Introducing Sonic DL for highly accelerated isotropic acquisitions

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Over the past 40 years, MR imaging has largely grown along two "dimensions" of invention—advancements in image quality and improvements in scan efficiency. These dimensions can be at odds with one another, as improvements in efficiency typically come at the cost of image quality. Artificial Intelligence (AI) can serve as a "third dimension" of innovation for MR imaging. Through AI-enabled technologies, we believe the future of MR is one where access and sustainability, population health, patient care pathways and new clinical indications for MR have the potential to markedly improve the quality of healthcare provided globally. Recently, this "third dimension" has seen the development of two transformative deep learning (DL) technologies that serve to bridge the divide between image quality and scan time: AIR™ Recon DL and Sonic DL™.

The concept for AIR Recon DL began in 2015 when Marc Lebel, PhD, a scientist at GE HealthCare, and his colleagues were investigating ways to streamline the MR image reconstruction process and improve image quality by reducing the number of different image manipulation stages. Key design goals were to move away from inherent deficiencies with existing methods for image reconstruction, including advancing denoising techniques and removing the apodization (raw data) filter for sharper images. As DL emerged in the industry, the team developed a prototype, and it became clear based on initial results and external clinical feedback that this approach was the best option. Although reducing scan time was not a primary goal at first, it increasingly became apparent that this would be a key benefit of AIR Recon DL. In 2020, GE HealthCare received its first FDA clearance for AIR Recon DL.

Sonic DL debuted in 2023 for cardiac imaging and showed significant improvements in image quality and an 83% reduction in scan time for 2D FIESTA Cine acquisitions. With FIESTA Cine being the workhorse of cardiac imaging, these reductions in scan time greatly improved the workflow efficiency for cardiac imaging. Additionally, the higher acceleration factors helped reduce the number of cardiac cycles needed to acquire the Cine images—as low as a single heartbeat. This could not be done without Sonic DL, and truly allows the acquisition of images at the speed of life. These results are impressive, and Sonic DL Cine serves as a launching pad to expand the acceleration technology to a broader array of imaging sequences. This will compound the collective impact of Sonic DL, where it can deliver outcomes aligned to all three dimensions of MR innovation.

To ensure that similar gains in efficiency are seen in volumetric acquisitions, Sonic DL is being expanded to support 3D imaging sequences. Sonic DL 3D[‡] offers acceleration factors as high as 12 times and can offer an 86% reduction in scan time compared to non-accelerated acquisitions. While Sonic DL Cine highly under-sampled the phase and temporal dimensions of *k*-space, Sonic DL 3D under-samples the phase and the slice dimensions. A pre-trained, physics-constrained neural network is used to reconstruct the highly under-sampled *k*-space to generate artifact-free images. The announcement of 3D image compatibility

[‡] 510(k) pending at US FDA. Not yet CE marked. Not available for sale.

with Sonic DL represents the culmination of years of work to optimize parameters that ensure results meet the highest standards for quality.

While there are scan-time benefits from both AIR Recon DL and Sonic DL, these are distinct features, and when used in combination, their scan time benefits are cumulative. As AIR Recon DL reduces noise in images, it allows modifications in the protocols to reduce scan time while still maintaining the image quality. For example, the number of averages (NEX) can be reduced or the receiver bandwidth can be increased—both can reduce the scan time but cause an increase in the noise. However, AIR Recon DL reduces that additional noise. Conversely, Sonic DL is an acceleration method much like ARC (parallel imaging) or HyperSense (compressed sensing), but is designed to support higher acceleration factors. When used in combination, the Sonic DL acceleration factor can be increased beyond the threshold of acceptable image quality otherwise possible due to the integration of AIR Recon DL's noise reduction effect. In essence, Sonic DL's acceleration is increased when used with AIR Recon DL—they are better together.

