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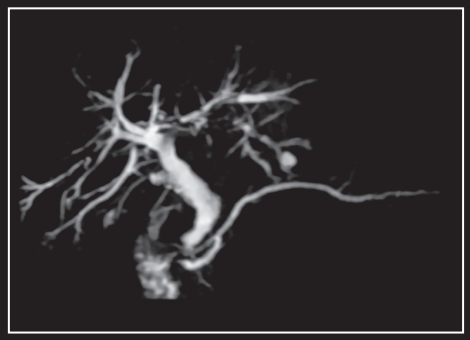

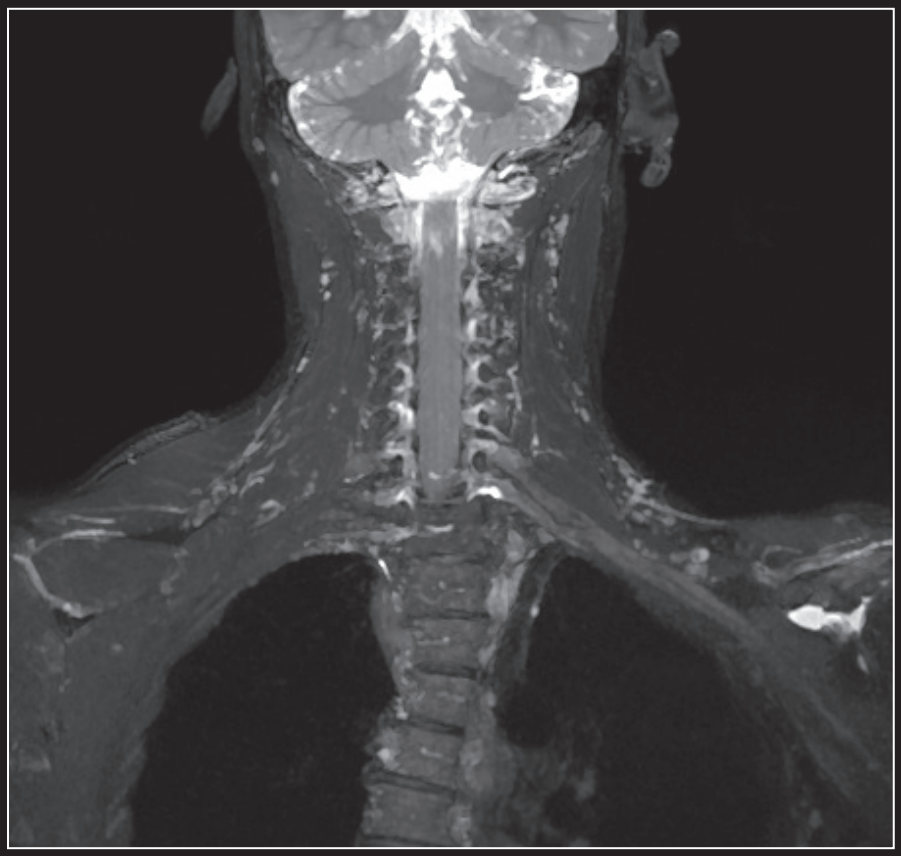

HyperSense

Compressed sensing and other advanced acceleration techniques

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Reducing scan time is one of MR's biggest challenges. To keep up with the demands of today's patient population, clinicians need advanced imaging solutions to help reduce scan times and produce accurate, high-resolution images the first time around. Less time spent in the bore leads to less chance of motion artifacts, high-quality images and faster patient throughput.

To address this widespread challenge, GE Healthcare was first to market a breakthrough compressed sensing technique, HyperSense at the 2016 Radiological Society of North America (RSNA) annual meeting in Chicago. An application that truly lives up to its name, HyperSense has been rapidly adopted by clinicians around the world, delivering the operational and clinical benefits the industry has been looking for. In fact, GE Healthcare has the largest install base around the world, with over 1,000 daily use cases and counting and more than 100,000 compressed sensing exams performed in the first year after the introduction of HyperSense.

The power behind HyperSense is its acceleration, which speeds up scans by acquiring less *k*-space data and uses a special reconstruction algorithm to recover the missing information without a significant impact on image quality. For use in over 88 percent of clinical procedures for 3D scans, HyperSense can deliver higher spatial resolution images or reduced scan times, enabling faster imaging without the penalties commonly found with conventional parallel imaging techniques. To add even more value, HyperSense is not dependent on coil geometry and is less sensitive to image artifacts or SNR loss at higher accelerations and can be combined with other acceleration methods like Autocalibrating Reconstruction for Cartesian imaging (ARC), GE's longstanding, robust technique that speeds up both 2D and 3D acquisitions.

Completing complex exams has just become a whole lot easier. We've compiled a series of articles for you that share insight into the full clinical value HyperSense can deliver from head to toe on GE 1.5T and 3.0T MR scanners. You'll also read how HyperSense combined with other acceleration techniques, such as HyperCube and Flex, can even further reduce scan times. See for yourself how HyperSense can bring an immediate benefit to your growing clinical needs.

HyperSense:

An advanced compressed sensing technique enabling faster scan times or higher resolution

Compressed sensing is a technique that can reduce scan time by acquiring less *k*-space data and using an iterative reconstruction method to reconstruct images without an appreciable loss in image quality. Building upon prior published work that described using variable density *k*-space sampling and sparse sampling in MR, researchers at Stanford University presented a theory of compressed sensing and implementation details for rapid MR imaging in a 2007 research paper published in *Magnetic Resonance in Medicine*.[1] The authors were able to demonstrate a five-fold acceleration in contrast-enhanced MRA. Lead author Michael Lustig, PhD, now Associate Professor of Electrical Engineering and Computer Sciences at the University of California-Berkeley, is widely considered the originator of compressed sensing in MR imaging.

GE Healthcare, Stanford University and UC Berkeley have a rich history of research collaboration in MR imaging. Today, this collaboration extends to multiple clinical areas, including musculoskeletal, body, neuro, pediatric, cardiac, PET/MR and 7.0T, in addition to core technology developments, such as advanced reconstruction methods.

In April 2017, GE Healthcare received US FDA clearance for its compressed sensing technique, HyperSense. HyperSense, part of the SIGNA™Works productivity portfolio, was the first compressed sensing reconstruction technique that attained commercial clearance from any MR vendor. This application can deliver higher spatial resolution images or reduced scan times, enabling faster imaging without the penalties commonly found with conventional parallel imaging. HyperSense is combined with Autocalibrating Reconstruction for Cartesian imaging (ARC) for improved acceleration performance.

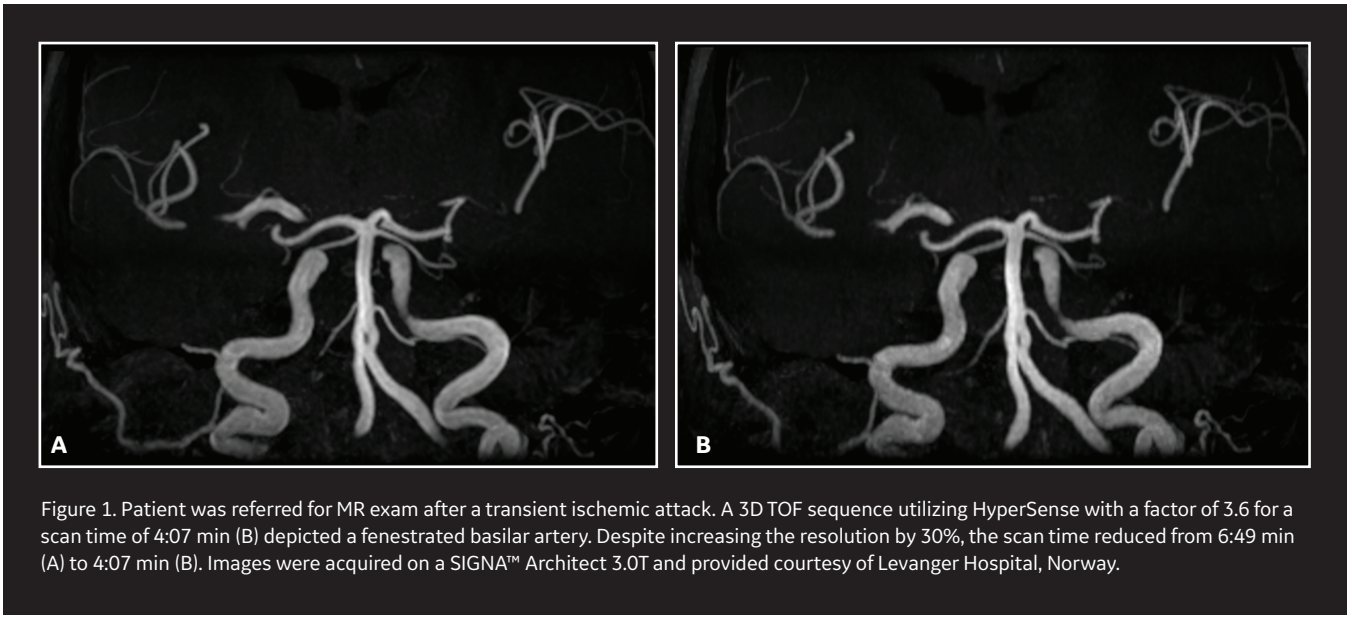

Figure 1. Patient was referred for MR exam after a transient ischemic attack. A 3D TOF sequence utilizing HyperSense with a factor of 3.6 for a scan time of 4:07 min (B) depicted a fenestrated basilar artery. Despite increasing the resolution by 30%, the scan time reduced from 6:49 min (A) to 4:07 min (B). Images were acquired on a SIGNA™ Architect 3.0T and provided courtesy of Levanger Hospital, Norway.

As with most compressed sensing reconstruction techniques, HyperSense utilizes iterative reconstruction (IR), which is implemented by minimizing the pixel-to-pixel variations in the image while maintaining consistency with the acquired *k*-space data. More specifically, a conjugate gradient minimizer reduces the L1 norm of the total variation followed by replacement of the *k*-space data at the acquired locations with the original value. This is repeated for each coil and the resulting sample pattern is used for ARC. With ARC, remaining sample locations are filled and the standard sum of squares reconstruction delivers the image.[2]

This development could not have been done without significant reconstruction processing power and infrastructure. Orchestra is GE Healthcare's powerful and completely redesigned MR reconstruction platform that enables rapid modular application development while ensuring advanced balanced loading of multi-processor/core platforms.

HyperSense can be used from head to toe in 3D acquisitions and with applications that are more sparse in nature and thus amenable to compression. These include Time-of-Flight Cube, Cube DIR and Cube FLAIR for brain, head and neck, spine, MSK, abdomen and pelvis. For all 2D acquisitions, ARC remains an effective technique for reducing scan times while preserving image quality.

In clinical practice, GE recommends using protocols with preset ARC and HyperSense factors. These protocols have been validated for diagnostic quality and scan time reduction. If protocol modifications are desired, then it is recommended to pre-validate by first pushing ARC as high as possible without creating parallel imaging artifacts and then increasing the HyperSense factor until images become noticeably grainy.

HyperSense can decrease scan time by 30 to 50 percent or increase spatial resolution, depending upon the patient need (Figure 1, 3). The application is available on 1.5T and 3.0T systems, including the new ultra-premium SIGNA™ Premier 3.0T MR.

10-minute cardiac and knee exams

For cardiac imaging, GE Healthcare offers ViosWorks 3D and ViosWorks 4D acquisitions, which allow for a short, whole chest scan—in one breath-hold for 3D Cine function and free-breathing for 4D Flow—with a technique called HyperKat (kat-ARC), a GE-patented, exclusive sparse reconstruction technique. Designed and optimized for the heart, the acceleration is achieved with parallel imaging utilizing both spatial and temporal dimensions. The additional temporal component is important since heart motion over time needs to be considered. The temporal component is adaptive (according to systolic and diastolic phases), thereby increasing accuracy of the acquisition. Both ViosWorks 3D and ViosWorks 4D can be acquired in less than 10 minutes.

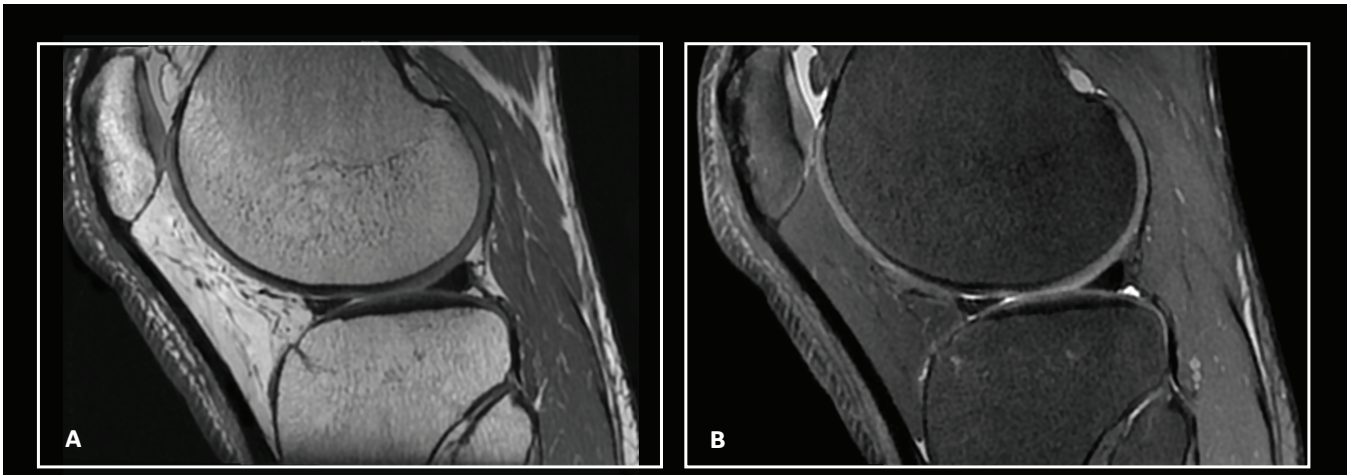

Figure 2. In 3D knee imaging, two acquisitions consisting of (A) Cube PD and (B) Cube PD FatSat can each be acquired in 5 min (total scan time of 10 min) with 0.5 mm isotropic images by utilizing HyperSense, ARC and HyperCube. Selecting a PD FatSat instead of T2 FatSat enables cartilage segmentation.T2 weighting may introduce unwanted signal variation in the cartilage, making segmentation difficult. With the PD FatSat, there is sufficient fluid signal. Images were acquired on a SIGNA™ Premier 3.0T using a QED 18-channel TR Knee Coil. Parameters: TE/TR=min/1000ms; FOV=16 cm; Acceleration =2 x 2 (ARC) x 1.2 (HyperSense).

Combining ViosWorks 3D and ViosWorks 4D with state-of-the-art cardiac MR post-processing tools, a unique, streamlined workflow is achieved to measure function and 4D flow. The result is a fast scan, fast reconstruction and fast analysis.

In MSK imaging, GE Healthcare enables a rapid, 10-minute knee exam that includes both Cube PD and Cube PD FatSat (Figure 2). The short acquisition times can be achieved with ARC, HyperSense and HyperCube. The knee exam is compatible with several coils, including the QED 16-channel TR Knee Coil, QED 18-channel TR Knee Coil as well as medium and large GEM Flex Coil arrays that can accommodate larger-sized knees.

Clinical studies demonstrate high image quality

The development of HyperSense was focused on ensuring any image quality tradeoffs are minimized, as demonstrated in several studies:

- Using Cube with ARC factor of 2 x 2 and HyperSense factor of 1.5 reduced scan times in the knee by 30 percent without a corresponding decrease in SNR.[3]
- In shoulder imaging comparing Cube with and without HyperSense, SNR and CNR were higher in the sequence utilizing HyperSense.[4]
- An evaluation of a 3D Navigator-triggered MRCP with combined parallel imaging (PI) and HyperSense found that by adding HyperSense, scan times were reduced by approximately 50 percent with comparable image quality to MRCP with PI alone.[5]
- In two studies examining MR angiography in the carotid arteries, one study reported comparable hyper-intense blood intensity, background tissue suppression and delineation of calcifications in the HyperSense 3D TOF sequence, tested with a factor of 2 and a factor of 4, as in the conventional 3D TOF.[6] The other study reported robust and reproducible morphology assessments of the 3D carotid black-blood, multi-contrast protocol when using HyperSense factor of 1.5 in combination with a PI factor of 2.[7]
- Using HyperSense factor of 1.3 on a Discovery™ MR750 3.0T scanner decreased exam time by 27 percent and preserved diagnostics for the detection of MS plaques.[8]

One year after HyperSense received US FDA clearance, several hundred sites are using the application in clinical routine. To date, it has been used in more than 100,000 exams across all installations.

