High Resolution Anatomic and Physiological Imaging of the Optic Nerve and Optic Chiasm at 3T

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Introduction

We have begun a comprehensive program aimed at imaging the optic nerve (ON) and the optic chiasm (OC) at 3T. Our approach involves obtaining high resolution anatomic MR images as well as physiological images of these structures. The rationale is that many patients with multiple sclerosis (MS) exhibit optic neuritis as their first symptoms. Previous studies of MS conducted at 1.5T [1-6] have demonstrated the potential diagnostic and prognostic values of MRI of ON at MS. Since the ON is a relatively small structure we felt that using 3T would result in higher resolution images and therefore might lead to better evaluation in MS patients. In this work we have obtained high resolution anatomic images of the ON and OC and have made substantial progress in optimizing a 3D magnetization transfer (MT) sequence.

Methods

Imaging was performed on the 3T scanner (Signa LX, General Electric, Waukesha, WI). First, high resolution anatomic images were obtained employing a custom designed head coil. This coil consists of a coil array (25 cm diameter) and contains four 30×30cm squared coils. Oblique axial and oblique sagital Fast Spin Echo (FSE) images were acquired with 1.5mm slice thickness and FOV18×18cm. Other imaging parameters were: TR/TE=5400/102.2, NEX=4, 512×256 matrix size, and TR/TE=5417/96.5, NEX=3, 512×384 matrix size for axial and sagital images, respectively.

Second, a pilot study of MT was performed. Our initial optimization of MT was carried out using the standard head coil. The MT effect was measured on 3D gradient echo images with TR/TE=100/1.7ms, flip angle 20 degrees, NEX=1, FOV24×18cm, 128×128 matrix size, 3mm slice thickness. The MT saturation pulse was applied prior to GRE sequence. The width of the MT pulse was optimized to achieve a maximal MT contrast at RF offset of 1200Hz and was equal to 10msec. The reference image, i.e. image with no MT, was obtained by placing the MT RF offset value very far from the resonance. The magnetization transfer ratios (MTR) were measured at the regions of interest by manual calculation.

After this optimization, MT experiments were performed using a custom designed four-channel coil described previously. Here, high resolution images were obtained together with MT, employing 3D TOF-GRE and using 1.5 mm slice thickness, FOV24×18cm, 256×256 matrix size, TR/TE=200/2.5ms, flip angle 20 degrees, NEX=1.

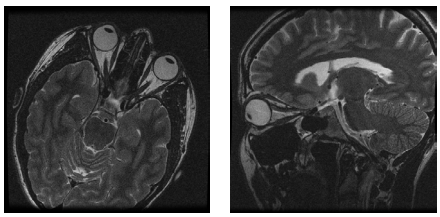

Figure 1: *High Resolution FSE images: oblique axial plane(left) and oblique sagital plane (right)*

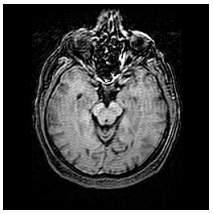

Figure 2: *The difference axial image obtained by a subtraction of the MT prepared image from the reference image*

Results

The ON and OC were clearly visualized in the FSE images acquired. Two of these images are shown in Figure 1. The use of a high sensitivity four-channel coil and 3T field allows obtaining high resolution anatomic images, with the in-plane resolution as low as $352\times469\mu^2$. This resolution enables clear and detailed demonstration of ON and OC in a relatively short scan time of 5 min (sagital images) to 6 min (axial images).

MT contrast enhanced images were acquired to provide quantitative physiological measure. Figure 2 shows one of the axial images obtained via the standard head coil. This image was calculated by a subtraction of the MT pre-saturated image from the reference image. The MTR measured in the experiments are 35% to 45% for the white matter, 20% to 30% for the gray matter and are approaching 0% for CSF. These values are in the range of typical MTR values. In the tissues damaged by MS the MTR is expected to decrease [4].

Next, MT experiments were performed using the four-channel coil. This enabled acquisition of high resolution MT images with the slice thickness of 1.5mm and in-plane resolution of $938\times938\mu^2$ in a scan time of 10 min. Optimization of MT sequence in terms of saturation RF pulse length and RF offset values is underway.

Conclusions

We have shown that it is possible to acquire high resolution anatomic images at 3T scanner with the slice thickness as low as 1.5mm and in-plane resolution as low as $352\times469\mu^2$. This resolution and image quality are very difficult to obtain with a standard coil and lower magnetic fields. We have also shown that it is possible to do MT experiments at 3T at high spatial resolution within SAR guidelines. Preliminary results presented here pave the way towards MR imaging of ON and OC damage in MS.

References

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