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Standardized and quality assured prostate diffusion MRI

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Aims and objectives

Diffusion Weighted Imaging (DWI) is an essential part of multiparametric MRI (mpMRI) for the detection of prostate cancer [1,2]. Due to the lack of standardization in clinical imaging protocols, however, data quality and apparent diffusion coefficient (ADC) values are not comparable in general. The aim of this work was the quantification and reduction of deviations in the measured ADC values within a consortium of imaging centers which collaborate for prostate mpMRI (RaDiagnostiX).

Methods and materials

Data Acquisition: DWI sequences of seven imaging centers (vendors: Siemens, Philips, GE; field strengths: 1.5 and 3 T) were quantitatively evaluated and compared by phantom and volunteer (healthy, 34 y, with a prostate cyst) measurements. The measurements were performed by using the in-house MR sequences as well as a specifically optimized and standardized MR sequence. The standardized DWI sequence parameters follow the recommendations stated in [3]. Key parameters are: in-plane resolution 2 x 2 mm^2, slice thickness 3 mm, b-values: 50, 1000 and 1500 s/mm^2.

Diffusion Phantom: A spherical phantom (diameter: 20 cm) with an aqueous polyvinylpyrrolidone (PVP) solution and an integrated thermometer was used (HQ Imaging, Heidelberg, Germany). The temperature dependency of the ADC was taken into account based on previously published calibration curves [4]. For this purpose, the temperature within the phantom was read out before each MRI measurement and the ADC was determined at a common standard temperature of 20 °C.

Data analysis: The ADC values were analyzed in the peripheral zone of the prostate as well as in the phantom. Exemplary regions of interest (ROIs) are shown in Fig. 1 on page 4. The ADC in the phantom was evaluated in a centrally located ROI of constant size. The mean ADC value of the phantom, its standard deviation and the correction of temperature effects were automatically determined by an analysis software (HQ Imaging, Heidelberg, Germany).
The obtained results from the RaDiagnostiX consortium were compared with the results from analogous measurements within the German Cancer Consortium (DKTK) [5]. Here nine university hospitals were analyzed. At DKTK one scanner vendor (Siemens), with field strengths of 1.5 T and 3 T was analyzed at each site. There was another choice of b-values for the standardized protocol at DKTK (b = 50, 400, 800 s/mm^2).

Images for this section:

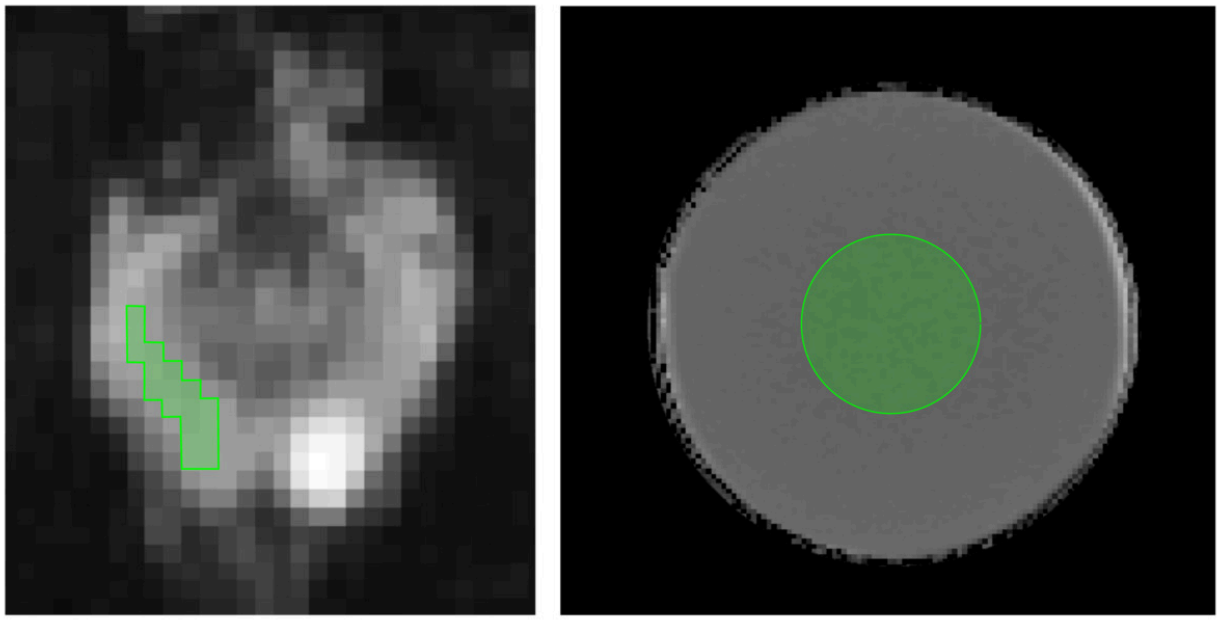

Fig. 1: ROIs (green) in the peripheral zone of the prostate (left) and in the phantom (right).

