

Scantime optimized 3D radial Ultra-short Echo Time imaging for breathhold examinations

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Target Audience – Researchers interested in 3D radial UTE methods; Clinicians interested in 3D UTE breath hold exams.

Purpose – Spoiled gradient echo UTE acquisitions typically use shortest possible TRs and require therefore efficient spoiling. The combination of RF spoiling and gradient spoiling, as commonly used in Cartesian sampling, requires the same constant spoiling moment within every single TR to deliver predictable results¹. With direction dependent radial spokes this requires center-out-in trajectories to reset the direction dependent readout gradient moment and subsequent large constant direction spoiler gradients. While the center-out-in trajectory allows for the acquisition of a second echo, the minimal TR is extended by both the center-in part of the trajectory and the

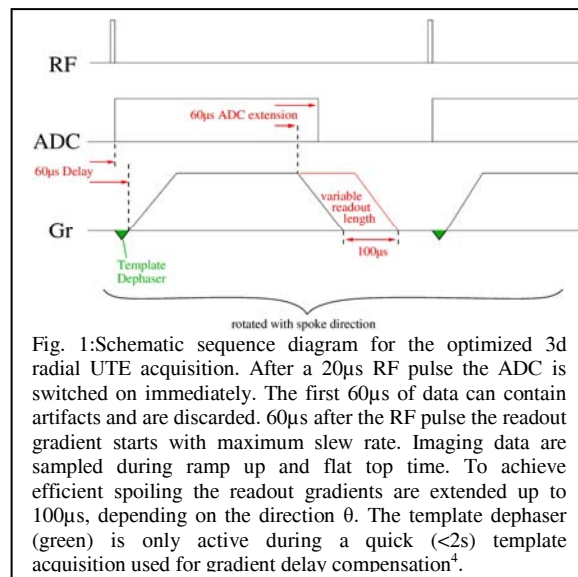


Fig. 1: Schematic sequence diagram for the optimized 3d radial UTE acquisition. After a 20µs RF pulse the ADC is switched on immediately. The first 60µs of data can contain artifacts and are discarded. 60µs after the RF pulse the readout gradient starts with maximum slew rate. Imaging data are sampled during ramp up and flat top time. To achieve efficient spoiling the readout gradients are extended up to 100µs, depending on the direction θ . The template dephaser (green) is only active during a quick (<2s) template acquisition used for gradient delay compensation⁴.

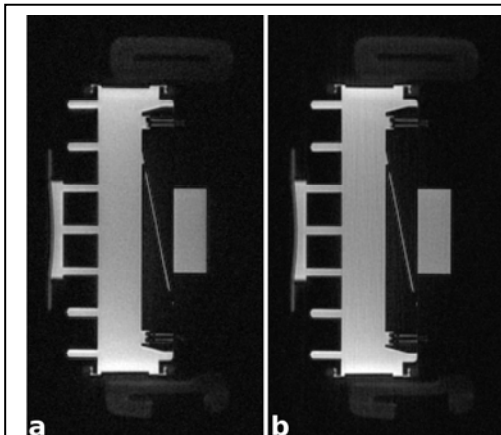


Fig. 2: Phantom images acquired with the optimized spoiling (a) and constant z-spoiling (b). Scan parameter were FoV=220mm, matrix 256, TE=60µs, dwelltime 2.1µs. Repetition time was TR=1.1ms for the optimized sequence (a) and 1.8ms for (b). In (b) residual striping artifacts are clearly visible which are completely suppressed in (a).

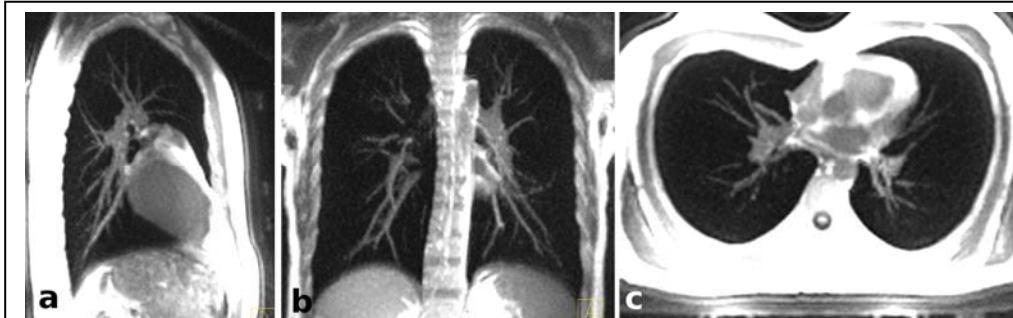


Fig. 3: UTE lung images in three planes reconstructed from a single 3D data set. To improve the vessel visualization maximum intensity projection over 2cm are presented. The scan parameters were FoV=300mm, matrix 160, dwelltime 1.5µs, TR=0.9ms, TE=60µs. 31,058 radial readouts were acquired, corresponding to 39% of full Nyquist sampling, within a total acquisition time of 29s.

Discussion & Conclusion – The aim was to provide a TR optimized 3D radial UTE sequence which simultaneously reduces artifacts from insufficient spoiling. This was accomplished by using only center-out trajectories where the readouts in their current direction are efficiently extended to provide spoiling. Direction dependent variations of the extension distributes the magnetization in all directions, suppressing unwanted refocused magnetization. Compared to a sequence using a standard constant z-spoiler (Fig 2b) the artifacts are clearly reduced (Fig 2a) while both the signal of water and short T2 components like rubber gaskets and fixation cushions are nearly identical. The successful suppression of stripe artifacts remains the same for different scan parameters and different subjects as varied as phantoms and *in vivo* knee, ankle or head images as well as mouse and rat imaging. One example for the *in vivo* image quality of single breath hold lung imaging is presented in Fig 3. Here the time optimized sequence permits a very short TR of 0.9ms, which is essential to acquire the necessary number of readouts for artifact free image reconstruction. The presented sequence seems to be the limit of acquisition based speed up, but 3d radial acquisition provides a high potential for further acceleration using compressed sensing or other new non-linear reconstruction methods.

References [1] Scheffler K. Concepts Magn Reson, (1999) 11(5):291-304. [2] Crawley AP, Wood ML and Henkelman RM. MRM (1988) 8:248-260. [3] Herrmann KH, Krämer M, Reichenbach JR. Proc. ISMRM 2013 #3239. [4] Krämer M, Herrmann KH, Reichenbach JR. Proc. ISMRM 2013 #3785. [5] Zwart NR, Johnson KO, Pipe JG. MRM 2012: 67:701-710.