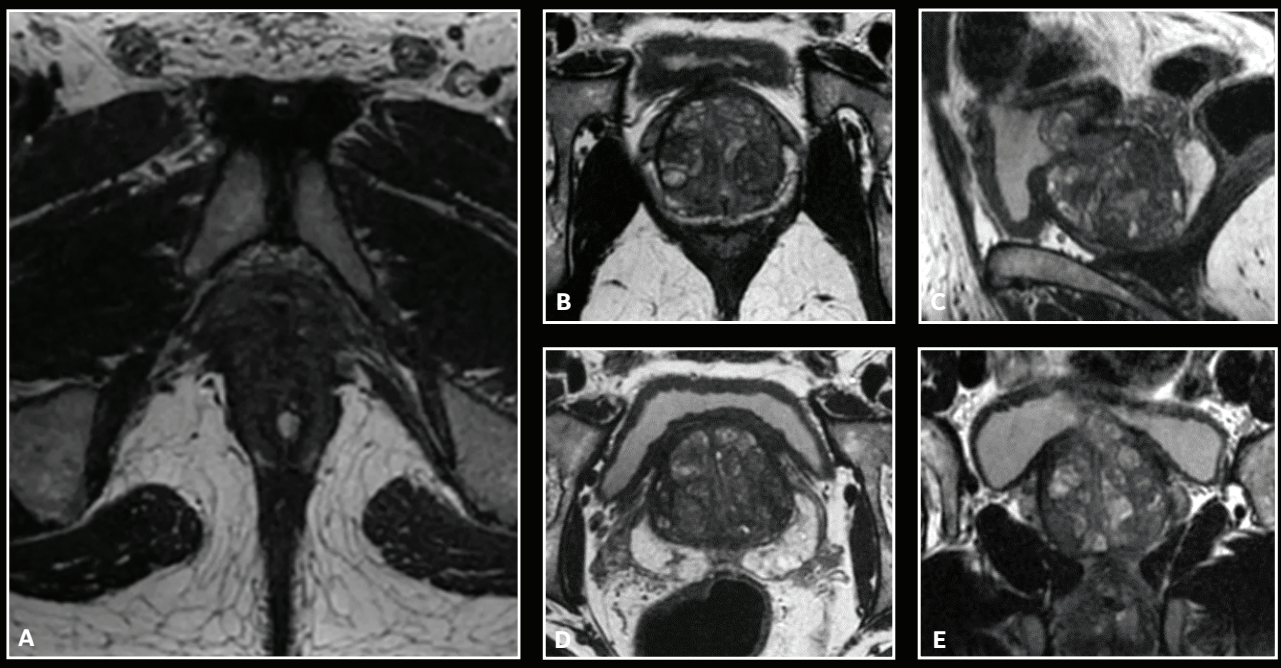

Figure 3. With HyperCube and HyperSense, high-resolution imaging is achieved in a fraction of the time. (A-E) Axial T2w HyperCube with HyperSense, 0.8 mm slices. Total scan time was 5 min.

Further development will include extending HyperSense to other 3D sequences, such as gradient echo-based applications. In addition, alternative artificial intelligence driven methods are being explored for more efficient acceleration of aggressively undersampled data.†

† Technology in development that represents ongoing research and development efforts. These technologies are not products and may never become products. Not for sale. Not cleared or approved by the U.S. FDA or any other global regulator for commercial availability.

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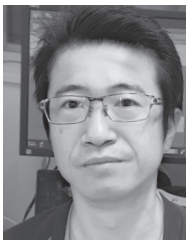


Koji Uchida, RT
PICTORU Izumo Imaging Center
Eda Clinic Orthopedics Surgery
and Rehabilitation in Japan

A boost in productivity

SIGNA™ Works helps imaging center increase both productivity by up to 15% and daily patient throughput

By Koji Uchida, RT, Assistant Director, PICTORU Izumo Imaging Center, Eda Clinic Orthopedics Surgery and Rehabilitation in Japan

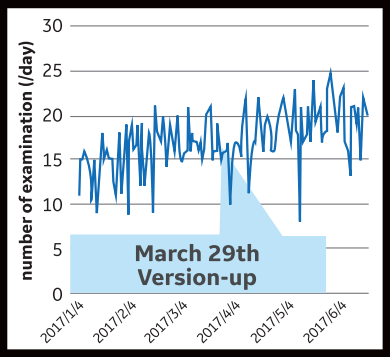
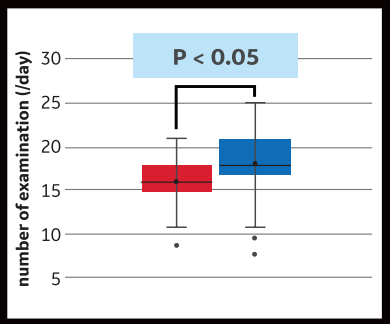


Figure 1. The benefit of new scan protocol with SIGNA™ Works as shown in the increase in daily volume.



	Before	After
Number of exams (per day)	16.0	18.4

At the end of March 2017, our SIGNA™ Pioneer 3.0T MR system at PICTORU Izumo Imaging Center was upgraded to the SIGNA™ Works productivity platform. After upgrading, this platform has helped dramatically increase patient throughput without impacting image quality. We also have the option to increase spatial resolution and maintain prior scan times. As a result, we are receiving excellent feedback from radiologists, referring physicians, patients and C-level-suite administrators regarding the SIGNA™ Works upgrade.

Prior to having SIGNA™ Works on SIGNA Pioneer, we were scanning 16 patients each day on average. Figure 1 shows the number of patients before and after implementation.

With the addition of new sequences and techniques, such as HyperSense and HyperCube, we have increased patient throughput by 2.4 patients each day.

Before			After		
	Sequence	*Scan time (min)*	*Sequence*	*scan time (min)*	*Advantage*
	SSFSE 3P	0:06	SSFSE 3P	0:09	
1	DWI Axial	1:30	HB DWI Axial	0:45	50% scan time reduction by HyperBand
2	Head TOF-MRA	5:04	Head HS TOF-MRA	3:13	40% scan time reduction by HyperSense
3	FLAIR Axial	2:44	FLAIR Axial	2:44	
4	T2*w Axial	3:25	T2*w Axial	3:25	
5	T1w Axial	3:21	T1w Axial	3:21	
6	T2w Axial	2:30	T2w Axial	2:30	
7 (opt.)	Neck TOF-MRA	9:01	Neck HS TOF-MRA	4:51	45% scan time reduction by HyperSense
Total		27:40		20:58	

Figure 2. Routine head protocol before and after implementation of SIGNA™Works.

Figure 3. Routine head/neck MRA with HyperSense. (A) 1 mm slice thickness, 1 slab, FOV 20 cm, 352 x 224, ARC 2.0, HyperSense factor of 1.3, scan time of 3:13 min. (B) 2 mm slice thickness, ZIP 2, 34 x 8 slab, FOV 24 cm, 320 x 192, ARC 2.0, HyperSense factor of 1.5, scan time of 4:51 min.

Neuro imaging

In a routine neuro exam, head and neck MR angiography (MRA) with HyperSense and head DWI with HyperBand have made significant contributions in reducing scan time.

As shown in Figure 2, the scan time for a neck MRA has been reduced by 4 minutes, from 9 minutes to 5 minutes, representing a 45% reduction in scan time. Further, HyperBand can be applied to diffusion sequences, such as diffusion-weighted imaging (DWI) and diffusion-tensor imaging (DTI), and we've seen up to a 50% scan time reduction. The result is now a head exam that can be completed in 20 minutes, including two MRA (head and neck) sequences. (Figure 2).

Spine imaging

We are most impressed by SIGNA™Works' increase in image quality for spine exams. The signal-to-noise ratio (SNR) of spine imaging is enhanced without increasing scan time. This is primarily due to SIGNA Pioneer's Digital Surround Technology (DST) which is compatible with ARC, a parallel imaging method.

Coronal STIR PROPELLER gives us good fat-suppressed images and MR myelography, which is robust even in the presence of patient movement. Patients in severe pain may often inadvertently move, degrading image quality. Now, for these patients, we apply PROPELLER at the beginning of the examination. Prior to the SIGNA™Works upgrade, an Axial T2 acquisition covering only the intervertebral foramen would take more than 4 minutes. Now, we can achieve wider coverage with an Axial T2 of the spine in thin slices using HyperCube with HyperSense in a scan time that is less than 4 minutes.

Cube is suitable for imaging lateral cervical disk herniation and hyperostosis of Luschka's joints because we can apply thin slices compared to a 2D sequence. Flow void often occurs on 2D FSE and impacts the clinician's diagnosis. However, it does not occur on Cube because of the optimized flow compensation technique. For lumber spine imaging

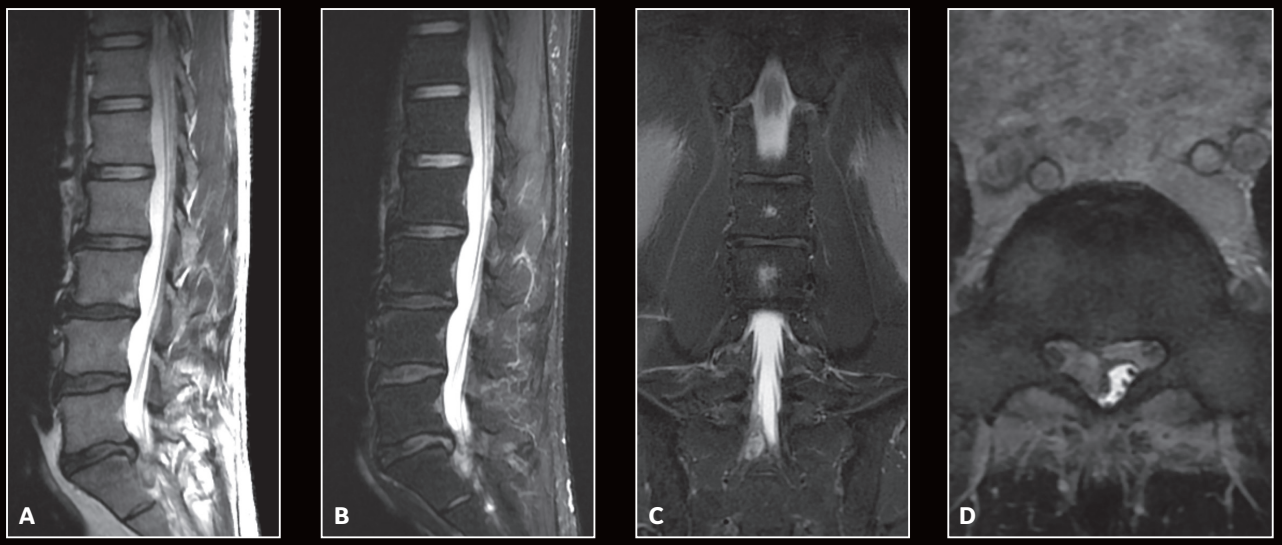


Figure 4. Routine spine examination. (A) T2w Flex of the spine; (B) DST with ARC; (C) PROPELLER STIR; (D) T2w HyperCube with HyperSense.

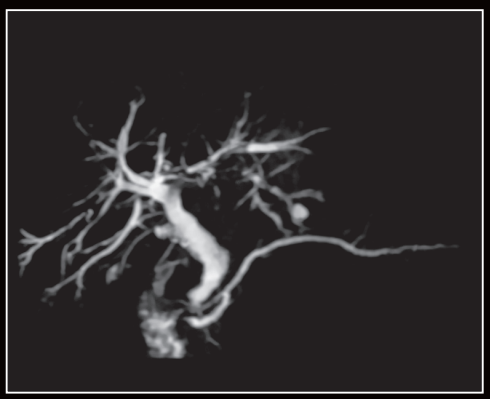


Figure 5. 3D MRCP with HyperSense. 1.2 mm slice thickness, 384 x 260, ARC 2.0, HyperSense factor of 2.0, scan time of 3:27 min.

Cube is effective for scanning the entire vertebrae and herniated disc, which is difficult to perform when using a 2D sequence. Total scan time reduction for routine spine imaging is 21%.

Abdomen imaging

3D MRCP with HyperSense delivers high image quality with 1.2 mm slice thickness and a 384 x 260 matrix in a shorter scan time for routine imaging. Before the upgrade to SIGNA™ Works, a thin slice 3D MRCP sequence would take approximately 7 minutes to acquire. Now 3D MRCP with HyperSense takes less than 3.5 minutes, so we have built it into our routine abdomen protocols (Figure 5).

Orthopedic imaging

In some clinical scenarios, our clinicians request additional sequences that tap into the exceptional image quality that SIGNA Pioneer with SIGNA™ Works together deliver. An example is in our routine knee exam. We've added Sagittal PD-weighted scans with HyperCube and HyperSense because it provides high-quality meniscal and cartilage images and excellent reformat images. These reformatted images contribute detailed image data to assist our clinicians in their diagnosis and identification of anteromedial/posterolateral bundle on the anterior cruciate ligament. This valuable information is obtained in a scan time of only 3 minutes.

Summary

SIGNA™ Works can make a significant impact on routine examinations. From technologists to radiologists to referring clinicians, we all strongly believe in the clinical benefits of SIGNA™ Works, especially with HyperSense and HyperCube. By implementing this productivity platform in our facility, we have increased patient throughput as well as enhanced image quality.

Study examines accuracy of HyperSense in 3D FLAIR exams of MS patients

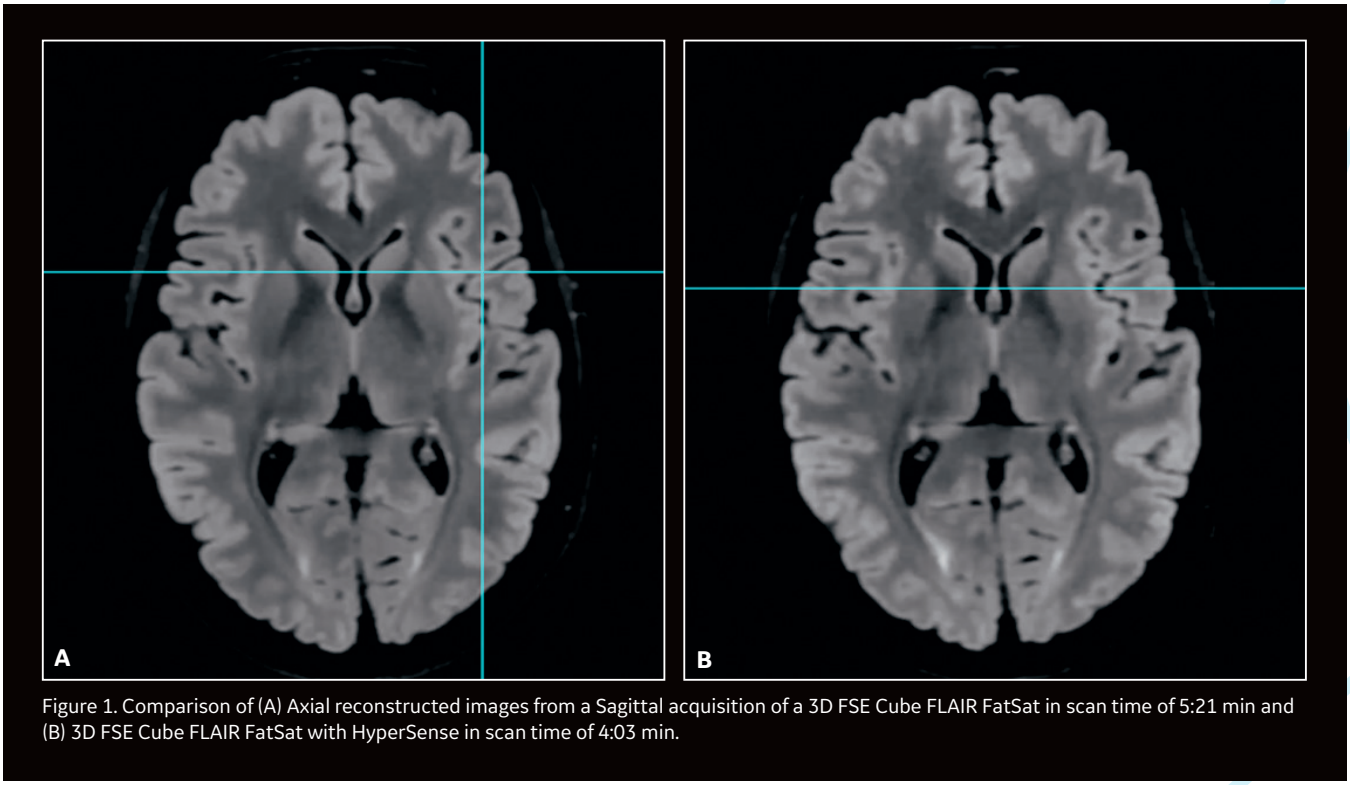


Figure 1. Comparison of (A) Axial reconstructed images from a Sagittal acquisition of a 3D FSE Cube FLAIR FatSat in scan time of 5:21 min and (B) 3D FSE Cube FLAIR FatSat with HyperSense in scan time of 4:03 min.

