11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

Finite Element Modeling of Endovascular Treatments

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Key Words: *Aneurysm, Finite Element Modelling, Endovascular.*

Endovascular coiling is the most common treatment for cerebral aneurysms [1]. During coiling, a sequence of embolic coils with different stiffness, shapes, sizes, and lengths is deployed to fill the aneurysmal sac. Although packing density has been clinically correlated with treatment success, many studies have also reported success at low packing densities, as well as recurrence at high packing densities [2]. Such reports indicate that other factors may influence treatment success. In this study, we use a novel finite element approach and computational fluid dynamics (CFD) to investigate the effects of packing density, coil shape, aneurysmal neck size, and parent vessel flow rate on aneurysmal hemodynamics [3]. The study examines a testbed of CFD simulations of post-treatment flows in idealized basilar tip aneurysm models. Simulated coil deployments, as shown in Figure 1, were validated against in vitro and in vivo deployments. Among the investigated factors, packing density had the largest effect on intraaneurysmal velocities. However, multifactor analysis of variance showed that coil shape could also have a considerable effect, depending on packing density and neck size. Further, linear regression analysis showed an inverse relationship between mean void space in the aneurysm and mean intraaneurysmal velocities, which underscores the influence of coil distribution and thus coil shape. Our study suggests that while packing density has a large effect on post-treatment hemodynamics, other factors such as coil shape, aneurysmal geometry, and parent vessel flow are also important factors. In addition to coils, the study will present new finite element models of stents and flow diverters among other endovascular devices [4]. An example flow diverter deployment is shown in Figure 2. The effects of the different devices on post-treatment aneurysmal flows will be compared, and results from their clinical use in interventional planning will be presented.

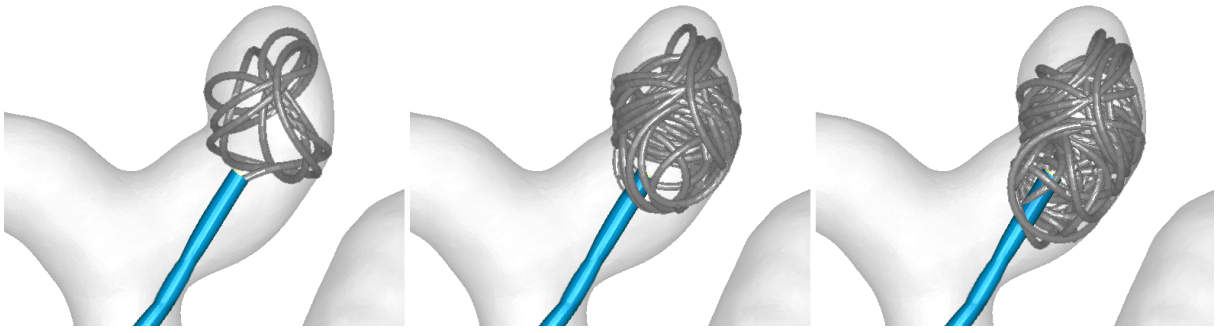

Figure 1. Finite element model embolic coil deployment.

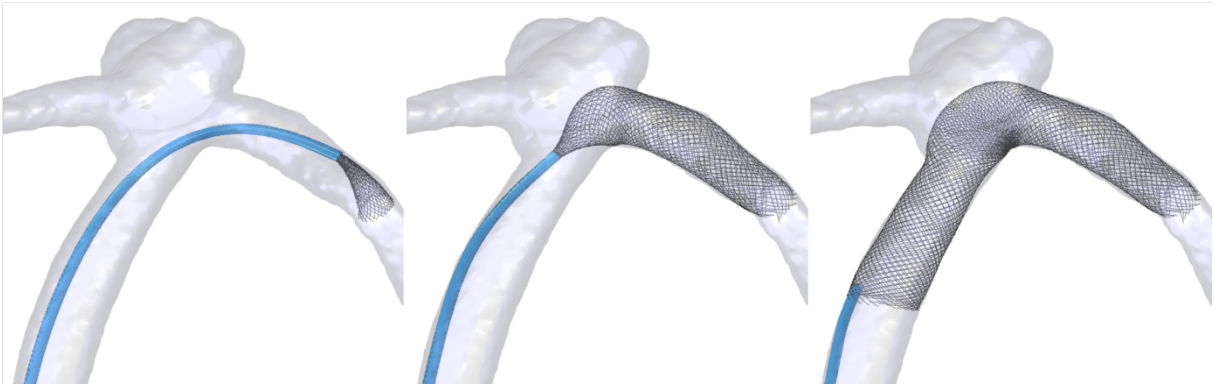

Figure 2. Finite element model flow diverter deployment.

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