ANALYSIS OF INFLUENCE OF HUMAN HEAD MOVEMENT ON CERVICAL SPINE LOADING CONDITIONS

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1. Introduction

Anatomy and physiology of neck spine is quite well known but knowledge about biomechanical aspects as soft tissue mechanical influence on skeletal system is not satisfied. Especially correlation between spine movement, internal forces and muscles roles demands precise interdisciplinary researches, engaged medical and technical scientists. Activity of neck muscles is very important for head and cervical vertebrae movement during physiological and accidents situations. Many science institutions focus researches on neck muscles influence on head behaviour during situations corresponding to road accidents less attention concentrate on physiological aspects. Improvement of knowledge about correlation between dynamics, human body behaviour and internal cervical phenomena could contribute to the defence against spine failures. The best information about above mentioned correlation could be obtained during test on volunteers but experimenting on people is usually impossible because of its dangerous character moreover nowadays not exist suitable technique. Another way to study the behaviour of the human body and internal interactions during different situations is the mathematical modelling. This is proposal a non-invasive method [1,2].

The general aim of the presented researches is creation dynamical 3-dimensional model suitable for analysis of correlations between head movement and internal dynamical forces.

2. Modelling research

Modelling process was preceded by studies on anatomy of human cervical spine, properties of particular elements and kinds of living organisms modelling. 3–dimensional dynamical model of human cervical spine as author program was created on the basis of multibody methodology. Model consists of (figure 1a):

- head, seven cervical vertebrae are treated as 6 degrees of freedom rigid elements and immovable trunk, movement of the elements is depended on muscles, intervertebral discs, facet joints and ligaments activity,
- muscles are divided in two main groups: first deep muscles treated as non-linear spring dumper elements and second group main muscles responsible for head and vertebrae movement. Muscles of second group are represented by forces calculating on the basis of optimization methods, coefficients was determined on the basis of experimental MRI and EMG methods,
- intervertebral disc is divided into isolated segments, representing anulus fibrosus as nonlinear spring element acting during extension and compression and nucleus pulposus as nonlinear spring - damper element acting only during compression,
- facet joints is treated as nonlinear spring – damper element taking into consideration relative motion possibility of connected vertebrae, additional resisting moment appears when physiological relative motion between neighbour vertebrae is exceeded,
- ligaments are divided in parallel strips acting as forces only during elongation,

The model was verified on the basis of experimental researches as comparison of vertebrae relative motion and action of muscles (figure 1b).. Necessary information about material parameters were obtained from tests on specimens of cadaver spines (figure 1c).

a) b) c)

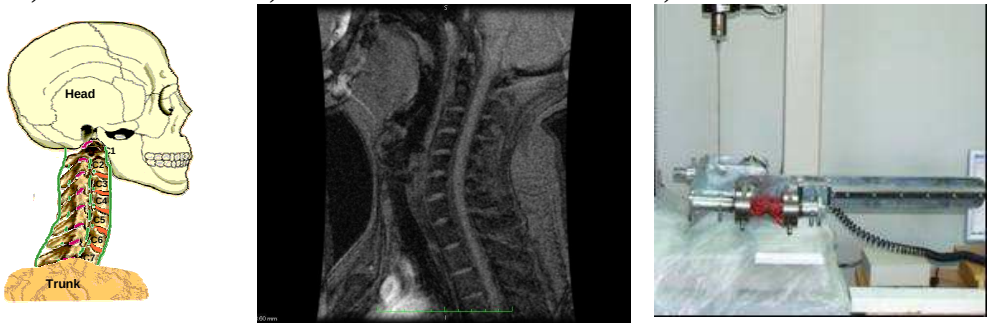

Figure 1 a) Model of human cervical spine.
Experimental research: b) MRI scans of cervical spine during movement in middle saggital plane, c) test on spacemen of cadaver spine with use of special device

3. Results

Two variants of spine loading were analysed: during physiological head flexion movement and during situation corresponding to car head-on collision (8kmph velocity of accident). Figure 2 presents maximal forces insight examples anatomical parts for two variants.

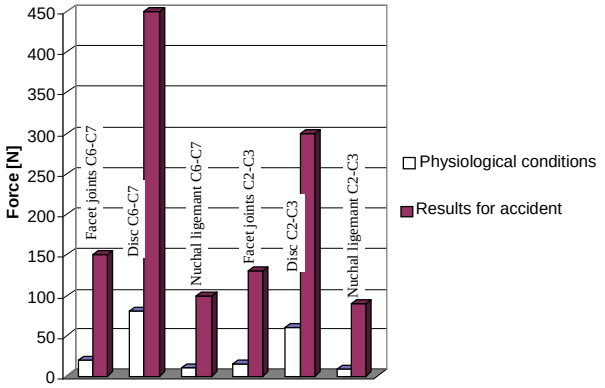

Figure 2 Comparison of maximal forces insight anatomical parts for physiological activity and accident situation

4. Conclusions

Neck muscles it is very complicated system. Analysis of biomechanical aspects of relations between movement, internal reactions and muscles forces demands to carry out common experimental and modelling researches. Presented model allows to carry out numerical simulation of dynamical forces inside anatomical parts of human cervical spine. Neck loading analysis in case of two variants physiological activity and car collision revealed increase of internal forces about five times.

5. References

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[2] M. Gzik (2007). *Biomechanika kręgosłupa człowieka*, Wydawnictwo Politechniki Śląskiej, Gliwice.