A project of bioresorbable self-expanded vascular stents

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Abstract

The vascular stents are important in treating problems with stenosis of constrictions of human vessels. The polymer based stents are in focus of research and development for about ten years due to some better properties then used currently metallic stents. The biocompatibility, induced lower stresses on artery wall, bioresorbable properties are some of the good sides of the polymer stents. The paper presents preliminary results in designing of bioresorbable self-expanded vascular stents.

Keywords: bioresorbable self-expanded vascular stents, FEM, crimp simulation

1. Introduction

The stents are important for treating stenosis in arterials. The polymer stents can be used instead of metallic ones, but the geometry must be changed due to different stiffness of material [1,4]. The crucial moment during introducing stents into vessels is expanding after insertion in proper place. The expansion of polymer stents can be performed with use of balloons. The self-expanded stent can open due to rise of temperature if the polymers with proper material properties are used [4]. The stent can be produced using injection mould in open state. The product must be crimped on the catheter before insertion to the organism. The following chapter presents the numerical simulation of crimping of the stent.

2. The stents geometry

The geometry of the stent is important due to many factors. The stent must fit into artery before expansion, the diameter after expansion should correspond to the diameter of the artery. The length of the stent is also connected with the typical disorders. The process of insertion of the stent is straightforward for the medical staff, but from the point of view of mechanical loads one can distinguish bending of the stent in different axes during insertion, so during the design of the geometry one should also consider such loads. The production of the stents also plays important role in design. The large amount of polymer stents presents on market uses laser cutting of the plastic pipes [3] lead to some limits on geometry. The mould injected stents considered in the paper allow wide range of shapes, but also the process is vulnerable on shape of the geometry. For this reasons the proper flow of the plastic during injection must be guaranteed [4].

The example of numerical model of polymer stents geometry is shown in Fig. 1.

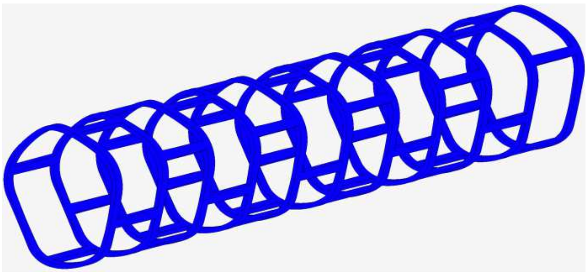

Figure 1: The geometry of one of the proposed polymer stents

3. The numerical simulation of the polymer stent

The numerical simulation of the stents during crimping, expanding, and also the state of the artery after implantation, can be performed with the use of the Finite Element Method (FEM). The polymers have nonlinear material models, also the artery should be modelled as hyperelastic material [2,5,6].

The numerical simulation of crimping is shown in Fig. 2. The stent diameter is reduced 2-3 times during crimping. The numerical simulation is performed with use of rigid surfaces, the inner pipe corresponds with the catheter diameter and the outer simulates the crimping tool. The large deformations and nonlinear behaviour of the stent can be modelled. The crimping is performed after rise of temperature. The stent model after diameter reduction is shown in Fig. 2b.

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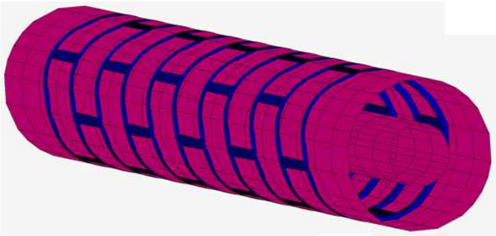
a) 

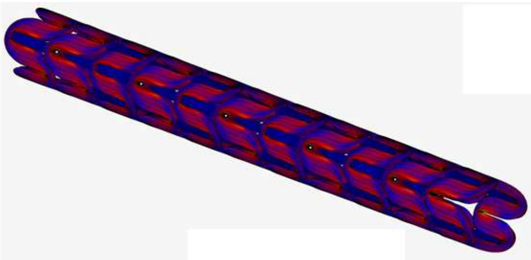
b) 

Figure 2: Simulation of crimping of the stent on catheter, a) the stent, catheter and crimping tool models, b) stent geometry after crimping

4. Conclusions

The important factors in the polymer stent design are discussed in the paper. The numerical simulation of the crimping procedure for the sample geometry of the polymer self-expandable stent were presented. The results of numerical simulations are promising and future investigation, also sample stents production and in vivo tests are planned in the future.

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