Parallel RF transmission in body MRI for reduced dielectric shading, improved B1 homogeneity and accelerated imaging at 3.0T: Initial clinical experience in 40 patients using MultiTransmit

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Introduction

Electromagnetic wave propagation in tissue is known to cause dielectric resonance effects if the wavelength reaches the object dimension[1]. At 3.0T, dielectric resonance effects are visible in body MR imaging predominantly in heavier patients and in patients with intraabdominal fluid collections (i.e. ascites). The use of multiple transmit channels can provide better control of the radio frequency (RF) field by allowing to send independent RF pulses and therefore yielding more uniform excitation and receive fields[2]. Improved homogeneity and consistency of the images obtained by multi-source transmit RF technology has been previously shown in phantom studies and healthy volunteers[2-5], but has not been evaluated in patients. Our study was carried out to test the clinical usefulness of a parallel RF transmit body MRI system with patient-adaptive RF shimming and parallel transmission as compared to conventional single transmit MRI using standard sequences for routine clinical use in body applications including liver, pelvis, colon and spine imaging in patients at 3.0T.

Methods

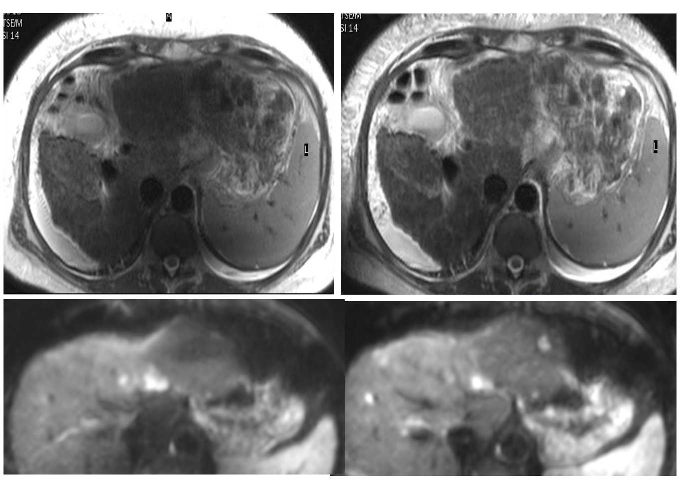
All imaging was performed on a clinical whole-body 3.0T MRI system (Philips Achieva 3.0T TX) equipped with fully flexible multi-source RF transmission (MultiTransmit, mTX). The RF power was distributed to the ports of the system body coil using multiple independent RF transmit channels under full software control. With this design it is possible to independently control phase, amplitude and shape of the RF waveforms. 40 patients (15 male, 25 female; mean age: 47 years [range: 22-99 years]) were referred for routine body MRI of the following anatomies: liver/abdomen/colon, n=20; pelvis, n=9; spine, n=11. 36 patients first underwent conventional MR imaging using the standard sequences for routine clinical use. In 4 patients (spine) only MultiTransmit MRI was obtained. MR imaging was repeated with parallel transmission in the 36 patients depending on the anatomy and clinical indication. For intraindividual comparison, axial T2w TSE w/ and w/o fat saturation (fs) and axial diffusion-weighted imaging (liver/abdomen), coronal T2w TSE (colon), axial high spatial resolution T2w TSE (pelvis) and sagittal T1w, T2w w/ and w/o fs were obtained using conventional (convT) and parallel transmission. Due to better control of the local energy deposition (SAR) shorter repetitions times could be implemented with MultiTransmit, thus accelerating the image acquisition. Two radiologists evaluated the resulting images of conventional and MultiTransmit MRI with respect to image homogeneity, presence of local signal loss (dielectric shading), overall diagnostic image quality, lesion conspicuity and examination time.

Results

MultiTransmit imaging was successfully completed in 40/40 patients (100%). Intrainidividual comparison of image homogeneity revealed better results for mTX as compared to convT in liver/abdomen and colon. Local signal loss due to dielectric shading was markedly reduced by mTX as compared to convT especially in the 8 patients with ascites (Fig. 1). Lesion conspicuity was rated to be superior with mTX as compared to convT in the left liver lobe but not in the right liver lobe. Mean acquisition time for mTX of the spine was accelerated by 30% as compared convT while overall diagnostic image quality did not differ between the two. In the MR colonography study the saving in time with mTX was used to turn the respiratory triggered coronal T2w sequence into a single breath hold of 15 sec duration. In MRI of the pelvis with high spatial resolution ($0.45 \times 0.46 \times 4 mm^3$) the acceleration with mTX enabled a shorter acquisition time with an identical parameter setup (5:00 versus 8:27 min.).

Conclusion

Parallel RF transmission in body MRI allowed for reduced dielectric shading, improved B_1 homogeneity and accelerated imaging in patients at 3.0T. To our knowledge these are the first results using parallel RF transmission in a routine clinical setup. Parallel RF transmission significantly improves the performance of clinical body MRI at 3.0T by addressing the challenges of high-field imaging at the origin. Our initial results are very promising for future high-field and ultra-high-field developments.



Conventional MultiTransmit

Fig. 1: Intraindividual comparison of axial T2wTSE (top) and axial DWI (bottom) acquired with convT (left) and mTX (right). Please note the standing wave artifacts in convT and the improved homogeneity with mTX

References

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