Outside the Bore

5 Break through to Tomorrow’s MR... Today with SIGNA™ Premier and SuperG

6 Weill Cornell Medical Center invests in ultra high-field 7T MR research

6 GE MR welcomes Michael Brandt

7 GE Healthcare welcomes new President/CEO

7 Whole-body staging of solid tumors in pediatrics without gadolinium

Issue Spotlight

8 Synthetic diffusion: a robust sequence for prostate cancer diagnosis and patient management

13 Increased PET sensitivity with TOF & Q.Static elevates clinical confidence

16 Pursuing an MR-only approach to radiation therapy planning

20 Making a difference in MR oncology imaging

In Practice

26 Optimized clinical pathway propels high utilization of PET/MR at Pitié-Salpêtrière Hospital

32 “Child first and always” philosophy drives investment in advanced MR technology at Intermountain Healthcare

38 Using an efficient, quantitative sequence to aid in patient treatment decisions

42 SIGNA™ Explorer Lift revives our MR

47 Going digital with SIGNA™ Artist helps prepare Dunedin Hospital for the future

52 A boost in productivity

Publications Team:
Stephanie Broyhill
Editor-in-Chief
Advertising & Promotions Leader, Global MR

Anna Brown
Associate Editor
Advertising & Promotions Director, Global MR

Kerry Adapathy
Associate Editor
Advertising & Promotions Leader, Global MR

Mary Beth Massat
Associate Editor

GE Contributors:
Ibrahim Alabdulaaly
Clinical Leader, MR

Holly Blahnik
Clinical Development Specialist, MR

Raphael Doustaly
Zone Clinical Leader, MR

Almos Elekes, PhD
Global Product Marketing Manager, PET/MR, Oncology and Molecular MR

Luciana Fracchia
Product Marketing Specialist, MR

Stephen Gibbs
Global Product Marketing Operations Director, MR

Kentaro Goto
Modality Sales Specialist, MR

Moonjung Hwang
Scientist, MR

Brian King
Region Modality Leader, MR

Joonsung Lee
Advanced Applications Leader, MR

Greg Lochmann
Region Modality Leader, MR

Jun Nagata
Product Marketing Manager, MR

Barbara Pizgossi
Region Clinical Applications Leader, MR

Richard Prorok
Strategic Marketing Manager, MR

James Sedorovich
Clinical Product Marketing Leader, MR

Janice Sich
Regulatory Affairs Manager, MR

Matt Sumsinski
Business Development Manager, PET/MR

Fotis Vlachos, PhD
Global Product Manager, Premium MR

Guillermo Zanoli
Clinical Marketing Manager, MR
Case Studies

55 Two-minute MR ultra-fast neuro protocol
58 Pediatric brain tumor assessment using MAGIC
62 Pediatric imaging with MAGIC
65 Pediatric MR enterography

Tech Trends

68 Total freedom in coil positioning and handling with the AIR Technology Suite
Welcome

Earlier in October, I had the privilege of hearing John Flannery, GE’s Chairman and CEO, speak at the 2017 Minds + Machines event in San Francisco. As he succinctly retold GE’s 30+ year history in MR—yes, it marks 35 years next year!—I was struck by how closely his narrative reflected the theme for RSNA. This year’s theme of course revolves around three core tenets: Explore, Invent and Transform. Thirty-five years ago, in GE’s labs, our engineers and scientists were exploring magnetic resonance imaging, leveraging technology 30,000 times stronger than the earth’s magnetic field. That led to the invention of the industry’s first high-field 1.5T MR scanner, our first SIGNA™ system, which enabled clinicians to see inside the human body and obtain images and information like never before. That was a quantum leap that helped radiology transform healthcare.

Now our challenge is to make the next leap, and this time we are doing it in the context of a more digitally-enabled world. Along with our research and clinical partners, we are focused on applying deep learning-based Artificial Intelligence (AI) and analytics to our portfolio of SIGNA™ MR scanners and connected devices. Our aim is to reduce exam times and exam time variability, improve consistency of image quality and eliminate rescans and recalls. You’ll benefit from real productivity gains and your patients will benefit from a better MR experience and maybe an improved clinical outcome… our ultimate scorecard.

So, what will you see at RSNA this year? We are excited to take you on an interactive journey of innovation that brings to the forefront technology that embodies SIGNA™: Tomorrow Today. Great products begin with exploration and that exemplifies the roots of the SIGNA™ Premier, a powerful ultra-premium scanner you’ll have the opportunity to view in our booth. Developed in partnership with the NFL and academic institutions, this scanner is designed for both high-end research and leadership clinical utility. SIGNA Premier combines the exceptional capabilities of 3.0T imaging with a 146-channel Total Digital Imaging (TDI) RF chain and SuperG gradient technology that delivers a 70 cm wide bore with the cutting-edge stability and Human Connectome performance only available on 60 cm systems. And the intelligence factor? SIGNA Premier’s sophisticated platform uses advanced diffusion applications to automatically correct distortion and was developed with machine learning to precisely optimize SAR limits for each patient.

And cardiac imaging? Our newly expanded ViosWorks post processing platform leverages cloud computing and deep learning algorithms to automate cardiac MR analysis, delivering accurate, quantifiable results. Through exploration comes invention, which brings us to SIGNA™Works. Developed through partnerships with our academic collaborators, SIGNA™Works is a fully customizable platform designed to drive productivity and clinical excellence by optimizing operational throughput with greater imaging speed, accuracy and consistency. This extensive portfolio includes GE’s HyperWorks applications: HyperSense, HyperBand and HyperCube, designed to deliver up to 8 times faster imaging efficiency and streamlined workflow. For example, HyperSense technology delivers increased speed for 3D exams by incorporating compressed sensing reconstruction for research and 88% of all clinical procedures.

We’ve explored and invented, now it’s time to transform. You’ll also see our industry-first AIR Technology created with people in mind. This unique RF coil technology benefits patients with an ultra-lightweight, flexible design that conforms comfortably to all patient shapes and sizes. Also included in this suite is the 48-channel TDI Head Coil, designed to fit 99.9% of patients with high SNR and acceleration factors for superior brain imaging. Available initially with SIGNA Premier, the suite allows technologists to experience new freedom in coil handling and positioning.

Of course, there will be more to see at RSNA, but I’d rather you hear about those innovations from the passionate people that made them possible. Stop by the GE booth and see the strides we’ve made in partnership with you as we Explore, Invent and Transform to deliver SIGNA: Tomorrow Today.

Eric Stahre
President and CEO
Global MR, GE Healthcare
SIGNA™ Premier, the result of a four-year collaboration with the National Football League (NFL) and research institutions worldwide, will bring a new level of clinical performance and added research capabilities to clinicians across the globe. Featuring SuperG, the most powerful gradient technology GE Healthcare has ever developed for a wide bore 3.0T system, SIGNA Premier delivers high homogeneity, superb stability and outstanding performance in a 70 cm bore that is comparable to ultra-high performing, research-class 60 cm bore MR systems.

SuperG gradient coil technology improves acquisition speeds by leveraging force-balanced, all-hollow conductors with independent cooling circuits for X-, Y- and Z-axes. By directly cooling each gradient layer, SIGNA Premier maximizes the duty cycle for Human Connectome protocols (MultiShell DTI and high resolution fMRI) and high-resolution body, musculoskeletal and cardiac imaging without sacrificing patient comfort or bore size.

“We are thrilled to bring SIGNA Premier to clinicians,” says Eric Stahre, President and CEO of GE Healthcare, MR. “We believe that its advanced applications and breakthrough innovations will deliver research-focused clinical capabilities and wide bore patient comfort. This new system will help clinicians push the boundaries of what’s possible with MR.”

In addition to SuperG, SIGNA Premier also features a new, digital RF transmit and receive architecture. The RF technology of SIGNA Premier provides 146 independent receive channels that allow the simultaneous acquisition of patient data from multiple high-channel density surface coils for faster scanning, higher image quality and overall enhanced clinical performance compared to prior generations of GE Healthcare MR systems. Clinical and research applications benefit from this high-performance hardware as well as software that was developed with machine learning, which includes cloud analytics.

Fueled by the SIGNA™Works productivity platform, SIGNA Premier helps departments redefine productivity across the breadth of core imaging techniques with innovative applications such as HyperWorks, ImageWorks, SilentWorks and ViosWorks.

---

**Break through to Tomorrow’s MR... Today with SIGNA Premier and SuperG**

---

**UW-Madison**

is using the newest MR technology to conduct research that will help them further their understanding of disease.

[tiny.cc/spa171](tiny.cc/spa171)

---

Learn more about SuperG, the latest in gradient technology from GE Healthcare.

[tiny.cc/spa170](tiny.cc/spa170)
Weill Cornell Medical Center invests in ultra high-field 7T MR research

In early 2019, Weill Cornell Medical Center will install GE Healthcare's SIGNA™ 7T™ platform for use in research applications and a training program for ultra high-field MR clinical staff and scientists. Weill Cornell Imaging received an educational grant to serve as a training center for ultra high-field MR for clinical staff and scientists from around the world. The goal of this training is to equip the next generation of MR users to better understand and utilize ultra high-field MR in a research setting.

“Our vision at GE Healthcare is to bring MR technology to more patients around the world and to push the boundaries of what's possible with MR; this collaboration with Weill Cornell will help achieve that vision through novel research and training of the next generation of MR users,” says Eric Stahre, President and CEO of GE Healthcare, MR.

7T MR systems are used for scientific and medical research, primarily for morphological and functional imaging of the brain while steadily expanding to all anatomies. Researchers using ultra high-field scanners hope that their research will contribute to earlier disease detection, more accurate diagnosis and increased effectiveness of investigational therapies for disorders and diseases. 

GE MR welcomes Michael Brandt

GE Healthcare is pleased to announce Michael Brandt has joined the team as Chief Marketing Officer, Global MR. Brandt has over 20 years of strategic leadership experience in the medical imaging industry as well as global expertise in business development for multi-national medical device companies (specializing in MR-guided radiotherapy, robotic radiosurgery, CT and MR).

Prior to joining GE, Brandt served as Vice President Sales, Marketing and Business Development at Anatomage, Inc., Senior Vice President of Sales and Marketing at ViewRay, Inc. and General Manager: Americas at Accuray. While at ViewRay, Brandt oversaw the commercial introduction of the world’s first MR-guided radiation therapy system. Brandt also distinguished himself at Philips Medical Systems where he held a variety of international MR management positions in the UK, the Netherlands, South Africa and the U.S.

Brandt remains as passionate about MR now as he was as a young engineer installing and servicing MR equipment in his hometown of Johannesburg, South Africa. From understanding the system mechanics to his vision for advancing MR in radiation therapy, Brandt believes the power of MR imaging can continue to have a significant impact on the diagnostic advancements for cancer treatments, neurodegenerative diseases and cardiovascular disease.

“At GE Healthcare, we have a magnificent product line and a strong engineering team committed to patient care,” Brandt says. “There are many marketing channels available to us in the 21st century, but our primary focus is the patient.”

Keeping his sights set on what’s important—elevating patient care through innovation—he sees more similarities than differences in how MR is utilized worldwide.

“Our customers, regardless of where they are located, are essentially reading the same literature and examining the same patient on the same equipment for the same disease,” he says.

Brandt is excited to be part of the GE Healthcare team and hopes to continue the vision that has consistently held the company at the forefront of medical imaging technology.

Brandt is a graduate of Vaal University of Technology in Vanderbijlpark, South Africa with a degree in electrical engineering.

1The SIGNA 7T MR system is technology in development. It is not cleared or approved by the US FDA or other global regulatory body for commercial availability for clinical use. This system is for research only.
GE Healthcare welcomes new President/CEO

Kieran Murphy was appointed President and CEO of GE Healthcare, succeeding John Flannery who will replace GE Chairman and CEO Jeff Immelt. Prior to his appointment, Murphy was President and CEO of GE Healthcare Life Sciences, where he oversaw significant revenue growth and geographic expansion of the Molecular Imaging business.

In a released statement, Immelt said, “Having led the strategic combination of GE’s Life Sciences and Medical Diagnostics units, Kieran Murphy has distinguished himself as a strong customer advocate with great commercial instincts. Alongside the outstanding team at GE Healthcare, we anticipate that the business will experience continued global growth under Kieran’s leadership.”

Murphy has over 20 years of experience in the global life sciences and biotechnology industry beginning his career with Janssen Pharmaceutical, a division of Johnson and Johnson, followed by leadership roles with Mallinckrodt, veterinary medicines provider Vericore, Novartis, Adprotech, ML Laboratories and Innovata plc. Having earned his bachelor’s degree in 1984 from University College, Dublin, he subsequently graduated from the University of Manchester Institute of Science and Technology with a master’s degree in marketing.

Whole-body staging of solid tumors in pediatrics without gadolinium

Stanford researchers have achieved whole-body staging of solid tumors in pediatric patients without the use of gadolinium. A study published in *Molecular Imaging and Biology* in July 2017, reports that the use of ferumoxytol-enhanced PET/MR scans provided images showing the location and size of the tumor and whether the cancer had spread. Researchers were able to stage the tumor in less than 1 hour with equal or superior results compared to clinical standard tests in 17 out of 20 patients. The study also reported significantly reduced radiation exposure with a mean of 3.4 mSv compared to a mean of 13.1 mSv with PET/CT. While PET/MR had comparable detection rates to PET/CT for pulmonary nodules with diameters of 5 mm or greater, it detected fewer nodules with diameters less than 5 mm.

Read the full study at: tiny.cc/spa172
Isabelle Boulay-Coletta, MD  
Groupe hospitalier Paris Saint-Joseph  
(St. Joseph Hospital) in Paris, France

Synthetic diffusion: a robust sequence for prostate cancer diagnosis and patient management

Located in the heart of Paris, the Groupe hospitalier Paris Saint-Joseph (St. Joseph Hospital) has a strong reputation for the diagnosis and treatment of urologic cancers, including prostate, kidney and bladder. For the last 15 years, Isabelle Boulay-Coletta, MD, radiologist, has been using MR for prostate imaging—first at 1.5T and in the last eight years at 3.0T with the Discovery™ MR750. An average of 20 MR prostate exams are conducted each week.

When Dr. Boulay-Coletta began to use MR for prostate imaging, the exam was most often used to depict the extent of the disease—patients were already diagnosed with the cancer based on prostate biopsy. Today, this has dramatically changed. MR is being increasingly used prior to prostate biopsy to avoid artifacts due to hemorrhage and to aid in the diagnosis of prostate cancer in men with elevated prostate-specific antigen (PSA) levels.

Although there is not yet a clear consensus in the literature about when to perform prostate MR, the role of MR imaging is rapidly extending to a variety of clinical situations, both before and after prostate biopsy. For example, when performed after a positive prostate biopsy, MR is an important tool for treatment decisions. In cases of a negative prostate biopsy with elevated PSA, a clinician will want to be sure that no significant prostate cancer is undetected by the biopsy before reassuring the patient on the status of their disease.

In the same setting, patients potentially eligible for watchful waiting, or active surveillance, are referred to MR to rule out significant cancer before being included in the program. During active surveillance, if PSA increases with no prostatitis then another MR is performed to detect any modification and/or appearance of a new target for MR transrectal ultrasound (TRUS) fusion biopsy.

Finally, more patients are being referred to MR prior to prostate biopsy as a means of aiding the clinician with a diagnosis and to image the suspected cancer.

Diffusion MR sequences are of increasing importance to delineate the target and guide the TRUS biopsy. Based on MR, Dr. Boulay-Coletta will decide whether to add targeted biopsy, especially to lateral and anterior locations.
Figure 1. A 67-year-old patient with elevated PSA (9 ng/ml) referred to MR prior to biopsy. (A) Axial T2 FSE; (B) acquired FOCUS DWI b2000; (C) synthetic FOCUS DWI b2000; (D) ADC map based on FOCUS DWI. It is very challenging to detect the prostate cancer based on Axial T2 FSE. With diffusion imaging (acquired or synthetic) and ADC map, it is possible to delineate a significant cancer in the right apex of the prostate. In addition to randomized standard biopsies, apical biopsies could be performed in this case.

Figure 2. FOCUS DWI: (A) b50; (B) b500; (C) b1000. Using MAGiC DWI, (D) b2000 and (E) b2500 are synthetic.

**Value of MR imaging**

In cases of known cancer confirmed by biopsy, the hospital’s protocol initially included three T2 sequences acquired in each orthogonal plane, followed by FOCUS DWI and contrast-enhanced DISCO. In cases referred for diagnosis of prostate cancer, Dr. Boulay-Coletta performs a Sagittal 3D HyperCube T2 followed by an Axial T2, FOCUS DWI and contrast-enhanced DISCO. She explains that HyperCube provides the reference MR images that, when fused with ultrasound, can guide a transrectal targeted biopsy if needed.

While DWI has always been a useful sequence for prostate cancer, the sequence has become essential in the PI-RADS™ Version 2 reporting scheme.
Dr. Boulay-Coletta explains, "So, you must be able to succeed with this sequence all the time. Utilizing FOCUS for diffusion-weighted images with a small FOV has improved overall image quality at 3.0T. To maximize the quality and minimize artifacts inherent to DWI, patient preparation before the exam is important. In our institution, we ask patients to administer an enema 2 hours before the MR to eliminate rectal gas."

To fulfill the PI-RADS™ technical requirement concerning diffusion, Dr. Boulay-Coletta relies on an ADC map acquired with b-values of less than 1,000 as well as diffusion-weighted images with a high b-value greater than 2,000. Therefore, it is necessary to acquire two different sets of diffusion images.

However, acquiring the b-value of 2,000 comes with a time penalty. So, when MAGIC DWI, also known as synthetic diffusion, became available, it was added to St. Joseph’s 3.0T scanner via an upgrade to SIGNA™Works. For the first three months, Dr. Boulay-Coletta and colleagues compared the image quality of acquired diffusion with a b-value of 2,000 with MAGIC DWI at the same b-value. Most importantly, Dr. Boulay-Coletta wanted to ensure that MAGIC DWI provided the same information as the high b-value acquired images. Also, the images generated by MAGIC DWI are slightly different in terms of noise and appearance, and she wanted to verify there would be no change in diagnostic confidence.

After comparing the high b-value MAGIC DWI images with those acquired using FOCUS, Dr. Boulay-Coletta determined that all the same necessary information was provided by MAGIC DWI. Radiologists at St. Joseph Hospital also became accustomed to reading and reporting from the MAGIC DWI images. After three months of image evaluation, the department confidently replaced conventional diffusion acquisitions of high b-values with MAGIC DWI. This has also led to time savings.

