

DYNAMIC VS. QUASI-DYNAMIC IN-VIVO CARPAL BONE KINEMATICS DURING FLEXION-EXTENSION AND RADIO-ULNAR DEVIATION OF THE WRIST

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INTRODUCTION

An in vivo approach to measurement of 3D motion patterns of carpal bones in the wrist may have future diagnostic applications, particularly following ligament injuries that do not present with obvious carpal malalignment in static images. Although in vivo carpal kinematics (i.e. translation and rotation parameters of each bone) can be measured by the use of quasi-dynamic methods, these methods only provide an approximation of the true in vivo kinematics of the carpal bones. To study whether the dynamically acquired kinematics differ from quasi dynamic acquired carpal motions, dynamically and quasi-dynamically acquired scans of the wrist were obtained during wrist flexion-extension and radio-ulnar deviation.

METHODS

For eight healthy subjects, a quasi-dynamic and a dynamic measurement of carpal kinematics was done for a flexion-extension and a radial-ulnar deviation movement. Dynamic scans were acquired by using the recently developed 4 dimensional x-ray imaging system (4D-RX) which allows us to acquire in vivo kinematic data [1,2]. Participants were scanned during an imposed cyclic motion of the wrist using the 4D-RX method. To assess quasi-dynamic images of the wrists stepwise static 3 Dimensional rotational X-ray scans were obtained during flexion extension motion and radial-ulnar deviation. To investigate the differences between the dynamically and quasi-dynamically acquired kinematics, the differences of the actual helical rotations and the X-, Y- and Z- components of the attitude vector at every 5 degrees of global wrist motion, were defined as the primary outcome values. Linear mixed model statistical analysis was used to compare the differences between the dynamic and quasi-dynamic measurements.

RESULTS AND DISCUSSION

In figure 1 the rotation components of the Scaphoid and Lunate during the radioulnar deviation of one subject are displayed as a function of the global wrist motion (Y-rotation component of the capitate). During flexion and extension there was significant difference between the dynamically and

quasi-dynamically acquired rotations (0.82 degrees (95% CI: 0.14:1.47, P=0.018)).

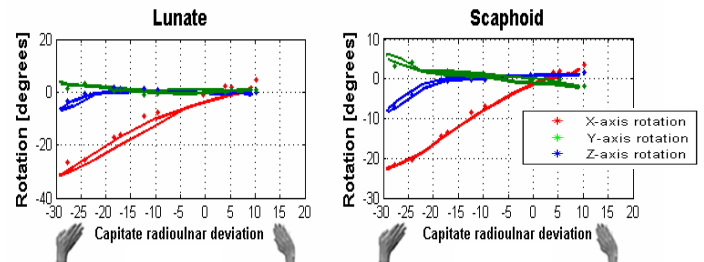


Figure 1: Rotation components of the Scaphoid and Lunate during the radioulnar deviation of one subject. Rotations are displayed as a function of the global wrist motion (Y-rotation component of the capitate). Dynamically acquired rotations are plotted as lines while the static measurements are marked by dots.

CONCLUSIONS

Small significant differences were observed between the dynamic scans and wrists scanned during a quasi-dynamic motion which were more distinct during the flexion and extension. The average difference between both methods was less than 1 degree of rotation. The conclusion of this study is that in the case of individuals without any pathology of the wrist, carpal kinematics can be studied either dynamically or quasi-dynamically. In vivo dynamically acquired carpal kinematics can reveal typical dynamic carpal derangements seen during the provocative manoeuvres. Therefore, further research is required to investigate the dynamic in vivo carpal kinematics in patients with dynamic wrist problems.

With an acquisition time of 80 seconds and an acceptable radiation dose of 0.026 mSv for each scan, the 4D-RX method is a safe and suitable *in vivo* method for investigation of the relationship between carpal motion patterns and wrist joint pathology.

REFERENCES

1. Carelsen, B, et al. IEEE Trans Biomed Eng. 2008 Dec 9. [Epub ahead of print]
2. Carelsen, B., et al., Med.Phys. **32**, 2771-2776, 2005.

Table 1: Mean helical rotation difference between the dynamically and quasi dynamically acquired kinematics during flexion extension and radioulnar deviation.

	Mean difference [°]	Std. Error [°]	95% Confidence Interval [°]	P-value
Flexion Extension	0.82	0.34	0.14 : 1.47	0.018
Radio-ulnar deviation	-0.19	0.17	-0.52 : 0.14	0.252