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**PRESENTATION TITLE**

Hybrid UTE/Dixon Acquisition for synthetic CT generation

**AUTHOR(S)**

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**ABSTRACT**

**Purpose:** Synthetic CT is an integral part of an MRI-only workflow for radiotherapy treatment planning on hybrid MRI-Linacs. Complex anatomy might require information on lung and bone density in addition to fat-water segmentation. The proposed k-space trajectory combines a 3D radial *Koosh ball* sampling for ultra-short echo time (UTE) imaging with a *stack-of-stars* acquisition for Dixon imaging and was optimized with the goal of minimizing slew rate demands to the MRI gradient hardware.

![Figure 1a: MRI gradient scheme corresponding to light red k-space trajectory in b,c. b: polar view (ϕ=0 equals kₓ=0) and c: side view (stack-position kₓ) of first seven TR d: self-gating signal from k=0.](image)

Figure 1a: MRI gradient scheme corresponding to light red k-space trajectory in b,c. b: polar view (ϕ=0 equals kₓ=0) and c: side view (stack-position kₓ) of first seven TR d: self-gating signal from k=0.
**Materials & Methods:** The k-space trajectory was calculated in MATLAB 2017b (The MathWorks, Inc., Natick, US) for an isotropic resolution of 1.25 mm and a coronal field-of-view of 400x400x320 mm³. A sample TR is shown in Fig.1a. Readout started at $\text{TE}_{\text{UTE}}=80 \mu s$ following a hard pulse with a density-adapted [1] 3D radial projection. Sampling of polar angle $\phi$ (Fig.1b) and its endpoint coordinate $k_z$ (Fig.1c) was governed by 2D golden means [2], with $\Delta \phi=5^\circ$ increments for opposed- and in-phase echo (both acquired at stack position $k_z$). Asymmetry of the opposed-phase echo ($\text{TE}_{\text{opp}}=2.38 \text{ ms}$) depended on $k_z$, while the in-phase echo ($\text{TE}_{\text{inp}}=4.76 \text{ ms}$) was acquired symmetrically. The sequence was implemented on a 1.5 T Siemens Aera scanner and 50000 radial projections with TR=7ms were acquired in free breathing (total scan time ≈6 min) in a consenting 70 year old male patient diagnosed with stage 4 lung cancer. A self-gating signal (Fig. 1d) was obtained by PCA of magnitude and phase of the k-space center signal with a temporal resolution of 98 ms (14x TR). A NUFFT-based image reconstruction was performed using the Michigan Image Reconstruction Toolbox [3].

**Results:**

![UTE, opposed-phase, in-phase images](image-url)

**Figure 2:** UTE (left), opposed-phase (middle) and in-phase (right) images reconstructed at 1.25 mm isotropic resolution acquired in free breathing in a lung cancer patient. Lung parenchyma is well visualized in the UTE image. Apart from minor streaking in the in-phase image, no artifacts are present.

**Conclusions:**

Combined UTE and Dixon MRI with high spatial resolution from only one MRI acquisition is feasible in free breathing in the thorax, which has previously only been demonstrated in the head [4]. Once techniques for reduction of streaking artifacts (particularly at $\text{TE}_{\text{inp}}$) are implemented, the imaging data, which provides information on lung density, water and fat, can be used for synthetic CT generation. Gradient encoding specifications were chosen such that the trajectory could be run on virtually every available 1.5 T MRI system on the market, particularly with high-field hybrid MRI-Linacs in mind. SNR at $\text{TE}_{\text{opp}}$ was low, but could be increased by a joint image reconstruction. Robust self-gating—potentially enabling 4D synthetic CT—is feasible.

**References:**