The multiple b-value DWI sequence would take approximately 4:50 minutes with b-values of 50, 500, 1,000 and 2,000. However, with MAGIC DWI and comparable image quality, 50, 500 and 1,000 FOCUS b-value images can be acquired in 2:30 minutes and synthetically processed to generate the b2000 images. This helped save more than 2 minutes off the acquisition.

HyperSense with HyperCube is another sequence enabling higher image quality without a time penalty. Dr. Boulay-Coletta acquires HyperCube T2 in the Sagittal plane and then reconstructs in the Coronal plane. She continues to acquire a 2D Axial T2 to obtain the highest quality Axial plane. PROPELLER Multi-Blade can be added if the patient cannot control movement or has contractions.

“We decided to use HyperSense with 3D HyperCube T2 to improve the image quality rather than reduce scan time,” Dr. Boulay-Coletta explains.
“Now, we have very high confidence when using MR to detect prostate cancer,” she adds. “All these new sequences also give us the information we need to report into PI-RADS™ Version 2. So, when we tell the patient that his imaging results are normal, we can be very reassuring that if the MR exam is negative, the patient has no significant cancer.”

**MR for treatment planning**

In cases of a positive diagnosis of prostate cancer, MR is an important tool for determining the extent of disease and the appropriate treatment. For example, today many men with non-significant, localized cancer will undergo a period of active surveillance. The idea behind active surveillance is that often, prostate cancer will grow slowly and if localized to only this gland, the cancer is unlikely to harm the patient or decrease his life expectancy. In fact, a recent study on active surveillance has found that less than 1% of men with local, slow-growing and non-metastatic disease had meaningful progression of their disease after 15 years.²

“The key is, of course, to monitor these patients regularly and begin treatment if the disease becomes more aggressive,” Dr. Boulay-Coletta says.

MR is considered as a baseline exam at St. Joseph Hospital and it is used to determine if the patient will be placed on active surveillance. The information from MR can also impact the planning for radical prostatectomy in patients undergoing surgical treatment.

“Surgeons and radiologists are using MR imaging data to determine the type of surgery for the patient,” Dr. Boulay-Coletta explains. “They review the images to detect any irregularity of the capsule and evaluate the extension to the neurovascular bundle. For capsule extension, high-resolution Axial T2 is mandatory and sometimes high spatial resolution DISCO can help to distinguish normal vessels from capsule extension.”

All prostate MR imaging examinations are performed on the Discovery MR750 3.0T scanner, mainly because the department does not use an endorectal coil and therefore, they need an intrinsically high SNR. Dr. Boulay-Coletta continues to use DISCO each time DWI and T2 show an abnormality.
Figure 4. A 65-year-old patient with elevated PSA (14.5 ng/ml); biopsy indicated a tumor of Gleason 6 and the patient was referred to MR due to the PSA level and discrepant pathology finding. (A) Axial T2 FSE 3 mm; (B) HyperCube and HyperSense with voxel size 0.9 x 0.9 x 0.9 mm³ acquired in 6:12 min; (C) MAGIC DWI (synthetic DWI) b2000; (D) ADC map; (E) DISCO, 0.9 x 1.3 x 1.6 mm³, 15 sec/phase. MR demonstrated an anterior apical target of 22 mm. MR fusion TRUS biopsy was performed and confirmed 88 mm cancer extension on four targeted biopsies. The volume of cancer found on the MR-guided biopsy was in line with the high PSA level. A radical prostatectomy was recommended.

because it increases her confidence for diagnosis and helps determine the extent of disease. Yet, it is the inclusion of MAGIC DWI and ADC maps that she believes has made the greatest impact.

“I would advise other institutions to use MAGIC DWI. It is a robust sequence that considerably reduces the exploration time in every prostate case.”

Dr. Isabelle Boulay-Coletta

References
1. PI-RADS™ v2 guidelines suggest the use of diffusion b-values greater than 1,400.
In October 2015, Michael Soussan, MD, began evaluating a newly installed SIGNA™ PET/MR system at CEA Service Hospitalier Frédéric Joliot (SHFJ) in Orsay, France. Dr. Soussan compared sensitivity, specificity and clinical confidence between the new PET/MR and an existing prior generation PET/CT in order to better understand the role that PET/MR should play in patient management.

Oncology staging is currently the primary utilization of PET/CT, accounting for approximately 80% of patient scans at CEA-SHFJ. PET/CT is also used for brain exams.

According to Dr. Soussan, a major challenge is to demonstrate the ability of PET/MR to enhance the confidence associated with the interpretation of PET and MR imaging data. The hospital’s clinicians currently rely on the interpretation of PET/CT images. He believes demonstrating that PET/MR increases the certainty with which the physician comes to a conclusion based on the PET and MR images would certainly contribute to a large acceptance of the new system for patient management.

The PET component on the SIGNA PET/MR features a digital Silicon PhotoMultiplier (SiPM) detector that is up to three times more sensitive than conventional PET technology. It also features ultra-fast coincidence timing resolution enabling Time-of-Flight (TOF) reconstruction. With TOF reconstruction, the arrival times of each coincident pair of photons are more precisely detected, and the time difference between them is used to localize the PET signal accurately. TOF leads to improved PET image quality with higher structural detail and improved signal-to-noise ratio.

**Results**

Nuclear physicians were asked to provide their assessment regarding the overall PET image quality (image contrast and resolution) and the ease of interpretation. They compared the
PET/MR scans to the PET/CT scans. For this assessment, 150 patients underwent both a PET/CT and PET/MR. “Many of the differences we observed in the images are due to the different PET technology between our PET/CT and PET/MR scanners. This demonstrates the huge progress made in PET detector technology over the years, by taking advantage of TOF, enhanced reconstruction including point spread function modeling and scatter recovery,” Dr. Soussan says. “The PET/MR clearly demonstrated better contrast, resolution and image quality over the prior generation PET/CT scanner.”

The PET/MR is a big advancement in technology, he adds, with this new combination of modalities providing improved lesion detectability and more accurate interpretation of the signal. Motion correction using Q Static was also evaluated on every patient undergoing a PET/MR exam at CEA-SHFJ. “We could already see the difference in quantitation and lesion appearance but the most important point is that we can use it routinely, which will help us make a comprehensive assessment of the clinical benefit of motion compensation. Using PET/MR, motion correction can now enter the clinical practice, and it is possible to use it for every patient. With the high PET sensitivity, we can perform a shorter acquisition with Q Static retaining about half the signal and still have images perfectly suitable for interpretation,” he says.

“Improving the spatial resolution and image quality of PET is very important—it helps make the technique more precise and efficient than with prior generation technology,” Dr. Soussan adds. He is hopeful that a higher PET sensitivity can help clinicians address the issue of false positives and false negative lesions when these situations occur in clinical practice.

Case 1
A 75-year-old patient with colorectal cancer, treated six months earlier with adjuvant chemotherapy, referred to PET/CT (non-TOF PET/CT system: 371 MBq, 75 min post IV, 4 min/bed position, no PSF modeling in reconstruction) followed by PET/MR (100 min post IV, 4 min/bed position, TOF and PSF modeling reconstruction).

The improvement in sensitivity leads to homogenous liver and better contrast recovery of small lesions. This case shows that PET/MR enables a precise staging of liver metastasis, improving the therapeutic strategy.

Figure 1. (B) The PET image from the PET/MR shows better conspicuity of one liver subcapsular lesion, only slightly visible in the (A) PET image from the PET/CT.

Figure 2. Illustrates the higher diagnostic confidence with multi-modality imaging. Additional liver metastases are slightly visible on the PET from the (B, arrows) PET/MR, not visible on the PET from the (A) PET/CT, and clearly seen on the MR diffusion-weighted images.
Case 2
A 76-year-old patient with initial diagnosis of well-differentiated, midgut neuroendocrine tumor with lymph nodes and liver metastasis. The patient was scanned with F18-DOPA PET/MR (245 MBq, 94 min post IV, 6 min/bed, 4 beds, TOF and PSF modeling reconstruction). Q.Static was employed for respiratory gating.

Figure 3. The impact of respiratory gating with Q.Static can be clearly seen. In the (A) static images, two right liver lesions are blurred (black and red arrows) and the upper lesion almost appears as two lesions (black arrow, SUVpeak 1.9, metabolic volume [42% threshold]: 3 cm³). With (B) Q.Static reconstruction, the images are clearer with an increase in lesion conspicuity for a diagnosis of two lesions (B, black arrows). The quantitation of the upper lesion is improved (SUVpeak 2.2, metabolic volume [42% threshold]: 0.8 cm³). Furthermore, in the Q.Static image, a third lesion previously poorly visible was also identified (blue arrow).
For over a decade, the University Hospital of Umeå has been using MR for radiation therapy (RT) planning. MR imaging is a useful adjunct to CT because of its ability to depict soft tissue anatomy. The clinical impact is most established for cervical cancer. In fact, the European Society for Radiotherapy & Oncology (ESTRO) released new guidelines in 2012 for the use of MR in volumetric treatment planning in cervical cancer brachytherapy.¹

Pursuing an MR-only approach to radiation therapy planning
According to Professor Tufve Nyholm, PhD, Department Head, Radiation Physics, Oncology at Umeå University, MR is used at the institution in treatment planning for nearly all cancers across different therapy regimens—external beam RT (EBRT), brachytherapy and proton therapy. A standalone CT is still acquired for density information on each patient for use in dose calculations. “The target is defined by MR imaging,” Professor Nyholm says. Umeå was one of the first institutions worldwide to install the SIGNA™ PET/MR in January 2015.

