High-fidelity mechanical modeling & FEM placement of the Contour device for intracranial aneurysms

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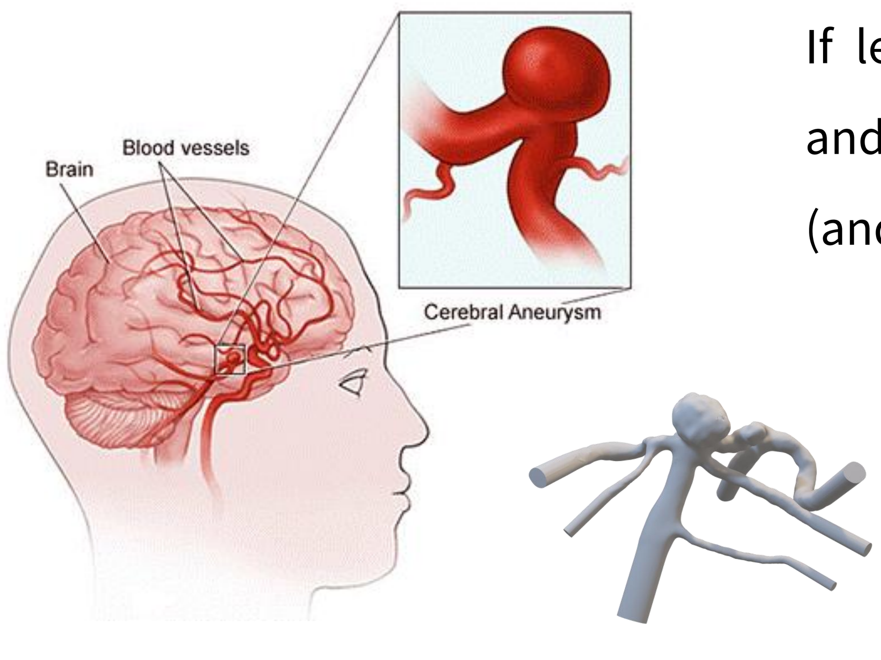
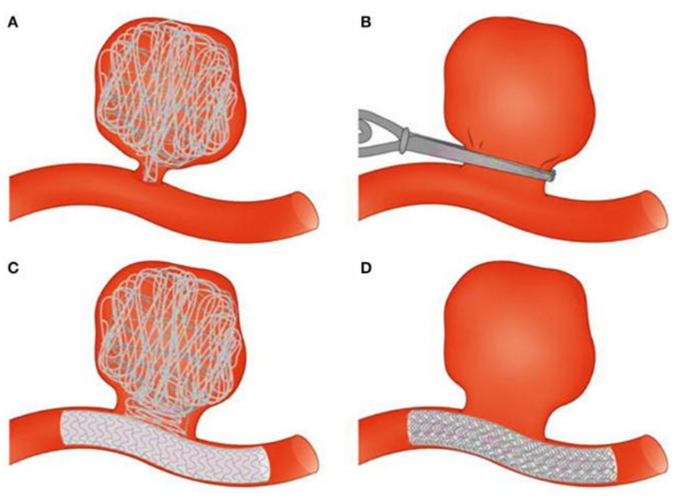
1. Motivation

Intracranial aneurysms (IAs) are localized abnormal ballooning in the brain arteries due to weakness in the vessel wall.

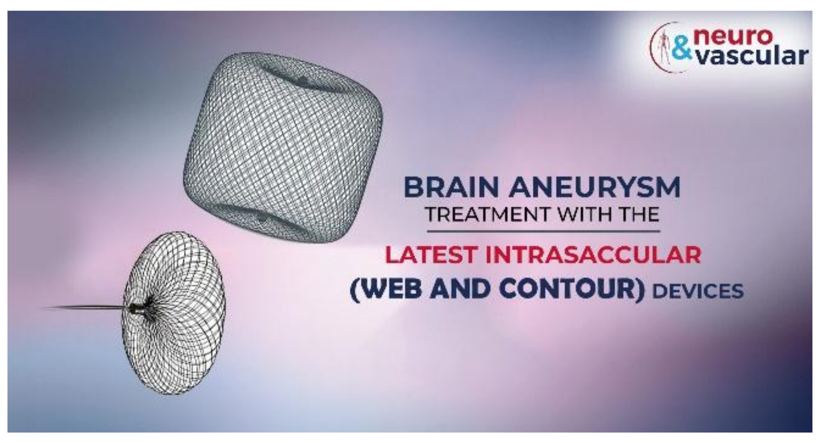


https://www.rwjbh.org/rwj-university-hospital-new-brunswick/

If left untreated, this can lead to rupture and *aneurysmal subarachnoid hemorrhage* (and other fatal outcomes).



