# An 8+4-Channel Phased Array for Magnetic Resonance Imaging of Newborns and Premature Infants at 3T in an MR-Safe Incubator

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**Introduction** Magnetic resonance imaging (MRI) of newborns and premature infants got more attention over the past few years as it provides precise diagnostics without the use of ionizing radiation. However, there are some major challenges which have to be overcome first. Premature infants and newborns, especially when they are in a weakened state, need optimum environmental conditions during the measurement procedure, namely with regard to temperature and humidity. Since there is an MR-safe incubator available [1], imaging of the brain and thorax under optimum conditions was possible using a circular polarized birdcage resonator [2]. But especially at high fields, scans can be challenging due to SAR limits (specific absorption rate) and movement artifacts from the patient. Both issues can be dealt with by applying parallel imaging techniques, resulting in reduced scan time and SAR. Because of these reasons and to benefit from improved SNR of multi-element resonators, an 8+4-channel phased array was designed, which is shape-optimized to fit in an MR-safe incubator.

**Material and Methods** The coil system consists of two main elements (Figure 1); a patient table with eight integrated rx-elements ("bottom array") and a flexible top part ("flex array") with four rx-elements (50mm x 120mm). The elements are decoupled via critical overlap from nearest neighbors and via preamplifier decoupling from next nearest neighboring elements [3]. In the case of the bottom array, preamplifiers are placed apart from the loop elements. Proper preamplifier decoupling is achieved by the phase shift of the cable plus an additional phase shifter. A placement of the preamplifiers in the loops was deemed most suitable for the flex array to minimize the geometry of the array. All elements were equipped with a three stage safety design. It consists of an active and passive detuning circuitry and finally a fuse is implemented for the very unlikely case that both detuning circuits malfunction.

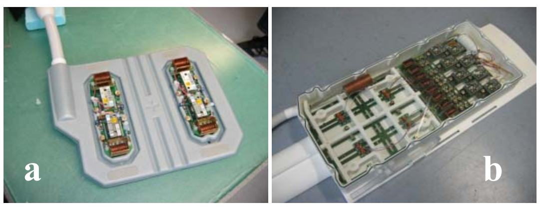


**Figure 1: (a) The thermo baked 4-channel flex array and (b) the patient table with 8 integrated rx-elements.**

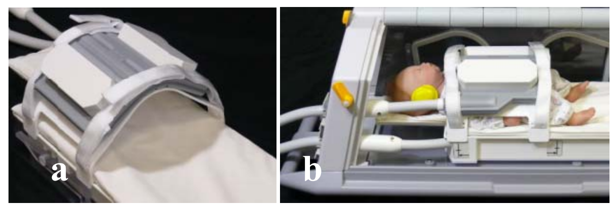


**Figure 2: (a) The combination of bottom array and the flexible part. (b) Demonstration of the phased array coil setup with a puppet in the MR-safe incubator.**

Image evaluations were run on a Magnetom Trio TIM (Siemens Medical Solutions, Erlangen, Germany) with a spoiled gradient echo sequence (TR/ TE/ $\alpha$ = 100ms/10ms/25°).
All in vivo images were acquired in an MR-safe incubator ("LMT nomag® IC", LMT Lammers Medical Technology GmbH, Lübeck, Germany). A holding device was used for the flex array to prevent any mechanical stress from the patient (Figure 2).

**Results** The single elements show a good decoupling in between the single elements when both arrays are combined (Figure 3). In addition, the SNR was increased (Figure 4) in comparison to a standard coil ("12-channel head matrix", Siemens Medical Solutions GmbH, Erlangen, Germany) not only in the region close to the receive elements (400%) but also in the center (15%) using a 2l phantom (1.25g NiSO4*6H2O + 5g NaCL per liter, diameter 12cm). Because of the elements' sensitivity profiles, the SNR will improve if smaller patients are imaged.
High resolution turbo spin echo in vivo images were acquired from a 1500g premature infant, non-sedated, free-breathing (Figure 5).

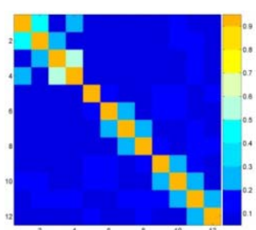

**Figure 3: Noise correlation for the combined bottom and flex array.**

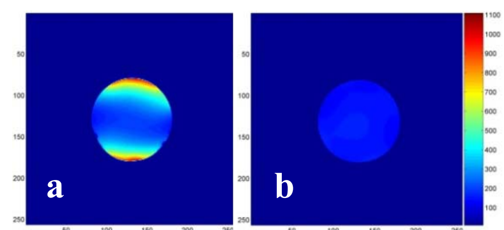


**Figure 4: SNR maps of the (a) 8+4-channel phased array in comparison to the (b) Siemens 12-ch Head matrix. A fourfold SNR gain close to the receive elements and 15 % in the centre can be observed. This gain improves when smaller patients are imaged.**

**Discussion** This new combination of multi-element phased array technology and an MR-safe incubator opens up new ways for diagnostics of premature infants and newborns. It provides highly improved SNR, maximum patient comfort and safety and the benefits of parallel imaging techniques, where scan times and SAR is being reduced by under sampling k-space. In particular, the last point should not be underestimated, as the patients are very light-weight (1-5kg) and a general issue is that SAR limits at 3T are being reached quickly , especially for applications such as. cardiac imaging.

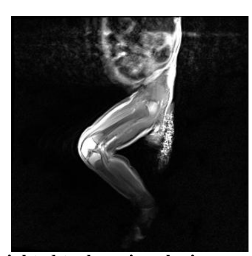

**Figure 5: High resolution $T_2$ weighted turbo spin echo image of a premature infant (1500g), which was imaged because of a head sized terratome at the coccyx. Since the patient was free-breathing and not sedated, slight moving artefacts can be observed.**

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**References**
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