A 32 Channel receive-only 3T array optimized for brain and cervical spine imaging

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Introduction: Simultaneous imaging of the brain and cervical spinal cord is integral to the study of pathologies involving both structures such as multiple sclerosis. Imaging the spinal cord is challenging due to its small size (~1cm diameter) and the presence of large B_0 inhomogeneities that result in severe image distortions in diffusion-weighted and functional MRI acquisitions. These issues call for increased detector sensitivity to achieve high spatial resolution, and for highly parallelized array coils to accelerate the image acquisition and thereby reduce vulnerability to susceptibility effects. In this study, we present a highly parallel 32-channel coil array that allows coverage of both the full brain and cervical spine region. The sensitivity of the array is compared with the standard manufacturer head, neck and spine coil.

Methods: To accommodate both the head and spinal cord, our design is based on a 3D surface reconstruction of a representative segmented MPRAGE, fabricated with a 3D printer (Fig. 1), with coil elements arranged similarly to our 32-channel 3T coil design [1]. The brain region has 20 overlapped circular loop elements, 9.5 cm wide, and the neck and cervical-spine region has a total of 10 elements, 8.5 cm wide. A separate paddle with two elements is placed on the forehead. The elements, made of wire loops [2] with four lumped capacitors each, are tuned and matched to an impedance of 200+j50 Ohms, as required at the input of the preamp. The active detuning is done with a PIN diode in a parallel LC circuit. The preamp decoupling is achieved with a cable length of 4.2 cm, with the preamps placed on the coil elements.

The array is compared on a 3T scanner (Siemens TIM Trio) with the standard 12-channel matrix head coil, 4-channel matrix neck coil, and 24-channel spine coil (only the three cervical-thoracic-area elements of the latter were used). Array noise covariance was estimated from a thermal noise acquisition (i.e., without RF excitation), and SNR maps were computed for the root sum-of-squares (rSoS) and Optimal SNR combinations (using the channel noise covariance) following the methods of Kellman & McVeigh [3]. A four-echo MEMPRAGE was acquired with TR=2530ms, TE=1.64/3.50/5.36/7.22ms, TI=1200ms, 1x1x1 mm^3, bandwidth=650 Hz and *R*=3.

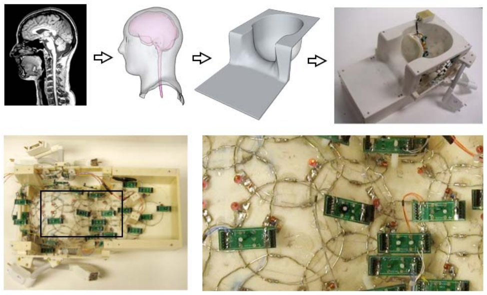

Fig.1: (Top) Design and building coil using 3D printer. (Bottom) Photograph of coil array.

Results: Each element shows a Q unloaded-to-loaded (with a human head) ratio of ~240/40. S21, loaded, between neighboring elements ranges from -18 dB to -12.5 dB. S11 reflections showed the elements tuned and matched to 200+j50 ohm. Fig. 2 compares the sagittal- and coronal-slice SNR maps and the noise correlation coefficient matrices between the Siemens coils and the 32 channel head/spine coil. The results show an increase in SNR by a factor of 2 in the spinal cord and by a factor of 3 in the brain. Comparing the 32-channel array with the Siemens array, the mean SNR is 334 versus 221 in the brain, 234 versus 107 in the upper cervical vertebrae (C1-C4) and 179 versus 112 in the lower cervical vertebrae (C5-C6). The off-diagonal matrix values for the noise correlation coefficient averaged to 7.7% for the 32-channel spine array and 8.5% for the Siemens array. In an ROI covering the brain and spinal cord, the SENSE G-factor is also improved (Fig. 3), allowing four-fold acceleration without noticeable reconstruction artifacts. Fig. 4 shows a MEMPRAGE of the brain and the spinal cord through the sixth thoracic vertebra.

Conclusions: The 32-channel head and spine coil increases overall SNR twofold over the Siemens coils, with G-factor suitable for parallel imaging. These capabilities will be beneficial for both functional and diffusion-weighted imaging of the brain, brainstem and spinal cord, as the two latter regions will particularly benefit from an increased sensitivity and from parallel imaging for the reduction of susceptibility distortions.

References: [1] Wiggins *et al.* (2006) *MRM* 56:216-23. [2] Allagappan *et al.* (2009) *Proc ISMRM.*

Acknowledgments: This work was supported by NCRR P41-RR14075

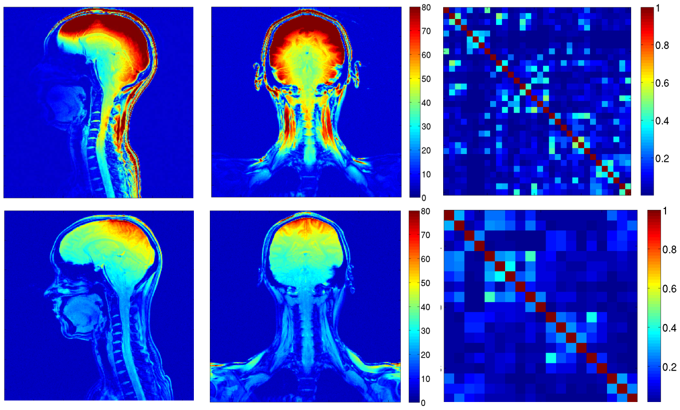

Fig 2. Optimal SNR and noise correlation coefficient matrix comparison between the 32-channel coil (top row) and Siemens array (bottom row)

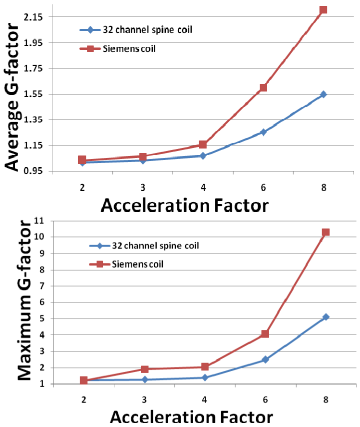

Fig 3. Comparison of average and maximum G-factors between coil arrays at different acceleration factors

Fig 4. MEMPRAGE of full brain and spinal cord