Standardized and quality assured prostate diffusion MRI

Poster No.: C-2163
Congress: ECR 2019
Type: Scientific Exhibit
Authors: M. Bach¹, M. Röthke², T. Henzler³, M. Kreft¹, B. Amler¹, H.-P. Schlemmer¹; ¹Heidelberg/DE, ²Hamburg/DE, ³München/DE
Keywords: Quality assurance, Image verification, Cancer, Technical aspects, Imaging sequences, MR-Diffusion/Perfusion, MR, Oncology, MR physics, Abdomen
DOI: 10.26044/ecr2019/C-2163

Any information contained in this pdf file is automatically generated from digital material submitted to EPOS by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply ECR's endorsement, sponsorship or recommendation of the third party, information, product or service. ECR is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.
As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method is strictly prohibited.
You agree to defend, indemnify, and hold ECR harmless from and against any and all claims, damages, costs, and expenses, including attorneys' fees, arising from or related to your use of these pages.
Please note: Links to movies, ppt slideshows and any other multimedia files are not available in the pdf version of presentations.
www.myESR.org
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 mm², slice thickness 3 mm, b-values: 50, 1000 and 1500 s/mm².

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/mm²).
Fig. 1: ROIs (green) in the peripheral zone of the prostate (left) and in the phantom (right).

© - Heidelberg/DE
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 µm²/s before standardization and 894 ± 41 µm²/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 µm²/s. The low standard deviation indicates very good comparability of quantitative ADC values for different MRI scanners, especially including different vendors.
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).

© - Heidelberg/DE

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.

© - Heidelberg/DE

<table>
<thead>
<tr>
<th>REGION</th>
<th>IN HOUSE</th>
<th>STANDARDIZED</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean ADC</td>
<td>standard deviation</td>
</tr>
<tr>
<td>1.5 T prostate peripheral zone</td>
<td>935</td>
<td>103</td>
</tr>
<tr>
<td>1.5 T prostate cyst</td>
<td>1867</td>
<td>211</td>
</tr>
<tr>
<td>3 T prostate peripheral zone</td>
<td>944</td>
<td>92</td>
</tr>
<tr>
<td>3 T prostate cyst</td>
<td>1744</td>
<td>298</td>
</tr>
</tbody>
</table>

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

© - Heidelberg/DE

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

Acknowledgement

We wish to thank the following persons for their great support of this study:

Dr. Rüdiger Arndt
Radiologiezentrum Mannheim

Dr. Wilfried Berning
Bilddiagnostisches Zentrum Münster

Dr. Udo Bühring
Radiologie Landau

Prof. Dr. Thomas Henzler
Diagnostik München

Martin Kollerer
Radiologie Marktredwitz

Olaf Mallien
Conradia Berlin

Dr. Frank Müller
Radiologie und Nuklearmedizin Ludwigshafen

Dr. Jonas Müller-Hübenthal
Praxis im Köln Triangle

Priv. Doz. Dr. Matthias Röthke
Conradia Hamburg

Dr. Jörg Rückforth
Radiologie Team Rur

Dr. Michael Scherer
Radiologie Kassel am Stern

Bernhard Schneider
Bildgebende Diagnostik Wertheim
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).

Dr. Michael Bach

German Cancer Research Center / HQ Imaging, Heidelberg

phone: +49 177 1490 696

e-mail: m.bach@hq-imaging.de
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
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
calibration of aqueous polyvinylpyrrolidone (PVP) solutions for isotropic
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.
and perfusion in intravoxel incoherent motion MR imaging. Radiology; 168:
497-505
Diffusion-Weighted MRI: Reality and Challenges. American Journal of
Roentgenology196:6, 1351-1361