Bakk::Mas Day 2023

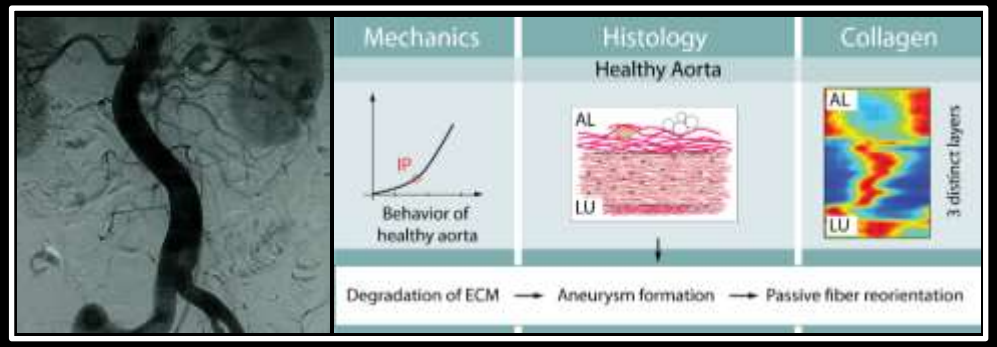
Gerhard Sommer

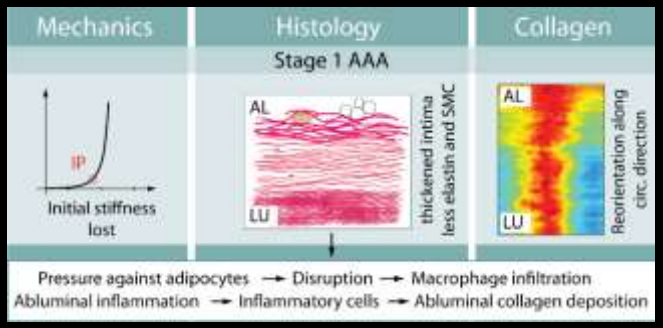
March 3rd, 2023

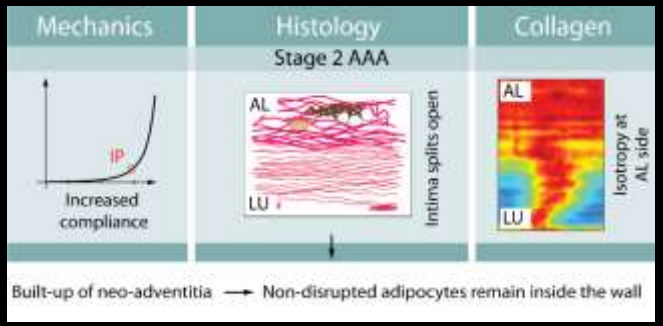
Institute of Biomechanics
Graz University of Technology, Austria

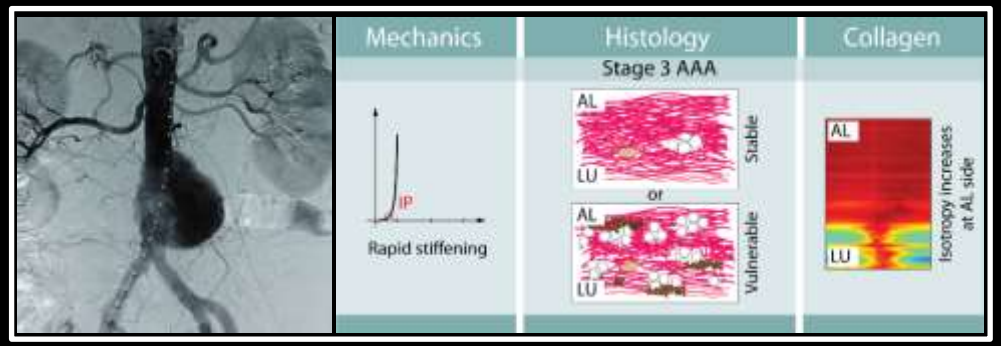
Goal: Better understanding of biological tissues in order to