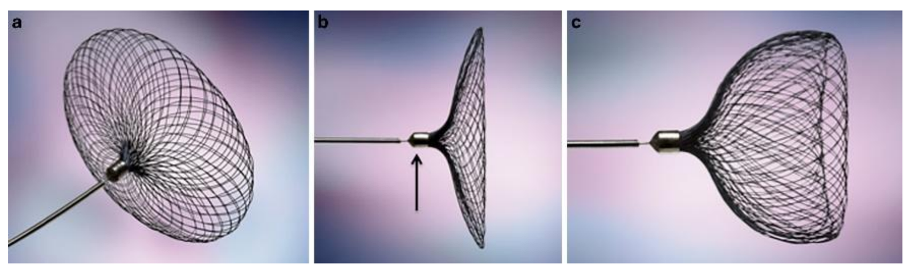
https://doi.org/10.3389/fphys.2018.00306



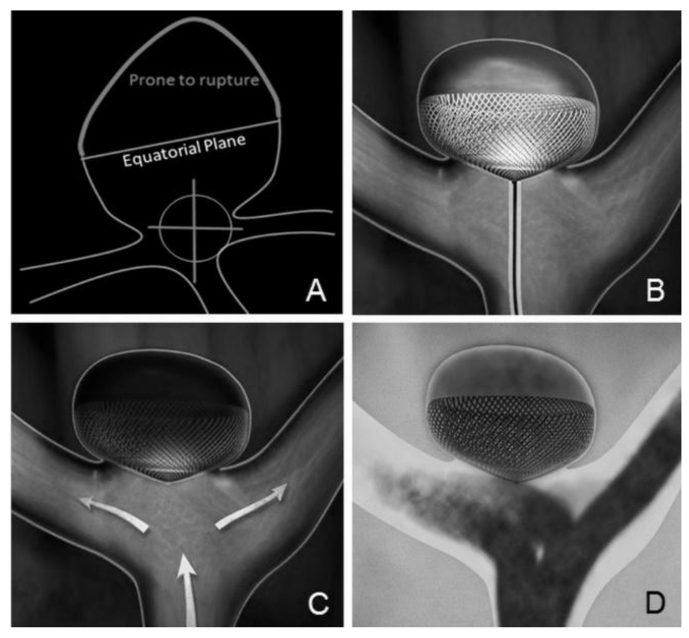
https://neuroandvascular.com/

A coiling
B clipping
C stent-assisted coiling
D flow-diverter stent

2. Contour Neurovascular System



https://doi.org/10.1007/s00062-020-00876-4

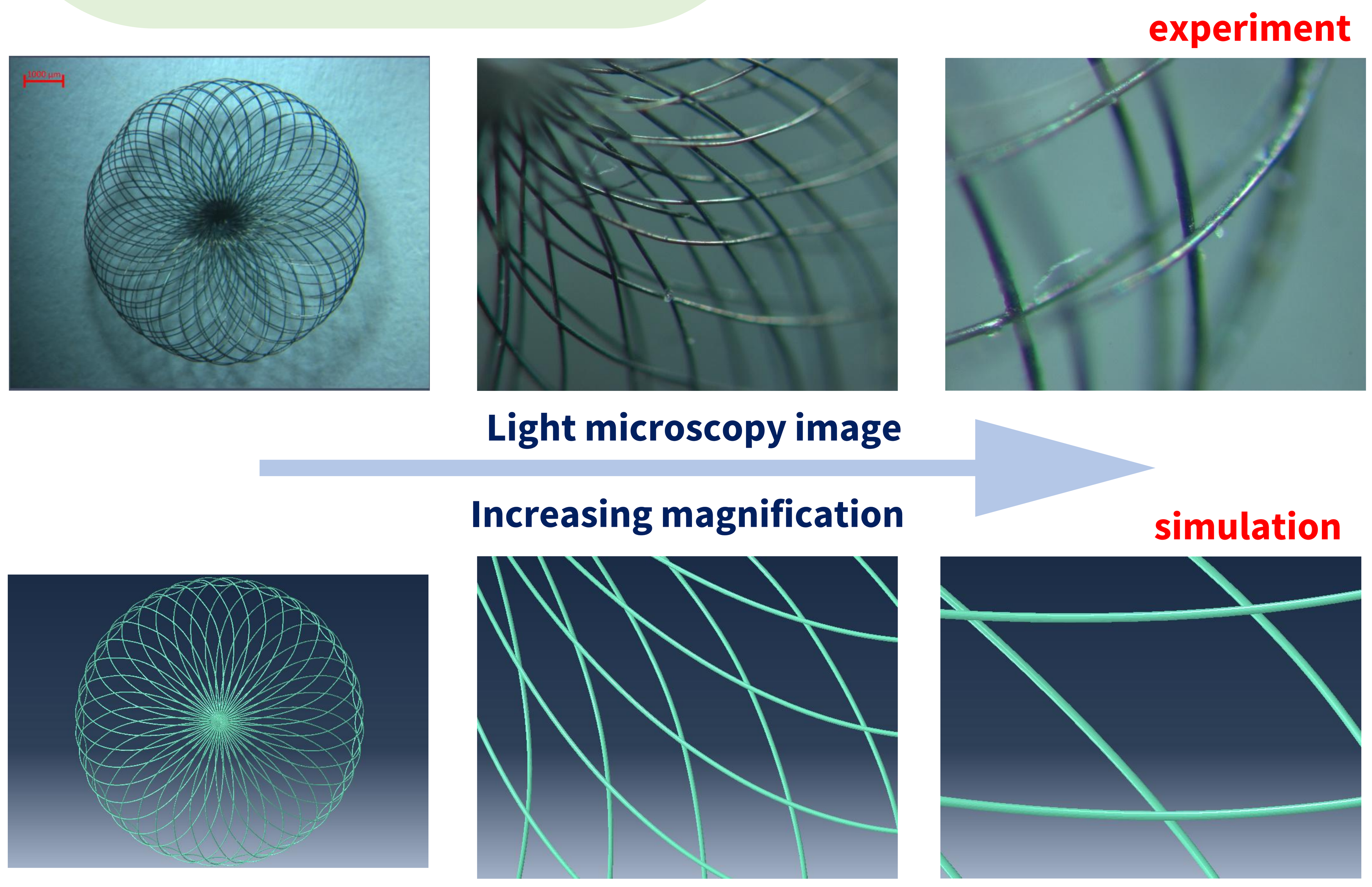


