GE Healthcare

Customer Testimonial

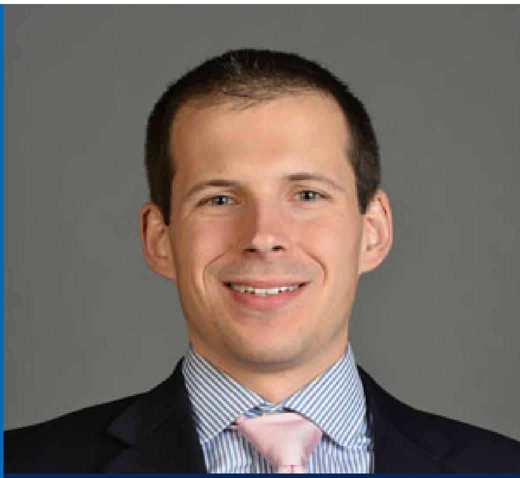
Customer Experience: University of Wisconsin-Madison Advances CT Protocols with Deep Learning Image Reconstruction Technique

Article based on University of Wisconsin-Madison's experience with deep learning image reconstruction.

University of Wisconsin-Madison is home to the world's largest medical physics department. That technical knowledge is put to use by UW-Madison's Department of Radiology's CT protocol optimization team, a group well-known for developing and modifying CT imaging protocols validated in academic, rural, clinic, and hospital settings: for clinical indications including head, whole body, cardiac and vascular CT applications. Their comprehensive modern protocols help reduce dose, acquire more clinically useful images, and avoid repeating scans in an effort to image wisely and image gently.

Staying ahead of the curve often means becoming early adopters of CT technology, which the UW-Madison team accomplishes through their active involvement in collaborative relationships like the one the team has built with GE Healthcare.

"Our relationship with GE Healthcare allows us to partner with their scientists and engineers in ways that enable faculty members to acquire insights and take full advantage of technological advancements and unique capabilities offered by the latest GE CT scanner platforms at the earliest possible opportunity," said Dr. Tim Szczykutowicz, PhD., DABR, Associate Professor, University of Wisconsin-Madison. "As the relationship with GE Healthcare has evolved over the years, we've built a continuously reviewed and updated library of the most advanced CT protocols made available worldwide to current and future GE CT users."



Dr. Tim Szczykutowicz

When the UW-Madison research faculty was introduced to the new advanced CT image reconstruction method from GE Healthcare at RSNA 2018, the team was so convinced by what they saw that they initiated phantom tests at GE headquarters immediately to evaluate TrueFidelity, a deep learning iterative reconstruction (DLIR) approach that is one of the early deep learning algorithms to receive clearance by the Food and Drug Administration (FDA). The team wanted to ensure they would be prepared to hit the ground running when TrueFidelity was implemented at UW-Madison and used on their patients.

