ANALYSIS OF COMPLEX *IN-VIVO* CARPAL BONE MOTIONS

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INTRODUCTION

Many common musculoskeletal disorders affect the wrist joint. An understanding of both asymptomatic and symptomatic wrist motion is required to design effective treatments for these disorders. Unfortunately the *in-vivo* three-dimensional kinematics of the wrist in pathological conditions is poorly understood. Recently some researchers have developed novel methods to examine carpal bone kinematics from CT images [1-5]. However so far researchers have applied these methods only to simple flexion-extension or radial-ulnar deviation motions[4-8]. In this study, we studied complex carpal bone motions for one normal subject.

METHODS

A healthy left wrist from a 48 year old female was CT scanned in three positions: the clinical neutral position of the forearm, the pronated and maximum extended wrist posture, and the supinated and maximum flexed wrist posture. The scans were obtained using a GE8800 scanner at 120kV and 40mA. The voxel size was 0.234mm X 0.234mm X 1.0mm. Each carpal bone as well as the radius and ulna were volumetrically separated. Proprietary software based on the marching cubes algorithm was used to produce three-dimensional reconstructions of each bone. The radius bones from each posture were aligned to remove any errors introduced by movement of the patient's forearm between CT scans. Principal axes registration methods developed by Upal *et al* [3] were used to quantify the carpal bone kinematics. Helical axis parameters were used for the motion analysis.

RESULTS AND DISCUSSION

In-vivo carpal bone kinematics during complex wrist movements differed from the previously studied simple motions. For example, previous studies have found that the primary motion of the capitate follows the global motion of the wrist during simple wrist flexion-extension [5-7]. Surprisingly for the complex pronation and extension motion, the capitate rotated ulnarly out of the plane of motion. The only previous study of pisiform motion has shown that during flexion-extension the pisiform moves in the plane of motion [8]. However during pronation and extension, the pisiform rotated ulnarly; while in flexion and supination, the rotation was a combination of flexion and supination. As well the trapezium and trapezoid did not rotate together as one unit. In addition, during combined flexion and supination, the carpal bones followed the global wrist joint motion more closely than during combined extension and pronation.

Although these findings provide grounds to question previous carpal bone kinematics theories, much more research is required to understand the causal mechanisms and to develop the framework needed to design effective treatments for wrist joint disorders.

REFERENCES

1. Belsole RJ, Hilbelink DR, Llewellyn JA, Dale M, Ogden JA. *Mathematical analysis of computer carpal models*. Journal of Othopaedic Research 1988; 6(1): 116-122.
2. Crisco JJ, McGovern RD, Wolfe SW. *Noninvasive technique for measuring in vivo three-dimensional carpal bone kinematics.* Journal of Orthopaedic Research 1999; 17(1); 96-100.
3. Bulow H, Dooley L, Wermser D. *Application of principal axes for registration of NMR image sequences.* Pattern Recognition Letters. 2000;21:329-336.
4. Upal MA, Small C, Sellens R, and Pichora D. *Carpal bone and ligament kinematics from CT and MR data*. WCB, 2002, Calgary.
5. Fiepel V, Rooze M. *Three-dimensional motion patterns of the carpal bones: an in-vivo study using three-dimensional computed tomography and clinical applications.* Surgical & Radiologic Anatomy. 1999;21(2):165-170.

6. Wolfe SW, Neu C, Crisco JJ. *In vivo scaphoid, lunate, and capitate kinematics in flexion and extension*. Journal of Hand Surgery – American Volume. 2000 Sep; 25(5):860-869.
7. Neu CP, Crisco JJ, Wolfe SW. *In vivo kinematic behavior of the radio-capitate joint during wrist flexion-extension and radio-ulnar deviation.* Journal of Biomechanics. 2001 Nov; 34(11):1429-1438.
8. Moojen TM, Snel JG, Ritt MJ, Venema HW, den Heeten GJ, Bos KE. *Pisiform kinematics in-vivo*. Journal of Hand Surgery – American Volume. 2001 Sep; 26(5):901-907.