3D ARTHROKINEMATIC ANALYSIS OF COUPLED MOTION IN THE HUMAN UPPER-CERVICAL SPINE: IN VITRO ANALYSIS OF HIGH VELOCITY THRUST TECHNIQUES

Cattrysse Erik, Baeyens Jean-Pierre, Clarys Jan-Pieter, Van Roy Peter
Dep. Experimental Anatomy, Vrije Universiteit Brussel, Brussels, Belgium
ecattrys@vub.ac.be

INTRODUCTION

Three dimensional analysis of coupled segmental motions in the cervical spine was only studied sparsely and in pure moment analysis. Only preliminary information exists on the kinematics of manual segmental mobilization. The present study focuses on the in vitro registration of upper cervical segmental coupled motions during manually performed therapeutic high velocity thrust techniques (HVT). The aim of the study was to collect qualitative information on the kinematics behavior of the upper-cervical spinal motion segments during planar induced movements and while applying manual therapeutic manipulation techniques. The information can help to understand the effect of manual therapy on spinal motion.

METHODS

Seven cervical spine specimens were taken from embalmed human cadavers at the level of the occiput to the first thoracic spine. Each specimen was clamped on a rigid stand to hold T1 in such a way that the cervical spine was fully free to move. 3D electromagnetic tracking sensors were fixed on the head, C1 and C2. Subsequently, each specimen was first moved in the three main planes of motion. Consecutively in 4 specimens a segmental manipulative high velocity thrust in axial traction direction was performed on the level of C0-C1 followed by a segmental rotational high velocity thrust on the level of C1-C2. The position and orientation of each sensor were collected by an electromagnetic tracking device (Flock of birds-Ascension technologies). At a later stage, the positions of local anatomical landmarks were digitized with a 3D drawing stylus (3DX-Microscribe). The individual sensor data were used to describe coupled movements by means of the parameters of the finite helical axes (Spoor and Veldpaus, 1980; Woltring et al., 1994) for discrete sampling ranges of the movements between the different bones: i.e. orientation, position, shift along and rotation about the estimated helical axis. The anatomical data were used for the definition of local bone embedded co-ordinate systems. To analyze the 3D arthrokinematics of the antlanto-occipital and atlanto-axial joints, the finite helical axes were related to a co-ordinate system based on the centre line through mastoid processes and the transverse processes of C1 and C2. The effect of segmental manual high velocity thrust techniques were analyzed in a six degrees of freedom approach. The results are analyzed by the Euler angle approach and finite helical angles representations.

RESULTS AND DISCUSSION

The results show that all planar induced movements include 3-dimensional coupled motions. During the main flexion-extension motion on the atlanto-occipital segment important associated rotation and lateral bending takes place that can even equal or sometimes exceed the main motion.During HVT traction on the C0-C1 level the thrust results in a 3-dimensional translation. The main direction is lateral, coupled with a smaller axial and sagittal displacement. The rotational HVT on the level C1-C2 results in an additional axial rotation component of approximately 2°, with almost no rotational components in flexion-extension or lateral bending directions (fig 1). This axial rotation component is however again accompanied by translational displacements in all three directions. The largest translation takes place in the lateral direction (fig 1).

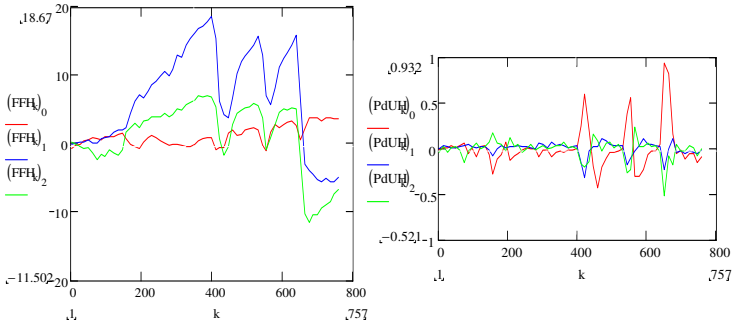

Fig.1 cumulative helical angles (left) and intra-articular translations (right) C1-C2 during rotational HVT (specimen 4)
(FFH1)0≈flexion-extenion (PdUH1)0≈ lateral translation
(FFH1)1≈axial rotation (PdUH1)1≈ cranio-caudal translation
(FFH1)2≈lateral bending (PdUH1)0≈ sagital translation

CONCLUSIONS

These results show that manual induced segmental coupled movements in the upper cervical spine can be analyzed in vitro by means of an electromagnetic tracking device. The largest motion at the atlanto-occipital level is flexion-extension as is described in literature (Panjabi et al., 1993), while at the atlanto-axial level the rotation is the motion whit the largest amplitude. HVT-techniques can induce axial translational displacements andadditional axial rotation in traction and rotation techniques respectively. Therapists have to realize however that coupled rotations and translations take place. In the presented HVT's these coupled motions can not be excluded and may increase stress on vital structures.

REFERENCES

1. Panjabi, M. M., T. Oda, J. J. Crisco, J. Dvorak and D. Grob, 1993. Posture Affects Motion Coupling Patterns of the Upper Cervical- Spine. Journal of Orthopaedic Research 11(4), 525-536.

2. Spoor, C. W. and F. E. Veldpaus, 1980. Rigid Body Motion Calculated from Spatial Coordinates of Markers. Journal of Biomechanics 13(4), 391-393.

3. Woltring, H. J., K. Long, P. J. Osterbauer and A. W. Fuhr, 1994. Instantaneous Helical Axis Estimation from 3-D Video Data in Neck Kinematics for Whiplash Diagnostics. Journal of Biomechanics 27(12), 1415-1432.