Radiology

Better Image Quality for Diffusion-weighted MRI of the Prostate Using Deep Learning

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Prostate MRI has an established benefit of improving clinically significant prostate cancer diagnosis through guiding biopsies (1). In addition, prostate MRI may be useful for ruling out the presence of clinically significant prostate cancer, saving patients from unnecessary biopsies (2). The growing evidence for the benefit of prostate MRI is reported by academic centers. To date, it is unclear if the successful results reported by academic centers can be reproduced in routine community practice. These concerns are closely linked to the nonuniform quality of prostate MRI scans and guided biopsies across various practices (3).

The inconsistent quality is likely the result of the complex nature of the MRI-guided localized prostate cancer diagnosis pathway. Multiple key steps are involved: prostate MRI scan acquisition, MRI scan interpretation, data processing for biopsy guidance, biopsy procedure, and biopsy specimen interpretation. These steps are handled by professionals from different disciplines, including an MRI technologist, diagnostic and interventional radiologist, urologist, and pathologist (4). Acquisition of a good-quality MRI scan is the first step of this pathway.

To establish a standard for this first step of obtaining a good-quality MRI scan, the Prostate Imaging Reporting and Data System (PI-RADS) committee has established minimum technical requirements in their guideline documents (5). Adherence to these requirements is quite variable and does not necessarily ensure acquiring good-quality prostate MRI scans (6,7). In an attempt to improve the image acquisition quality control process, the PRECISION trial study group introduced the Prostate Imaging Quality (PI-QUAL) system in 2020. PI-QUAL aims to assess prostate MRI quality at the front line and to provide a level of confidence to act on prostate MRI findings and help scan variability through a formal feedback mechanism (8). PI-QUAL and its impact on improving prostate MRI quality are currently being evaluated in a number of studies, and it will be interesting to see outcomes of this research.

PI-RADS and PI-QUAL aim to deliver high standards for consistent image acquisition and quality evaluation to improve prostate MRI-guided clinical care. In addition, several proactive research initiatives have been undertaken to improve the quality problem in prostate MRI—mainly by optimizing image reconstruction using deep learning (DL). In a study by Gassenmaier et al (9), with 30 patients, DL-based T2-weighted MRI scan acquisition was much faster than acquisition without DL (1.5 minutes vs 4.5 minutes, respectively), with lower noise levels and superior image quality. Although the impact of this approach on lesion detection and read-out performance was not assessed in a prospective manner, the DL method aims to tackle image quality problems at the level of image acquisition.

In this issue of *Radiology*, Ueda and colleagues (10) evaluate whether DL reconstruction (DLR) can improve the quality of images obtained at diffusion-weighted imaging (DWI) at *b* values ranging from 1000 to 5000 sec/mm^2 in patients with prostate cancer. For DWI, both its apparent diffusion coefficient (ADC) maps and high-*b*-value (*b* value = 1400 sec/mm^2) components have been reported to be useful for locating prostate cancer lesions and for estimating their aggressiveness (5). In their retrospective study of 60 consecutive patients with biopsy-proven prostate cancer, MRI scans obtained at DWI with *b* values of 0, 1000, 3000, or 5000 sec/mm^2 were reconstructed with and without DLR. Signal-to-noise ratio, contrast-to-noise ratio, and ADCs were compared with and without DLR for each DWI method. Additionally, the authors evaluated image quality with a five-point visual scoring system (1: very poor, 2: poor, 3: equivocal, 4: good, 5: excellent).

The key results indicated that DWI with *b* values of 1000, 3000, and 5000 sec/mm^2 had higher signal-to-noise and contrast-to-noise ratios with DLR than without DLR. Closely related to this quantitative analysis, the qualitative evaluation revealed that DWI with DLR had a higher visual quality than DWI without DLR. ADCs of benign versus cancerous foci for DLR-based MRI showed the same trends as MRI without DLR. This is critical to ensure that DLR does not insert adverse features into the images. Finally, the comparisons made by the authors of DLR and conventional MRI had high intra- and interobserver agreement.

Ueda et al have thus presented one of the first proactive approaches to improve DWI quality using DLR. This new

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Conflicts of interest are listed at the end of this article.

See also the article by Ueda et al in this issue.

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method uses a convolutional neural network with three layers for denoising images and improving image quality. Despite being a strong pulse sequence for detecting and characterizing prostate cancer, DWI is one of the most fragile techniques of prostate MRI because it can be frequently corrupted by susceptibility artifacts (eg, rectal gas, hip replacement prosthesis). Routine use of DLR can be helpful for improving the image quality of such a useful but nonrobust pulse sequence. This study did not include a patient sample negatively impacted by either rectal gas or prosthesis artifacts on DWI scans. However, a DLR-based denoising strategy can improve image quality in such challenging scenarios.

This study by Ueda and colleagues is not without limitations. This is a retrospective study. Thus, actual clinical read-outs of DLR-based DWI scans by radiologists did not happen. Therefore, the actual impact of this approach on prospective lesion detection and delineation and the comfort level of radiologists in reporting the detected lesions must be carefully studied. As previously mentioned, the DLR algorithm must be challenged with nondiagnostic DWI data, which include clinically significant artifacts. If it maintains the good performance defined in this study in terms of quality improvement, it is a clear win for patients and their physicians.

In summary, maintaining a uniform, high-quality MRI-guided biopsy pathway for clinical management of localized prostate cancer is critical. Ueda et al demonstrate a new DLR approach for improved DWI quality. This method can potentially be a first step for optimizing the performance of an MRI-guided diagnosis pathway. However, DLR-based DWI first needs validation in prospective studies depicting near real-world situations.

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