point remains true, it is however possible to calculate absolute values of Tissue Hemoglobin Saturation (SO2) provided that light scattering is well accounted for in the modified Beer's Law equation for tissue. A study by Stratonnikov and Loschenov [J.Biomed.Opt. 6, 457-467 (2001)] has demonstrated that tissue SO2 can in fact be calculated from CW measurements in the visible region by approximating the additive scatter component (G) with a wavelength-dependent Taylor Series expansion and then fitting measured spectra to the Modified Beer's Law equation [Cope et al, Proc. SPIE. 141, 251-263 (1991)]. We have developed a different approach for calculating SO2 from fixed-distance CW-NIR measurements from 700-900nm. Our approach defines G as the spectral residual that encodes the mismatch between the measured tissue spectrum and the pure component spectrum generated from the relevant tissue chromophores (i.e. oxyhemoglobin, hemoglobin, and water). An initial estimate of G allows us the refine the fit of the measured spectrum to the modified beer's law equation in the manner described in the Stratonnikov study.

To demonstrate that G determined from our approach incorporates tissue scatter information, we obtained a linear correlation of G with levels of Lower Body Negative Pressure (LBNP) applied to several volunteer subjects (average R2 = 0.86, N=9) during progressive central hypovolemia - i.e. decreased blood volume. LBNP is used as an experimental tool to simulate loss of central blood volume (e.g., hemorrhage) in humans [Cooke et al. J.Appl.Physiol. 96, 1249-1261 (2004)].

6430A-47, Poster Session

Pigmented skin conditions diagnosed by Raman spectroscopy

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Melanoma is the most aggressive skin cancer and is invariably fatal if left untreated. Melanoma removal at early stages is almost always curative and therefore early detection is essential. Removal of every pigmented lesion is unacceptable for the patient, especially in the case of multiple skin lesions or lesions localized in cosmetically important parts of the body such as the face because of risk of scarring. All disease states, without exception, are caused by fundamental changes in cellular and tissue biochemistry. The development of a technique to detect these changes in a noninvasive way is therefore crucial for melanoma detection. For these reason, many physical methods for in situ tissue analysis have been explored by investigating the molecular vibrational spectroscopy. These methods have numbers of advantages, including minimal or no damage to the sample. Raman spectroscopy is a technique that provides information about the molecular structure of the investigated sample.

In this study, we have used FT-Raman Spectroscopy to investigate through PCA analysis of normal and pathological skin spectra, the alterations in the molecular structure that occurs in melanoma carcinogenic process, comparing normal skin, pigmented nevi, melanoma, and lymphatic metastasis tissues.

Normal Skin, Pigmented Nevi, Acral Melanoma, and Lymphatic Metastasis samples were obtained from 15 patients assisted in the Department of Plastic Surgery of UNIFESP. All samples, soon after the surgical procedure, were identified, snap frozen and stored in liquid nitrogen (77 K) in cryogenic vials (Nalgene (r)) before the FT-Raman spectra recording. For FT-Raman data collection, samples were brought to room temperature and kept moistened in 0.9 % physiological solution to preserve their structural characteristics, and placed in a windowless aluminum holder to the Raman spectra collection. A FT-Raman spectrometer (Bruker RFS 100/S) was used with an Nd:YAG laser at 1064 nm as excitation light source. The laser power at sample was kept 252 mW while the spectrometer resolution was set to 4 cm-1. The spectra of normal and pathological skin tissues were recorded with 500 scans. Soon after, the samples were fixed in 10 % formaldehyde solution, to further histopathological analysis. PCA were performed for the spectral analysis.

6430A-48, Poster Session

Tumor progression investigated by in vivo polarimetry and optical coherence tomography

