INSPIRING INNOVATION | INNOVANTE PAR TRADITION

Ecole Nationale Supérieure des Mines SAINT-ETIENNE

Centre for Biomedical and Healthcare Engineering

LCG CNRS UMR 5146

Stéphane Avril, Nicolas Demanget, Pierre Badel, David Perrin, Laurent Orgéas, Christian Geindreau, Ambroise Duprey, Jean-Pierre Favre, Jean-Noël Albertini

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Computational comparison of the bending behavior of stent grafts

10/05/2013

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Introduction

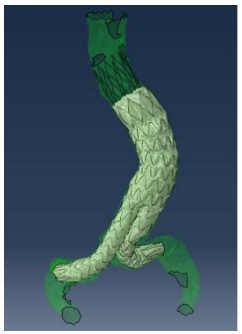
Objectives

Objective #1

Implementation of multi-material numerical models of marketed SG limbs and corresponding experimental validation

Objective #2

Comparison of SG mechanical performances through different mechanical tests more and more representative of the loading conditions during endovascular interventions



Outline of the presentation

- **Materials & Methods**

- **Study #1:** Finite element analysis of the mechanical performances of 8 marketed SGs

- **Study #2:** Numerical simulation of SG deployment

- **Perspectives**

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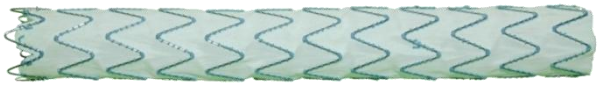
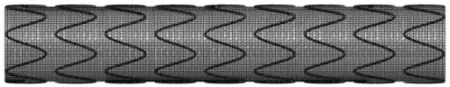
Materials & Methods