- understand the causes and progression of diseases better



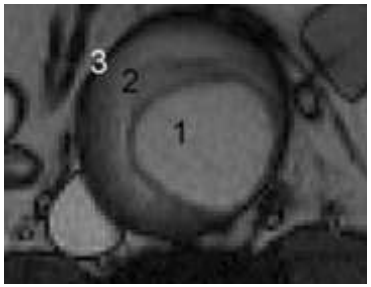


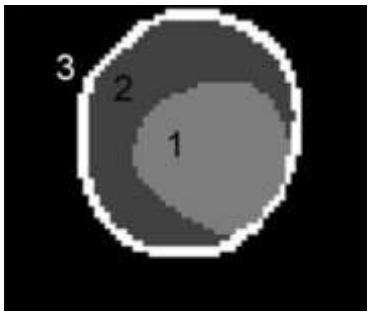


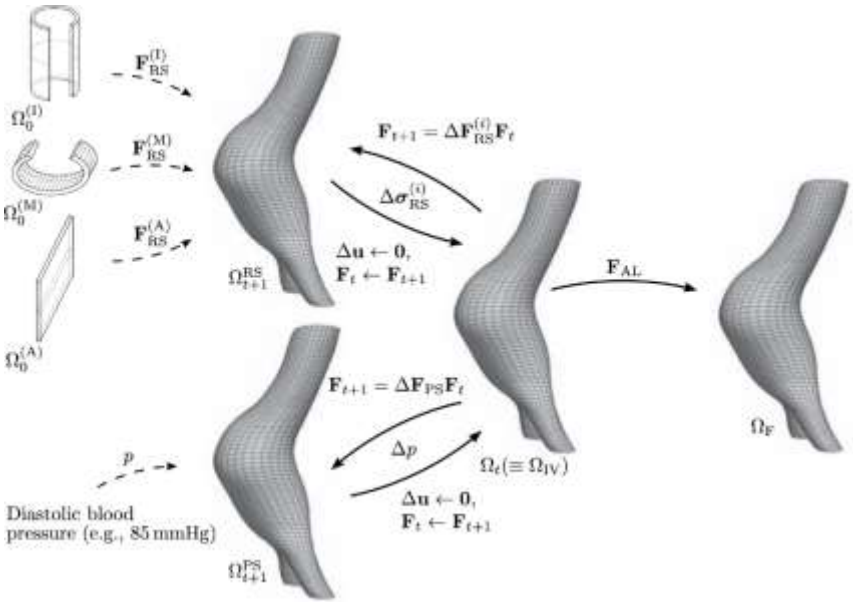


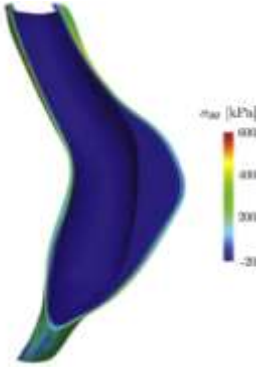
Goal: Better understanding of biological tissues in order to

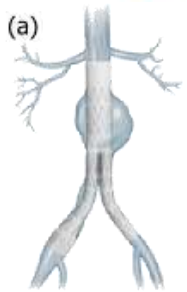
- understand the causes and progression of diseases better
- provide doctors with decision support for complex interventions