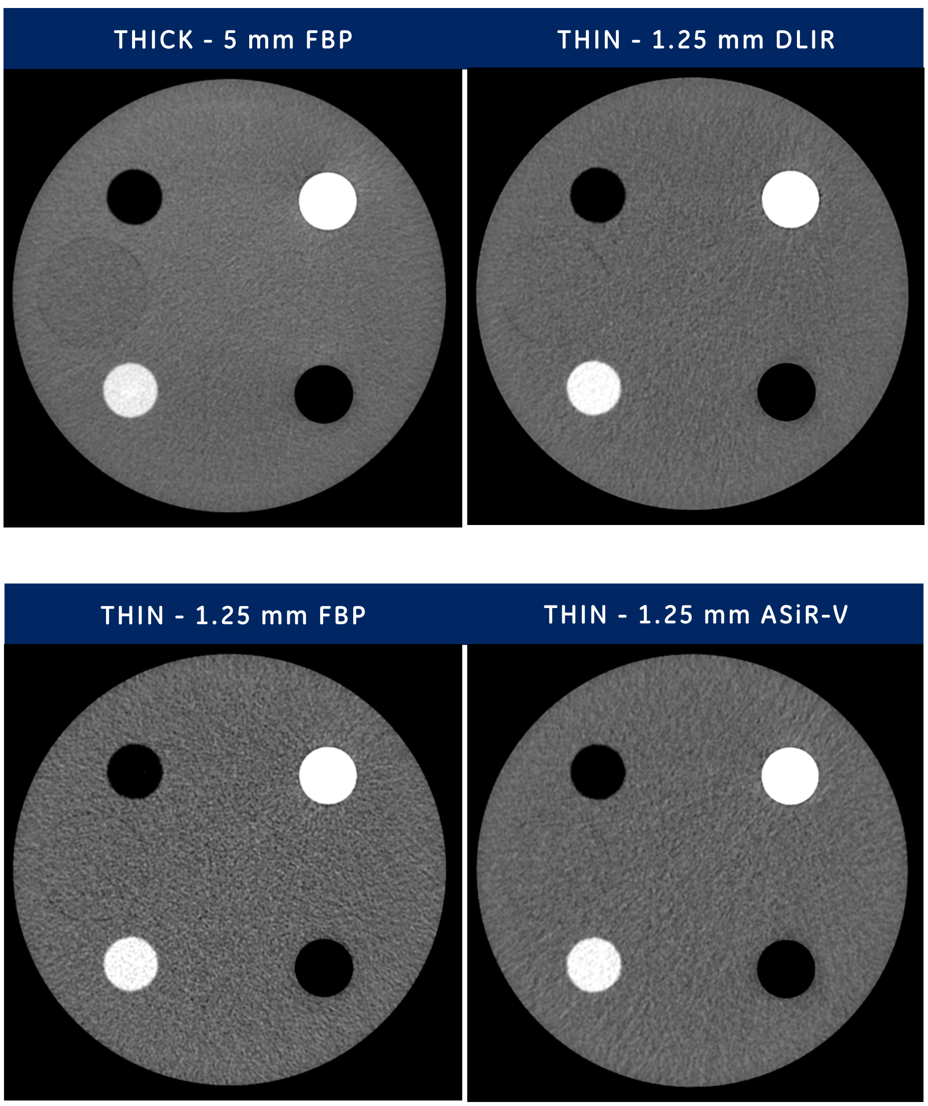
Thin is better than thick

One of the most powerful early phantom results reported by the researchers at UW-Madison was seeing images that were reconstructed with DLIR slices at 1.25 mm looking as good as 5 mm slices using statistical iterative reconstruction.

"In other words, what we found were slices four times thinner than conventional thickness that had the same image quality," said Dr. Szczykutowicz. This result was observed when the TrueFidelity reconstruction approach was applied to American College of Radiology (ACR) CT Accreditation testing to evaluate the possibilities for dose and/or slice thickness reductions.

While all slice thicknesses, reconstruction types, and dose levels passed ACR requirements for uniformity and CT number for all of GE's different reconstruction options, the CNR performance was highest for DLIR.

Results demonstrated TrueFidelity images passed ACR testing using thinner slices and/or lower doses relative to existing filtered back projection (FBP) and statistical image reconstruction techniques.



Independent spatial resolution with further noise reduction

"Another key finding from our TrueFidelity phantom evaluations was that this advanced CT image reconstruction method produced the same spatial resolution results regardless of high versus low contrast or dose level," said Dr. Tim Szczykutowicz.

FBP has historically been the preferred image reconstruction method, in part because of its ability to produce the same image quality regardless of the type of scan being performed albeit using a high dose. By comparison, existing non-linear iterative reconstruction methods produce different spatial resolution results depending on the anatomical region being scanned.

