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The optical properties of aging and diseased tissue interfaces: what are your gums and bones telling you?

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Detection of inflammation and classification of pathological lesions, for example in the oral diseases and cancer applications, has typically be restricted to expensive imaging modalities such as X-rays which suffer from poor spatial resolution and lack functional information for early diagnostics. Other traditional imaging such as computed tomography (CT) cannot be used during treatment or surgical procedures and are difficult techniques to access sensitive areas of a patients'oral cavity. Moreover, CT and X-ray imaging are not sufficiently sensitive and specific to sense early stage biomarkers of inflammatory response in aging and pre-diseased tissue. Here we present the development of a non-invasive optical coherence tomography (OCT) technique to examine the structural integrity and connectivity at the interfaces of soft and hard tissue surfaces as a pre-diagnostic biomarker of oral disease. We evaluate the efficacy of this method for lesions discrimination from healthy tissue based on measurement of optical property variances, namely scattering and refractive index, in periodontal tissue multilayer interfaces. Specifically, we use stable and well-controlled optical phantoms to examine the OCT-derived properties across 1-2mm tissue-bone models to determine the limit of detection for periodontal pocket depth. We aim to compare these model systems with *in vivo* characterizations of bone structures through small layers of epithelial cells of the gum. We further introduce a multi-modal approach for *in vivo* time-resolved near infrared-OCT (NIR-OCT) which enables a novel *in situ* probe for structural-functional optical assessment of inflamed tissues through examination at these soft-hard tissue interfaces, such as through observation of variations of oxy-/deoxy- hemoglobin absorption local gradients of pH. We will also demonstrate the design and integration of biocompatible optical clearing agents for enhanced functional contrast. To compliment and overlay the high resolution optical scattering map of the gum-hard tissue interface, we aim to co-register it with NIR functional contrast associated with the local inflamed microenvironment. Finally, we discuss the broader relevance of this time-resolved NIRS diffuse reflectance method as a means for optically-stable biochemical contrast in other inflammatory environments and applications. Our technique presents new opportunities for exploring combined structure-function optical classification of soft-hard interfaces in connective tissues as biomarkers for understanding aging and early detection of degenerative diseases.

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