A recently published study in the American Journal of Neuroradiology examined the accuracy of a new technique that shortens MR exam times for the detection of multiple sclerosis lesions. HyperSense, introduced by GE Healthcare at the 2016 annual meeting of the Radiological Society of North America (RSNA), is a compressed sensing technique that can reduce scanning time by 30 to 50 percent. The study, "Accuracy of the Compressed Sensing Accelerated 3D-FLAIR Sequence for the Detection of MS Plaques at 3.0T," found that by using a compressed sensing factor of 1.3 on a 3.0T MR scanner (Discovery™ MR750), the 3D FLAIR sequence was 27% faster, and it preserved diagnostics for the detection of MS plaques. The study utilized a 32-channel head coil.

Twenty-three consecutive patients with relapse-remitting MS were scanned at Saint Joseph Hospital (Paris, France) using the following protocol: DWI, 3D gradient-echo magnetization-prepared T1-weighted BRAVO, T2 weighted and 3D FLAIR. Contrast was not used. Each patient underwent a 3D FLAIR sequence with and without compressed sensing (HyperSense), acquired in the Sagittal plane with a parallel imaging acceleration factor of 2.

Even with the 27% reduction in scan time for the 3D FLAIR sequence, which translates to a 1:25-minute time savings, the authors reported the diagnostic performance was similar to a conventional FLAIR sequence. A factor of 1.3 for compressed sensing was determined based on the authors' testing of a wide range of acceleration factors.

The study appeared online in January, 2018 and can be accessed at: tiny.cc/sps181

Reference

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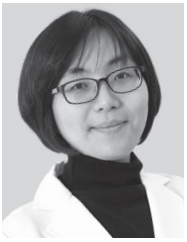

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Rapid neuroimaging utilizing HyperSense and 3D sequences

MR is known for its range of soft tissue contrasts to depict anatomy in greater detail and its high sensitivity and specificity for brain abnormalities, lesions and injuries. CT is often used for acute and trauma cases due to its inherent speed. "Time is brain" in clinical imaging and therefore CT is often the modality of choice.

However, recent advancements in MR scanner technology—gradients, sequences and coils—have reduced scan times and also improved sensitivity. Fast MR pulse sequences and the utilization of compressed sensing, i.e., HyperSense, have helped close the time gap between CT and MR leading to greater utilization of MR in acute cases.

At Gyeongsang National University Changwon Hospital (GNUCH) in South Korea, Hye Jin Baek, MD, PhD, Associate Professor, and colleagues have been routinely using 3D FLAIR with HyperSense on SIGNA™ Architect for routine neuroimaging, including cranial nerve (IAC protocol) and brachial plexus imaging. Prof. Baek and her colleagues have also developed a two-minute neuro protocol for acute cases by utilizing HyperSense and HyperBand (see SIGNA™ Pulse of MR, November 2017 issue, pages 55-57).

Preferred sequences for MR neuroimaging at GNUCH include MAGiC, Time-of-Flight (TOF) MRA with HyperSense, 3D FLAIR with HyperSense, 3D T2 Cube, 3D FLAIR Cube and HyperCube with Flex. Prof. Baek recently conducted a 4-point Likert scale survey of colleagues to determine their satisfaction with the image quality of these new neuroimaging techniques: 1 = inadequate; 2 = sufficient; 3 = good (acceptable for diagnostic use); and 4 = excellent. MAGiC was rated as 3 while all other techniques received a score of 4.

"3D images provide ancillary information regarding anatomical details and lesion characteristics during a single scan because 3D sequences help to overcome inherent limitations related to the spatial resolution of 2D images, which are generated only in one plane during a single scan," Prof. Baek explains. In her experience, and similar to reports by other researchers, synthetic T2 FLAIR has a marginal hyperintensity along the brain surface. However, Prof. Baek believes this does not have a significant impact on diagnosis.

Prof. Baek uses MAGiC to acquire all the basic contrasts in a reduced scan time. Then, by adding 3D FLAIR, she can acquire high-resolution, thin-slice images that can be post-processed into any plane. This approach provides her with a more comprehensive view of the patient's anatomy and condition.

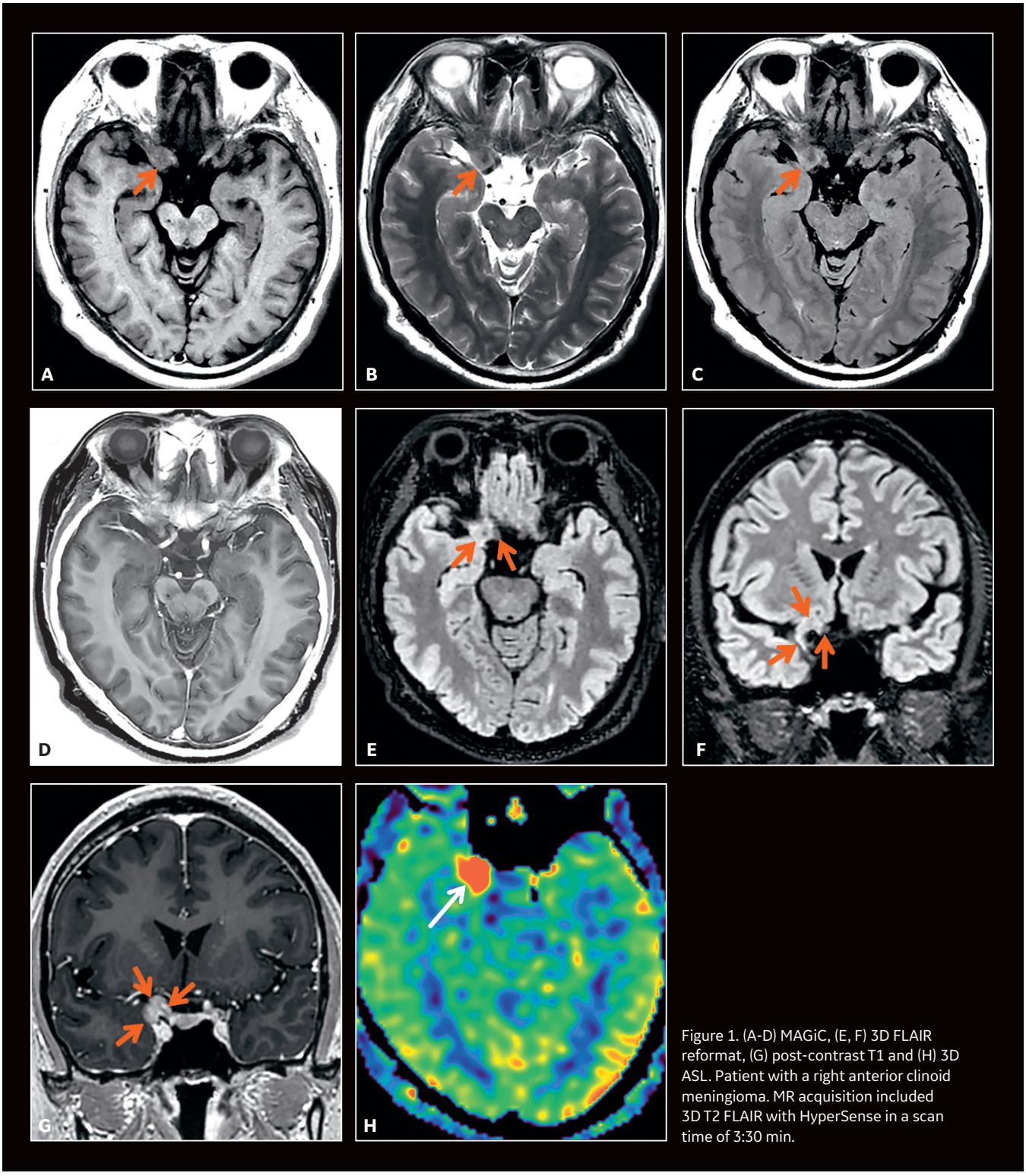

Figure 1. (A-D) MAGiC, (E, F) 3D FLAIR reformat, (G) post-contrast T1 and (H) 3D ASL. Patient with a right anterior clinoid meningioma. MR acquisition included 3D T2 FLAIR with HyperSense in a scan time of 3:30 min.

By adding HyperSense to 3D FLAIR, Prof. Baek can further reduce scan time, which enables the opportunity to add other sequences, such as post-contrast T1 and 3D ASL, without increasing the overall exam time (Figure 1).

"We think the additional acquisition of 3D FLAIR with HyperSense can help enhance a radiologist's familiarity with synthetic MR during an initial adaptation period."

Prof. Hye Jin Baek

According to Prof. Baek, the ability to reduce scan time with HyperSense delivers additional patient and clinical benefits. For instance, faster scans can reduce the need for rescanning due to motion artifacts, lessen the need for patient sedation, allow for the acquisition of additional sequences and enable rapid decision-making and the prompt initiation of therapy.

Even advancements in coil technology, such as GE Healthcare's 48-channel Head Coil, can make a difference. "Especially in pediatric patients, it has the effect of improving the image quality of synthetic MR and intracranial MRA," she explains. "Additionally, patients who have been scanned with this coil have said it is more comfortable than other MR head coils they have previously experienced."

Prof. Baek believes that continued research and development in compressed sensing and 3D neuro imaging could help increase its utilization.

"Brain tissue is vulnerable to some insults such as ischemic stroke or trauma; therefore, rapid evaluation is very important. These techniques—HyperSense, HyperCube, 3D FLAIR, etc.—can reduce scan time and enhance image quality to aid in rapid diagnosis that assists with the appropriate management of patients."

Prof. Hye Jin Baek

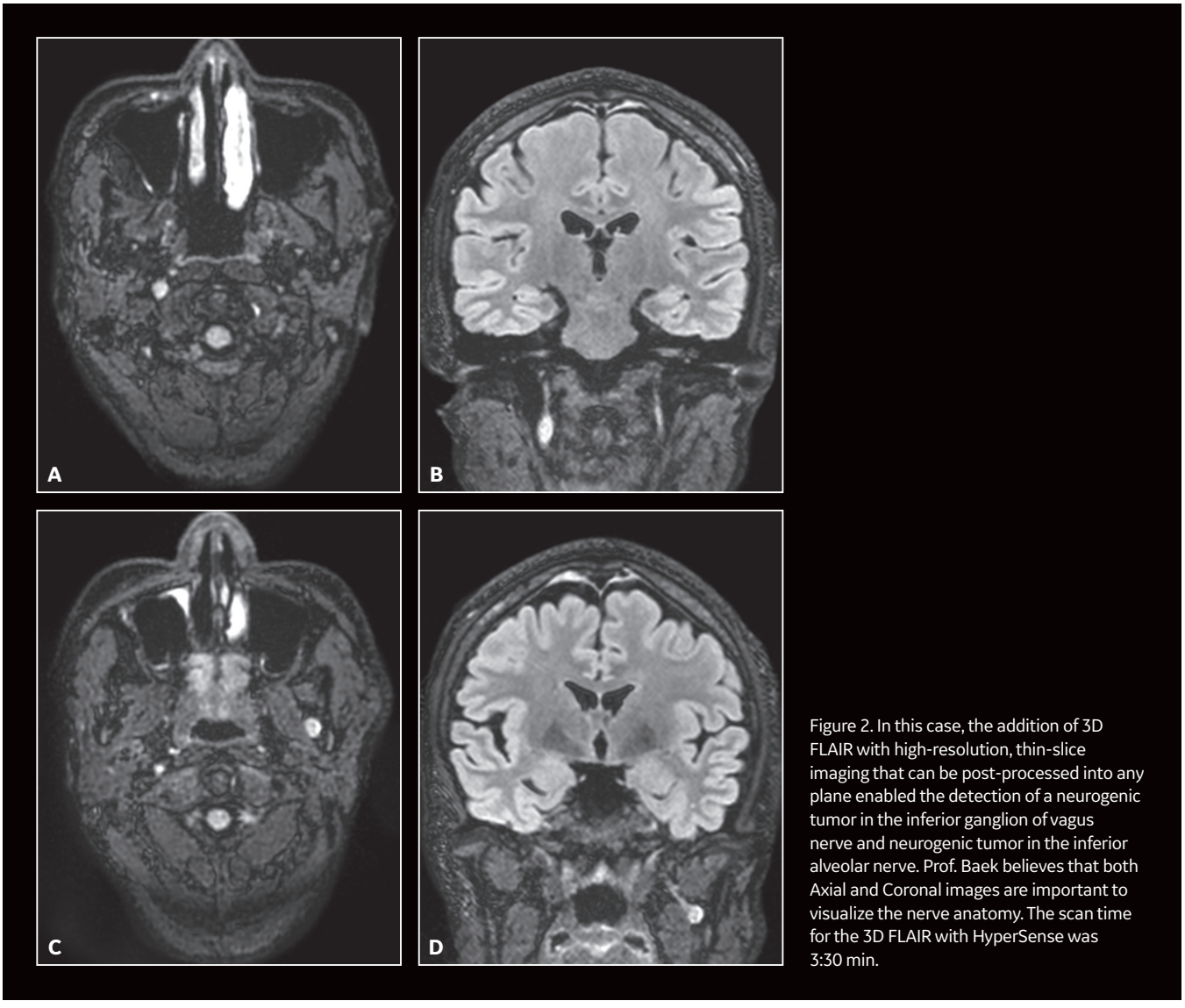

Figure 2. In this case, the addition of 3D FLAIR with high-resolution, thin-slice imaging that can be post-processed into any plane enabled the detection of a neurogenic tumor in the inferior ganglion of vagus nerve and neurogenic tumor in the inferior alveolar nerve. Prof. Baek believes that both Axial and Coronal images are important to visualize the nerve anatomy. The scan time for the 3D FLAIR with HyperSense was 3:30 min.

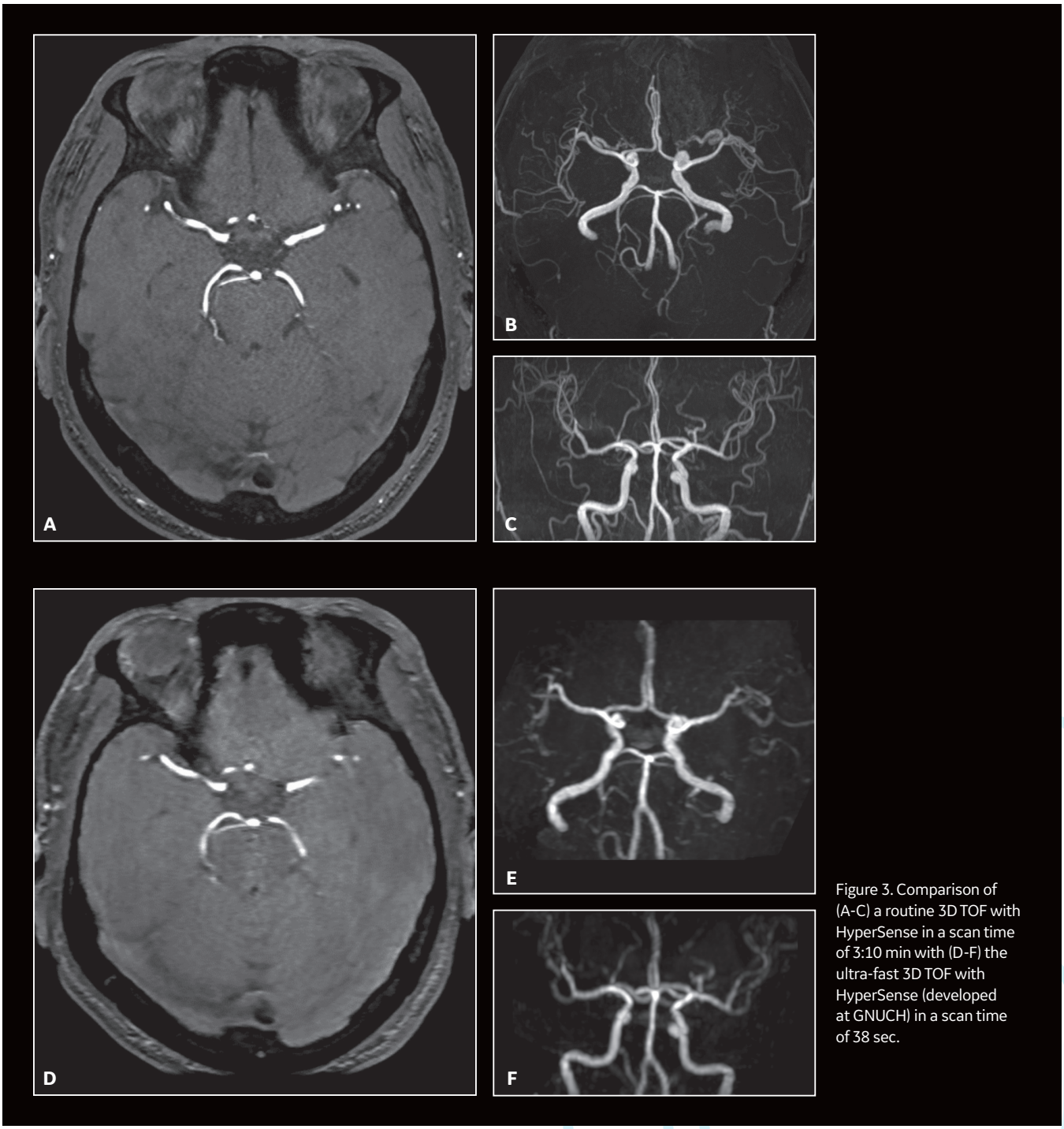

Figure 3. Comparison of (A-C) a routine 3D TOF with HyperSense in a scan time of 3:10 min with (D-F) the ultra-fast 3D TOF with HyperSense (developed at GNUCH) in a scan time of 38 sec.

