The congruence of the distal radioulnar joint

A magnetic resonance imaging study

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The functional anatomy of the distal radioulnar joint was studied in 10 healthy volunteers. The joint surfaces of both the ulnar head and the sigmoid notch of the radius form arcs of circles with small areas of contact because the diameters of the circles are different. The distal radioulnar joint is congruent throughout its range of motion, but the area of contact shifts from dorsal in the sigmoid notch in pronation to volar in supination. The insertion of the distal radioulnar ligaments on the ulnar head explains the congruence of the joint.

Most previous investigations of the distal radioulnar joint have been performed by dissection (af Ekenstam and Hagert 1985 a, b, Lippman 1937, Palmer 1984, Spinner and Kaplan 1970). We have analyzed the relationship between the radius and ulna in this joint during forearm rotation with the aid of magnetic resonance tomography in normal living subjects.

Subjects and methods

The study was carried out in 10 healthy volunteers – 5 men and 5 women, aged 25 to 62 years. The MR examinations were performed with a superconductive 0.5 T apparatus (Magnetom, Siemens). A cylindric coil with a diameter of 12 cm was used. Spin-echo technique with single echoes was applied, with a repetition time (TR) of 500 ms and an echo time (TE) of 30 ms. The slice thickness was 3 mm and the examinations were carried out in the axial plane. The matrix size was 256 × 256.

The subject was placed prone on the examination table with one arm extended above the head and placed in the coil. The forearm was firmly fixed inside the coil using soft padding material. Care was taken to place the center slice in the middle of the distal radioulnar joint. Images were obtained with the forearm in pronation, neutral position, and supination. Drawings of the contours of the radius and the ulna on all the images were made on transparent paper as described by Cone et al. (1983). For each subject the drawings of the three rotational positions of the forearm were oriented to show the radius rotating around the ulna.

With the aid of a computer, a circle was fitted over the image of the ulna and adjusted to concentricity with the outline of the ulnar head, which is an arc of a true circle. The distances from the center of this circle – i.e., the center of motion of the joint to the volar and dorsal aspects of the sigmoid notch – were recorded.

For each individual the linear regression of the volar and dorsal distances in relation to forearm rotation was calculated. The null hypothesis was that these distances did not differ with forearm rotation. The Student's *t*-test was used.

Results

The area of contact between the joint surfaces of the ulna and radius is very small (Figure 1). The joint surfaces of both the ulnar head and the sigmoid notch of the radius form sectors of circles with the former much smaller than the latter. These two circles are not concentric. From the superimposed drawings of the contours of the two

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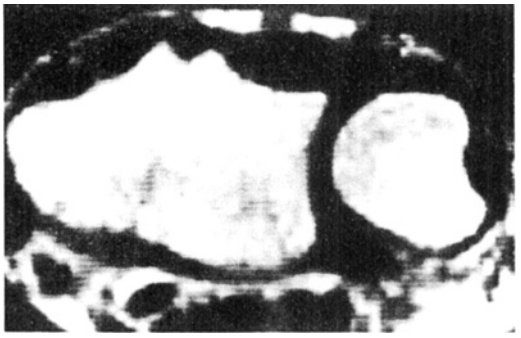

Figure 1. Magnetic resonance image of a cross section of the distal radioulnar joint. The joint surfaces of the ulnar head and the sigmoid notch of the radius are sectors of circles. Note the difference in size between these two circles, and also the lack of concentricity.

