ORIGINAL ARTICLE

ROLE OF SCAPHOID IN THE ABDUCTION AND ADDUCTION MOVEMENTS OF WRIST JOINT

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ABSTRACT

Background: Being a carpal bone scaphoid has an important role in wrist movements. Wrist joint is a synovial modified ellipsoid joint where movements like flexion, extension and adduction, abduction take place around two axes (transverse and antero-posterior). These movements at the wrist joint are associated with considerable range of movements at the mid carpal joint, as same group of muscles act on both of these joints.

Methodology: A study has been done amongst 120 persons at the tertiary care hospital during the period from 2006-07 to detect the important movements of scaphoid bone specially during the abduction and adduction of wrist joint (which occur in association with the intercarpal joints) and also to detect whether such movements have any speciality in the population.

Results: In fully abducted position, it was 45^o among 53.3% subjects and the average among all the subjects was 60^o. So, the degree of abduction was 30^o. The extent of movement was more in adduction (ie, 1.90 cm - 1.03 cm = 0.87 cm) than in abduction (ie, 1.03 cm - 0.72 cm = 0.31cm).

Conclusion: It was found in this study that the scaphoid acts as a link bone between the two rows of carpal bones and prevents the buckling of midcarpal joint especially of the capitato- lunate joint interface.

Keywords: Scaphoid, Abduction, Adduction, Wrist joint

INTRODUCTION

Supremacy of human being in the animal kingdom has been achieved through a process of evolution and in this process the activities were entrusted to the distal part of forelimb i.e, the hand. A number of short bones are, therefore, placed in the wrist to allow the different movements of wrist joint in a composite manner for achieving a specific purpose. A total of eight carpal bones are arranged in two rows, each having four members. Carpal bones of the proximal row (from lateral to medial) are scaphoid, lunate, triquetral and pisiform, whereas carpal bones of the distal row (from lateral to medial) are trapezium, trapezoid, capitate and hamate.[1] Scaphoid is the largest and the lateral most bone in the proximal row indicating its vital role in different movements of the hand. The proximal row is an intercalated segment with no tendinous attachment. It is inherently unstable and controlled by specific retaining and gliding ligaments.[1]

The wrist joint is a synovial, biaxial, compound ellipsoid joint and is formed by articulation of the distal end of the radius and the triangular articular disc with the scaphoid, lunate, triquetral bones.[1] The proximal concave articular surface has one long transverse axis and the distal articular surface is convex.[1] The midcarpal joint is the joint between the scaphoid, lunate, triquetral bones (proximally) and trapezium, trapezoid, capitate and hamate distally in a compound articulation divided descriptively into medial & lateral parts.[1]

Movements at the radiocarpal and midcarpal joints are considered together since they are both involved in all movements as well as being acted upon by the same muscles.[2] Movements allowed in these joints are the flexion (85^o) and extension (85^o) occurring around the transverse axis of the joint; adduction (45^o) and abduction (15^o) occurring around the anteroposterior axis of the joint and circumduction (combination of the above mentioned movements occurring serially). Eight carpal bones in proximal and distal rows are also considered by many authors to form three columns - medial, intermediate and lateral. The lateral column in such description is constituted solely by scaphoid. So scaphoid is considered to be the most important among all the carpal bones. Scaphoid straddles proximal and distal rows in different movements of the wrist joint.[1]

The present study has been undertaken to detect the importance of scaphoid bone in these movements (specially in abduction and adduction) and whether such movements have any speciality in our population.

MATERIALS AND METHODS

Relatives of the patients attending the outpatient department of radiology in the tertiary care hospital were

selected for this study. The total numbers of subjects were 120. Male persons belonging to the age group of 20 to 30 years with normal upper limbs were selected, because the ossification in all the carpal bones and in the distal ends of radius and ulna is complete by the age of 20 years and moreover, before the age of 30 years the osteo-arthritic changes are unusual in the joints concerned. The study was done from 2006-07 for a period of 2 years. The x-rays (skiagrams) were taken of the right wrist joint only when the persons were standing in erect posture (Fig 1) and the appropriate measurements were done on the right sided wrist joints.

