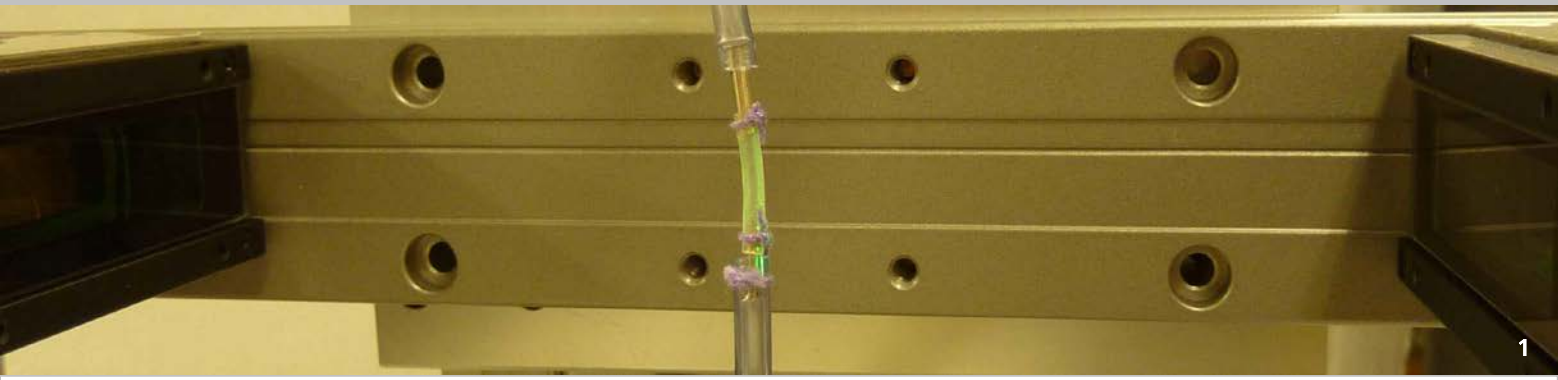

1 *Testing of a segment of an additively manufactured blood vessel.*

MECHANICAL CHARACTERIZATION OF ARTIFICIAL BLOOD VESSELS

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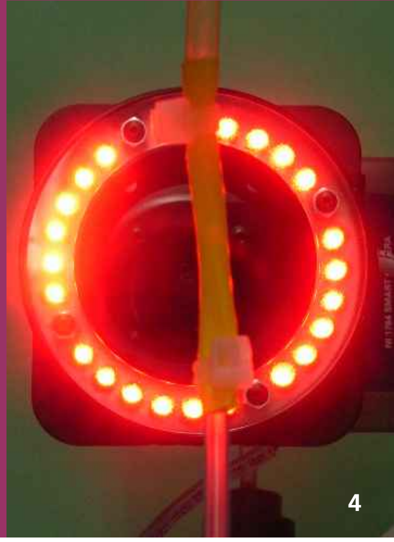
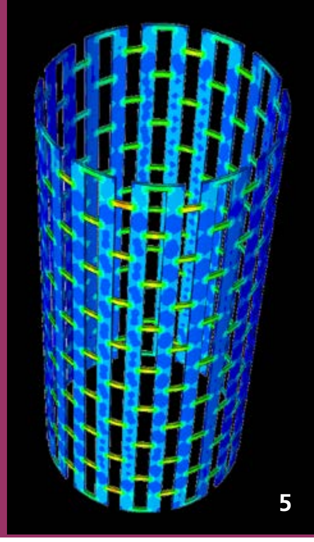
Biomedical materials and implants have to meet very high standards regarding their performance and reliability. In addition to being bio-compatible, artificial blood vessels have to fulfill a range of mechanical criteria in order to reliably replace natural blood vessels. Primary mechanical requirements are a sufficient burst strength of the vessels and their sutured joints to the natural blood vessels or a sufficient creep and fatigue resistance.

Adequate mechanical characteristics of the biomedical material are not only important for the mechanical reliability of the implant, but also for the desired cell growth. Cells are able to sense local stresses caused by the pulsating blood-flow and the slight deformation of the vessel wall. As a result, an artificial blood vessel should mimic the stiffness of a natural blood vessel in order to achieve the desired cell-material interaction.

The research group »Biomedical Materials and Implants« carries out research on the mechanical performance and the reliability of biomedical materials (like bone cements, dental filling materials, hydrogels) and implants (dental implants, ceramic hip balls, osteosynthesis plates, etc.).

In order to study artificial blood vessels, a testing set-up is available which can apply static and dynamic pressure profiles to linear and branched artificial blood vessels. The resulting strain response of the blood vessels is determined using a laser scanner or image processing. The recorded data are used to determine the compliance (and its strain dependency) and the strength of the artificial blood vessels.

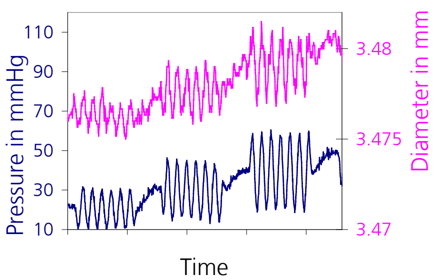




Our Expertise for Your Benefit

Mechanical Characterization of Blood Vessels

Linear and branched blood vessels can be studied in a testing set-up which is able to apply complex fluid pressure profiles to the vessel system. High resolution measurements of the vessel deformation can be recorded with a laser scanner, the 2-D strain response due to the bi-axial loading can be studied by image processing. Since the set-up relies on non-contact measurements of the strain response, the measurements can also be carried out on vessels in a suitable bioreactor. Flow sensors are available for measuring the distribution of flows in a branched system.



Applied pressure and strain response of a vessel

Finite Element Analysis

Stress distributions and the strain response of homogeneous or structured vessel walls can be studied using Finite-Element-Analysis. A range of materials models are available to describe the mechanical properties of different biomedical materials.

Optimal Lay-Out of a Branched Vascular Tree

The optimal branching structure of a vascular tree (i.e. lengths and diameters of the individual vessels, branching points and branching angles) can be determined using an optimization routine. The input parameters are the position, pressure and flow for the input and terminal branches. Output of the routine is a CAD-file of the blood vessel system.

Electrostatic Spinning

An electrostatic spinning set-up is available for generating porous tubular structures from biocompatible polymers. The electro-spun non-wovens can be characterized in the blood vessel test stand or standard tensile testers. A mechanical model for non-wovens is available to simulate mechanical properties of non-wovens and the interaction of non-wovens with media.

Mechanical Testing of Biomedical Materials and Implants

In order to evaluate the reliability and performance of biomedical materials and implants we have developed specific testing methods to study, for example, their strength, fatigue, creep or wear behavior. Simulation tools are used to analyze and solve specific problems. Our experimental techniques and simulation tools are used to study dental implants, ceramic hip balls, osteosynthesis plates, additive manufactured implants, dental filling materials, hydrogels, or non-wovens.

Services

- Mechanical testing of blood vessels:
  - Modulus
  - Burst strength
  - Strain response
- Finite-Element-Analysis of homogeneous or structured vessels
- Optimal branching of a vascular tree
- Electrostatic spinning of porous tubular structures
- Mechanical testing of biomedical materials and implants
  - Stiffness / compliance
  - Strength
  - Fatigue
  - Creep behavior
  - Abrasion resistance
  - Friction coefficient
  - Internal stresses

2 *Testing a tubular electro-spun non-woven*
3 *Flow through a branched system*
4 *Recording the strain-response to a bi-axial stress*
5 *Finite-element analysis of a structured vessel wall*