Highly accelerated 7 T prostate imaging using parallel imaging

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Introduction

Due to stronger signal attenuation and high SAR levels, prostate imaging at 7 Tesla is a challenging procedure. Nevertheless, it has been demonstrated with various surface coil array designs [1,2,3]. For this work we used an array of single-side adapted dipole antennas [1]. The elements of this array have been designed according to a radiative design principle maximizing the power flow towards the prostate resulting in higher B_1^+ efficiency at depth. With this antenna design the SAR levels can be reduced by a factor of 4 compared to conventional coil designs and the B_1^+ field level in the prostate reaches 10 µT using 8 x 1 kW amplifiers. Consequently, good receive performance of this array is expected as well. On top of that, the short wavelength and the distinct sensitivity patterns of the individual elements promise good parallel imaging performance. To quantify this, we characterized the parallel imaging performance of this array for prostate imaging at 7 Tesla.

Materials and methods

For all measurements we used a surface array consisting of 8 transceive elements aligned like a belt around the pelvis (figure 1a). Each element consists of a 7 x 4.2 x 14.3 cm^3 dielectric ceramic substrate. At the distal side of the substrate a copper tape dipole antenna is mounted where the length of the legs of the antenna is tuned to support a standing λ/2 wave. The element is fed through a BalUn and a matching network (figure 1b). A reference image was obtained by travelling wave imaging [4] using a SQL antenna (figure 1c, [5]). Spoiled GRE images (TR/TE = 28/1.5 ms, FA = 45°, 2 x 2 x 10 mm^3, 2D) were obtained using SENSE with a reduction factor varying from 1 to 8. Dynamic noise scans were used to determine the SNR. From these images the SNR in the prostate and the geometry factor distribution were determined for each reduction factor.

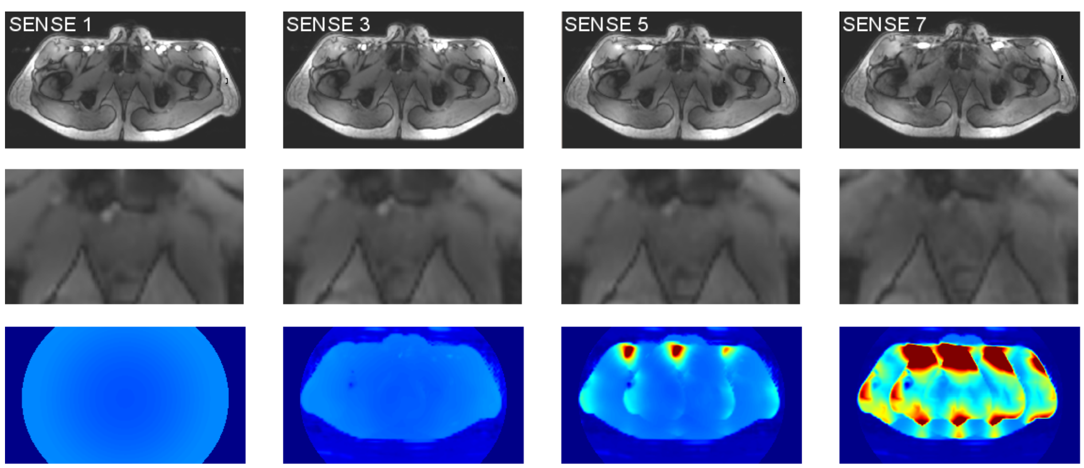
Figure 1: (a) Position of array elements on volunteer. (b) Single coil array element (c) SQL-antenna

Results and discussion

The SNR in the prostate was determined to be 81, 50, 37 and 19 for reduction factors of 1, 3, 5 and 7 respectively. In figure 2, SENSE images are presented with indicated reduction factors. As we expected, the individual elements have very well separated sensitivity profiles which is reflected by good parallel imaging performance up to a reduction factor of 6. g-Factor distributions show that the SNR penalty is limited, particularly in the prostate. Note that although these results were obtained with spoiled gradient echo sequences, the results apply to any sequence. The reduction in scan time can be traded off with various other parameters. For the clinically relevant T2 weighted TSE imaging, the echo train length can be reduced which will drastically reduce the number of SAR expensive refocusing pulses. As 7T prostate imaging comes with considerable SAR challenges, we particularly foresee potential of using the good parallel imaging performance to reduce SAR levels. But the procedure can also be used to reduce the EPI echo train in DWI.

Conclusion

In addition to having good transmit efficiency and low SAR levels, the array of single-side adapted dipole antennas also has very good parallel imaging properties. The sensitivity patterns of the individual elements are well separable allowing large reduction factors of up to 6 for prostate imaging. The high acceleration factor can be exploited to significantly accelerate a 7T prostate exam or can be traded off with other sequence parameters. As such, this will boost the clinical feasibility of 7T prostate imaging.



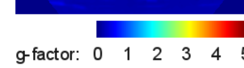


Figure 2: GRE prostate images obtained with indicated SENSE factors. Presented are full FOV images, zoomed prostate images and reconstructed geometry factor maps. These maps indicate that particularly in the prostate the sensitivity profiles of the dipole antennas can be well distinguished.

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