SG modelling process

SG limb



Finite Element Model



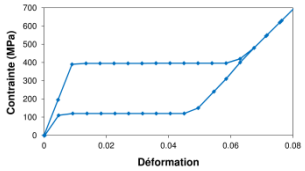
Geometry and mesh

Stent

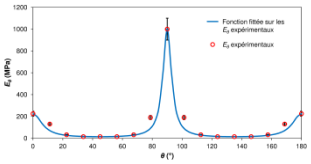
Graft

Materials and corresponding constitutive laws

Metal



Fabric



Modelling specificities

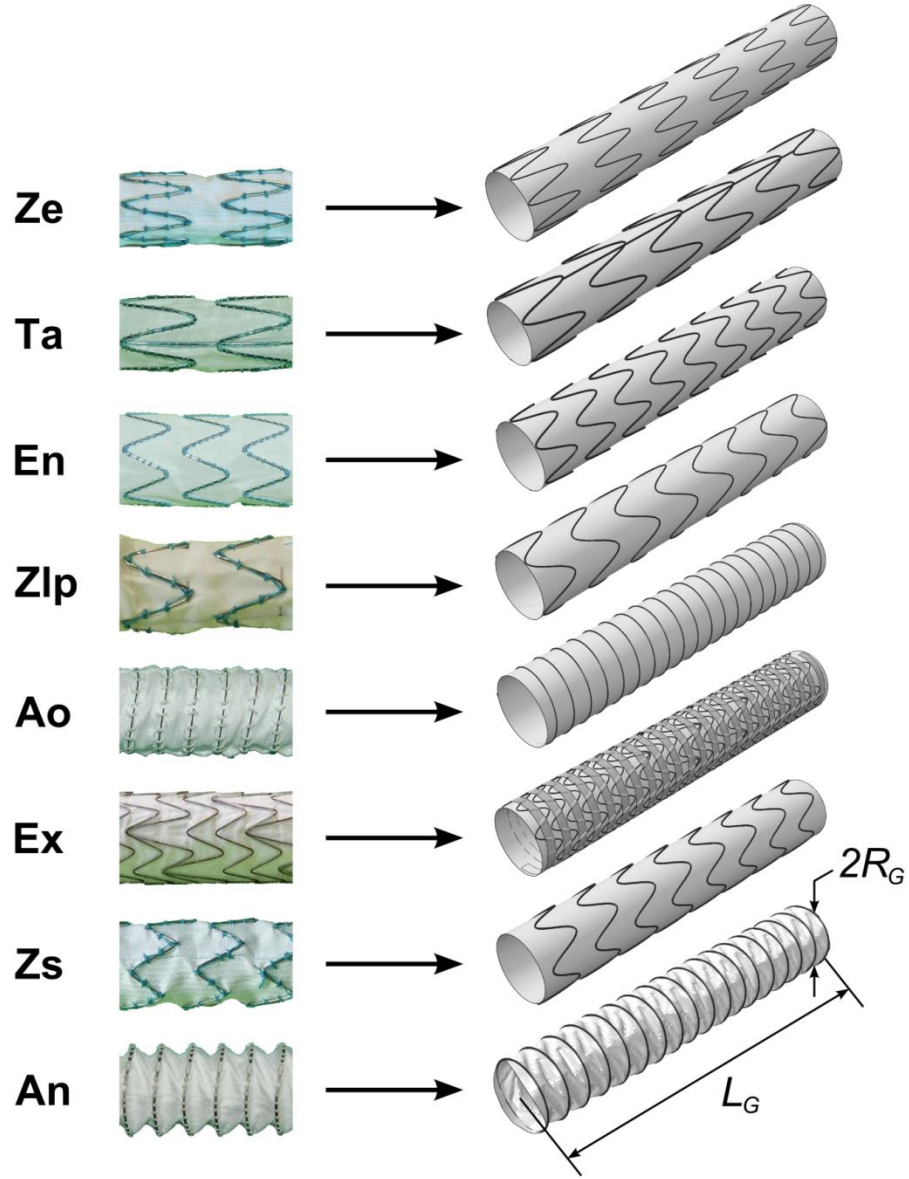
Stents/Graft bonding

Ta-SG, An-SG and Ex-SG specificities

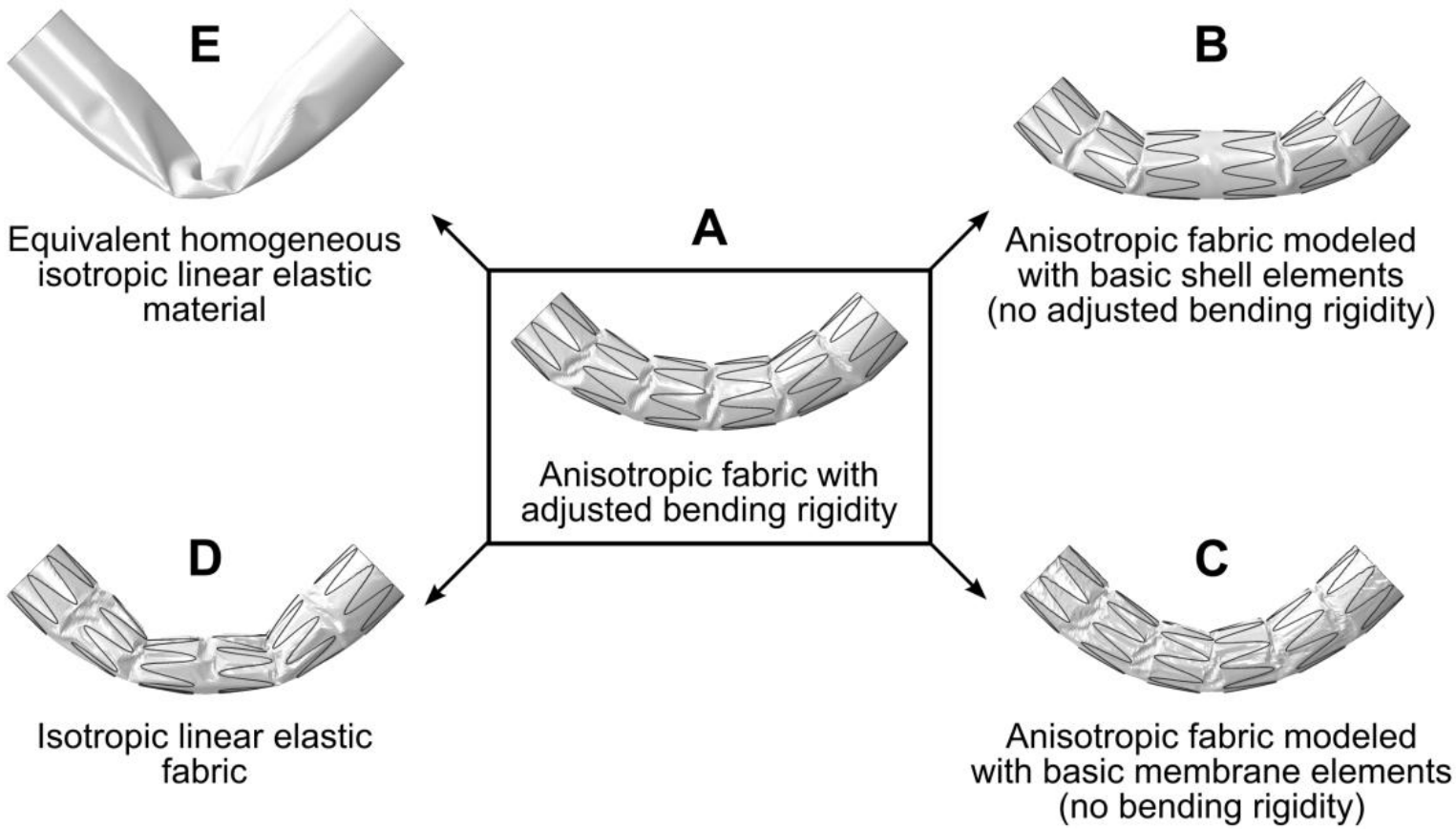
Experimental validation of SG numerical models

SG limbs

- **Marketed SG limbs**
  - SGs with **several Z-shaped stents**
    - (**Ze**) – *Cook Medical*
    - (**Ta**) – *Medtronic*
    - (**En**) – *Medtronic*
    - (**Zlp**) – *Cook Medical*
  - SG with a **single spiral stent**
    - (**Ao**) – *Lombard Medical*
  - SGs with a **single Z-spiral stent**
    - (**Ex**) – *Gore Medical*
    - (**Zs**) – *Cook Medical*
  - SG with **several circular stents**
    - (**An**) – *Vascutek*
  - Dimensions:
    - R_G = 8 mm
    - $L_G \approx$ 90 - 110 mm