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Results

Volunteer measurements: All in-house sequences used reasonable clinical imaging parameters, but inter-site deviations up to 30 % were found in the measured ADC values (Fig. 2 on page 6). The error bars in Fig. 2 on page 6 indicate the standard deviations of the ADC in the analyzed ROIs. The main reason for the high inter-site deviations without protocol standardization is related to the implementation of varying b-values and an uncontrolled influence of perfusion effects [6, 7]. After optimization and standardization of sequence parameters, the deviations could be reduced by a factor of two. The mean ADC and its standard deviation among centers are 930 ± 96 $\mu m^2/s$ before standardization and 894 ± 41 $\mu m^2/s$ after standardization.
These findings are in line with the results from DKTK (Fig. 3 on page 6)[5]. The error bars in Fig. 3 on page 6 indicate the standard deviations of the ADC in the analyzed ROIs. ADC values in the cyst are depicted in blue, ADC values in the peripheral zone in green. The range of ADC values measured among the sites is depicted in red.
Analogous to RaDiagnostiX strong deviations in the measured ADC values of up to 30 % occur at the different DKTK centers. Protocol standardization reduces the deviations among the acquisition centers by a factor two to three. Mean ADC values and their standard deviations among the sites are summarized in Table 1 on page 7. At DKTK other b-values were used than at RaDiagnostiX. Thus, differences in the measured ADC have to be expected.
There is an obvious outlier in the ADC values at 3.0 T for site "E" which can be explained with a too low signal to noise ratio (SNR) at the high b-values, most likely due to coils problems at the specific site, leading to an underestimation of the ADC values.

Phantom measurements: The phantom measurements reflect the ADC determination under ideal conditions: high SNR, no partial volume effects, no perfusion. Hardware problems and post-processing differences can introduce deviations in the measured ADC among different sites. Fig. 4 on page 7 shows the results of the phantom measurements with the standardized sequences in the RaDiagnostiX consortium. The mean ADC and its standard deviation among centers are 1610 ± 12 $\mu m^2/s$. The low standard deviation indicates very good comparability of quantitative ADC values for different MRI scanners, especially including different vendors.

Images for this section:

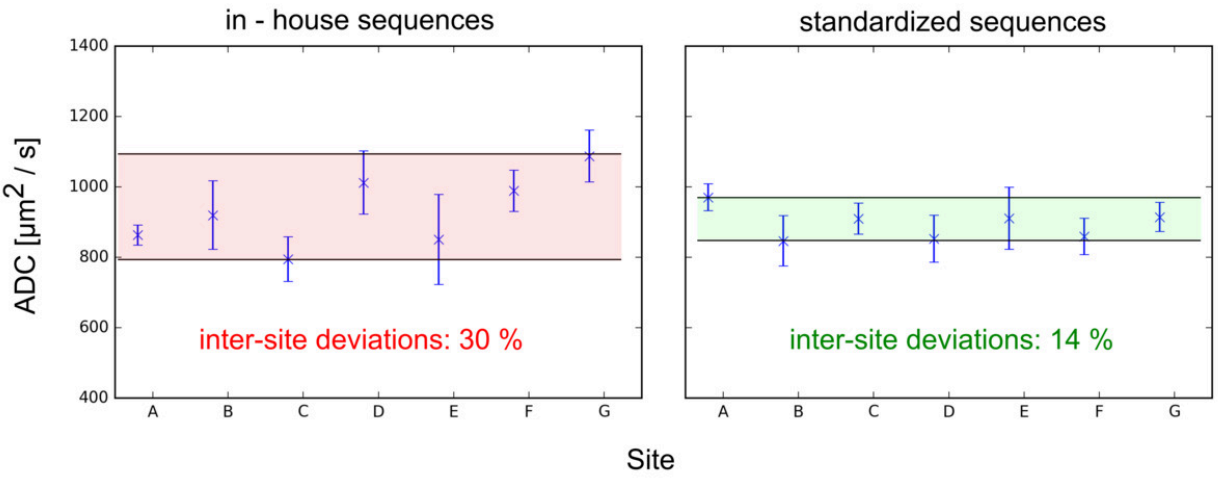

Fig. 2: Measured ADC values in the peripheral zone of the prostate with the in-house sequences (left) and standardized sequences (right). The ADC deviations are clearly reduced by standardization of imaging parameters (red and green area).