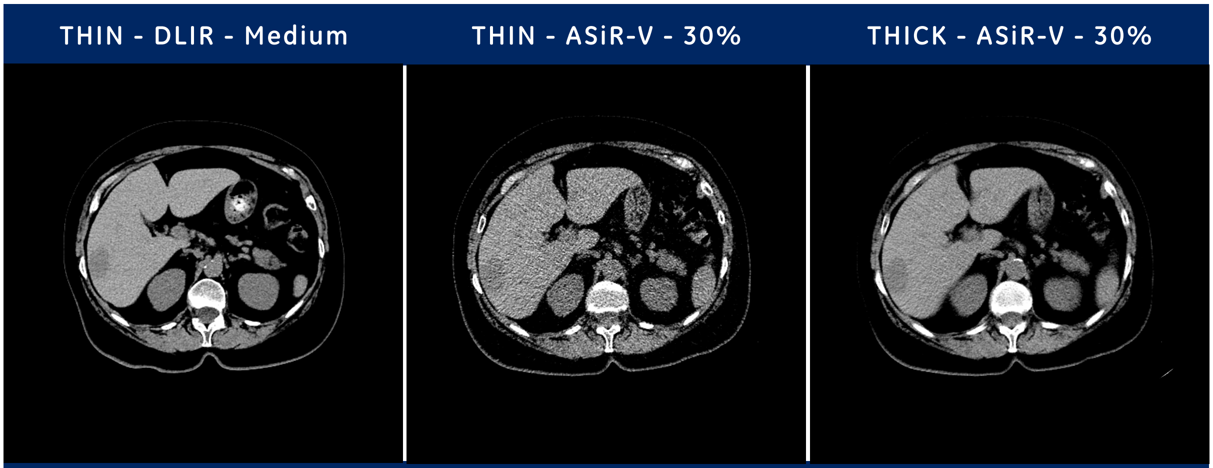
UW-Madison phantom evaluations that assessed spatial resolution results demonstrated that TrueFidelity deep learning reconstruction does not exhibit contrast or dose-dependence compared to other advanced model-based methods. For this test, the CT number insert region of an ACR CT Accreditation phantom was imaged using three dose levels. Results compared six methods of image reconstruction. No difference in resolution was found across contrast or dose levels for FBP and the new DLIR.

"Clinically, this means one shouldn't expect low contrast lesion edges to become blurred or high contrast nodules to be artificially unenhanced as we saw with previous advanced reconstruction methods," explained Dr. Szczykutowicz.

Natural noise texture with further noise reduction

"Our evaluations of TrueFidelity reconstruction with phantoms, and later also what we saw with UW-Madison patients, did not produce images with an artificial or plastic appearance," noted Dr. Szczykutowicz. "In fact, the noise level with TrueFidelity reconstruction was so low that radiologists believed what they were seeing was blurry until we showed them the image results were the same with FBP. In other words, our radiologists were believing that when we removed noise we were also removing spatial resolution, but this wasn't happening. Our radiologists just were not used to these lower levels of image noise."

This level of noise reduction is essential for discerning lung nodules, fractional flow reserve calculation, and subtle lesion detection in solid organs and detecting brain hemorrhages, where sensitive differentiations are key to accurate exam interpretation.



"A great example of DLIR showing a liver lesion to advantage on a thin-section, non-contrast chest CT. Compared to the priors reconstructed using ASIR-V, the lesion is much more conspicuous with DLIR." *–Jeff Kanne, M.D. Professor and Chief of Thoracic Imaging at UW-Madison. Chair of the American College of Radiology's (ACR) Expert Panel on Thoracic Imaging.* **"Additionally, the DLIR images have much better noise texture than ASiR-V,"** *said Dr. Kanne.*

Faster adoption with no resistance from radiologists

Once the UW-Madison team realized they could achieve FBP-like noise texture from the new DLIR method using thin slices at low doses, it became a primary factor in convincing them to implement TrueFidelity across their protocols.

This contrasts with early evaluations of prior advanced image reconstruction methods that traditionally focus only on the changes in noise magnitude without preserving FBP-like noise texture. What was often realized later after implementation in clinical applications was that the texture had also changed and at times appeared to mimic pathologies or became "waxy" in appearance and looked unnatural.

When it comes to the impact on UW-Madison protocol design, the team found some game-changing results.