https://jnis.bmj.com/content/12/10/987

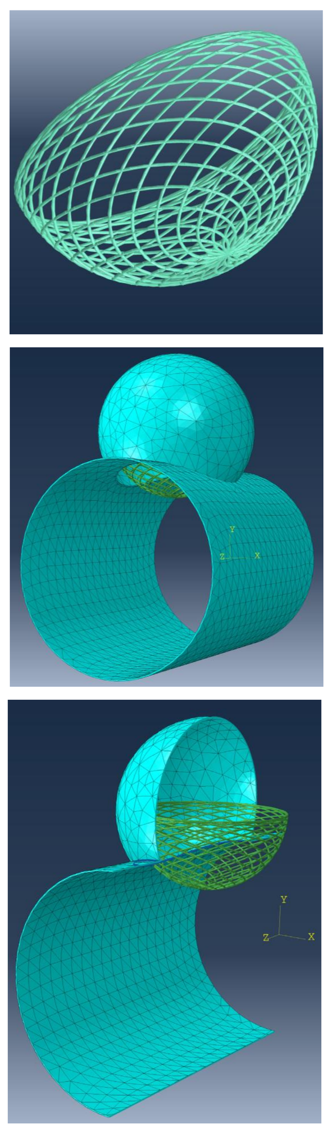
Ingredients
3D quadratic beam elements
Nonlinear beam theory
Contact interactions
Sliding friction

Thin Nitinol wires
72 interwoven wires
Dual layer braided mesh

Braiding strategy
Parametric design (hemisphere model)
Radial & tangential weaving

