Composite synthetic vascular prosthesis design

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Introduction
Bypass or replacement of diseased medium-sized arteries (coronary, femoral and carotid) is mostly performed using autologous veins. Clinical practice reveals that commercially available synthetic artery prostheses can be used only for arteries with large flow, small resistance and large diameter (> 10 mm). Failure of medium-sized and small (< 5 mm) synthetic prostheses is often contributed to a mechanical mismatch with the host artery [1], [2].

Objective
- Development of a synthetic vascular prosthesis which is mechanically compatible with the host artery, based on an experimentally validated computational model.

Methods
Mechanical characterisation

Dynamic bi-axial tensile test
- Axial extension → longitudinal properties
- Pressurisation → circumferential properties
- Torsion → shear properties
- Dynamical loading → viscoelastic properties

Prototype development

Reactive Injection Molding
- Viscoelastic matrix (hydrogel)
- Non-linear elastic fibres (Lycra)
- Optimized fibre layout

Computational
- Geometrically & physically nonlinear
- Incompressible (mixed formulation)
- Composite modelling
- FEM

Results

Conclusion
Fibre reinforced hydrogel tubes show better results than existing prostheses, but are still mechanically incompatible. Extended measurements of natural coronary or femoral arteries are needed to decide whether the composite prostheses are able to mimic their dynamic mechanical behaviour.

References: