Advanced diffusion-weighted imaging of prostate cancer: correlation with histopathology

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Background

Diffusion-weighted imaging (DWI), which measures the diffusion of water molecules in tissue, is a promising MRI technique for noninvasive characterization of prostate cancer (PCa) There has been recent interest in assessing quantitative advanced DWI parameters in PCa. Fractional anisotropy (FA) values from diffusion tensor imaging (DTI) measurements have shown to be positively correlated with Gleason score. Technical advancements have enabled DWI with high b-values (>1000 s/mm^2), which allows for modeling of non-Gaussian behavior of water diffusion using diffusion kurtosis imaging (DKI) or stretched-exponential (SE-DWI) models. The **goal** of this study was to correlate advanced DWI parameters in PCa with tissue composition measurements from histopathology.

Methods

MRI acquisition and analysis

24 patients (mean age 63 y, range 53 – 76 y) with PCa that underwent 3T prostate MRI including high b-value DWI and DTI at 3.0T (Siemens Skyra) before (2 – 102 days) undergoing prostatectomy were included in this prospective IRB-approved study. DKI [apparent diffusion coefficient ADC_{DKI} and kurtosis parameter K] and SE-DWI [ADC_{SE} and anomalous exponent α] parameter maps were constructed from the high b-value DWI data. A monoexponential fit was performed to determine ADC_{ME} (conventional ADC). DTI (ADC_{DTI} and FA) parameter maps were generated by the scanner console. Parameters were quantified in healthy peripheral zone (PZ) tissue and in the index PCa lesion. Both lesions in the PZ and transition zone (TZ) were included.

Histopathology

For each PCa lesion, an H&E-stained section was available. Using semi-automated segmentation, nuclear, cytoplasmic, cellular (nucleus + cytoplasm), stromal and luminal tumor tissue fractions and nuclear-cytoplasmic ratios (N/C=nuclear/cytoplasmic fraction) were derived.

Statistics

Differences in diffusion parameters between PZ and PCa lesions were tested using Wilcoxon signed rank tests. Spearman correlation analysis was performed to assess the correlation between PCa diffusion parameter values and histological measurements.

Results

24 lesions were analyzed (1/patient, average size 15 ± 6 mm, PZ/TZ 19/5, Gleason 7/8/9 17/3/4, pathology stage T2/T3 19/5). All parameters were significantly different between PZ and PCa ($P<0.019$). ADC_{ME}, ADC_{SE} and ADC_{DKI} all significantly negatively correlated with cytoplasmic and cellular fractions (r range -0.435 – -0.546, $p<0.034$) and positively with stromal fractions (r 0.619 – 0.669, $p<0.001$). ADC_{DTI} and FA correlated with stromal fractions only ($r=0.512/-0.413$, $p<0.045$, respectively). α did not correlate

with histological parameters, while K showed multiple significant correlations (cytoplasmic/cellular/stromal fraction r=0.487/0.485/-0.422, $p<0.040$, respectively).

Conclusions

Advanced DWI methods showed significant correlations with tissue composition in PCa. The suitability of advanced DWI parameters as surrogate biomarkers of histopathological measurements for PCa characterization needs to be verified in larger studies.

Conflict of Interest

The authors have no potential conflicts of interest.

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