Investigation of Interaction between Guidewire and Native Vessel Using Finite Element Analysis

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Abstract: Endovascular aneurysm repair involves insertion of an introductory component called guidewire through native vessels to help with the guidance of the delivery catheter. Guidewire tends to alter the vessel geometry due to its higher stiffness compared to the vessel wall. Very limited data is available to understand such interactions. Investigation of interaction between guidewire and native vessels could provide useful insight into vessel stresses and guidewire deformation in-vivo. This could further help in understanding the initial conditions for delivery catheter and device performance testing to improve deliverability in tortuous anatomy. So, in this study, we evaluated the vessel deformation during guidewire insertion using 3-D finite element analysis with undeformed vessel geometry developed from patient specific Computed-Tomography (CT) scans. Pre-operative CT scans were used to generate 3-D reconstructions of human iliac region using Mimics (Materialise, Ann Arbor, MI). A finite element model was set up to simulate the vessel deformation where a guidewire was introduced from the distal end of the iliac and pushed up to the aneurysm region. The guidewire insertion analysis was run with both Abaqus/Standard and Abaqus/Explicit to compare the performance and to determine advantages of using one procedure over the other. Both Abaqus/Standard and Abaqus/Explicit were able to successfully predict the overall deformed shape of the vessel accurately. It was also observed that the guidewire has a tendency to significantly deform the native vessels specifically around sharp bends in the iliac resulting in reduced tortuosity.

Keywords: Vessel Deformation, Implantable Medical Device, Guidewire

1. Introduction

Aneurysm (Figure 1) is a disease in which the aorta swells abnormally which could lead to rupture of aorta if not treated in a timely manner. Endovascular Aneurysm Repair (EVAR) is a procedure to treat aneurysm in which a delivery device catheter is inserted through femoral iliac artery and a stent-graft is implanted at the aneurysm site (Figure 1). The delivery catheter tends to be very stiff as compared to the human vessel. So, in order to facilitate smooth insertion of delivery catheter through the vessel and to prevent any damage in the vessel due to direct insertion of delivery catheter, a stiff guidewire is inserted first into the vessel. The delivery catheter is then loaded on to the guidewire and pushed in to access the aneurysm site. The guidewire, which is typically made up of 0.035” steel wire, is stiff enough to prevent any kinking when the delivery device is pushed through sharp bends in iliac. Due to its stiffness, the guidewire tends to straighten the iliac thus making it less tortuous for the delivery catheter. Since the performance of delivery catheter depends on the tortuosity of iliac, and the tortuosity depends on the native vessel geometry as well as the straightening due to guidewire, it is important to first understand the interaction between the