# VIRTUAL STENT GRAFT DEPLOYMENT AS AN AID IN PATIENT-SPECIFIC SELECTION AND SIZING

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## INTRODUCTION

An abdominal aortic aneurysm (AAA) of the aorta is a local pathological dilatation of the aortic arterial wall, between the renal arteries and the aortic bifurcation. Over time, AAA expand, followed by eventual rupture. Elective treatment of the disease is often performed minimally invasive with endovascular repair by stent graft deployment, as an alternative to open surgical repair.

Stent graft design has progressed quickly over the last 2 decades. There has been an increase in the number of commercially available stent graft designs on the market. Selection of the most optimal design and size for a given patient is not a trivial task, and there is a growing need for a comparative evaluation of stent graft performance.

In this work, we perform patient based specific deployment simulations as a possible aid in stent selection and sizing. To achieve this, we constructed finite element of 4 CE approved stent grafts. Mechanical tests were coupled with finite element analysis of the devices to ensure a correct mechanical behavior of the virtual devices. The patient specific deployment is demonstrated for a patient treated with an Excluder graft.

## METHODS

In earlier work [1], four stent grafts were examined: three nitinol (a nickel-titanium alloy) stents (Talent, Excluder and Zenith LP) and one stainless steel stent (Zenith Flex). Comparing experimental (flat plate and radial compression) with finite element calculations mimicking these tests allowed us to build finite element models with a mechanical behavior similar to the one observed *in vitro*.

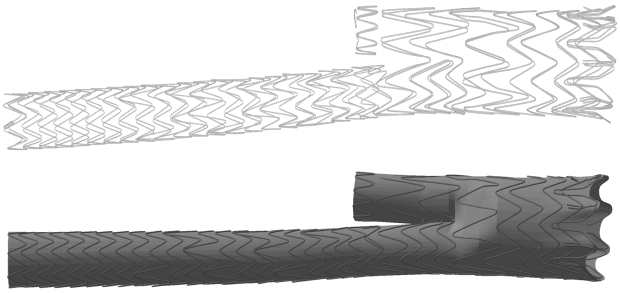

Figure 1: Excluder stent graft: µCT (top) and finite element (down) rendering.

Using the finite element model of the Excluder, we virtually deployed the stent graft in a patient specific anatomy, using an adjusted method as described in [2]. The entire deployment procedure is mimicked *in silico:*

- crimping and bending of the main graft body into a delivery catheter
- deployment of the main graft body in the aneurysm sac
- crimping and bending of the contralateral iliac limb
- deployment of the contralateral limb, sealing the aneurysm

The geometry consisted of a descending aorta with bifurcations to the renal and iliac arteries, obtained from CTA imaging. Segmentation was performed using slicer3 (www.slicer.org/). Wall thickness was considered constant at 1.5mm. The aneurysm contains thrombus and calcifications (Figure 2). Average material values were assigned to the different tissues. An anisotropic hyperelastic material (Holzaphel-Gasser-Ogden form) was used for the aortic and iliac tissue [3,4], while an isotropic hyperelastic neo-Hookean material law was used to describe the behavior of intraluminal thrombus and calcifications [5].

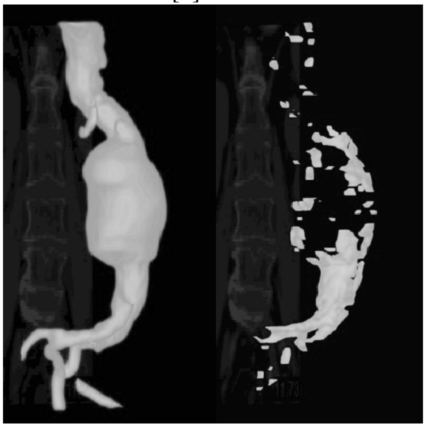

Figure 2: AAA geometry (l.) and calcifications (r.)

## RESULTS

The potential of the finite element method in patient-specific stent selection and sizing is demonstrated for the Excluder device and a complex geometry, including calcifications and thrombus. The result of the virtual deployment of the Excluder device is shown in Figure 3 (l.). The result matches qualitatively with the post- operative CT imaging in Figure 3 (r.)

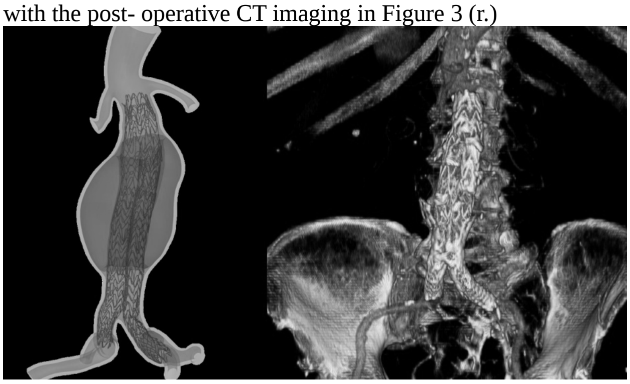

Figure 3: Virtual deployment result (l.) and post-operative CT rendering (r.)

## DISCUSSION

Combining validated finite element models with a virtual deployment simulation and 3D imaging, enable the assessment of the mechanical behavior of stent grafts in vivo.

Ongoing work focuses on a suitable quantitative comparison of simulation results and post-operative imaging, and the application of the presented method for multiple stent grafts and geometries. In the future, this method can aid in stent graft selection and sizing, for specific patient aneurysm geometries.

## ACKNOWLEDGEMENTS

The radial crimping test was performed using equipment by MPT Europe, the authors would like to thank Jurgen de Vries for supplying this hardware. This work was supported by a grant from Ghent University—BOF10/GOA/005.

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