# Development and evaluation of a solid endorectal coil for 7 Tesla

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**TARGET AUDIENCE:** Clinical researchers interested in a practical endorectal coil (ERC) for performing high resolution prostate cancer imaging studies at 7T.

**PURPOSE:** The long range goal of our work is to develop a prostate imaging platform at 7T which is practical for performing patient studies with the highest achievable sensitivity (i.e. using an ERC). Previous studies have demonstrated RF coil configurations similar to that used at clinical field strengths on receive (i.e. an ERC paired with a surface array for signal reception) with the exception that the surface array is also a multi-channel transmitter[1]. The ERC used in these previous studies was a modified version of a balloon-type coil (bERC) which is a disposable (non-sterilizable) device[1]. If available commercially this is a viable option, but at 7T no such commercial coils exist, and therefore, each study requires building a new coil. An alternative ERC design uses a rigid, sterilizable external housing combined with a modular internal structure that includes the coil elements and electronics. A commercial version of this solid ERC design (sERC) (Hologic, Toronto, Ontario) is currently available for 1.5T and 3T. In this work, we adapted the sERC design to accommodate a 2-channel 7T coil insert. The new coil was evaluated in terms of its receive performance compared to the bERC and its ability to perform high quality functional MRI studies in comparison to the external surface array.

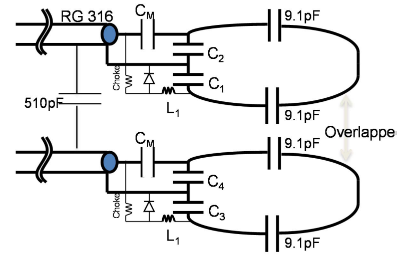


**Figure 1:** Schematic of the actively detuned solid ERC (sERC).

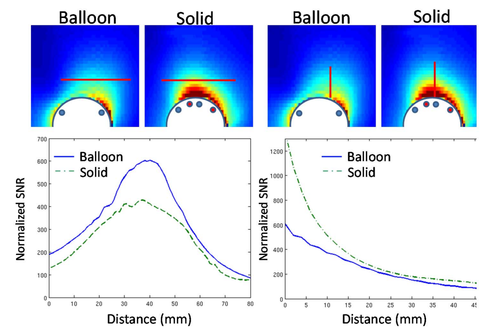


**Figure 2:** SNR performance of the two-channel solid ERC compared to the single channel ballon-type ERC.

**METHODS:** The two channel loop array was constructed on a solid core which is positioned inside a sterilizable housing. Two versions of the coil were built; one as a transceiver array and one for receive-only with active detuning, with the schematic for the latter in Figure 1.

<u>Safety Testing:</u> The transceiver coil was used for heating studies to represent the receive-only coil in the tuned state. XFDTD, a finite difference time domain solver, was used to evaluate B1 and E-fields in the torso in a whole body model (REMCOM, Pittsburgh, PA). Heating studies were performed using ACRNEMA standards driving the coil with 16 W for 15 minutes and using fiperoptic temperature probes to record heating at 1 s intervals. In addition, bench measurements were performed to evaluate coupling of the ERC in the presence of the surface array when both tuned and detuned.

<u>Performance Evaluation:</u> The bERC and sERC were compared in terms of their receive performance using a previously described phantom[1]. Prior to all imaging, the transmit phases of the external transceiver array was optimized for RF efficiency in the region of the phantom just anterior to the ERC coils[2]. SNR measurements consisted of a gradient echo acquisition with a 10 s TR, 3.8 ms TE, 90º flip angle and resolution of 2x1x2 $mm^3$. Noise measurements were acquired in a separate scan with the same parameters but with a minimum TR and no transmitted RF. Three-dimensional transmit B1 maps were acquired using the actual flip angle technique [3]. Normalized SNR maps were calculated from these acquired data following the methods of Edelstein et al.[4].