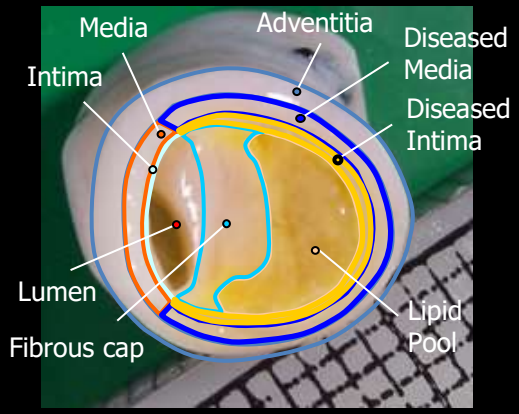


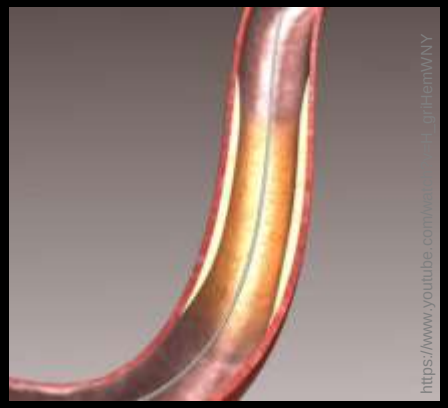


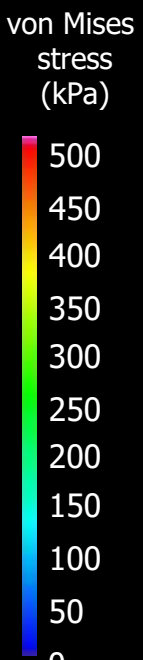


Goal: Better understanding of biological tissues in order to

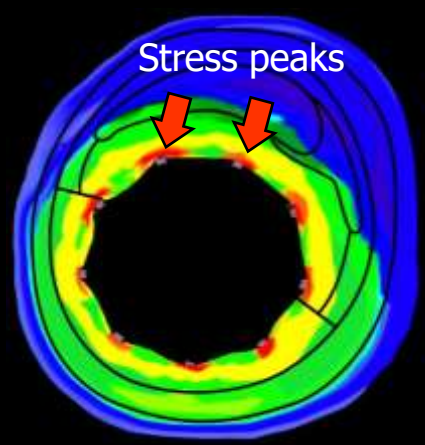
- understand the causes and progression of diseases better
- provide doctors with decision support for complex interventions
- develop implants and optimize medical interventions