"There is a need for further improvements in MR acquisition speed and greater access to availability because MR is a very sensitive modality for lesion detection and differentiation in the field of neuroradiology," Prof. Baek explains. "In addition, as imaging technology evolves, more detailed anatomical information is required, and there is also an increasing need to quantify and characterize specific anatomy."

Two-minute MR ultra-fast neuro protocol

By Hye Jin Baek, MD, PhD, Associate Professor Brain, Head & Neck Imaging, Department of Radiology, Gyeongsang National University School of Medicine, Gyeongsang National University Changwon Hospital, South Korea

SIGNA™ Architect

MR imaging can be utilized for differentiating healthy versus damaged brain tissue in suspected stroke patients even though MR imaging is still challenging due to long scan times. MR has been demonstrated to be more sensitive for lesion detection and more specific for delineation of healthy versus damaged brain tissue compared with CT in patients with acute ischemic stroke.[1-4] However, there is a need for further improvements in MR acquisition speed and limited availability.

The phrase "time is brain" emphasizes that brain tissue is rapidly destructed as ischemic stroke progresses, so rapid evaluation with prompt therapy is very important.

Therefore, the practicalities of using MR for imaging brain tissue as one tool in the diagnostic work up for suspected acute stroke patients, especially in restless and uncooperative patients, remains challenging even for major academic institutions.

In this patient case, there is a strong suspicion of acute ischemic stroke. The patient also had end-stage kidney disease and showed a severe degree of irritability during the physical examination. Therefore, there were physiological difficulties in performing a neuroimaging study.

Using HyperSense and HyperBand from the SIGNA™Works productivity platform, we performed a 2-minute ultra-fast neuro protocol MR exam.

Image Parameter	Ultra-fast T1	Ultra-fast T2	Ultra-fast FLAIR	Ultra-fast DWI	Ultra-fast T2*	Ultra-fast MRA
Sequence:	T1 SPGR	T2 SSFSE	T2 FLAIR EPI	SE EPI	T2* Gradient	3D TOF SPGR
FOV (cm):	24	24	24	24	24	20
Phase FOV (cm):	0.75(18)	1(21.6)	0.9(21.6)	0.9(21.6)	1	1.84(16.8)
Slice thickness (mm):	5	5	5	5	5	1.6
TR (ms):	167.7	392.7 min	10000	2511(auto)	1600	27
TI (ms):			2200			
TE (ms):	2.6	102	100	74.9	22.2	2.6
ETL (ms):						
Frequency matrix (mXn):	260	320	128	128	128	320
Phase matrix (mXn):	190	320	256	128	320	160
Bandwidth (kHz):	31.25	83.33	250	250	250	35.71
ASSET/ARC factor:	ARC 2	ASSET 3		ARC 2	ASSET 3	ARC 2, HS 2
Imaging options:	FC, EDR	EDR, TRF		EDR,HB	FC	FC, EDR, ZIP2, ZIP512, FS
Scan time (sec):	15	8	25	13	6	38

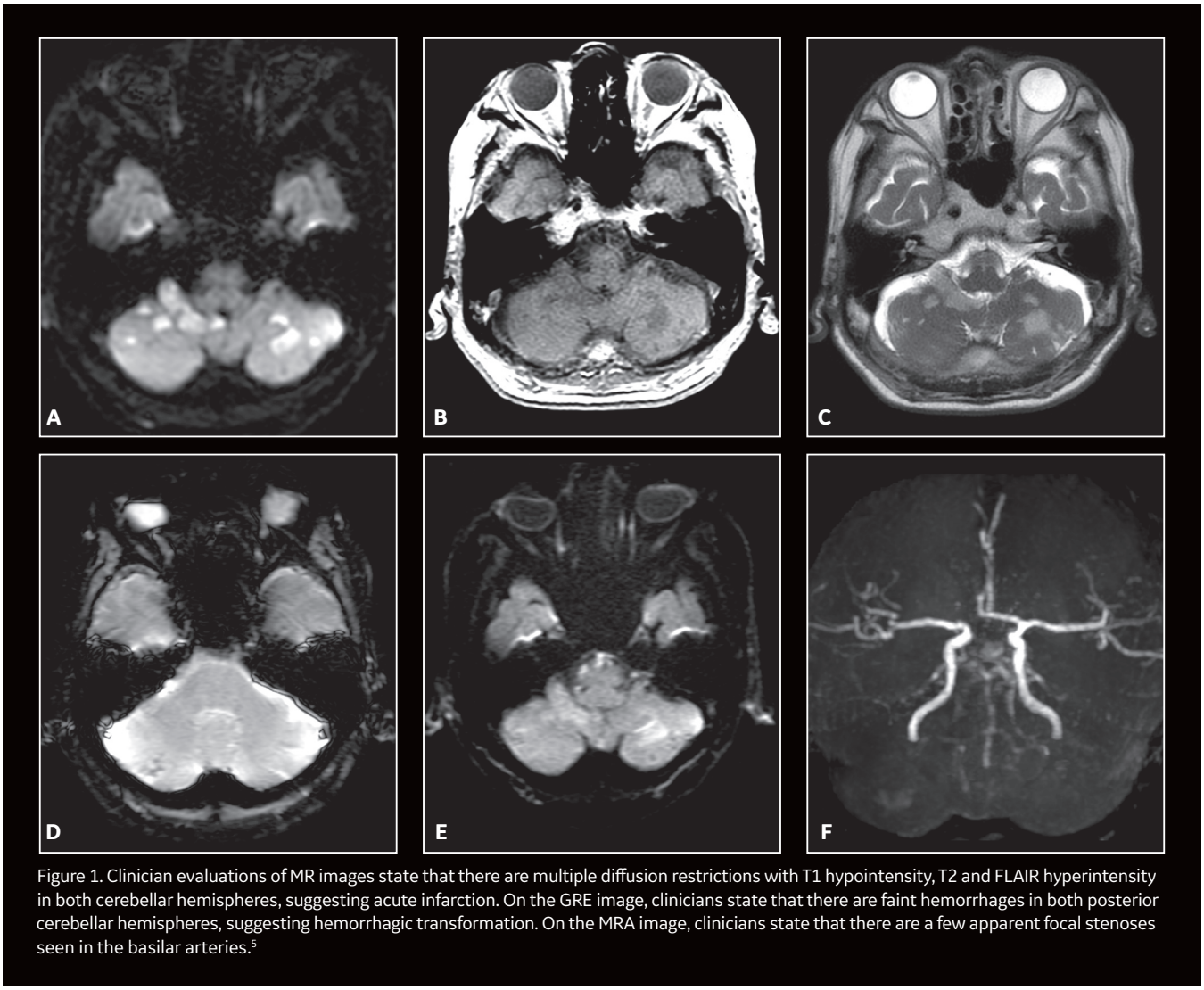

Figure 1. Clinician evaluations of MR images state that there are multiple diffusion restrictions with T1 hypointensity, T2 and FLAIR hyperintensity in both cerebellar hemispheres, suggesting acute infarction. On the GRE image, clinicians state that there are faint hemorrhages in both posterior cerebellar hemispheres, suggesting hemorrhagic transformation. On the MRA image, clinicians state that there are a few apparent focal stenoses seen in the basilar arteries.[5]

Patient history

An 83-year-old patient, weighing 128 lbs (58 kg) and 5 feet 4 inches (164 cm) tall, with underlying disease (hypertension, end-stage kidney disease and diabetes mellitus) with sudden onset of dysarthria and vertigo.

MR findings

MR images showed multiple hyperintense lesions on diffusion-weighted images and FLAIR with coexisting hemorrhages in both cerebellar hemispheres. With this imaging data, we were able to identify acute embolic infarctions due to cytotoxic edema and distribution of the lesions. We also found a few apparent stenoses in the basilar artery with underlying hypoplasia due to fetal variant of both posterior cerebral arteries. On the initial neurologic examination, NIHSS was 7 points (dysarthria 2 points, ataxia 2 points, facial palsy 2 points and sensory change 1 point). Atrial fibrillation was confirmed during hospitalization, causing cerebellar infarctions.

Discussion

Using HyperSense and HyperBand on the SIGNA™ Architect, we acquired valuable images which aided in determining patient diagnosis and management without the use of contrast media or concern for motion artifacts and scanning time (Figure 1).

Imaging data helped to confirm our initial neurologic diagnosis by depicting a conspicuous delineation of the lesions despite the patient's uncooperative state. We also performed an ultra-fast MRA to image major intracranial arteries in a very short scan time. In this case, our evaluation of the MR images enabled us to achieve an appropriate course for patient management.

This case suggests that our 2-minute ultra-fast neuro protocol using HyperBand and HyperSense can be a useful imaging tool in patients with presumed acute ischemic stroke and provide

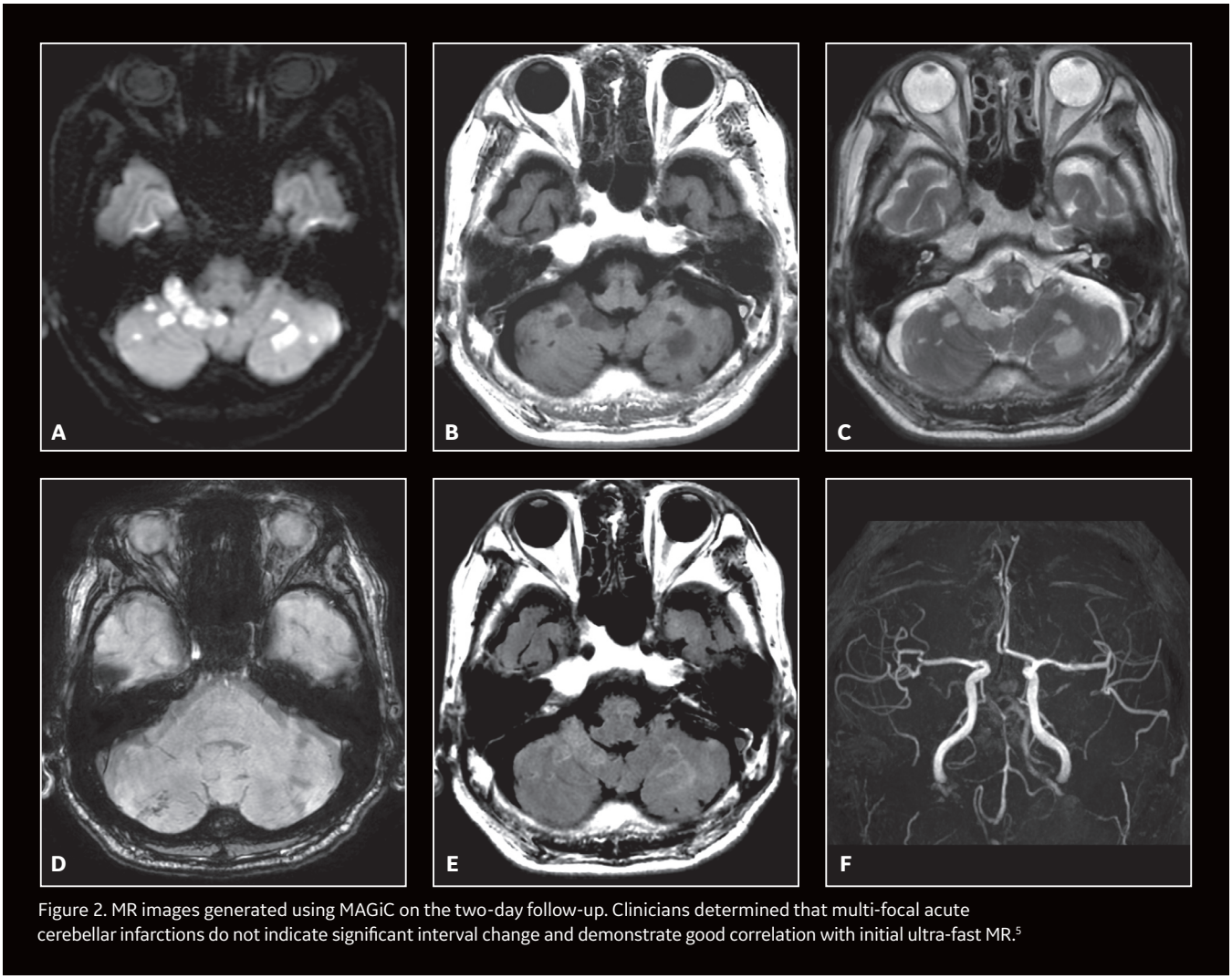

Figure 2. MR images generated using MAGiC on the two-day follow-up. Clinicians determined that multi-focal acute cerebellar infarctions do not indicate significant interval change and demonstrate good correlation with initial ultra-fast MR.[5]

an added benefit in patients who are unable to endure longer acquisition times or are contraindicated for contrast. In this case, using this protocol aided in our rapid diagnosis that assisted with patient management decisions.

Additionally, we performed a two-day follow-up MR using MAGnetic resonance imaging Compilation (MAGiC) in this patient, providing an interesting comparison of two different fast imaging protocols (Figure 2). Our clinicians were already familiar with fast imaging using MAGiC as a routine neuroimaging protocol in our institution. Therefore, it was not difficult to implement a 2-minute ultra-fast neuro protocol as other challenging fast MR protocols exist in our clinical practice.

Now we have more than 30 clinical cases utilizing our 2-minute ultra-fast neuro protocol. Our clinicians are satisfied with this protocol due to its shorter scan time, acceptable image quality and diagnostic capability. Although the image quality is perceived as slightly inferior to that of a routine 20-minute protocol with MAGiC, the use of a 2-minute ultra-fast neuro protocol is feasible to visualize brain tissue, which aids in our evaluation of time-critical diseases like stroke. In the clinical setting, it has a particular benefit for the patient who cannot tolerate a longer scan time by reducing motion artifact and minimizing the need for sedation. We believe that these advantages of a 2-minute ultra-fast neuro protocol may extend indications of MR examination into the pediatric, non-cooperative and emergency patients.

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5. The figures in this article will be used in future journal publications, for which the manucript is in preparation.

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(Left to right) Axel Hartwig (GE), Dr. Lucas Lönn, Patrik Vikström, Lars Blomberg, Mitra Pedersen, Holly Blahnik (GE), Pernilla Persson (GE), Stefan Petersson (GE)

First European installation of SIGNA Premier at the new Karolinska

As one of Europe's premier healthcare facilities, Karolinska University Hospital (Stockholm, Sweden) has a rich history in the development of clinical innovations and advancements in medicine. In close collaboration with industry, Karolinska's clinicians and researchers work together to identify clinical needs, pinpoint areas for innovation and develop the best possible solution—all with a patient-centric approach.

Lars Blomberg, RT(R)(MR)

Karolinska University Hospital,
Stockholm, Sweden

Patrik Vikström, RT(R)(MR)

Karolinska University Hospital,
Stockholm, Sweden

In fact, the new Karolinska University Hospital opening in 2018 will provide highly-specialized care in a patient-focused setting that merges clinical practice, research and education. It will replace the existing hospital that was built in the 1930s.

According to Lucas Lönn, MD, neuroradiologist, the concept for the new hospital was to create a smaller-sized facility packed with high-tech equipment that would enable clinicians to deliver advanced care to more patients. For example, once all equipment is installed, the hospital will have 16 MR scanners across numerous care areas. Patient care will revolve around clinical specialties, for example, neurology, with the understanding that patients today can live with a disease for a long period of time—in some cases decades. This approach represents a new era in Stockholm's healthcare system.

