

UPPER CERVICAL SPINE MODELLING: *IN-VITRO* 3D KINEMATICS

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INTRODUCTION

For the global kinematics of the cervical spine, the upper cervical spine plays a considerable role for maintaining the head in the horizontal plane or for compensating coupling motion occurring at cervical lower segments. Presently, for a better understanding of human biomechanics, procedures using computerized human models have been implemented to analyze the structural mechanics of the human body in attempt to obtain accurate virtual models [1,2,3]. The aims of this study are to develop a standardized protocol for analyzing the *in-vitro* kinematics of the upper cervical spine, and to combine individual kinematics data with anatomical data for 3D bone modelling and simulation.

METHODS

Specimens were sampled from donors and processed according to strict ethical regulations. Medical imaging was acquired by computed tomography (Siemens SOMATOM) in neutral position for nine specimens. Individual morphometric data were extracted for each osseous segment. 3D reconstruction was performed after object segmentation and identification using Amira® (Germany). For each specimen, the lower cervical segments and related soft tissues were removed as well as the mandible and anterior neck viscera. The upper cervical segments and their ligaments, suboccipital muscles and fascias were kept intact. Fiducial markers (Fidm) (aluminium balls: Ø 4mm) were placed on the atlas, axis and skull (figure 1). Using a 3-D digitizer (Faro® arm, model 08 Bronze, USA), each Fidm was identified in 5 successive specimen positions of each flexion-extension and axial rotation. For each bone, a local reference system was defined using anatomical landmarks according to the International Society of Biomechanics recommendations [4]. For each vertebral displacement, rotation and translation were computed according to anatomical axis (x,y,z). Helical axis orientation and location were also computed and implemented in kinematics models (figure 2).

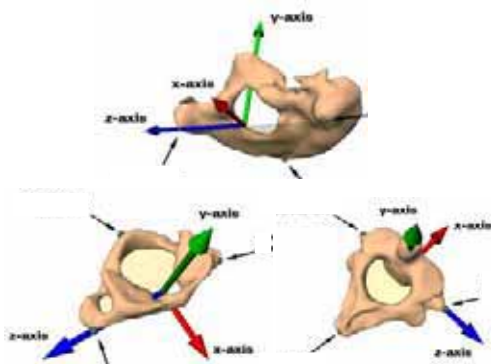


Figure 1: Anatomical landmarks and local reference system of the occipital bone.

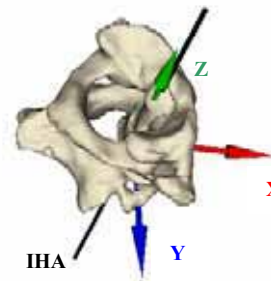


Figure 2: Kinematics model and instantaneous helical axis (IHA) during axial rotation at C1-C2 level

RESULTS

The different steps of this protocol for combining morphological data and interpolation of kinematics data from discrete positions were carried out using a validated registration method². Moreover, a reliability study performed for anatomical and metallic marker digitizing demonstrated good reproducibility of the 3D digitizing. For each specimen, different kinematics patterns were observed, although primary motion was similar (figure 3).

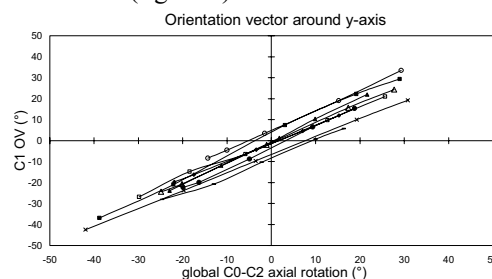


Figure 3: Axial rotation of C1 on C2 (orientation vector, OV) as a function of global C0-C2 movement for each specimen.

DISCUSSION

Considering the presence of surrounding tissues (muscle, fascia) our results are comparable to those found in the literature for the global range of movement as well as for motion patterns. Sampling of human morphological data and modelling represents a significant source of information in the understanding of the biomechanical processes. Such validated models are also needed in the field of advanced care and health knowledge. Moreover, combining *in vitro* and *in vivo* data analysis of the normal mechanical behaviours of the musculoskeletal system would provide the design of specific biomechanical models for understanding of pathogenic functional mechanisms of the upper cervical spine.

REFERENCE

1. Hilal I, PhD Thesis, Université de Rennes I, 2000.
2. Van Sint Jan S et al. J Biomech, 2002, 1475-1484
3. Vasavada AN, Spine 1998, 412-422.
4. Wu G, J Biomech, 2002, 35, 543-548.