Multimodal, Minimally Invasive Imaging for Early Disease Detection

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We aim to visualize every cell in the body to detect diseases at the earliest possible stage. Optical Coherence Tomography (OCT) is akin to ultrasound but achieves much higher resolution by using light, which has a shorter wavelength than sound. However, structural imaging by OCT alone is sometimes insufficient for accurate disease diagnosis. Thus, we combined OCT with fluorescence, which reveals chemical and molecular information to provide richer, more informative, and more clinically relevant imaging.

One notable application of multimodal OCT is imaging atherosclerotic plaques in coronary arteries. Plaques with high lipid content and inflammation increase the risk of coronary events, such as heart attacks. The Tearney Lab and Dr. Farouc Jaffer— an expert in atherosclerosis molecular imaging and interventional cardiologist at Mass General —discovered these plaques emit near-infrared autofluorescence (NIRAF) linked to oxidative stress and intraplaque hemorrhage, which are critical to plaque progression. They developed a multimodal imaging catheter combining OCT and NIR fluorescence imaging, which was later converted into a next-generation clinical system by Canon Medical. The device is now being used in a clinical study assessing the role of OCT-NIRAF in managing coronary disease; the study aims to correlate NIRAF with plaque progression. In the future, inflammation-targeted molecular agents could be used to predict plaque risk even more accurately. Identifying such "vulnerable plaques" before a heart attack could provide a new personalized approach to coronary risk assessment and allow for optimized preemptive intervention, potentially saving many lives.

We are also applying multimodal OCT to detect gastrointestinal cancers at their earliest stages. The current standard, endoscopy, is too invasive for broad-based screening due to the need for sedation. Thus, we developed OCT-tethered capsule endomicroscopy (OCT-TCE): a swallowable pill connected to an imaging system via a tether that captures 3D OCT images as it travels through the upper GI tract. This technology has proven effective in detecting precancerous conditions like Barrett's Esophagus (BE). Integrating visible and NIR fluorescence imaging enables more specific identification of BE cases at high risk of developing cancer. By using targeted molecular agents that accumulate in high-risk BE tissue, the device can better assess future cancer risk.

The value of multimodal imaging exceeds the sum of its parts. Our innovative multimodal screening technologies for cardiovascular disease and gastrointestinal cancer hold promise for early disease detection and prediction, potentially decreasing the incidence of advanced disease and reducing morbidity and mortality.

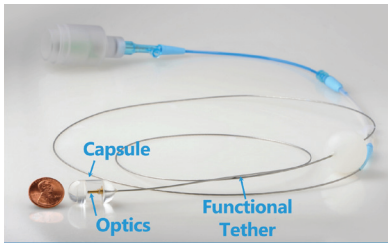

Figure 1: Capsule OCT .

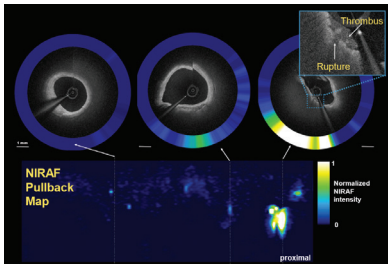

Figure 2: Molecular/chemical coronary imaging with OCT-NIRAF.

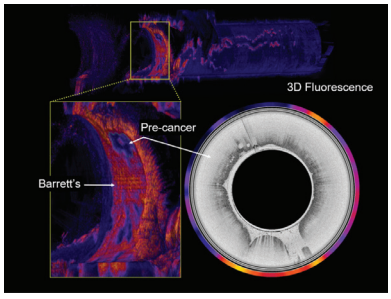

Figure 3: Identifying Barrett's pre-cancer with a fluorescence-OCT tethered capsule.