Because of the value of MR for lesion visualization and delineation, Umeå has transitioned a majority of treatment planning cases to SIGNA PET/MR. The exception are suspected lung tumors and head and neck cases where PET/CT is used in the diagnostic workup and therefore, also utilized for RT planning. Depending on the body part, either T1-weighted or T2-weighted images provide a good depiction of the patient’s anatomy, Professor Nyholm explains. Then, to define the volume of the pathology, T2-weighted images are used for cancers of the pelvic region and contrast-enhanced T1-weighted images are preferred for brain cancers.

“The main difference between diagnostic and therapy planning with PET/MR is we tend to use more 3D imaging in RT. We also use much longer acquisition times in the bed position where the tumor is located.”

Typically, the patient is scanned for 25-30 minutes in one bed position on the PET/MR. The goal is to acquire as much information on the target area as possible. Patients referred to RT have already received a diagnostic workup and are identified with localized, not metastatic, disease. “We know the area to treat so there is no need to image the rest of the body with another bed position,” he adds. “We want to acquire as much information as possible to define the volume for treatment. Even a millimeter in one direction is important for the patient’s plan—in these instances more is better.”

Professor Nyholm also points out that it is well known that most Treatment Planning Systems (TPS) are not optimized for MR imaging—they are simply not designed to handle the volume of data that MR
Head and neck cancer is another area where MR has made a significant impact. Images from patients with implants or fillings in their teeth result in significant artifacts in CT. “With MR, we can suppress these artifacts and obtain good image quality. Obviously, in patients with brain tumors MR is preferred. Even in an ideal case we often can’t get the information we need with CT.”

Addressing prior challenges to using MR in RT

Acquiring images for planning with the patient in the treatment position is important for the accuracy of the plan. Historically, this has been an issue with the use of MR in RT. However, the development of wider bores and smaller, more flexible coils has helped to diminish this challenge.

Volumetric Modulated Arc Therapy (VMAT). The accuracy of treatment delivery is enabled by the clarity and precision of modern medical imaging such as CT and MR. These imaging modalities provide the detailed information physicists and oncologists need to treat only the cancerous lesion and avoid healthy tissue.

At Umeå, Professor Nyholm and his colleagues see the impact of MR imaging in treatment planning because they can clearly visualize the lesion and surrounding healthy tissue. “We have not yet reduced margins but we have seen a change in the volumes we are treating,” he explains. “In prostate cancer, we have reduced target volumes by using MR imaging.”

Umeå is in the validation phase for planning radiotherapy based on PSMA.
Umeå has been working with GE Healthcare to develop the infrastructure needed to acquire patient images in the right position. However, Professor Nyholm believes other options exist, as well.

“One idea is to explore the possibility to treat the patient in the imaging position rather than image them in the treatment position. If this is possible, then we won’t have this problem. It seems to be the obvious thing to do.”

Professor Tufve Nyholm

Geometric inaccuracies are another area that have historically been a concern when using MR for RT. MR distortions can be caused by gradient field nonlinearity, which can impact PET attenuation correction.

Professor Nyholm believes that if the physicist has a knowledge of MR imaging and potential issues, they can avoid this issue. He is a co-author of a published paper that concluded when using a well-adjusted sequence bandwidth, the distortions caused by patient susceptibility effects can be kept at an acceptable level. It has already been verified in several publications that when using 3D distortion correction the small remaining distortions have a minimal effect on the quality of the treatment.

Umeå is also involved in a collaboration between academic institutions in Sweden and industry leaders, including GE Healthcare. The focus of the consortium, Gentle Radiotherapy, is to develop MR-only RT. Professor Nyholm shares that Umeå is responsible for developing the methodology for MR-based RT in the pelvis, e.g., bladder, cervix and anal cancer, excluding prostate. The consortium already has a joint publication on MR-only treatment planning for prostate.

“The biggest challenge is education,” Professor Nyholm says. “MR is complex and it requires both the physicist and the radiation oncologist to have this knowledge before it is possible to take full advantage of MR in RT.” Hence close collaboration with radiologists is essential.

In general, Professor Nyholm believes the benefits of MR in RT outweigh any remaining educational gaps. “The quality of the imaging data is really phenomenal,” he says.

“RT is almost entirely an image-driven specialty. The importance of MR imaging will increase and start to impact RT in other ways, such as how we shape the treatment beams and position and treat the patient.”

Professor Tufve Nyholm

References
Oncologic imaging represents a steady volume of the MR imaging performed at Fairfax Radiology Consultants (FRC), the largest private radiology practice in the Washington D.C. metropolitan area. Referring physicians rely on the expertise of 70 subspecialized radiologists and skilled technologists to deliver the information they need for patient management. Two of the practice’s three 3.0T MR systems, SIGNA™ Architect and Discovery™ MR750, are increasingly utilized for body, pelvic, rectal and gynecologic cancers.

So, it comes as no surprise that Tom Schrack, ARMRIT, CS, Manager of MR Education and Technical Development for MR Services at FRC, has seen an increase in volumes as referring physicians gain confidence in FRC’s diagnostic quality. Most of the growth has been in rectal and prostate cancer imaging and, to a lesser extent, other pelvic cancer imaging, he notes.

“Our prostate MR imaging growth has been substantial, in the area of 60%,” Schrack says. “A year ago, we averaged five to six prostate MR cases each week. Now we are imaging two to three each day.”

Guidelines now recommend the use of high-resolution MR as the first choice for primary staging and postoperative chemoradiation restaging of rectal cancer. As a result, FRC developed a colorectal imaging program utilizing standardized reporting, well-defined protocols and subspecialty radiologists for rectal MR imaging.

According to Melany Atkins, MD, Radiologist at FRC, GE Healthcare’s SIGNA™Works productivity software platform, which features BodyWorks, OncoWorks and innovative HyperWorks sequences, is making a difference in MR oncology imaging. The synthetic diffusion sequence, called MAGIC DWI, is very helpful in rectal, prostate and gynecologic cancers. MAGIC DWI helps overcome the issue of poor signal-to-noise ratios (SNR) when using high b-values in diffusion-weighted imaging (DWI).

“The beauty of synthetic diffusion is we can achieve excellent SNR and increase our sensitivity from the high b-value,” Dr. Atkins explains. “That gain in SNR and sensitivity is very useful when looking for subtle lesions in the prostate and evaluating tumor extension for staging in the rectum or cervix. Using traditional diffusion, we are limited by spatial resolution as the b-value increases.”
Nearly all prostate MR imaging is performed with an endorectal coil utilizing MAGIC DWI, FOCUS, and to a limited extent DISCO. With FOCUS, users can obtain high resolution DWI images by reducing the phase field-of-view (FOV) without the concern of wrap artifacts. With DISCO, very high temporal resolution T1-weighted images can be obtained for evaluating contrast enhanced characteristics of lesions. Dr. Atkins sees image quality improvement when using FOCUS, especially in patients with hip prosthesis.

“We love FOCUS compared to regular diffusion and find it is superior with less geometric distortion in a small field of view. Plus, it is easy to use and doesn’t take a lot of time.”

Tom Schrack
While DISCO hasn’t yet been integrated into many of the oncology imaging protocols due to the practice’s continued use of multi-phasic LAVA imaging, Dr. Atkins anticipates it will be adopted more in the near future as they continue to evaluate its impact. In cases where patient motion is an issue, PROPELLER Multi-Blade, an advanced motion correction technique, is available to use at a moment’s notice to eliminate the associated artifacts.

There is also HyperSense, a sequence that Schrack says the practice absolutely loves. “We use it on every imaging study that we possibly can.” HyperSense enables the use of compressed sensing to reduce scan times, something that Schrack is closely watching.

“These time savings allow us to add sequences like HyperCube without increasing our time slots,” he adds. FRC uses HyperCube often as the first sequence on pelvic malignancies to help select the imaging plane.
HyperCube enables aliasing-free isotropic imaging with a reduced FOV and increased matrix. The combination of HyperCube and HyperSense, in conjunction with conventional parallel imaging, helps decrease imaging time yet delivers the very thin, isotropic heavy-weighted T2 imaging that aids a radiologist in their diagnosis.

“First we acquire HyperCube—it is our ‘lay of the land’ sequence—and then we can reformat in any plane, which is very useful especially if a patient returns for a post-treatment exam.”

Tom Schrack

Figure 3. Rectal cancer with MAGIC DWI. (A) Axial T2; (B) ADC map; (C) b1000; (D) b1000 synthetic; (E) b1200 synthetic; (F) b1400 synthetic; (G) b1600 synthetic; (H) b2000 synthetic.
“MR images provide us with information to improve the accuracy of our biopsies, which, in turn, provides us with valid results across the entire gamut of prostate cancers. While we believe that accuracy has something to do with the quality of our MR scanners, it also is a reflection of the excellent product we put out by following PI-RADS™ and systematic reading and reporting.”

Dr. Melany Atkins

For patients with prior exams, having the ability to reformat to match the plane used in a prior exam can be invaluable for the radiologist.

Aside from accelerating with HyperCube, Schrack has also worked on reducing respiratory and abdominal wall motion and has seen a significant improvement in the image quality of the interior abdomen.

Dr. Atkins adds that they still acquire the high resolution T2 in addition to the T2 3D HyperCube images. The T2 images are of such high quality on their MR systems that Dr. Atkins finds it difficult to remove the sequence.