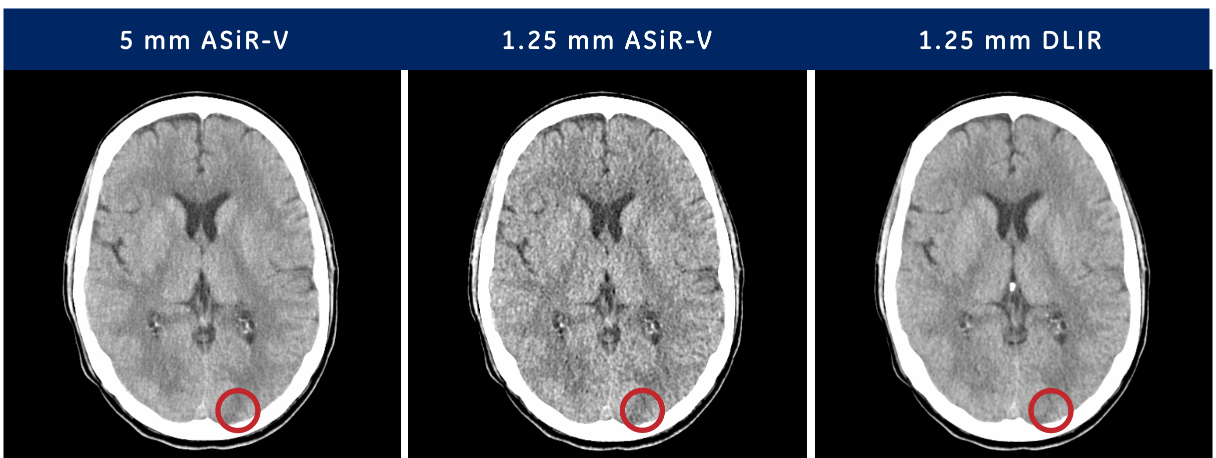
Routine thin slice imaging to see more

Up to now, reconstruction of images with existing non-linear methods has still required thin and thick slices depending on the type of structure or tissue scanned. Traditionally, radiologists have had to review and interpret two stacks of images. One set of thick-slice images for one purpose, and a second set of thin-slice images for another.

Based on initial evaluations and characterizations, UW-Madison researchers found TrueFidelity DLIR can produce high-quality images for many indications in a thin slice. Performance of DLIR was predictable and better than FBP and ASiR-V at five slice thicknesses across and three dose levels representing low, routine and high clinical dose levels.

"When one set of thin-slice images can serve what previously required two sets, a new streamlined workflow begins to form where radiologists now only need to spend the time reviewing one stack of images," noted Dr. Szczykutowicz. "So we may have reduced dose and radiologist workload while increasing productivity because of quicker interpretation, and that can translate to improved accuracy and diagnostic confidence.

“Because of DLIR, I look at the thins a lot more often now. At 1.25 mm slice thickness I enjoy better anatomical detail at the noise we used to have at 5 mm,”commented Dr. Megan Lubner, Chief of CT at the University of Wisconsin-Madison.

