An Improved 28 Channel Coil Array for Optic Nerve Imaging

R. Merrill[1], J. Hadley[1], E. Minalga[1], D. Parker[1], S. Vijayakumar[1], S-E. K. Choi[1], L. Bell[1], and J. Rose[2,3]
[1]Dept. of Radiology (UCAIR), Salt Lake City, UT, United States, [2]Neurovirology Laboratory VASLCHCS, [3]Brain Institute

Introduction: The purpose of this work was to design and construct an RF coil optimized for imaging the Optic Nerve (ON) on a Siemens 3T MRI scanner. The specific goals were to optimize signal sensitivity from the orbit to the Optic Chiasm and improve SNR over the design previously presented [1].

Methods: The Optic Nerve (ON) coil was constructed using two fiberglass formers that fit together to surround the entire head. The anterior former supports 26 overlapping coil elements in a mask arrangement as shown in Fig. 1. The posterior former supports the neck and head and houses two additional overlapped coil elements, totaling to 28 elements. In this design, the two formers can slide over each other to accommodate any arbitrary head size, while maintaining close coupling near the eyes and around the head in general. This design eliminates the air void regions that occur between the coil elements and the forehead when smaller heads are imaged in one-piece, non-adjustable coil formers. The elements were placed using a soccer ball layout [2]. In addition, the coil elements were designed and placed to optimize parallel imaging along the optic nerve from the orbit to the chiasm. Elements were circular in shape and constructed from 14-gauge wire to minimize any flux shielding effect that might occur when using dense arrays of etched copper loops [3]. Phantom studies were performed using a homemade fiberglass, $CuSO_4$ solution head phantom in a Siemens 3T TIM Trio MRI scanner (Siemens Medical Solutions). Phantom images were used to assess and compare the relative SNR (rSNR) and inverse g-factor maps of the two coils.

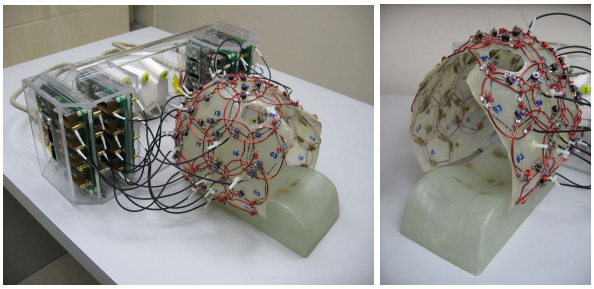

Figure 1. Optic Nerve (ON) coil with 28-channel adjustable former design

Results: rSNR profiles from phantom imaging studies showed that the ON coil provided ~35% greater rSNR at the region of the optic chiasm and approximately 300% near the orbits compared to the 12-channel commercial coil. rSNR plots also show a 300 to 400% improvement near the coil elements when compared to the 12-channel coil. Inverse g-factor maps show that the ON coil performs well for parallel imaging over the region of the optic nerve. The current design has much improved g-factors over the previous ON coil design [1] due to the larger number of coils that surround the head. DTI images from volunteer and patient studies with the ON coil reveal plaques that correspond well with the patient disease history of chronic bilateral optic neuritis (Fig. 2).

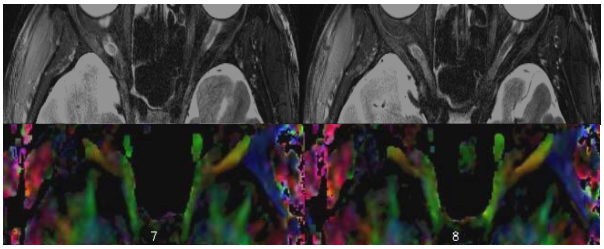

Figure 2. DTI parameter maps from a patient with optic neuritis, 28-channel ON coil. Upper plot: Ax T2. Lower plot: RGB.

Discussion: The ON coil significantly improves rSNR and parallel imaging performance over the 12-channel conventional head coil. This is due to the increased number of loops, the loop positions, and the tight fit of the coil to the anatomy. The fiberglass former used in the ON coil conforms well to most patients, but can cause increased claustrophobia in some patients. The improved rSNR in the optic nerve region allows performance of high resolution DTI. DTI provides a qualitative measurement for evaluating optic neuritis, and provides a level of image analysis not always obtained through visual inspection of the image data.

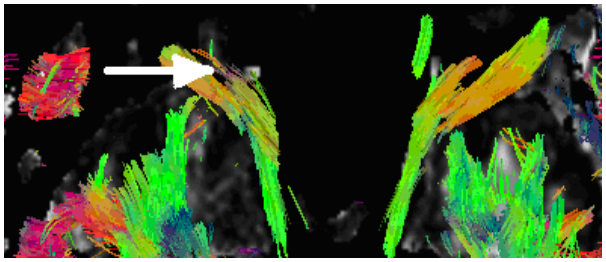

Figure 3. DTI fiber tracking from patient in Fig. 2 showing apparent loss of optic nerve organization at the site of plaque (arrow).

Conclusions: The ON coil provides significant rSNR improvement along the length of the optic nerve from the chiasm to the orbits. Parallel imaging performance is improved as well, allowing decreased patient imaging time and consequently a possible reduction of eyeball motion artifacts. Correspondence of image findings with patient disease histories demonstrates that optic neuritis can be visualized and detected in patients using 3T MRI with advanced imaging coils, providing improved patient care. This work has shown that fiber tracking of the optic nerve is achievable using high-resolution DTI techniques demonstrating detailed nerve and muscle fiber orientations (Fig. 3).

1. Hadley JR, Minalga E, Parker DL; 20 Channel Coil Array for High Resolution Imaging of the Optic Nerve, ISMRM 2007, pg 1055
2. G.C. Wiggins, C. Triantafyllou, A. Potthast, et al; 32-Channel 3 Tesla Receive-Only Phased-Array Head Coil With Soccer-Ball Element Geometry, Magnetic Resonance in Medicine 56:216–223 (2006)
3. G. C. Wiggins, V. Alagappan, A. Potthast, et al; Design Optimization and SNR Performance of 3T 96 Channel Phased Array Head Coils, Proc. Intl. Soc. Mag. Reson. Med. 15 (2007)