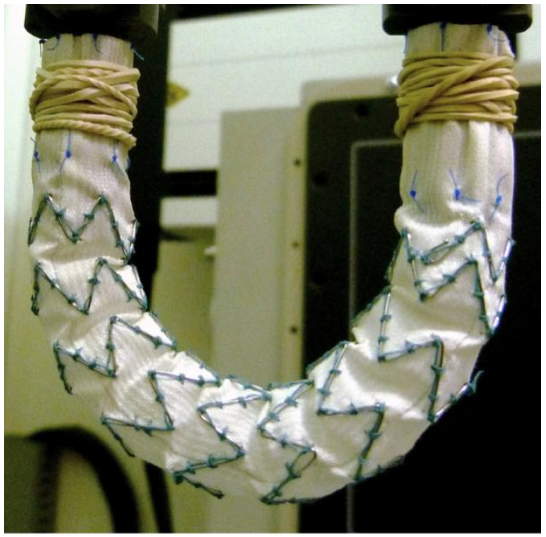


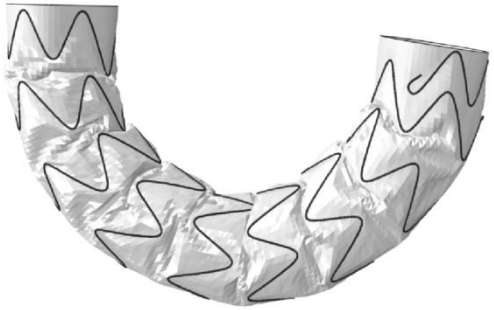
Importance of material properties on SG response