Lars Blomberg, RT(R)(MR), radiographer and MR super user at Karolinska, adds that a key benefit of the new hospital is that the services needed for a particular specialty are all geographically close.

"For patient treatment, everything was kept in close proximity. The neuro intensive care unit is right next to where the neuro MR scanners are sited. We don't have to transport the patient far within the hospital."

In the neuro department of the new hospital, there are five MR labs, two CT labs and three angiography suites. Although the department is separated on two floors, it was designed so that all emergency or urgent care patients could be assessed and treated on the first floor while ambulatory or outpatients could be evaluated on the second floor.

Of the five MR scanners, three are SIGNA™ Premier, the most advanced 3.0T, 70 cm bore MR system developed by GE Healthcare. The other two are Optima™ MR450w 1.5T 70 cm wide bore systems.

An investment in the future

From the start, the neuroradiology team at Karolinska University Hospital knew they wanted to implement advanced 3.0T MR systems at the new hospital. As a multi-vendor facility, the team did a thorough evaluation of all available 3.0T MR systems. It became clear that SIGNA™ Premier was the best possible choice for the facility and its patients.

The department is very hands-on with its MR scanner, including developing coding for advanced sequences. Therefore, Dr. Lönn says the team wanted the fastest gradients available today to perform advanced imaging techniques. SIGNA™ Premier delivered.

"Initially, we had planned for three 1.5T and two 3.0T systems for the new hospital," Dr. Lönn says. "We decided to change that around because we believe that most, if not all, of the advanced neuro MR techniques that will become available in the future will be in 3.0T. Now that we've scanned with the SIGNA™ Premier, I know we made a very good decision to select it."

Dr. Lönn has no doubt that with SIGNA™ Premier, the team will be able to push the boundaries in terms of clinical care and research.

"On the SIGNA™ Premier, we instantly got reasonable image quality," Dr. Lönn says. "It is a brand new system, so I initially expected to have issues. But, we were up and running from day one, with more or less no trouble optimizing the system. I was very impressed with that; it was like buying a new car, putting in the keys and it just runs."

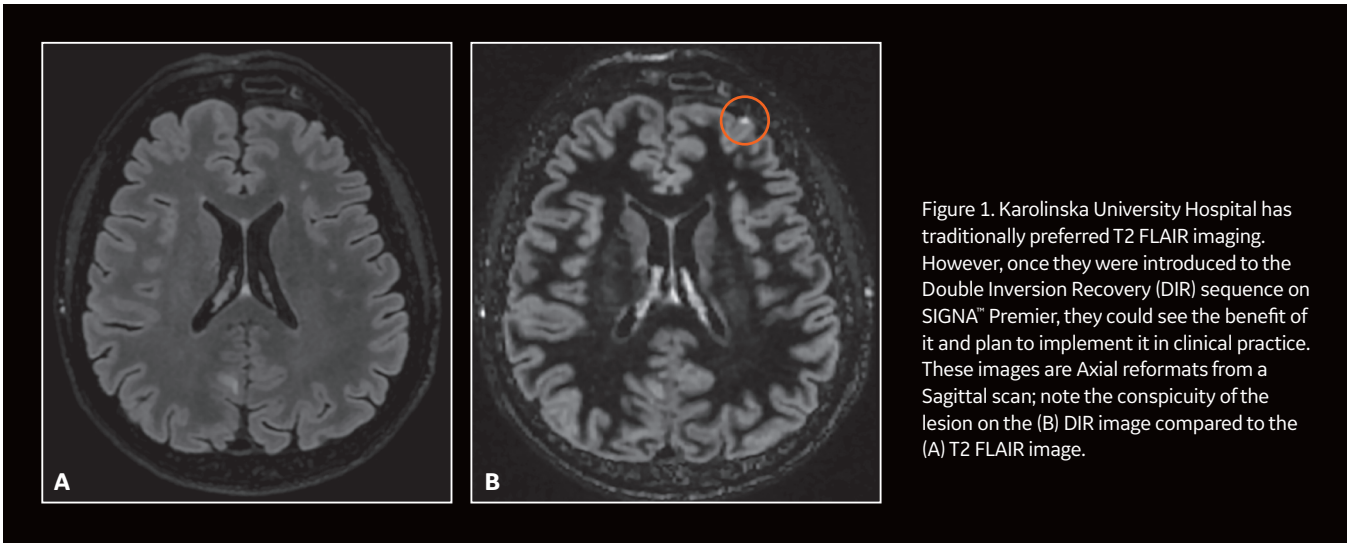

Figure 1. Karolinska University Hospital has traditionally preferred T2 FLAIR imaging. However, once they were introduced to the Double Inversion Recovery (DIR) sequence on SIGNA™ Premier, they could see the benefit of it and plan to implement it in clinical practice. These images are Axial reformats from a Sagittal scan; note the conspicuity of the lesion on the (B) DIR image compared to the (A) T2 FLAIR image.

Simply elegant

Patrik Vikström, RT(R)(MR), radiographer and MR super user at Karolinska, is also impressed after the first four weeks of scanning. "So far we've mainly been optimizing our existing standard sequences but it will be very exciting to see what we can do with all new techniques."

However, Vikström does appreciate the capabilities to perform reformats and MIPs on the same page in the user interface. He also finds the drag-and-drop feature an efficient tool that helps him navigate through the complexity of MR scanning.

Blomberg found the console in the examination room, as well as the different functions, were easy to learn and understand. While he is familiar with the interface, as it is similar to prior GE systems, he believes it will be easy to teach new radiographers how to use the new scanner.

Both Blomberg and Vikström have been equally impressed by GE Healthcare's 48-channel Head Coil, designed to fit 99.99% of the patient population while preserving or increasing SNR.

"With the 48-channel Head Coil, patient comfort is very high," Vikström says. "There is a lot of room in the coil so it doesn't feel so tight or restrictive to the patient."

It is easier to position the patient and the Comfort Tilt that has been added to the coil serves almost like a pillow for the patient, Blomberg adds. In fact, he had a patient who had been scanned on an older system with a different head coil. "The patient commented that the comfort was much better on the new SIGNA™ Premier system with the wider table and more spacious head coil."

The wider patient table really contributes to patient comfort and easier patient positioning for the radiographers, Vikström adds. Other features that can help the technologists more efficiently scan patients include the ease of placing landmarks, table speed, auto coil selection and additional choices for matrix.

Pushing the limits of neuro MR imaging

From the beginning, the team's goal was to obtain the same image quality as the Discovery™ MR750w, and then work step-by-step to optimize scanning in terms of exam time. While the team also worked to enhance image quality, Dr. Lönn says that capability is second to speed.

"Our main objective was to optimize the scan time. We are going to scan thousands of patients over the year, and we want to get as many patients as possible in the scanners," Dr. Lönn says. "At the same time, we must have good image quality."

After one month using SIGNA™ Premier, the team has already achieved significant success. Overall, scan times are down 30% for most of the neuro sequences they've used. Dr. Lönn believes they can scan even faster without impacting diagnosis. And, the ability to obtain higher resolution scans is an added bonus.

"For select cases, we can increase image quality by spending more time scanning," he adds. "That's a nice option to have."

One sequence that has really impressed the team is the Double Inversion Recovery

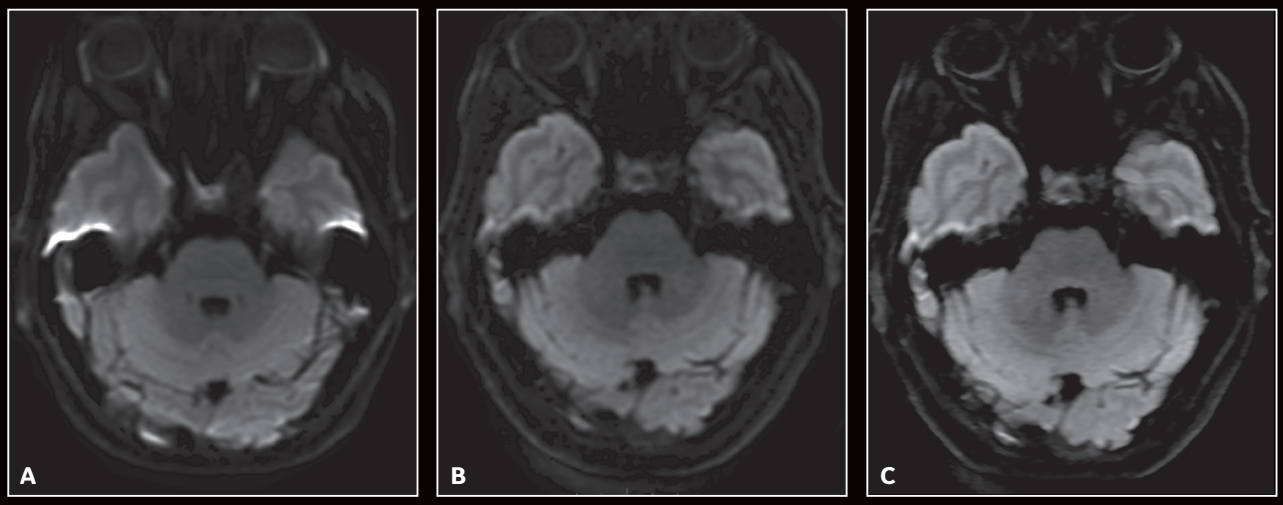

Figure 2. MUSE reduces blurring and distortions in areas vulnerable to susceptibility artifacts and allows Karolinska's neuroradiologists to see structures in the brain on DWI like never before. (A) DWI, (B) Fast MUSE with diffusion correction and (C) high-resolution MUSE with diffusion correction images. The DWI demonstrates many areas of distortion and signal pile up, making it difficult to assess pathology. With MUSE and diffusion correction, the distortion from the surrounding structures (air) is greatly reduced, making it possible to visualize difficult structures. such as the pituitary gland and inner ear.

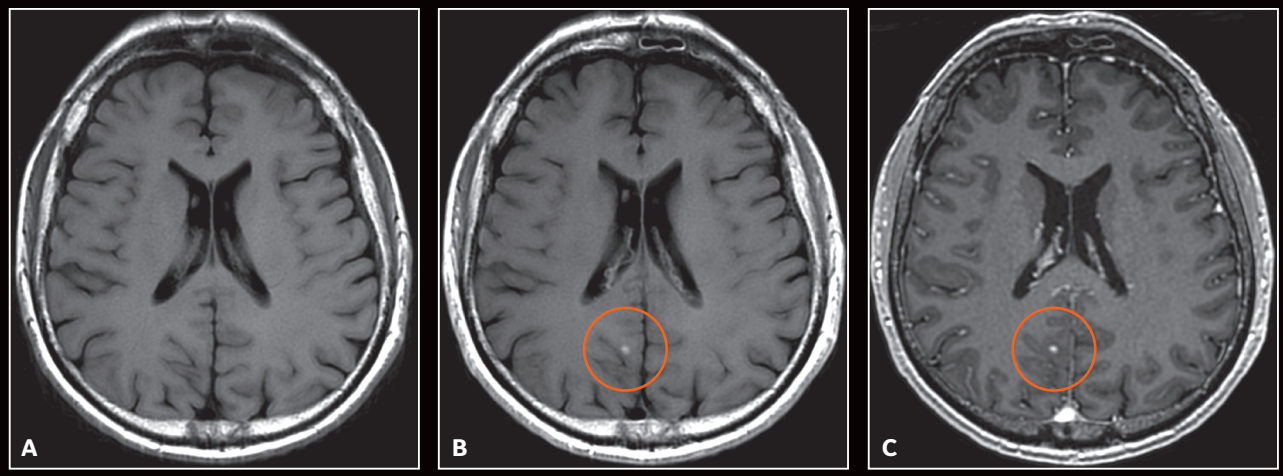

Figure 3. In these images of a patient with metastatic cancer, Karolinska used T1 FLAIR, T1 FLAIR PROPELLER and MPRAGE with PROPELLER to evaluate lesions in the brain. The lesion is more clearly depicted in the (C) 3D MPRAGE than in either the (A) Axial T1 FLAIR or (B) Axial T1 FLAIR PROPELLER images.

(DIR) sequence with HyperSense. In the same scan times, Dr. Lönn noted increased differential of pathology with a Sagittal T2 Cube DIR compared to a Sagittal T2 Cube FLAIR. In one case, the DIR sequence depicted cortical lesions in a multiple sclerosis patient that could not be seen with any other sequence (Figure 1).

"DIR could be a very important tool in MS, and I expect we'll incorporate it into regular MS patient follow-up exams," he explains. Dr. Lönn is also impressed with the MultiShot Diffusion EPI (MUSE)[‡‡] diffusion of the brain after only three days of optimizing the sequence. "With MUSE and its distortion reduction, we can see structures in the brain like never before," he says. "Compared to the old diffusion, we are getting really good quality because MUSE allows higher spatial resolution with reduced EPI-based distortions. That is a really big step in the right direction, and it's now our new standard diffusion sequence." In one case, he could clearly see the resected pituitary gland and inner ear (Figure 2).

For evaluating metastatic lesions in the brain, Karolinska has relied on BRAVO for 3D T1 imaging. However, Dr. Lönn is quite satisfied with the results of MPRAGE compared to BRAVO (Figure 3).

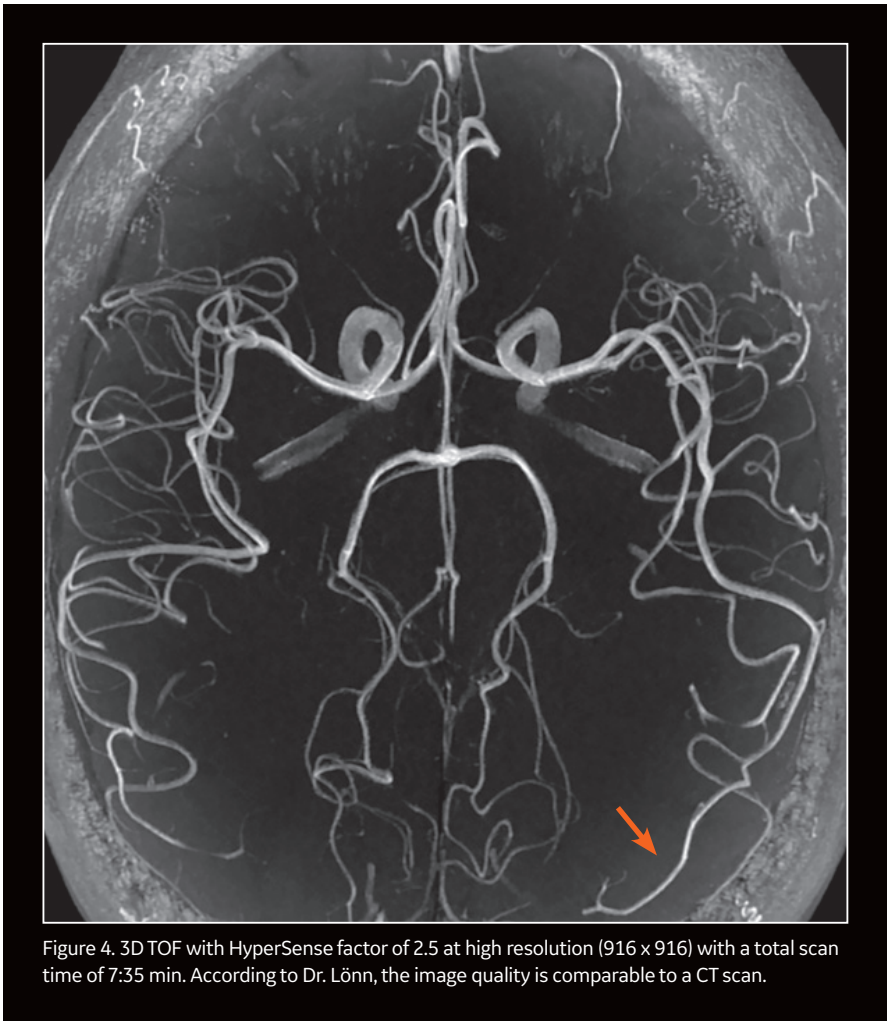

Figure 4. 3D TOF with HyperSense factor of 2.5 at high resolution (916 x 916) with a total scan time of 7:35 min. According to Dr. Lönn, the image quality is comparable to a CT scan.

"With MPRAGE we can get better contrast compared to using BRAVO," he explains. "In select cases, such as epilepsy or cortical dysplasia where we are looking for subtle changes in the grey-white matter junction, this is very nice to have."

The team has also examined the benefits of HyperSense. Vikström utilized 3D T2 FLAIR with HyperSense using a factor of 1.3 and was able to achieve a 40% reduction in scan time with image quality that was as good as before.

