Breast Cancer Characterization with Optical Spectroscopy integrated into an MR Breast Biopsy Plate

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Background

Optical spectroscopy is being developed as a tool to increase the information content available during MR imaging of breast cancer, with the ultimate goal of increasing specificity of contrast MR exams, prior to biopsy. Using multiple wavelengths of near-infrared light, maps related to tissue physiology can be acquired, characterizing absolute concentrations of oxygenated hemoglobin, deoxygenated hemoglobin, water, lipid, and scattering particles. These can be quantified in regions with MR guidance [1, 2].

Malignant tumor regions are distinguished by: increased total hemoglobin, expected from the leaky, densely packed vasculature, decreased blood oxygen saturation, expected from the increase in metabolism of malignant tumor, and contrast in the size and density of organelles, expected from the abnormal vasculature.

Operating optical devices in the confines of the MRI bore requires analysis of obtaining maximum optical tissue sampling field of view, and optimal data collection strategies. In addition, it requires mating an optical fiber system to a standard MRI breast coil configuration. This paper investigates the issues in combining MRI and optical imaging and compares coregistered information given by optical imaging and MR with *in vivo* abnormal patient MR.

Methods

A fiber optic holder was created to mate to two geometries: a circular fiber holder, and a slab grid designed around a breast biopsy attachment. These interfaces are shown in Fig.1. Optical images were acquired simultaneously with T1-weighted MR which was segmented into regions of adipose, fibroglandular, and a region of interest via DCE-MR. These regions were input into a finite element algorithm along with optical measurements of changes in light intensity and phase. Images were reconstructed on the high resolution mesh to determine spectral properties in 3D. A case study of a patient with an infiltrating ductal carcinoma is shown in both geometries in Fig. 2.

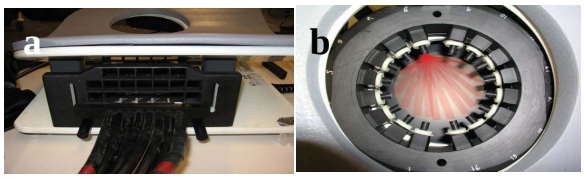

Figure 1: Optical Imaging / MRI breast fiber interfaces show: (a) the slab geometry array mated to a commercially available biopsy coil, and (b) the circular geometry array. In the latter image, an illustration shows the optical light paths from one source fiber.

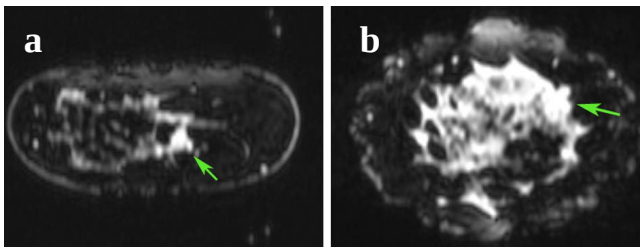

Figure 2: (a) DCE-MR T1-W GRE image of patient in slab optical interface with a suspicious lesion indicated by green arrow. Fiducial markers seen on the extreme upper right and lower right indicate the position of the fibers **(b)** DCE-MR T1-W GRE image of the same patient in the circular geometry with a suspicious lesion indicated by the green arrow. The impressions circumferentially around the breast indicate optical fiber positions

Results

The ability of the slab interface to easily adjust to various planes is a significant advantage over the circular geometry. In addition, it mimics a geometry familiar to clinicians, as many breast MR coils utilize immobilization plates to reduce MR image motion artifacts. Fig. 3 shows the results of simulated noisy data reconstructed on these geometries in 3D, to exhibit the ability to distinguish tumor physiological characteristics from the adipose and fibroglandular tissue.

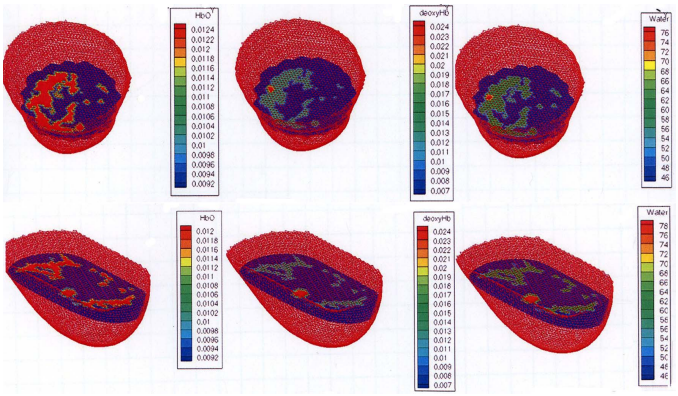

Figure 3: (top) Reconstruction optical imaging results of a simulated small 10mm tumor generated on patient breast MR in the circular geometry, **(bottom)** Results of a simulated small 15mm tumor generated on patient breast MR in the slab geometry

Acknowledgements

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References

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