Ultra-High Field MRI of Primary Brain Tumors: Contrast and Resolution

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INTRODUCTION

Primary brain tumors are well-known for their heterogeneous presentation and/or therapeutic response which often requires higher imaging specificity than that provided by conventional MRI scans. In the setting of this disease, imaging of primary brain tumors at Ultra-High magnetic Fields (UHF, >3 Tesla) magnetic resonance imaging (MRI) has tremendous appeal due to the expected improvements in contrast at spatial resolution scales previously unpractical for in vivo human MRI [1]. In addition, the improvements in signal-to-noise ratio (SNR) available at UHF allow the removal of partial voluming effects that could sometimes compromise the quantification of novel signal mechanisms such as multiple and single quantum editing sodium MRI. In this work, we discuss the technical hurdles required for taking advantage of UHF's unique advantages and demonstrate the use of UHF in the context of primary brain tumors of different grades.

METHODS

Data Acquisition: Images were acquired at two field strengths in order to assess the advantages of UHF MRI. Studies were performed *in vivo* using whole body TIM Trio 3 Tesla or Magnetom TIM 7 Tesla scanners (Siemens AG, Erlangen, Germany). Data acquisition at 3T took place using a dual-tuned (^{23}Na/^{1}H), dual-quadrature, four-port birdcage RF coil (Advanced Imaging Research, Cleveland, Ohio) and/or a twelve-channel, receive-only RF coil. All 3T studies included the use of standard imaging sequences (FLAIR, CSI, T1, T2, etc.) in order to provide anatomical referencing and a comparison with conventional imaging schemes. All studies (3T/7T) were performed in accordance to an approved Institutional Review Board (IRB) protocol. At 7 Tesla, proton data were acquired using an 8-channel transmit/receive head coil and sodium data using a single channel, four-port, transmit/receive birdcage sodium coil. All sodium data were collected using a pulse sequence based on a twisted projection imaging [2] readout and reconstructed off-line using in-house image reconstruction software.

RESULTS

Figure 1 shows representative 7T images acquired on a high-grade brain tumor. The images on the top correspond to a high resolution gradient echo (TR=700ms, TE=17ms, 250 microns in-plane) and susceptibility weighted imaging (SWI) proton scans while those in the middle correspond to low/high resolution (left/right) sodium scans (3mm and 2mm, respectively). The proton scans clearly illustrate the increased contrast between the vascular bed and the surrounding brain parenchyma, especially in the SWI data set. The sodium images clearly depict the increase in signal intensity that is known to take place during this brain pathology. These changes are better quantified in the high resolution scan due to its lower level of partial voluming effects as it its clearly depicted in the profiles through the images shown at the bottom of the figure.

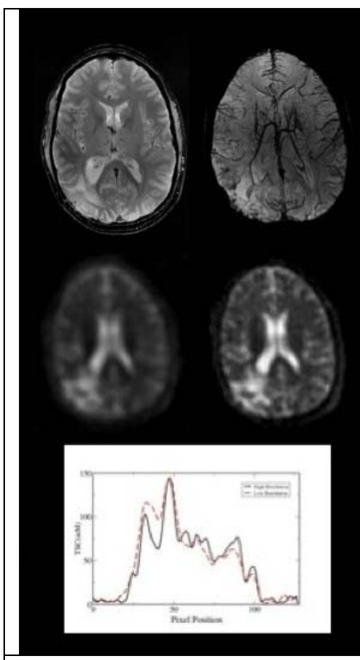

Figure 1: *High resolution gradient echo (top left), SWI (top right), low/high resolution sodium (middle left/right) and profile through the low/high (red/black lines) sodium images from a anaplastic astrocytoma acquired at 7T.*

CONCLUSIONS

We have demonstrated the use of UHF MRI for the study of primary brain tumors. Our results indicate that there are practical benefits for UHF MRI of this pathology due to the increased microvascular constrast for gradient echo and SWI imaging as well as the much reduced partial voluming effects during sodium MRI. This latter finding is significant as it allows a better characterization of high-grade brain tumors where necrosis and edema significantly bias the measurement of the tissue sodium concentration.

REFERENCES

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