IN VIVO KINEMATICS OF HUMAN WRIST JOINTS: COMBINATION OF MEDICAL IMAGING AND THREE-DIMENSIONAL ELECTROGONIOMETRY.

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INTRODUCTION

This paper described improvement of previous work [1] that allowed registration of both joint kinematics and medical imaging during in-vitro experiments. In that study, joint kinematics data were collected from three-dimensional (3D) electrogoniometry [2,3] and 3D bone morphological data from CT using inserted fiducial bony landmarks for registration. In parallel, Snel et al. [4] described an in-vivo method to study discrete wrist kinematics using dynamic 3D tomography.
The aim of this study was to develop a protocol of registration of in-vivo wrist kinematics using selected anatomical landmarks virtually and manually identified on both CT reconstruction and in situ.

METHODS

Subject. One subject (male, 50 years old) volunteered for the entire protocol.
Principle. The aim of the overall protocol was to register two datasets: bone morphology from medical imaging (Siemens SOMATON Volume Zoom, Siemens Corp, Iselin, N.J.) and joint kinematics data from custom made electrogoniometry. Anatomical landmark (AL) location allowed this registration. Prior to 3D electrogoniometry (3DE), the 15 ALs selected in the method were virtually identified (palpated) on the 3D reconstructed bone surface of the subject. From this virtual palpation, a booklet was produced with various views of the virtual ALs to facilitate AL representation during manual palpation. The spatial location of the same bony ALs was determined using a 3D digitizer (Faro® arm, Bronze series, USA) just before collecting joint kinematics data by 3DE on the subject.
The origins of 3D digitizer and 3DE coordinate systems were made coincident. Joint kinematics collected using the 3DE could then be registered to the 3D bone models using the AL coordinated obtained during both virtual and manual palpation. The protocol has been fully implemented in Matlab and allows quasi real-time visualization of joint motion of the subject while the latter is performing the motion. Anatomical angle and helical axis parameters were computed to describe the joint kinematics.
Precision. The precision of the manual palpation was evaluated by four experimenters repeating five times the procedure and estimated by the error norm. The palpation effect was also estimated on the anatomical angular and translational values calculated during dorsopalmar flexion, radioulnar deviation and circumduction. The intraobserver precision was 2.6 (0.3) mm and 4.8 (1.2) mm for interobserver precision. The ICC for intra- and interobservation was greater than 0.95.

RESULTS AND DISCUSSION

A view of animation is presented on Figure 1 with a set of Mean Helical Axis computed during the movement.

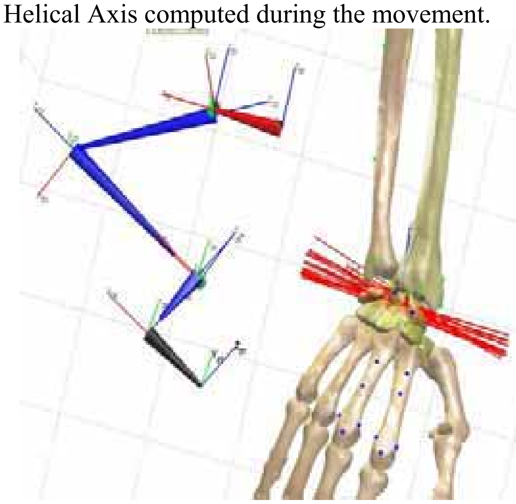

Figure 1: View of the animation. In red, the set of Mean Helical Axis during dorsopalmar flexion. The virtual representation of 3DE is also shown.

The propagation of the palpation error on anatomical angles and translation was less than 2° and 5 mm for the primary component of movement. For associated components, error curves showed some patterns underlying a "cross-talk" effect induced by the different definitions of the fixed anatomical coordinate system

DISCUSSION

A new protocol of in-vivo registration was developed. This animation of wrist kinematics helps us to better understand several kinematical parameters as orientation and position of helical axis. Precisions of our measurements are better than those shown by Della Croce [5]. This was probably due to the availability of the booklet describing manual palpation precisely, and allowing the observer to reach a higher precision.
Before proposing this technique in clinics, a study of the influence of imaging parameters on the 3D bone reconstruction quality must be done to reduce the effective dose absorbed by the subject.

REFERENCES

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