Growing use of MR in oncology

Dr. Atkins believes the adoption of PI-RADS™, the American College of Radiology’s Prostate Imaging Reporting and Data System, has also spurred growth in the utilization of MR imaging—particularly to help guide biopsy.

Active surveillance for prostate cancer has become well adopted by providers—radiologists, oncologists and urologists—with an increased recognition that many prostate cancers are slow-growing and localized. For that subset of patients, receiving radiation therapy for their prostate cancer may do more harm due to the side effects of treatment. However, the location where the biopsy is performed can significantly improve accuracy in determining the exact type of cancer a patient has. And that is where MR plays a crucial role.

Although MR imaging for gynecological cancers—cervix, vaginal and endometrial—hasn’t grown as much as prostate, FRC has solid volume from referrers in the area.

“The integration of these new sequences and capabilities has been helpful for our throughput and image quality,” Dr. Atkins adds. “Across the board, SIGNA™Works has improved SNR and our diagnostic confidence.”

Reference

Elevate your clinical proficiency with SIGNA™Works, GE Healthcare's latest productivity platform. Improve image quality, increase efficiency and streamline workflow. Performing a clinical exam has never been easier.

**SIGNA™Works. Fueling the future of MR.**

Visit www.signaworks.gehealthcare.com to learn more.
Optimized clinical pathway

As one of Europe’s largest teaching hospitals, Pitié-Salpêtrière Hospital is renowned for its innovative research and delivery of high-quality care to patients. In 2015, the Alzheimer Research Foundation in France, a partnership between the public hospital system and the University Hospital Brain and Spine Institute (IHU-A-ICM), provided funding for a PET/MR project at the hospital.

According to Aurelie Kas, MD, PhD, Head of the Department of Nuclear Medicine at Pitié-Salpêtrière Hospital Group, the utilization of the SIGNA PET/MR is equally divided between clinical and research use, with 2.5 days a week dedicated to each. The institution is currently participating in 45 clinical trials in oncology and neurology.

“In our experience, PET/MR imaging is feasible in a clinical setting with a throughput of 11 to 15 patients each day,” Professor Kas says.

The hospital conducts a staggering high volume of clinical PET/MR exams. SIGNA PET/MR complements a robust imaging environment in the nuclear medicine department that includes two PET/CT systems, two SPECT/CT systems and one ultrasound system. The department also provides radioactive iodine therapy for thyroid cancer patients with six beds that accommodate 12 patients each week. Six MR systems are also located in the radiology department primarily for neurology, oncology and cardiac imaging.

The clinical PET/MR service is a collaboration between the nuclear medicine and radiology departments. Professor Kas explains that in addition to radiology, the PET/MR implementation has further promoted the development of new collaborations with neurology, neuro-oncology, urology, gynecology and surgery.

At Pitié-Salpêtrière Hospital, patients with brain tumors, rare cancers and rare neurodegenerative disorders, such as atypical presentation of Alzheimer’s...
disease (AD), are now preferably referred to PET/MR rather than PET/CT or MR alone to obtain detailed images to aid in the detection, localization and diagnosis of diseases and disorders. Clinically, 75% of PET/MR imaging studies are for neurodegenerative disorders such as Alzheimer’s and Parkinsonism, 23% for oncology (approximately 33% neuro, 34% maxillofacial and 33% abdominal/pelvic) and 2% for drug-resistant partial epilepsy.

“We believe the diagnostic accuracy may be improved by combining metabolic information provided by PET with the structural and multi-parametric imaging of MR. This is especially helpful in the areas of neurodegenerative disorders with atypical presentation or vascular comorbidities, for the diagnosis of cancer recurrence and for tumor delineation before surgery in regions with complex anatomy.”

Professor Aurelie Kas
“In our facility, our research has found that PET imaging provides early biomarkers of many neurodegenerative disorders, but MR provides unique imaging information on age-related or pathological cerebral atrophy, vascular lesions such as stroke sequelae, microbleeds and leukopathy, and inflammatory abnormalities that cannot be reliably assessed with PET alone. In addition, using PET/MR image interpretation and comparing imaging biomarkers is optimal since the imaging studies are acquired simultaneously.”

**Diagnostic power of PET/MR**

In complex neurology and oncology cases requiring PET imaging, PET/MR is now preferred rather than PET/CT at Pitié-Salpêtrière Hospital. This is especially important if MR imaging is also indicated.

Professor Kas explains, “We utilize PET/MR for visualization of advanced head and neck cancers to assist with the assessment of disease status and, more specifically, to help with tumor delineation before surgery in this region with such complex anatomy. In follow-up examinations, hybrid PET/MR has advantages in the visualization of tumor differentiation, scars and edema after radiation therapy in head and neck cancer. It is also of great interest in brain tumors when MR images alone may not enable us to differentiate the viable tumor from necrosis with post-therapeutic changes, especially after radiation therapy.

“Hybrid PET/MR is also a helpful imaging tool in cases of atypical presentation or early-onset AD, Parkinson’s-plus syndromes and suspected mixed dementia when neurodegenerative and vascular processes coexist,” Professor Kas adds.

Prior to implementation of the SIGNA PET/MR, patients with complex indications in which PET and MR were both recommended often underwent two imaging exams. Now, a single imaging exam—PET/MR—can assist us in directly answering the clinical question.

“*Our patients benefit with less examination time and an increase in comfort, especially the older patients with comorbidities.*”

Professor Aurelie Kas

She adds, “Clinicians gain the advantage of a reliable imaging exam with increased diagnostic confidence as the combination of these imaging tools aid in accumulating evidence for a specific diagnosis. Additional gains in diagnostic accuracy can be achieved since PET/MR studies are interpreted by experts in both radiology and nuclear medicine, who together provide a single report.”

Since October 2015, more than 2,000 patients have undergone clinical PET/MR examinations in the facility. The department averages 11-15 clinical patients each day from 8 am to 5:30 pm, of which three to five exams are whole body and eight to 10 are brain exams.
Figure 3. Pelvic MR exam on a patient with endometrial adenocarcinoma. (A) Whole-body PET, 4 bed positions at 3 min/bed; (B) pelvic PET acquired in 16 min; (C) fused PET with Axial T2w PROPELLER; (D) Axial T1w LAVA post-contrast; (E) fused PET with Sagittal T2w PROPELLER; (F) Sagittal FOCUS DWI, b1000; (G) ADC map.
At Pitié-Salpêtrière Hospital, the typical protocol for neurodegenerative disorders averages 25 minutes. For oncology, it is slightly longer at a median of 45 minutes which also includes a regional multi-modal exam—for example one bed position on the neck or pancreatic area—and a whole-body PET. Often, ¹⁸F-DOPA PET/MR exams for brain tumors or atypical Parkinsonism syndrome indications last 45 minutes.

**Optimizing the clinical pathway**

To maximize clinical utilization and benefit of the PET/MR system in as many patients as possible, Professor Kas and her colleagues in nuclear medicine and radiology focused on optimizing the clinical pathway. One of the first steps was to start using the system in well-defined areas of MR imaging expertise, such as head and neck, digestive and pelvis, with very specific indications for each organ or anatomic area being examined.

The PET/MR imaging service was organized with a dedicated staff that includes four trained technologists with prior experience in MR, six physicians, two physicists and one administrative support position. The unit was designed with the PET/MR exam room, reading room and patient preparation room in close proximity to facilitate communication between technologists and clinicians in order to help reduce time between exams and enhance patient safety and satisfaction.

All acquisition protocols were evaluated and optimized by experts in nuclear medicine and radiology to avoid the collection of redundant information by the two imaging modalities and to ensure that protocols obtained all the required information for diagnosis. They also collaborated to determine the minimal scanner occupancy times to maximize clinical utilization since the scanner would be used only 50% for clinical applications. Regularly scheduled meetings were held with all PET/MR medical staff to review patient flow, optimize MR sequences and discuss any potential issues. Today, the PET/MR team regularly holds multi-disciplinary meetings to discuss the contribution of PET/MR imaging to help clinicians diagnose complex cases.

---

**Figure 4. PET/MR exam of a squamous cell carcinoma of the right intermaxillary commissure. PET/MR enables precise tumor delineation for pre-surgical planning.**

---

---
“Efforts have been made to optimize the imaging protocol to maintain short PET/MR acquisition times to ensure that we can acquire more than 11 clinical imaging studies in one day. On the other hand, it was obvious to us that the protocol had to achieve the highest diagnostic capability to provide at least as much information as sequential PET/CT and MR examinations.”

Professor Aurelie Kas

Therefore scan times are balanced between the desire for shorter acquisition times and high-quality imaging. While the hospital’s current acquisition protocols typically last 25 minutes for a neuro protocol and up to 50 minutes for exams that include whole-body PET for oncology, Professor Kas is currently working on new ways to further reduce scan times.

La Pitié looking forward

One area of research that Professor Kas and her colleagues plan to investigate is to study the added value of combined PET/MR biomarker imaging. Specifically, Professor Kas and her colleagues will examine the diagnosis of neurodegenerative disease and brain tumors and the prognosis and evaluation of therapeutic response in cancer patients.

The group is also examining the reliability of Zero Echo Time (ZTE) based attenuation correction (AC) for brain, head and neck PET/MR images. Currently, AC techniques in these anatomic areas are based on a CT atlas and the Dixon sequence to identify air, water and soft tissue. This approach, explains Professor Kas, is not always satisfactory for the AC of bony regions, especially in patients with a cancer of the jaw or a tumor extending to the base of the skull. The first results are encouraging, she adds, and suggests that ZTE sequences enable bone visualization and are appropriate for AC of the oral cavity.

