CARR-PURCELL-MEIBOOM-GILL (CPMG) IMAGING OF PROSTATE CANCER; TRADING TIME FOR INFORMATION: HIGH QUALITY T2 IMAGES AND QUANTITATIVE T2 VALUES FOR CANCER DISCRIMINATION

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Introduction: T2-weighted imaging (T2WI) is widely used in the clinical staging of prostate cancer and is typically performed using fast spin echo (FSE) imaging. While FSE reduces acquisition time compared to standard spin echo (SSE) imaging, it also produces image blurring that results from T2-related effects upon the point spread function not present with SSE. In the present study, we employed CPMG imaging, a multi-echo SSE technique, to (a) generate high quality T2WI of prostate cancer without FSE point spread function problems and (b) provide data for quantitative measurement of regional T2 values for discrimination of suspected cancer from normal tissue.

Methods: Ten patients with biopsy proven prostate cancer (age range 37-75 years, Gleason score range 3+3=6 to 4+5=9) provided written informed consent for an additional CPMG sequence during their clinical staging exam. All studies were performed with a 1.5T GE Signa scanner operating at the 9.x hardware/software configuration (GE Healthcare, Waukesha, WI) and an inflatable endorectal coil (Medrad, Indianola, PA) and included fast spoiled gradient echo T1WI and FSE T2WI (TR 6 s, TE 100 ms) performed using 3 mm oblique axial slices. CPMG was performed using 4 mm oblique axial slices orientation matched to the T1WI and T2WI, 14 cm FOV, 256 x 128 matrix, 2 averages, TR 2.5 s, 16 TEs spaced 14 ms apart (ie, 14 - 224 ms), with 8 - 10 slices acquired in 10.7 min. Using the CPMG approach, separate images were reconstructed for each TE at each slice. Mono-exponential fits of signal intensity vs. TE were used to generate T2 maps. Summed images from consecutive groups of 4 TEs were used for image evaluation. The most heavily T2W summed images were used to estimate signal-to-noise (SNR) from healthy peripheral zone (PZ) and to identify ROIs of suspected cancer and normal PZ from which T2 values were extracted. The ROI's were selected based on T2 signal intensity with suspected cancer having low signal and normal having high signal, were consistent with the available biopsy reports, and contained no MR evidence of hemorrhage.

Results and Discussion: High quality diagnostic images with minimal motion artifact were acquired with the CPMG sequence from each patient and a representative case is shown in Figure 1. SNR values in the heavily T2-weighted summed images were ≥ 6.2 (range 6.2 - 21.2) and were comparable to those measured in conventional T2-weighted FSE images. Significant differences were measured between the T2 values of normal tissue and suspected cancer within the PZ with mean ± standard deviation of 199 ± 47 ms and 104 ± 17 ms, respectively (N = 10, $p < 0.001$). The results indicate that quantitative T2 measurements (1,2) may be useful as part of a multi-parametric MRI methodology for characterizing prostate cancer which may also include spectroscopic, diffusion weighted, and dynamic contrast enhanced imaging.

Conclusion: High quality T2WI and quantitative T2 information can be acquired from the prostate using CPMG sequences in reasonable scan times and with considerably more information than available from conventional FSE scans. This approach circumvents the T2-associated image blurring that results from undesirable point spread function properties inherent with FSE while also providing quantitative T2 values for tissue discrimination. Additionally, proton density images become available for mapping RF receiver coil sensitivities which may prove useful for parallel imaging approaches to spectroscopic or dynamic contrast enhanced imaging studies performed following CPMG acquisitions.

References:

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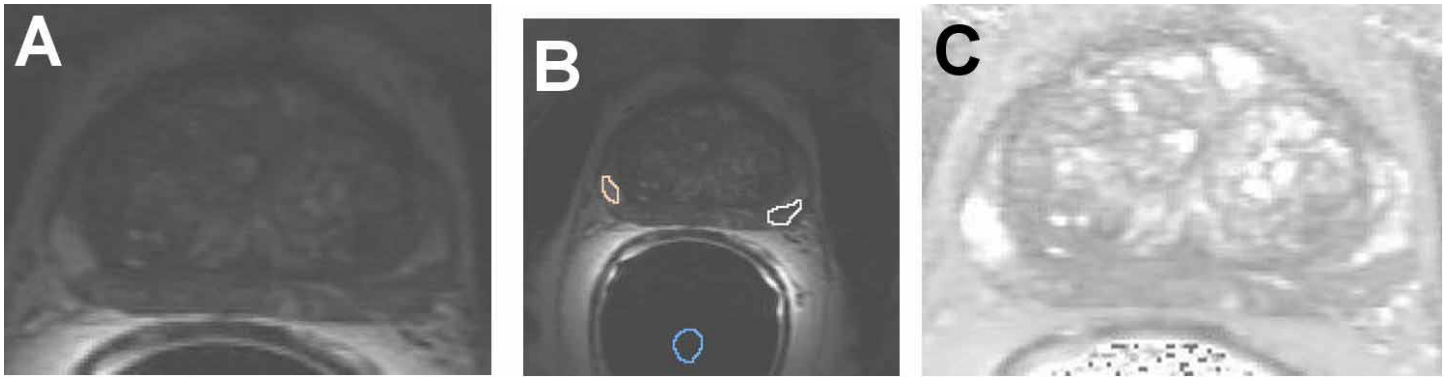

Figure 1. 63 yo male with biopsy proven prostate adenocarcinoma of the right lobe (Gleason 3+3=6, 5% of 1/3 cores) and left lobe (Gleason 4+3=7, 80%, 20% and 5% of 3/4 cores). A. CPMG image derived from last 4 echoes. B. ROIs used to select suspected cancer in the left mid-gland PZ (white), normal tissue in the right mid-gland PZ (yellow), and noise in the balloon (blue). C. T2-map derived from mono-exponential fit of all 16 echoes. All images taken from same slice location.

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