Fig 1 Antero-posterior Skiagram of Right Wrist Joint in Fully Adducted Position Showing the Scaphoid Bone Directed Straight Forward with Distal Parts of Radius and Ulna, Metacarpals and Phalanges Visible

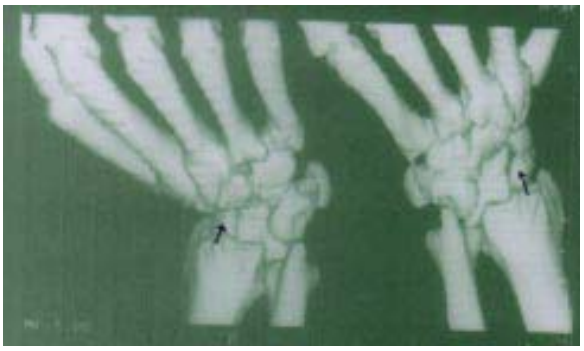

Fig 2: Spiral CT Showing Right Wrist Joint in Abducted Position and the Left Wrist Joint in Adducted Position

In case of spiral CT (Fig 2) both sided views of the wrist joint were taken on economic ground. Actually it was decided to do the study on one particular side. Right side was selected from the table of random number sampling. X-rays were taken in the following positions of the right hand: (1) Neutral position ie, the long axis of forearm coincides with long axis of middle finger. This view served as control in comparison to the other two positions. (2) Fully adducted position, (3) Fully abducted position. Measurements were carried out under the following parameters, to study the x-ray plates: (1) Angle between the line joining radial and ulnar styloid processes and long axis of the third metacarpal bone. (2) Distance between lateral end of scaphoid and tip of radial styloid process. (3) Length of the scaphoid bone. (4) Distance between the tip of styloid process of radius and base of 1st metacarpal bone. The references of these measurements were taken from the quantitative kinematic study of Lange *et al*[5]; also from the previous works of Henke[4], Erdman *et al*[5], Berger and Blair[6], Brumbaugh *et al*[7], Kauer[8], Gellman *et al*[9]. All the angles were measured from radial side for better understanding and comparison. In all movements of the wrist joint the subject was advised not to pronate or hypersupinate the forearm. The elbow was extended in all positions. Spiral CT of different movements of the wrist joint was done in 12 subjects (10% of the subjects). In spiral CT the relative change of position of different carpal bones and their articular surfaces at different stages of movement could be detected clearly.

RESULTS

The longitudinal axis of the 3rd metacarpal bone, when extended proximally intersects the line joining the styloid processes of radius and ulna. It was taken as a standard axis around which abduction and adduction were measured. The angle was measured between these two lines. In neutral position of the wrist joint in all subjects it was 90^{o}. In adducted position of the wrist joint it was 120^{o} on an average among all the subjects (Table 1). So the degree of adduction was 30^{o}. In fully abducted position, it was 45^{o} among 53.3% subjects and the average among all the subjects was 60^{o}. So, the degree of abduction was 30^{o}.

Table 1: Measurement of the Angle between the Line Joining the Styloid Processes of Radius and Ulna and the Longitudinal Axis of 3rd Metacarpal Bone (n=120)

Angle	Mean angle in cm(SD)	Cases (%)
Neutral	90 (0)	120 (100.0%)
Adduction	120 (2)	
120^{o}		88 (73.3%)
122^{o}		16 (13.3%)
118^{o}		16 (13.3%)
Abduction	60 (15)	
45^{o}		64 (53.3%)
75^{o}		24 (20.0%)
60^{o}		32 (26.7%)

Applying Z test, Z= 263.15, p< 0.01

Table 2 revealed that the distance concerned was on an average of 1.03 cm in the neutral position, 1.90 cm in adduction and 0.72cm in abduction. As it was accepted that the proximal row moves as a unit in deviation movement of the wrist, it was clear that during adduction the proximal row moves laterally and in abduction it moves medially. The extent of movement was more in adduction (ie, 1.90 cm - 1.03 cm = 0.87 cm) than in abduction (ie, 1.03 cm - 0.72 cm = 0.31cm). Compared to the findings of Table 1, it can be inferred that there must be some rotation of scaphoid around the transverse axis in abduction.

