Large FOV ZTE imaging in abdomen on a standard clinical scanner

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Target audience MR pulse sequence programmers and researchers interested in abdominal imaging

Purpose: Zero echo time (ZTE)[1-3] imaging recently gained a lot of interest mainly because MRI data can be acquired with acoustic noise levels similar to a CT scanner. The ZTE sequence itself is rather simple: an RF pulse, an acquisition trajectory and a slowly varying readout gradient which is also active during excitation. In practice some challenges need to be overcome which are related to the gradient being active during excitation and the non-zero switch delay between RF transmit and signal sampling causing missing k-space data around k_x,k_y,k_z=0,0,0. Another challenge is to obtain classic MRI contrasts like T_1- and T_2-weighting. So far many ZTE results were obtained in small FOV anatomies like head and knee and with modified hardware to obtain faster switch rates. This work investigates the potential of ZTE for large FOV abdominal imaging using the different available prepulses to modify the contrast on a standard 1.5T scanner.

Methods: All data was acquired with a 3D radial kooshball readout[4] using a 12.8 µs RF excitation pulse. The finite pulse duration, switch time and filter delays resulted in a 60 µs echo time. By restricting the readout gradient to 3 mT/ms, the excited FOV was 613 mm and the gap in k-space 9 samples. To sample the central part of k-space, a second interleave was performed at a factor 5 lower gradient strength as depicted in figure 1.

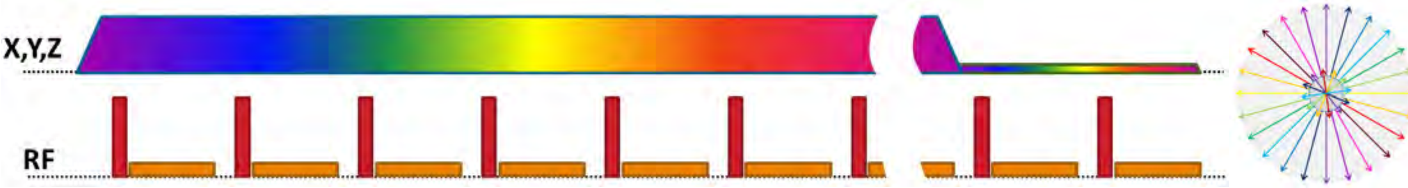

Figure 1. ZTE pulse sequence with k-space trajectory.

The FOV of the scans was 530 × 530 × 530 mm³ with a voxel size of 3 × 3 × 3 mm³, flip angle 3 degrees, TE/TR=0.060/1.9 ms with a radial density of 50%. Contrast manipulation and motion correction was obtained by segmenting the acquisition in shots of 200-300 ms and using the respiratory belt to trigger each shot. Total scan time was, dependent on the breathing characteristics, between 7 and 9 minutes. Each shot consisted of one or more prepulses followed by a ZTE-readout. For fat suppression we have tried both the chemical shift selective pre-saturation (SPIR) and the chemical shift selective adiabatic inversion (SPAIR) methods. The adiabatic inversion pulse was used for T_1-weighting and the T_2-prep pulse with 50 ms echo time for T_2-weighting. All scans were obtained on healthy volunteers using standard 1.5T clinical scanners (Philips Ingenia and Philips Ingenia CX) and the regular anterior and posterior coil.

Results: Figure 2 shows from left to right SPIR-ZTE, SPAIR-ZTE, T_2-prep-ZTE and a thin slab maximum intensity projection of a T_2-prep-ZTE combined with SPAIR fat suppression. These images demonstrate that adequate T_1 and T_2 contrasts can be achieved. Respiratory triggering sufficiently mitigates effects of respiratory motion. The favorable lack of flow sensitivity of the 3D radial ZTE sequence leads to negligible effects of blood flow on the images.

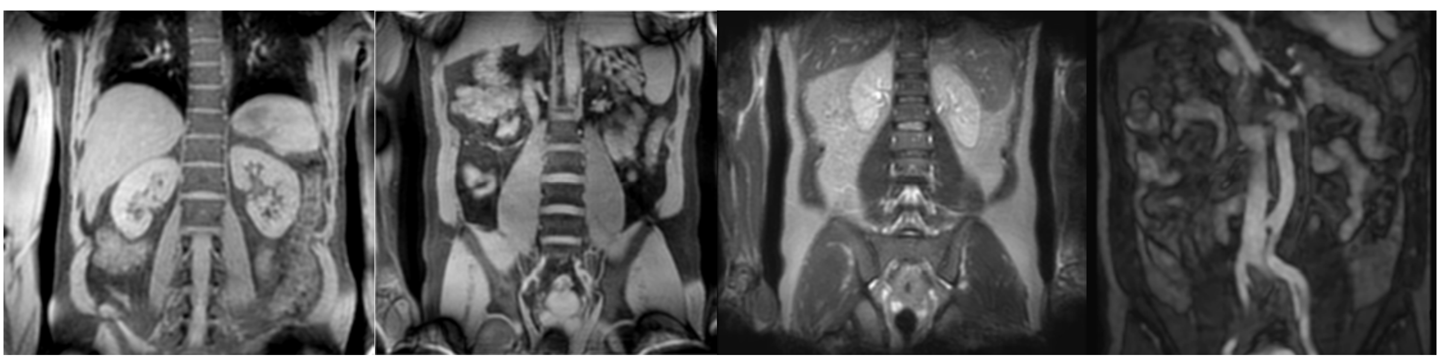
Figure 2. From left to right: SPIR-ZTE, SPAIR-ZTE, T_2-prep-ZTE and SPAIR-T2-prep ZTE with maximum intensity projection.

Discussion: ZTE can be combined with T_2-prep and inversion pulses to improve contrast. Fat suppression can be combined with these prepulses and is needed to avoid blurring. The limitation of a moderate transmit-receive switching delay was overcome by a straight forward sequence adaptation to acquire data near the k-space center. Due to the low gradient strength, some blurring can be seen in the images. Increasing the readout gradient strength is desirable. However, the limited bandwidth of the current RF excitation pulse would cause signal drop-off and increased background signal artifacts. This can be solved by increasing the excitation bandwidth[5].

Conclusion: We have shown that ZTE imaging with a large FOV and different contrast on a standard clinical scanner is feasible.

References: **1.** Wu Y *et al* MRM 2007, 57: 554-67; **2.** Grodzki D *et al* MRM 2012, 67:510-18; **3.** Weiger M *et al* MRM 2013, 70: 328-32; **4.** Wong S *et al* MRM 1994 32:778-84; **5.** Schieban K *et al* MRM 2014