BRAIN IMPACT STRUCTURAL ANALYSIS USING ADVANCED DISCRETIZATION TECHNIQUES: A PRELIMINARY STUDY

Marco Marques(1*), Jorge Belinha1,2, L.M.J.S. Dinis1,2, Renato Jorge1,2

1Institute of Mechanical Engineering and Industrial Management (INEGI), University of Porto, Portugal
2Faculty of Engineering of the University of Porto (FEUP), Portugal

(*Email: m.marques@fe.up.pt)

ABSTRACT

This work has the objective to compare the mechanical behaviour of a brain impact through the usage of distinct numerical techniques. A geometrical model was obtained through the processing of medical imagens. This technique allows to achieve a model with realistic geometry and it permits to define locally (for each interest point) the mechanical properties accordingly with the medical images colour scale. After defining the numerical model of the brain, the essential and natural boundary conditions are imposed to reproduce a sudden impact force. The analysis is performed using the Finite Element Analysis (FEM) and two distinct advanced discretization techniques. The obtained results were compared with the available literature.

Keywords: Brain, meshless analysis, finite element analysis.

INTRODUCTION

The traumatic brain injuries (TBI) occurs in the presence of an abrupt mechanical stimulus (due to an external factor) into the brain or to the cranium. This sudden action, can result in a diffuse lesion, if there are rotational and deceleration forces, or a focal lesion, result of the direct contact forces. [1] These lesions can result in the hospitalization of the subject, and it is estimated that one fifth of the hospitalized persons cannot return to a normal life. [2] Having the TBI devastating consequences and a significant incidence (1.4 million people in the US per year), considerable research has been devoted to understand and to prevent TBI. [3], [4]

Biomechanics computational simulation provides powerful tools allowing the study of the TBI event. One of the most applied popular numerical tool is the Finite Element Method (FEM), but in the last few years meshless methods came into focus of interest. The main advantage of the meshless method is that it does not require elements to discretize the problem domain. [5] In meshless methods, the problem domain is discretized using an unstructured nodal mesh. In Figure 1 both discretization are schematically shown. In biomechanics this discretization flexibility is advantageous, since it permits to discretize the problem domains using directly the medical images.

Fig. 1 - FEM and Meshless problem domain discretization
RESULTS AND CONCLUSIONS

This study shows that there are substantial differences on the spatial distribution of the stress levels of the results obtained with the FEM and with meshless methods. Nevertheless, the magnitude of the distinct solutions is very similar. Relating our work with the existing in the literature, being the magnitude of the forces applied equivalent to those applied in the literature, the obtained von Mises effective stresses are very similar, 110 KPa in the impact zone, when compared with the results published in the literature, 92 KPa.[4]

<table>
<thead>
<tr>
<th></th>
<th>FEM</th>
<th>RPIM</th>
<th>NNRPIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1 - 2D Effective Stress Results for FEM Method and for Meshless RPIM and NNRPIM method.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ACKNOWLEDGMENTS

The authors truly acknowledge the funding provided by Ministério da Educação e Ciência,- Fundação para a Ciência e a Tecnologia (Portugal), under grants SFRH/BPD/75072/2010, SFRH/BPD/111020/2015 and SFRH/BD/110047/2015, and by project funding UID/EMS/50022/2013 (funding provided by the inter-institutional projects from LAETA).

REFERENCES