Table 2: Distance between Lateral End of Scaphoid and Tip of Radial Styloid Process (n=120)

Distance (cm)	Cases (%)
Neutral	
0.8	16 (13.3)
1.3	72 (60.0)
1.0	32 (26.7)
Mean Distance (SD)	1.03 (0.25)*
Adduction	
1.8	16 (13.3)
2.0	72 (60.0)
1.9	32 (26.7)
Mean Distance (SD)	1.90 (0.10)*
Abduction	
0.4	16 (13.3)
0.7	32 (26.7)
0.8	32 (26.7)
1.0	40 (33.3)
Mean Distance (SD)	0.72 (0.66)*

* Mean distance (SD) in cm

The distance between tip of radial styloid process and base of 1st metacarpal was on an average 2.33 cm in neutral position, 3.33cm in adducted position and 1.36 cm in abducted position (Table 3).

Table 3: Measurement of the Distance between the Tip of Styloid Process of Radius and the Base of the 1st Metacarpal Bone (n=120)

Length (cm)	Cases (%)
Neutral	
2.6	72 (60.0)
2.4	32 (26.7)
2.0	16 (13.3)
Mean length (SD)	2.33 (0.30)*
Adduction	
2.8	32 (26.7)
3.2	48 (40.0)
4.0	40 (33.3)
Mean length (SD)	3.33 (0.61)*
Abduction	
1	24 (20.0)
1.5	48 (40.0)
1.6	48 (40.0)
Mean length (SD)	1.36 (0.32)*

* Mean distance (SD) in cm; Z= 263.15, p< 0.01

Therefore, the average increase in the distance in adduction was (3.33 cm- 2.33 cm) = 1cm and decrease in abduction was (2.33 cm- 1.36 cm) = 0.97 cm. It is clear that scaphoid maintains its length constant in anteroposterior (AP) view both in neutral and in adducted positions. But in abducted position the average length was reduced from 2.37cm (neutral) to 2.03cm. (abduction) ie, about (2.37cm -2.03cm) = 0.34cm (Table 4). The long axis of scaphoid was placed downwards and laterally both in neutral and adducted positions, but in abduction the long axis of scaphoid became perpendicular to the radius due to its rotation on a transverse axis to adjust the structure of carpus to allow the radial deviation of the hand.

Table 4: Measurement of the length of Scaphoid (n=120)

Length (cm)	Cases (%)
Neutral	
2.2	40 (33.3)
2.4	40 (33.3)
2.5	40 (33.3)
Mean length (cm) (SD)	2.37 (0.15)*
Adduction	
2.2	40 (33.3)
2.4	40 (33.3)
2.5	40 (33.3)
Mean length (cm) (SD)	2.37 (0.15)*
Abduction	
1.8	40 (33.3)
2.2	48 (40.0)
2.1	32 (26.7)
Mean length (cm) (SD)	2.03 (0.20)*

* Mean distance (SD) in cm

DISCUSSION

Mechanically the wrist is the most complex joint in human body and is generally considered as ellipsoid variety of biaxial joint. It has a large arc of motion, incremental adjustment capabilities and substantial resistance to forces and torques. Adduction of the hand is considerably greater than abduction perhaps due to more proximal site of ulnar styloid process and it occurs mostly at the radiocarpal joint; whereas the abduction from the neutral position occurs at the midcarpal joint, the proximal carpal row is not moving considerably.[10] The adduction / abduction movements occur around an AP axis perpendicular to the axis of the 3rd metacarpal bone if extended through the distal radius. In abduction much of the proximal articular surface of the scaphoid becomes subcapsular beneath the radial collateral ligament and forms a smooth, convex, palpable prominence in the floor of the anatomical snuff box 1. Radiographs of the abducted hand show that the capitate rotates around an AP axis while its head passes medially and the hamate conforms to this; the distance between the lunate and the apex of the hamate is increased. During abduction the scaphoid rotates around a transverse axis; its proximal articular surface moves away from the capsule to articulate solely with the radius. The scaphoid bridges the proximal and distal carpal rows and provides a functional couple between the two.[1] These abduction-adduction movements are of special functional values. The hand is commonly used with the carpus slightly extended and the forearm in midprone position. Skilled abducton- adduction movements manipulate a large variety of precision tools, from needles to hammers[2]. In the present study, a number of 120 healthy persons were studied thoroughly and 10% of them were studied radiologically and by spiral computerised tomography. The tomographic study was done to have a clear picture of the relationship of different carpal bones (of right hand) and their articular surfaces in full abduction and adduction of the wrist. The points of references of different measurements in this study were taken from the observations of previous workers. It was pointed by Henke[4] that dorsopalmar flexion and radio-ulnar devia-