High-resolution T2 HyperCube with HyperSense was compared to the FIESTA sequence, which is routinely used for imaging of the cranial nerves.

After optimizing the sequence, Dr. Lönn found the T2 HyperCube with HyperSense delivered better quality imaging than FIESTA with the added benefit of being able to perform it post-contrast with similar quality.

"If we immediately administer contrast, it is often a problem with FIESTA," Dr. Lönn explains. "We now have a very useful tool that will also help us speed up the exam." For example, by using T2 HyperCube with HyperSense, the contrast can be administered to the patient outside the scan room. That can lead to more efficient patient preparation that also frees up the scanner time.

"Most centers would agree that patient preparation time sometimes takes longer than the actual scan time," Dr. Lönn adds.

Perhaps most impressive was the 3D Time-of-Flight (TOF) with HyperSense. Vikström pushed the sequence to the maximum HyperSense factor of 2.5 and was able to achieve good image quality. Then, he scaled back just one-tenth, to a HyperSense factor of 2.4. Dr. Lönn was not only very satisfied with the image quality of the high resolution (916 x 916)‡ 3D TOF acquired in 7:35 minutes, he was thrilled at the imaging options presented to him.

"Peripheral vessels don't get that clear on MR," Dr. Lönn says. He found it comparable to a CT scan and even called the CT neuroradiologist to look at the images. "I would perform this scan on any patient who can't have a CT scan or contrast. With HyperSense, we can perform the MR sequence faster with the same quality or keep the scan time and get higher spatial resolution." (See Figure 4.)

Overall, the team is extremely pleased with the progress made in optimizing both new and old sequences on SIGNA™ Premier. "It is amazing that we could so quickly optimize the images to our standards on a new system," Vikström says.

"It is not hard to find stunning images from the first few weeks of scanning on the SIGNA™ Premier," adds Dr. Lönn.

‡ The high-resolution achieved was not possible prior to implementing HyperSense.

‡‡ Not all applications come standard on all systems. Please contact your GE Representative for the most current information.

Figure 1. Chrystal Barnes and Dr. Puneet Sharma in the SIGNA™ Artist MR suite.

Emory Johns Creek Hospital elevates performance and patient satisfaction with SIGNA Artist

Located 40 miles north of Atlanta, Emory Johns Creek Hospital is one of six hospitals affiliated with Emory Healthcare, the region's most comprehensive academic health system. The hospital recently installed the SIGNA™ Artist 1.5T MR system, replacing an older 1.5T system originally installed when the site opened in 2007.

For Emory Johns Creek Hospital, upgrading their MR technology wasn't about being a "pioneer"—it was about implementing a system that would serve the 200-bed hospital with more speed and high-quality imaging than what they had before.

"SIGNA™ Artist brought us a long way from our previous platform," says Chrystal Barnes, CRA, RT(R)(CT), Director of Imaging at Emory Johns Creek Hospital. "I just wanted to provide an upgrade in technology and quality to this hospital. GE Healthcare jumped in to provide all the software solutions we needed, and they worked with our physicians and technologists to ensure we maximized the technology. They leaped over the moon for us."

An upgrade in service

Barnes considered quotes from two vendors and paid particular attention to service capabilities. "GE provided everything we needed and then some," she says. "As an example, when I ask GE for a protocol, and they drive over to install that protocol in between patients, that's a wonderful example of going above and beyond."

Since installing the system, the service has continued to exceed expectations. "It's the best service that I've had in almost 40 years in radiology," she says.

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Emory Johns Creek Hospital, Johns Creek, GA

Puneet Sharma, PhD
Emory Johns Creek Hospital, Johns Creek, GA

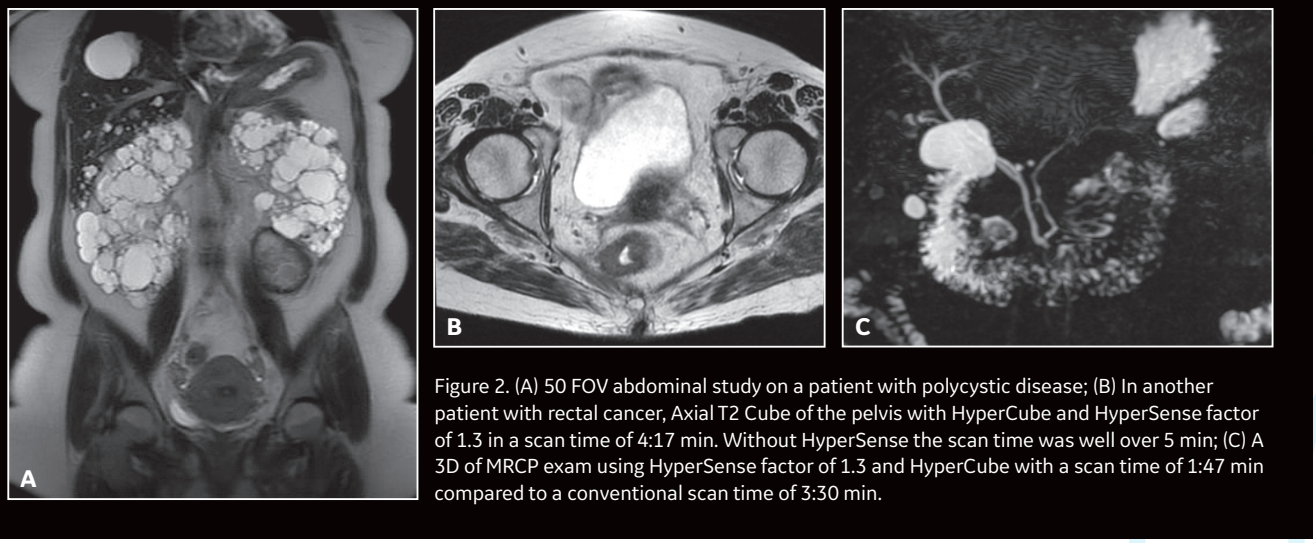

Figure 2. (A) 50 FOV abdominal study on a patient with polycystic disease; (B) In another patient with rectal cancer, Axial T2 Cube of the pelvis with HyperCube and HyperSense factor of 1.3 in a scan time of 4:17 min. Without HyperSense the scan time was well over 5 min; (C) A 3D of MRCP exam using HyperSense factor of 1.3 and HyperCube with a scan time of 1:47 min compared to a conventional scan time of 3:30 min.

Puneet Sharma, PhD, Assistant Professor, Department of Radiology and Imaging Sciences at Emory University, enjoys having GE's expert advice on hand for insight and collaboration. "They know the tips and tricks behind the sequences. We may know the theory, from research and literature, but it's good to have vendor experts on-site who know the software and system better than we do."

Consistent protocols

The Emory health system's overarching strategy is to standardize protocols across sites—a significant challenge due to the geographical spread, different software systems and mix of vendors at each location. Despite these complexities, the SIGNA™ Artist helped Emory Johns Creek Hospital establish protocols consistent with the main Emory campus.

"I felt confident propagating a lot of the protocols from Emory to Johns Creek, and it has been a pretty easy transition. With the SIGNA™ Artist, it was a pleasure to be able to easily replicate, almost one-for-one, sequences from the main campus to the system," says Dr. Sharma.

This process was a significant improvement over past experiences, and it has brought Emory Johns Creek Hospital to the forefront of technology across the different Emory sites. "In the past, I had to compromise on some of the sequences I selected on older models in our fleet, which diminished the radiologists' use of that particular system. Now I see it as a level playing field."

Powerful applications

With SIGNA™Works innovative applications like HyperCube and HyperSense, SIGNA™ Artist empowers Emory Johns Creek Hospital to deliver improved image quality, higher efficiency and a more streamlined workflow.

HyperCube expands the capabilities of 3D imaging to significantly reduce scan times and minimize artifacts by reducing the phase field-of-view (FOV) without the presence of aliasing artifacts. HyperSense is an acceleration technique based on sparse data sampling and iterative reconstruction that delivers higher spatial resolution images or reduced scan times, enabling faster imaging without the penalties commonly found with conventional parallel imaging.

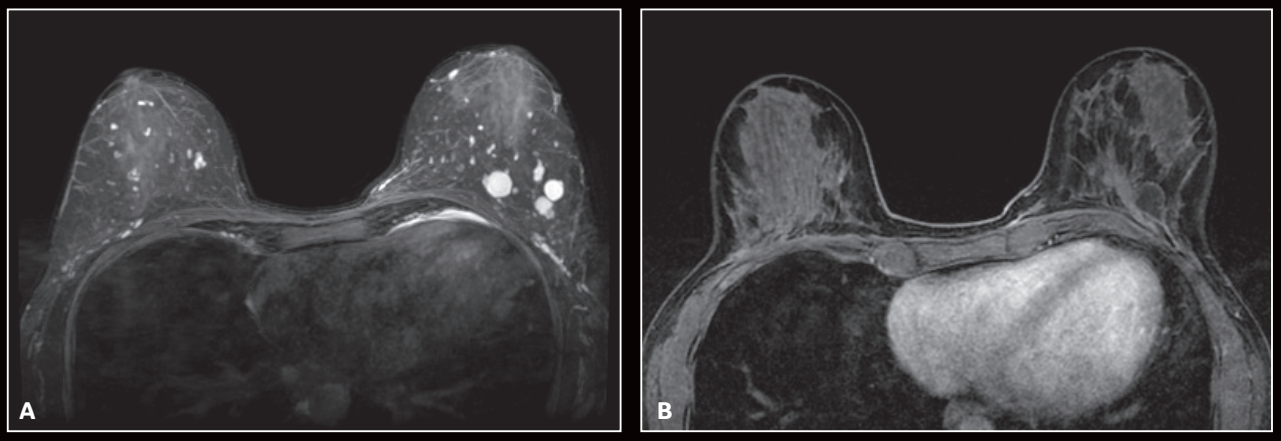

Figure 3. (A) T2 Flex HyperCube bilateral breast exam with HyperSense factor of 1.3 in a scan time of 3:37 min; (B) VIBRANT Flex.

High-resolution T2 imaging was previously a challenge on the prior MR system. Emory Johns Creek Hospital has begun using HyperSense with HyperCube for 3D imaging in neuro, body and pelvis scans. Dr. Sharma estimates the application has decreased scan time by 20-30% on average.

"There's been a significant drop in scan time. That is definitely one of the highlights. With HyperSense, we can achieve the same image quality in pelvis studies in almost half the time compared to other sites. Our goal is to run all of our T2 Cube imaging with HyperSense and/or HyperCube and all of our Time-of-Flight studies with the HyperSense version."

Dr. Puneet Sharma

The full 50 x 50 x 50 cm FOV in the 70 cm wide bore is another benefit, allowing Emory Johns Creek Hospital to more efficiently complete imaging exams that combine multiple stations, such as the chest, abdomen and pelvis. This, in turn, allows them to keep more exams in-house, rather than send them to the main Emory campus in Atlanta. In fact, abdomen-pelvis exams represent close to 50% of the body MR exams across all Emory sites. Previously, if these cases were not referred to the main campus, they would be split into separate exams at Emory Johns Creek, such as abdomen one day and then pelvis another day.

"We are able to do exams we couldn't do before, and now we can do these exams efficiently," says Dr. Sharma. And, that is also good for patients, who no longer have to travel longer distances or undergo two different MR exams for a large FOV study.

He also notes the newer body array coils are a tremendous improvement, with more signal sensitivity and more coverage, which has made a significant difference in breast MR exams. Plus, with the addition of VIBRANT Flex and HyperSense in the SIGNA™ Works portfolio, the technologists can acquire homogeneous fat separation in a single 3D volume scan that delivers water-only, fat-only, in-phase and out-of-phase images of the breast.

For the patient

SIGNA™ Artist has also helped improve staff and patient satisfaction rates.

The hospital streamlined redundant tasks with automated tools like auto breath-hold and the propagation of imaging parameters. In addition to the clean interface and easy-to-navigate system, it has made technologists' jobs easier. For example, the in-line post-processing tools have helped speed up the technologists' workflow.

"If you give staff the right tools to do their jobs, they become very happy people. Giving them SIGNA™ Artist was like handing them a treasure," says Barnes. "They have the ability to add patients in between scheduled exams because it's faster. That takes stress off the shoulders of my staff and therefore makes them happier."

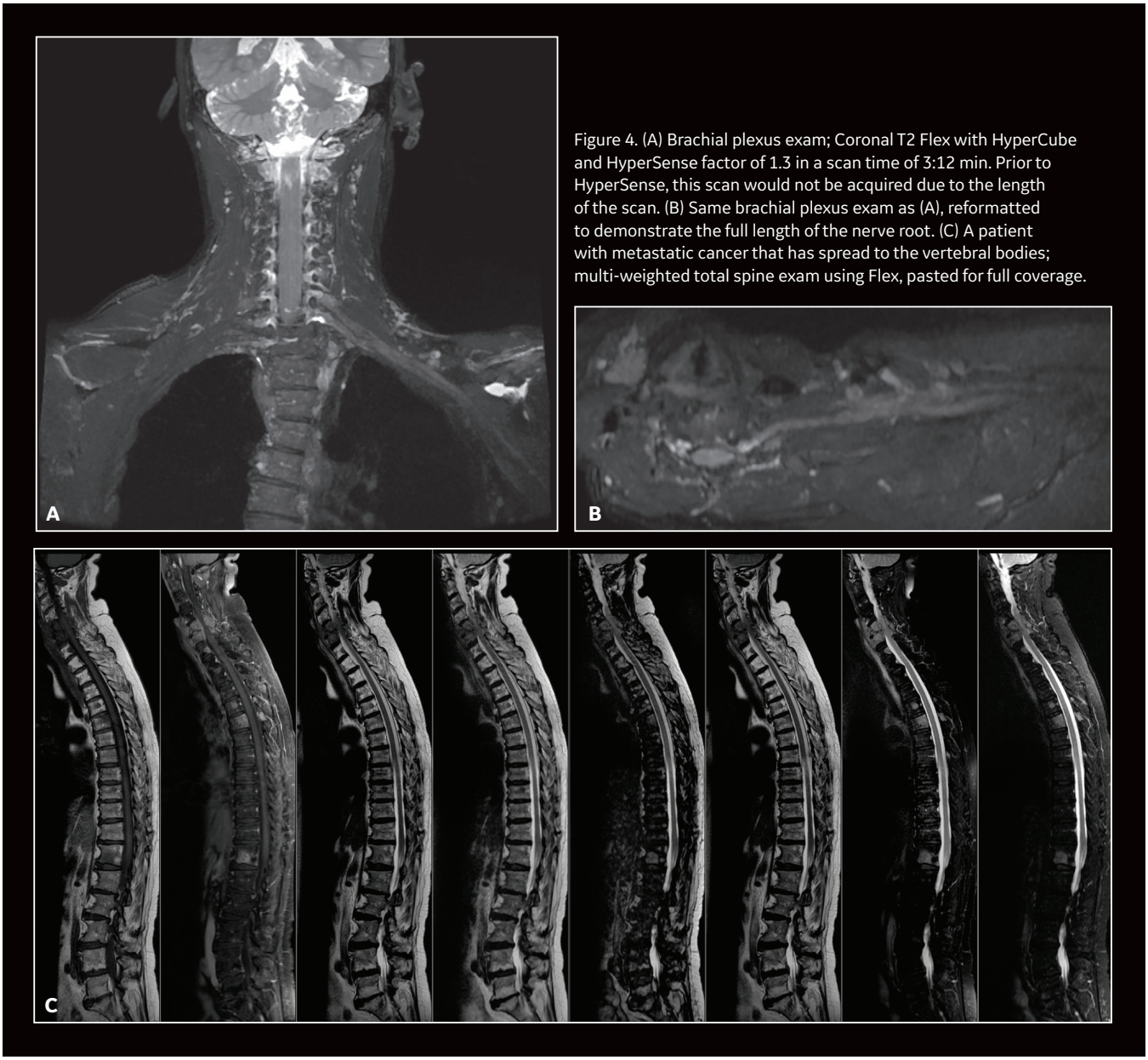

Figure 4. (A) Brachial plexus exam; Coronal T2 Flex with HyperCube and HyperSense factor of 1.3 in a scan time of 3:12 min. Prior to HyperSense, this scan would not be acquired due to the length of the scan. (B) Same brachial plexus exam as (A), reformatted to demonstrate the full length of the nerve root. (C) A patient with metastatic cancer that has spread to the vertebral bodies; multi-weighted total spine exam using Flex, pasted for full coverage.

Another factor is patient comfort, which directly affects patient satisfaction scores. Emory Johns Creek Hospital built a new suite around the SIGNA™ Artist to give patients a better overall experience. Now the site's Press Ganey scores have increased from single digits to the mid-90s. "It's a dramatic turnaround from where we were before. Patients are commenting, 'I come here often, and this is the fastest I've ever gotten out of here,'" says Barnes. "It's considerably faster than what we had in the past."

