MR Methods Description

WCC #55 - Feasibility of Novel Bone Biomarkers to Assess Effects of Chemotherapy, Radiation, and Surgical Menopause on Bone Health

Overview

The purpose of these measurements is to calculate the fat fraction of bone marrow in the pelvic region. The primary acquisition is a multipoint Dixon MRI scan, acquired using 3D GRE with 6 TE values, and reconstructed using the IDEAL method, with corrections for multi-component fat resonances and T2* of both water and fat. Single voxel MR spectra, also using an array of TE values to correct for T2, will be acquired in the marrow of the L4 vertebral body to validate the Dixon acquisition and reconstruction. The acquisitions and reconstructions are based on methods previously developed for a different 3T protocol (3184, PI Downs) but with additional TE values to enable T2* and multispectral lipid model, as recently demonstrated for liver water:fat quantification (1,2). As time permits, quantitative T2 maps and apparent diffusion coefficient (ADC) maps will also be acquired as exploratory measures of bone marrow health.

General Procedure

Patients will be scheduled for a 1-hour scanning session, and asked to arrive 30 minutes in advance for prescreening and to change into MR-compatible clothing. The patient will then be led to the 3T Trio scan room and positioned on the table supine and foot-first. The spine array and 2 sets of body matrix coils will be used to cover from mid-thigh through the lumbar spine. Subjects will then be scanned for ~50 minutes.

MR Acquisition Protocol

After 3-plane localizers, anatomical T2-weighted imaging (TR/TE=3000/100ms, 0.8x0.8x4mm, 36 slices, R=2) will be performed in the sagittal and axial planes, covering the pelvic region from mid-femur to L3. The Dixon acquisition will consist of 6 separate 3D GRE scans (TR=8.5ms, 0.9x0.9x3mm, 64 slices) with TEs of 2, 3, 4, 5, 6, 7 ms. A single-voxel MRS measurement will be performed in the marrow of the L4 vertebral body (modified svs_se, TR=3s, and TE=30, 35, 40, 45, 50 ms). Time permitting, a T2 map will be acquired using the se_mc sequence (TR=3s, 0.8x0.8x3mm, 7 slices, and TE = 13-314 ms in 24 steps). Additionally, an ADC map will be acquired with the monopolar DWI WIP sequence (TR/TE=4000/53ms, 1.8x1.8x4mm, b=0, 100, 800 s/mm2, 3 directions, 3 avearges). After the scan the DICOM images and the raw, complex Dixon data will be transferred to a CMRR server for processing.

MR Reconstruction and Processing

The complex multi-TE Dixon data will be loaded in Matlab and reconstructed using the IDEAL (iterative decomposition of water and fat with echo asymmetry and least squares estimation) technique with additional T2* and multicomponent lipid modeling (3). From these, a relative fat fraction map will be generated for ROI-based

analyses. The MRS data will be processed by fitting the water and lipid resonances with a Voigt lineshape model. The MRS peak amplitudes will then be fit to a monoexponential decay model to estimate T2 and M0 (amplitude at TE=0). The T2 and ADC maps will be processed offline with Matlab, fitting each pixel to a monoexponential decay to generate a maps of T2 and ADC for ROI analyses.

References

1. Meisamy S, Hines CDG, Hamilton G, Sirlin CB, McKenzie CA, Yu H, et al. Quantification of Hepatic Steatosis with T1-independent, T2*-corrected MR Imaging with Spectral Modeling of Fat: Blinded Comparison with MR Spectroscopy. Radiology. 2011 Mar 1;258(3):767 -775.
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3. Yu H, Shimakawa A, McKenzie CA, Brodsky E, Brittain JH, Reeder SB. Multiecho water-fat separation and simultaneous R2* estimation with multifrequency fat spectrum modeling. Magn Reson Med. 2008 Nov;60(5):1122-1134.