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A Numerical Framework for the Mechanical Analysis of Dual-layer Stents in Intracranial Aneurysm Treatment

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Abstract

Dual-layer stents and multi-layer stents represent a new paradigm in endovascular interventions. Multi-layer stents match different stent designs in order to offer auxiliary functions. For example, dual-layer stents used in the endovascular treatment of intracranial aneurysms, like the FRED^{TM} (MicroVention, CA) stent, combine a densely braided inner metallic mesh with a loosely braided outer mesh. The inner layer is designed to divert blood flow, whereas the outer one ensures microvessels branching out of the main artery remain patent. In this work, the implemented finite element (FE) analysis identifies the key aspects of dual-stent mechanics. In particular, dual-layer stents used in the treatment of intracranial aneurysms require the ability to conform to very narrow passages in their closed configuration, while at the same time they have to provide support and stability once deployed. This study developed a numerical framework for the analysis of dual-layer stents for endovascular intracranial aneurysm treatment.Our results were validated against analytical methods. For the designs considered, we observed that foreshortening was in average 37.5%±2.5%, and that doubling the number of wires in the outer stent increased bending moment by 23%, while halving the number of wires of the inner stent reduced von Mises stress by 2.3%. This framework can be extended to the design optimization of multi-layer stents used in other endovascular treatments.

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1. Introduction

An intracranial aneurysm, also known as cerebral or intracerebral aneurysm, is a weak or thin spot in an artery of the brain that inflates and creates a balloon-like bulging which fills with blood, Egan (2005); Moriyama et al. (1971).

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