Title

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Functional Diffuse Optical Spectroscopy of Human Breast Tissue

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Short Abstract

We describe a method for obtaining broad wavelength (650 nm-1000nm) quantitative optical property data with deep tissue penetration. The wavelength-dependence of absorption (μa) and scattering (μs') parameters is used to provide fundamental information on tissue biochemistry and structure.

Long Abstract

The use of reflectance spectroscopy to quantitatively characterize cm-thick biological tissues requires the ability to separate the effects of light absorption from scattering. Fundamentally, this can be accomplished by spatially-resolved steady-state, time-domain, or frequency-domain reflectance methods. However, practical considerations limit the applicability of each technique. For use in clinical breast examinations, for instance, the ideal system should acquire data rapidly, probe tissue deeply, and resolve the four major optical components of breast (oxy– and deoxy-hemoglobin, water, and fat) robustly (Figure 1). To ensure accurate predictions, this last requirement suggests the monitoring of as many wavelengths as possible.

Figure 1. Principal component spectra of breast tissue in NIR (from ref 1).

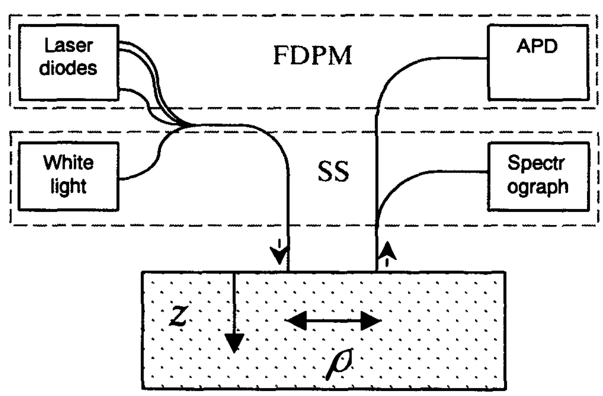

Figure 2. Combined steady state/Frequency domain system (from ref 3).

In this presentation, we describe a method for using steady-state (SS) and frequency-domain (FD) reflectance measurements in tandem to obtain broad wavelength (650 nm-1000nm) quantitative data with deep tissue penetration. The wavelength-dependence of absorption (μa) and scattering (μs') parameters are used to provide fundamental information on tissue biochemistry and structure. Preliminary clinical results using this technique demonstrate that diffuse optical spectroscopy and imaging can be used to quantify differences between pre- and post- menopausal breast tissue, and normal vs. tumor sites (Figures 3,4). We further show that total hemoglobin content, water, and lipid percentage can be measured quantitatively and these constituents vary with age, tumor type and menopausal status. Because of its unique sensitivity to hormone-dependent alterations, functional characterization using optical methods may provide important insight into physiologic changes accompanying breast disease as well as biologic processes associated with disease risk.

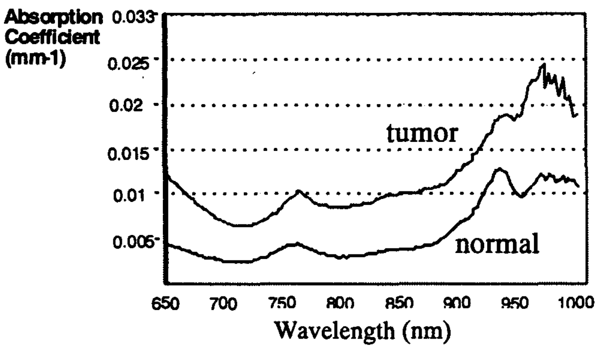

Figure 3. Absorption spectrum of malignant tumor vs. normal breast in post-menopausal subject.

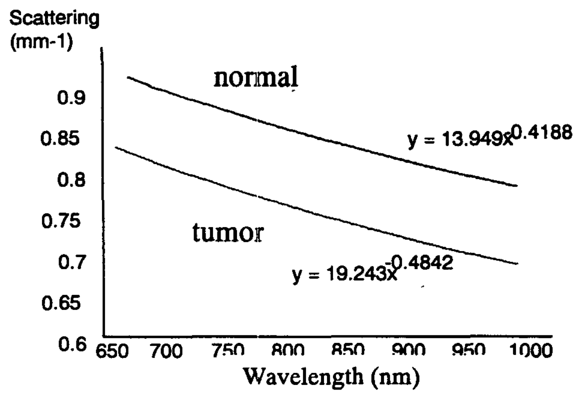

Figure 4. Scattering spectrum of malignant tumor vs. normal breast in post-menopausal subject.

References:

1) Tromberg, BJ., Shah, N., Lanning, R., Cerussi, A., Espinoza, J., Pham, T., Svaasand, L., Butler, J. *Non-Invasive In Vivo Characterization of Breast Tumors Using Photon Migration Spectroscopy.* Neoplasia, 2, 1-15, (2000).
2) Pham, TH., Coquoz, O., Fishkin, JB., Anderson, E., Tromberg, BJ., *A Broad Bandwidth Frequency Domain Instrument for Quantitative Tissue Optical Spectroscopy.* Review of Scientific Instruments, 71 , 1 – 14, (2000
3) Bevilacqua, F., Berger, AJ., Cerussi, AE., Jakubowski, D., Tromberg, BJ. *Broadband Absorption Spectroscopy in Turbid Media by Combined Frequency-Domain and Steady-State Methods.* Applied Optics, 39, 6498-6507, 2000.
4) Cerussi, AE., Berger, AJ., Bevilacqua, F., Shah. N., Jakubowski, D., Butler, J., Holcombe, RF., Tromberg, BJ. *Sources of Absorption and Scattering Contrast for Near-Infrared Optical Mammography.* Academic Radiology, 8, 211 – 218, 2001.
5) Shah, N., Cerussi, A., Eker, C., Espinoza, J., Butler, J., Fishkin, J., Hornung, R., Tromberg, B. *Non-Invasive Functional Optical Spectroscopy of Human Breast Tissue.* . Proceedings of the National Academy of Science, 98, 4420-4425, 2001.

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