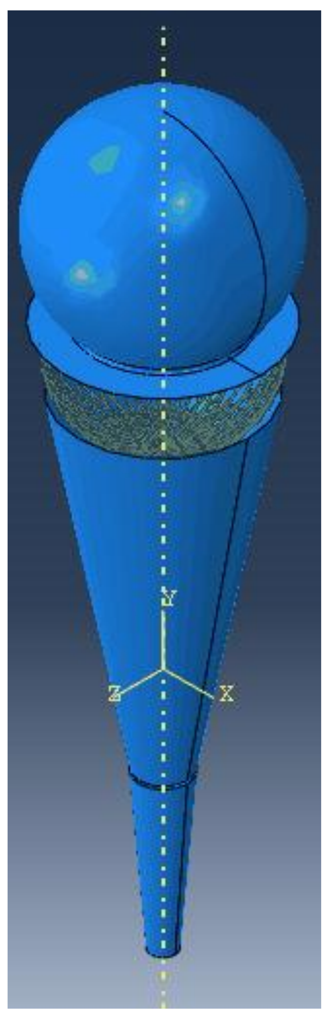


3. *In silico* deployment of the Contour device

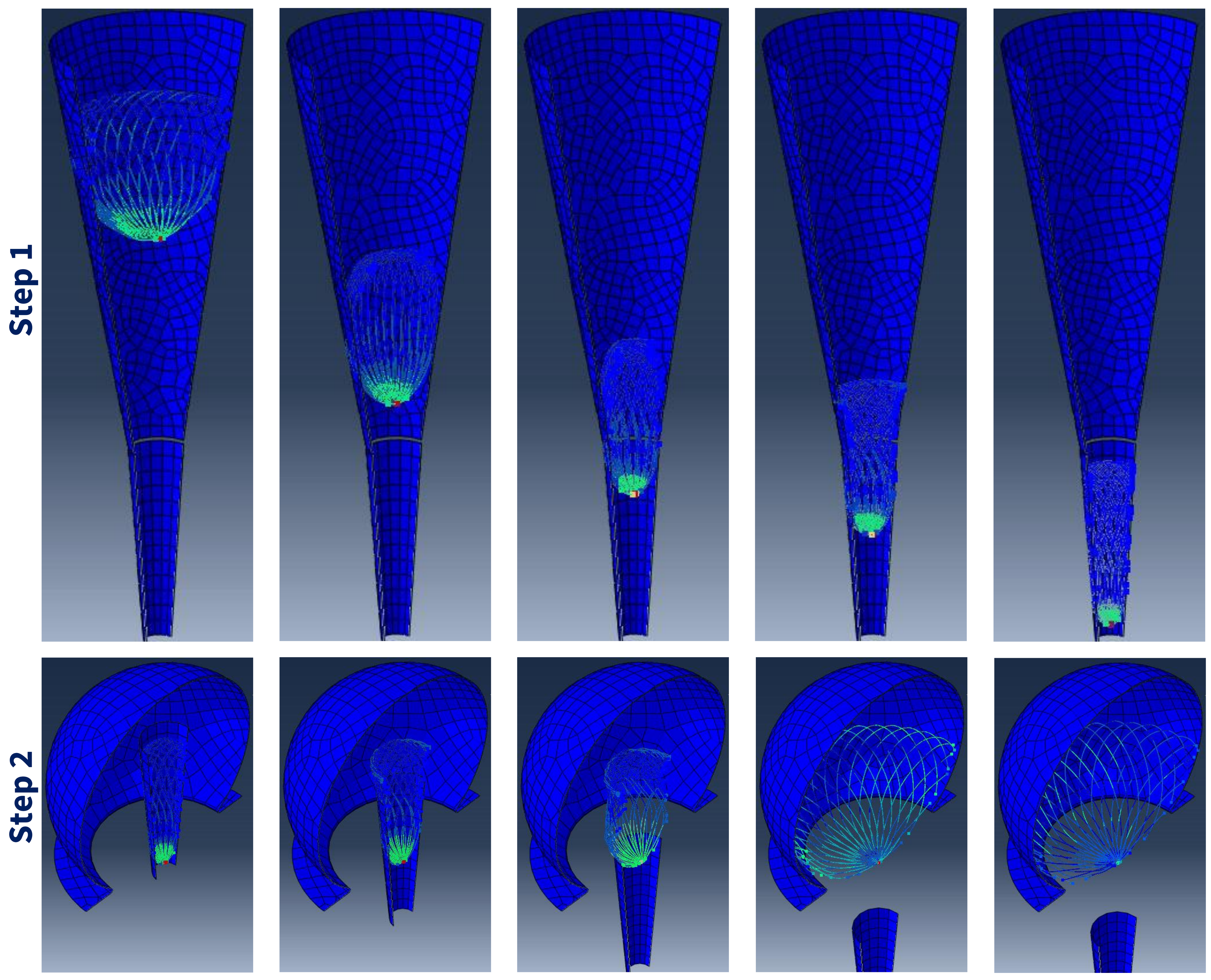


FEM placement

1. The Contour device is pulled into the catheter. The funnel-shaped component only facilitates gradual crimping, after which this is taken aside.
2. The catheter is gradually retracted keeping the Contour device in place. Subsequently, the device starts unfurling onto the aneurysm wall.



Schematic representation of the FEM placement of the Contour device. Below are snapshots depicting cut-section (i.e., cross-sectional) views of the entire procedure of the Contour device deployment in a **chronological** manner:



4. Conclusions

- **Interwoven** (braided) **wires** have been successfully set up to design the device.
- Insertion into the catheter was successful (**crimping** process).
- **Friction** between the wires and the catheter as well as aneurysm wall was implemented using the penalty formulation.

5. Prospects

- Device insertion within deformable **patient-specific aneurysm** is the next step.
- **Thrombus formation** is not accounted for and so is the fully-coupled **fluid-structure interaction** between the blood and the device/brain vasculature.
- **Material modeling** of the superelastic Nitinol wires is missing alongside the appropriate nonlinear mechanical behavior of the arterial/aneurysmal walls.
- **Automation** of the entire design process pipeline and leveraging the potential of computer simulations in health research and personalized medicine.

IDIR
This research was supported by the IDIR-Project (Digital Implant Research), a cooperation financed by Kiel University, University Hospital Schleswig-Holstein and Helmholtz Zentrum Hereon.