High-Resolution Diffusion-Weighted Imaging for the Diagnosis of Prostate Cancer

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Introduction
An early detection of prostate cancer is essential to reduce mortality rates. In the past years, several studies have shown that diffusion-weighted imaging (DWI) can differentiate tumor from normal peripheral zone [1-3]. Most of these studies have applied single-shot spin-echo EPI due to its high SNR-efficiency and its insensitivity to motion artifacts. However, susceptibility-induced artifacts and T2*-blurring limit the achievable resolution so that focal tumors might not be detected. Recent studies have addressed these problems using parallel imaging methods [3, 4]. However, the thereby achievable resolution is limited by spatial inhomogeneous noise amplification at high reduction factors. The present work demonstrates that a spatially reduced FOV can achieve submillimeter in-plane resolution for prostate cancer DWI. The technique is tested in a clinical study and the findings are compared with biopsy results as the gold standard.

Subjects and Methods
DW images were acquired using single-shot spin-echo EPI with a reduced FOV in phase-encode direction. Similar to parallel imaging methods, the echo train length is thereby effectively reduced leading to decreased susceptibility-related distortions and image blurring. However, the g-factor penalty that is associated with parallel imaging methods can be avoided. Aliasing artifacts were circumvented by a non-coplanar application of the spin-echo pulses in combination with outer-volume suppression [5, 6].

Results
The shortening of the readout train enabled DWI acquisitions with sub-millimeter in-plane resolution (0.7 x 0.7 mm²) without the occurrence of susceptibility-related artifacts leading to ADC maps that feature fine anatomical details (Fig. 1). The mean ADCs in the tumor tissue of the patients were significantly lower, the mean FA values significantly higher, than in the surrounding healthy tissue (one-tailed paired t-test, p < 0.05). However, no threshold for malignancy could be established. Moreover, the mean ADCs and FA values were not significantly different in the healthy tissue of the patients and the control group (two-tailed t-test) (Fig. 2). The two imaging techniques (T2-weighted and DWI) performed equally well in comparison with the biopsy results. Both methods feature high sensitivity but rather low specificity (Tab. 1). However, the outlines of the tumors were more clearly visible on the ADC maps.

Discussion and Conclusion
Reduced FOV single-shot EPI enables the acquisition of high-resolution DW images free of susceptibility-induced artifacts that show fine anatomical details. This enables accurate evaluation of diffusion parameters in localized structures of the prostate. As compared to T2-weighted imaging, ADC and FA values provide directly quantifiable markers. In the light of the rather low specificity the combination with complementary imaging techniques like spectroscopic or dynamic contrast enhanced imaging is mandatory. The high sensitivity shows the potential of the technique; especially when considering the mostly low PSA values (15 patients had PSA values lower than 9 ng/ml) in the present study.

References: