AI Scientific Evidence - MRI

AI enables high-resolution non-contrast MR Coronary Angiography

Non-contrast Magnetic Resonance Coronary Angiography (MRCA) is a technique to assess coronary morphology without a contrast agent or ionizing radiation. Despite the great potential of this technique for the diagnosis and management of coronary artery disease, it is not widely used. To make the use of non-contrast MRCA more common, a higher spatial resolution that does not prolong scan time is needed. Typically, an increase in resolution leads to a drop in SNR. Therefore, Yokota et al. chose in their study to increase the resolution but compensate the SNR drop by using Deep Learning Reconstruction (DLR) to reduce the noise.

Deep Learning Reconstruction for MR Coronary Angiography

The authors used the Advanced intelligent Clear-IQ Engine (AiCE) DLR technique from Canon Medical Systems to improve the image quality of high-resolution non-contrast MRCA. To evaluate the infl uence on image characteristics, the authors scanned ten healthy volunteers on Vantage Galan 3T MR system (Canon Medical Systems) using standard MRCA and a high-resolution MRCA protocol. The diff erence in resolution between the standard and high-resolution protocol was a factor of three. The high-resolution images were evaluated both with and without DLR (AiCE).

Signifi cant improvements in image characteristics

The standard and high-resolution images were evaluated quantitatively by looking at the contrast-to-noise ratio (CNR) and qualitatively by a visual evaluation by two experienced observers. The CNR improved signifi cantly when DLR was applied to the high-resolution images. Figure 1 shows the results of the qualitative analysis, which demonstrates that the sharpness and traceability of the vessels signifi cantly improved between standard MRCA and high-resolution MRCA plus DLR.

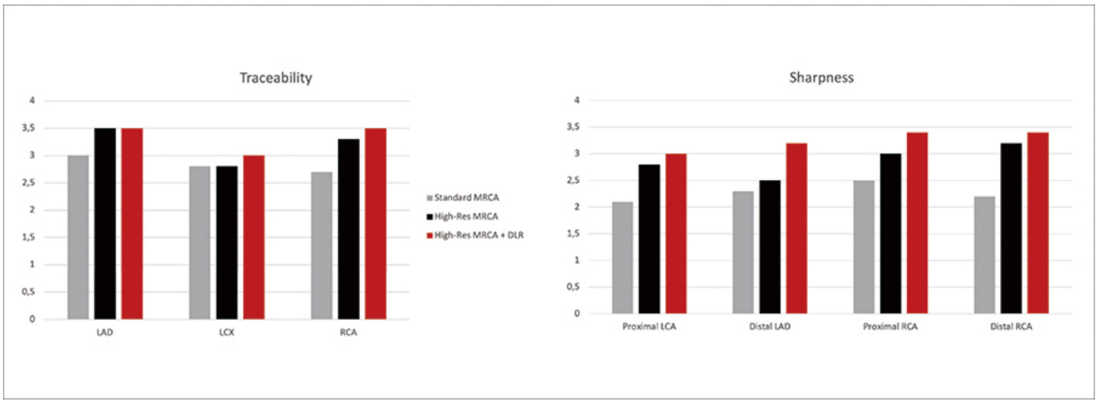

Figure 1. The sharpness and traceability of the vessels were scored by 2 experts on a scale for 1 (poor) to 4 (excellent). Except for the left circumflex (LCX) all scores were significantly different between the standard and the high-resolution MRCA+DLR. Abbreviations: left coronary artery (LCA), left anterior descending (LAD), right coronary artery (RCA)

As a next step, the authors recommend evaluating this in a patient cohort to demonstrate the clinical value. Important in clinical translation is also applicability to all fi eld strengths. In Figure 2 we show that this technique is not just successful at 3T, but can be extended to 1.5T. These images show how DLR improves the visualization of coronary arteries in volume renderings of high-resolution non-contrast MRCA images.

