Comparative Analysis of Continuous Table and Fixed Table Acquisition Methods: Effects on Fat Suppression and Time Efficiency for Single-Shot T2-weighted Imaging

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Target Audience: Body Radiologists, Translational Scientists, Clinical Physicists

Background: Uniform fat suppression on axial T2-weighted single-shot imaging (ssT2) is critical to accurately assess inflammatory diseases of the abdomen and pelvis. Fat suppression efficacy is frequently reduced in multi-slice ssT2 sequences in anatomic regions away from magnet isocenter due to field inhomogeneity across the imaging stack. Recently, continuous table movement (CTM) technology has been developed to allow sequential 2D acquisitions at or near magnet isocenter (1-3). CTM technology may provide improved quality of fat suppression compared to fixed table (FT) acquisitions, by allowing optimal slice homogeneity for spectral fat selection RF pulses. In addition, reduction in acquisition times may be realized with the CTM over large fields of view (FOV).
Purpose: a) To compare the quality of fat-suppression between CTM and multi-slice FT methods for ssT2 sequences and b) To compare differences in overall image acquisition times between the two methods.

Methods: ***Patients:*** This study was conducted with approval of the IRB, with all patients signing informed consent prior to imaging. Twelve patients undergoing routine abdomen (n=9) and abdomen-pelvis (n=3) MRI were recruited for this study. No additional exclusion criteria were implemented beyond standard clinical MR contraindications. ***Imaging:*** All imaging was performed on a 1.5T Siemens Aera scanner using an 18-channel phased-array surface coil. Each patient was imaged with a fat-saturated ssT2 fast spin echo sequence using both a CTM and a FT multi-slice acquisition mode. For both techniques, spectral adiabatic inversion recovery (SPAIR) was used for fat suppression, while the FOV in the slice direction was kept equivalent between the two methods. For combined abdomen and pelvis coverage, two multi-stack regions (with 50mm overlap) were prescribed for the FT method, with an automatic table movement between them. Maximum z-coverage for each FT stack was set to 300mm. Other imaging parameters included: TR/TE/flip = 1500/85ms/170; resolution = 1.3mm^2; slice thickness = 7mm; slice gap = 0.7mm; BW = 800Hz/px; GRAPPA = 2; concatenations = 4. The CTM method acquires each single-shot axial slice during continuous table movement. The table speed (V) is determined by the slice thickness (ST) and gap, and the acquisition time per slice (TA): V = (ST+gap)/TA. Data was concatenated to reduce saturation effects from neighboring slices, allowing greater SNR. ***Data analysis:*** All patient data were processed using Analyze 8.0 software (Mayo Clinic, Rochester, MN). For each patient, three slices at different table positions were analyzed using the FT acquisition as the reference volume: 1) mid slice, near the center of the imaging volume; 2) superior slice, near the top-most slice; and 3) an inferior slice, near the bottom-most slice. The slices were chosen such that adequate SNR and relevant imaging anatomy was present for analysis. Then, corresponding slices were chosen from the CTM method for each patient. For abdomen-pelvis cases, 6 slices were chosen (3 from abdomen, 3 from pelvis volumes). The subcutaneous fat was segmented semi-automatically from each slice, with the mean signal *intensity* representing the degree of fat suppression (zero being optimal), and the signal *variance* representing a measure of suppression "uniformity". Additionally, manual ROIs were drawn in visceral fat regions in mid- and inferior-slices (para-renal and pelvic, ROI ~ 3cm^2) to compare the same suppression and uniformity metrics. Imaging time was calculated from the first to last acquired slice, including table movement and shimming time. A paired Student's t-test was used to test significance between measurements.

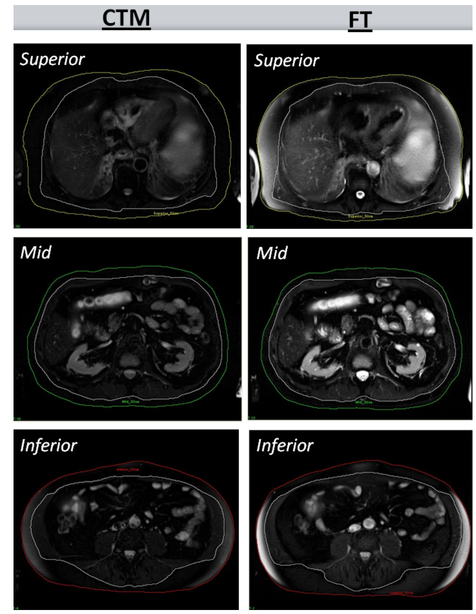

Figure 1. Object Maps of subcutaneous region for CTM and FT methods

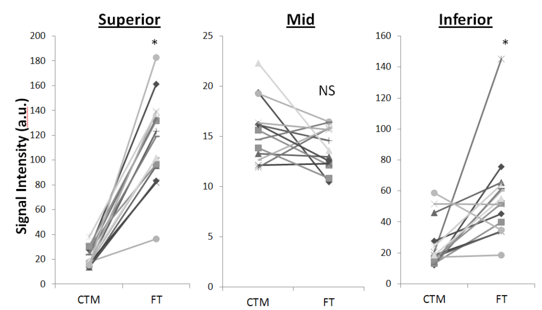

Figure 2. Change in mean subcutaneous signal of CTM and FT methods

Results: On average, the acquisition duration of the CTM method was significantly shorter for combined abdomen and pelvis coverage (121.5s vs. 132.9s, p<0.05, n=3), due to the added table shift and shim time of the FT method. Figure 1 shows both methods at three equivalent imaging slices in one patient. The average anatomic distance between the superior and inferior slice was 236.1 ± 31.4mm, while the mid-slice was acquired approximately 26.9 ± 19.4mm from isocenter in the FT method. As shown in Figure 2, the mean signal intensity was significantly lower for the CTM method in the majority of abdomen and pelvis subcutaneous fat regions for superior (21.4 ± 7.5 vs 115.1 ± 35.7, p<0.01, n=15), inferior (24.6 ± 15.0 vs. 55.7 ± 28.9, p<0.05, n=15), but not for mid-slice (15.8 ± 3.0 vs. 13.8 ± 2.1, p=0.6, n=15). Measures of uniformity (variance) were also significantly better for CTM (inferior: 1006.4 vs 7226.5; superior: 892.6 vs. 16350.6, p<0.05), except for the mid-slice (493.7 vs. 507.2, p>0.1). For selected ROIs of visceral fat at the three locations, a significant difference in inferior slices was found (CTM: 15.7 ± 8.61 vs. FT: 79.4 ± 14.0, p<0.05), but there were no significant differences in mid-slice visceral regions (CTM: 12.2 ± 8.1 vs. FT: 14.4 ± 9.3, p=0.25).

Discussion: Since the CTM does not require additional time interruptions for shimming following each table movement, the technique is more time efficient when applied to large imaging FOV. Moreover, the continuous table movement affords consistent imaging at or near isocenter, which is reflected by the improved fat suppression and uniformity measures compared to the conventional FT method, particularly at outer slice positions, where field inhomogeneity perturbs the fat-water frequency shift. Imaging at isocenter is vital in current ultra-short bore MR systems.

Conclusion: Fat-saturated T2-weighted singe-shot fast spin echo imaging is improved using a continuous table acquisition method, allowing more time efficient and consistent fat suppression, particular for large FOV abdominal and pelvic imaging.

References: 1. Barkhausen et al. Radiology 2001; 220:252-56; 2. Fautz HP et al. MRM 2006; 55:363-70; 3. Ludwig U, et al. MRM 2006; 55:423-30