Modeling of Biodegradable Stents

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INTRODUCTION

When having fulfilled the job of supporting the atherosclerotic blood vessel after angioplasty, the biodegradable stent gradually disappears (1). Unlike permanent stents, the biodegradable stent forms no obstacle for future interventions. Moreover, the degradable stent material presents an ideal vehicle for local drug delivery. Long term side effects inherent to drug eluting stents such as in-stent restenosis and late stent thrombosis might be avoided (2). To date, several bioresorbable stents are currently being tested in clinical trials. But the design of these stents is mostly based on the available biomaterials and inspired by classic metal stent designs.
Finite element modeling can play an important role in the design of novel stents. To correctly simulate the behaviour of degradable stents a material model must be developed that incorporates the effect of degradation on the material characteristics. We have developed a mechanical model for the hydrolytic degradation of bioresorbable polymers. The material model was used to simulate the mechanical behaviour of a generic bioabsorbable stent using finite element analysis.

MATERIALS AND METHODS

The stent material model is based on the mechanical and degradation properties of high MW poly-ε-caprolacton (PCL), as a possible biodegradable stent material. This model incorporates the effect of the mechanical environment on degradation, as proposed by Soares et al. (3).
The material model was implemented in the user subroutines UMAT and VUMAT for finite element simulations with Abaqus.

A stent geometry was generated using the open-source software pyFormex, currently under development at UGent (bioMMeda).

RESULTS AND DISCUSSION

The simulation of the expansion of a PCL stent in a stenosed blood vessel indicates zones of high internal stresses or large deformations. As incorporated in the material model, these zones will degrade at a larger rate, which affects the evolution of the global stent structural behavior in time.

CONCLUSIONS

We have implemented a material model for PCL that incorporates hydrolytic degradation. We have combined this material model with the generation of a generic stent geometry to simulate the behavior of a biodegradable stent in time. Future work will involve model refinement and further extensive model validation.

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