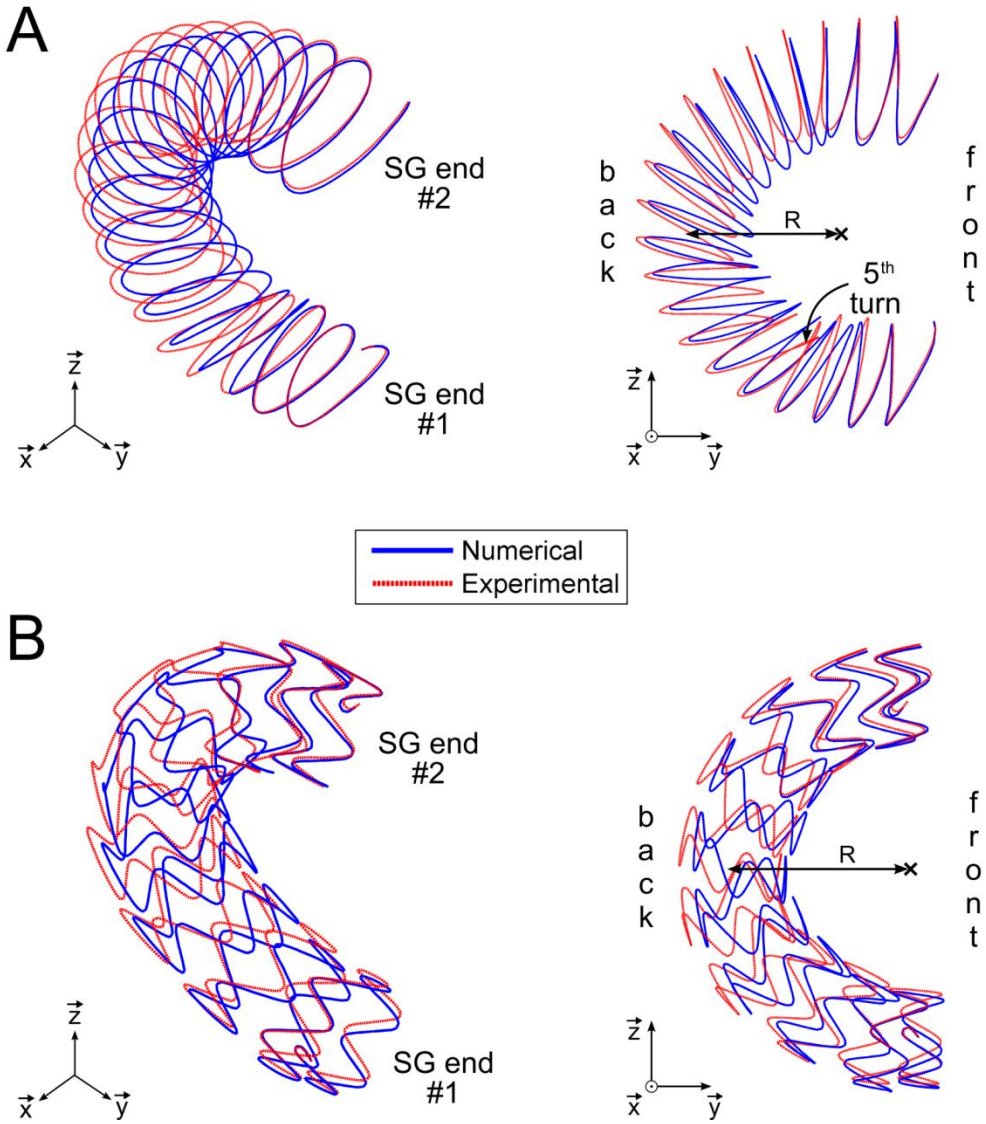


Experimental validation of SG models

- **Comparison between CT scans and the FE simulations**







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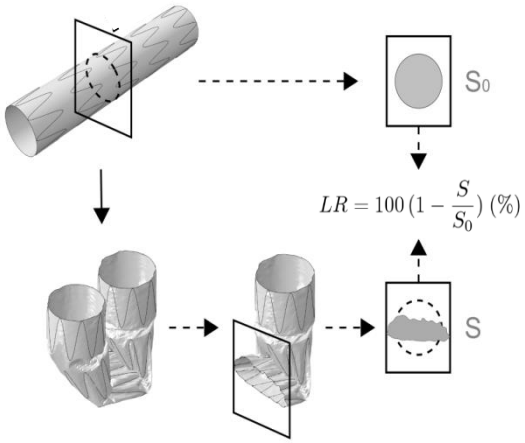
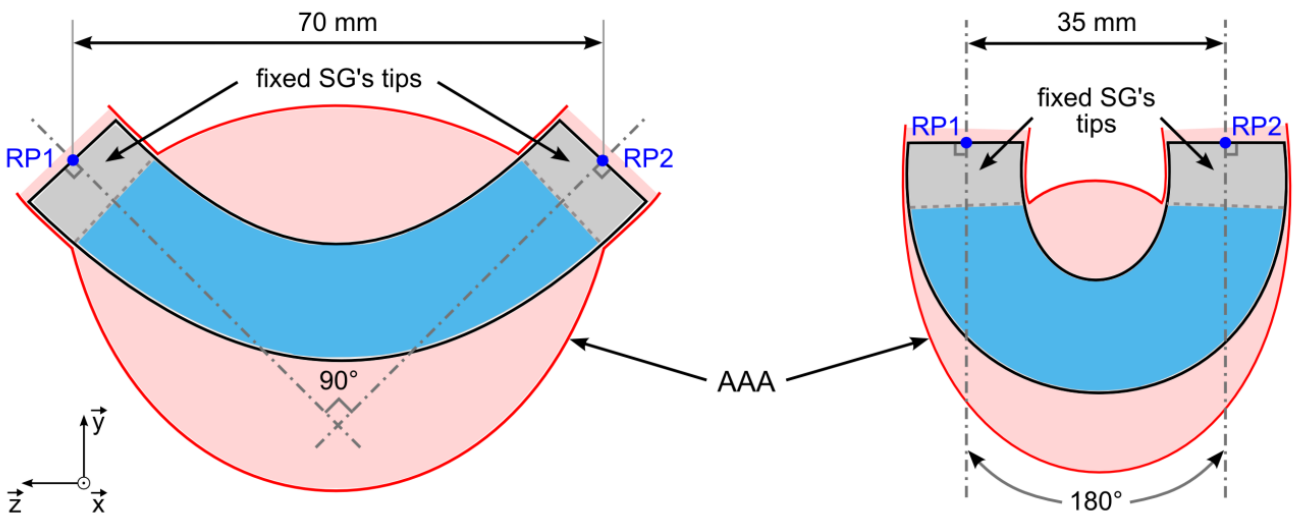