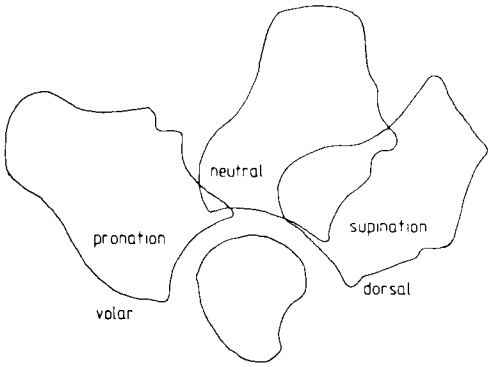

Figure 2. Drawings of the contours of the bones were made on transparent paper. When the drawings are superimposed with the contours of the ulna corresponding, congruence of the joint surfaces is apparent, with the area of contact located dorsally in pronation and volarly in supination.

bones, it was seen that the radius moves congruently around the ulnar head throughout its range of motion (Figure 2). The motion occurs around an axis placed at the midpoint of a circle that fits the joint surface of the ulnar head. It was also noted that the area of contact moved during motion, i.e., the radius must also perform a gliding motion against the ulnar head. With the forearm in pronation the area of contact was in the dorsal part of the sigmoid notch, and in supination it was in the volar part.

The distance from the midpoint of the circle that fits over the joint surface of the ulnar head to the volar aspect of the sigmoid notch decreased as the forearm was rotated from pronation to supination, whereas the corresponding distance to the dorsal aspect of the sigmoid notch increased during the same forearm rotation (Table 1).

Table 1. The distances from the center of motion in the distal radioulnar joint to the volar and dorsal borders of the radial joint surface respectively. Values are mean (SD) mm

Distance	Pronation	Neutral	Supination
Volar	13.6 (1.5)	13.2 (1.7)	12.3 (2.1)
Dorsal	12.7 (1.7)	13.9 (1.3)	14.9 (1.4)

Discussion

The distal radioulnar joint has a lax capsule. Stabilization is provided by the distally located triangular fibrocartilage and the volar and dorsal ligaments (Lippman 1937, Palmer 1984, Rose-Innes 1960).

Functionally, the joint has been thoroughly investigated in cadaver or amputation specimens. Various interpretations of the functional anatomy, several of which are contradictory, have been presented. Our observations confirm Lippman's (1937) claim that the radius rotates around the ulna. He postulated that the volar radioulnar ligament becomes stretched in supination and slack in pronation, and the dorsal ligaments having opposite function. Similar findings have been made by Rose-Innes (1960). However, we have not found any evidence of this slacking and stretching of ligaments, and we do not believe in this concept. We suggest that the ligaments of the ulnar head act as reins, probably with the same tension throughout the entire range of motion. During forearm rotation the radius moves as in Figure 3. Af Ekenstam and Hagert (1985 a, b) described the circular appearance of the ulnar head and the sigmoid notch of the radius. They also recognized the difference in diameter between these two circles and the lack of concentricity. In accordance with Palmer et al. (1982) and Cone et al. (1983), they observed that the area of contact between the radius and ulna shifted during motion, being dorsal in pronation and volar in supination. This finding was also confirmed in our study.

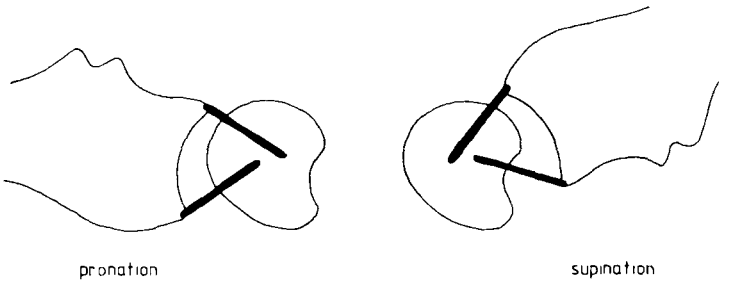

Figure 3. Our hypothesis of the functional anatomy: The insertion of the volar and dorsal ligaments of the triangular fibrocartilage occupy a certain area of the ulnar head not corresponding to the center of motion. This configuration forces the dorsal aspect of the sigmoid notch closer to the ulnar head in pronation and the volar aspect closer in supination.

In addition to the rotation, there is also a simultaneous pistonlike motion of the radius from a distal position in supination to a proximal one in pronation (Epner et al. 1982, Palmer et al. 1982), which is, however, not possible to investigate with our technique.

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