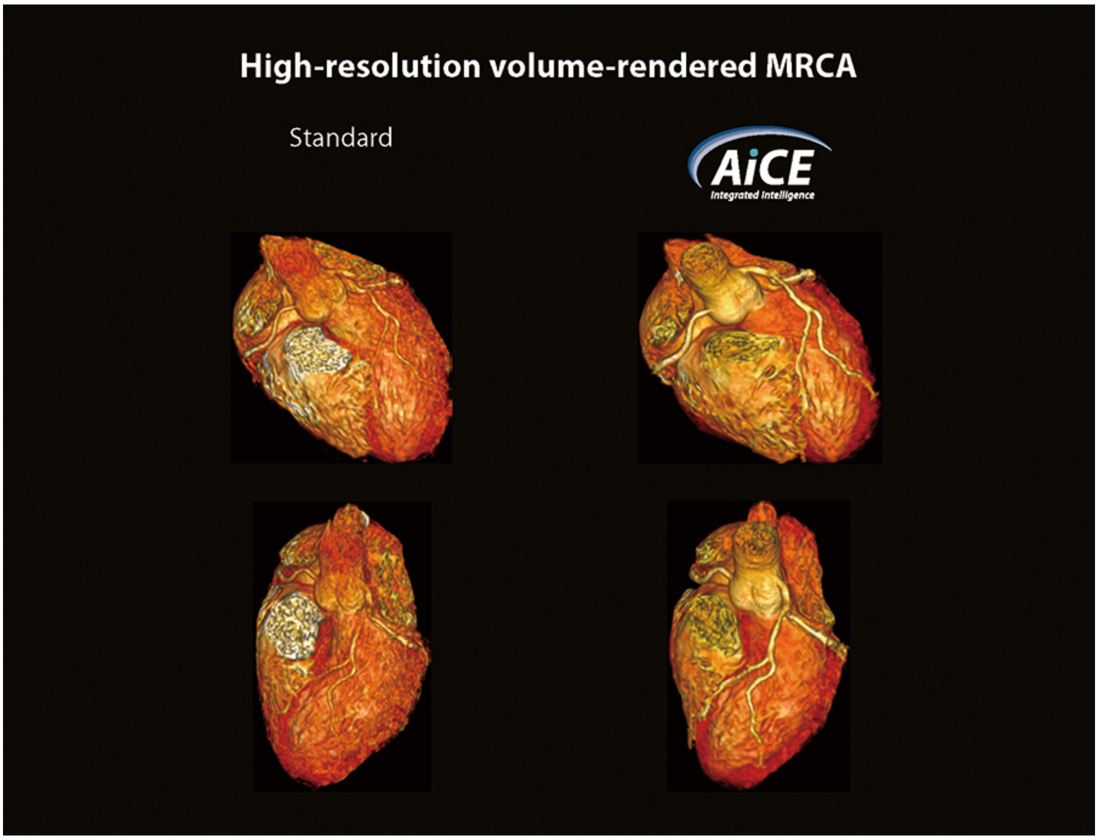

Figure 2. Example acquired on a 1.5T Vantage Orian of high-resolution non-contrast MRCA without (left) and with (right) Canon Medical's DLR technology AiCE. The volume rendered images nicely demonstrate the improved visibility of the coronary arteries with AiCE.

Reference

Yokota et al. | Effects of Deep Learning Reconstruction Technique in High-Resolution Non-contrast Magnetic Resonance Coronary Angiography at a 3-Tesla Machine | Can Assoc Radiol J (2021)
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Deep Learning Reconstruction improves the reliability of quantitative diff usion-weighted imaging

In MR there is always a trade-off between scan time, resolution and SNR. Deep Learning Reconstruction (DLR) is a technique that alleviates this trade-off by removing noise from the images to expand diagnostic capabilities for anatomical imaging. However, the value of DLR for more quantitative techniques like Diff usion-Weighted Imaging (DWI) and Diff usion Tensor Imaging (DTI) is less investigated. For these techniques it is important for the quantitative value not to change when DLR is applied. This means that the values of the Apparent Diff usion Coeffi cient (ADC), Fractional Anisotropy (FA) or fi ber volume are the same with and without DLR. To research this, Sagawa et al. have investigated the infl uence of DLR on DWI and DTI in the brain.

Fast DTI protocol combining MultiBand SPEEDER and DLR

The researchers included 20 patients with various brain diseases who were scanned on a Vantage Galan 3T (Canon Medical Systems) using a 32-channel head coil. The DTI scans were acquired with a b-value of 1000 s/mm^2 and 12 gradient directions. To prevent long scan times, the scans were accelerated with Canon Medical's technique for simultaneous multi-slice acquisi- tion: MultiBand SPEEDER. Two scans were performed: one single acquisition in 1:05 min (NAQ1) and a ground-truth scan with 5 averages of 5:45 min (NAQ5). The single acquisition scan was reconstructed twice, one time using standard reconstruction and once using the Advanced intelligent Clear-IQ Engine (AiCE) DLR technique from Canon Medical Systems.