S #1

Study #1

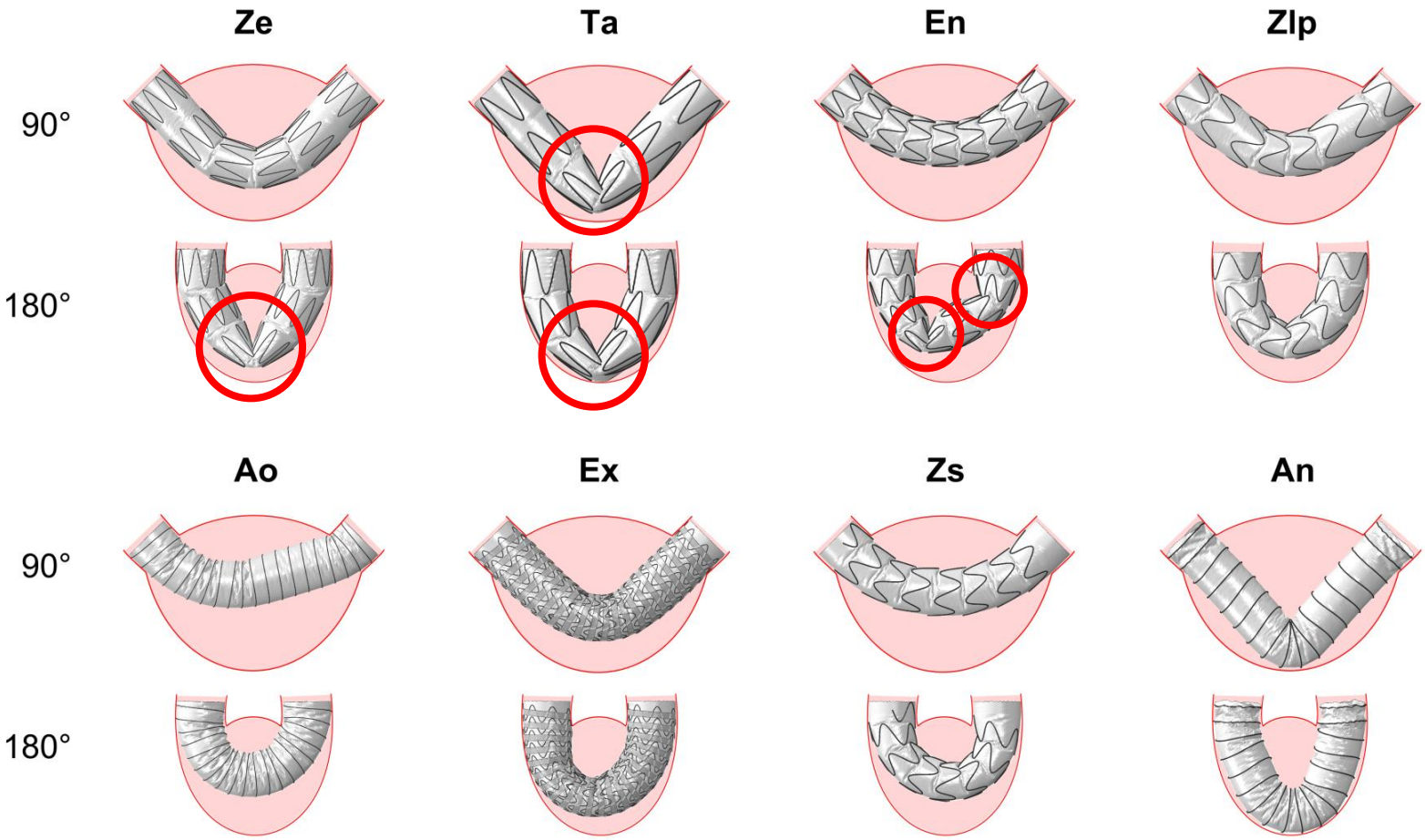
- **Finite element analysis of the mechanical performances of 8 marketed SGs**
  - Assessment and comparison of
    - SG flexibility
    - Stresses and strains within SG components



