3D T2-weighted Turbo Spin-Echo Body Imaging at 3T using a Multi-Channel Parallel RF Transmission Technology: Initial experience

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Introduction

Over the past years, several studies have shown the potential of 3D turbo spin echo sequences (TSE) with variable refocusing flip angles[(1)] for 3T body imaging[(4-7)]. This new technique allows the use of very long spin-echo trains, while keeping blurring and SAR under control, thereby allowing for good image quality within clinically acceptable scan times. However, very recent studies[(6,7)] also reported an increased sensitivity to B1 inhomogeneities (i.e. dielectric effects) compared to standard multi-slice TSE sequences with constant refocusing angles, leading to substantial image degradation at 3T. Multi-channel parallel RF Transmission (MTX) has demonstrated that it is possible to improve B1 homogeneity and flip angle accuracy inside the body at high field[(2,3)]. This paper aims to demonstrate the benefit of MTX for improving image quality of a 3D TSE sequence with variable flip angles (VFA) in 3T body imaging. We report our initial experience on male pelvis (including prostate) and abdomen.

Materials and Methods

Experiments were carried out on 3 volunteers using a 3T Achieva TX MR system (Philips Healthcare) equipped with a 16-channel SENSE-compatible torso coil and a multi-channel parallel RF transmission (MTX) technology. For the prostate experiment, 3D TSE-VFA was performed in the sagittal plane using the following parameters: TR=1500ms, TE=211ms yielding an equivalent TE (TEequiv) of 90ms, variable refocusing flip angles (FA) with FAmin=25° and FAmax=110°, TSE factor=145, FOV=250x250mm and 200 slices, acquired pixel size=1x1x1.5mm, reconstructed to 0.75mm in the slice direction, SENSE factor 1.4 and NSA=2 for a total scan time of 5:01min. The abdominal scan was performed in the transverse orientation using the following parameters: TR=1600ms, TE=213ms and TEequiv=90ms, FA variable from 19° to 110°, TSE factor=155, FOV=375x300mm and 117 slices, acquired pixel size 1x1x2.5 reconstructed to 1.25mm in the slice direction, halfscan=0.9, SENSE 2(AP)x1.5(FH) with 2 NSAs and respiratory navigation leading to a total nominal scan time of 5:06min. This sequence was also performed with fat suppression.

In both applications a DRIVE pulse was used to restore transverse magnetisation at the end of the TSE train. Also for both applications, 3D TSE-VFA was repeated on the same volunteer with and without MTX. In non-MTX mode, the integrated transmit body coil was used in its standard quadrature settings. In MTX mode, the 2 channel transmit coil was driven by 2 independent RF amplifiers allowing for independent adjustment of the amplitude and phase of the RF excitation pulse applied on each port. RF amplitude and phase optimization was performed during a short preparation phase at the beginning of the examination.

Results

Figure 1 and 2 show 3D TSE-VFA images obtained for the different volunteers on, respectively, the pelvis and abdomen. In Figure 1, image windowing was adjusted such that hyperintense structures in the prostate look visually identical. The non-MTX sagittal image (a) shows substantial signal shading in the anterior part of the pelvis (red arrow). The corresponding MTX image shows improved image homogeneity. Furthermore, both sagittal and transverse MTX images (c, d) demonstrate improved overall contrast uniformity over the full FOV as compared their non-MTX counterparts (respectively a and b). In Figure 2, image a) obtained without MTX shows dramatic signal shading in the anterior and posterior parts of the abdomen associated with poor tissue contrast in these areas. The corresponding MTX image (b) demonstrates improved image and contrast uniformity as well as visual improvement in tissue contrast, e.g. fat/muscle and fat/spleen interfaces. The fat suppressed 3D TSE-VFA MTX image c) demonstrates the good signal and contrast homogeneity also obtained in the Feet-Head direction over a large FOV when MTX is used.