While Sonic DL and AIR Recon DL provide obvious benefits to scan time and image quality, the use of multiple DL applications in a series can increase the computational burden. This could significantly hamper the usability of the feature by increasing the time to reconstruct images, thereby nullifying any benefit gained by reducing the scan time. The ability to perform thousands of calculations as part of the DL reconstructions also posed a technical challenge that was resolved with a careful, thoughtful design of a multi-GPU-based solution that provides upgradeability to our existing customers. The updated reconstruction hardware ensures a timely reconstruction of the images, obscuring the computational burden from the end user. These changes truly help maintain the overall benefit of reducing exam time and allowing larger number of patients access to MR imaging.

Increasing a community's access to healthcare is a demonstrable benefit of adopting technologies like AIR Recon DL and Sonic DL, but it shouldn't come at the expense of diagnostic confidence for the providers. Radiologists will be the first to observe an increase of in-plane and through-plane resolution without a scan time penalty. For example, clinicians will now have the ability to acquire the often time-intensive dual inversion recovery (DIR) Cube volumetric exam in neuro in just 2 minutes with sufficient resolution to appreciate small calcifications and subtle hyperintensities.

Since 2018, our team has released a growing body of products that use AI to improve image quality, reduce setup and workflow times,

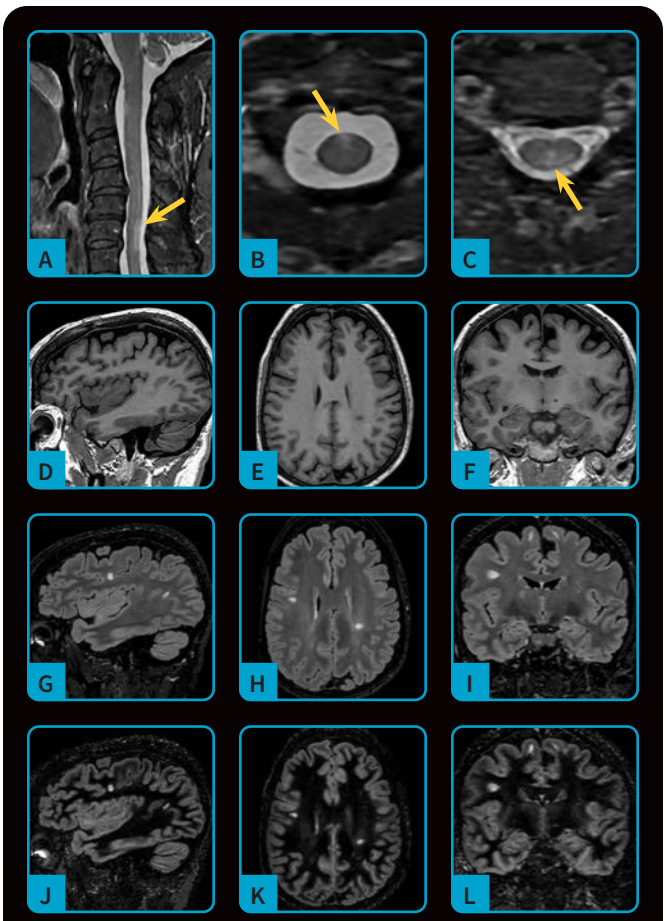

Figure 1. Brain and cervical imaging on a person with multiple sclerosis using Sonic DL 3D with AIR Recon DL. (A) Sagittal STIR Cube, 0.9 x 0.9 x 1 mm, 80 slices, 1:26 min. and (B, C) axial reformats depicting spine lesions. (D) Sagittal 3D BRAVO, 1 x 1 x 1 mm, 150 slices, 1:03 min. with (E) axial and (F) coronal reformats. (G) Sagittal T2 FLAIR Cube, 1.1 x 1.1 x 1.4 mm, 150 slices, 2:13 min. with (H) axial and (I) coronal reformats. (J) Sagittal DIR Cube, 1.2 x 1.2 x 1.4 mm, 150 slices, 1:56 min. with (K) axial and (L) coronal reformats.