The SIGNA™ Artist's 70 cm wide bore design helps alleviate a patient's fear of entering the MR bore. The expansive diameter, soft lighting and soothing fans help ease patient anxieties and concerns. The wider table design sits lower to the ground, enabling easier patient positioning. Lightweight and adaptable coil designs conform gently to a patient's anatomy, elevating the patient experience. The SIGNA™ Artist's eXpress table, with a memory foam surface, delivers feet-first or head-first imaging and features a detachable egress and IntelliTouch positioning.

"The whole experience moves us toward the ultimate goal of a spa-like experience for patients," says Dr. Sharma. "SIGNA™ Artist is certainly progress toward that goal, and it's good to see GE Healthcare continuing to innovate the way forward on that."

Paul Malcolm, MBBS, BSC, MRCP, FRCR
Norfolk and Norwich University Hospital,
Norwich, England

Using HyperSense to reduce scan times and elevate diagnostic success

As part of the NHS Foundation Trust, Norfolk and Norwich University Hospital provides comprehensive care to more than 800,000 residents of Norfolk and North Suffolk counties in England. Approximately 1 million outpatient appointments, day-case procedures and inpatient admissions are performed annually across the Trust's healthcare sites, which include two hospitals: Norfolk and Norwich University Hospital and Cromer and District Hospital.

The Trust has four MR scanners, with three sited at Norfolk and Norwich University Hospital. In December 2016, the hospital's Discovery™ MR750w, a 3.0T wide bore scanner, was upgraded to the SIGNA™Works productivity platform. This new platform includes an array of imaging solutions that cover a wide variety of contrasts, 2D and 3D volumetric data, motion correction capabilities and the high-efficiency HyperWorks suite with GE Healthcare's compressed sensing solution, HyperSense. HyperSense is an acceleration technique based on sparse data sampling and iterative reconstruction that enables faster imaging without the penalties commonly found with conventional parallel imaging.

Paul Malcolm, MBBS, BSC, MRCP, FRCR, consultant radiologist, specializes in gynecological and urological imaging with an emphasis on body MR. Dr. Malcolm wanted to explore the new advantages of the SIGNA™Works productivity platform upgrade and believed that one area where HyperSense could make a difference was in MRCP exams.

"We believed that MRCP would benefit from employing HyperSense to achieve results in a shorter time," Dr. Malcolm explains.

Over the next few months after the implementation of SIGNA™Works, Dr. Malcolm performed a series of MRCP exams with the existing protocol and also with a new protocol using HyperSense. He alternated between running the old and new protocol first.

"I wanted to see if the sequence was reliable and robust and whether it generated new artifacts, resulted in poor imaging or if it could reduce scan times. We started in small increments and compared it in real clinical situations," Dr. Malcolm adds.

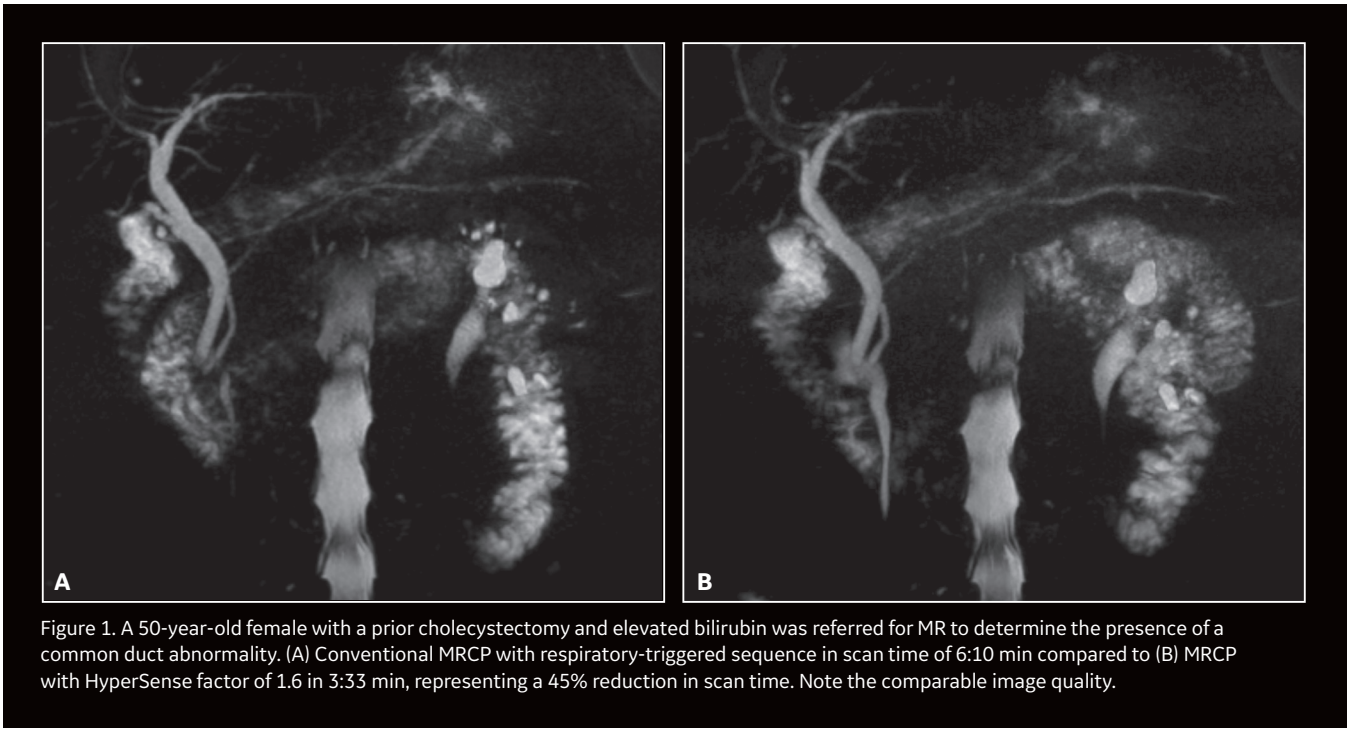

Figure 1. A 50-year-old female with a prior cholecystectomy and elevated bilirubin was referred for MR to determine the presence of a common duct abnormality. (A) Conventional MRCP with respiratory-triggered sequence in scan time of 6:10 min compared to (B) MRCP with HyperSense factor of 1.6 in 3:33 min, representing a 45% reduction in scan time. Note the comparable image quality.

Previously, the hospital's MRCP protocol was acquired in two sequences. The first was a 3D respiratory-triggered, high-resolution sequence that would take approximately four to six minutes. Unfortunately, some larger-sized patients would not tolerate the scan well and in others there would be movement, leading to artifacts. Due to this movement, a second breath-hold radial sequence with thick slices was employed. While this series of rapid, radial scans could be completed in as little as 40 seconds, image quality was limited.

After comparing approximately 30 MRCP cases, Dr. Malcolm felt he had sufficient imaging data to assess the clinical value of HyperSense. While evaluating if HyperSense could be used to shorten the respiratory-triggered sequences, Dr. Malcolm found several advantages.

First, by using a HyperSense factor of 1.6, he could generate similar image quality in the high-resolution, respiratory-triggered sequence in about two-thirds the time, sometimes less.

The next step was to evaluate the breath-hold sequence with and without HyperSense. By using HyperSense, this sequence could be reduced to 25 seconds with very high image quality.

"When we compared the faster sequence using HyperSense, the image quality was similar. That is a substantial gain. Just as important, when we ran the faster scan with HyperSense, the patient could better tolerate the sequence and did not move as much. Sometimes with the conventional breath-hold radial sequence we would get a non-diagnostic scan with movement. But with HyperSense, we could obtain a diagnostic scan and get a result where previously we couldn't."

Dr. Paul Malcolm

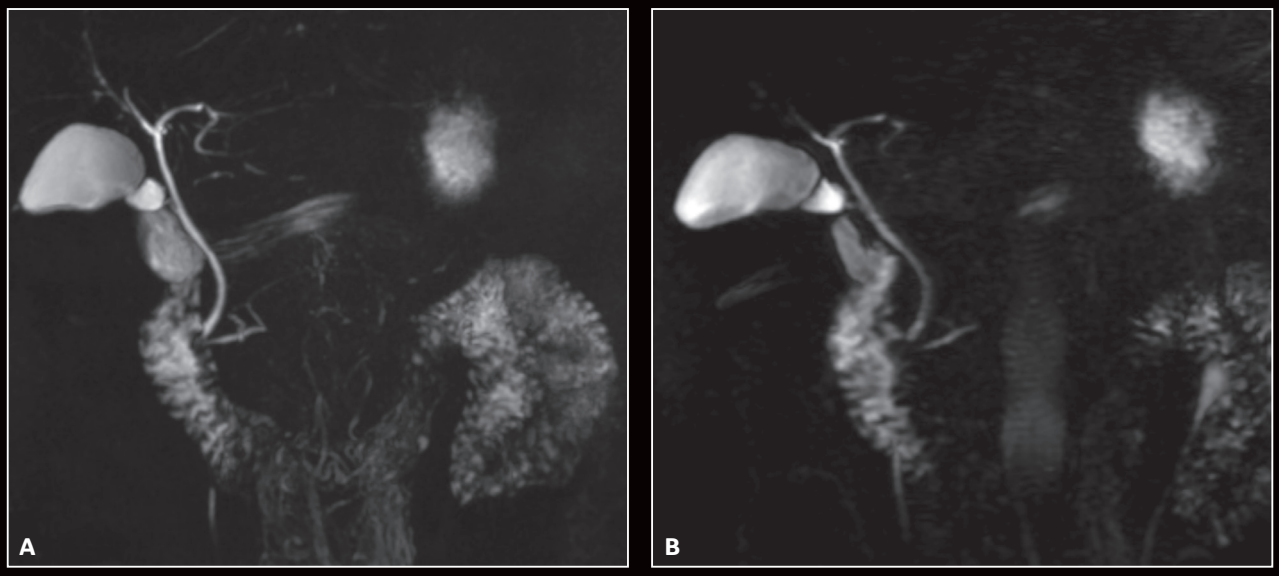

Figure 2. A 47-year-old male with primary sclerosing cholangitis and cirrhosis of the liver. Patient was claustrophobic and couldn't tolerate a second 3D respiratory-triggered sequence. (A) Conventional MRCP with respiratory-triggered sequence was acquired in 5:41 min. (B) HyperSense was employed with the fast breath-hold radial sequence with a scan time of 25 sec.

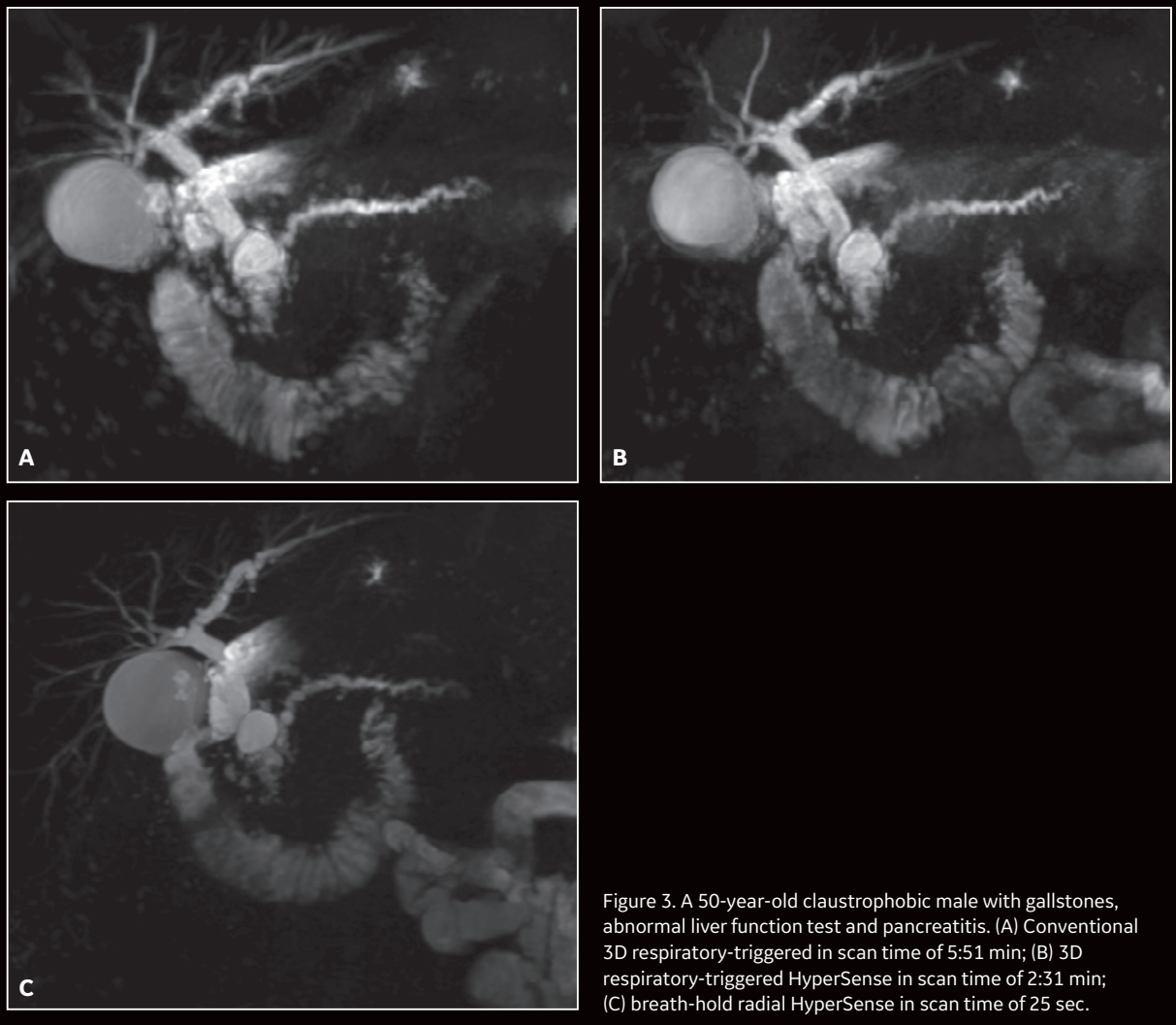

Figure 3. A 50-year-old claustrophobic male with gallstones, abnormal liver function test and pancreatitis. (A) Conventional 3D respiratory-triggered in scan time of 5:51 min; (B) 3D respiratory-triggered HyperSense in scan time of 2:31 min; (C) breath-hold radial HyperSense in scan time of 25 sec.

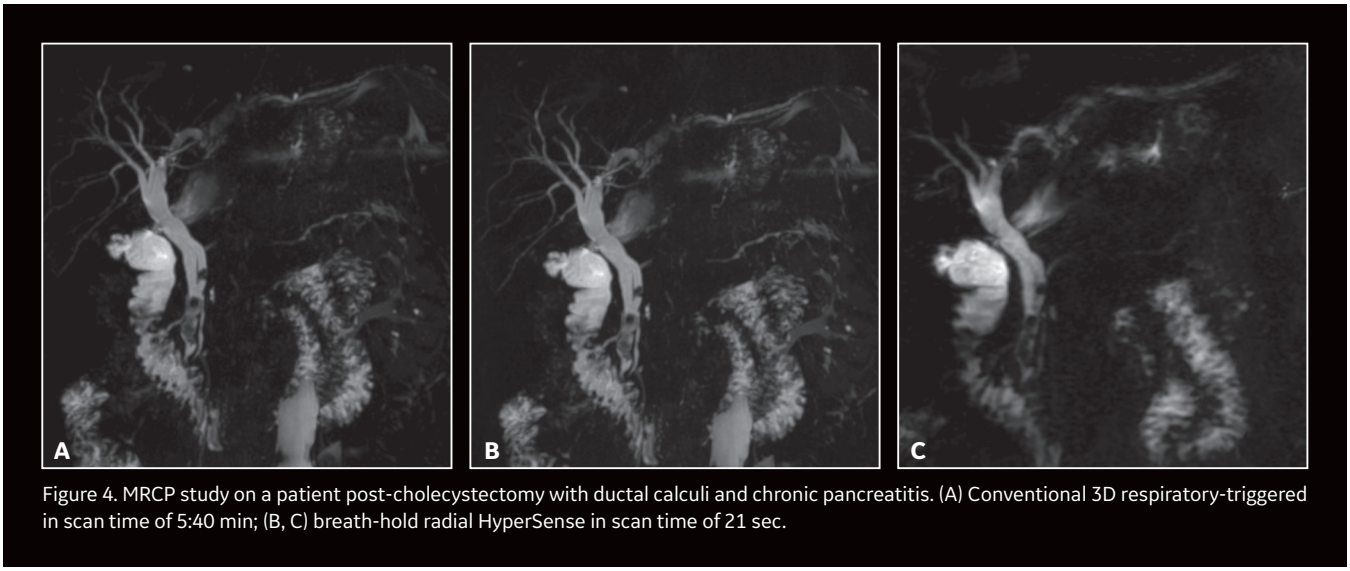

Figure 4. MRCP study on a patient post-cholecystectomy with ductal calculi and chronic pancreatitis. (A) Conventional 3D respiratory-triggered in scan time of 5:40 min; (B, C) breath-hold radial HyperSense in scan time of 21 sec.

