Simulation of Bioresorbable Scaffold and Metallic Stent Deployment in Concentric and Eccentric Coronary Lesion Models

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Abstract

The introduction of bioresorbable vascular scaffolds has provided a new option for the treatment of coronary artery disease with the promise of improved long-term vessel behavior when compared to permanent metallic drug eluting stents. While this long term benefit holds great promise, further characterization is required to understand the impact of design changes and material differences between these two implant types. In this study, finite element analysis was used to compare the head-to-head deployment mechanics of a bioresorbable vascular scaffold (Absorb, Abbott Vascular) and a cobalt chromium metallic drug eluting stent (Xience V, Abbott Vascular) with respect to the predicted levels of recoil and stress induced in the vessel wall. Crimping and deployment of each implant were modeled in Abaqus (Dassault Systems Inc,) and incorporated constitutive behaviors for both polymeric and metallic materials as well as for arterial wall layers and plaque. Plaque morphology was also modeled as both concentric and eccentric to clarify differences in implantation behavior between both implant types in these two lesion scenarios. In the simulations performed, Absorb showed a higher degree of recoil than Xience V, which suggests that balloon post-dilatation is important for effective treatment of tight and calcified plaques. However, the Absorb scaffold induces significantly lower stresses on the artery-plaque system, along with lower contact pressures, which can relate to improved biological response and an improved long-term clinical safety profile. When comparing deployment in both concentric and eccentric plaques, deployment in an eccentric plaque results in non-uniform vessel expansion and is associated with considerably higher levels of stress in the media and adventitia layers of the artery wall. In these situations, the choice of implant, in terms of materials and designs, is of paramount importance. Our results imply that the benefits of Absorb scaffolds are amplified in these cases.

Keywords: Bioresorbable scaffold; Stent deployment; Vessel Injury; Vessel Stress; Eccentric plaque.