Hybrid Acquisition for Water and Adipose tissue Imaging (HAWAII)

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Purpose: To facilitate an MRI-only workflow for lung radiotherapy treatment planning on MRI-Linacs a hybrid trajectory is proposed, which combines a 3D radial *Koosh ball* sampling for ultra-short echo time (UTE) imaging with a *stack-of-stars* acquisition for motion-robust Dixon imaging.

Methods: The k-space trajectory was designed in MATLAB 2017b (The MathWorks, Inc., Natick, US) for an isotropic resolution of 1.25 mm and a coronal field-of-view of 400x400x320 mm^3 and is displayed for the first 7 of 50000 TR (Fig.1). A *hard pulse* was followed by a density-adapted 3D radial readout [1] and a 2-point Dixon *stack-of-stars* readout. Angular increments $\Delta\phi$=5° were employed (similar to [2]). Sequence implementation at 1.5 T (MAGNETOM Aera; Siemens Healthcare, Erlangen, Germany) respected typical slew rates and gradient strengths for hybrid MR-Linacs [3]. Sampling of polar angle ϕ and endpoint k_z of the 3D radial projection followed 2D golden means [4]; asymmetry of the opposed-phase echo depended on k_z, while the in-phase echo was fully sampled (TE=0.08/2.38/4.76 ms, TR=7 ms). Self-calibrating GRAPPA operator gridding [5] was followed by an iterative reconstruction based on the Dixon-RAVE framework [2].

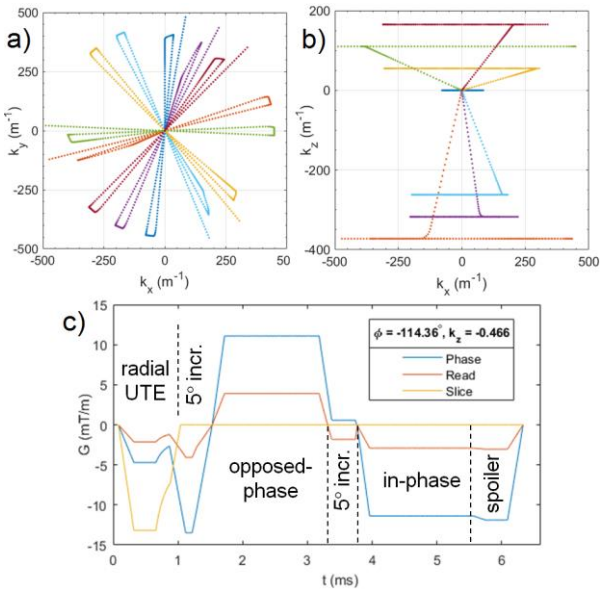

Figure 1: a, b) k-space trajectory for first 7 TR c) gradient timing for light-red trajectory in a, b

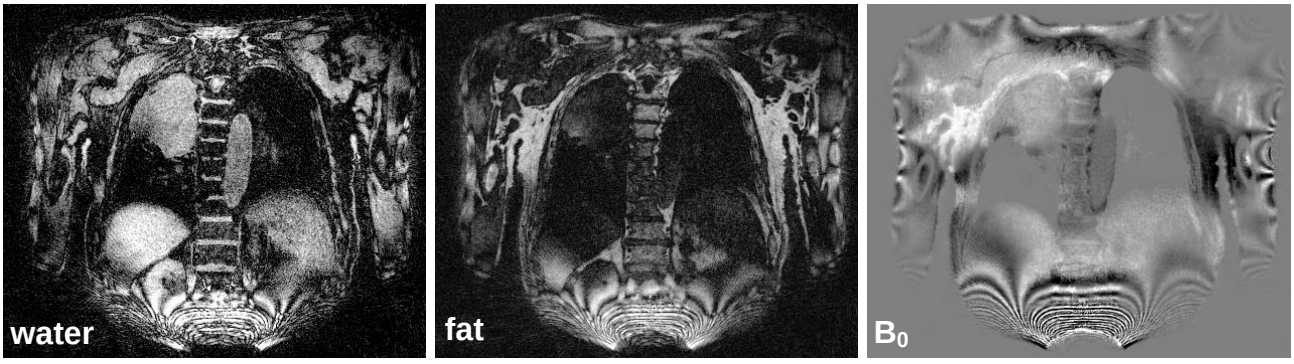

Figure 2: water and fat image and field map in a 70 year old male patient with stage 4 lung cancer.

Results & Conclusions: The presented hybrid UTE-Dixon sequence enables fat-water separation in free breathing in the thorax with 1.25 mm isotropic resolution. It was designed for use on MR-Linacs, where it could provide the ingredients required for synthetic lung CT [6] to facilitate radiotherapy treatment planning (RTP) on daily anatomy. Adding UTE imaging provides lung density information, otherwise not accessible on MRI. Initial results suggest that a field map, associated with geometric fidelity—highly relevant for RTP—could be obtained simultaneously, where stronger regularization might prevent migration of anatomical features (Fig.2). Respiratory self-gating (Fig.3) highlights potential of the HAWAII sequence to enable 4D synthetic CT.

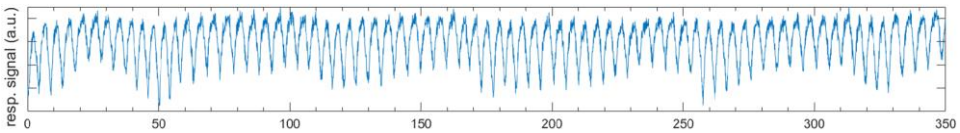

Figure 3: self-gating based on k-space centre obtained by PCA

References:

[1] Nagel AM *et al.* Magn Reson Med 2009;62:1565
[2] Benkert T et al. Magn Reson Med 2017;78:565
[3] Bruijnen T *et al.* Proc 26th ISMRM 2018; p. 1764
[4] Chan RW et al. Magn Reson Med 2009;61:354
[5] Benkert T *et al.* Magn Reson Med 2018;80:286
[6] Freedman J et al. ESTRO 37 2018; PO-0959