The ADC ratio of tumour to normal prostate as a robust method for quantifying diffusion weighted imaging of the prostate

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Objectives: To investigate the robustness of apparent diffusion coefficient (ADC) ratios of tumor-to-normal prostate compared to absolute ADC values.

Introduction: Diffusion-weight imaging has become an essential component of multiparametric-MRI (mpMRI) of the prostate, providing functional information relating to tumor cellularity and tissue composition. However, absolute ADC values can show substantial variability depending on the b-values selected [1-2], as a result, despite their potential for tumor grading, absolute ADC values should be used with caution for diagnostic purposes. A potential method for overcoming the variability in absolute values is to use the ratio of the tumor ADC to that of normal tissue, assuming that the variability due to ADC in normal tissue is equivalent to that within tumors, Thus, the purpose of this study was to investigate the robustness of an ADC ratio to overcome variation related to b-value selection.

Methods: 39 patients with prostate cancer underwent 3.0T-MRI (General Electric Healthcare, Waukesha, USA) using an 8-channel phased-array coil. T_2W parameters: TE/TR = 80-85/4000 ms; FOV 22x22 cm; 4 signal averages; matrix 256x256. A slice thickness of 3 mm was used, with a 1.5 mm gap. Axial DWI was performed using a customized dual spin echo-planar imaging pulse sequence (TE/TR = 78/4400 ms; FOV 30×30 cm; acquisition matrix 128×128). Parallel imaging with ASSET was used with acceleration factor 2, with 8 signal averages. Isotropic diffusion-weighted images were automatically obtained by combining images with three perpendicular diffusion axes, and b-values of 0, 150, 750 and 1000 s/mm^2 were acquired. Multiple ADC maps were generated using the following combination of b-values: 0, 1000 s/mm^2; 150, 750 s/mm^2; 150, 1,000 s/mm^2; and 150, 750, 1,000 s/mm^2, using in-house software programmed with Matlab (MathWorks, Natick, MA). Histological-derived regions-of-interest were defined for tumor and benign prostate to generate ratios. The concordance correlation coefficient (CCC) was used to evaluate agreement and reproducibility and Bland-Altman plots for the pattern of relative measurement difference between b-value combinations. ADC to Gleason score (GS) relationship was tested by Spearman's rank correlation.

Results: ADC values varied between b-value combinations. CCC was higher for ADC ratios (0.883; 95% CI 0.816-0.927) compared to absolute normal (0.873; 0.799-0.921) and tumor (0.792; 0.688-0.864) ADC values. The ADC ratio CCC for transition zone tumors ratio was considerably higher in all cases. Bland-Altman analysis demonstrated higher variation for ADC maps incorporating a b-0 value for both ratio and absolute values. ADC ratios had a stronger inverse relationship to GS (-0.35 to -0.46) compared to absolute ADC values (-0.12 to -0.38).

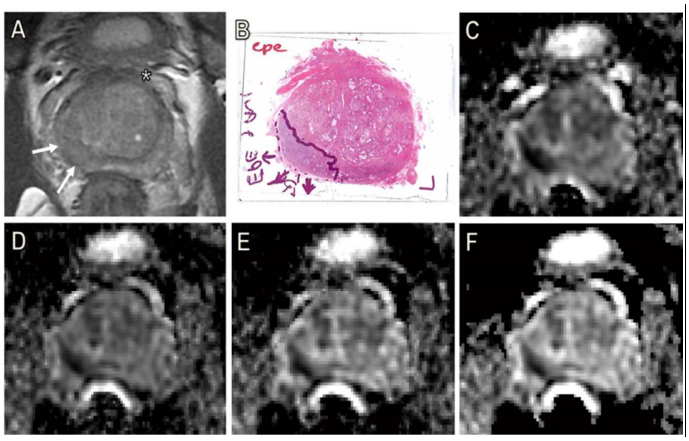

Figure 1. Variation in ADC maps from different b-values. A: axial T_2 shows tumor (arrows), confirmed on histology (B). ADC maps from 0/1,000 (C), 150/750 (D), 150/1,000 (E), and 150/750/1,000 (F). Despite differences in lesion conspicuity, ratios of ADC: normal PZ were similar.

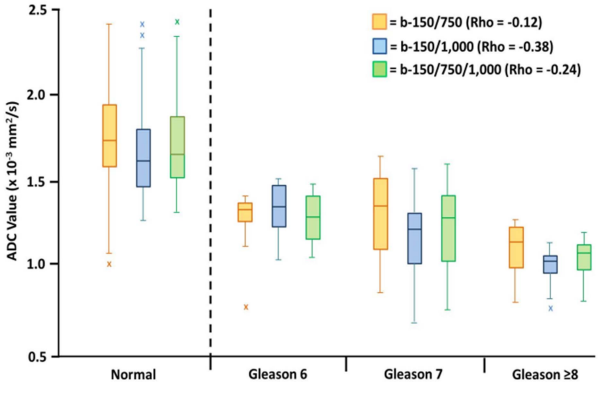

Figure 2. Correlation of ADC tumour ratios to Gleason grade. ADC values from different b-value combinations (see key). Spearman's correlation (Rho) listed in key. Top/bottom of boxes represent 25th/75th percentiles, line in the box = median value.

Discussion: Tumor ADC ratio values consistently outperformed absolute values across all b-value combinations. The ratio was particularly beneficial for transition zone (TZ) tumors, which may reflect correction of the variability caused by the heterogeneous nature of normal TZ. Combinations using a b-0 value for the normal peripheral zone were shown to be more concordant than the equivalent tumor ratio values. This may reflect the additional pseudo-perfusion effect seen with this low b-value [3]. Perfusion effects would be expected to be less in the PZ which is typically less vascular than either tumors or normal transition zone. In conclusion, ADC ratios improved concordance between different b-value combinations and could provide a more robust means of assessing restricted diffusion in the prostate.

References [1] Thörmer G,et al. Eur Radiol 2012;22(8):1820-8; [2] Peng Y,et al. AJR 2014;202(3):W247-53; [3] Le Bihan D,et al. Radiol. 1988;168:497-505