Brain arrays for neonatal and premature neonatal imaging at 3T

Azma Mareyam[1], Duan Xu[2], Jonathan R Polimeni[1,3], Eli Siskind[1], Vijay Alagappan[4], James N Blau[1], Boris Keil[1,3], Nan Tian[2], Wei Zhao[1,3], and Lawrence L Wald[1,3]
[1]*A.A. Martinos Center for Biomedical Imaging, Department of Radiology, Charlestown, Massachusetts, United States,* [2]*UCSF School of Medicine, San Francisco, California, United States,* [3]*Harvard Medical School, Boston, Massachusetts, United States,* [4]*GE Healthcare, Cleveland, Ohio, United States*

Target Audience: RF coil engineers, pediatric neuroimagers and neuro-radiologists.

Introduction: Imaging premature and neonatal babies in incubators is challenging due to time and sensitivity constraints and motion artifacts. Additionally distortion artifacts in diffusion and functional EPI studies requires mitigation via parallel imaging. The rapid growth of the head requires specialized detectors for different age ranges. Previous studies have illustrated the benefits for age-matched 32-channel arrays for brain imaging in children from newborn through age 7 compared to adult coils or pediatric birdcage coils.[1] In our work, we extend this philosophy to premature infants. We have developed and tested two incrementally-sized 16-channel coils for premature neonatal imaging and one 32-channel coil for term neonatal imaging. The SNR and g-factors of the arrays are compared with that of the standard manufacturer adult head coil.

Methods: The coils are designed to fit in a home-built MR compatible incubator with the premature baby's head lying comfortably inside the coil helmet. The 16-channel 27 wk GA premature coil helmet (LxWxH: 9.5x9.5x11cm) consists of two pieces, a deep posterior segment and a paddle for the forehead region. The 16-channel 36 wk GA premature coil (LxWxH: 11x9.5x12.5cm) and the 32-channel term neonate coil (LxWxH: 18x14.5x15.5cm) helmet is a single piece. Both designs keep the face un-obstructed to allow access to the patient's airways. Each helmet was sized from a 3D surface reconstruction of average segmented MPRAGE and fabricated with a 3D printer (Fig. 1). The premature infant coils were designed for GA 27 and 36 weeks, while the term neonate was based on standard size charts. The layout of the wire (16 AWG) circular overlapping elements is similar to the pediatric designs [1] (loop diameter: 4.2cm for the 16-channel 27wk GA premature coil, 4.7cm for the 16-channel 36wk GA premature, and 4.5cm for the 32-channel term neonate coil). All elements are tuned to 127.8 MHz and matched to a loaded impedance of 50 Ohms to minimize the noise figure of the preamplifiers (QED, Cleveland, Ohio). Preamplifier decoupling is achieved with the low-impedance preamps. The active detuning circuit is formed across the match capacitor using an inductor and PIN diode. In addition, a passive diode detuning circuit is added to each loop as additional protection during transmit.

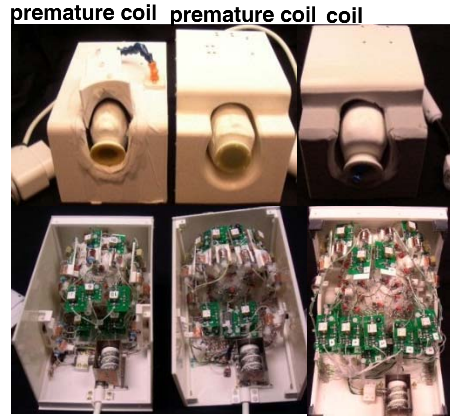

Fig. 1: Arrays with 3D-printed plastic head phantoms (top); elements laid out on formers (bottom).

Data were acquired on a 3.0T whole body scanner. For SNR and SENSE g-factor comparison, proton density-weighted gradient echo images were obtained with and without RF excitation using head-shaped loading water phantoms (also created from 3D printouts from 3D MRIs). The SNR maps were calculated for the optimal SNR combination incorporating noise covariance information [2]. The coils were compared to the commercially available 8-channel adult head coil. Finally, the 16 channel 27 wk GA array's performance was tested in 2x-accelerated anatomical and Diffusion imaging *in vivo* (Fig. 5).

Results: All three arrays show S_{11} > -20dB and nearest neighbor S_{12} ~ -15dB when loaded with the head-shaped phantom. Typical unloaded-to-loaded Q values range from 3.3 for the premature coils to 4.7 for the 32-channel neonate coil. Fig. 2 shows coronal slice SNR maps comparing the two arrays with the 8-channel adult coil. The SNR gain of the 16-channel 27wk GA coil compared to the adult coil ranges from 4.1-fold on the phantom's edge to 1.7-fold at the center. Fig.3 shows the SNR gain of the 32-channel term neonate coil compared to the adult coil which ranges from 4.9-fold on the phantom's edge to 2-fold at the center. The off-diagonal values of the noise correlation coefficient matrix average to 10.5% for the 16-channel 27wk GA premature coil and 18.9% for the 32-channel term neonate coil. The g-factor comparison (Fig. 4) shows that the 32-channel coil and the 16-channel coil are comparable for the R=2x2 and 2x3 cases, but the 32-channel array performs moderately better at higher acceleration factors.

Conclusion: Two 16-channel and one 32-channel phased-array head coils were constructed and optimized for premature and neonatal imaging. The coils are well-suited for highly-accelerated diffusion-weighted pediatric brain imaging and provide significant improvements in SNR and acceleration, potentially reducing motion-related artifacts.

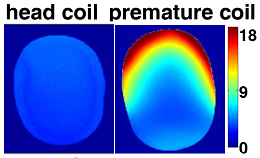

Fig. 2: SNR maps using premature loading phantom, TR/TE/flip:10ms/4.84ms/20 º, Slice:1mm,FOV:120mm, matrix: 384x384, BW:62.5MHz

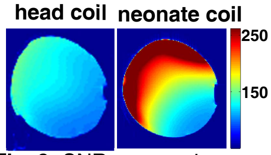

Fig. 3: SNR maps using neonate loading phantom, TR/TE/flip:8.58ms/4.14ms/30 º, Slice:2mm,FOV:200mm, matrix: 256x256, BW:31.25MHz

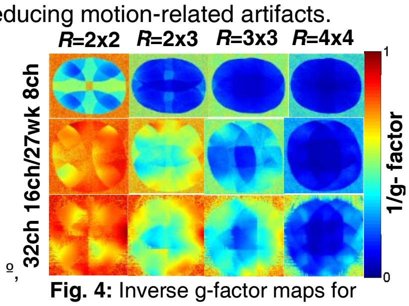

Fig. 4: Inverse g-factor maps for different accelerations using age-matched phantoms in comparison to 8ch adult coil.

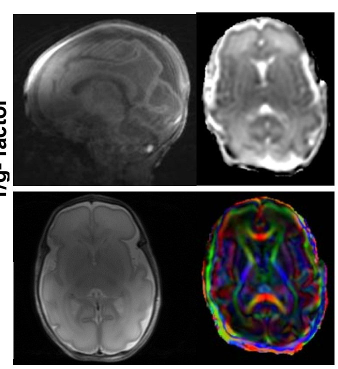

Fig. 5: Images acquired using 16-channel 27wk GA coil. Counter-Clock-wise: Uncorrected T1 and T2. Processed ADC and color FA maps.

References: [1] Keil *et al.* MRM 2011, 66(6): 1777-87, [2] Kellman *et al.* MRM 2005, 54(6): 1439-47.

Acknowledgements: We acknowledge Robb Fraser from GE Healthcare, Ohio for his support.