Simultaneous T2 Prep and Motion Tracking Using Volume Projections

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TARGET AUDIENCE – Researchers who desire T2 weighting in cardiovascular and abdominal imaging and need to deal with motion.

PURPOSE: We test the feasibility of performing motion tracking during T2 preparation ("T2 prep") for the purpose of scan time reduction. As the standard magnetization-preparation scheme for obtaining T2-weighted contrast, T2 Prep [1] has been widely used in T2-weighted imaging and T2 mapping of coronary vessels [2,3], the myocardium [4], and the abdomen [5] – all of which present significant respiratory motion. When data acquisition time exceeds the limit of patient breath-hold, motion tracking is required to detect respiratory motion in order to gate or correct data accordingly. Typically motion tracking is implemented separately from T2 prep in the form of a 2D-selective "pencil beam" navigator that costs tens of milliseconds [6, 2]. While such time cost is not prohibitive, we explore the possibility of eliminating it altogether by inserting motion tracking into the typical T2 prep pulse train.

METHODS: Sequence – a balanced and fully refocused readout gradient is inserted into the classic nonselective T2 prep pulse train such that its temporal midpoint coincides with that of the innermost pair of refocusing pulses (Figure 1). AT 1.5T, T2 prep typically used one pair or more pairs of MLEV-weighted [7] composite 180° pulses ($90°_x - 180°_y - 90°_x$) for refocusing. The single-axis readout provides the 1D projection of the entire active volume along that axis. The readout gradient is implemented using HOT (hardware optimized trapezoid) gradient waveform design [8] for fastest transitions, as was the rest of the sequence. Immediately following T2 prep, a k-space segment of imaging data is acquired with balanced steady-state free precession (bSSFP) or spoiled gradient echo (SPGR). T2 prep and imaging acquisition interleave continuously to visualize motion in the present study, although this may not be amenable to the desired contrasts in patient scans. Scans are performed on the Siemens 1.5T Espree system (Siemens Medical Solutions, Erlangen, Germany). **Phantom study** – A phantom with agar gels of varying T1/T2s was adapted to move periodically (Figures 2, 4). Displacement was controlled manually using a pneumatic pump to mimic respiratory motion during imaging. The 2D bSSFP Imaging data was acquired at 300x300x5mm, with TR=3.2ms, matrix size 256x256.

RESULTS: Figure 3 shows Projection along axis slice direction (z-axis for this prescription). Note that the motion of the phantom can be estimated using standard motion detection techniques.

CONCLUSION: T2 prep generates coherent magnetization while creating T2 contrast. During this time, it is possible to detect underlying motion, as shown by this preliminary phantom study. This type of acquisition should be adaptable to both abdominal imaging and cardiovascular imaging, as both applications heavily rely on T2 contrast during diagnostic imaging and suffer from motion artifacts.

REFERENCES: [1] Brittain MRM33:689(1995). [2] Botnar Circulation 99:3139(1999). [3] Shea JMRI 15:597(2002). [4] Giri JCMR 11:56(2009). [5] Hoad MRM 63:356(2010). [6] Liu MRM 30:507(1993). [7] Levitt JMR 47:328(1982). [8] Derbyshire MRM 64:1814 (2010).

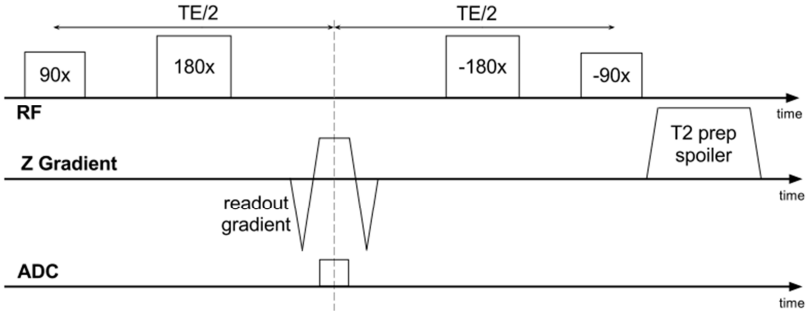

Figure 1. Pulse sequence diagram of a 2-MLEV T2 prep with a fully balanced readout gradient along the z-axis inserted at the midpoint. The readout gradient need not to be on z-axis only. Also note that its duration and those of the RF pulses are exaggerated for illustration purposes.

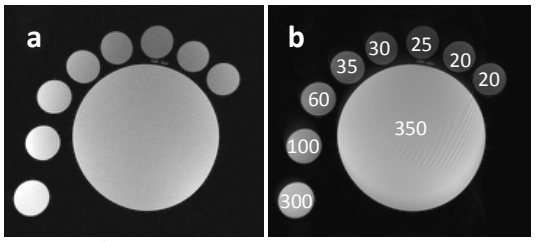

Figure 2. a) Phantom imaged while stationary using bSSFP without T2 prep, and b) with T2 prep of TE=20ms. T2 values as measured by another standard T2 mapping sequence are labeled.

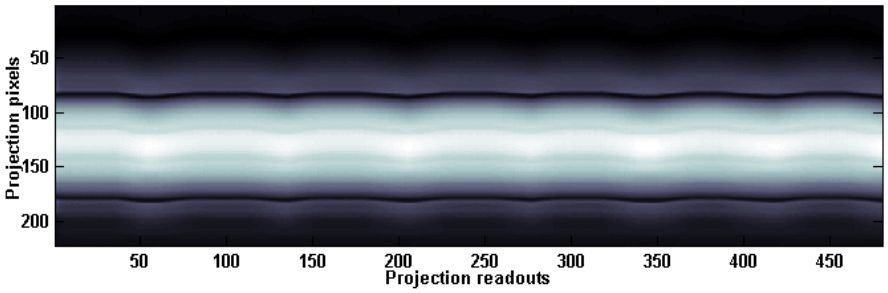

Figure 3. Time course of the inserted projection along the y-axis, showing projections from 480 T2 preps over the course of 1.5 minute.

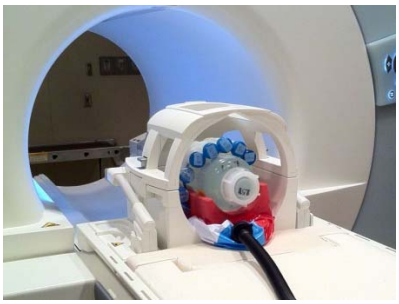

Figure 4. The T2 phantom displaced pneumatically during imaging to mimic respiratory motion