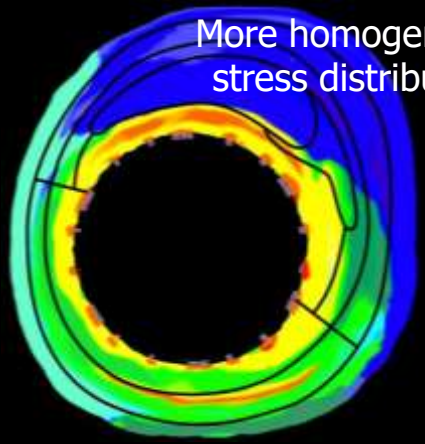


Stent design A

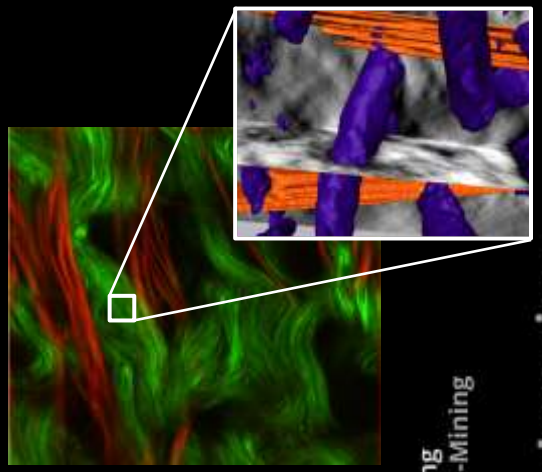


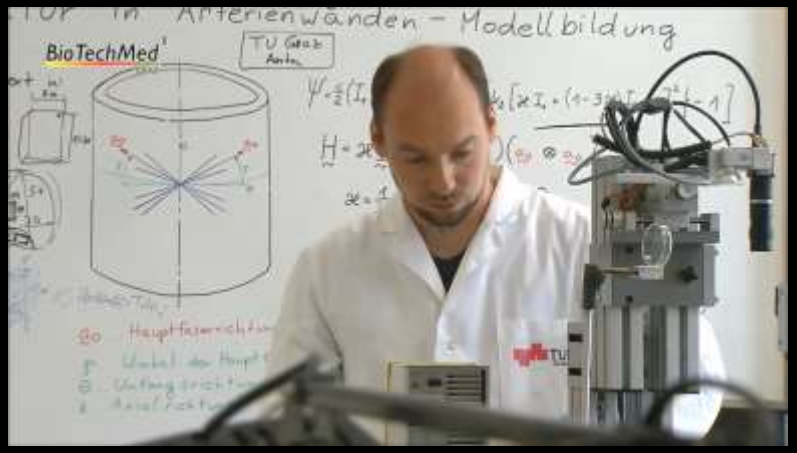
High restenosis risk

Stent design B



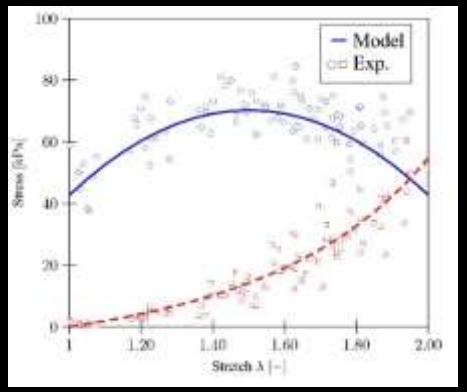
Reduced restenosis risk



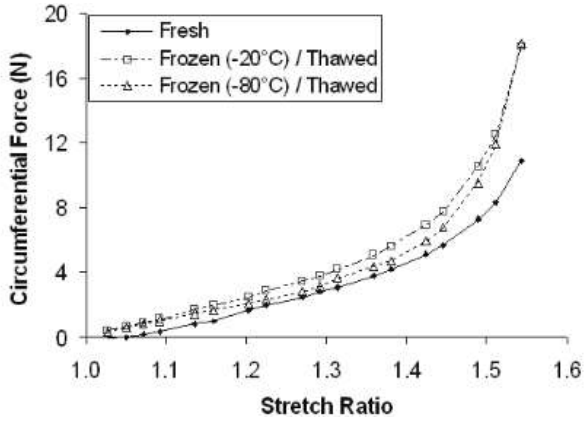


Stress-Stretch Behavior
Microstructure
Nanostructure
Patient Data
Mathematics
Strength of Materials
Deep Learning
Data-Mining
Bio-Imaging
Material Model
Statistical Analysis
Statics
Biology
Anatomy
Biomechanical Experiments
Continuum Mechanics
Dynamics
Pathology
Physiology
Chemistry
Multiscale
Machine Learning

$$\Psi_{\text{fib}} = \frac{k_1}{2k_2} \sum_{i=4,6} \left\{ \exp\left[k_2 \left(\mathbf{C} : \mathbf{H}_i - 1 \right)^2 \right] - 1 \right\}$$

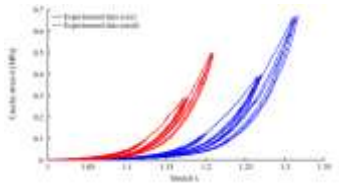


P1: Effects of storage protocols and testing conditions on biomechanical properties of porcine aorta



Jorge O. Virues Delgadillo et al., Effect of freezing on the passive mechanical properties of arterial samples, Journal of Biomedical Science and Engineering, 2010

Mechanical tests

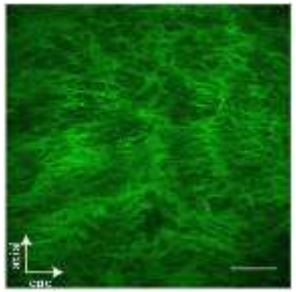


B. Fereidoonnezhad et al., Stress softening and permanent deformation in human aortas: Continuum and computational modelling with application to arterial clamping

Histology

S. Sherifova et al., Failure properties and microstructure of healthy and aneurysmatic human thoracic aortas subjected to uniaxial extension with a focus on the media

SHG



Holzapfel et al., On fibre dispersion modelling of soft biological tissues: A review

P1: Bachelor & Master projects

- Topic:
  - Effect of the different storage protocols and of testing condition on the biomechanical properties of porcine aorta
- Requirements:
  - Basic knowledge of biomechanics
  - Strong interest in hands-on lab work
- Responsibilities:
  - Performing biomechanical tests
  - Evaluation, interpretation and documentation of results
  - Literature research on storage protocols
- Supervisors:

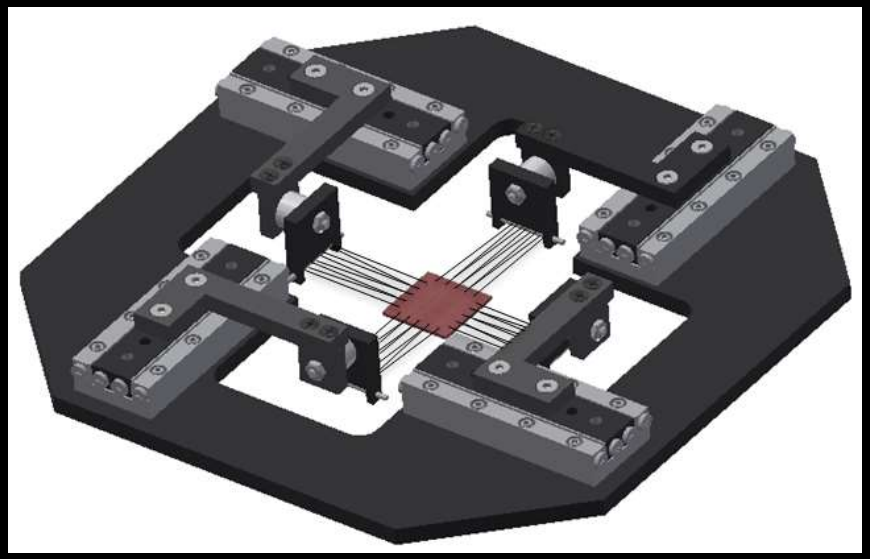
F. Bogoni

G. Sommer

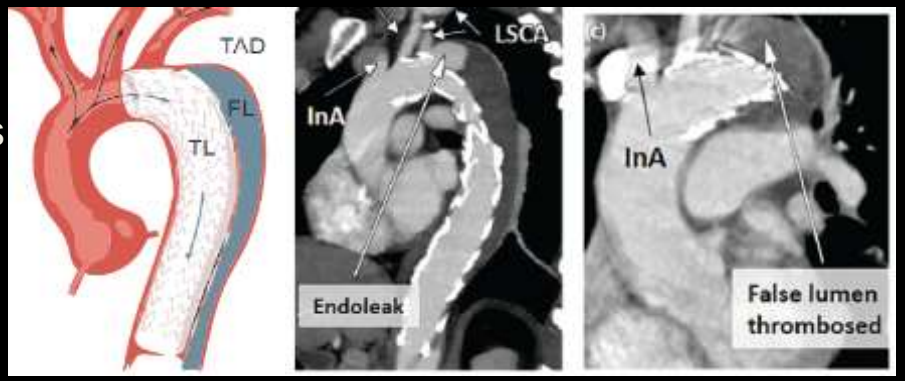
P2: Bachelor project

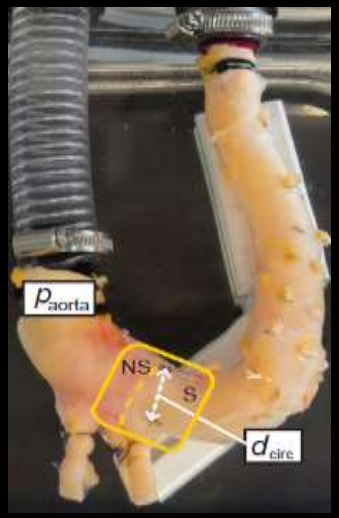
- Topic:
  - Reverse engineering – specification, documentation, and user manual of already existing biaxial extension device
- Requirements:
  - Basic knowledge of sensors and actuators design
  - Basic knowledge of LabView software
- Responsibilities:
  - Specification of already existing device for biaxial extension tests
  - Documentation of the hardware and software used
  - Preparation of a user manual

Anna Pukaluk



- Stent implantation treats aortic diseases
- Induces many **postoperational** complications
- **Cause: Stent-induced stiffness**

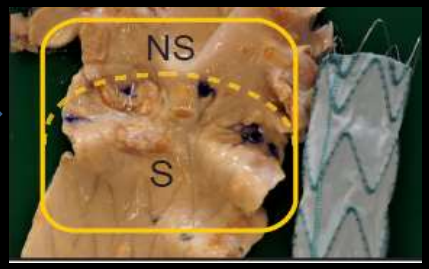




Ex vivo perfusion of stented aorta

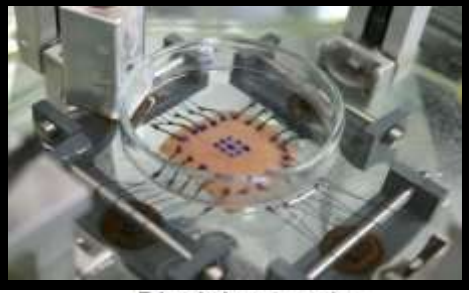
Post-stent quantification of **aortic stiffness**