Overall, the utilization of PET/MR in a dual clinical and research environment has been successful. Professor Kas says, “It is important to optimize imaging protocols to ensure complementary imaging data and avoid redundant information between these modalities.”
“Child first and always” philosophy drives investment in advanced MR technology at Intermountain Healthcare

Named one of the top-ranked pediatric hospitals in the nation by *U.S. News & World Report’s* 2017-18 Best Children’s Hospitals¹, Primary Children’s Hospital (Salt Lake City, UT) delivers exceptional care across 10 pediatric specialties, from cancer care to neurology. In fact, the Intermountain Healthcare facility is one of 24 hospitals in the nation to be ranked in all 10 specialties rated by the publication.

“As a dedicated pediatric hospital, we strive to have an environment where we have the full gamut of pediatric imaging, whether it is for a routine study to rule something out or the most complex scenario working with neurosurgeons or oncologists,” says Jayson Argyle, Director of Imaging for Intermountain Healthcare. “What really differentiates us is our ability to care for these children. Our philosophy is child first and always.”

Embracing that commitment to pediatric care, Primary Children’s was one of the first hospitals in Utah to implement a 3.0T MR system in 2005. A decade later, the hospital replaced its 60 cm 3.0T MR with the Discovery™ MR750w, a 70 cm wide bore system. “We wanted to stay on the cutting edge of technology with the more robust sequences that became available, such as the T1 PROPELLER and PROPELLER Multi-Blade,” says Derek Maxfield, MR Supervisor. When GE Healthcare launched its SIGNA™ Lift program, enabling existing Discovery MR750w sites to upgrade to SIGNA™ Architect, Primary Children’s embraced the opportunity.

SIGNA Lift allows facilities to reset the life of an existing GE MR scanner with new applications and the latest generation hardware. The new system includes the SIGNA™Works productivity platform and new electronics, software and hardware that are built around the site’s current magnet.
“Often, there is a financial concern when the question of a new scanner is brought up,” Maxfield adds. “However, we worked with GE through the SIGNA Lift program to navigate that concern and make it affordable so we could acquire the best technology.”

Adds Argyle, “We did our due diligence and looked at the pros and cons of a new system versus keeping our magnet intact and upgrading the software and hardware. It made more sense economically and clinically to go with the upgrade.” The hospital also avoided the added expense of construction to remove and replace the existing magnet.

Not only was the upgrade cost-effective, it was streamlined. The GE engineering and applications team arrived on a Thursday, worked through the weekend and had the upgraded scanner back up and running by the following Tuesday.

“We were able to move the patients requiring an MR study to other areas where we had a scanner available, such as scheduling outpatients in our satellite clinics,” says Maxfield. “The entire process was rapid and minimized the negative impact on our patients.”

Embracing advanced apps

“When we first turned it on and started scanning with it, my first impression was that this is what 3.0T scanning should be,” says Maxfield. “You get more of everything and less of what you don’t want.” Having scanned with first generations of 3.0T MR scanners, he has seen first-hand the leap in technological advancements.

For example, dielectric effects that can exist in 3.0T imaging have been resolved with SIGNA Architect thanks to the new RF receive chain. SAR is also greatly reduced.

“It opens the door to shift exams from one scanner to another based on clinical and patient needs.”

Technologists at Primary Children’s are always trying to achieve the best possible image quality. With Total Digital Imaging (TDI) on SIGNA Architect, they can achieve increases in image quality thanks to the reduction of noise with Direct Digital Interface (DDI), intelligent Micro Electro-Mechanical Switches (MEMS) in the RF coil design and exceptional SNR and sensitivity from surface coils along with superior homogeneity and deeper signal penetration with Digital Surround Technology (DST).

The imaging team was also interested in the 3D imaging options, particularly SIGNA™Works’ Auto Navigated Turbo LAVA free-breathing Magnetic Resonance CholangioPancreatography (MRCP).
Auto Navigator further combats respiratory motion in abdominal imaging. In addition to MRCP, Auto Navigator is also compatible with other pulse sequences such as diffusion, dynamic T1 imaging and PROPELLER MB.

Maxfield recalls a situation when the department was behind schedule and therefore, decided to try an abdomen exam on the SIGNA Architect. Maxfield explains, “Previously, we wouldn’t have tried it due to the respiratory motion in the abdomen. When we applied the Auto Navigator in conjunction with T2 and MRCP, I saw that this is a whole new ballgame and we need to rethink our abdominal imaging protocols and consider moving to 3.0T.”

Another key advancement on the new MR system at Primary Children’s is HyperWorks, which includes HyperCube, HyperBand and HyperSense. HyperCube expands the capabilities of 3D imaging by allowing the department to reduce scan times and reduce artifacts such as motion and aliasing. HyperBand enables the acquisition of more slices or directions in diffusion imaging while HyperSense is an acceleration technique based on sparse data sampling and iterative reconstruction for faster imaging without the penalties commonly found in parallel imaging.

“Using Cube FLAIR with HyperSense, we are able to get that sequence down to under 4 minutes with as much signal as a longer sequence. That is just amazing,” Maxfield explains.

In neuro imaging, Maxfield is evaluating MAGnetic resonance image Compilation (MAGiC) to understand its benefits. “It’s a huge advancement that we are very excited about,” he says. With a single MAGiC scan, Maxfield can get multiple image contrasts including T1, T2, Inversion Recovery (e.g., T1 FLAIR, T2 FLAIR, STIR, PSIR and DIR) and PD contrasts of the brain. He can also change the contrast of the images post acquisition by manipulating TR and TE values after the patient has left, which helps ensure no detail is missed and also avoids call backs and rescans if the wrong contrast was acquired.

GE Healthcare’s new 48-channel TDI Head Coil is also making heads turn with the increase in SNR. Brian Davis, Manager of the Imaging Department at Primary Children’s, says he has received great feedback from the radiologists and neurosurgeons who rely on the MR images for pre-surgical planning.

“*They have never seen so much signal in a neuro MR exam. They are learning and growing with the technology because the images do look so much different due to the added SNR.*”  

*Brian Davis*

With FSE Flex, a Dixon-based 2D and 3D dual echo fat-water separation technique, Maxfield can see the uniform fat suppression in one of the most challenging areas to image—the soft tissue in the neck. Reliably, reproducibly and with no increase in time, he can achieve exceptional T1 and T2 fat-suppressed images.
In orthopedics, which represents a large portion of the MR imaging service at Primary Children’s, PROPELLER, T2 and the increased SNR are making a big difference. In moderately compliant teenaged children, technologists are now adding PROPELLER to account for any slight motion. The new generation high-density coils—the 18-channel T/R Knee, 16-channel T/R Wrist and the 16-channel Shoulder—are helping to propel faster imaging speeds with increased image quality and resolution.

GE Healthcare’s Flex Coils are also making an impact in patient care. While the imaging team tries to use dedicated coils whenever possible, Maxfield recalls a situation where a Flex Coil was used for spine imaging on a 4.5 lb. infant.

“This is really what neuro images should look like... we are just raising the bar on imaging with this system and the 48-channel TDI Head Coil.”

Derek Maxfield

“...The Flex Coils let us fill that gap for comprehensive body imaging and are our second line of defense when we don’t have a coil to fit on a particular body area,” he says.

Derek Maxfield
A Caring Suite
Calming anxious pediatric patients and their parents is a challenge in medical imaging and especially in MR. To help alleviate anxiety and fear of the MR scanner, Intermountain also implemented GE Healthcare’s Caring Suite, an environment designed to help improve and humanize the patient experience through the reassuring senses of sight, sound and touch.

Sometimes, the most difficult aspect of a pediatric MR exam is that initial break from the parent—the child may cling to their parent and may be unwilling to enter the scanner.

“The Caring Suite really engages the child as they enter the room by providing a calming atmosphere and ambience. They can change the colors in the room, interact with pictures and watch a video on the TV, so they really feel in control. It really helps break that psychological barrier and also helps us to gain their trust and respect.”

Brian Davis
From the advanced SIGNA Works applications to the powerful new TDI and the Caring Suite, SIGNA Lift has enabled Intermountain to tap into all that the SIGNA Architect has to offer. According to Maxfield, in addition to benefiting patients, the system is also a great recruitment tool for attracting the best and brightest technologists.

Argyle points out that financial pressures will continue in healthcare and the upgrade path through SIGNA Lift is an excellent option that allows facilities to spend more of their budget on acquiring the latest technology while spending less on construction.

“The ability to upgrade also offers a site that is growing or starting out with less advanced procedures a pathway to progress into new capabilities and more complex studies in an efficient and cost-effective timeframe,” says Argyle. “Most important for us, this has been an excellent tool that helps us focus on our philosophy of the child first and always.”

Jayson Argyle
As part of the University of Chicago Medicine health system, the six-story, 525,000-square-foot Duchossois Center for Advanced Medicine (DCAM) is an outpatient diagnostic and treatment facility for adults, both primary and specialty care, and pediatric specialty care. Of the center’s three GE Healthcare MR scanners, one was a nearly 17-year-old SIGNA™ HDxt 1.5T. Recently, it was upgraded to a SIGNA™ Explorer as part of GE Healthcare’s SIGNA™ Lift program. A key advantage of the upgrade is the center now has access to many of GE Healthcare’s advanced technologies and sequences, like the multi-contrast MR technique, MAGnetic resonance image Compilation (MAGiC). With MAGiC, a single scan generates multiple image contrasts including T1, T2, Inversion Recovery (e.g., T1 FLAIR, T2 FLAIR, STIR, PSIR and DIR), and PD contrasts of the brain.