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Early detection of cancer remains the best way to ensure patient patient survival and quality of life. Accounting for 96% of all oral cancers, squamous cell carcinoma is usually preceded by dysplasia presenting as white, red, or mixed red and white epithelial lesions on the oral mucosa. Dysplasic lesions carry a risk for malignant conversion of 90%. Thus, oral cancer is predominantly preceded by white or red lesions that are visible to the naked eye, and often present for a considerable period of time prior to transformation. A noninvasive diagnostic modality would enable monitoring of these lesions at regular intervals and detection of treatment needs at a very early, relatively harmless stage. The specific aim of this work was to test a multimodality approach to noninvasive diagnostics of oral premalignancy and malignancy. In the hamster cheek pouch model (9 hamsters), in vivo polarimetry provided Mueller matrix images to allow quantitative information in epithelial tissues and optical coherence tomography (OCT) mapped epithelial and subepithelial changes throughout carcinogenesis. Images were classified by retardance images of Mueller matrix and were showed and quantified by neoplasia-related epithelial and subepithelial changes at specific locations and stages throughout cancinogenesis and were diagnosed by two blinded, prestandardized investigator using a scale from 0 (healthy) to 6 (squamous cell carcinoma, SCC) for all modalities. After sacrifice, histopathology was evaluated on a scale of 0 to 6.

6430A-49, Poster Session

Integrated endoscopy system for simultaneous fluorescence imaging and spectroscopy: Improvement of the lung cancer diagnostic specificity

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We present and evaluate an integrated white light/fluorescence endoscopic imaging system with spectral measurement module attached for improving lung cancer detection. The endoscopic system can measure the diffuse reflectance spectra in a non-contact manner during routine enodoscopic imaging. The measured reflectance spectra were analyzed using a specially developed light-transport model to obtain quantitative information about cancer-related, physiological and morphologic changes from the mucosa layers. The extracted parameters, namely the microvascular blood volume fraction, the tissue blood oxygen saturation, the scattering micro-particle volume fraction and size distribution, were then used in conjunctions with the statistical techniques to classify the measured lesions into normal tissue/benign lesions and malignant lesions. The device and the method was validated using in vivo data measured from 219 different lesions (184 normal tissue/benign lesion sites and 35 malignant lesion sites.The sensitivity and the specificity of the endoscopic imaging system was evaluated and compared with and without the spectral module attached. The results demonstrated significant improvement in the diagnostic specificity (50% increase) without significant loss in the diagnostic sensitivity (10% decrease).

6430A-50, Poster Session

Synchrotron microtomography and 3D image analysis for studying the degradability of biocompatible ceramics within biopsies sampled after sinus floor augmentation

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The utilization of autogenous bone grafts is an established technique in implant dentistry for bone reconstruction. But within recent years the concept of guided bone regeneration (GBR) using biomaterials as bone substitutes (bioactive calcium phosphate ceramics) has become a predictable and well-documented surgical approach. We applied synchrotron microtomography (μCT) and subsequent 3D image analysis in order to quantify bone formation and biodegradation of the bone substitute material in three dimensions.

Ideally, a bone substitute material should resorb rapidly, but still stimulate osteogenesis at the same time. Therefore, in order to optimize the biodegradability, the current development focuses on ceramics with higher porosities for applications in GBR. In the current study the effect of two particulate graft materials on bone regeneration and expression of osteogenic markers was evaluated in biopsies sampled 6 months after augmentation of the sinus floor.

Tomographic images of these specimens with μm-resolution were obtained at the storage rings ANKA and BESSY. By using monochromatic synchrotron radiation for imaging it is possible to separate the newly formed bone tissue and the implanted bone substitute materials within the volume images. By means of 3D image analysis we are then able to quantify how the inserted bone substitute materials are supporting bone regeneration while characterizing the degradation of the bone substitute material at the same time (decrease of volume of bone substitute material). Additionally, a comparison of histology and microtomogaphy allows us to evaluate the stage of development of the newly formed bone.

6430A-52, Poster Session

Multi-wavelength photoplethysmography for simultaneous recording of skin blood pulsations at different vascular depths

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New technique for parallel recording of reflection photoplethysmography signals in broad spectral band (violet to NIR) has been developed, and its potential for assessment of blood microcirculation at various depths from the skin surface is discussed. PPG signals have been simultaneously detected at cw laser wavelengths sets comprising 405 nm, 532 nm, 645 nm, 807 nm and 1064 nm. Various signal baseline responses to breath holding and different shapes of the PPG pulses originated from the same heartbeat but recorded at different wavelengths have been observed, indicating a depth-variety of the skin blood pulsation dynamics.

Reflection photoplethysmography (PPG) is a non-invasive method for studies of the skin blood volume pulsations by detection and analysis of the back-scattered optical radiation. Skin blood pumping and transport dynamics can be monitored this way at different body locations with relatively simple and convenient PPG contact probes.

