An FSI modeling approach to combine IVUS and OCT for more accurate patient-specific coronary cap thickness and stress/strain calculations

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Abstract

Accurate cap thickness and stress/strain quantifications are of fundamental importance for vulnerable plaque research. An innovative modeling approach combining intravascular ultrasound (IVUS) and optical coherence tomography (OCT) is introduced for more accurate patient-specific coronary morphology and stress/strain calculations.

In vivo IVUS and OCT coronary plaque data were acquired with informed consent obtained. IVUS and OCT images were merged to form the IVUS+OCT data set, with biplane angiography providing 3D vessel curvature. Virtual histology (VH) IVUS data were processed with minimum cap thickness set as 50 and 180 micron to generate IVUS50 and IVUS180 data sets, respectively. 3D FSI models based on IVUS+OCT, IVUS50 and IVUS180 data sets were constructed to investigate the cap thickness impact on stress/strain calculations.

Mean cap thickness (unit: mm) from Patient 1 was 0.353 (OCT), 0.201 (IVUS50), and 0.329 (IVUS180), respectively. Patient 2 mean cap thickness was 0.320 (OCT), 0.224 (IVUS50), and 0.285 (IVUS180). Compared to OCT, IVUS50 underestimated cap thickness (27 slices) by 34.5%, overestimated mean cap stress by 45.8%, (96.4 vs. 66.1 kPa). IVUS50 maximum cap stress was 59.2% higher than that from IVUS+OCT model (564.2 vs. 354.5 kPa). Differences between IVUS and IVUS+OCT models for cap strain and flow shear stress were modest (cap strain <12%; FSS <6%).

IVUS+OCT data and models could provide more accurate cap thickness and stress/strain calculations which will serve as basis for further plaque investigations.

Keywords: Vulnerable plaque; OCT; IVUS; cap thickness; patient-specific model; FSI.