HUMAN BRAIN IMAGING AT 9.4 TESLA USING A COMBINATION OF TRAVELING WAVE EXCITATION WITH A 15-CHANNEL RECEIVE-ONLY ARRAY

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Introduction

The combination of a circularly polarized (CP) volume coil for spin excitation with a multi-channel receive-only array is a successful setup for routine human brain imaging at 7 Tesla. For reception, the use of multiple surface coils is important for a high SNR and for the utilization of parallel imaging techniques. For transmission, the main strength of the CP coil is the reasonable B_1^+ homogeneity over a large FOV in unison with simple usage, which is in contrast with more sophisticated static or tailored RF shimming techniques using multichannel transmit coils.
At 9.4 Tesla, however, the even shorter RF wavelength in tissue causes the B_1^+ field to be unacceptably inhomogeneous, especially in the ventral parts of the brain. In addition, the field-of-view of coils that are based on half-lambda resonators further decreases. Therefore, a substitute for the CP coil with a more uniform B_1^+ field pattern over a large FOV is desirable. Traveling wave imaging [1] using a Tx/Rx patch antenna has the potential to provide a more homogeneous spin excitation over larger regions [2, 3], but in turn suffers from poor sensitivity. Therefore, we tested the combination of traveling wave excitation with a 15-channel receive-only array and show initial results utilizing this setup for human brain imaging at 9.4 Tesla.

Materials and Methods

Experiments were performed on a 9.4 Tesla whole-body magnet (Siemens/Magnex) equipped with a head-only gradient insert with an RF shield of 40cm in diameter. Note that the cutoff frequency of this waveguide (439 MHz) is considerably above the system's Larmor frequency. Therefore, it is important to place the transmitting patch antenna close to the subject in order to avoid severe attenuation of the traveling wave.
Fig.1A shows the complete setup: The tunable patch antenna [2] is placed at a distance of approximately 25cm behind the head of the subject. The receive-only array (Fig.1B) consists of 15 mutually decoupled loops which were connected to an assembly comprising 15 preamplifiers; the latter was positioned between the antenna and the receive coil. All elements of the receive array were actively detuned during transmission. Since the receive array can also be used in combination with a circular 16-channel Tx-only array, a dummy shield around the receive coil was used to emulate this environment.

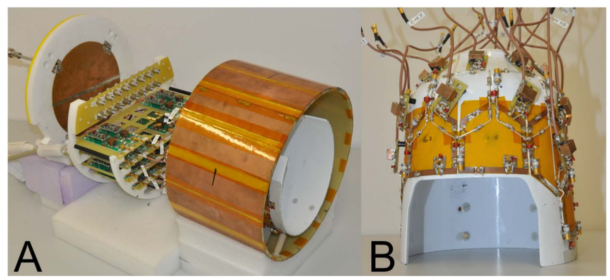

Figure 1: (A) The setup consisting of the patch antenna, an assembly for the preamplifiers and the receive array inside a dummy shield. (B) The receive-only array consists of 24 loops arranged in three rows. However, only the 15 elements in the lower two rows were used for signal reception in this study.

Results

Figs. 2 and 3 show first low flip angle FLASH images obtained with the presented setup: The B_1^+ field produced by the distant antenna is able to cover the whole brain and together with the high SNR provided by the receive array, this coil combination allowed for high-resolution brain imaging over large field-of-views (Fig. 3).
On the other hand, we observed B_1^+ artifacts which were not present when the patch antenna alone was used for imaging. Furthermore, roughly three times the driving voltage was needed to achieve comparable flip angles in relation to a circularly polarized microstrip head array.

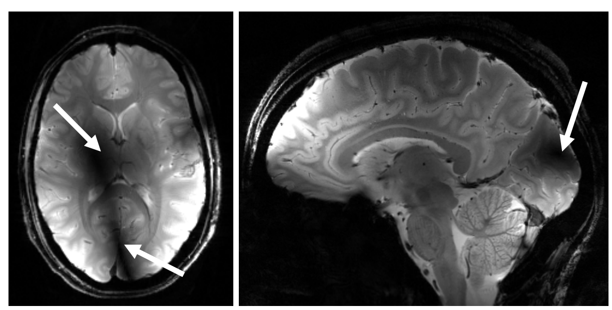

Figure 2: FLASH images demonstrating the coverage as well as B_1^+ artifacts (arrows). TR/TE=400/8ms (axial) and 400/10ms (sagittal).

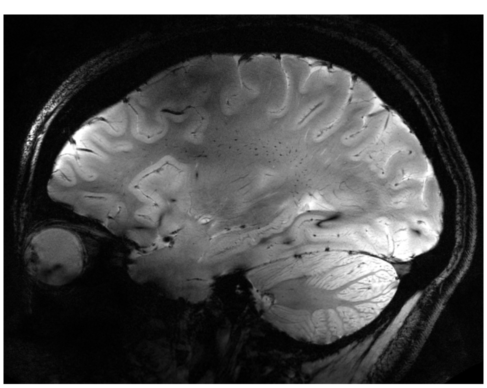

Figure 3: High-resolution sagittal FLASH image covering a brain region which is free from B_1^+ artifacts. (Matrix 624x768, FOV 186x229mm, TR/TE=400/10ms, slice 2mm, 3 averages, R=2)

Discussion

In principle, the patch antenna has the potential to provide a more homogeneous excitation compared to a standard CP volume coil [2], but the presence of some elements of the receive hardware seems to perturb the transmit field propagation. Since this spoils the anticipated advantages of the setup, future work must investigate this aspect.
Assumed that the B_1^+ problem can be resolved, the presented setup provides the benefits of spin excitation over a large field of view combined with high-SNR signal reception and simple usage. The major drawback is still the power inefficiency during transmission, which limits the method to low flip-angle imaging.

References

[1] Brunner et al. Nature 2009, 457:994-999
[2] Hoffmann et al. Proc ISMRM 2010, p.3802
[3] G. Wiggins et al. ISMRM 2009, p.2942