High-Resolution In-Vivo Imaging of Multiple Sclerosis at 7T

M. Metcalf[1], D. Pelletier[2], D. Xu[3], L. Carvajal[3], D. T. Okuda[2], R. Srinivasan[3], D. Kelley[4], S. J. Nelson[1,3], and D. B. Vigneron[1,3]

[1]UCSF/UCB Joint Graduate Group in Bioengineering, University of California, San Francisco, CA, United States, [2]Neurology, University of California, San Francisco, CA, United States, [3]Radiology, University of California, San Francisco, CA, United States, [4]GE Healthcare, San Francisco, CA, United States

Introduction: Multiple sclerosis (MS) is a multi-focal, inflammatory, demyelinating condition traditionally regarded as a disorder of the white matter. Postmortem pathologic studies reveal significant involvement of the gray matter[1] affecting principally the cingulate gyrus, fontal, parietal, and temporal lobes.[2] White matter lesions are detected easily *in vivo* at the conventional field strength of 1.5T, with better resolution obtained at 3.0T. Cortical grey matter lesions are poorly detected at these field strengths due to their small size and limitations in achieving proper spatial and contrast resolution. At 7T, the SNR increase improves spatial resolution allowing for the visualization of smaller anatomical structures in addition to providing morphological details. The objective of this study was to develop and apply high-resolution 7T MRI techniques using high sensitivity specialized phased-array coils and optimized acquisitions for improved grey and white matter differentiation to better detect and define *in vivo* pathological changes in MS.

Methods: Seven patients with clinically definite MS and four healthy volunteers were scanned on a 7T GE Signa MR scanner (GE Healthcare, Waukesha, WI) with 40 mT/m maximum gradient amplitude, a commercially available volume excite coil (Nova Medical, Wilmington, MA), and a custom-made, 8-channel phased-array coil. A gradient echo pulse sequence was used to acquire T2* weighted images with an in-plane resolution of 195x260 microns (TE = 15 ms, TR = 250 ms, 20 cm FOV, 1024x768 matrix, 20° flip, BW = 31.25, 2 mm thick, 1.5 mm skip, 3 NEX, acquisition time = 9:38 min.). Coil intensity correction and image contrast inversion were carried out using software built with IDL (ITT Visual Information Systems, Boulder, CO).

Results: The custom fabricated phased array coil provided a 2.5-fold increase in SNR at the cortex and 30% increase in deep brain parenchymal structures compared to the commercial 8-channel phased array resulting in high resolution images of the brain, cerebral vasculature and grey/white matter (Figure A). White matter lesions were easily detected and better delineated from adjacent structures compared to lower field strengths (3T). With these improvements in resolution, it was possible to differentiate between juxtacortical white matter lesions and cortical lesions (Figure B). Figure C demonstrates a cortical lesion originating from the pia, extending through the grey matter to the sub-cortical white matter.

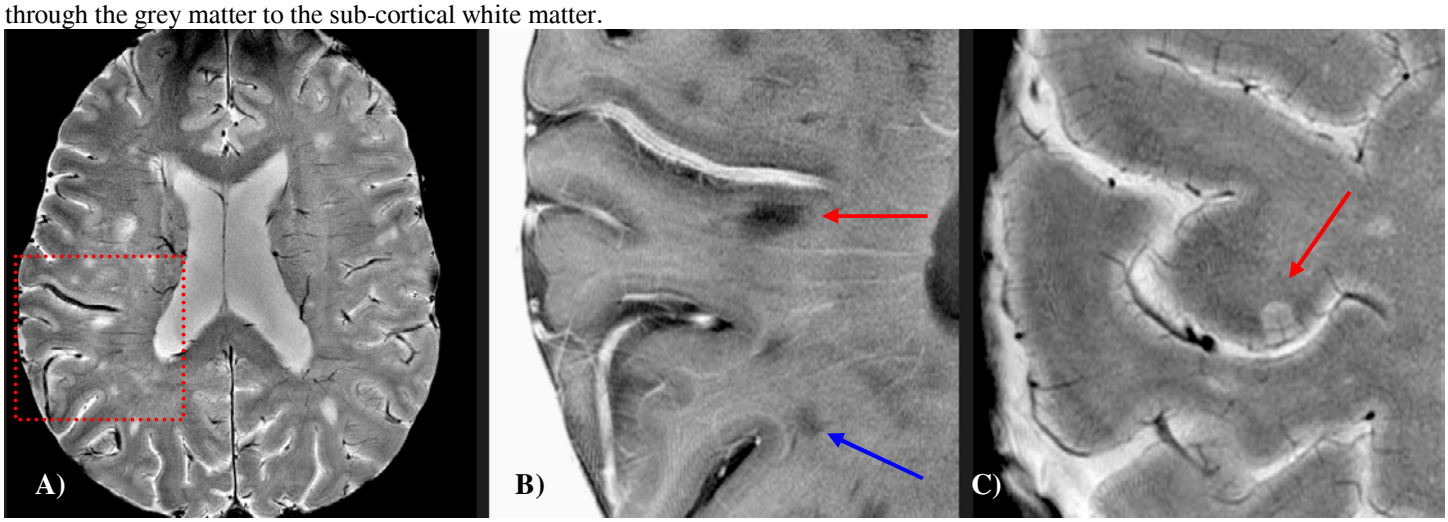

Figure: A) 195x260μm T2*-weighted images of a MS patient with numerous white matter lesions. **B)** Enlarged contrast-inverted image of highlighted selection from Figure A demonstrating a subcortical white matter (blue arrow) and juxtacortical (red arrow) lesion. **C)** Cortical lesion (red arrow) from a different MS patient.

Conclusion: Very high field MR imaging of MS patients at 7T was well tolerated and provided high-resolution anatomical images allowing for the visualization of structural abnormalities localized near or within the cortical layers. These initial results suggest that scanning MS patients at 7T is not only feasible, but also can detect lesions at a higher spatial resolution than at lower fields. MS lesions were detected in the white matter, and lesions in the cortical grey matter ribbon, rarely observed at lower field strengths, were clearly observed. These data suggest that MS pathology is clearly not limited to white matter structures. Higher contrast resolution within the neocortex is important to further investigate the cortical pathology in MS that is only now beginning to be visualized.

References:

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