A Histological Slice Imaging Coil for 7.0 T MRI

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INTRODUCTION

To assess the appearance of microscopic pathology in MRI, it is important to be able to register MR images exactly with histological slides. Our approach to accomplish this has included novel coil designs to image a thin slice of tissue before histological processing (1, 2). Here we describe the design of a novel histological RF (radiofrequency) coil for a 7.0T MRI (Magnetic Resonance Imaging) system. The coil was designed using the Finite Difference Time Domain (FDTD) numerical method of field calculation, and constructed using conventional methods. Finally, we present ex-vivo MRI images of mouse brain and agar phantom slices which have sufficient resolution for high frequency microimaging.

METHOD

Different coil designs for imaging a 60 μm thick slice of tissue between glass plates were evaluated with the FDTD method using commercially available software (xFDTD; Remcom, inc.; State College, PA). The coil was designed to operate at 300Mhz. The final coil design had a width of 25.4 mm, a length of 33mm, and was made of 0.05mm thick copper tape (3M Electrical Tape) in a U-shaped configuration with a gap between sides of 0.36 mm for insertion of the histological slide (Figure 1). The open end of the U-shaped coil is connected with a chip capacitor (American Technical Ceramics, Huntington Station, New York, USA), two non-magnetic trimmer capacitors (Voltronics Co., Denville, New Jersey, USA) for coil tuning and matching, and balun (Balanced and Unbalanced Circuit) to reduce coupling between the coil and other components. A coil former was created by cutting delrin sheet using 100-W computer-guided laser (Universal Laser System, Scottsdale, Arizona, U.S.A.). MR Imaging was performed on our 7T imaging system (Bruker Biospec GmbH, Ettlingen, Germany).

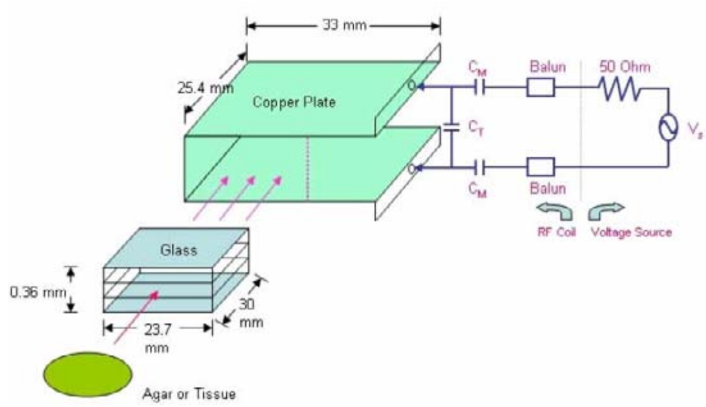

Figure 1 The Histo-coil geometry for the experiment. Balun and balanced matching circuits were used. The coil length was decreased from 44 mm to 33 mm. The agar and mouse brain tissue samples were 60 μm thick and the glass cover slip thickness was 150 μm.

RESULTS

Field calculation results show that our coil design has better uniformity and field strength than a two-plate coil with a conventional slotted-tube resonator (STR) based design (3) (Figure 2). The mouse brain tissue image obtained by our designed RF coil has high SNR and resolution sufficient for comparison to histological study (Figure 3).

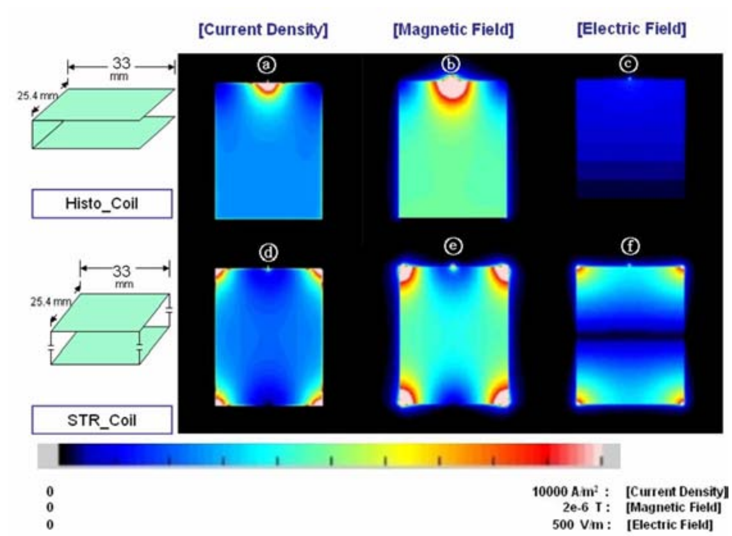

Figure 2 Calculated field plots of the Histo-coil (top) and STR-based coil (bottom). (a) and (d) show normalized current density, (b) and (e) show normalized magnetic flux density, (c) and (f) show electric field intensity. Our design (top) has better magnetic field uniformity, lower electric fields, and stronger magnetic fields for a given current than the STR-based design (bottom).

DISCUSSION

In summary, we have presented a novel coil for high frequency micro-imaging for histological studies. We verified that our designed Histo-coil has a better electro-magnetic performance compared to the flat two-sheet STR coil in terms of field uniformity, field strength and power loss using numerical calculations. Using our designed Histo-coil, we acquired a high resolution mouse brain tissue image on our 7.0T MRI system. We believe that the Histo-coil and the design concept are very useful for high-field microimaging.

REFERENCES

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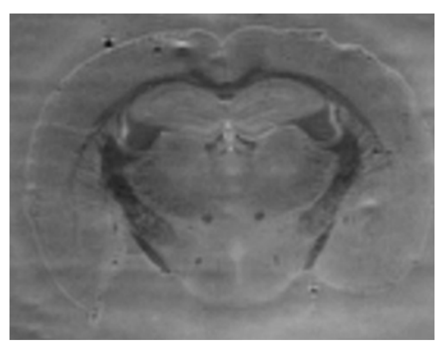

Figure 3 T_2-weighted mouse brain tissue multi-echo combined image: TR=1329ms, TE=11.2 to 134.4ms, 12 echoes, 16 averages, tissue thickness=60μm, FOV=23x23mm^2, matrix size=256x256, total scan time=1.5hrs.