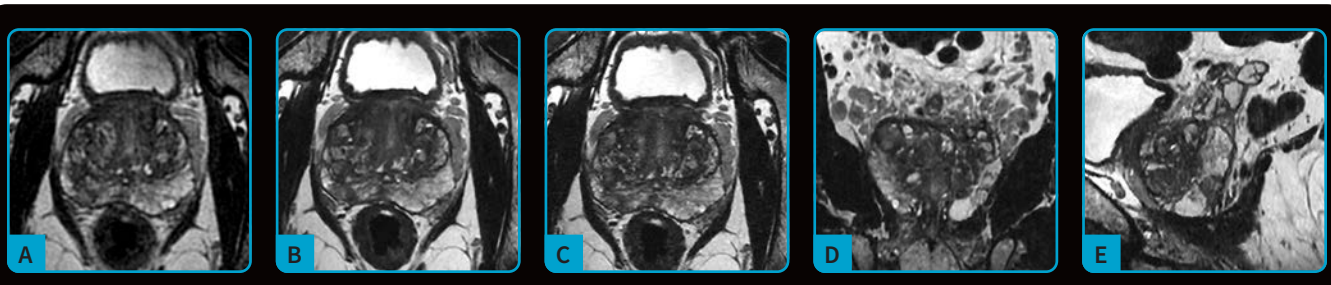

Figure 2. Prostate imaging with Sonic DL 3D and AIR Recon DL, demonstrating 31% scan time reduction and 50% resolution improvement when (C) both Sonic DL and AIR Recon DL are used. (A) Axial T2 Cube with HyperCube without AIR Recon DL or Sonic DL, 0.8 x 0.8 x 1 mm, 4:27 min., 244 slices. (B) Axial T2 Cube with HyperCube with AIR Recon DL and without Sonic DL, 0.7 x 0.7 x 1 mm, 3:42 min., 244 slices. (C) Axial T2 Cube with HyperCube, AIR Recon DL and Sonic DL, 0.6 x 0.6 x 0.9 mm, 3:04 min., 280 slices, reformatted into (D) coronal and (E) sagittal planes.

