Movement of the Scaphoid in the Normal Wrist
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The radiological images of 30 normal wrists in varying degrees of radial and ulnar deviation were analysed by measuring parameters of flexion and translation of the scaphoid bone. Results demonstrated a linear relationship, indicating that movement is consistently either by flexion of the scaphoid, translation or more commonly a combination of the two. The significance of this is discussed. There did not appear to be any age or sex related differences.


There have been many theories about the movements of individual carpal bones on radial and ulnar deviation of the wrist. Classically the carpus has been divided into two rows: a distal row consisting of the hamate, capitate, trapezium and trapezoid and a proximal row consisting of the triquetrum and lunate with the scaphoid being seen as a bridge between the two sets. In this theoretical model radial and ulnar deviation of the wrist are facilitated by translation of the scaphoid in its fossa on the radius in the AP plane.

Taleisnik (1976) described the column theory proposed by Navarro in 1921. Navarro suggested that the carpus is made up of three columns: the central; the lateral; and the medial. The central consists of the lunate, capitate and hamate, the lateral of the scaphoid, trapezium and trapezoid and the medial column is formed by the triquetrum and pisiform. This theory was further modified by Taleisnik (1976) who believed that the distal row effectively acted as a single unit with the lunate. As a consequence he felt that radial and ulnar deviation only occurred when the scaphoid flexed and extended on the distal radius.

Lichtman et al. (1981) further modified the row theory when they postulated the “oval ring concept”. They thought that movement occurs between the capitate and lunate in radial and ulnar deviation as well as with flexion and extension. The scaphoid-trapezium and triquetrum-hamate joints act as physiological links that if damaged, cause abnormal movements between individual bones.

Many authors have measured the angles of the scaphoid and lunate with reference to the radius in cases of suspected carpal instability. Craigen and Stanley (1995), following a detailed analysis of 52 wrists, were able to show a spectrum of movement of the scaphoid. In some wrists the scaphoid predominantly flexed and in others it predominantly translated in its fossa. They found that women were more likely to show translation. They proposed the CR index (scaphoid length obtained in radial deviation divided by the value in ulnar deviation) as a way of quantifying these movement as well as a predictor for the success of some of the surgical procedures.

They also stated that the T index represented the amount of radioulnar deviation of the scaphoid. This ratio is the distance between the ulnarmost point of the proximal pole to a line parallel to the axis of the distal radius, tangential to the lateral edge of the radial styloid process in ulnar deviation, divided by the distance obtained in radial deviation (Fig 1).

Garcia-Elias et al. (1995) compared patients with lux wrists and normal volunteers and found that in the former the scaphoid rotated more, that is flexed more than in the controls. They also described a measurement, the scaphoid-flexion index (SFI) to quantify this movement.

It seems that there is a spectrum of movements of the scaphoid, in at least two, and probably three planes but a number of questions remain to be answered. What is the range? Is it linear? Does the scaphoid behave differently in varying positions of radial and ulnar deviation? Do these movements change with age and sex? What are the normal variations? The last may well be important for diagnostic and therapeutic reasons. We report a study designed to answer these questions.

SUBJECTS AND METHOD

Thirty patients undergoing radiological screening and arthroscopy as part of the investigation of wrist pain underwent fluoroscopy of the contralateral asymptomatic side. With the arm abducted, the elbow at 90° and the
forearm in neutral, the wrist was centred over the X-ray tube. The wrist was then moved slowly from the extreme of radial to ulnar deviation whilst a video recording was obtained. In addition a minimum of 12 black and white prints were taken, with the wrist in various positions of radial and ulnar deviation. The central long axis of the radial shaft was determined using the technique of Kreder et al (1996). The central long axis of the middle metacarpal was also obtained. The angle formed between these two axes was measured on each radiograph. If the angle deviated toward the ulna it was deemed to be positive and radial deviation was negative (Fig 1).

The prints of each wrist were digitized at a resolution of 200 dpi. Scaphoid length (S) and radial-ulnar deviation (RUD) distance were measured using the method of Craigen and Stanley (1995). CR and T indices were calculated using the method described by the same authors. In addition the S and RUD lengths were plotted against the deviation angle and a regression line was drawn using the least squares method. The length of the middle metacarpal was used to check for variation in radiograph magnification.

RESULTS
CR and T indices

The Pearson product moment correlation coefficient of the CR and T indices for all 30 wrists was r=0.39 (P<0.05) that indicates a linear association between the two indices. The CR index was then plotted from the highest CR value (row wrist) to the lowest (column wrist) together with the respective T value for each wrist (Fig 2). It can be seen that there is wide variation in T values for the row region of this scatterplot. The effect of this variation is to blur the distinction between row and column wrists above a CR value of 0.8.

Movement equations

Twenty-six of 30 wrists had significant (P<0.05) linear scaphoid movement equations. The mean (SD) slope of S length was 0.06 (0.02) with a mean (SD) intercept of 18.4 (2.7). The average rate of change in S length was 0.06 mm/degree deviation.

All wrists had significant (P<0.05) linear radioulnar deviation (RUD) movement equations. The mean (SD) slope of RUD length was −0.08 (0.02) with a mean (SD) intercept of 16.4 (2.1). The average rate of change in RUD length was 0.08 mm/degree deviation. The row wrist presented in Figure 3 had a zero S slope. There was no shortening of the scaphoid at any deviation angle. The rate of change of RUD was very high at −0.15 mm/degree deviation.

The plot in Figure 4 is of a column wrist. In this case the S slope had a high value of 0.10 mm/degree and the RUD slope a low value of −0.03 mm/degree. However,
both S and RUD slopes indicate that the scaphoid is moving in both frontal and sagittal planes.

The correlation between S slope and CR index was \(-0.87\) \((P<0.001)\) and between the RUD slope and T index was \(0.78\) \((P<0.001)\), indicating that each index has a straight line relationship with its respective rate of change in scaphoid movement.

**Comparisons between different age groups and sexes.**

t-tests indicated that there were no significant differences between rates of change in S length between those older or younger than 30 years or in the two sexes.

**DISCUSSION**

This work confirms that there is a spectrum of movements of the scaphoid in two planes. More specifically the scaphoid can either flex, translate or supinate on the radius, or more commonly move by combination of two or three of these during radial and ulnar deviation. This has been reported previously by both Craigen and Stanley (1995) and Garcia-Elias et al (1995). However, this study has shown for the first time that the change in scaphoid shortening and/or translation is linear for individual wrists, indicating that the pattern of movement of an individual scaphoid is uniform through all planes of radial and ulnar deviation. In addition, although the CR index can determine wrist type (row or column) the correlation is less clear for values above 0.8. At present the reasons for this are unclear. Also in contrast to Craigen and Stanley (1995), we would concur with Garcia-Elias et al (1995) in that there did not appear to be sex or age related differences in any of the calculated values.

What is the clinical relevance of these findings? It would seem that wrists do not have an ability to compensate and thus regain radial and ulnar deviation when one of the planes of scaphoid movement has been lost. This may account for some unexpected loss of movement following various surgical procedures. For example, a scaphoid-trapezoid-trapezium fusion undertaken in a column type wrist will result in greater loss of movement than in a row wrist.

The authors acknowledge the limitations of this work, in particular that it is a two-dimensional evaluation of what is a three-dimensional process. However, the work was done in vivo and has the advantage of being easily reproducible.

**REFERENCES**


