BIOMECHANICS OF THE CERVICAL SPINE: INFLUENCE OF THE LIGAMENTS

Paula C. Fernandes, João Folgado, Paulo R. Fernandes
IDMEC – IST, Portugal

Introduction

The cervical spine is one of the most complex structures of the human body. This region has a high incidence of trauma and degenerative disease. The aim of this work is to develop a finite element model of the cervical spine and to study the influence of the ligaments on the movements of its structural units.

Materials and Methods

A C2-T1 finite element model was developed in order to simulate the biomechanical behavior of the cervical spine. The interactions and material properties of the model are similar to Fernandes *et al.* [Fernandes, 2012]. Five major cervical spine ligaments were incorporated into the model: the anterior (ALL) and posterior longitudinal (PLL), ligamentum flavum (LF), interspinous (ISL) and capsular ligaments (CL). These structures were defined as tension only truss elements. To perform the finite element analysis, all materials were considered linear elastic, and the applied loads were based on the work performed by Panjabi *et al.* [Panjabi, 2001] in order to simulate the basic movements of the spine. It was studied the influence of material properties and cross sectional area (csa) of the ligaments on the range of motion results (ROM) and its validation with others in vitro and computational models.

Results and Discussion

The finite element analysis was performed to study the influence of the ligaments on the ROM. The incorporation of the major cervical spine ligaments increased the stiffness of the model as expected. The model's stiffness decreased with the changes of material properties of all ligaments and of the cross section area of CL. The ROM for the extension movement was less influenced by these changes as expected. Finally, all ROM results from our model were compared and are in good agreement with others in vitro and computational models (Fig. 1).

Conclusion

The development of a model which accurately reproduces the behaviour of the cervical spine is important to the study the influence of trauma and diseases in the biomechanics of the spine. The ROM results were validated with other models confirming its feasibility.

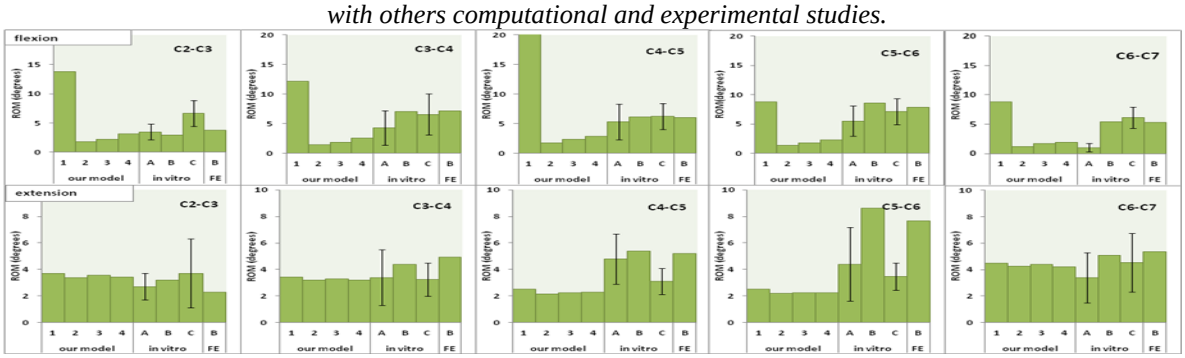
Acknowledgements

This work was supported by FCT through the project PTDC/EME-PME/104498/2008 and PhD scholarship SFRH/BD/61196/2009.

References

Fernandes, P.C.*et al*, Comp. Meth. Biomech and Biomed Eng. 15:1337-1346, 2012.
Kallemeyn, N *et al*, Med. Eng. & Phy.32: 482–489, 2010.
Panjabi, M.M. *et al*, Spine. 26: 2692-700, 2001
Teo, E.C.*et al*, Med. Eng. & Phy. 23:155-164,2001.
Zhang, Q.H. *et al*, J Biomech Eng. 127: 729-735, 2005.
Zhang, Q. H. *et al*, J Biomech 39: 189-193, 2006.

Figure 1. Comparison of ROM values obtained with the present computational model with others computational and experimental studies.



For our model: 1 - without ligaments; 2- 4 with ligaments: (2, 4 - mat prop Zhang et al, (2005, 2006): ALL E=30 MPa, PLL E=20 MPa, LF, ISL, CL E=10 MPa; 2,3 - csa 5mm^2; 3 - mat prop Teo et al, 2001: ALL E=54,5 MPa, PLL, CL E=20 MPa, LF, ISL E=1,5 MPa; 4 csa 1,25 mm^2). A - Panjabi et al, 2001; B- Kallemeyn et al, 2009; C - Zhang et al, 2006