

# Endorectal Combined Surface Array for Prostate Imaging at 7T

G. J. Metzger<sup>1</sup>, S. Moeller<sup>1</sup>, C. J. Snyder<sup>1</sup>, K. Ugurbil<sup>1</sup>, P-F. van de Moortele<sup>1</sup>, and G. Adriany<sup>1</sup>

<sup>1</sup>Center for Magnetic Resonance Research, University of Minnesota, Minneapolis, MN, United States

**INTRODUCTION:** The motivation for developing the necessary methods and hardware for prostate imaging studies at ultra high magnetic fields originates from the promise of increased spatial, temporal and spectral resolution. Towards this goal, we have previously demonstrated the tradeoffs between an external 16 channel transmit-receive stripline array coil (trSAC) [1] and a transmit-receive endorectal coil (trERC) [2]. While the trERC provided a higher peak transmit B1 (B1+) and SNR, the trSAC provided a more homogenous B1+ in the region of the prostate resulting in more uniform contrast on T2w acquisitions. Ideally, the advantages of each coil could be combined to achieve the highest SNR on receive while maintaining a homogeneous B1 on transmit. Therefore, the focus of this paper is on the development and characterization of a new receive-only ERC (roERC) combined with the previously reported trSAC (roERC+trSAC).

**METHODS:** The MRI system used for this study included a Magnex 7T, 90cm bore magnet with Siemens console and whole body gradients. For transmit, a series of 16, 1 kW amplifiers with independent phase and gain control (CPC, Pittsburgh, PA) were optimized for transmit efficiency in the region of the prostate with a local subject dependent B1 shimming procedure [3]. All 16 channels of the trSAC were used for RF transmission. On receive, one of the outer most channels of the trSAC was replaced with the roERC. The roERC coil was built using the housing of a commercial 3T balloon-type ERC design (BPX-30, Medrad, Pittsburgh, PA) with modified circuitry to match to 50  $\Omega$  at 297 MHz. The size of the coil loop was 3x7 cm<sup>2</sup>. Besides the capacitive shortenings of previously presented trERCs [2,6], both active and passive diodes were added to securely detune the ERC during transmit. To assess diode performance and coil safety, S21 benchtop measurements were performed in vivo with an HP 4396A network analyzer (Palo Alto, CA). While the S21 measurements provided a reasonable indication of roERC detuning from the transmit side, MR measurements on phantoms allowed us to evaluate the influence of the coil's loop structure on local B1+. These measurements were accomplished by first B1+ shimming on a region the size of a prostate with both active and passive decoupling followed by a two flip angle B1+ mapping acquisition under several conditions: active and passive decoupling, passive decoupling only and no decoupling.

In vivo imaging data were collected on a healthy volunteer with both a trERC and the roERC+trSAC coil under an IRB-approved protocol. Anatomic T2w turbo spin echo (TSE) images were acquired with to assess image quality and visualization of critical structures (TR 3500 ms, TE 130 ms, turbo factor 9, resolution 0.5x0.5x3.0 mm<sup>3</sup>). These were followed by 2D GRE sequences (TR 76 ms, TE 3.8 ms, flip angle 10°, resolution 1.3x1.3x10 mm<sup>3</sup>) from which SNR images [4] and local parallel imaging performance [5] were evaluated. Parallel imaging performance was assessed by calculating the mean and maximum geometry factors (g-factors) in the region of the prostate.

