15th International Symposium on Computer Methods in Biomechanics and Biomedical Engineering
and
3rd Conference on Imaging and Visualization
CMBBE 2018
P. R. Fernandes and J. M. Tavares (Editors)

Abstract ID-75

NUMERICAL SIMULATION OF THE DEPLOYMENT PROCESS OF A NEW STENT PRODUCED BY ULTRASOUND-MICROCASTING: THE ROLE OF THE BALLOON'S CONSTITUTIVE MODELLING

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Keywords: ultrasonic-microcasting, stent, FEM analysis, balloon constitutive modelling

Summary: A stent is a tiny wire mesh tube-like structure made of metallic alloys or biopolymers, whose radial deformation within a blocked blood vessel allows its reopening, re-establishing the normal blood flow. Generally, the expansion of this device is promoted by the inflation of a balloon inside the stent until a target diameter is reached. This procedure is considered minimally invasive and presents good results in the treatment of coronary heart diseases.

The application of the finite element method (FEM) allows to predict the behavior of a stent during the deployment process and when in service, being a powerful tool to use in its design and development. To guarantee that the obtained results are trustworthy, it is crucial a correct definition of the system, namely in terms of the material constitutive models applied to the involved elements. As the promoter of the stent's expansion, the balloon plays a very important role, offering a strong influence on its performance, mainly during the deployment process. This element is usually built in a rubber-like material such as polyurethane, being modelled as linear elastic or hyperelastic with a Mooney-Rivlin description

This work aims, through FEM analysis, the study of the influence of the adopted material formulation – linear elastic or hyperelastic -, as well as the respective material constants and properties for the balloon modelling on the performance of a biocompatible magnesium stent regarding a set of metrics. Furthermore, a comparison is established between those results and the obtained ones in the scenario of application of pressure directly in the inner surface of the stent, neglecting the balloon.

The obtained results suggest that material formulation has direct influence on the stent deployment process. Concerning to hyperelastic models, three different combinations of parameter values were tested, showing a similar behavior in terms of dogboning and foreshortening, while the required expansion pressure was significantly different. The same relation was found between the results obtained with the tested linear elastic models, while the scenario of neglecting the balloon suggests providing the highest values of dogboning, foreshortening and recoil, with an expansion pressure comparable to that of hyperelastic models.