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DESIGN OF STENTS USING GEOMETRICALLY AND MATERIALLY NONLINEAR TOPOLOGY OPTIMIZATION

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Chronic narrowing of the iliac arteries (IA) and/or femoral arteries (FA) due to atherosclerosis, is a common cause of the peripheral artery disease (PAD). PAD symptoms include restricted blood flow towards the lower limbs, which can lead to leg pain, skin ulcers, tissue death, and other severe complications. Atherosclerosis is commonly treated using angioplasty combined with stent placement. Unfortunately, interventions due to restenosis or stent failure are relatively frequent.

Stents within the IA/FA are especially prone to failure [1]. In daily activities such as walking or sitting, the IA and FA undergo large deformations. This leads to bending, twisting and compression of the artery and the stent. The stent structure has to be flexible enough to follow these deformations, while exhibiting high radial forces to guarantee for sufficient blood flow. Current commercial stents are based on uniform patterns in terms of geometry and shape, which do not take into account large deformations. Commonly used superelastic nitinol stents exhibit excellent flexibility but lack required radial force properties [2]. Therefore, a novel stent design, which allows for the necessary flexibility, but is radially strong, is desired.

We employ topology optimization (TO) to generate structures which satisfy the requirements of a stent within an IA/FA and additionally can be individualized to patient-specific geometries. TO is a established structural design method, able to generate non-intuitive designs for complex problem settings. The key idea is to achieve the flexibility by means of the geometric layout, rather than by material superelasticity and thus allow for non-superelastic material choices. To achieve this, the optimization model considers geometrically as well as materially nonlinear mechanics, with focus on plasticity. The chosen TO problem formulation, the simulation setup as well as the solution procedure, are presented.

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