Comparison of Electromagnetic Properties of Normal Breast Tissue at Optical and Microwave Frequencies

Mariya Lazebnik[(1)], Changfang Zhu[(1)], Gregory Palmer[(3)], Josephine Harter[(2)], Sarah Sewall[(2)], Nirmala Ramanujam[(3)], and Susan C. Hagness[(1)]
Departments of (1) Electrical and Computer Engineering and (2) Pathology, University of Wisconsin, Madison, WI
(3) Department of Biomedical Engineering, Duke University, Durham, NC

Due to the limitations of current breast cancer detection and diagnosis methods, researchers at the University of Wisconsin – Madison are developing novel microwave and optical breast cancer detection and diagnostic techniques. Accurate knowledge of the physical properties of breast tissue at microwave and optical frequencies is essential for the development of these methods. In addition, since different physical tissue parameters are measured in the microwave and optical regimes, combining both modalities may result in enhanced diagnostic capability. Accurate characterization of normal breast tissue is important for establishing baseline properties. Therefore, the goal of this study is to simultaneously perform microwave and optical spectroscopy measurements on normal tissue samples obtained from breast reduction surgeries and correlate the findings.

To this end, we conducted microwave and optical measurements on 60 normal breast tissue samples from 17 patients undergoing breast reduction surgery at the University of Wisconsin Hospital and Clinics. Dielectric spectroscopy measurements were performed with a precision open-ended coaxial probe in conjunction with a vector network analyzer from 0.5 to 20 GHz. The recorded complex reflection coefficient at the probe aperture was converted to complex permittivity using de-embedding and rational function models (D. Popovic, *et al*, IEEE Trans. Microwave Theory Tech., 53:1713—1722, 2005). Diffuse reflectance spectra were measured using a fiber optic probe coupled to a multi-wavelength optical spectrometer from 350 to 600 nm. A Monte-Carlo based inverse model was employed to extract the absorption and scattering coefficients of breast tissue from the measured diffuse reflectance spectra (G. M. Palmer and N. Ramanujam, Appl. Opt., 45, 2006, in press).

Following each measurement, we inked the exact measurement site on each tissue sample, and transverse sections were cut and stained for histopathology. The tissue composition in the probe sensing volume of each section was categorized as % fat, % glandular, % loose connective and % dense fibrous tissue. The non-parametric Spearman rank correlation was employed to measure the correlations between (1) optical and microwave breast tissue properties, (2) microwave properties and tissue composition and patient age, and (3) optical properties and tissue composition and patient age.

In this talk we will present the results of this study. As expected, we found a significant correlation between tissue composition and electromagnetic properties at optical and microwave frequencies, while no correlation exists between tissue properties and patient age. In addition, we found significant correlations between the microwave dielectric properties and the optical absorption coefficient at 460 nm, and a significant, but small, correlation between the microwave properties and the optical scattering coefficient. We will discuss the conclusions of this study, as well as any implications for the potential development of joint optical and microwave breast cancer detection and diagnostic techniques.