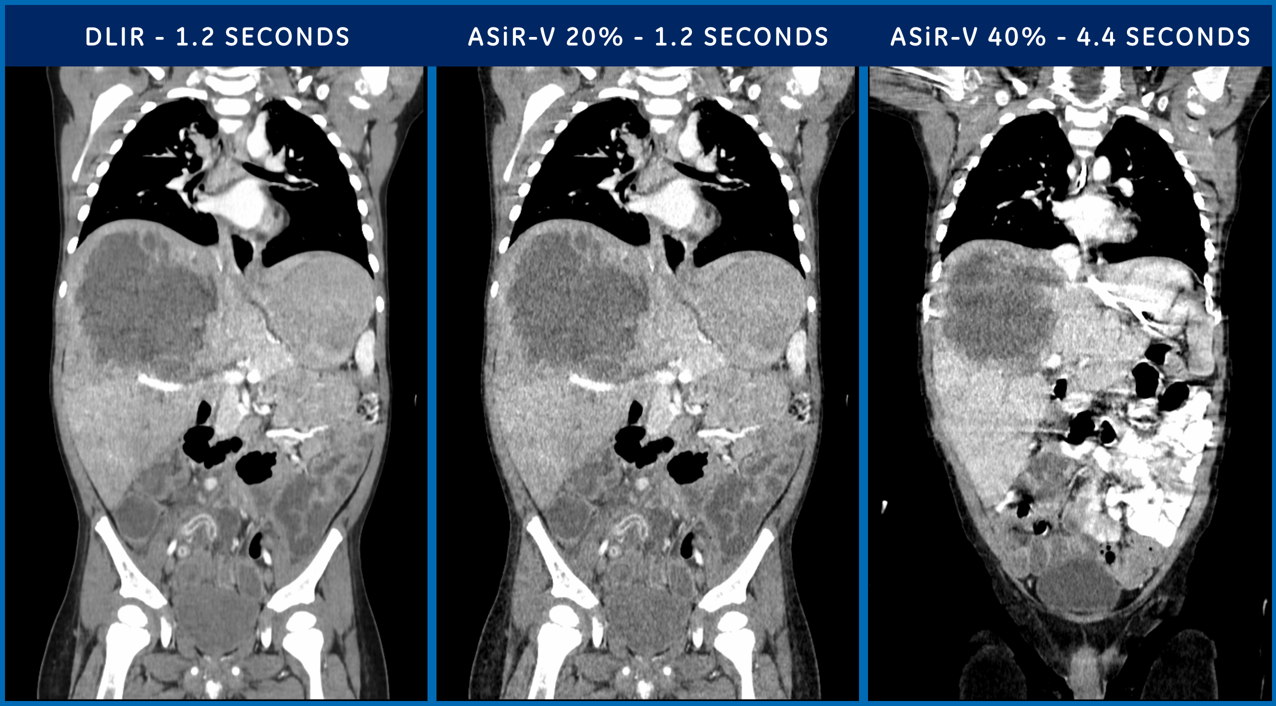


Dr. Bruce, an Associate Professor in neuroradiology at UW-Madison, was pleased with the high quality of thin slice DLIR reconstructions, calling them “quite impressive”. In one clinical example, it was possible to see how the image quality provided by the thin slice DLIR compared to the thick ASiR-V images. “High quality, thin slice images were quite impressive using deep learning. We had the ability to discern small petechial hemorrhages (red circle) on thinner slices” noted Dr. Avey, an Assistant Professor of neuroradiology at UW-Madison and head of neuro CT.

TrueFidelity with HyperDrive

Another significant transformation in protocols that impacted UW-Madison patient care occurred with the first patient scanned using TrueFidelity with the HyperDrive option.

"Our first TrueFidelity patient was a three year-old," explained Dr. Szczykutowicz, "and the team was able to perform the scan while the child was awake and breathing without sedation and further delay in monitoring fluid build-up in the child's lungs. So now UW-Madison pediatric surgery teams specifically ask for their patients to be scanned with TrueFidelity/HyperDrive technology."