Using an efficient, quantitative sequence to aid in patient treatment decisions

John Collins, MD, PhD, Assistant Professor of Radiology, University of Chicago Medicine, is a neuroradiologist at University of Chicago. He had the opportunity to utilize MAGiC to image Multiple Sclerosis (MS) patients. Dr. Collins and his colleagues have developed specific protocols for patients based on their pathology and disease. In many cases, the protocols include additional sequences, as the
goal is to obtain as much information on the patient as possible: time on the scanner is not a key concern.

For the MS patients who undergo a neuro MR exam, the primary benefit of MAGiC for these patients is the sequence’s T1 and T2 mapping capabilities. Dr. Collins finds the T1 and T2 mapping capabilities to be a valuable addendum to the patient’s neuroimaging evaluation.

“We’re using the T1 and T2 mapping capabilities to look for changes in the MS lesions resulting from therapy that we can’t otherwise image with conventional sequences.”

Dr. John Collins
“This provides the potential to rethink how we scan patients,” Dr. Collins adds. “That’s not a new idea, we do this with CT imaging right now with different settings for soft tissue such as lungs, or different window leveling for the liver, kidney or bowels. It is intuitive that we can benefit in MR from this same approach. We could repeat sequences, but clinically that is not efficient. However, with MAGiC we can generate different contrasts, such as T2 or Proton Density, after the scan.”

Once the settings within MAGiC are established, Dr. Collins says that generating different contrasts does not take a lot of additional time. There is a learning curve, but the benefits are clear to him.

“If we can see more lesions or get a truer sense of the lesion size, then I think this will catch on because it could change patient management,” he adds.

While scanner time is not an issue at DCAM, there is the potential for sites to achieve scan time savings by using

Dr. Collins finds the T1 and T2 maps can be more sensitive than conventional T2 or FLAIR sequences.

The process involves marking the regions of interest in the lesions, tabulating the T1 and T2 values and then following the patient over time to see if the values correlate with the progress of the disease—and if the patient is responding to therapy.

“Are there imaging characteristics that we can use to predict whether a person will respond to therapy?” Dr. Collins asks. That’s the key question he is hoping MAGiC with T1 and T2 mapping capabilities can help him answer.

While still too early to share any definitive results, Dr. Collins does see the value of MAGiC for his study.

“Lesion conspicuity is definitely enhanced with parametric T1, T2, R1, R2 and PD maps for our further analysis of MR acquisition data,” he adds.

With MAGiC, Dr. Collins can set specific parameters for T2 and FLAIR imaging, including additional image contrasts. For each disease process—whether it be for an MS or oncology patient—he can optimize these settings.

For example, the parameters for T2 of the brain are the same for most conditions—infecion, MS, suspected stroke and tumors. However, there may be a situation when he wants a more sensitive evaluation, such that even the subtlest lesions might be visualized in an MS patient.

“Being able to see one or two tiny lesions can mean the start or change of therapy in an MS patient,” he explains. “There are other situations where I don’t want that level of detail.”

While with conventional sequences only one contrast is acquired at the scanner, with MAGiC a range of contrasts can be potentially processed. The optimal contrast for an MS patient may not be the same for a head and neck cancer patient.

“Lesion conspicuity is definitely enhanced with parametric T1, T2, R1, R2 and PD maps for our further analysis of MR acquisition data,” he adds. With MAGiC, Dr. Collins can set specific parameters for T2 and FLAIR imaging, including additional image contrasts. For each disease process—whether it be for an MS or oncology patient—he can optimize these settings.

For example, the parameters for T2 of the brain are the same for most conditions—infecion, MS, suspected stroke and tumors. However, there may be a situation when he wants a more sensitive evaluation, such that even the subtlest lesions might be visualized in an MS patient.

“Being able to see one or two tiny lesions can mean the start or change of therapy in an MS patient,” he explains. “There are other situations where I don’t want that level of detail.”

While with conventional sequences only one contrast is acquired at the scanner, with MAGiC a range of contrasts can be potentially processed. The optimal contrast for an MS patient may not be the same for a head and neck cancer patient.
MAGiC. This could be particularly useful in pediatric patients. In this patient group, Dr. Collins sees the potential to perform a diffusion-weighted sequence and then use MAGiC to generate additional contrasts. By reducing sequences, scan time could be dramatically shortened which could lead to fewer pediatric patients being sedated for an MR exam.

“We could almost obtain a complete brain MR in 10 minutes and that is not possible with conventional sequences. This is a new technology that we really need to step back and re-examine how we image with MR. We should not limit it to just a few pathologies. With the customized contrast levels, MAGiC could be helpful for a variety of conditions.”

Dr. John Collins

Head and neck tumors are another condition where MAGiC may be helpful. Daniel Ginat, MD, Assistant Professor of Radiology, University of Chicago Medicine, is interested in using MAGiC to optimize MR protocols for these types of patients.

“The literature suggests that lesions are more conspicuous on the T1 sequences,” Dr. Ginat explains.1-4

“But these sequences also tend to be noisier, so it would be an advantage to optimize our T1 protocol for head and neck applications.”

Currently at DCAM, additional sequences beyond T1 are acquired for these patients. However, shortening the scan time by post processing additional contrasts with MAGiC could help reduce motion artifacts. Dr. Ginat explains that by the end of a long scan, patients may become irritable and move.

“If we can run a 5-minute scan to get 15 minutes worth of MR imaging data, then it might lead to fewer motion artifacts and incomplete exams. Ultimately, shorter scan times are better for the patients and increase throughput for radiology departments,” he says.

While his experience with MAGiC is currently limited, Dr. Ginat did have one case where a lesion was more conspicuous on the MAGiC post-processed FLAIR than on the conventionally acquired FLAIR scan.

“T1 mapping may be useful to provide an assessment of lesions,” Dr. Ginat explains.

“I believe there are some important advantages of using MAGiC to characterize abnormalities in the head and neck, but further research is needed.”

Dr. Daniel Ginat

Both Dr. Collins and Dr. Ginat hope to continue exploring MAGiC and the impact it may have on managing MS and head and neck cancer patients.

References
In 2025, it is predicted that one in three Japanese citizens will be over 65 years old and one in five will be over 75 years old. This age shift will drastically change the medical environment for our 151-bed hospital. While small in size, Seirei Fuji Hospital contributes significantly to regional medical care by enhancing advanced capabilities and strengthening cooperation with other regional medical facilities.

Although our hospital is advanced in many areas across the prefecture, our 2001 MR system was somewhat obsolete. Due to the system’s age, we often had breathing artifacts around the chest area due to long scan times and the lack of motion correction techniques, which hampered our diagnosis. We also could not perform upper abdominal scans (Liver, MRCP) in a wide range, so we had to scan the abdomen separately in three stations: upper, middle and lower. This made it very difficult to interpret the images for a diagnosis because each series was reconstructed separately, and this was most pronounced when the radiologist was reading remotely. Particularly problematic were patients with unstable breathing as the breath-hold would appear completely different in each series, making it very difficult to ascertain the continuity of each station. The system had additional shortcomings as well. MR brain and spine exams did not have sufficient image quality for our referring physicians (Figures 1 and 2).

Finally, our radiology staff would attend academic meetings and sessions to learn the latest techniques, but could not utilize that learning back at the hospital due to our system’s outdated technology.

We were convinced that the above issues could be solved by investing in a new MR system. On the other hand, we were concerned about the cost. Fortunately, we learned it was possible to upgrade our MR to the latest model, SIGNA Explorer, by replacing all components other than the magnet with SIGNA Explorer Lift.
The main objective of upgrading our MR was to improve image quality. We visited another site that had recently upgraded and compared images to another recently installed (new) SIGNA Explorer and found them to be comparable. We therefore chose the SIGNA Explorer Lift with confidence. The cost was also lower since the magnet did not need to be replaced, making the downtime for the upgrade significantly less.

After the upgrade
SIGNA Explorer Lift significantly improved the performance and image quality of our MR exams and shortened exam times. We could now provide a patient-friendly MR scan and immediately accept emergency patients. The scan time reduction enabled an increase in the number of patients in a day, providing an economic benefit to our hospital.

Before the upgrade, we performed an average of 240 exams/month operating five days each week; now we increased that number to approximately 300 exams/month in the same operating time. A key reason for the increase in the number of examinations is the system’s image quality and clinical capability, further increasing referrals from local physicians.
We reviewed 40 MRCP cases: 20 gallstone cholecystitis, 11 pancreatic neoplastic lesion and 9 other cases. The 18 male and 22 female patients were an average age of 65.8 years (maximum 85 and minimum 36 years). All cases were scanned with respiratory synchronization, although MRCP can be acquired with diaphragm synchronization. The use of Auto Navigator was reported to improve the image quality.

Our evaluation reported 27 cases as "very good," 10 cases were "rescan not necessary," and only three cases required rescans. For the cases rescanned, 3D frFSE was again used under breath-hold but with increased slice thickness. Since 3D frFSE collects in-phase data with single shot, it is necessary to decrease the number of slices or shorten TR to achieve scan time reduction. Increasing slice thickness will lower the resolution but improve SNR. Shortening TR causes lower SNR even if fast recovery is used. Considering these points, our hospital optimizes the protocols based on slice thickness, the number of slices and TR to keep breath-hold times less than 25 seconds (Figure 3).