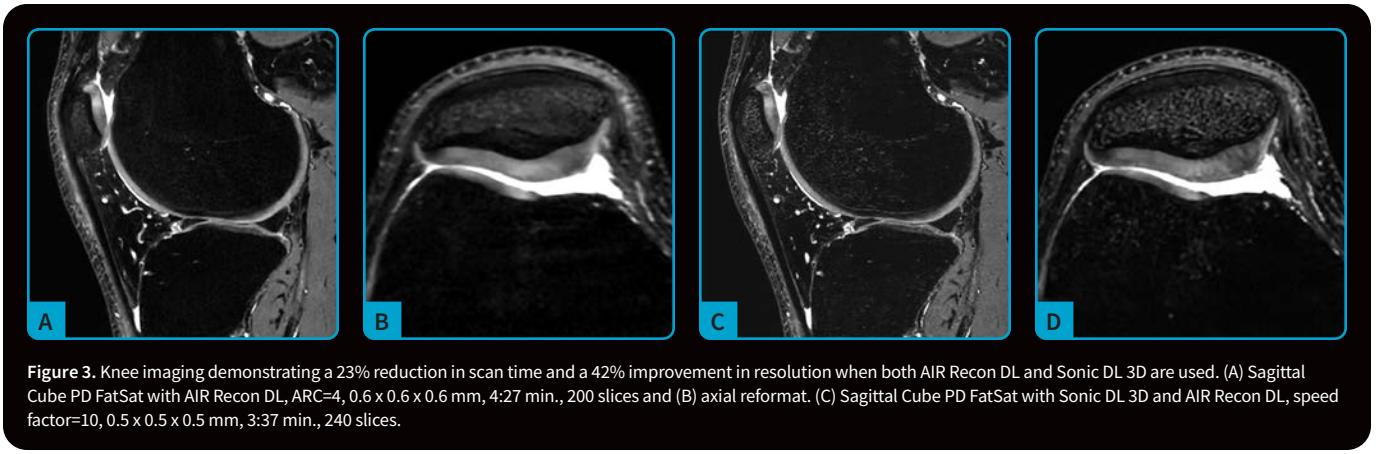

Figure 3. Knee imaging demonstrating a 23% reduction in scan time and a 42% improvement in resolution when both AIR Recon DL and Sonic DL 3D are used. (A) Sagittal Cube PD FatSat with AIR Recon DL, ARC=4, 0.6 x 0.6 x 0.6 mm, 4:27 min., 200 slices and (B) axial reformat. (C) Sagittal Cube PD FatSat with Sonic DL 3D and AIR Recon DL, speed factor=10, 0.5 x 0.5 x 0.5 mm, 3:37 min., 240 slices.

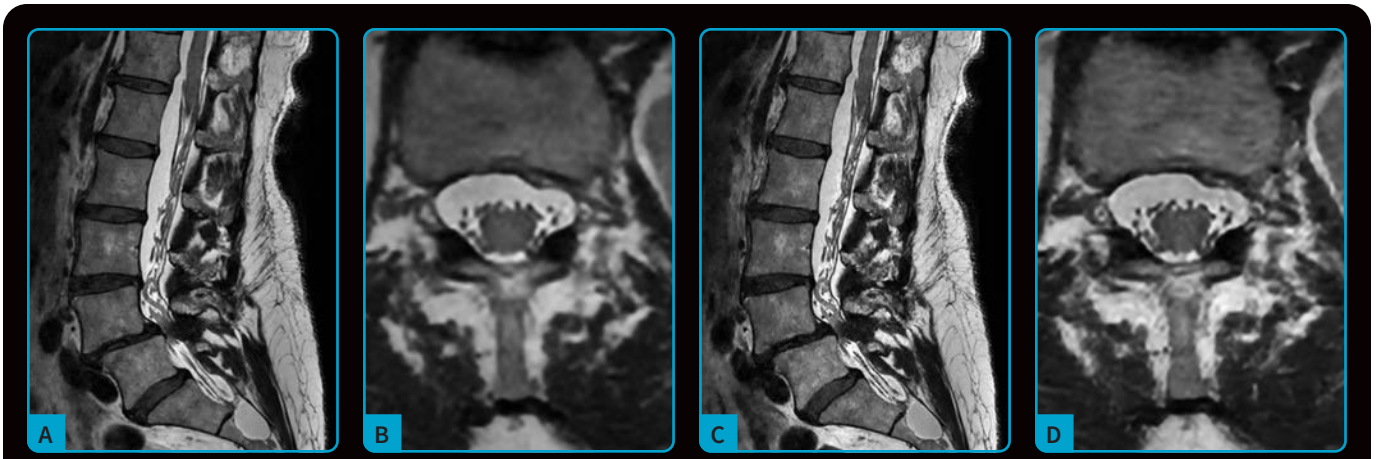

Figure 4. Spine imaging demonstrating a 58% improvement in resolution when both AIR Recon DL and Sonic DL 3D are used. (A) Sagittal T2 Cube with AIR Recon DL, ARC=2, 0.8 x 0.8 x 0.8 mm, 4:31 min., 136 slices and (B) axial reformat. (C) Sagittal T2 Cube with Sonic DL 3D and AIR Recon DL, speed factor=6, 0.6 x 0.6 x 0.6 mm, 4:31 min., 180 slices and (D) axial reformat.

and reduce scan times. These innovations have come incrementally, each building on the last to broaden the scope and coverage of the products, while honoring our history of the SIGNA™ Continuum™ and the clear mandate from our customers to develop products that grow and evolve over time without the need for replacement. AIR Recon DL has grown from initially supporting 2D FSE sequences to now including DWI/EPI, DTI, 3D, PROPELLER and MAGiC multi-contrast imaging. The evolution of Sonic DL is expected to evolve in a similar fashion, with new sequences and capabilities to come over time. We hope you'll join us on this journey through the new "third dimension" of MR.