SCAPHOID AND LUNATE ROTATIONS ARE MINIMIZED WITH WRIST MOTION ALONG THE DART THROWER'S PATH: IMPLICATIONS FOR STABILITY IN HIGH-DEMAND TASKS

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INTRODUCTION

The radiocarpal joint (radio-scapho-lunate articulation) is responsible for as much as 85% of overall wrist motion, depending on direction the wrist is moved in [3]. However, there appear to be directions of wrist motion where radiocarpal motion is significantly reduced [2,4]. An interesting example is the "dart thrower's" motion, which involves movement of the wrist from a position of combined extension and radial deviation (radial extension) to a position of combined flexion and ulnar deviation (ulnar flexion). The dart thrower's motion is used for activities that require fine control, such as fly casting, as well as high-demand activities that require maximal grip and stability, such as hammering. This study was performed to explore possible motion minima in the 3-D kinematics of the radiocarpal joint *in vivo*, throughout the entire range of wrist motion.

METHODS

The 3-D kinematics of the capitate, scaphoid and lunate were measured *in vivo* in both wrists of 14 male (25.6 years; range 22-34), and 14 female (23.6 years; range 21-28) healthy volunteers using CT volume images of 481 static wrist positions and established segmentation and registration procedures for markerless bone tracking [1]. This study was approved by the IRB and all volunteers were enrolled after informed consent. Carpal kinematics were calculated relative to the radius, with respect to the neutral wrist position, and described using helical axis of motion variables. Multiple linear regression was used to analyze carpal rotation as a function of wrist position.

RESULTS AND DISCUSSION

For all wrist positions, regardless of direction, the scaphoid (Fig. 1) and lunate rotated primarily in flexion or in extension. Scaphoid and lunate rotations and translations were minimized *only* at wrist positions along the path of the dart thrower's motion (Fig. 1, dashed line). This behavior was independent of gender and was consistent across all subjects (RMS errors of scaphoid and lunate rotation as a function of wrist rotation were 6.6° and 6.9°). 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.

CONCLUSIONS

Using the largest database of subjects and wrist positions to date, we found that the kinematics of the radiocarpal joint is dominated by flexion and extension rotations of the scaphoid and lunate, regardless of the direction of wrist motion. We also found that radiocarpal motion was *uniquely* minimal only along the path of the dart thrower's motion. It is unclear why wrist motion along this path is shifted to the midcarpal joint (esp. scaphocapitate and lunocapitate), but it is consistent with the unique functional importance of this motion which is used for both low and high demand activities that require exquisite control and stability.

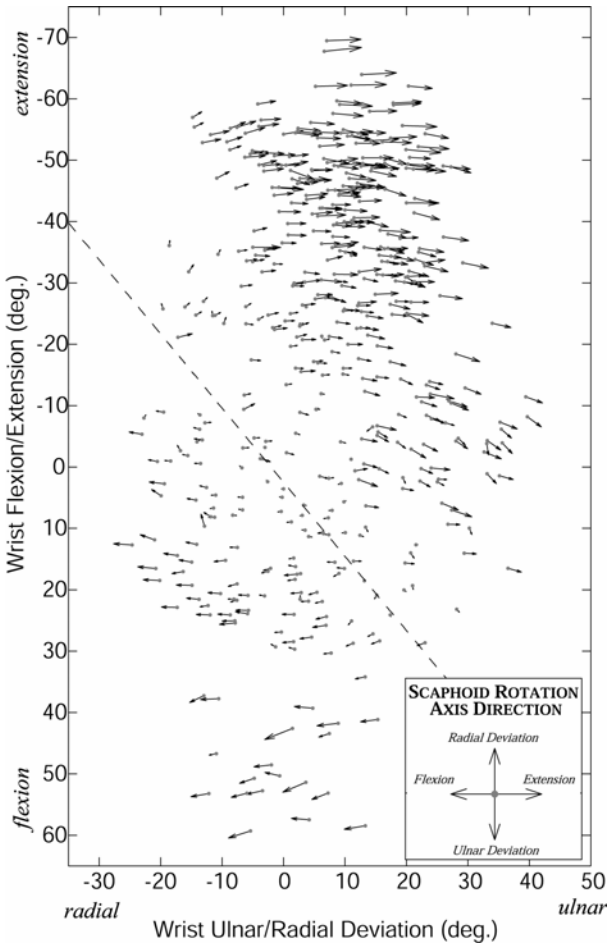

Figure 1: The scaphoid rotation axes (see legend) were almost exclusively in the flexion-extension direction for all wrist positions. The dart thrower's path of motion (dashed line) differentiated wrist positions at which the scaphoid flexed from those at which it extended. Scaphoid rotation values near this path approached zero (the length of each vector is a measure of the magnitude of scaphoid rotation).

REFERENCES

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ACKNOWLEDGEMENTS: Funded by NIH AR044005