- **Materials & Methods**
  - Boundary conditions
    - SG bending
    - Adjustment of the distance between SG tips
    - Intraluminal pressurization



Study #1



- **Strong influence of stent design on SG mechanical performances**
- **Greater flexibility and lower stress values for spiral and circular-stented SGs**

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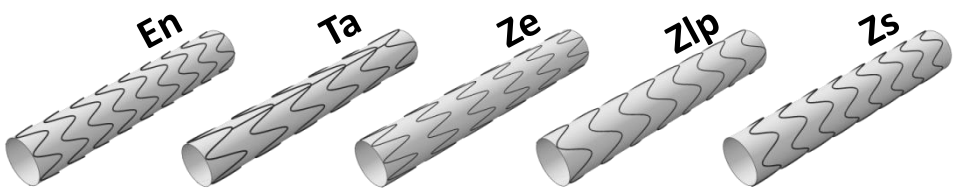
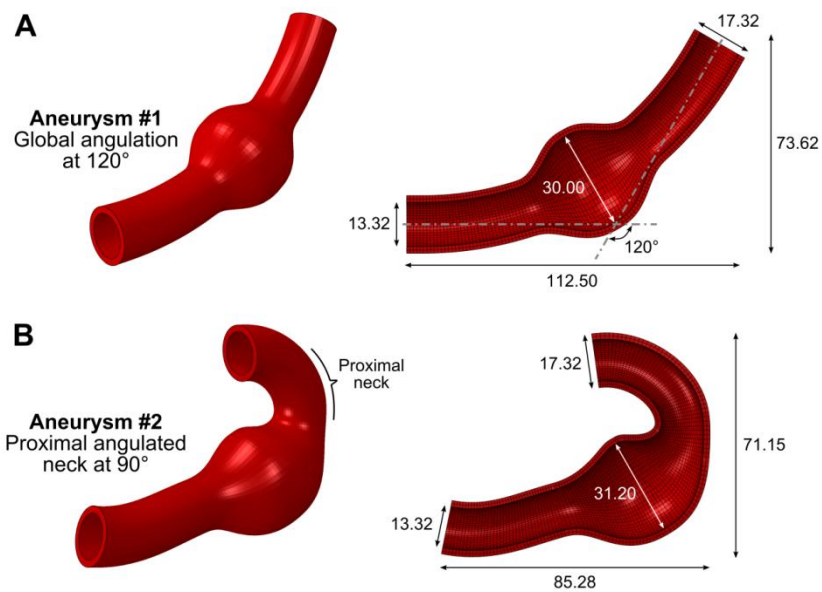
S #2

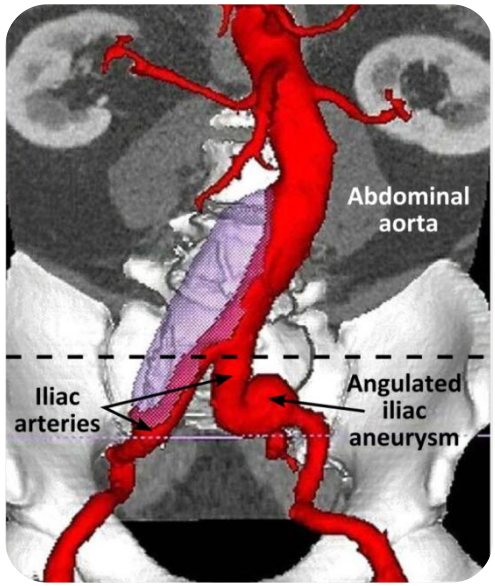
Study #2

- **Numerical simulation of SG deployment**
  - Deployment of marketed SG limbs within two idealized aneurysm geometries
  - Assessment and comparison of SG mechanical performances