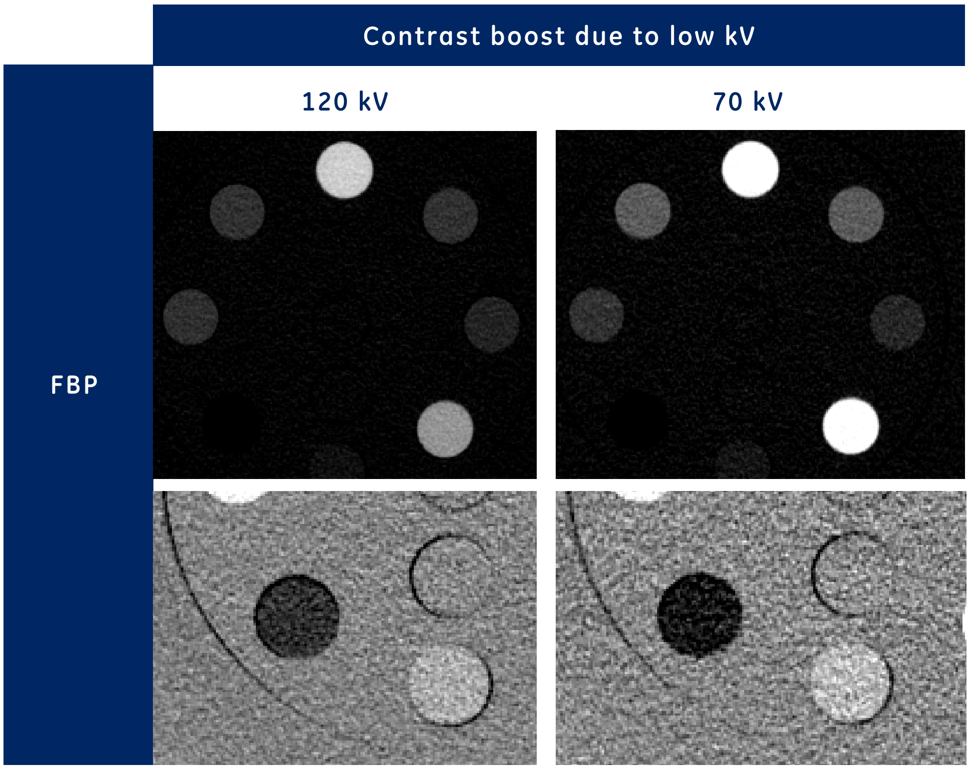


TrueFidelity with low kV scans

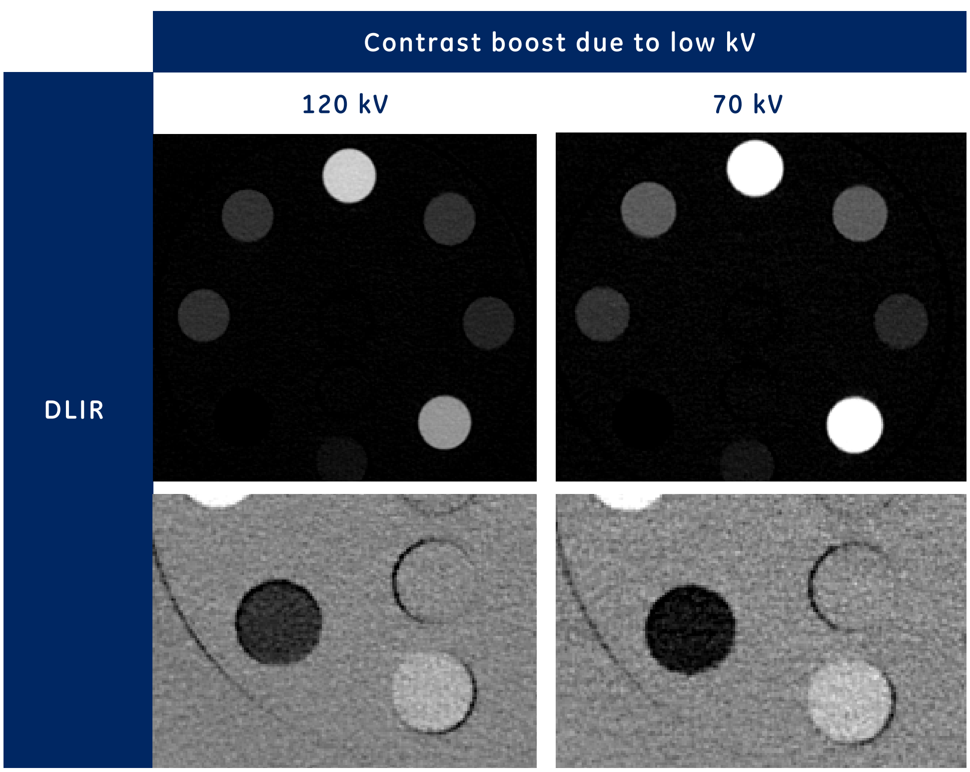
Another impact and advantage of the TrueFidelity approach is the ability to achieve high-quality images using lower beam energies, which is particularly good for pediatric patients. As a result, a major workflow change occurred for pediatric surgery at UW-Madison.

"Our pediatric surgery teams now specifically ask for their patients to be scanned with HyperDrive and TrueFidelity technology because it mitigates their need to do the scan under sedation and provides images of higher quality," said Dr. Szczykutowicz. Pediatric cases are currently sent directly to the Revolution CT scanner with HyperDrive that performs reconstruction with DLIR because of the faster scanning, low radiation dose, and lower beam energies now possible.

When UW-Madison researchers conducted phantom evaluations to assess the ability of TrueFidelity to allow lower doses and noise while imaging at reduced peak kilovolts (kVp), they found that the new deep learning method allowed for more dose efficient low kVp imaging relative to FBP and ASiR-V. For example, low effective atomic number materials that normally get noisier at low kVs on angiograms were found to actually have better image quality at low kV using TrueFidelity relative to FBP.



