Clinical prostate T1 quantification using a magnetization-prepared spiral technique


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Introduction: Current efforts in T1 quantification are motivated by a need to quantify exogenous contrast concentration dynamics from signal time-courses, plus characterization of partial oxygen pressures and hemorrhagic pathology (1,2). This research describes the optimization of a magnetization-prepared spiral imaging for clinical T1 quantification of the prostate gland. Termed T1prep, the method provides time-efficient multi-slice coverage of the entire gland without compromising robustness, as demonstrated via in vitro quality testing and pilot clinical studies.

Methods: A magnetization-prepared vascular oximetry technique, termed T2prep (2), was adapted for T1-prepared acquisitions using a non-selective adiabatic inversion followed by a delay of duration TI. Slice selection and spatial encoding are performed using a spectral-spatial pulse and spiral imaging gradient. Multi-slice imaging is performed by repetitive slice selection and spatial encoding at frequent intervals (~ every 20ms in different slices). A second delay of value TI trails a final spoiler gradient. After the TI delay, a BIR-4 adiabatic half-passage pulse is applied to null the residual longitudinal and transverse magnetization. By preserving a constant summation of TI+TI' across variable TI, the period of longitudinal recovery is kept independent of TI selection for any TR. Also intrinsic to T1prep is RF cycling to reduce data sampling to 2 TI only. Simply, the inversion pulse is applied on every other sequence iteration only and the difference signal is extracted. The difference signal is the decaying component of T1 relaxation (3) and T1 regression is reduced to the robust linear fitting of a logarithmically-transformed monoexponential decaying signal with TI values of 14 and 1014ms. It is unnecessary to increase TI values by increments of the imaging interval duration (~20ms) for adjacent slices because the slope of a linear fit depends only on the TI separation rather than on the absolute TI values. Multi-slice T1prep reproducibility testing used a 750ml MnCl2-doped water volume within a standard head coil (1.5T GE Sigma). T1prep acquisitions (TI = 13, 1013ms, 1.1x1.6x6mm voxels) were then repeated at RF amplifier mis-tunings between ±20%. T1prep accuracy was tested using 7 serial dilutions of Gd-DPTA in 2cc eppendorf tubes within a doped water bath (T1 between 400 and 2200ms). T1prep (TI of 14, 414, 814, 1214, 1614, 2014ms) was compared to gold standard inversion-recovery spin-echo acquisitions (TI of 50, 400, 800, 1200, 1600, 2000, 4000ms). Clinical pilot studies involved 15 patients with low and intermediate risk localized prostate cancer and no prior treatment history. The MRI examination was performed on a 1.5T GE Signa with patients positioned supine and a torso-phased array, including full gland coverage using (TI=1014ms), and T1prep map (windowed between 800 and 1600ms). An arrow demarcates the location of a small peripheral-zone tumor.