<u>Imaging Evaluation:</u> All studies were performed on a single subject in an IRB approved study. In addition to T2-weighted anatomic scans, diffusion weighted imaging (DWI), diffusion tensor imaging (DTI) and three-dimensional spectroscopic imaging (3DSI) were performed with the surface array combined with the receive-only sERC. For comparison, the surface array coil was used alone for receive in a separate study on the same subject. T2-weighted imaging parameters included: TR/TE 6000/89 ms, 160 mm FOV, in-plane resolution 0.5x0.5 $mm^2$, slice thickness 2 mm. Diffusion weighted imaging parameters included: TR/TE 5000/46 ms, 160 mm FOV, in-plane resolution of 1.25x1.25 $mm^2$, b-values of 0 and 800 s/$mm^2$, and 6 directions. Surface array imaging used similar parameters with a larger FOVs of 220 mm for both T2w imaging and diffusion weighted scan. For the diffusion scans, apparent diffusion coefficient (ADC) and fractional anisotropy (FA) were calculated by scanner software. For spectroscopy, semi-LASER was used for spectroscopic imaging with an echo time of 65 ms made possible by the use of GOIA refocusing pulses. Nominal voxel resolution was 80 µL.

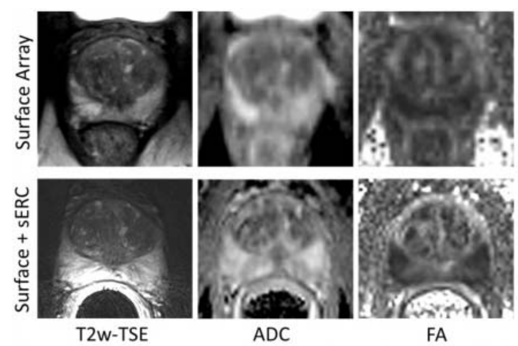


**Figure 3**: Comparison results from the surface array (top) and the surface array combined sERC coil (bottom) for anatomic T2w images and calculated ADC and FA maps from diffusion weighted data.

**RESULTS / DISCUSSION:** Evaluation of local SAR and heating of the transceive version of the coil were relatively consistent between heating studies and simulation. The input power that produced 2 degrees of heating was ~2.8W while FDTD simulation estimated ~2.4W to stay within IEC local 10g SAR guidelines but over a single gram of tissue. S12 measurements showed 15 dB decoupling between the nearest external array element and the sERC when tuned and 38 dB when actively detuned. SNR results based on a root sum of squares reconstruction of the data revealed SNR gains for the sERC compared to the bERC, Figure 2. These gains are expected and realized in studies performed at lower field strengths with the product version of the coil. The surface array only contributed minimally to the SNR with equal contribution at 3 cm from the surface of the sERC and the bERC (data not shown). Spectroscopy results showed high SNR and good spectral quality throughout the prostate, Figure 4. Both spectroscopy and diffusion require extremely high B0 homogeneity which was achieved with this coil in these studies without the need for susceptibility matching fluids as used with the bERC. The sERC has been used in repeat studies with consistent performance. Standard sterilization procedures use for ultrasound probes is being used for cleaning the coil between uses.

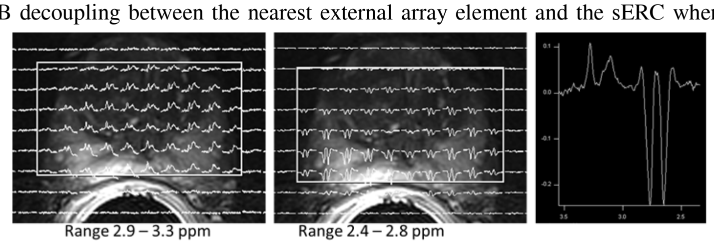


**Figure 4:** 3DSI data acquired with the surface array combined sERC using a semi-LASER acquisition and 80 µL nominal voxel resolution.

**CONCLUSION:** A reusable, multi-channel ERC with improved receive performance has been constructed and validated for use in both anatomic and demanding functional studies of the prostate at 7T. The availability of a sterilizable coil will make the use of an ERC a viable option for clinical trials at UHF.

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ACKNOWLEDGEMENTS: Funding Provided by R01 R01CA131013, R01 R01CA131013-S1, NCI R01 CA155268 & NIBIB P41 EB015894. We would also like to acknowledge Hologic for supplying the coil housings and supports as well as for their scientific collaboration.