High Resolution 3D MR Spectroscopic Imaging and J-resolved MRS of the Prostate at 3 Tesla

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Introduction: MR spectroscopic imaging (MRSI) has become a powerful clinical and research tool to characterize prostate cancers based on endogenous cellular metabolite levels and to detect early response to therapy (1). Virtually all prior studies have been performed at 1.5T. The goal of this study was to develop 3T techniques for prostate MRSI data to obtain increased SNR, spectral resolution and spatial resolution as compared to 1.5T studies. We also investigated the j-modulation of citrate and polyamines in vivo at 3T using single voxel, j-resolved MRS (2).

Methods: Since the frequency range for the metabolites of interest (choline, creatine, polyamines and citrate) are doubled at 3T, new rf pulses were required for observing the metabolites and suppressing water and lipid resonances. Also new reduced peak power rf pulses were necessary for 3T body coil excitation. A novel phase-modulated dual-band spectral spatial pulse was designed using similar methods to those we developed at 1.5T (3). The new 30 ms dualband RF pulse was designed for attenuated (100-fold) water excitation, full choline to citrate excitation, exclusion of lipids and a +75/-45 Hz tolerance (3 times 1.5T pulse) to B0 inhomogeneities.Phase-modulation reduced peak power by 62%, the peak amplitude was 0.146G. This was critical for 3T body coil excitation. A pre-pulse train of fixed and graphically-prescribed Very Selective Saturation pulses (VSS; 4). The new 3T MRSI sequence was applied in 6 patient and volunteer studies on a GE 3T scanner using body coil excitation and reception with a MedRad 3T endorectal coil. The 3D MRSI data were acquired in 16 minutes at 0.15cc (half typical 1.5T resolution) or 0.34cc (1.5T resolution). The 2d J-resolved data was acquired from a ~4cc volume with 32 steps of 10ms intervals from TE=35 to 345ms. All subjects also were also studied at 1.5T using standard MRI/MRSI acquisition protocols (1).

Results: The patient 3T studies demonstrated that good quality MRSI data could be obtained throughout the prostate using the specialized pulse sequence developed for this study. The in vivo 2d-J acquisitions (Figure 1) showed different modulation of the citrate resonances than at 1.5T with the best echo times being 90ms for an inverted citrate resonance and 260ms for an upright citrate resonance. 3D MRSI was acquired throughout the gland at TE= 90ms, 130ms and 260ms. The TE=90ms data showed maximally inverted citrate and greatly improved separation of choline, polymanine and creatine resonances than 1.5T data (Figure 2). While the TE=260ms demonstrated upright citrate, the other resonances were low due to T2 losses. Choline SNR calculations at 3T (TE=90ms) showed a 1.87fold increase compared to 1.5T, corrected for voxel size.

Conclusion: This study demonstrated the feasibility of obtaining 3D MRSI data from prostate cancer patients at 3T and the ability of obtaining high spatial resolution MR spectra throughout the prostate in vivo with improved discrimination of choline, creatine and polyamine resonances.

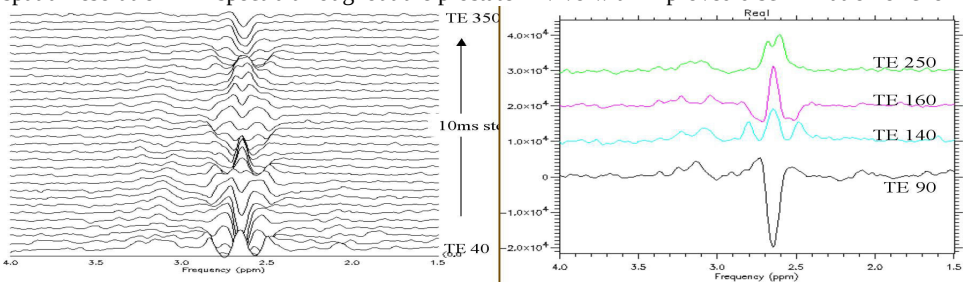

Figure 1. 3T Prostate 2dj studies from a normal appearing PRESS selected region. This data was acquired from a volunteer patient in 9 min with TE's ranging from 40-350ms in 10ms steps. A minimum for citrate was observed at 90ms with maximums for the center lines at 160ms and at 250ms where the outer lines were minimum.

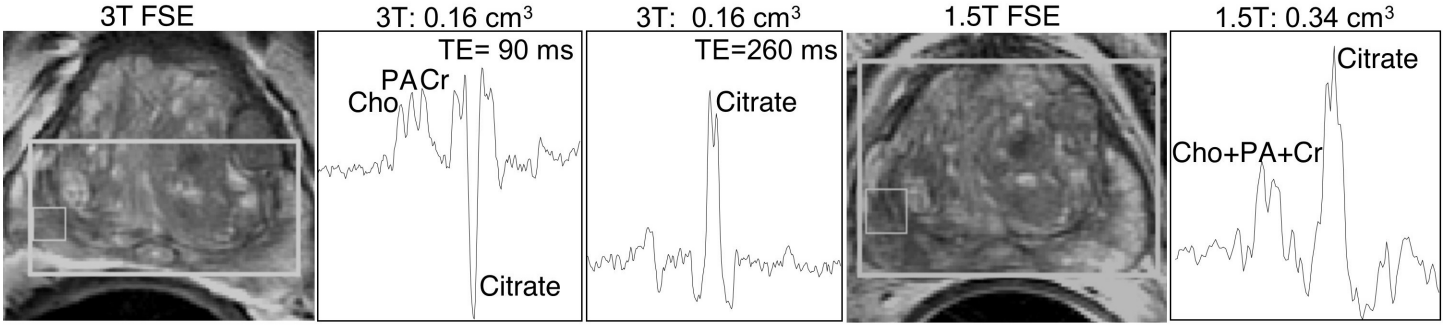

Figure 2. Prostate MRSI data acquired at 3T (left) and at 1.5T (right) from the same patient on the same day. Note the improved SNR and spectral resolution for the 3T TE=90ms MRSI data.

References

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