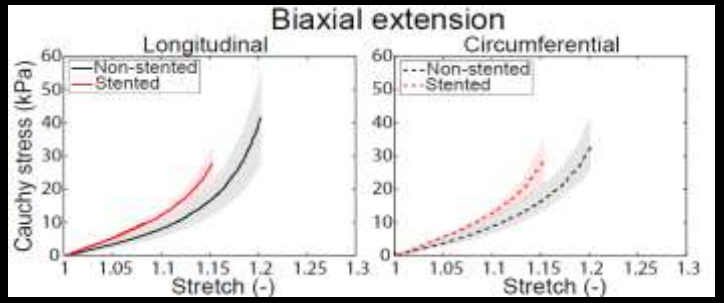
Post-Stent



Non-stented vs stented areas

NS=non-stented; S=stented





Agrafiotis, E. et al. "Global and Local Stiffening of Ex Vivo-Perfused Stented Human Thoracic Aortas: A Mock Circulation Study." *Acta Biomaterialia* (2023).

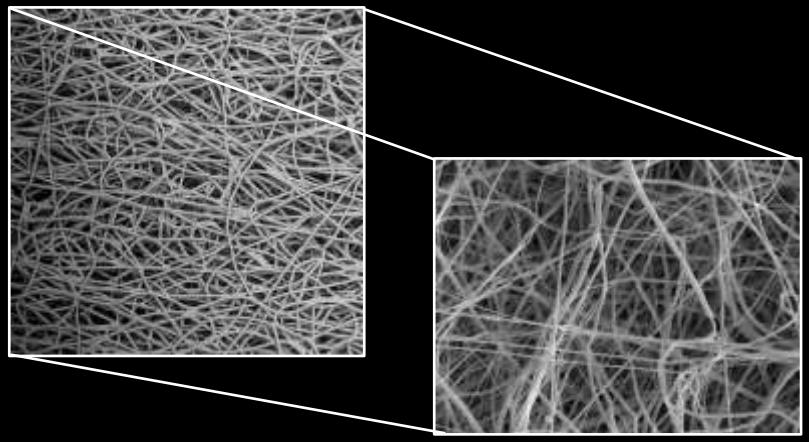
P3: Bachelor or Master project

- Requirements:
  - Knowledge of nonlinear solid mechanics
  - Knowledge about mechanical testing
- Responsibilities:
  - Preparing biaxial samples
  - Performing biaxial Tests
  - An insight into tissue damage mechanics (Literature survey)
- Supervisor:

