

Modeling and Numerical Analysis of a Cervical Spine Unit

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INTRODUCTION: The main objective of this study was to obtain a sufficiently accurate model of a functional unit of human cervical spine, both implanted and non-implanted and to analyze the biomechanical behavior of the implanted model, using Finite Element Method.

Based on CT scans and 3D reconstruction techniques a multisolid model that reproduces more accurate the geometry of a cervical vertebra was developed.

Using CAD techniques, a second model of a functional unit of human cervical spine, both implanted and non-implanted, was developed. The developed model guarantees that the functional unit geometry can be imported and easily handled with ANSYS software, without compromising the functionality that this geometry accomplishes [1-2].

METHODS: The modeling is focused on the main element of the cervical spine, the vertebra. The performed study refers to a multisolid 3D reconstruction of a third cervical vertebra. In this way, the vertebral body is created taking into account the material non-homogeneity and underlying the importance of the density influence.

A cadaveric third cervical vertebra was scanned using Siemens SOMATOM Plus 4 Power system in Medical Imaging Laboratory of CMPICSU Research Centre in Politehnica University of Timisoara. The 2D DICOM images were imported into *Mimics* software and processed using Geomagic Studio software to obtain surface generation and SolidWorks CAD software to accomplish solid generation.

The second model of the cervical spine unit is anatomically detailed and partially differentiates between the cervical tissues. Structures implemented in the FE model are: the cancellous and cortical bone of the vertebra, intervertebral disc, cervical ligaments, and facet joints. There are not considered the neck muscles.

The mechanical elements used in implantation of the functional unit consist in a stabilization system, which has the role of rigidly fixing the two vertebrae (C2–C3). This stabilization system consists of the following elements: one plate, four fixation screws and four locking screws.

The numerical analysis was focused on two different behaviors: the stresses-strains acting on the plate-screw interface and stresses-strains acting on the bone-screw interface. There were analyzed three cervical units, the differences between these assemblies consisting of different geometry of reinforcing screws.

RESULTS: The multisolid model of the cervical vertebra consists in two different 3D models: the inner body corresponding to the cancellous bone and the outer shell corresponding to the cortical bone (fig.1). The model of the implanted cervical unit is presented in figure 2.

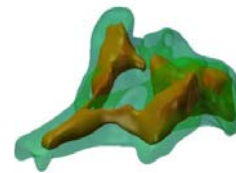


Fig. 1: Multisolid vertebral body of C3 vertebra

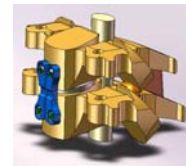


Fig. 2: Implanted functional unit of cervical spine

The numerical analysis highlights the influence of the thread type, depth, pitch and crossing size of the screws, towards the bone tissue.

DISCUSSION & CONCLUSIONS: Solid model of a cervical spine unit provides two important features: the geometry is identical with the natural one; the density is selective, being possible to assign different values for the cortical and spongy bone. The good mechanical behavior on the interface is provided by a suitable design and material properties of the screws and plate.

REFERENCES: ¹H. Li, Z. Wang, (2006) Intervertebral disc biomechanical analysis using the finite element modeling based on medical images in *Computerized Medical Imaging and Graphics*, Vol. 30, Issue 6, pp. 363-370 ²E.C. Teo, H.W. Ng (2004), The biomechanical response of lower cervical spine under axial, flexion and extension loading using FE method in *International Journal of Computer Applications in Technology*, Vol. 21, No.1/2 pp.8-15.