tion were brought about by a combination of movements that occur either on the same direction or in opposite direction at the radiocarpal and midcarpal levels. Erdman *et al*[5] showed through stereoscopic instrumentation that very slight amount of rotation of the carpus can occur on the longitudinal axis of the forearm in dorsiflexion. Berger and Blair[6] evaluated the mechanism underlying the movement of the hand to the forearm through the use of mechanical models. Brumbaugh *et al*[7] studied the wrist kinematics in-vivo and calculated the mechanical equivalent of the radiolunate joint and lunatocapitate joint as a simple pivot located at the centre of rotation of each joint. Gellman *et al*[9] had an in-vitro analysis of wrist motion by simulating radiocarpal and intercarpal arthrodesis in 12 fresh cadavers by means of external fixation. Kauer[8] explained that palmar rotation of scaphoid suggesting a shift at the midcarpal level that is influenced by the course of the ridge between the two facets of the distal surface of scaphoid. During palmar flexion, however, as the scaphoid rotates faster than lunate, palmar part of interosseous ligament must bridge an increasing proximodistal distance between the palmar aspects of scaphoid and the lunate. In the present study insignificant movement between scaphoid and lunate was notioced. Quantitatively kinematic study of Lange *et al*[3] also supports the evidence of this minute degree of mobility. Bellinghunsen *et al*[11] demonstrated that scapholunate interosseous ligament has a shorter dorsal and a longer palmar part making the mobility of scaphoid and lunate maximum at the palmar aspect. The interosseous ligament allows these bones to move in relation to each other in a highly complex manner. From Table 2, it was evident that in adduction the proximal row moves laterally and distal row moves medially. In abduction, similarly, the proximal row moves medially and distal row, laterally. Therefore, it can be inferred that in spite of slight movements between the proximal carpal bones themselves, the row moves as a single unit in both adduction and abduction. Rybski[12] stated that during abduction or radial deviation, the proximal carpal row moves medially on the radius and radio-ulnar disc, while the distal row of carpal bones is displaced laterally. If movement occurs in a single plane (frontal), the distal row will swing radially during radial deviation to push the scaphoid into radial styloid process. The distal portion of the scaphoid rotates towards the palm and the proximal row exhibits some flexion due to the scapholunate ligament. Adduction or ulnar deviation occurs similarly, with the triquetrum moving much like the scaphoid in radial deviation. In the present study, the length of scaphoid was reduced by 0.34cm (Table 4) during abduction. When the wrist joint was examined radiologically and in spiral CT also, it was revealed that scaphoid had rotated on the palmar surface on a transverse axis to adjust the carpals to allow radial deviation of the hand. In adducton, the axis of scaphoid was directed longitudinally and in this position lunatocapitate or midcarpal movement had been eliminated. It had also been noted in the study that the trapezium (along with the base of 1st metacarpal) moved on the distal surface of scaphoid during radial and ulnar deviation. According to Rybski[12] the trapezium moves dorsally during abduction of wrist and during adduction it moves ventrally on the scaphoid. In the present study, the AP axis of distal radius during abduction and adduction of wrist was accepted to pass through the ridge on distal articular surface between the facets for lunate and scaphoid. The extent of rotation in this study was 30^{o} in adduction and also 30^{o} in abduction on an average. These values differ slightly from the findings of previous workers which may possibly be due to either the different approach of the present workers or the racial and geographical difference of the population concerned.

CONCLUSION

It was found in this study that the scaphoid acts as a link bone between the two rows of carpal bones and prevents the buckling of midcarpal joint especially of the capitato- lunate joint interface.

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