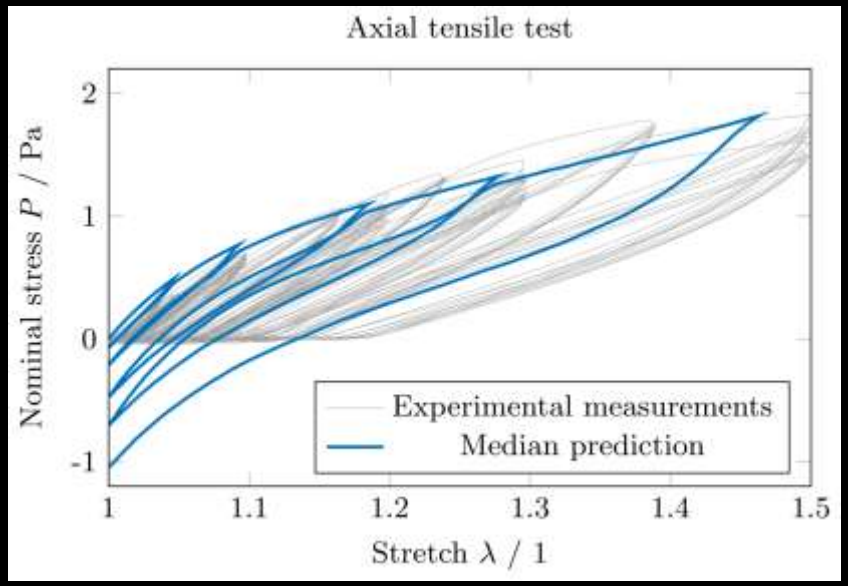
  Masoud Yusefi, Gerhard Sommer

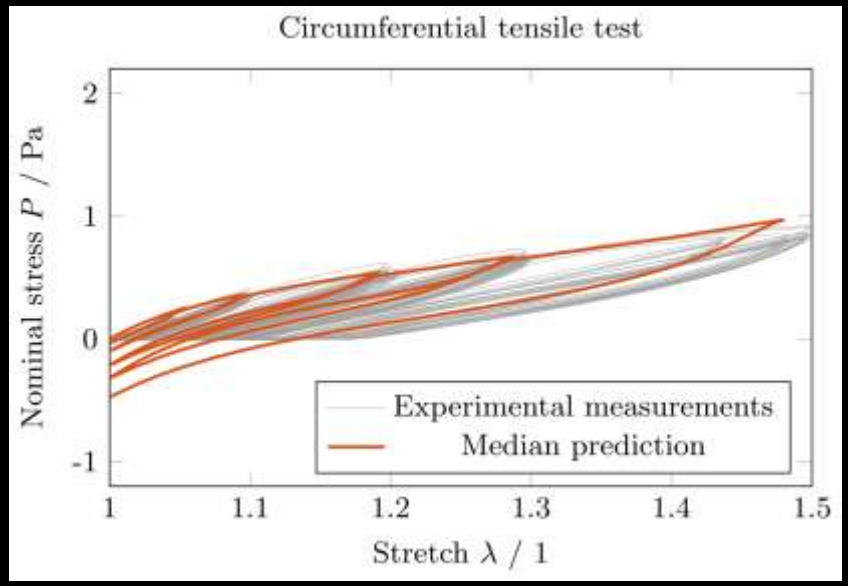
P4: Modeling of anisotropic materials

Implantable heart valve by Xeltis



Microstructure made of fibers





P4: Bachelor and Master Theses

- Topics:
  - Master thesis: *Accuracy of inference about a fiber distribution from the power spectrum of a 2D image*
  - Bachelor thesis: *Review of implemented anisotropic material models in commercial FEM solvers*
- Requirements:
  - Interest in mathematical modeling
  - Some experience with programming languages, e.g. MATLAB or Python
  - Basic knowledge of continuum mechanics
- Responsibilities:
  - Master thesis:
    - Reimplementation of an algorithm for the extraction of fiber orientations
    - Benchmarking of said algorithm
  - Bachelor thesis:
    - Review of FEM solvers and their documentations
    - Summary (and benchmarking) of the anisotropic material models therein
- Supervisor:

