Novel 3-Dimensional Vessel and Scaffold Reconstruction Methodology for the Assessment of Strut-Level Wall Shear Stress After Deployment of Bioreabsorbable Vascular Scaffolds From the ABSORB III Imaging Substudy

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A 72-year-old female patient underwent successful deployment of a single 3.0 × 18 mm Absorb biodegradable vascular scaffold (Abbott Vascular, Santa Clara, California) to the mid right coronary artery (Figures 1A and 1B). The scaffolded segment was imaged simultaneously with coronary angiography and with the C7 Dragonfly (LightLab Imaging Inc., St. Jude Medical, Westford, Massachusetts) optical coherence tomographic (OCT) system at 100 frames/s with a motorized pull-back speed of 20 mm/s and a flush rate of 3 ml/s. Images demonstrated adequate scaffold apposition, with no evidence of edge dissections or tissue prolapse (Figure 1C).

This patient was enrolled in the ongoing imaging substudy of the ABSORB III randomized clinical trial, RESTORATION (Evaluation and Comparison of Three-Dimensional Wall Shear Stress Patterns and Neointimal Healing Following Percutaneous Coronary Intervention with the Absorb Everolimus-Eluting Biodegradable Vascular Scaffold Compared to the Xience V Everolimus-Eluting Metallic Stent), which aims to evaluate the differential effects of the Absorb biodegradable vascular scaffold compared with the Xience metallic stent on local hemodynamic conditions at 3 years (1). The OCT study endpoints include the changes in wall shear stress (WSS) from post-procedure to 3-year follow-up and the relationship between strut-level derived WSS after deployment to neointimal tissue healing at 3 years.

The fusion of 3-dimensional angiographic acquisitions (including vessel curvature) with OCT imaging (Figures 1A to 1C) is a novel approach for the assessment of vessel-level and strut-level WSS following device deployment. This novel methodological approach includes the following steps: 1) semiautomatic strut detection from the OCT image acquisition through shape recognition algorithms; 2) semiautomatic reconstruction of the scaffold wire frame that displays the patient-specific scaffold pattern; 3) automatic lumen extraction following stacking of the OCT cross sections over the patient-specific vessel curvature obtained from angiography; 4) realignment of the stent wire frame to the patient-specific scaffold pattern.
specific curvature and reconstruction of the stent geometry onto the wireframe (Figure 1D); 5) subtraction of the scaffold strut geometry to obtain the computational fluid dynamics domain; 6) prescription of realistic boundary conditions; and 7) computational fluid dynamics analysis using finite element methods over the reconstructed domain (Figures 1E and 1F).

We will prospectively investigate whether the larger struts of bioresorbable scaffolds (strut thickness \( \approx 150 \mu m \)) will generate greater microcirculatory zones of low WSS at the strut sides (Figure 1E, strut surfaces 2 and 4) compared with the metallic stents (strut thickness \( 81 \mu m \)) \((2,3)\). We postulate that the resultant robust neointimal generation in response to the low WSS, in conjunction with the ongoing resorption of the struts, will result in a homogenous neointimal response that will reduce the risk for late or very late scaffold thrombosis \((4)\) (Figures 1E and 1F).

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REFERENCES


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