Introduction

Advances in imaging and arthroscopy have shown ligamentous injury to the triangular fibrocartilage complex (TFCC) to be functionally limiting and a common cause of ulnar sided wrist pain. Despite these advances, there is still much debate about the in vivo biomechanics of both the uninjured and the injured wrist with respect to distal radial ulnar joint (DRUJ) stability in pronation and supination.

Histologic studies have shown that both the dorsal and volar radioulnar ligaments (DRUL and VRUL) of the TFCC can be further subdivided into deep and superficial bundles. Many studies have looked at the relative contributions of the deep and superficial portions of the DRUL and VRUL to DRUJ stability and have reached seemingly opposing conclusions about their functions. Some studies have reported a reciprocal function of these bundles, where the superficial volar and deep dorsal RULs are loaded in supination, and the superficial dorsal and deep volar RULs are loaded in pronation. Other studies have reported no reciprocal function of the bundles. However, there is limited data on the function of these ligaments under in vivo loading conditions. The objective of this study was to analyze in vivo ligament deformations of the RUL bundles in the uninjured wrist using 3T MRI and biplanar fluoroscopy. Additionally, the congruity of the DRUJ as a function of wrist rotation was also analyzed. We hypothesized that both the deep and superficial volar fibers are loaded in supination while the deep and superficial dorsal fibers are loaded in pronation. We also hypothesized that the DRUJ is most congruous in a somewhat supinated position.

Materials and Methods

Fourteen wrists from seven subjects with no history of ulna or radius fracture or DRUJ injury (6 male, 1 female, age 24-38) were included in this study. First, MR images were acquired using a 3.0T magnet (Tim, Siemens, Germany), an 8-channel wrist coil (Invivo, Orlando, FL), and a coronal SPACE sequence (flip angle: 40º, echo time: 15ms, repetition time: 5ms) with an isotropic voxel size of 0.3mm. Images were imported to a solid modeling program (Rhino, McNeel, Seattle, WA) where the outlines of the radius and ulna were traced in each slice to create virtual 3-D bone models. In addition, the ulnar and radial attachment sites of the RULs were traced in each slice, combined to form surfaces, and divided to model the attachment sites of the deep and superficial bundles of both the dorsal and volar RULs.

Both wrists of each subject were imaged using two orthogonally aligned fluoroscopes (Pulsera, Philips, The Netherlands) at seven positions of wrist rotation ranging from full pronation (Pro) to full supination (Sup). This was repeated while grasping a 5lb dumbbell at both deep and superficial volar and dorsal RULs were loaded in supination, and the superficial dorsal and deep volar RULs were loaded in pronation. These results agree with previous cadaveric work, which showed that contact area was maximized in supination. In slight supination, the ulnar head is well centered in the sigmoid notch of the radius, which is likely to be a low strain position for the RULs. This study also suggests that the optimal position to maximize DRUJ congruity is 20±5º of supination. These results bring into question the reciprocal loading hypothesis by showing increased ligament lengths in both volar bundles in supination and in both dorsal ligaments in pronation. This data provides important insight into the function of these critical stabilizers of the DRUJ. In addition, this study also suggests that the optimal position to minimize DRUJ congruity is 20±5º of supination. This study used a novel, in vivo means of analyzing the biomechanics of the DRUJ ligaments. The results bring into question the reciprocal loading hypothesis by showing increased ligament lengths in both volar bundles in supination and in both dorsal ligaments in pronation. This data provides important insight into the function of these critical stabilizers of the DRUJ. In addition, this study also suggests that the optimal position to minimize DRUJ congruity is 20±5º of supination. This study used a novel, in vivo means of analyzing the biomechanics of the DRUJ ligaments. The results bring into question the reciprocal loading hypothesis by showing increased ligament lengths in both volar bundles in supination and in both dorsal ligaments in pronation. This data provides important insight into the function of these critical stabilizers of the DRUJ. In addition, this study also suggests that the optimal position to minimize DRUJ congruity is 20±5º of supination.