Improved reliability of quantitative values and better fi ber tracking with DLR

There were no signifi cant diff erences in the signal intensity of the b-1000 diff usion images or the ADC values in any of the brain regions for the three datasets (NAQ1, NAQ5 and NAQ1 plus DLR). The same holds for the FA values, except in the deep gray matter. In the deep gray matter, the FA values were lowest for NAQ5 and highest for NAQ1. It is known that for areas with a low SNR, like the deep gray matter, the FA value tends to be overestimated. This overestimation was lower when DLR was applied, indicating that DLR improves the reliability of the scan. Also the decreased standard deviation and improved SNR in most brain regions demonstrates improved reliability with DLR (Figure 1).

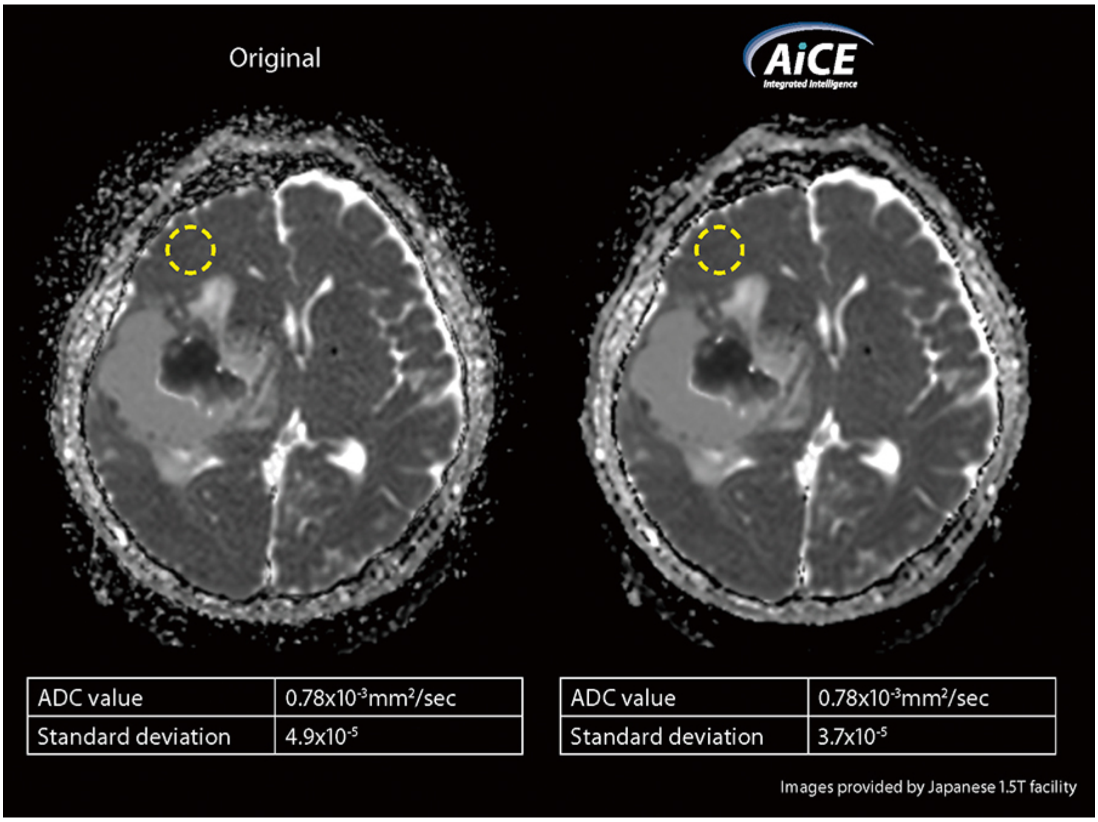

Figure 1. Example ADC map acquired at 1.5T (Vantage Orian) confirming the observations by Sagawa et al. The ADC value is the same with and without AiCE, but the standard deviation has improved for the map reconstructed with AiCE.

To evaluate the infl uence of DLR on Diff usion Tensor Tracking (DTT) of the pyramidal tracts, the Fiber Volume (FV) was determined. When the SNR is low, tracking points are terminated due to image noise, resulting in a low FV. Figure 2 shows the Fiber Volumes of the three datasets. Both NAQ5 and NAQ1 plus DLR are signifi cantly better than NAQ1 (Figure 2), demonstrating the feasibility of single averaging fast DTT with DLR for depicting white matter fi bers for preoperative planning.

Sagawa et al. demonstrated in their study that DLR not only reduces noise, but also improves the reliability of ADC and FA values. In this study, the scan time of the scans with DLR was fi ve times lower than the ground truth, which can have a big impact on workfl ow and patient comfort.

