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BOOK OF ABSTRACTS

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BIOMECHANICAL ANALYSIS OF PDMS CHANNELS USING DIFFERENT HYPERELASTIC CONSTITUTIVE MODELS

Cátia Cardoso[1], Carla Fernandes[1], Rui Lima[1,2], João Ribeiro[1,3]

[1-] Polytechnic Institute of Bragança, Bragança, Portugal
[2-] University of Minho, Mechanical Engineering Department, Guimarães, Portugal
[3-] Institute of Mechanical Engineering and Industrial Management, Porto, Portugal

ABSTRACT

A constitutive model for a mechanical analysis is a relationship between the response of a body (for example, strain state) and the stress state due to the forces acting on the body, which can include the environmental effects. A wide variety of material behaviours are described with a few different classes of constitutive equations [1].
The hyperelastic models have been used extensively to model the non-linear behaviour and anisotropic material, since the soft tissues under large deformations often regain their elasticity. The constitutive behaviour of hyperelastic materials is defined in terms of deformation energy potential [2].
In this study, were performed simulations of Newtonian fluid flow in channels with disorders such as the aneurysms. The main goals of these simulations were to analyse the fluid flow in the channels and the mechanical behaviour of channels walls. The material used for channels was the PDMS which has a hyperelastic behaviours and to simulate that structure were used different constitutive models, under the same conditions, aiming to analyse the most appropriate model for this type of study. Thus, the deformations suffered were visualized on the walls of the channels, caused by the internal pressure induced by the internal fluid.
It was used Ansys® - *Fluent* software, to perform the simulation of the Newtonian fluid flow (glycerin, with well-known properties and sufficient viscosity to measure the pressure drops), in order to determine the speed and the internal pressure. This pressure, approximately $11.742e^{-6}$ MPa for an input flow rate of 300 µL/min, was imported into the channels in Ansys® - Static Structural, in order to be able to evaluate and analyse the deformations and stresses in the channel wall, caused by internal pressure induced by the fluid flow. To do this, was used the most known hyper-elastic constitutive models.Six constitutive models were simulated, they being: *Ogden* 2nd and 3rd *Order*, *Yeoh* 2nd and 3rd *Order* and *Mooney-Rivlin* 5 and 9 *Parameter*. All the analysed constitutive models converged for a solution.
The obtained results of numerical simulations for these six models showed little variation among them. This small variation is explained because the flaw rate used in the Fluent simulation induced a low pressure within the channel which caused a small deformation field and for these values all the constitutive models could follow the material mechanical behaviour. If the internal pressure is much higher, probably the results obtained for the different constituent models will be very different. In Fig. 1 is presented an example of the resulted obtained for two different constitutive models.

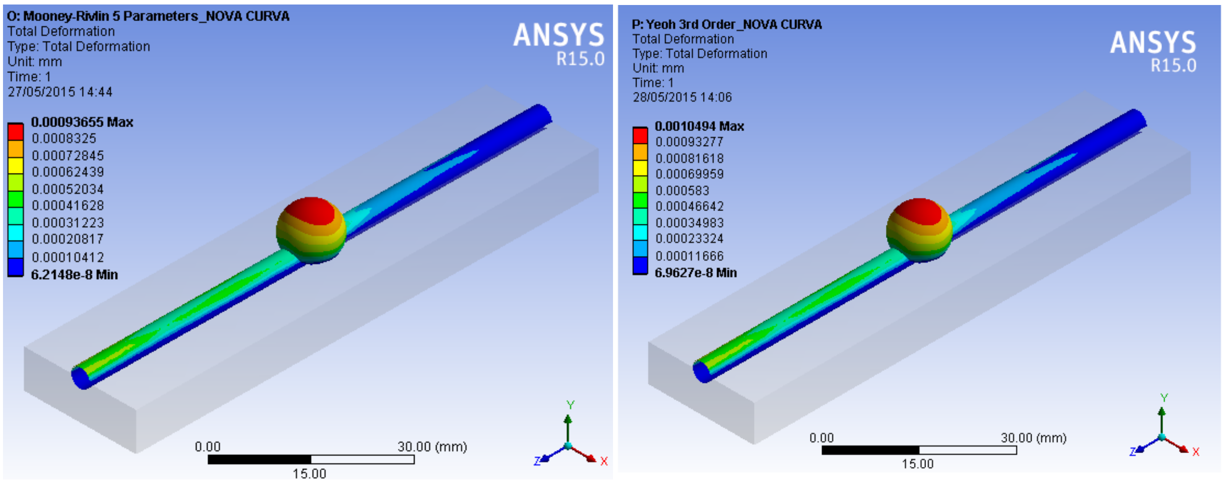

Figura 1 - Total deformation occurred in the channel wall calculated by the constitutive model of Mooney-Rivlin 5 Parameter and Yeoh 3rd Order, respectively.

In the Table 1 is present the comparison among the maximum and minimum displacements obtained in the FEM simulations. It is possible to verify that the obtained displacements are very low for all the analysed models, even for maximum values. The standard deviation is also low that indicates the calculated values tend to be very close to the average and range from 0.755E-4 and 0.05E-8 for the maximum and minimum values.

Tabela 1 Maximum and minimum values of the different models and mean and standard deviation corresponding.

Constitutive model	***Maximum value [mm]***	***Minimum value [mm]***
Mooney-Rivlin 5 Parameter	9,366E-04	6,215E-08
Mooney-Rivlin 9 Parameter	8,865E-04	5,883E-08
Ogden 2nd Order	10,27E-04	6,816E-08
Ogden 3rd Order	9,672E-04	6,418E-08
Yeoh 2nd Order	10,88E-04	7,216E-08
Yeoh 3rd Order	10,49E-04	6,963E-08
Average	9,924E-04	6,585E-08
Standard deviation	0,755E-04	0,500E-08

In summary, it is concluded that any constitutive model referred to above, can be applied to such studies, allowing the study behaviour of the PDMS channel wall, particularly for the analysis of stress and displacement field on the aneurysm. In further studies it would be interesting analyse the channel wall behaviour for higher internal pressures and for a Non Newtonian fluid which the properties were more close to blood.

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