“DART THROWER’S” WRIST MOTION IS ACHIEVED IN VIVO WITH MINIMAL RADIOCARPAL MOTION

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INTRODUCTION: Wrist motion is typically described by rotations of flexion/extension (F/E) and radial/ulnar deviation (R/U) that occur about two anatomical, orthogonal axes. While describing wrist motion as two independent rotations is convenient, most daily activities require motions that are a combination of these two rotations [1,2]. The most common wrist motion is the “dart thrower’s” motion, which occurs when the wrist is moved back and forth from a position of extension and radial deviation to a position of flexion and ulnar deviation, essentially a motion that is diagonal to the anatomical axes. This motion is used for activities that require control, such as fly-fishing casting, as well as high demand activities that require maximum grip strength, such as hammering.

All wrist motions are accomplished through the complex articulations of the eight carpal bones of the carpus, which are controlled passively by their articular shapes and ligamentous structures, since there are no substantial muscle insertions on them. The two primary articulations of the carpus are the midcarpal (scapho-luno-capitate) joint and the radiocarpal (radio-scapho-lunate) joint.

The purpose of this study was to determine the 3-D in vivo kinematics of the radiocarpal joint throughout the entire range of wrist motion and to test the hypothesis that the dart thrower’s motion is achieved almost entirely through the midcarpal joint and only minimally through the radiocarpal joint.

METHODS: The 3-D kinematics of the capitate, scaphoid and lunate were measured in vivo at a total of 481 wrist positions in both wrists of 14 male (25.6 years; range 22-34), and 14 female (23.6 years; range 21-28) healthy subjects using CT volume images and established segmentation and registration procedures for markerless tracking [3]. Subjects were enrolled into the study after informed consent and approval by the IRB. Carpal kinematics were calculated relative to the radius and with respect to neutral. Global wrist rotation was defined by the calculated rotation of the capitate. Kinematics were described using helical axis of motion variables: rotation about and translation along a unique axis in 3-D space.

Scaphoid and lunate kinematics (dependent variables) were analyzed as a function of wrist rotation (independent variables). We tested our hypothesis in several steps: 1) determining if carpal bone rotation was a linear function of wrist flexion/extension and ulnar/radial deviation rotation, 2) finding a 3-D best-fit plane to carpal bone rotation as a function of wrist flexion/extension and ulnar/radial rotation, and 3) determining if the orientation this plane was dependent on wrist rotation.

RESULTS: Scaphoid and lunate rotations reached minimum values during the dart thrower’s wrist motion (approximately 45° to the principal anatomical axes) and were different (P < 0.01 for both carpal bones) from the rotations that occurred during wrist F/E and R/U (Figure 1). This behavior was independent of gender and varied linearly with wrist F/E and R/U across all subjects (RMS errors for the best-fit planes to scaphoid and lunate rotation as a function of wrist rotation were 6.6° and 6.9°). For all wrist motions, the scaphoid and lunate rotated either in flexion or in extension; their rotation axes were consistently oriented in a flexion/extension direction (s.d. 18° and 21°). Neither carpal bone rotated in radial or ulnar deviation for any wrist motion. The scaphoid and lunate translated radially 1.5 ± 0.9 mm and 1.3 ± 0.9 mm when they extended, but only 0.5 ± 0.4 mm and 0.5 ± 0.4 mm when they flexed.

DISCUSSION: In vivo kinematic analysis of 28 healthy individuals demonstrated that the dart thrower’s wrist motion is achieved with minimal radiocarpal motion. A recent cadaveric study examined various dart thrower’s motions and suggested that there may be a motion associated with minimal scaphoid and lunate motion [4]. Our data confirms this but further indicates that the dart thrower’s motion occurs with almost no radiocarpal motion. This becomes clinically important when designing specific postoperative rehabilitation protocols that may require limitations in radiocarpal motion.

These findings provide new fundamental insight into the in vivo mechanics of the carpus and suggest that the dart thrower’s wrist motion is used in both fine motor activities and high demand tasks is accomplished with maximal radiocarpal stability (i.e. minimal motion).


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