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ADJOINT SHAPE OPTIMIZATION OF ARTERIAL BYPASS-GRAFT ANASTOMOSES CONSIDERING FLUID-STRUCTURE INTERACTION

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The development of intimal hyperplasia (IH), is caused among other factors by unnatural wall-shear-stresses (WSS) and constitutes the main reason for the failure of bypass-graft surgeries. In particular, the so called oscillating shear index (OSI), which is a measure for the change in the direction of the WSS during one cardiac cycle, has been linked to the development of IH. In order to minimize critical flow features such as large regions with a high OSI, the shape of the distal anastomosis (the connection where blood flows from the graft into the artery) is oftentimes manipulated by surgical techniques to obtain a so called cuff. Also precuffed grafts are manufactured, that have an improved, non-circular shape at the distal end [1].
So far the design of improved cuff shapes has been based on empirical studies. Numerical simulation methods for fluid-structure interaction problems combined with mathematical optimization techniques are a promising tool to find optimal shapes for cuffed grafts. We combine the partitioned solution approach for arterial blood flow simulations from [2] with the adjoint optimization framework introduced in [3]. With the goal of minimizing the OSI, which is not readily accessible for an optimization, a suitable auxiliary cost functional and the corresponding adjoint problem are derived. The optimization strategy is then applied to anastomoses with different initial shapes in order to find optimal cuff shapes.

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