A Prototype System for Measuring Temperature in-vivo during RF Exposure

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INTRODUCTION

Although the estimation of SAR and resulting temperature changes in experimental animals is frequently undertaken using modeling methods, this of necessity involves assumptions and simplifications. Direct measurement of temperature change is sometimes achieved using cadavers or implanted fluoroptic probes in live animals [1]. The disadvantage of the latter is that the use of probe arrays to give a spatial map disrupts sensitive tissue, in rodent brain for example. We have developed a method that enables a 3D map of temperature change to be obtained in-vivo using a fused silica coherent optical fiber bundle together with a temperature-sensitive dye, Rhodamine-B (Rho-B, [2]). This uses a method previously developed in this laboratory for measuring calcium changes in living rat cortex [3]. At the time of abstract submission, the Rho-B/fiber bundle method has only been used in in-vitro brain slices, but this presentation will describe the method to be followed using a carousel RF exposure system for live rodents.

MATERIALS AND METHODS

The imaging system is a modified rigid endomicroscope (Optiscan Imaging, Melbourne, Australia) as shown below (Figure 1). This is an optical fiber-based confocal system, where the confocal spot is focused on to the face of a coherent fiber bundle (Fujikura, Japan: 0.75 m length, 0.46 mm diameter viewing area, $10^4$ individual fibers, each 2.9 $\mu$m diameter, 4.6 $\mu$m separation). The distal end of the bundle is placed in contact with, or inserted into the biological tissue. The resulting image (Figure 2) is quite adequate for identifying mm scale temperature gradients. Temperature gradients in RF-exposed mice have been modeled [4].

RESULTS

In preliminary experiments, rat brain slices (0.3 mm thick) were fixed and incubated with Rho-B (1 mg/l). Slices were placed in small Petri dishes and the fiber bundle placed as shown in Figure 1. The dish was then warmed (via a hotplate) and the temperature monitored. Imaging software (ImageJ, NIH) was used to obtain total pixel counts in corresponding regions of images captured at different temperatures. The changes in intensity are consistent with the 2% Celsius$^{-1}$ calibration obtained previously [2]. Although each fiber is smaller than an individual cell, there is insufficient resolution to accurately image cellular architecture. Images have a pixilated character due to the size of individual fibers (Figure 1: inset). This can be removed, if required by scanning the focal spot a little way into the bundle (giving a defocused effect as shown in Figure 2). Images shown are of fixed rat brain slices. For live imaging, the distal end is inserted into the brain via a burr hole drilled through the skull, following our previous methodology [3]. A non-metallic positioner is used to avoid perturbing RF fields in the exposure system. The bundle itself is non-perturbing.
Figure 1: Scanning system for obtaining remote microscopic images: portion of image shown inset.

Figure 2: Image of region of brain slice at 28, 35, and 48 °C (approx). Area: 300 x 300 μm (512 x 512 pixels) approximately. Image counts in selected area: 3.7, 3.3, 2.0 (x 10^7): image defocused to eliminate pixilation effect due to individual fibers in bundle (see inset in Figure 1). Black line at top left is sheath of fiber bundle.

CONCLUSIONS

The ‘proof of concept’ experiments described indicate that this system is capable of measuring changes in tissue, particularly brain, temperature in live animals during RF exposure. Further preliminary data will be presented at the conference.

REFERENCES