- **Materials & Methods**
  - 5 marketed SG limbs
  - 2 iliac aneurysms

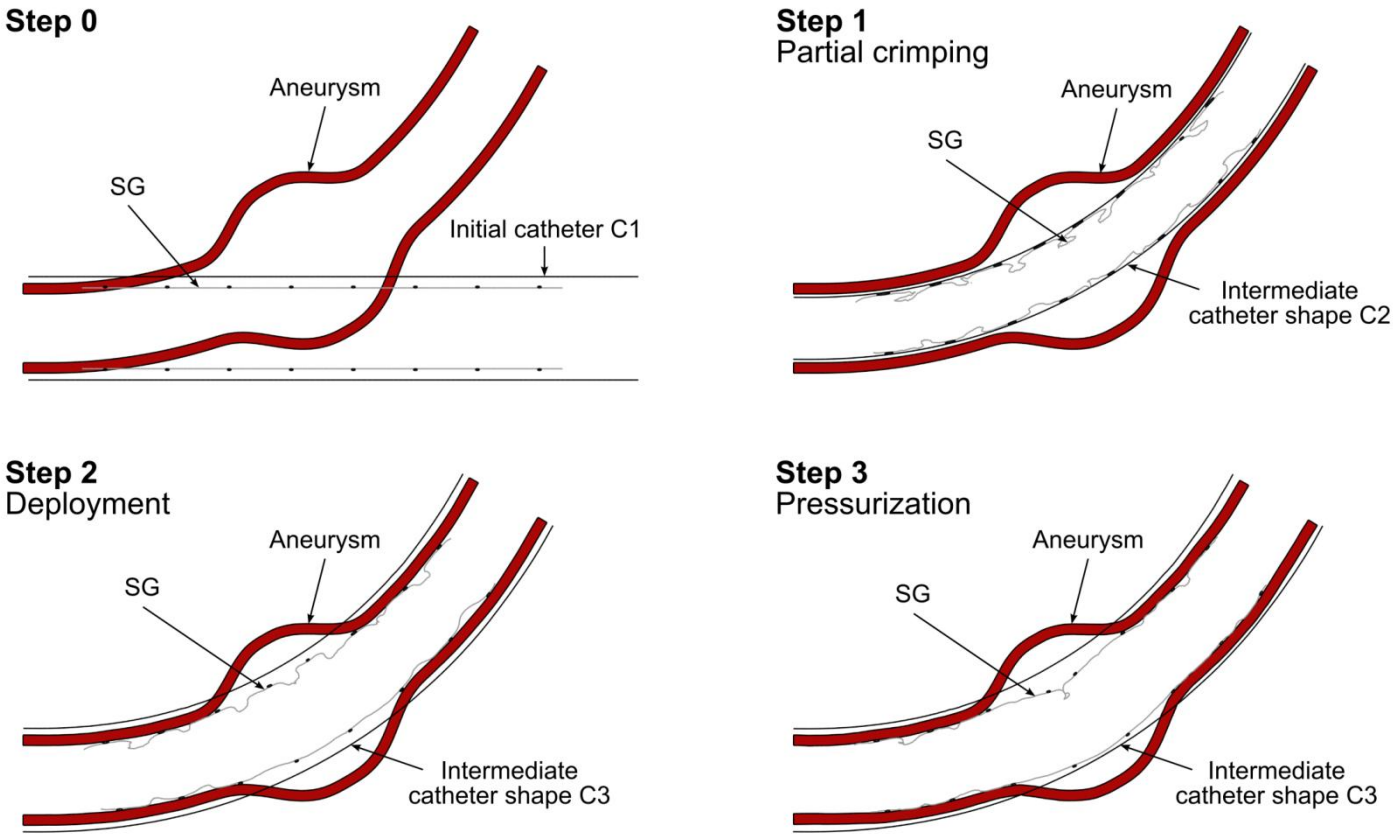






Study #2

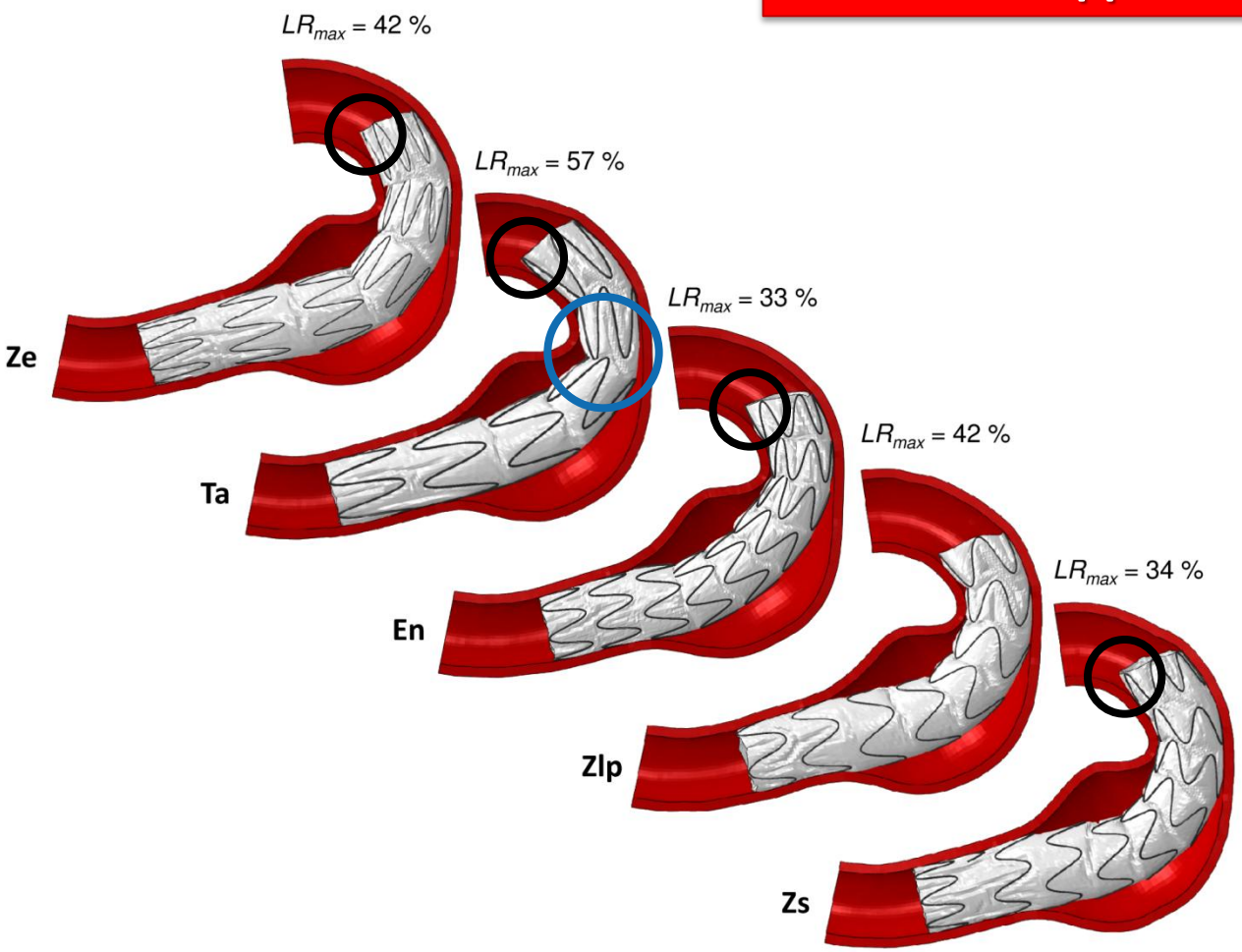
- Boundary conditions
  - *Step 1*: **Partial crimping** of the SG within the catheter
  - *Step 2*: **SG deployment** by radial expansion of the catheter
  - *Step 3*: **Intraluminal pressurization** of the SG