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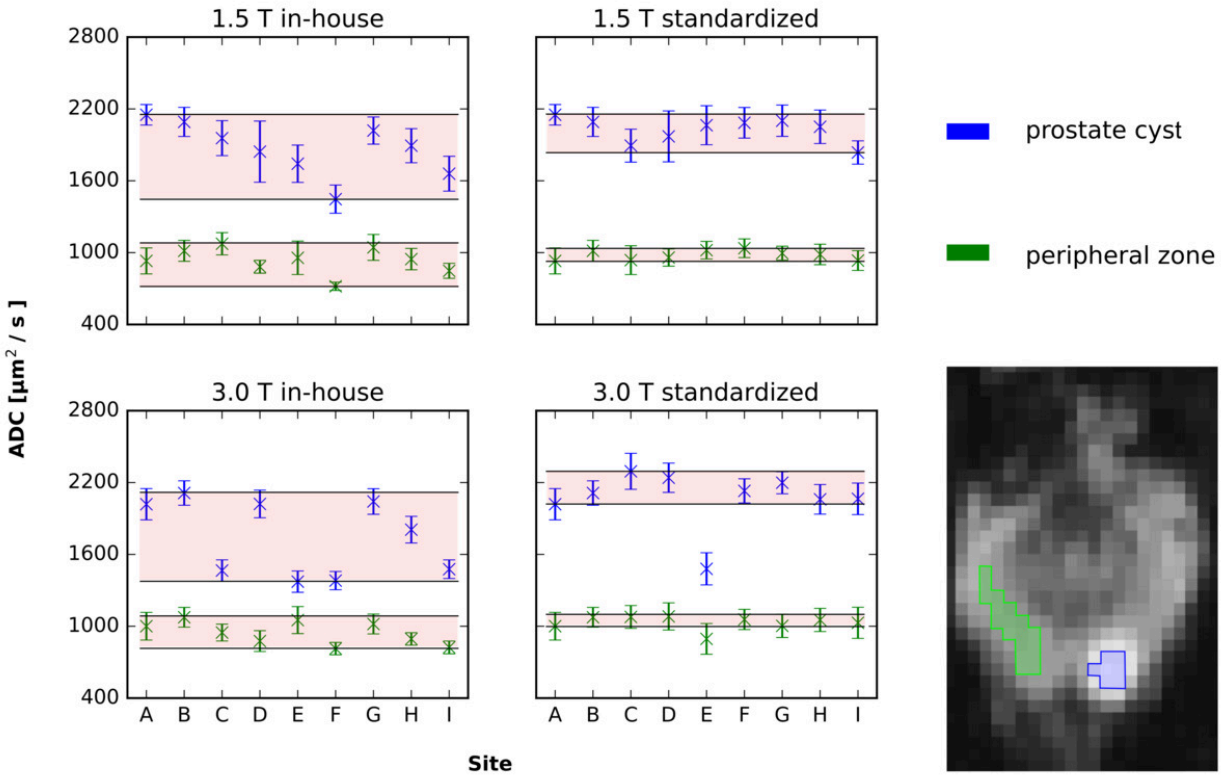

Fig. 3: DKTK prostate volunteer ADC measurements. Left: in-house protocols, right: standardized protocols, top: 1.5 T, bottom: 3,0 T. The measured ADCs in the peripheral

zone is depicted in green, the ADCs in the cyst in blue (see also the image of the prostate and corresponding ROIs in the lower right). The error bars indicate the standard deviation of the ADC within the ROI.

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REGION	IN HOUSE		STANDARDIZED	
	mean ADC	*standard deviation*	*mean ADC*	*standard deviation*
1.5 T prostate peripheral zone	935	103	979	38
1.5 T prostate cyst	1867	211	2027	99
3 T prostate peripheral zone	944	92	1047	31
3 T prostate cyst	1744	298	2140	90

Table 1: Mean ADC values and their standard deviations among the DKTK sites.

