11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20–25, 2014, Barcelona, Spain

SIMULATION OF IMPLANTED AORTIC STENTS

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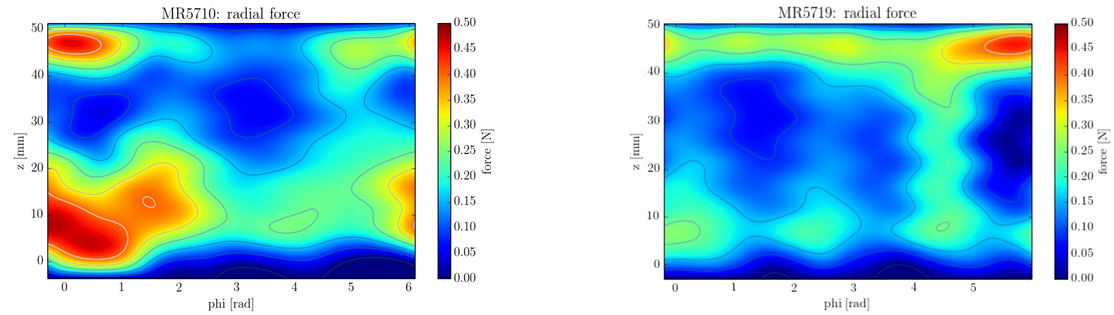
Key words: *FEM, Beam Elements, TAVI, Stent, Nitinol.*

To evaluate the mechanical biocompatibility of a medical implant, its contact interaction with the surrounding host tissue must be analyzed. In the case of transcatheter aortic valve implantation (TAVI), insufficient or excessive contact forces between stent and tissue might lead to severe medical complications [1].

Recently, a method to reconstruct the reaction forces between stent and tissue has been presented by Gessat et al. [2]. The study introduced a finite element model of the CoreValve stent by Medtronic. The stent model was meshed with linear beam elements and a linear elastic constitutive law was used. Additionally, a novel procedure to obtain kinematic boundary conditions from noisy CT data was introduced. The present work comprises further analysis about the applicability of the whole procedure and the presentation of patient data.

The CoreValve stent is made out of nitinol. Here, a linear elastic material is used. One of main assumptions that lead to this choice, was that the deformation imposed on the stent after implantation remains in the small strain regime for the whole structure (with very localized exceptions). This simplification is investigated using a selection of patient data sets to represent physiologically relevant loading states and performing simulations with both linear and nonlinear material models. It is concluded, that choosing a linear elastic material for this task reduces the computation time by a magnitude with a small impact on the global force response. A comparison of both material models under symmetric radial compression quantifies the deviations for decreasing diameters.

Further, the simulation procedure involves an iterative method to reach the stents deformed state. This method introduces parameters which can not be determined a priori. In order to investigate the influence of these parameters, a corresponding analysis is carried out for representative patient loading cases. Simulated patient data sets are superimposed with artificially generated noise and fed back into the simulation pipeline in order to inspect the overall stability of the procedure.



(a) (b)

Figure 1: Heat maps for two different patients.

For visual inspection of the simulated force fields, interpolated heat maps with contour lines as shown in both figures for an unwrapped stent, can provide a helpful tool to find correlations between contact forces and the clinical outcome. Figure 1a shows a case with excessive force in the annular region while figure 1b shows significantly lower forces. Further investigations are required to improve the understanding of the relationship between force field and medical outcome.

REFERENCES

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