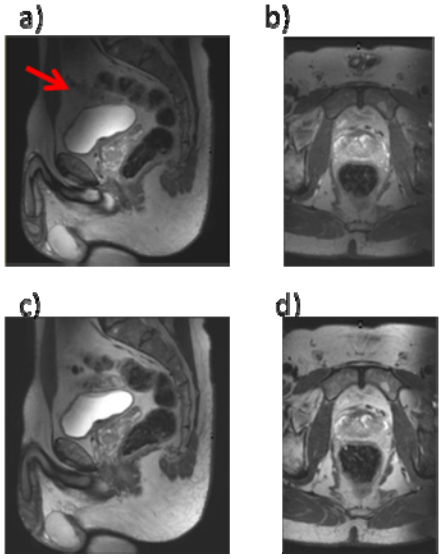

Figure 1: 3D TSE-VFA images of a male pelvis without MTX (upper row) and with MTX (lower row). Sagittal source images (a,c) and transverse reformats (b, d). Note the substantial signal shading on the sagittal non-MTX image (a, red arrow) and overall improvement in signal and contrast uniformity on MTX images.

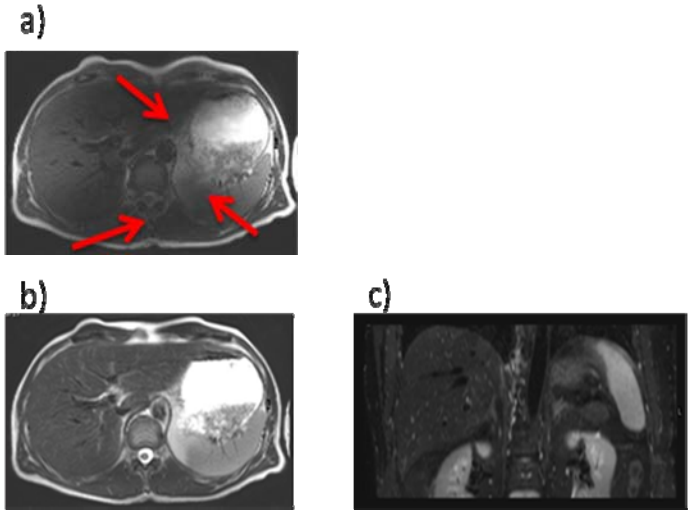

Figure 2: 3D TSE-VFA abdominal images obtained without (a) and with MTX (b and c): source transverse image (b) and fat suppressed coronal reformat obtained on a different volunteer (c). Note the dramatic signal shading and decreased tissue contrast on the non-MTX image (red arrows). Using MTX improved signal and contrast uniformity is demonstrated over a large FOV both in the transverse and coronal planes

Conclusions

These initial results show that the multi-channel parallel RF transmission (MTX) technology is beneficial for the application of 3D T2w turbo spin-echo sequences with variable flip angle to 3T body imaging. Signal and contrast uniformity improvement was demonstrated to be dramatic in the abdomen and substantial in the male pelvis when looking at the overall FOV. More clinical data would be needed to demonstrate the additional clinical value of the 3D-VFA+MTX combination as compared to the standard approach using a single channel technology. However, given the amount of image quality improvement we expect this approach to be relevant in clinical practice for abdominal imaging as well as pelvis imaging (male and female), especially when large FOVs are to be imaged.

References 1. R.F Busse et al., MRM., 55:1030-1037 (2006). 2. I. Graesslin et al., Proc. ISMRM, 126 (2006). 3. Y. Zhu et al., Proc. ISMRM, 13:2752 (2005). 4. C.M. Haystead et al., Radiology, 246(2):589-595 (2008). 5. S. Arizono et al., JMRI, 28:685-690 (2008). 6. A. B. Rosenkrantz et al., Proc. ISMRM, 17:4016 (2009). 7. E. Hecht et al., Proc. ISMRM, 17:2087 (2009).