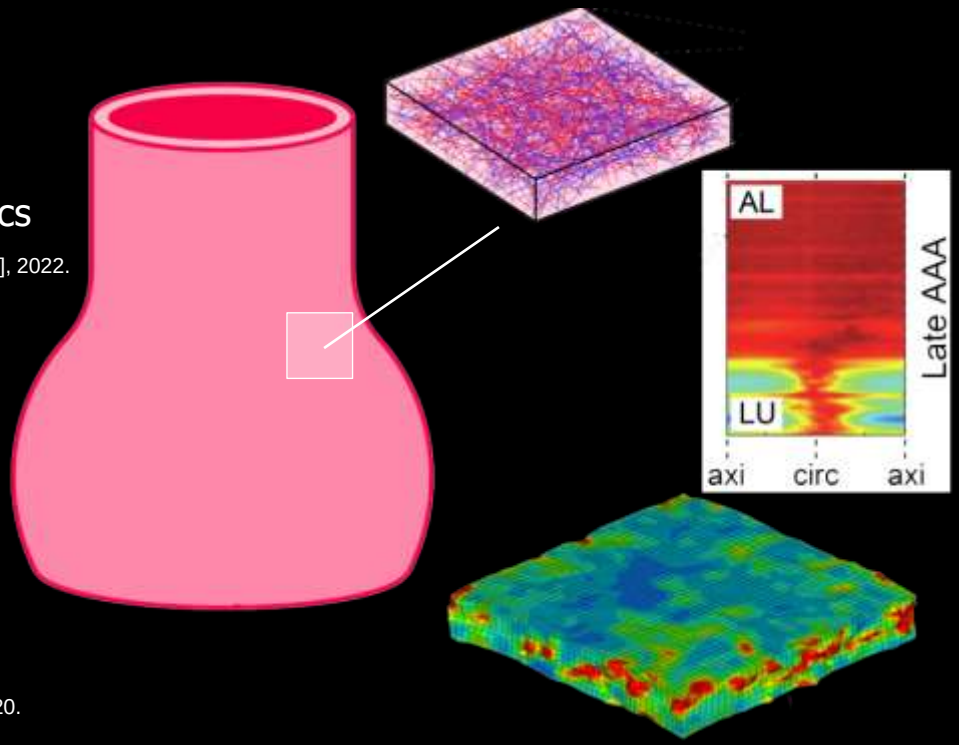
Maximilian Wollner

P5: Computational models of soft tissues

- Applications:

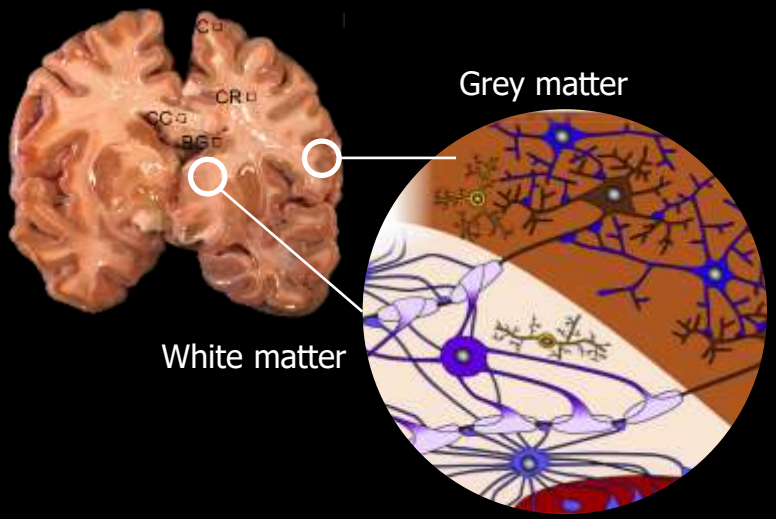
Cardiovascular mechanics

Adapted from Dalbosco et al. [Acta Biomater.], 2022.

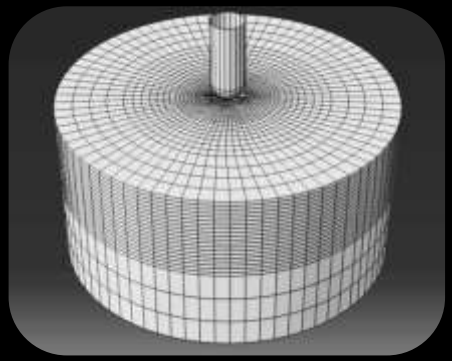


Brain mechanics

Adapted from Budday et al. [Acta Biomater.], 2020.



Mechanics of tissue-mimicking materials



P5: Bachelor- und Masterarbeiten

- Bachelor:
  - An Insight into Brain Mechanobiology from Advanced Imaging Techniques (Literature survey)
  - Finite Element Modeling of Soft Tissue Indentation
  - Influence of Geometric and Mechanical Parameters in Needle Insertion
- Master:
  - Modeling nonlinear viscoelasticity in soft tissues
  - Simulations of failure and crack propagation in soft tissues
- Requirements:
  - Knowledge of nonlinear continuum mechanics
  - Knowledge about Finite Element Method
- Responsibilities:
  - Writing and verification of codes
  - Performing finite element analyses
- Supervisor:

  Dr. Michele Terzano

Bachelor and Master Theses

- Overview
  - Experimental studies
  - Literature research
  - Development of new testing devices
  - Implementation of material models (parameter studies)
  - Structural and mechanical parameter estimation
  - Finite element simulations
- Supervision of master theses in corporation with companies
- If a topic has aroused your interest – come by and talk to us about your ideas!
- Announcements: https://biomech.tugraz.at/teaching
- Contact details: https://biomech.tugraz.at/people