Triangular receiver coils to support superior/inferior acceleration

Paul T. Weavers[1], Jacob N. Gloe[1], Eric G. Stinson[1], Phillip J. Rossman[1], Thomas C. Hulshizer[1], and Stephen J. Riederer[1]
[1]*Radiology, Mayo Clinic, Rochester, Minnesota, United States*

Target Audience: Those interested in improving parallel imaging as applied to dynamic prostate imaging.

Purpose: Dynamic Contrast-Enhanced Magnetic Resonance Imaging (DCE-MRI) of the prostate is a useful tool for aiding in the detection and staging of prostate cancer (1). Relevant to the determination of the kinetic parameters of contrast uptake are the spatial and temporal resolutions, necessarily trading off against one another in MR imaging. Maintaining spatial resolution while increasing temporal resolution can be achieved by employing parallel imaging (2) and view-sharing (3) as has been described previously for the prostate in Ref (4).

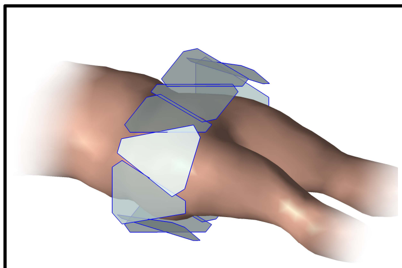

Figure 1: Render of triangle coils as envisioned in application.

The clinical prostate DCE protocol at our institution utilizes 2.5 fold acceleration L/R and 1.5 fold acceleration S/I employing the built-in GEM coil suite (GE Healthcare, Waukesha, Wisconsin). High parallel imaging related noise amplification was seen near the edges of the field-of-view (FOV) in the superior/inferior (S/I) direction, corresponding to regions experiencing aliasing due to S/I acceleration. We postulated that this was due to insufficient coil-to-coil sensitivity differences in that direction for the applied acceleration. The purpose of this work is to design a receiver coil array to support improved parallel imaging in the S/I direction given constraints on the acquisition matrix that the readout direction be anterior/posterior (A/P), slab (S/I), and phase left/right (L/R) to avoid signal ghosting in the prostate from the endorectal receiver coil.

Methods: The receiver coil array was based on triangular elements. Numerical Biot-Savart simulations were performed to estimate the appropriate base:height ratio. This ratio was used with the number of available receive channels and FOV requirements to select a triangular element size of 22.5 × 22.5cm. Four elements were fabricated and employed in an IRB-approved segmented acquisition at 2mm isotropic resolution. Acquisitions such that 10 different receiver positions were available were combined to simulate a linear circumferential array with a human volunteer as represented in Fig. 1. This fully-sampled data was then retrospectively undersampled to various levels of acceleration and reconstructed with SENSE.

Results: The results of the Biot-Savart simulation are shown in Figure 2a, where the sensitivity variation along the S/I direction of two oppositely-oriented receiver coils is shown at a depth comparable to the prostate. Figure 2b shows experimental coil sensitivity profiles vs. S/I position of two triangle coils in the prostate of a volunteer. Figure 3 compares axial images of the prostate at 1.5, 2.0 and 2.5 fold acceleration in the S/I direction.

Discussion: The dissimilarity in signal level of two adjacent triangular coil elements in the simulation is borne out in the experimental studies. Experimental results appear to provide almost a two-fold improvement in speed of acquisition for similar SNR compared to current methods. In the future the receiver array will be completed with up to 16 total elements in order to simultaneously test L/R and S/I acceleration in human volunteers.

Conclusion: Simulation suggests differential receiver coil falloff in the S/I direction, allowing the possibility of improved acceleration in that direction. In-vivo testing of receiver coil falloff confirms simulations. Retrospectively undersampled images reconstructed with SENSE demonstrate acceleration in the S/I direction.

References: 1. Verma S, AJR, 2012;198. 2. Pruessmann KP., MRM 1999;42. 3. Riederer SJ, MRM 1988;8. 4. Saranathan M., JMRI 2012;5.

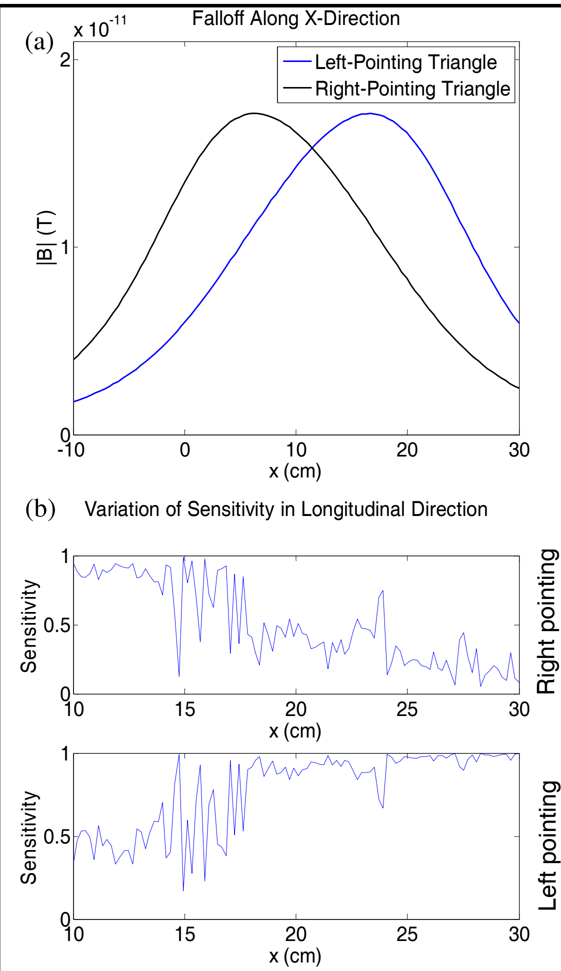

Figure 2: Simulated (a) and experimental (b) line profiles from receiver arrays arranged as in Fig. 1. Note dissimilar signals received, potentially allowing for acceleration to be applied along that direction.

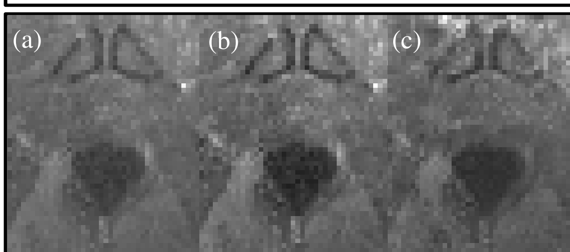

Figure 3: Retrospectively undersampled images with N_C=10 with through-plane acceleration of R=1.5 (a), 2.0 (b), and 2.5 (c).