Study #2

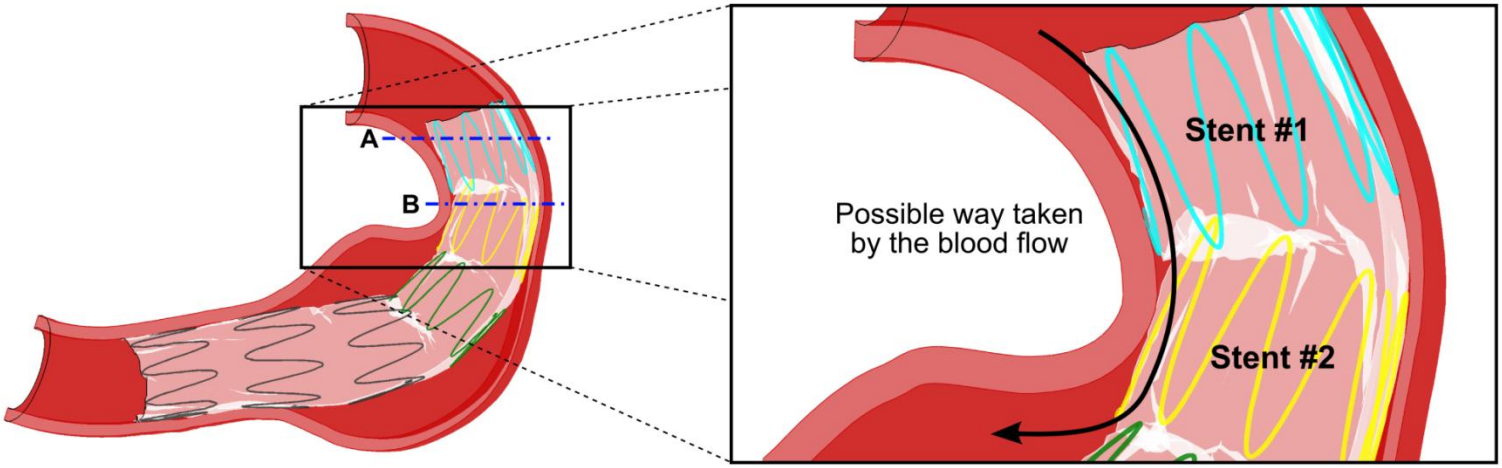
- Aneurysm #2
  - Qualitative results

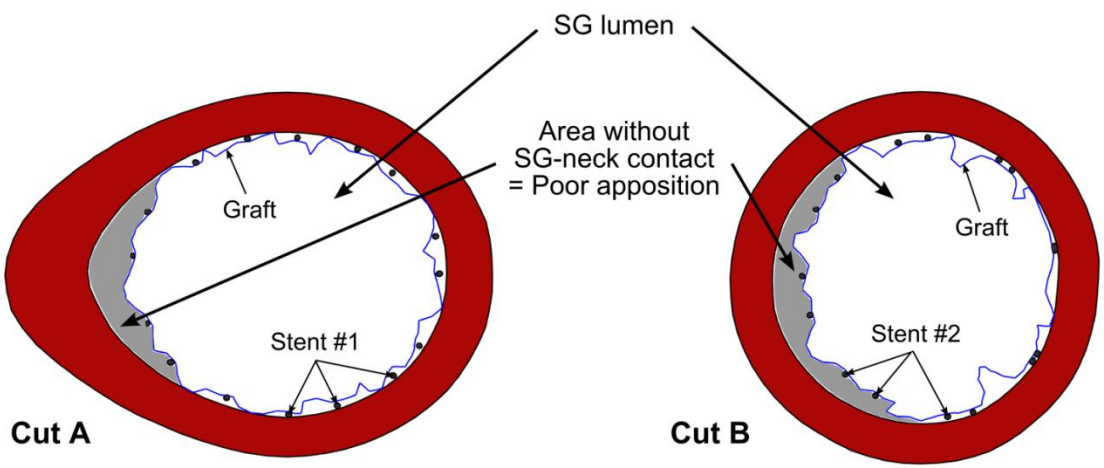
=> Proximal apposition issues

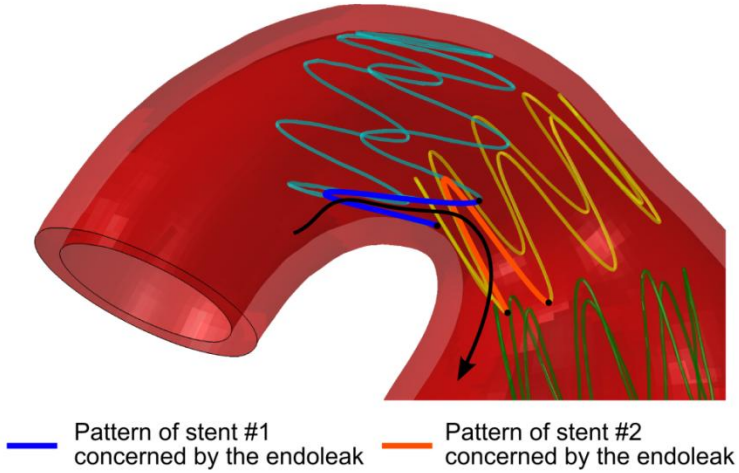


Study #2

- Risk of type I endoleak for aneurysm #2







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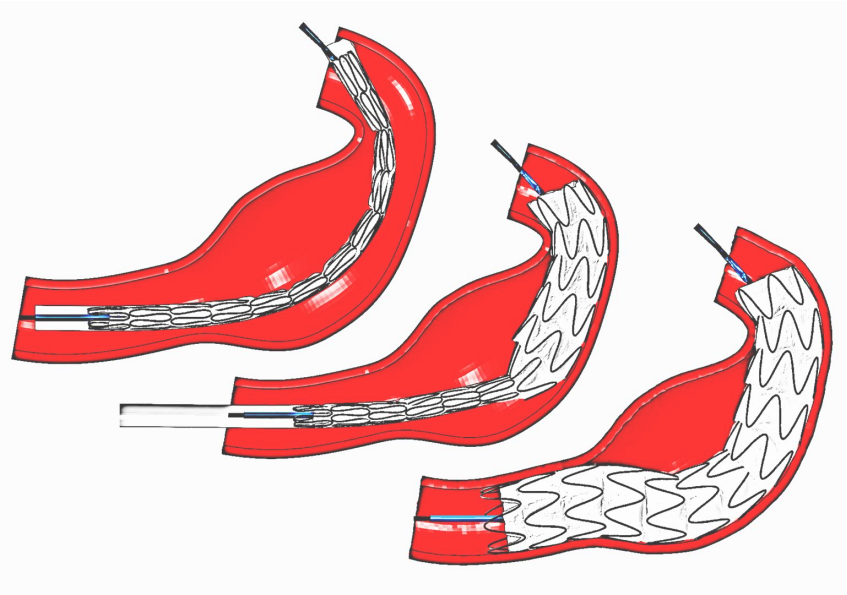
Perspectives

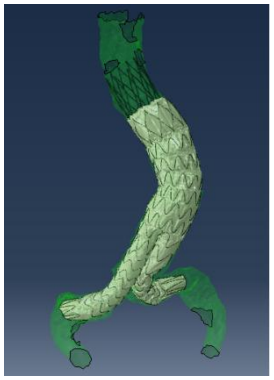
Perspectives

Realism improvement of models and simulations

- SG models (geometry from CT-scan, bifurcated devices)
- Aneurysm models (patient-specific, thrombus, anisotropy)



Predictive patient-specific simulations



Towards computer-aided tool for EVAR

Publications:

N. Demanget, S. Avril, P. Badel, L. Orgéas, C. Geindreau, J. N. Albertini, J. P. Favre.
Computational comparison of the bending behavior of aortic stent-grafts. *J Mech Behav Biomed Mater*, 5(1):272–82, 2012

N. Demanget, P. Latil, L. Orgéas, P. Badel, S. Avril, C. Geindreau, J. N. Albertini, J. P. Favre.
Severe bending of two aortic stent-grafts: An experimental and numerical mechanical analysis. *Ann Biomed Eng*, 40(12):2674-86,2012

N. Demanget, A. Duprey, P. Badel, L. Orgéas, S. Avril, C. Geindreau, J. N. Albertini, J. P. Favre.
Finite element analysis of mechanical performances of eight marketed aortic stent-grafts. *J Endovasc Surg,* in press.

N. Demanget , P. Badel, S. Avril, L. Orgéas, C. Geindreau, J. N. Albertini.
Deployment of stent-grafts in tortuous aneurysmal arteries: towards predictive FEA. *JCVET*, submitted.