A COMBINED MICRO-CT AND FE METHOD TO STUDY STENT PARAMETERS

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INTRODUCTION

Balloon expandable stents are small laser cut metallic tubes that are used in medical percutaneous interventions to prop open narrowed arteries. These stents are typically crimped on a folded balloon catheter that is inflated at high pressure during the procedure in order to induce plastic deformations in the stent. Once the desired diameter of revascularisation has been reached, the balloon is deflated and retracted, leaving the deformed stent to scaffold the reopened blood vessel.

The stent-geometry has a major impact on the short- and long-term success of the procedure because it defines how the stent will behave. For example, the crosing profile (diameter in crimped state) determines the lesions that can be stented, foreshortening of the stent will damage the endothelial layer and because of elastic recoil the arterial wall is unnecessarily stressed. Also the stent-cell size is important as it defines how well the artery is scaffolded and how easily another stent or balloon can be introduced in a side branch during bifurcation stenting.

In this work, a method is described to obtain several of these important parameters and it was applied on five recently commercialized cardiovascular stents.

METHODS

Five cardiovascular balloon expandable stents (Table 1) with a nominal diameter of 3 mm were selected. Two micro-CT scans were performed on each crimped stent in order to get accurate information on the stent geometry. An STL of the stent was created and used as input to generate a parametric model of the stent, which is used for the finite element (FE) simulations.

Table 1: The five studied stents and their manufacturer

Stent Geometry (Manufacturer)
1. Taxus Liberté™ *(Boston Scientific)*
2. Promus™ *(Boston Scientific)*
3. Pro-Kinetic™ *(Biotronik)*
4. Endeavor ™ *(Medtronic)*
5. Coroflex™ *(B. Braun)*

For the micro-CT scans, an in-house developed setup [1] was used. The stents were first scanned at lower resolution (7 µm voxel pitch) in order to obtain the entire geometry of the stent and subsequently at high resolution (1 µm voxel pitch) to obtain more detailed information on the stent struts.

The CT data was used to generate numerical STL meshes of the stents with Mimics (Materialise, Leuven , Belgium). These STL's were used to generate parametric models in pyFormex [2], in-house developed open source software, which are easily adaptable and readily converted to high quality hexahedral meshes which are used for the finite element simulations in ABAQUS (Dassault Systems). During the calculation a radial expansion was simulated using a rigid cylinder as expansion medium. Although this does not realistically simulate the transient expansion behavior of the stent, it is a good assumption to study the geometrical alterations past that point [3].

RESULTS AND DISCUSSION

From the five stents, an STL mesh was generated (Figure 1) and the stent strut thickness was measured. The Pro-Kinetic™ has the thinnest struts (60 µm) and also the lowest crossing profile (0,95 mm) while the Taxus Liberté has the largest crossing profile (1,15 mm) and the Coroflex the thickest struts (115µm).

These meshes are converted to high quality hexahedral meshes (Figure 2) and a radial displacement is introduced at the inner side of the stent to perform the radial expansion. At the time of submitting the abstract, the FE simulations were still under calculation. Out of these calculations the foreshortening in function of stent diameter, maximal opening of the stent cell in function of the diameter and elastic recoil at nominal diameter will be calculated and compared for the different stents.

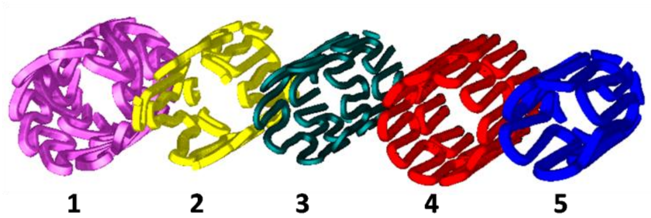

Figure 1: Visualization of the STL mesh of the five stents, numbers correspond with Table1

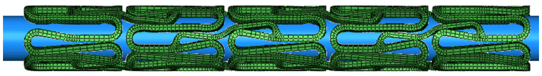

Figure 2: Hexahedral mesh of the Coroflex™ stent with a rigid cylinder inside used for the radial expansion

CONCLUSIONS

Using the methodology described here, it is possible to obtain many different stent parameters. Since the numerical models are obtained from a parametric model, it is possible to easily study the effect of geometrical variations.

REFERENCES

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