"In the acquisition plane, we achieved similar image quality with the breath-hold HyperSense when compared to the 3D respiratory-triggered sequence," Dr. Malcolm explains. "While the spatial resolution wasn't the same, the 3D breath-hold HyperSense sequence could often provide the information that we needed for a confident diagnosis. So, even if the patient couldn't tolerate the high-resolution 3D scan, the breath-hold HyperSense scan alone often resulted in a successful examination.

"We were able to move from a situation where we had limited information from a breath-hold radial sequence to an MRCP study that provides us with the information we need to make a diagnosis. HyperSense has significantly improved our imaging ability and reduced our imaging scan times, thus increasing the proportion of patients in whom we can obtain a quality diagnostic MRCP study.

Dr. Paul Malcolm

As a result, the MRCP MR imaging exams at Norfolk and Norwich University Hospital have now been modified to always include HyperSense. Parallel imaging is also being used with HyperSense to gain the maximum benefit of both; yet, the technologists don't have to push the limits of using parallel imaging and avoid the signal loss that would otherwise occur.

While the preference is to always collect the 3D respiratory-triggered sequence with HyperSense, Dr. Malcolm knows that he has a back-up sequence with the breath-hold HyperSense scan. Although the time-saving benefits using HyperSense are obviously important, the fact that Dr. Malcolm can acquire diagnostic exams on patients who move or are claustrophobic—and typically have non-diagnostic MR studies—is significant.

With nearly two minutes saved per patient in MRCP cases, Dr. Malcolm and the department have gained added flexibility in patient scheduling.

"With this flexibility, we can squeeze in cases where we couldn't have done that before," he adds.

The technologists are also pleased with the time savings. They would often try to reduce scanning time, especially in claustrophobic or obese patients where the possibility of a non-diagnostic scan was higher. Now, with HyperSense, they have an increased chance for success.

Next, Dr. Malcolm intends to evaluate the use of HyperSense in other areas such as vascular imaging where HyperSense has the potential for time savings without loss of quality and can enable diagnostic studies in more challenging patients.

Imaging the brachial plexus in a 10-minute 3D MR scan

By Ngo Van Doan, MD, MMed, Vice Head of the Diagnostic Imaging Department, Vinmec Times City International Hospital, Hanoi, Vietnam

SIGNA™ Pioneer

PARAMETERS	*Coronal HyperCube STIR with nerve optimization*	*Axial T2w HyperCube with CSF optimization*
TR:	3000 ms	2540 ms
TE:	83 ms	150 ms
TI:	260 ms	
ETL:	120	120
FOV:	40 x 40 cm	18 x 14.4 cm
Interpolated slice thickness:	1 mm	0.5 mm
Acquired slice thickness:	2 mm	1 mm
Frequency:	400	260
Phase:	300	260
NEX:	2	2
rBW:	62.5 kHz	62.5 kHz
ARC acceleration:	Phase x 1.5	Phase x 2
	Slice x 1	Slice x 1
HyperSense acceleration:	x 1.3	x 1.5
Scan time:	4:23 min	5:41 min
Imaging options:	NPW	FOCUS DWI

Ngo Van Doan, MD, MMed

Vinmec Times City International Hospital, Hanoi, Vietnam

Introduction

MR imaging of the brachial plexus often involves several clinical challenges. Complex anatomy, comprised of roots, trunks, divisions and chords can be challenging, particularly if the patient has an abnormal variant of the nerve root. Further, investigating injuries or lesions in the brachial plexus with traditional 2D imaging can be further complicated if it resides in the trunk, divisions or chords, although this is not a common occurrence.

At our facility, HyperSense and HyperCube have been implemented on the SIGNA™ Pioneer. A key benefit of 3D imaging using HyperCube is the acquisition of high-resolution data that facilitates the identification of normal anatomy as well as lesion location and classification.

In cases involving a vehicular accident (motorbike or car), it is not uncommon for the patient to sustain a rupture or avulsion—a pseudo-meningocele of the spinal cord. In these cases, a rapid yet comprehensive MR exam is preferred for diagnosis.

Patient history

A 22-year-old involved in a motorbike accident one month prior presented with numbness in the right arm. The patient was previously diagnosed with an injury to the brachial plexus. MR imaging was performed to confirm prior diagnosis and further evaluate the injury.

MR findings

1. C5-C6 nerve roots: complete post-ganglionic rupture.
2. C7 nerve root: partial rupture, decreased post-ganglionic nerve's diameter without nerve stretching.
3. C8 nerve root: nerve root avulsion, T2 hyper-signal post-traumatic pseudo-meningocele, edema with increased diameter of the post-ganglionic nerve.
4. T1 nerve root: no abnormality noticed.

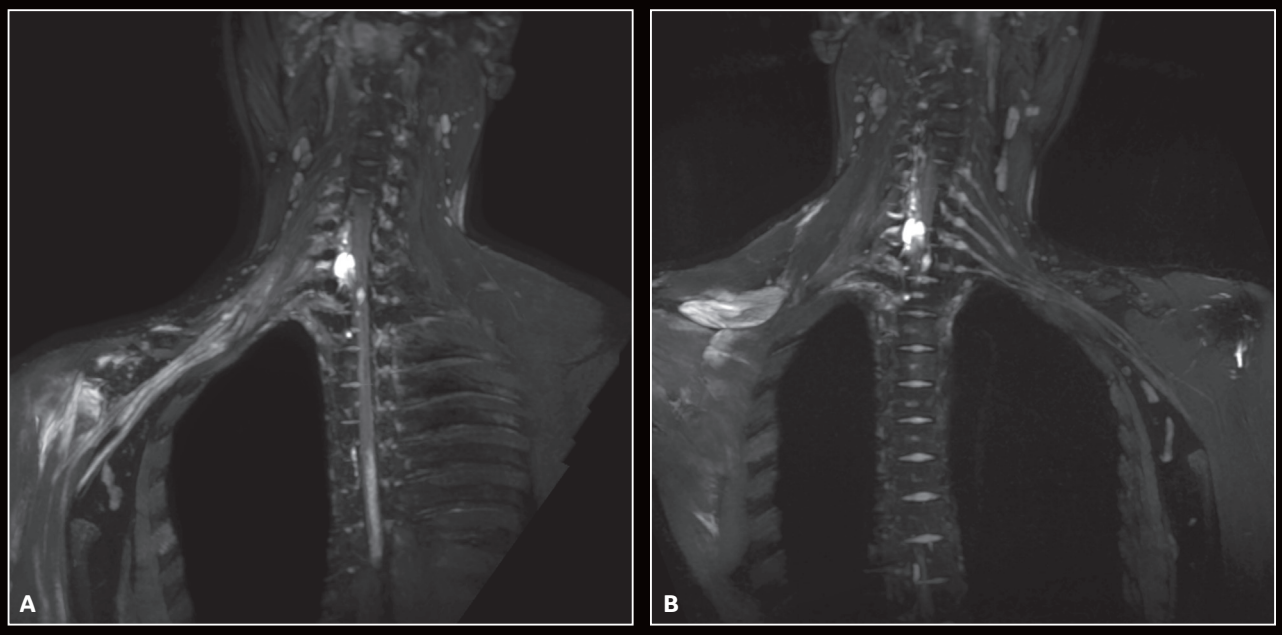

Figure 1. Coronal HyperCube STIR sequence in a 4:23 min scan time with 1 mm slice thickness and a 40 x 40 cm FOV. (A) Right brachial plexus oblique reformat and (B) left brachial plexus oblique reformat.

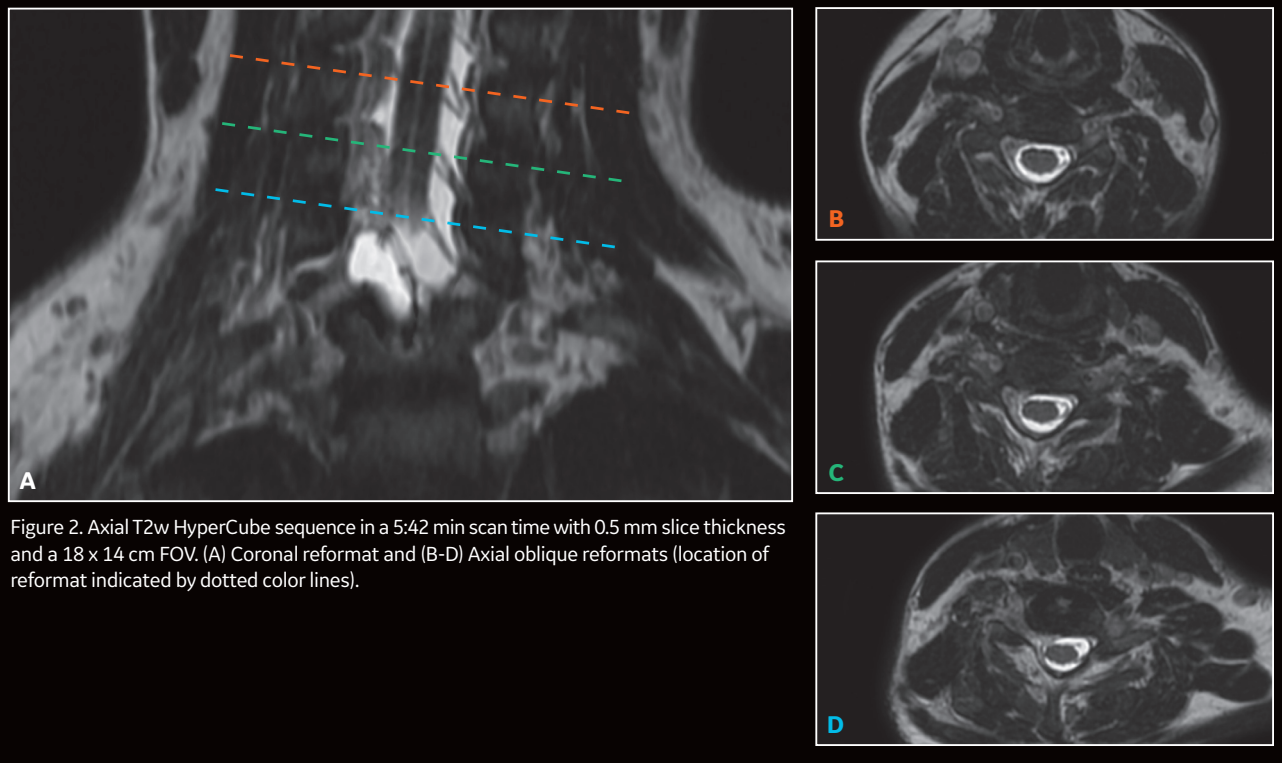

Figure 2. Axial T2w HyperCube sequence in a 5:42 min scan time with 0.5 mm slice thickness and a 18 x 14 cm FOV. (A) Coronal reformat and (B-D) Axial oblique reformats (location of reformat indicated by dotted color lines).

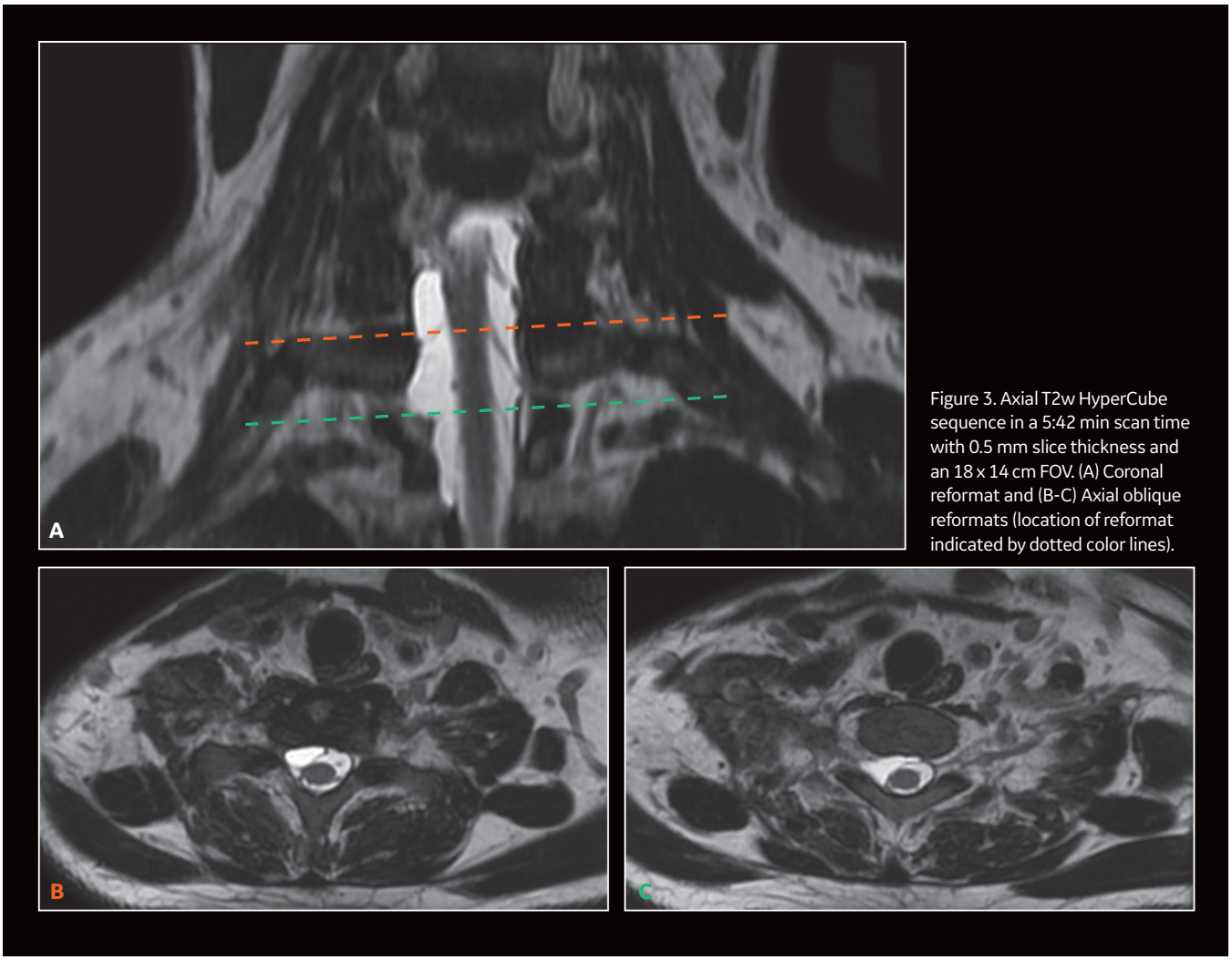

Figure 3. Axial T2w HyperCube sequence in a 5:42 min scan time with 0.5 mm slice thickness and an 18 x 14 cm FOV. (A) Coronal reformat and (B-C) Axial oblique reformats (location of reformat indicated by dotted color lines).

Discussion

By utilizing 3D HyperCube with STIR, it is easy to visualize the brachial plexus post-ganglionic branches with background flow suppression and nerve contrast optimization. The C8 branch is difficult to view on conventional MR imaging techniques but it can be clearly seen using this new sequence.

The pre-ganglionic lesion is well appreciated on the high-resolution T2-weighted HyperCube sequence. The nerve roots can be clearly visualized and evaluated in scanning and reformat planes without losing spatial detail. The dark nerve roots are well delineated in contrast to the uniformly bright cerebrospinal fluid throughout the volume of scan coverage.

The high spatial resolution and good image contrast are helpful to recognize the normal and variant nerve structures and the lesion or injury.

Using volume rendering and maximum intensity projections on the Advantage Workstation, we can more easily visualize the lesion and its exact position. HyperCube provides us with better tissue contrast and spatial resolution compared to conventional 2D imaging. Additionally, a brachial plexus MR examination can be completed in a total scan time of 10 minutes by using two high-resolution HyperCube sequences with a HyperSense acceleration factor of 1.3 with the STIR sequence and a 1.5 factor with the T2-weighted sequence. At Vinmec, we are routinely using these sequences due to the advantages of reduced scan time and high-resolution imaging.

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