Comparison of Quantification Approaches in Diffusion Tensor Imaging of Prostate Cancer at 3T

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Introduction

In Magnetic Resonance Imaging (MRI), T_2-weighted images (T_2WI), Dynamic Contrast Enhanced MRI (DCE-MRI) and Diffusion Weighted Imaging (DWI) have been used to localize prostate cancer (1). However, difficulty still exists in the diagnosis of prostate cancer if prostate cancer is in the inner gland (IG) or if it shows similar Apparent Diffusion Coefficient (ADC) values to the peripheral zone (PZ). ADC values can be approximated by using at least two b-values but actually DW images acquired with different b-values show an exponential decay (2, 3), so that an appropriate exponential fitting curve to calculate ADC may be more sensitive to differentiate prostate cancer. Diffusion tensor imaging (DTI) has also been used as a new, promising method to describe the diffusion in the human prostate (4, 5). In this study, we calculated ADC values for prostate cancer, benign prostatic hypertrophy (BPH), PZ and IG using mono-exponential data fits. We investigated if this method can help to delineate prostate cancer and compared this method to the common method with only two b-values. Additionally, fractional anisotropy (FA) values were calculated to determine if additional information for prostate cancer diagnosis can be obtained.

Materials and Methods

In this study 15 patients (53 - 72 years, mean 57.9 years) with prostate cancer underwent a 3T MR examination (Achieva, Philips Medical Systems) using an 8-channel phased-array coil before prostatectomy. DWI was performed with a single-shot EPI-sequence [parameters: TR/TE = 2579/68 ms, number of excitation = 3, slice thickness = 3 mm, matrix size = 256 x 256, field of view = 20 x 20 cm, b-values = 0, 333, 667 and 1000 s/mm^2, motion probing gradient (MPG) with three axes for three patients and with six axes for twelve patients]. ADC values were calculated in all patients and in twelve of fifteen patients also FA values were measured. We retrospectively compared pathological results and MR images including T_2-weighted images and dynamic contrast enhanced images to identify locations of prostate cancer, BPH, PZ and IG. ADC maps were calculated with an in-house developed software using IDL 6.4 (ITT Inc. Boulder, CO, USA). Average ADC and FA values were measured in ROIs on ADC and FA maps. ADC values were calculated with four methods: Method [1] calculated ADC values from a mono-exponential fitting curve from four b-values = 0, 333, 667 and 1000 s/mm^2. At the same, ADC values were also approximated by using only two b-values (method [2] 0 and 333 s/mm^2, method [3] 0 and 667 s/mm^2, and method [4] 0 and 1000 s/mm^2). The results of method [1] were compared with the results of the other three methods. FA maps were calculated with DTI-Studio (provided by Laboratory of Brain Anatomical MRI and Center for Imaging Science, Johns Hopkins University, Baltimore, MD, USA) using DWI of b-values = 0 s/mm^{2}and b = 1000 s/mm^2 with six axes. These values were statistically analyzed by ANOVA with Bonferroni post hoc using SPSS 13.0 (SPSS Inc. Chicago, IL, USA). $p < 0.05$ was considered significant for ANOVA.

Results

Average ADC values of method [1] in prostate cancer were 0.96±0.28 x 10^{-3} mm^2/s, in BPH 1.60±0.22 x 10^{-3} mm^2/s, in PZ 1.75±0.18 x 10^{-3} mm^2/s and in IG 1.25 ± 0.25 x 10^{-3} mm^2/s, respectively (Figure 1). Significant differences between prostate cancer and BPH, prostate cancer and PZ, prostate cancer and IG, and PZ and IG were found. All examined methods [1]-[4] were sensitive to differentiate prostate cancer. ADC values of method [2] were higher than those of methods [1], [3] and [4]. Methods [1], [3] and [4] showed similar results. Average FA values in prostate cancer were 0.50±0.12, in BPH 0.38±0.07, in PZ 0.29±0.56 and in IG 0.47 ± 0.07, respectively (Figure 1). Significant differences between prostate cancer and BPH, prostate cancer and PZ, and between PZ and IG were found but prostate cancer showed no significant difference to IG.

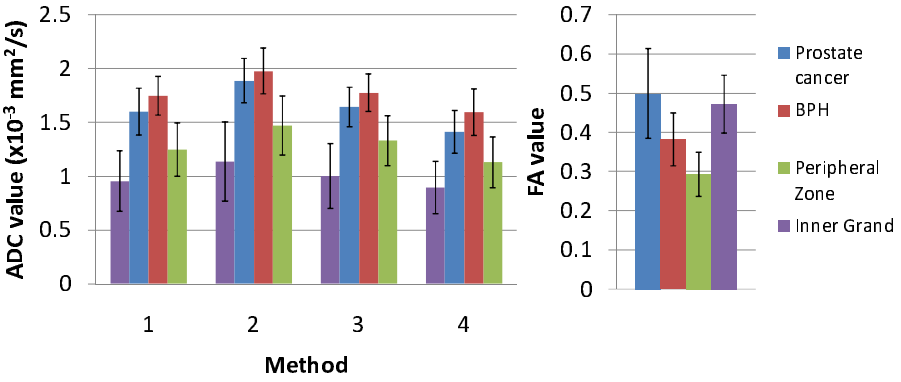

Figure 1. Average ADC and FA values (Mean±SD) of prostate cancer (blue), BPH (red), PZ (green) and IG (purple).

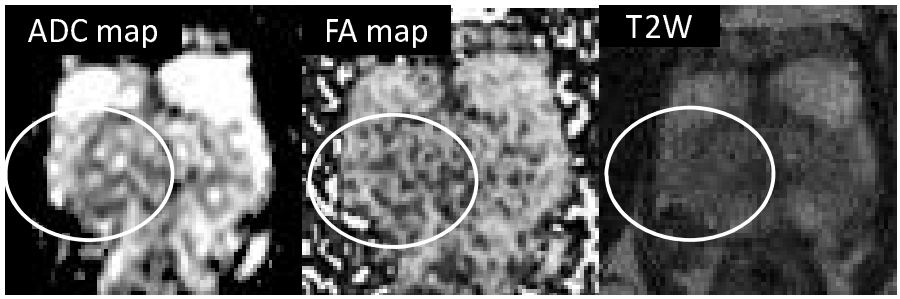

Figure 2. ADC map, FA maps and T_2-weighted image of a prostate tumor patient. Circles indicate histology proven prostate cancer

Conclusion

ADC values calculated with method [1], [3] and [4] can differentiate prostate cancer. FA values can provide additional information for the diagnosis of prostate cancer.

References

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