Numerical Study of Metal Fatigue in a Superelastic Anchoring Stent Embedded in a Hyperelastic Tube

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Abstract: In this study we compare various way of quantifying high cycle radial fatigue behavior in a percutaneous Mitral repair device using Goodman methods. In order to provide an improved representation of the tissue-device interaction, we use an Ogden hyperelastic model to simulate the native vessel with parameters obtained from pressure-diameter test data of human cadaver heart coronary tissue, and published data presented in previous work. We also examine how the computed peak tensile strains at the surface of this device differ from (a)The values computed at integration points in the 3D and (b) The same integration point values extrapolated to the nodal points and averaged over adjacent elements.

Keywords: Abaqus Explicit, Abaqus Standard, Cardiovascular Therapy, Constitutive Model, Contact, Fatigue, Fatigue Life, Hyperelasticity, Implantable Medical Device, Mass Scaling, Minimally Invasive Surgery, Mitral Valve Repair, NiTinol, Percutaneous Devices, Ogden Model, Percutaneous Stent Delivery, Superelasticity, Tissue Modeling, UMAT, VUMAT

1. Introduction

This paper analyzes the strains in the proximal anchor for a mitral repair device being developed at Edwards Lifesciences. Our aims are to:

1. Provide a quantitative comparison between modeling a device embedded in a rigid enclosure versus one in a hyperelastic deformable enclosure.
2. Compare results from hyperelastic enclosure using data from human cadaver heart coronary tissue and published data for the Great Saphenous Vein (DeHerrera, Sun, 2007).
3. Study the difference in peak strains computed at different topological locations.

The first phase of this study consists of simulating crimping of the stent to a smaller OD with a subsequent cyclic radial load to help evaluate pulsatile fatigue behavior in the stent. The second phase analyzes the behavior of the stent when deployed in a hyperelastic tube that mimics the Coronary Sinus (CS) undergoing a cycled pressure loading. The final phase compares the peak