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IMAGES IN INTERVENTION

Feasibility of Optical Coherence Tomography–Derived Computational Fluid Dynamics in Calcified Vessels to Assess Treatment With Orbital Atherectomy

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A 72-year-old male patient presented with stable angina, and coronary angiography showed a heavily calcified mid left anterior descending coronary artery lesion (diameter stenosis ≈ 75%). Optical coherence tomographic (OCT) assessment (C7-XRsystem, C7 Dragonfly catheter; LightLab Imaging, St. Jude Medical, St. Paul, Minnesota) demonstrated a minimal luminal area of 1.80 mm^2, with severe circumferential calcification proximal to the minimal luminal area (**Figures $1A_1$ and $1A_2$**). Lesion "preparation" was performed to optimize stent deployment using the 1.25-mm classic crown Diamondback 360 Coronary Orbital Atherectomy System (OAS) (Cardiovascular Systems, St. Paul, Minnesota) (1). Three runs of 25 s were performed, using a rotational speed of 80,000 rpm. Repeat OCT assessment post-OAS deployment demonstrated a numeric gain in the luminal area of the selected cross sections, with the most significant circumferential calcification from 4.10 ± 0.98 to 4.27 ± 1.07 mm^2 ($p = 0.80$), a relative change of 3.8%. Thereafter, a 3.0×12 mm Xience stent (Abbott Vascular, Santa Clara, California) was deployed at 12 atm, followed by post-dilation with a noncompliant balloon at 16 atm.

A novel methodological approach to assess the potential effects of OAS in vessel compliance is the application of computational fluid dynamics analysis using finite-element methods in the treated segments. This post-processing analysis fuses angiographic with OCT acquisitions, including the following steps: 1) automatic luminal extraction following stacking of the OCT cross sections over the patient-specific anatomy (curvature) obtained from angiography; 2) extraction of the patient-specific computational fluid dynamics domain; 3) implementation of realistic inflow boundary conditions; and 4) computational fluid dynamics analysis using finite-element methods over the reconstructed domain. A recent analysis indicated that 3-dimensional optical coherence tomography-derived wall shear stress assessment was in close agreement with earlier techniques using intravascular ultrasound and angiographically derived shear values (2).

In this assessment, following evaluation of circumferential wall shear stress over the selected cross sections with the largest burden of calcium, a numeric increase from 7.05 ± 0.73 to 7.30 ± 0.46 dynes/cm^2 ($p = 0.73$), was observed. This preliminary feasibility

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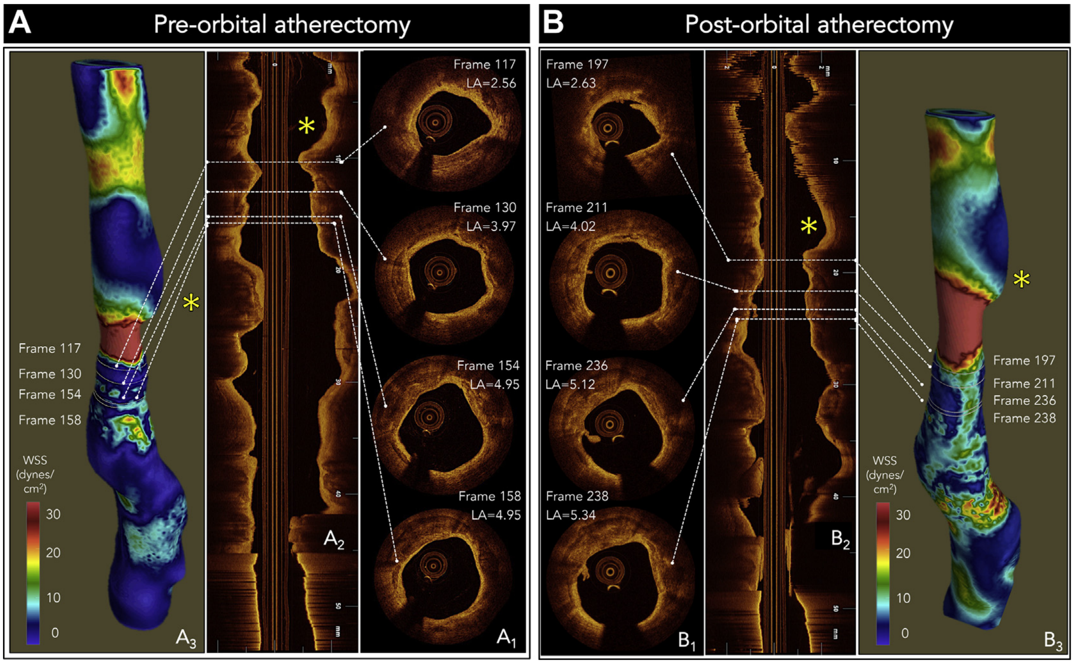
FIGURE 1 Computational Fluid Dynamics Following Treatment With the Orbital Atherectomy System



(A_1, A_2) Selected optical coherence tomographic cross sections illustrating the circumferential distribution of calcium matched in the longitudinal view. **(A_3)** Computational fluid dynamics (CFD) domain with wall shear stress (WSS) assessment. The selected cross sections are demarcated over the CFD domain. **(B_1, B_2)** Selected optical coherence tomographic cross sections following Orbital Atherectomy System (OAS) application, demonstrating thrombotic material as well as small dissection flaps. **(B_3)** CFD domain with WSS assessment after OAS application. LA = lumen area.

analysis addresses the change of local fluid mechanics following OAS application; meanwhile, further studies are needed to evaluate if these observations are associated with changes in vessel compliance after reducing the circumferential burden of calcium.

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KEY WORDS calcified lesion, computational fluid dynamics, orbital atherectomy