MR-Guided Near-Infrared Spectroscopy System for Rodent Tumor Tomography

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Synopsis

A unique spectroscopy system has been constructed and tested for imaging with near-infrared (NIR) light inside a small animal body coil, designed for a Philips 3T system. The broad spectrum capability provides access to transmission, fluorescence or bioluminescence signals as needed, while not inhibiting the ability for MR imaging of the animal. Preliminary images of the ability to complete MR-guided molecular spectroscopy in vivo are shown.

Introduction

Near-infrared spectroscopy can provide quantitative information about absorbing and scattering components of tissue, but when used in tomography mode, has extremely poor resolution. Integration with MR imaging is a natural progression of both modalities, and opens up the potential to image many optically active molecular contrast agents in vivo. The key factor in making a truly useful system is to have the optical sources and detectors built into the MR coil in a way which provides data from both at the same time, and does not compromise on quality of the data from either. This system was constructed for a Philips 3T MR system by modifying the rodent coil, and is being used to study production of the fluorescent compound protoporphyrin IX in glioma tumors.

Methods

A 3T rodent coil was specially designed and fabricated by Philips Research Hamburg, complete with holes for the fibers to be placed through the coil, and onto the rodent inside. The system was tested with rat and mouse tumors. The spectroscopy is completed with sixteen bifurcated fibers, where one end of the bifurcation goes to a laser sequencer, and the other ends all go to individual spectrometers (Princeton Instruments, Acton MA). The spectrometers are front illuminated Insight-400F systems cooled to -75^{o}C, with 2MHz readout at 16 bits. The system is capable of detecting emission spectra from fluorophores as well as broadband NIR transmission through tissue to determine absorption and scattering properties Reconstruction of the interior tissue values is done with spatial mapping onto the MR image, using standard segmentation methods of the tissue volumes.

Results

A photograph of the rodent coil hardware system is shown below, with a photograph of the 16 spectrometer system. The fibers can be seen in (b) as black cables entering into the body coil for rodent imaging. This rodent coil is being used for imaging NIR and MR simultaneously. In (c) some preliminary simulations are shown with the a mouse mesh generated by the MOBY map, and tagged with region labels, as shown in the color bar. Each region is given a unique set of optical spectra as estimated by literature values. Simulations using this mesh, to examine imaging the fluorescence from brain tumors are shown in (d).

Discussion

Calibration and testing of the rodent coil with fibers in place is underway, and spectral tomography with the 16 channel system has been completed. Fluorescence imaging and absorption imaging of molecular features of the tissue is possible, and MR-guided imaging of tissue spectroscopy is the next stage, as has been illustrated recently in breast imaging (1,2).

References

1. Brooksby et al, J. Biomed. Optics. 10(5) 0505041 (2005).
2. Brooksby et al, Proc. Nat. Acad. Sci. USA 103(23) 8828-8833 (2006).

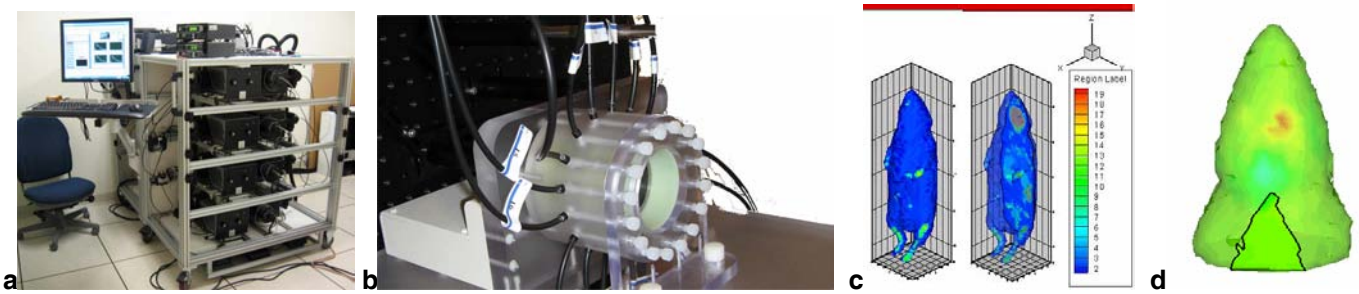

Figure 1. In (a) the 16 spectrometer system is shown, computer coupled with LABVIEW driver program. In (b) the fibers from the spectrometers are shown fitting into the 3T rodent coil as designed and constructed by Philips Research Hamburg. In (c) the MOBY mouse mesh is used to segment the different organs, and are tagged with optical properties. In (d) a simulation of fluorescence reconstruction is shown for a brain tumor within the mouse head, using only remission geometry fibers.