kinematics joins the first row. Radio-ulnar deviation of the wrist is shared equally between the radiocarpal and midcarpal joints. This sharing of wrist movement between the two rows constitutes for us a double cup carpal model.[15]

CONCLUSION

Within the limitations of the present study, it can be concluded that the ulnar deviation of the wrist is seen to cause radial translation ad dorsal rotation of the proximal carpal row. Similarly, the radial deviation was seen to cause ulnar translation and volar rotation of the proximal carpal row.

REFERENCES

1. Weber E R. Concepts governing the rotational shift of the intercalated segment of the carpus. Orthop Clin North Am. 1984;15:193–207.
2. Moritomo H, Murase T, Goto A, Oka K, Sugamoto K, Yoshikawa H. Capitate-based kinematics of the midcarpal joint during wrist radioulnar deviation: an in vivo three-dimensional motion analysis. J Hand Surg Am. 2004;29:668–675.
3. Sarrafian S K, Melamed J L, Goshgarian G M. Study of wrist motion in flexion and extension. Clin Orthop Relat Res. 1977;126:153–159.
4. Landsmeer J M. Studies in the anatomy of articulation. I. The equilibrium of the "intercalated" bone. Acta Morphol Neerl Scand. 1961;3:287–303.

5. Navarro A. Luxaciones del carpo. Anal Fac Med. 1921;6:113–141.
6. von Bonin G A note on the kinematics of the wrist-joint J Anat 192963(Pt 2):259–262.
7. Stoesser H, Padmore CE, Nishiwaki M, Gammon B, Langohr GDG, Johnson JA. Biomechanical Evaluation of Carpal Kinematics during Simulated Wrist Motion. J Wrist Surg. 2017;6:113–119.
8. Rainbow MJ, Kamal RN, Leventhal E, et al. In vivo kinematics of the scaphoid, lunate, capitate, and third metacarpal in extreme wrist flexion and extension. J Hand Surg Am. 2013;38:278–288.
9. Seradge H, Sterbank PT, Seradge E, Owens W. Segmental motion of the proximal carpal row: their global effect on the wrist motion. J Hand Surg Am. 1990;15:236-9.
10. Green DP, O'Brien ET. Classification and management of carpal dislocations. Clin Orthop Rel Res. 1980;149:55–72.
11. Irwin LR, Paul R, Kumaren R, Bagga TK. Complex carpal dislocation. J Hand Surg [Br] 1995;20B:746–749.
12. Rosado AP. A possible relationship of radio-carpal dislocation and dislocation of the lunate bone. J Bone Joint Surg. 1966;48B:504–506.
13. Norbeck DE, Jr, Larson B, Blair SF, Demos TC. Traumatic longitudinal disruption of the carpus. J Hand Surg. 1987;12A:509–514.
14. Primiano GA, Reef TC. Disruption of the proximal carpal arch of the hand. J Bone Joint Surg. 1974;56A:328–332.
15. Garcia-Elias M, Dobyns JH, Cooney WP, III, Linschied RL. Traumatic axial dislocation of the carpus. J Hand Surg. 1989;14A:446–457