Parallel Imaging of the Prostate at 7T using a B0 Crusher Coil to suppress Aliasing Artifacts

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Introduction: In order to get a high quality image of the prostate, a many element body receive array can be used which can be placed tightly around the patient. In this way, there is minimal signal loss caused by distance to the prostate and parallel imaging can be used to speed up the acquisition. However, a disadvantage of such a body array is the inhomogeneous receive sensitivity. The signal coming from the outer rim of the patient can be magnitudes higher than the signal coming from the prostate. This phenomenon is especially troublesome when a method like sensitivity encoding (SENSE) is used to reconstruct the image. SENSE, which is used to reduce scan time, can cause typical aliasing artifact by the reduced field-of-view. The outer rim of the patient, which has a relative high intensity, will protrude somewhere in the middle of the patient when a SENSE factor 2 or higher is used. To reduce this artifact, a B_0 crusher coil [1] was developed and placed around the patient. In this way, the signal coming from the outer rim of the patient can be crushed and is therefore removed from the region of interest.

Methods: The crusher coil was constructed of a 2mm thick copper wire that was mounted on a flexible housing. This sheet could be placed around the patients waist, which made the copper wire go around the patient in five loops with a spacing of 5cm. The copper wire was mounted in such a way, that through neighboring conductors the current ran in opposite direction. The current through the crusher coil could be increased up to 10A to increase spoiling depth. For safety reasons, insulation tape was used to cover the copper wire. The amount of undesirable heating of the copper wire was tested by measuring the temperature of the wire before and after constant use of 10A. The crusher coil was also simulated to predict the produced magnetic field. With the crusher coil, single slice images were made of the prostate on a 7T MRI scanner. A body array consisting of 8 transmit and 16 receive elements (MR Coils BV, Drunen, The Netherlands) was used and placed on top of the crusher coil. A gradient echo sequence was used with a TR = 50ms, TE = 1.5ms and a voxel size of 1 x 1 x 10mm (RL x AP x HF) with varying SENSE factors (up to 4).

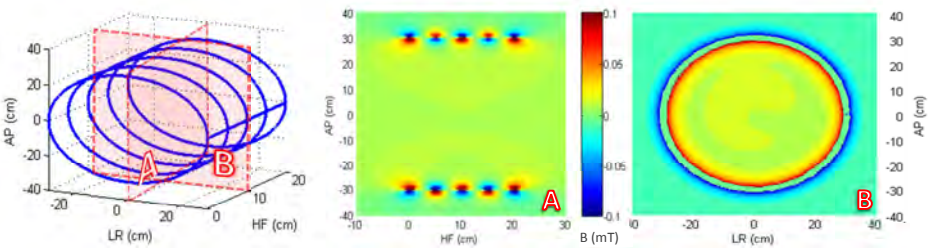

Figure 1. *Simulation of the crusher coil. The figure on the left is a schematic view of the design of the crusher coil. Through each consecutive loop, which are connected by a straight piece of copper wire, the current runs in the opposite direction. The magnetic field it produces was simulated and depicted in figure A (transversal slice through the middle loop) and in figure B (coronal slice).*

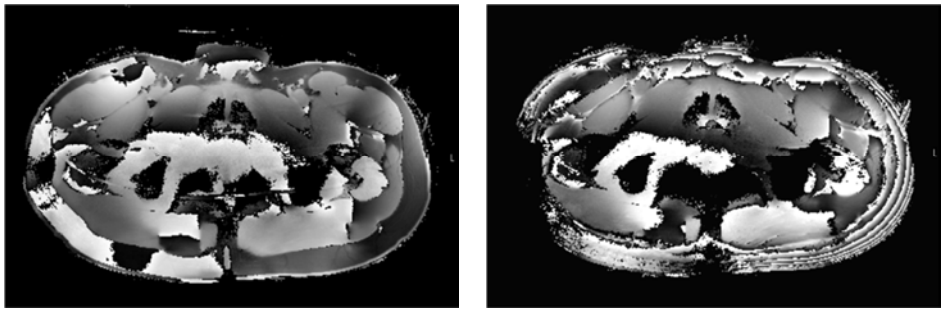

Figure 2. *Two MRI phase images of a transversal slice around the prostate. The one the left is a phase image were SENSE was used, but were the crusher coil was inactive. The one on the right was constructed under the same conditions, but this time a current was applied on the crusher coil. Compared to the image on the left, a strong fluctuating phase can been seen on the rim of the body.*

Results: In figure 1, the outcome of the simulation is shown. A strong fluctuation magnetic field can be seen around the copper wire, which will cause dephasing of the signal. However, the magnetic field in the center of the coil is relative homogeneous, which will keep the signal coming from the prostate unimpaired. Figure 2 shows two phase images of a transversal slice at the level of the prostate. One with and the other without the crusher coil activated. The effect of the fluctuating magnetic field can clearly be seen in the outer rim of the image, causing dephasing and therefore crushing of the signal in that area. The result on the magnitude images is shown in figure 3. Here, the absence of the SENSE artifact can be seen when the crusher coil is activated.

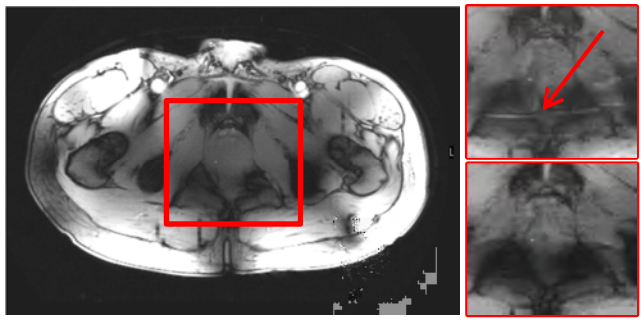

Figure 3. *Three MRI images of the prostate. The image one on the left is constructed using SENSE factor 1. The image on the top right was made under the same conditions, only a factor 4 SENSE was used to reconstruct the image. This holds also for the bottom right image, however this time a current of 1A was applied on the crusher coil. The SENSE artifact, which can been seen in the top right image, is almost gone in the bottom right image.*

Discussion: It has been shown that when using a B_0 crusher coil, SENSE aliasing artifacts can be suppressed while the signal coming from the prostate stays unimpaired. Inner-volume imaging is another method to reach the same goal [2]. This method however demands to alter the RF sequence design severely, whereas this method can be used with every desired sequence.

References: [1] Crowley MG, Ackerman JJH. Enhanced surface-coil spatial localization with an inhomogeneous surface gradient. J Magn Reson 1985;65:522-525. [2] Schneider JT, Kalayciyan R, Haas M, Herrmann SR, Ruhm W, Hennig J, Ullmann P. Inner-volume imaging in vivo using three-dimensional parallel spatially selective excitation. J Magn Reson 2013;5:1367-1378.