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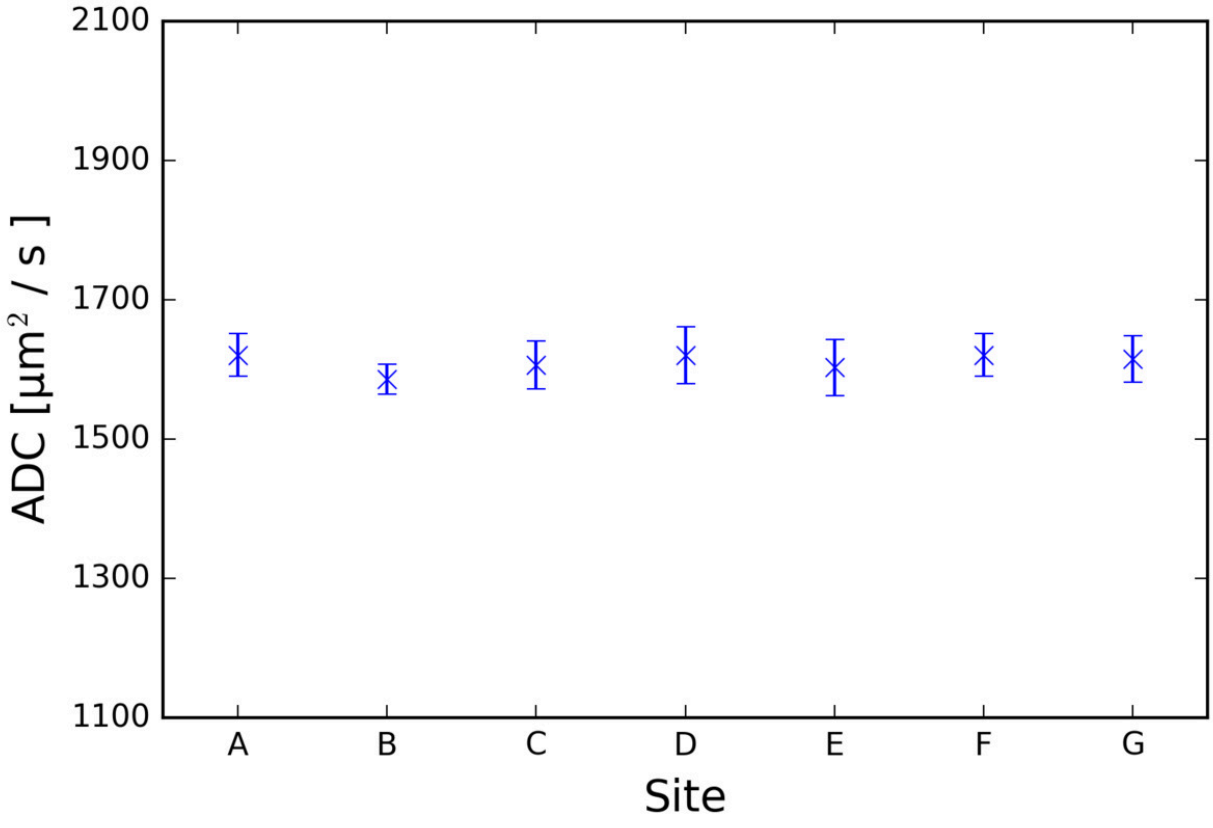

Fig. 4: Measured ADC values in the phantom for the RaDiagnostiX sites with standardized sequences.

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Conclusion

Significant deviations in measured ADC values have to be expected for different MR scanners if conventional diffusion-weighted MR sequences are used. Optimization and standardization of MR sequences yield the high comparability of ADC values and enabling comparable ADC measurements even when MR scanners from different vendors are in use.

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Personal information

Please, do not hesitate to contact us if you have any questions regarding MRI standardization and protocol optimization (diffusion imaging and MRI in general).

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References

1. Veeru Kasivisvanathan, Antti S. Rannikko, Marcelo Borghi et al. (2018) MRI-Targeted or Standard Biopsy for Prostate-Cancer Diagnosis. N Engl J Med; 378:1767-1777
2. Weinreb JC, Barentsz JO, Choyke PL et al. (2016) PI-RADS Prostate Imaging-Reporting and Data System:2015,Version 2. Eur Urol; 69(1):16-40
3. Franiel T, Quentin M, Mueller-Lisse UG et al. (2017) MRI of the Prostate: Recommendations on Patient Preparation and Scanning Protocol. Fortschr Röntgenstr; 189: 21-28
4. Wagner F, Laun FB, Kuder TA et al. (2017) Temperature and concentration calibration of aqueous polyvinylpyrrolidone (PVP) solutions for isotropic diffusion MRI phantoms. PLoS ONE 12(6): e0179276
5. Kleesiek J, Bach M, Antoch G et al. (2018) Harmonizing Multi-Center MR-Diffusion Imaging using Standardized Phantom Calibration: Initial Results of the German Cancer Consortium Joint Imaging Platform (DKTK-JIP) Initiative. Manuscript submitted for publication.
6. Le Bihan D, Breton E, Lallemand D et al. (1988) Separation of diffusion and perfusion in intravoxel incoherent motion MR imaging. Radiology; 168: 497-505
7. Koh DM, Collins DJ, Orton MR (2011) Intravoxel Incoherent Motion in Body Diffusion-Weighted MRI: Reality and Challenges. American Journal of Roentgenology196:6, 1351-1361