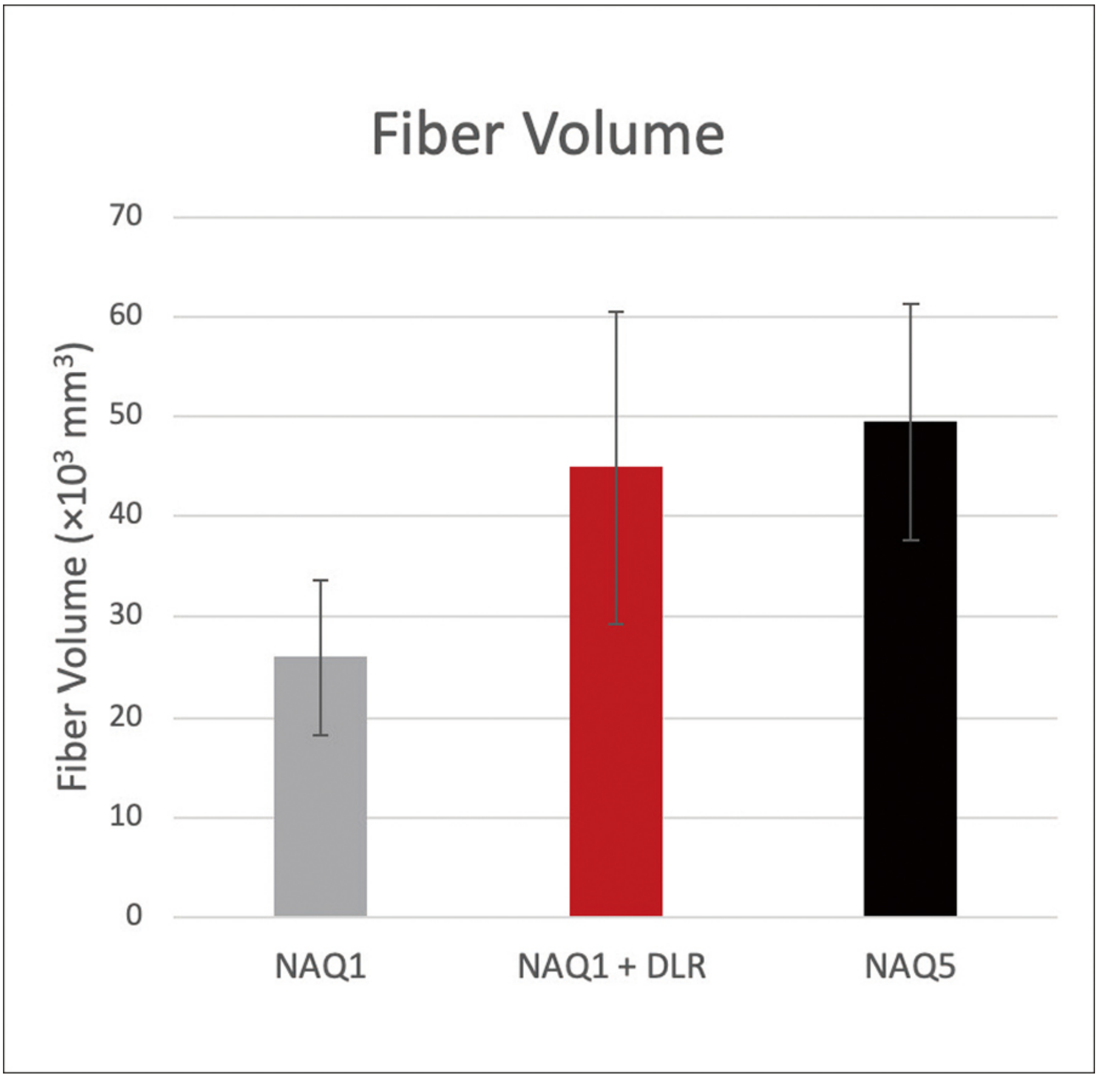

Figure 2. Fiber Volume of the pyramidal tracts. Both NAQ5 and NAQ1 + DLR are significantly better than NAQ1. There was no significant difference between NAQ5 and NAQ1+DLR.

Reference
Sagawa et al. | Deep Learning-based Noise Reduction for Fast Volume Diffusion Tensor Imaging: Assessing the Noise Reduction Effect and Reliability of Diffusion Metrics | Magn Reson Med Sci (2020)
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