7562-28, Session 7

Nanorose and lipid detection in atherosclerotic plaque using dual-wavelength photothermal wave imaging

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Atherosclerosis and specifically rupture of vulnerable plaques account for 23% of all deaths worldwide, far surpassing both infectious diseases and cancer. In atherosclerosis, macrophages can infiltrate plaques which are often associated with lipid deposits. Photothermal wave imaging is based on the periodic thermal modulation of a sample using intensity modulated light. Intensity modulated light enters the sample and is absorbed by targeted chromophores and generates a periodic thermal modulation. We report use of photothermal wave imaging to visualize nanoroses (taken up by macrophages via endocytosis) and lipids in atherosclerotic plaques. Two excitation wavelengths were selected to image nanoroses (800 nm) and lipids (1210 nm). Atherosclerotic plaque in a rabbit abdominal artery was irradiated (800 nm and 1210 nm) to generate photothermal waves at a frequency of 4 Hz. The radiometric temperature at the tissue surface was recorded by an infrared (IR) camera over a 10 second time period at the frame rate of 25.6 Hz. Extraction of images (256 × 256 pixels) at various frequencies was performed by Fourier transform at each pixel. Frequency amplitude images were obtained corresponding to 800 nm and 1210 nm laser irradiation. Computed images suggest that the distributions of both nanorose and lipid can be identified in amplitude images at a frequency of 4 Hz. Observation of high concentration of nanoroses in atherosclerotic plaque confirms that nanoroses are present at locations associated with lipid deposits.

7562-29, Session 7

Method for measuring ocular aberrations induced by thermal lensing in vivo

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An adaptive optics imaging system was used to qualitatively observe the types of aberrations induced by an infrared laser in a rhesus eye. Thermal lensing was induced with an infrared laser radiation wavelength of 1150-nm. The adaptive optics system tracked the temporal response of the aberrations at a frequency of 30 Hz for continuous-wave exposures. Results are compared against thermal lensing aberrations of an artificial eye.

7562-30, Session 7

New method to visualize subsurface absolute temperature distributions and dynamics during laser-tissue interactions using thermo cameras

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The visualization of temperature fields using thermal imaging has always been limited to the surface of a medium. We have developed a new strategy to look below the surface of biological tissue by viewing through a ZincSelenide window from the side to a block of tissue. When exposed from above with an energy source like a laser, the temperature distribution below the surface can be observed through the window. This new method was compared to a technique to visualize temperature gradients in a transparent tissue model based on color-Schlieren imaging.

The thermo dynamics during laser tissue interaction of various medical laser systems were studied to obtain a better understanding of the working mechanism of medical laser interventions. Simultaneously with thermal imaging, normal close-up video footage was obtained to support the interpretation of the thermal imaging.

The basic temperature distribution and dynamics underneath the surface of chicken breast and steak were studied with various laser sources: 810 nm Diode, 1064 nm Nd YAG, 2.1 µm pulsed Holmium, 2.0 µm continuous thulium and 2.78 µm Er:YSGG. The laser source was either in a static position or scanned over the surface. The thermal imaging was compared to normal video and color-Schlieren images. The three imaging modalities showed to be both compatible and complementary showing the pro- and cons- of each modality.

The new subsurface thermal imaging method will give a better understanding of interaction of various lasers and RF devices and contribute to the safety and the optimal settings for various medical applications.

7562-31, Session 7

Effect of temperature on fluorescence: an animal study

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The fluorescence yield of collagen is known to be a function of the temperature of the collagen sample. In this study, we have evaluated the effect of temperature on the fluorescence properties of enucleated porcine eyes, excised porcine cornea, and rat skin. A pulsed nitrogen laser at 337 nm excitation was used for fluorescence measurements and a white light source was used for diffuse-reflectance measurements. Tissue temperature at the time of fluorescent measurement was acquired using a thermal camera. The samples were mounted in a saline bath and measurements were made as the tissue temperature was increased from -20°C to 70°C. Results indicate that temperature affects several fluorescence spectra characteristics: the peak height decreased as temperature increased; at temperatures above 60°C, the peak position shifted to lower wavelengths; and the signal to noise ratio decreased as temperature increased. Heating and cooling the cornea indicated that the process is reversible with heating to 50°C but irreversible past 60°C. The diffuse-reflectance spectra indicated a change in optical properties past 60°C. Prior to the denaturation temperature for collagen at 57°C, no change in optical properties was observed. This implies that the temperature-dependent decrease in fluorescence is a property of fluorescence and not a result of altering optical properties.

7562-32, Session 7

Collagen thermal denaturation study for thermal angioplasty based on modified kinetic model: relation between the artery mechanical properties and collagen denaturation rate.

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We have been developing the novel heating angioplasty in which sufficient artery lumen dilatation was attained with thermal softening of the collagen fiber in artery wall. In the present study, we investigated on the relation between the mechanical properties of heated artery and thermal denaturation rate of arterial collagen in ex vivo. We employed Lumry-Eyring model to estimate the temperature- and time-dependent thermal denaturation rate of arterial collagen fiber during heating.