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PROSTATE TISSUE CHARACTERIZATION WITH BIEXPONENTIAL ANALYSES OF WATER DIFFUSION DECAY OVER A RANGE OF EXTENDED B-FACTORS

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PURPOSE

Water diffusion measurements may prove useful for detecting and staging prostate cancer. This study tests the hypothesis that the standard monoexponential model for water diffusion decay in prostate tissue is inadequate for detailed measurements that include high b-factors (>3000 s/mm²). Biexponential analyses better characterize the diffusion decay curves; the slow diffusion coefficient provides an index suitable for discriminating between central gland (CG) and peripheral zone (PZ).

METHOD AND MATERIALS

Nine men (mean age 66 ± 8 years) with biopsy-proven prostate cancer underwent 1.5T endorectal coil MRI staging and consented to an additional 6 min quantitative line scan diffusion imaging (LSDI) acquisition. MRI was performed at a mean of 12 weeks post-biopsy (range: 4-21 weeks). A single 10 mm thick slice with a 3.8×2.8 mm in-plane resolution was scanned using 12 b-factors (range: 5 to 3500 s/mm²) along three orthogonal directions with TR/TE=4000/75. Detailed diffusion analysis was performed on 1.5 ml regions of interest in the CG and PZ that were determined to be free of hemorrhage and tumor by T1- and T2-weighted images.

RESULTS

Semi-log plots of the water signal decay vs. b-factor from both PZ and CG were clearly not monoexponential. The decay curves were well suited to biexponential analyses. The fractions of the fast diffusion component in the PZ and CG were 0.78 ± 0.07 and 0.82 ± 0.04 , respectively. The fast diffusion coefficients in the PZ and CG were 2.16 ± 0.27 and 2.17 ± 0.18 $\mu\text{m}^2/\text{ms}$, respectively. Slow diffusion coefficients in the PZ and CG were 0.16 ± 0.10 and 0.34 ± 0.08 $\mu\text{m}^2/\text{ms}$, respectively. The difference of the slow diffusion coefficients between CG and PZ was statistically significant (Students paired t-test, $p < 0.05$).

CONCLUSIONS

The monoexponential model for water diffusion decay is inadequate for detailed measurements in the prostate that include b-factors > 3000 s/mm². Sampling a wide range of b-factors reveals that signal decays are better modeled with bi-exponential functions, a finding similar to results in the brain. The clinical potential of these additional prostate tissue characterization parameters in the assessment and/or staging of prostate cancer remains to be determined.