Different shapes of PPG signals have been observed previously in conditions when the same skin area was subsequently exposed to radiation of different wavelength bands; the shape variations were generally explained as result of wavelength-dependant radiation penetration depth under the skin surface. Other optical multi-wavelength systems have been also described in literature, e.g. laser Doppler and PPG measurements at several wavelengths for analysis of blood flow at different vascular levels.

More advanced technology - parallel multi-wavelength detection of reflection PPG signals related to the same heartbeats with subsequent shape analysis - may lead to better understanding of the blood pulsations in selected under-skin layers. To our knowledge, no data on shape parameters of the PPG signals related to the same heartbeats at multiple wavelengths have been available so far.

This work was aimed at developing and testing of new experimental technique for simultaneous detection of PPG bio-signals at any selected wavelength of the spectral range 400...1100 nm with 2 nm spectral resolution and 50 ms temporal resolution. Essential feature of multi-wavelength approach is use of the multi-channel array of spectrometer instead of traditional single-channel detector, e.g. photodiode. This adds spectral resolution to the well-established single-wavelength PPG method. The equipment details and bio-signal processing principles will be presented, as well as our first results of simultaneous multi-spectral reflection PPG measurements at five selected laser wavelengths.

The newly developed multi-wavelength PPG measurement principle has been implemented and tested. Simultaneous use of several cw lasers with multi-fiber coupling to skin and further to a standard multi-channel array spectrometer proved to be successful for this kind of measurements. The first obtained results demonstrated feasibility of this methodology; it might be further applied for studies and assessment of skin blood microcirculation at various vascular depths. This approach may have good future prospects in skin diagnostics, e.g. by comparing the multi-wavelength PPG data sets recorded from the healthy and diseased skin regions.

6430A-73, Poster Session

Minimally invasive NIR spectroscopy for breast tissue characterization during core needle biopsy

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About 1.4 million needle biopsies, a minimally invasive procedure for obtaining a sample from the breast lesion, are performed annually in the United States for breast cancer diagnosis. However, the procedure has a limited sampling accuracy because only a few small pieces of tissue are taken from random locations in the suspicious mass for histology. As a result, the needle biopsy procedure has a false-negative rate of 1% - 7% and a repeat biopsy rate of 9% - 18%. Furthermore, up to 80 percent of women who undergo the biopsy procedure are ultimately found to only have benign lesions. These unnecessary procedures carry a significant physical, emotional, and financial cost for the patient. In this article, we report a minimally invasive fiber optic sensor based on near-infrared spectroscopy for improving the accuracy of image-guided core needle biopsy. The sensor is composed of three side-viewing optical fibers providing two source-detector separations. The entire assembly is inserted into a core biopsy needle, providing radiologists with real-time diagnosis of the tissue adjacent to the biopsy needle, giving them the opportunity to reposition the needle to a more optimal location before a biopsy is taken. A multi-wavelength frequency-domain near-infrared instrument is used to collect diffuse refelctance in the breast tissue through an aperture on the biopsy needle before the tissue is removed for histology. Preliminary in vivo measurements performed on histology sites in 10 normal/benign breast tissues from 5 women undergoing stereo- or ultrasound-guided core needle biopsy show the ability of the system to determine tissue optical properties and constituent concentrations. Extracted total hemoglobin concentration indicated significant correlations with tissue adipose and blood contents, respectively.

6430A-75, Poster Session

Auto fluorescence spectroscopy for early diagnosis of "cancer eye"

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Bovine ocular squamous cell carcinoma, commonly called "cancer eye" is a dreaded disease of cattle. It is basically a skin cancer occurring on eye and eyelids. The cause of the disease is not clearly known. However, genetic predisposition of the cattle together with prolonged exposure to ultraviolet light, are believed to be the major contributory factors. Presently "cancer eye" comprises of about 80 percent of all tumors reported in cattle and is the leading cause of carcass condemnation leading to heavy financial losses to ranchers. Therefore, early detection followed by appropriate treatment of eye tumors is important for effective management of the disease. We report an in-vitro autofluorescence spectroscopic study of cow eye tissue to explore the applicability of the approach in discriminating early stage "cancer eye" from normal squamous eye tissues. Significant differences were observed in the autofluorescence signatures between the "cancer eye" and normal eye tissues. The spectral