Spectrally Selective B1 Insensitive T2 Preparation Sequence for 3T Imaging

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Introduction: T_2 magnetization preparation (T_2 Prep) and spectrally selective fat suppression (FatSat) sequences are commonly used to enhance imaging contrast [1]. Increased B_1 inhomogeneity at 3T necessitates a preparation sequence that is more robust with respect to B_1 inhomogeneity. We propose a spectrally selective, B_1 insensitive, T_2 Prep sequence for imaging at 3T. Numerical simulations, phantom and *in-vivo* images acquired using this technique are presented.

Theory: **T_2 Prep:** A novel B_1 and B_0 insensitive T_2 magnetization preparation sequence is presented which results in a uniform T_2 Prep across the imaging field of view. This sequence is based on the simultaneous frequency and amplitude modulation of the applied RF pulses [2]. A segmented BIR4 with insertion delays of t = **T** between pulse segments 1 and 2, 3 and 4 respectively was calculated for a net flip angle of -360^0 or 0^0 as shown in Fig 1. This segmented pulse forms a B_1 insensitive T_2 prep weighting sequence and was described earlier for use as a zero or double quantum filter [3]. The delay **T** can be set to achieve a desired contrast between different tissues. **Fat Sat:** we modified this segmented BIR4 further by inserting an extra delay $\delta\tau$ between the BIR4 segments 1 and 2 to suppress the signal from fat. The equal delay **T**in a segmented BIR4 causes the acquired phase in the first delay to be compensated in the second delay. However, by introducing non-equal delays, the acquired phase in the first segment will not be compensated in the second delay, which results in an additional frequency offset dependent phase. The phase difference between two main components of fat and water can be set to 90^0 by adding a time delay difference of $\delta\tau = 1/4\Delta f$, in which Δf is the resonance frequency difference of water and fat. The water component will return to longitudinal magnetization by the adiabatic half passage component of the pulse in the last segment. However, the adiabatic half passage will not return the fat signal to the longitudinal axis, instead the fat components will remain in the transverse plane. Subsequently, this transverse fat signal is dephased by a spoiling gradient, resulting in suppression of the fat signal without affecting the water signal.

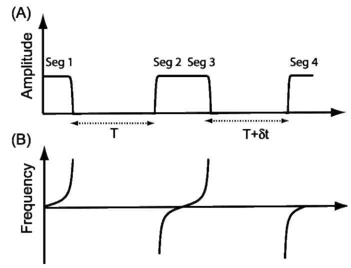

Figure 1: Proposed T_2 Prep pulse sequence. The sequence consist of four segments, a (1) reverse adiabatic half passage (rAHP), (2) AHP, (3) rAHP, and (4) AHP. Spoiling gradient is not shown.

Method: Simulations & Phantom Studies: To illustrate the response of the magnetization to the preparation sequence in the presence of B_1 and B_0 inhomogeneity, computer simulations were performed to calculate the normalized longitudinal magnetization M_z/M_{equ} after experiencing the T_2 Prep and T_2 Prep/FatSat pulse. To investigate the T_2 weighting, B_1 and B_0 variation, and T_2 Prep/Fat Sat efficiency, phantom studies were performed using (i) a water phantom containing 5 tubes filled with different T_2 species and (ii) another phantom consisting of a central fat tube surrounded with doped water. B_1 and B_0 insensitivity was demonstrated by changing the transmitted power and center frequency of the RF (data not shown). The T_2 weighting was studied by changing the insertion delay T. ***In-vivo*** **Study:** Axial images of the thigh were obtained in 4 normal volunteers to investigate the performance of the achieved T_2 weighting and fat saturation. All experiments were performed on a GE EXCITE 3.0T system (GE Medical System, Milwaukee, WI). A 2D gradient-echo imaging sequence followed the proposed T_2 Prep sequence.

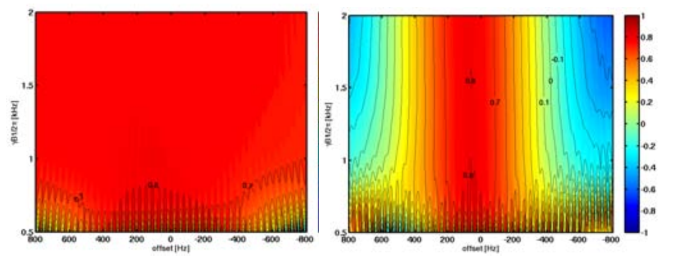

Figure 2: M_z/M_{equ} after experiencing T_2 prep sequence (A) without and with (B) fat suppression in the presence of B_0 (X-axis) and B_1 (Y-axis) variations.

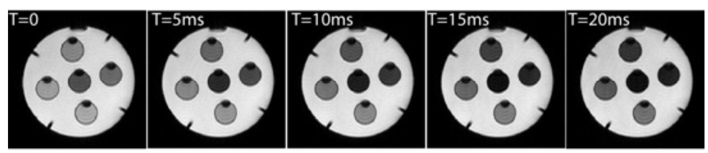

Figure 3: T_2 weighting achieved by increasing the insertion delay T: different tubes in the phantom have different T_2.

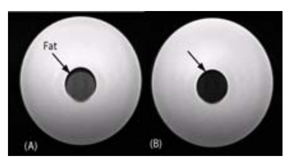

Figure 4: Phantom experiments acquired with (A) only T_2 Prep (B) T_2 Prep/FatSat.

Results: Fig. 2 demonstrates the longitudinal magnetization in the presence of B_1 and B_0 inhomogeneity experiencing the proposed (A) T_2 Prep and (B) T_2 Prep/FatSat. The results show a uniform magnetization response to the applied T_2 prep sequence in the presence of field inhomogeneity. Fig. 3 shows the enhanced T_2 contrast achieved by increasing the insertion delay T. Fig. 4 shows the fat suppression achieved in addition to the T_2 Prep. Fig. 5 shows the example *in-vivo* images acquired with (top row) only T_2 prep with various insertion delay and (bottom row) T_2 Prep/FatSat.

Conclusion: In this study, we propose a novel B_1 insensitive magnetization preparation scheme that simultaneously combines T_2 preparation and fat suppression. The simulation, phantom and *in-vivo* results illustrate the efficacy of the technique.

References: [1] Brittain JH ,Magn Reson Med. 1995 May;33(5):689-96 [2] Silver MS. Magn Reson 1984;59(2):347-351. [3]de Graaf RA J Magn Reson B 1995;109(2):184-193.

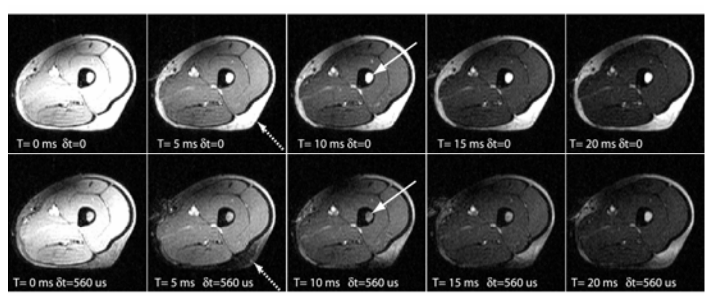

Figure 5: images acquired with T_2 prep with different insertion delay (A) fat saturation in upper row and (B) with extra delay $\delta\tau$ in bottom row.