Validation of optical tomography in vivo

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Introduction : Multi-modality imaging is becoming a trend in developing new generation *in vivo* imaging techniques for diagnosis [1]. Recently, our group has developed a high temporal resolution, dynamic MRI-DOT multi-modality imaging system [2]. Dynamic contrast enhanced MRI (DCE-MRI) has been proven to be the most sensitive modality in detecting breast lesions [3]. However, it has low specificity in differentiating benign and malignant lesions. Meanwhile, diffuse optical tomography (DOT) is a recently emerging optical imaging technique that uses arrays of sources and detectors to obtain spatially dependent optical parameters of tissue. It can also provide enhancement kinetics of an FDA approved optical contrast agent (ICG). The enhancement kinetics of ICG may have a potential to distinguish between the malignant and benign tumors and hence, DOT may be used adjunct to MRI to improve the overall specificity. In general, each component of a multi-modality system measures a different parameter set, which makes it difficult to cross-validate the parameters measured by different modalities. In this study, however, we used a bi-functional agent that provides contrast for both optical and MR imaging to validate the optical molecular imaging system in vivo.

Methods: The fiber-optic adaptive interface was integrated with the MRI RF-coil, Figure 1.a. A novel polymer based bi-functional MR/optical agent was constructed by GE Global Research, NY. Fisher rats bearing subcutaneous R3230 ac tumors were injected with this bi-functional agent for dual modality imaging. The molecular weight of the bi-functional agent was 70 kDa. 0.2cc saline solution containing 0.01 mM agent was injected intravenously. The enhancement kinetics of both agents was recorded simultaneously with this combined MR-DOT system. For MR imaging, 30-frame T1 weighted images with 120 mm FOV were acquired at TR=520 ms and TE=15 ms. For optical imaging, 32 frames of tomographic data were acquired during the experiment. The time resolution for MR and optical data acquisition were 23 and 16 seconds, respectively.

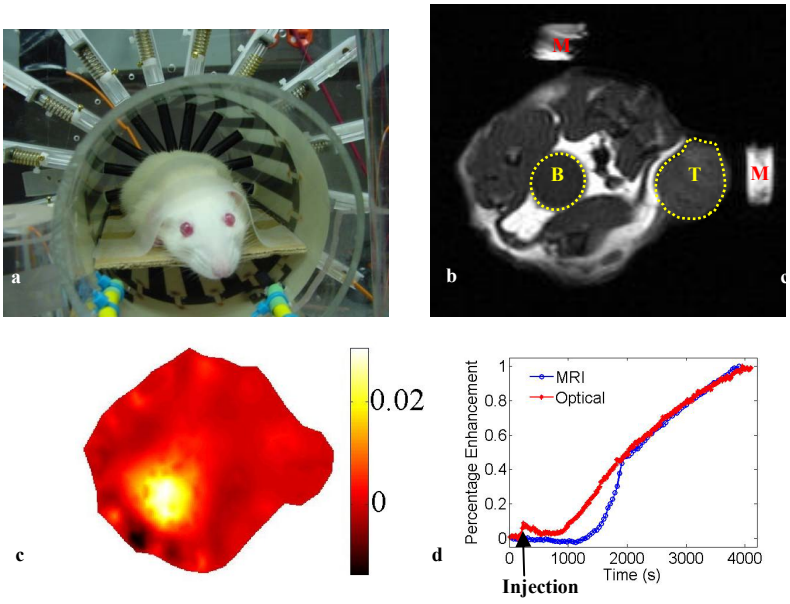

Figure 1.

(a) The integrated MR and optical interface.

(b) T1 weighted MR anatomical images. The fiducial markers are visible in the image (indicated by "M") and allows co-registration of optical and MR images. The tumor and bladder regions are indicated by yellow dashed lines as well as by "T" and "B", respectively

(c) Optical absorption enhancement image t = 3500s. The unit of the absorption is mm^{-1}.

(d) MR and optical enhancement time-course map. As seen from the curves, optical imaging picks up the enhancement earlier, presumably due to its higher sensitivity.

Results : Figure 1.b shows the T1 weighted MR anatomical and enhancement image, respectively. The enhancement absorption image at t = 3500s reconstructed from the optical data is shown in Figure 1.c. In this preliminary study, we did not observe the enhancement in the tumor region. The agent is mainly accumulated in bladder as shown both in the DOT enhancement map. The percentage enhancement was calculated for an ROI positioned at the bladder region. The optical and MRI enhancement curves agree very well as shown in Figure 1.d.

Discussion : This is one of our first studies that aims for validation of optical imaging in vivo. A uniqueness of this study was the utilization of a multi-modality system with a multi-modality contrast agent. Once the optical tomography is validated, this multi-modality system can be translated to clinical settings for breast cancer imaging. Our near future plan is to produce different molecular weight agents and used them in the validation studies.

References : 1. Frangioni, J.V. J Clin Oncol. 26:24 (2008) 2. Unlu, M.B., Birgul, O., Gulsen, G. Phys Med Biol. 53:12 (2008), 3.Turnbull, L.W. NMR Biomed. July (2008)

Acknowledgment : This research is supported in part by the California Institute for Regenerative Medicine through a CIRM training grant T1-00008 awarded to Y Lin and the National Institute of Health Grants # R33CA120175 and #R01EB008716