Simultaneous Optical and MR Imaging of Window Chambers

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Introduction: Optical imaging of implanted window chambers on the dorsal skinfold of mice is an established experimental technique that has been used extensively in basic cancer and vascular biology studies. It provides a means to image living tissue at high resolution with an optical microscope and has been used extensively in basic cancer and vascular biology studies. Previously, we showed that MRI of implanted window chambers is also possible using plastic rather than metal window chambers [1]. The ability to image with both optical and MRI modalities opens up many possibilities to cross-validate the measurements of one modality with those from the other. In addition, complementary information can often be obtained exploiting the unique characteristics of each imaging modality. While it is relatively straightforward to move animals from one imaging instrument to another for sequential imaging experiments and to co-register the resulting images, it is still a different experimental run with confounding issues of time, previous intervention, and extended anesthesia. In this work we report on simultaneous optical and MR imaging using a configuration where optical imaging can be done in the magnet at the same time as the MRI study.

Methods: MRI of mice implanted with custom-built plastic (polyacetyl resin) window chambers was accomplished with a volume coil transmitter and a DOTY surface receive coil on a Bruker Biospec 4.7 T instrument. The DOTY surface coil is 14 mm in dia. with an 11 mm hole that is approximately the size of the 11 mm field of view of the window chamber. Fig. 1 shows the set up with the animal held in position and the DOTY surface coil placed just above the exposed window chamber. When the animal is placed inside the 7 cm dia. volume coil, the top of the surface coil is 15 mm from the inner surface of the volume coil. An optical imaging system was constructed to image the tissue from above through the hole in the surface coil. The arrangement for the optical imaging system is shown in Fig. 2. In this system a coherent optical fiber bundle is used to relay the image of the tissue to a camera system located outside the magnet. A fold mirror and lens image the tissue plane to the distal end of the fiber bundle. On the proximal end of the flexible fiber bundle, a lens system images the face of the bundle onto the CCD camera. Illumination of the tissue is provided by another fiber bundle that can deliver either white light for standard reflectance imaging or laser light to induce fluorescence. In many animal studies fluorescently labeled cells and/or fluorescent dyes are used to provide optical contrast for the tissue of interest and it is useful to have the ability to directly image in both white light reflectance and fluorescence modes. For fluorescence imaging an appropriate bandpass emission filter is inserted between the lenses at the proximal (camera) end of the system.

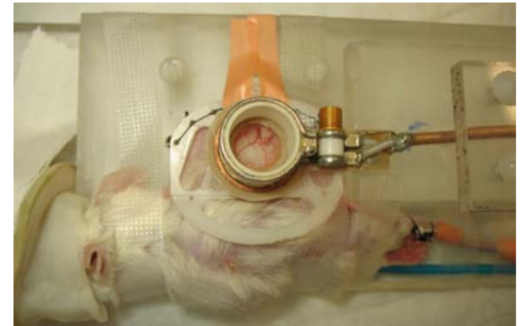

Fig. 1. Mouse with window chamber and MR surface coil

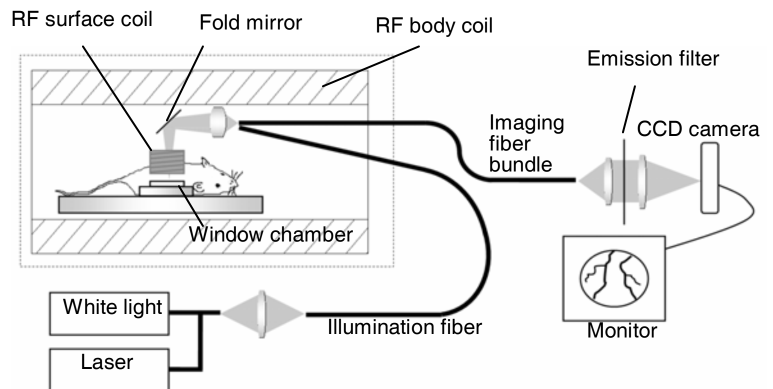

Fig. 2. Layout for the simultaneous MR and optical imaging system.

Results: Fig. 3 shows an MR image and an optical image of the same window chamber. The MR image is a standard T1 weighted spin echo image with TR=500, TE=15ms, 2.56cm x 2.56cm FOV (cropped for display), 256x256 matrix (100 micron square pixels), and 4 ave. (total imaging time 8:32). The optical image is with white light illumination and the optical magnification set such the whole 11 mm window chamber is imaged onto the 0.730mm face of the fiber bundle (mag=15 between fiber and tissue) so that the 3 micron individual fibers in the bundle are imaged to about 45 microns on the tissue. This is a single static frame captured with an integration time of about 100 ms. It should be noted that the optical image was obtained separately outside the magnet to demonstrate the principle.

Discussion: The results in Fig. 3 show that in principle high resolution MR and optical imaging of window chambers implanted in a mouse model can be achieved simultaneously. With sufficiently long fiber bundles the sources, camera, and monitor can be placed outside the magnet room to avoid noise pickup problems. If desired, much higher resolution optical imaging can be achieved simply by changing the magnification of the optics at the distal end of the fiber.

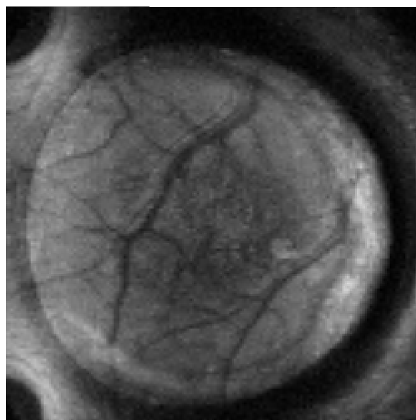

Fig. 3a MR Image

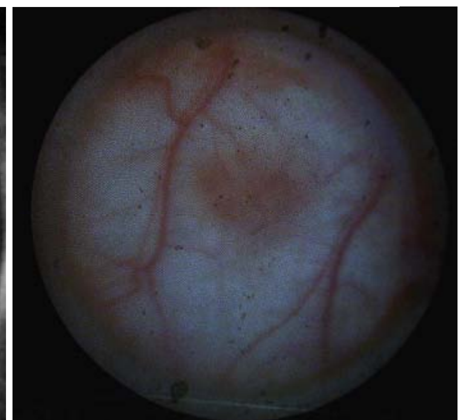

Fig. 3b Optical Image

Acknowledgement: This work is supported by NIH (CA093650).

References: [1] Gmitro AF, et al, Proc. ISMRM **14**, 51, 2006.