The 70 and 120 kV images were acquired at the same dose



The 70 and 120 kV images were acquired at the same dose

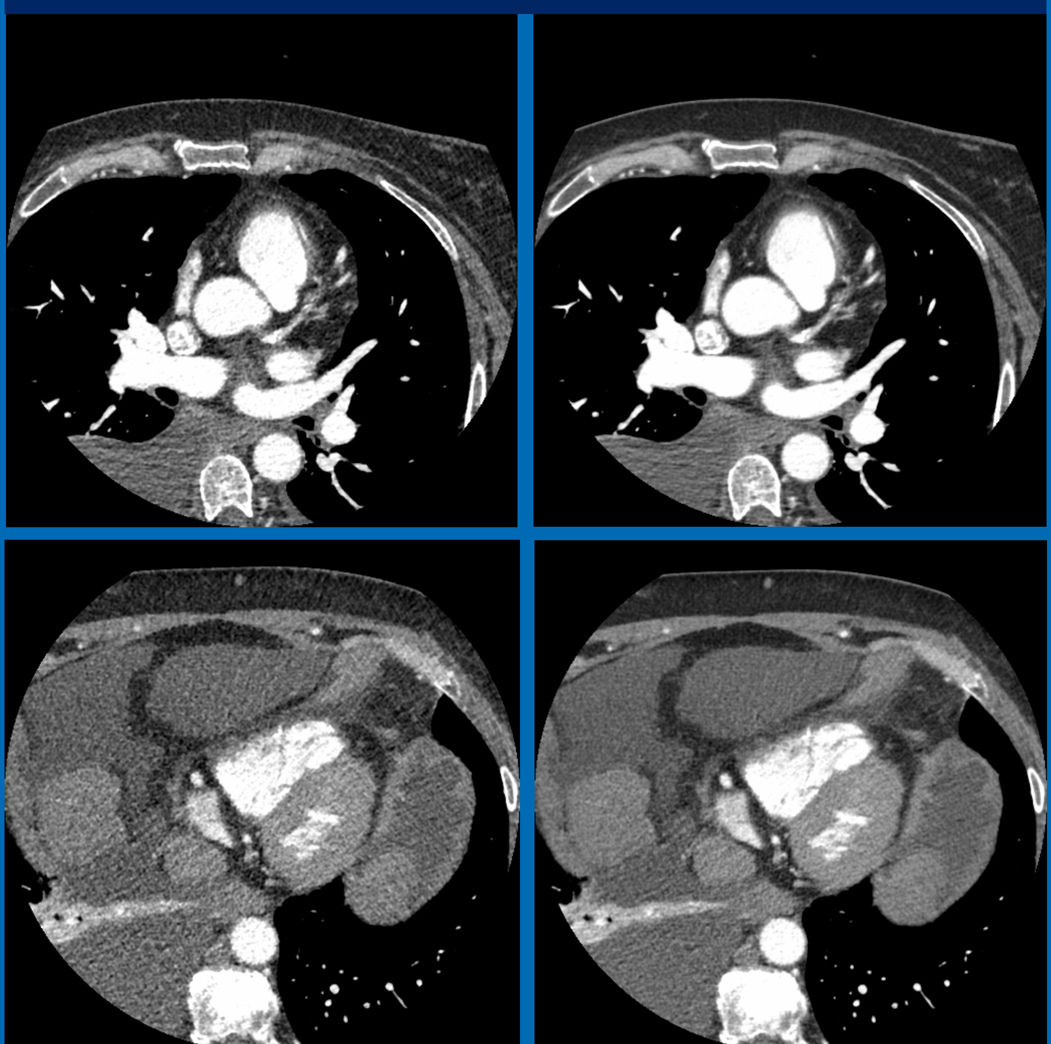
TrueFidelity for bariatric patients

A lower dose also proved game-changing for another group of patients. The UW-Madison team had been about to design a custom bariatric coronary CT angiography (CCTA) protocol for large patients that would increase dose and increase scan time. Faster is better during coronary scans because it reduces motion artifacts caused by the movement of the heart. Before TrueFidelity, the Madison team was looking at increasing rotation times for bariatric CCTA patients in order to deliver more dose. However, the UW-Madison team's TrueFidelity phantom evaluations revealed this was not needed as DLIR lowered image noise enough to mitigate the need for increasing rotation times as a means to improve image quality.

"Literally a week before DLIR was installed at UW-Madison, we were considering designing a new CCTA protocol with a longer rotation time of 0.35 to get more dose for larger patients," said Dr. Szczykutowicz. "But with TrueFidelity we have been able to avoid increasing scan times and doses, and have remained at a 0.28-second exam duration. Plans for this new CCTA protocol are now on the backburner."

Other UW-Madison protocol changes resulting from the implementation of TrueFidelity include revised rules for when patients need to be medicated before scanning, as well as new rules for pre-exam sedation.

ASiR-V 60% 0.625 mm slice thickness | **DLIR-H 0.625 mm thickness**



Conclusion

UW-Madison faculty have been leaders in implementing this deep learning next generation image reconstruction technology across CT protocols and in the clinical setting. Comprehensive phantom evaluation results that drove early adoption are now improving radiologists' confidence in diagnosing a wide range of clinical cases. Professionals who may be considering adopting TrueFidelity for their own facility but are hesitating due to earlier iterative reconstruction method limitations should know they will not experience those issues with this new technology.

"Don't be afraid to implement," said Dr. Szczykutowicz. "You will see improvement."

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