COVERED MICROSTENT FOR THE TREATMENT OF INTRACRANIAL WIDE-NECKED AND FUSIFORM ANEURYSMS: A FINITE ELEMENT ANALYSIS FOR THE DESIGN OF STENT COVERINGS

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Wide-necked and fusiform intracranial aneurysms are life-threatening diseases. Surgical procedures are frequently inadequate for effective treatment. Minimally invasive endovascular procedure includes coil embolization of the aneurysm cavity. However, these procedures are not ideal for the treatment of many wide-necked and fusiform aneurysms. An endovascular approach of placing a covered microstent across the aneurysm artifice is promising. Unlike bare stents, covered microstents will have the capability of completely preventing the blood flow into the aneurysm cavity and thereby reducing the risk of aneurysm rupture in the brain.

There are a few challenges that one has to overcome to accomplish research in this direction. Firstly, intracranial arteries are small (1.0 - 3.5 mm inner diameter) and delicate; secondly, the vasculature system in the brain is tortuous as shown in Figure 1. We are developing a series of highly flexible ultrathin (~100 micron) stent coverings. These coverings will be elastomerically captured onto the flexible metal stent. A thorough Finite Element Analysis (FEA) of the covered stent is necessary to address important covering design issues. Flexibility with respect to the covering thickness can be predicted. Calculation on the optimal inflation pressure with respect to the thickness is important for the covering manufacturing process.

Although a substantial amount of research on FEA has been carried out on bare stents [1-3], no literature is available on numerical analysis of the covered stent. In this study, the mechanical properties such as deployment pressure and elastic recoil of the covered stent will be investigated by nonlinear finite element method. The results will be compared to the mechanical properties of the bare stent. Figure 2 shows the primary deformation and stress distribution of the bare stent under uniform pressure. Two types of model stents have been considered in this work: Palmaz-Schatz PS 1541 and Cordis Bx-velocity. This study will also determine (i) an optimum covering thickness suitable for the safe deployment and (ii) the force versus displacement profile in a three point bend test configuration for the prediction of flexibility of the covered stent.

References:

1. Etave,F., Finet, G., Boivin, M., Boyer, J., Rioufol, G., and Thollet, G., 2001, "Mechanical properties of coronary stents determined by using finite element analysis," *J of Biomechanics*, Vol. 34, pp.1065-1075.
2. Migliavacca, F., Petrini, L., Colombo, M., Auricchio, F., and Pietrabissa R., 2002, "Mechanical behavior of coronary stents investigated through the finite element method," *J of Biomechanics*, Vol. 35, pp.803-811.
3. Dumoulin, C., and Cochelin, B., 2000, "Mechanical behavior modeling of balloon-expandable stents," *J of Biomechanics*, Vol. 33, pp.1461-1470.

Figure 1. An angiogram showing the presence of two intracenial aneurysms and the tortuous intracranial vasculature system in the brain.

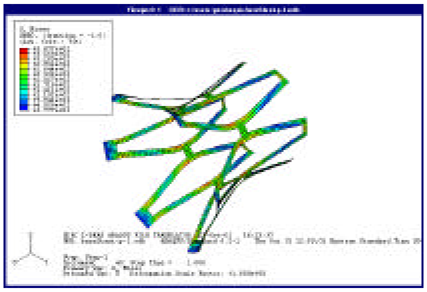

Figure 2. Deformation of the stent after applying the uniform internal pressure using Palmaz-Schatz PS 1541 model stent.