**RESULTS:** Network analyzer measurements indicated that the range of achievable decoupling between the individual elements of the trSAC and the roERC was  $-48.8 \pm 6.1$  db. The influence of diode detuning was verified with B1+ mapping in phantoms. Results showed a decrease in average B1+ and B1+ homogeneity with decreasing protection. The flip angles determined in the region of the prostate for 1) active and passive diodes, 2) passive diodes only and 3) no diodes were  $43 \pm 7$ ,  $34 \pm 10$  and  $32 \pm 12$  degrees respectively. The SNR of the roERC, trSAC and the combination of the two are shown for vertical and horizontal profiles through the prostate in Fig. 1. There is an over 5-fold increase in SNR in the prostate near the ERC, while the SNR of the roERC and trSAC are equal at a depth of approximately 2.8 cm (Fig. 1a). The horizontal SNR profile, which is 8 mm from the surface of the ERC, demonstrates the characteristic asymmetric receive profile predicted by simulations at 297 MHz for a loop coil (Fig. 1b). G-factors (mean, maximum) for a 3x3 reduction factor in the region of the prostate were (1.05, 1.18) for the combined coil and (1.44, 1.82) for trSAC alone. Finally, T2w anatomic imaging results are shown for the trERC (Fig. 2a) and the roERC + trSAC (Fig. 2b).

**DISCUSSION:** The active and passive detuning of the roERC during transmit proved to be effective as determined by the S21 and B1+ measurements. In addition, qualitative measures such the absence of artifacts near the coil conductors in the TSE and GRE images indicate that minimal coupling of the ERC with the SAC during transmit. As for SNR and parallel imaging performance, both improve when the roERC is combined with the trSAC with significant advantage over the trSAC alone. Finally, the image quality of the anatomic images are significantly improved with the combined coil (Fig. 2b) compared to the trERC (Fig. 2a). The inhomogeneous B1+ of the trERC, as characterized previously [2], severely degrades image quality in regions both near and far to the coil. The arrow in Fig. 2a demarcates a region of over-flipped spins reducing both contrast and structural detail while the contra-lateral side in the same image has the desired contrast. Along with increased SNR and consistent contrast across the entire prostate, the combined coil allows for better visualization of important structures close to the ERC including the prostatic capsule, rectum and neurovascular bundle.

**REFERENCES:** [1] Snyder et al. Proc Intl Soc MRM 2007; 15:164. [2] Metzger et al. Proc Intl Soc MRM 2008;16:171 [3] Metzger et al. Magn Reson Med 2008;59(2):396-409. [4] Kellman et al. MRM 2005; 54(6):1439. [5] Pruessman et al. MRM 1999; 42(5):952. [6] Klomp et al. Proc Intl Soc MRM 2008;1598.

**ACKNOWLEDGEMENTS:** Funding provided by BTRR - P41 RR008079, Minnesota Medical Foundation and the Keck Foundation

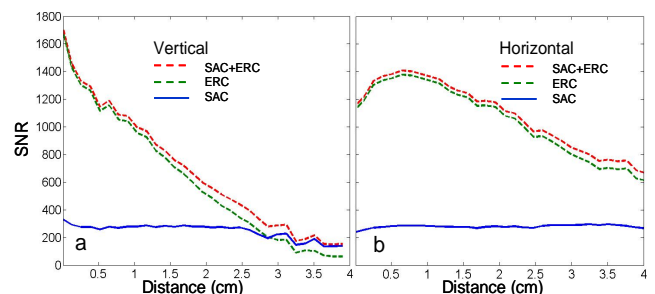


Fig. 1: Vertical (a) and horizontal (b) profiles from the SNR images created from the GRE acquisition.

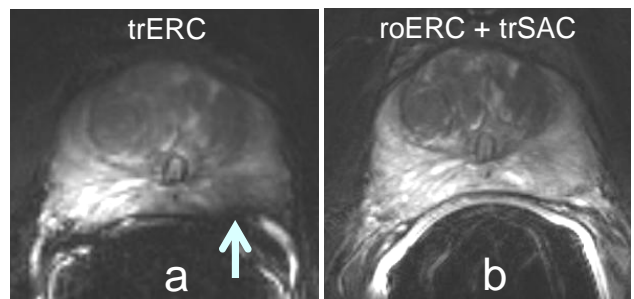


Fig. 2: T2w images obtained with the trERC (a) and the roERC combined with a trSAC (b). The region marked by the arrow is an effect of the inhomogeneous B1+ of the trERC resulting in over-flipped spins and loss of anatomic detail.