Advanced clinical capabilities
With the prior system, we scanned MRCP using 2D Fast Spin Echo (FSE). The newly upgraded SIGNA Explorer allows us to perform 3D Fast Recovery FSE (frFSE) combined with ASSET parallel imaging.

Using the 3D frFSE acquisition, it is possible to acquire higher signal with shorter TRs due to Fast Recovery. By using ASSET, it is possible to reduce the echo train of FSE, which helps to reduce blurring due to T2 attenuation. In addition, with 3D imaging we can view the data in various planes and angles. Furthermore, both respiratory synchronization and diaphragm synchronization are available.

In our case, we expect to realize a return on our investment within three years, including human resources and maintenance expenses. With the broader range of clinical capabilities, our staff is now motivated to improve their knowledge and skills.

Figure 3. Comparison of MRCP images between respiratory synchronization scan and breath-hold scan. Depending on the patient, we can choose either (A) respiratory synchronization scan or (B) breath-hold scan.
**LAVA Flex**

With the upgrade, we can now use LAVA Flex for T1-weighted (T1w) imaging. LAVA Flex, a 3D acquisition, uses a 2-point Dixon method. After collecting data in-phase and out-of-phase, the sequence estimates whether the signals are water dominant or fat dominant with reference to certain pixel data. It then calculates magnetic field inhomogeneity of all pixels from neighboring pixels. By identifying the signal intensity of each pixel from the results, it is possible to calculate a uniform water image (fat separation image) and fat image (water separation image).

There are several advantages to using LAVA Flex, including thinner slices with 3D imaging, robust fat separation and acquiring both with/without fat separation images in one acquisition. We can scan the same area on the patient with gapless 3.2 mm slice thickness in one breath-hold using LAVA Flex and obtain both with/without fat separation images (Figure 4).

Most importantly, these sequences help us address the problem of a patient who cannot hold their breath to acquire the imaging data. In these cases with the prior scanner, we often sacrificed image resolution to shorten breath-hold time by optimizing slice thickness or using phase-encoding to shorten breath-hold time. However, SIGNA Explorer is compatible with Auto Navigator and includes Auto Navigator-gating, which enables the acquisition of 3D T1-weighted images with free breathing. By performing LAVA Flex in conjunction with Auto Navigator-gating, it is possible to scan 3D T1-weighted images both with and without fat separation on patients who cannot hold their breath (Figure 5).

---

**Figure 4.** Image comparison of T1w (A) before and (B, C) after upgrade. (A) Prior to upgrade, breath-hold T1w 2D FSPGR FatSat. After the upgrade, we are using a (B) breath-hold T1w LAVA Flex FatSat. (Water) and (C) breath-hold T1w LAVA Flex in-phase). We can make the slices thinner using LAVA Flex, so the vessels in the liver can be observed without partial volume effect.
Conclusion
Just one month after the upgrade, our hospital recorded its highest patient volume for MR imaging. With SIGNA Explorer Lift, we have the latest imaging techniques at a fraction of the cost. A key clinical benefit for our patients and economic advantage for our hospital is that we can improve image quality without extending scan time. SIGNA Explorer Lift is a good solution for facilities seeking to improve clinical image quality in an economic way.

Footnotes
1. In the upgrade process, the existing magnet remains and all other components are replaced. After upgrading, the regulatory name and the number of the product will be changed.
In many hospitals, MR is a problem-solving tool that can help save the lives of critically ill or injured patients. This is especially true at Dunedin Hospital, a 388-bed tertiary and teaching facility that covers a large geographic area spanning the South Island of New Zealand’s second-largest city and surrounding areas.

“We have a fairly complex mix of pathologies and patients, both referred and brought into the ER by ambulance or helicopter,” says David Smit, MB.BCh, Director of MRI at Dunedin Hospital. “So, we need very robust equipment to handle the vast array of cases that we see each day.”

It is not uncommon for inpatients at Dunedin Hospital to have immobility issues and complex disease processes with multiple comorbidities. So, when it came time to replace the hospital’s 11- to 12-year-old SIGNA™ HDxt MR scanner, a key consideration was what their patients would require.

“It was not what we thought our patients would need, or what we could find available. Rather we looked at the complexity of our patients and what would truly benefit them,” explains Jill Oliver, DCR, MSc (MRI), Lead MR Technologist. One of the key considerations for any new system would be patient comfort—and not just the scanner hardware but also the coils.

Dr. Smit and Jill required a scanner that could grow with the hospital—a scalable platform that would enable them to stay on pace with advancements in technology, novel sequences and coil development.

“If we have up-to-date technology, then we can tackle clinical questions that we previously couldn’t answer, and that is clearly beneficial for our patients.”

Dr. David Smit

After witnessing installations in nearby Australia and assessing image quality and upgrade potential for hardware and software, Dr. Smit, Jill and their colleagues at Dunedin Hospital chose the SIGNA™ Artist through GE Healthcare’s SIGNA™ Lift program. This economical upgrade path started with the Optima™ MR450w with plans to transition to the SIGNA Artist.
when commercially available, making Dunedin Hospital one of the first worldwide installations for the new system.

**The upgrade**
A key reason Jill wanted the SIGNA Artist was the new hardware platform with Total Digital Imaging (TDI), which enables an increase in image quality. TDI eliminates unnecessary noise with a Direct Digital Interface, intelligent Micro Electro-Mechanical Switches (MEMS) in the RF coil design and exceptional SNR and sensitivity from surface coils. TDI also delivers superior homogeneity and deeper signal penetration with an upgrade path to Digital Surround Technology (DST), including compatibility with higher channel coils.

“TDI and the complete digital signal gave us a future upgrade path with 16-channel coils and other high-channel coils.”

Plus, the reliability of Dunedin Hospital’s SIGNA HDxt scanner over more than a decade of use was an important factor for staying with GE Healthcare’s MR technology.

“If we have robust technology that can keep pace with the future, then it’s possible we can reduce additional imaging tests to answer the clinical question,” says Dr. Smit. “It’s not just the capital outlay but the day-to-day operations and whether we can save on those other peripheral costs and avoid unnecessary or additional imaging.”

Once SIGNA Artist became available, GE Healthcare went to work with a plan that would minimize downtime for the department. The scanner was down for only five days, but what was most impressive was that Dunedin only lost two clinical working days.

“GE had a very good process that was well organized. They planned for a weekend when we didn’t have a long list of scheduled patients,” Jill says.

Adds Dr. Smit “It went as well as any install could go, and it seemed to me to be quite seamless and well-handled.”

**Clinical impact**
Patient imaging on SIGNA Artist has been impressive so far. Yet, what really stands out to Jill is the increase in SNR.

“The increase in signal has been fantastic. We were pleased with the Optima MR450w, but the addition of the TDI has given us more flexibility. Our quality assurance has increased 26-27% in SNR, delivering higher resolution. Or, we can choose to scan faster at the same SNR.”

What Jill and Dr. Smit wanted for their department was a 1.5T workhorse. And, that’s exactly what they got with the SIGNA Artist and the SIGNA Works productivity platform of applications.
Dr. Smit has found that HyperSense delivers clearer abdominal images with less patient movement due to the reduction in scan time. The department has shaved 4 seconds off Coronal FIESTA sequences of the liver with excellent image quality and signal. Dr. Smit says the department also performs a lot of liver imaging for HCC, metastatic disease and post-RF ablation. It’s these types of cases where the fast scans for contrast enhancement really make a difference.

HyperSense can also be utilized to gain spatial resolution while maintaining scantimes. This is especially important in Magnetic Resonance CholangioPancreatography (MRCP) exams in cases of suspected sclerosing cholangitis.

“I can see the narrowing and dilation of the intrahepatic ducts more clearly and have more confidence in the findings.”

---

Dr. David Smit

HyperSense and HyperCube are regularly used in pelvic imaging. According to Jill, the ability to reformat an Axial 3D HyperCube into Coronal and Sagittal planes along with TDI are making a big difference in the quality of fast scanning techniques.

Dunedin Hospital also does a large volume of prostate cancer imaging, where the new synthetic diffusion, MAGIC DWI, and FOCUS diffusion sequences are regularly used. “I’m more confident with a prostate cancer diagnosis than I was before, and these two sequences are a large part of that from my perspective,” says Dr. Smit.

Adds Jill, “The image quality for prostate is shockingly good at 1.5T with the new DWI sequences.” There is a large demand for prostate MR in the area, and Jill anticipates Dunedin can help alleviate existing backlogs with the speed and quality of the new MR system. She believes they are delivering the highest quality 1.5T MR prostate exams in their region.

DISCO is also regularly used in both prostate and liver imaging for its high temporal resolution. In the liver, DISCO has helped with the timing of breath-hold acquisitions.

For orthopedic imaging, FSE Flex in the spine and large field-of-views (FOVs) have also resulted in excellent image
Figure 4. High-resolution imaging of patient with “Turf Toe,” using the 16-channel Small Flex Coil. Sagittal FSE Flex PD and PD FatSat, 3/0.3 mm, 320 x 224, scan time of 2:24 min. (A) Water, (B) in-phase and (C) Coronal T1.

Figure 5. A 10-year-old patient with suspected Gaucher’s Disease. Protocol: Sagittal lumbar T1 & T2 with/without FatSat + Coronal femoral T1 + T2 without FatSat. Total exam time was 15 min versus 1 hour on prior system. (A, B) T2 FSE FLEX 3:30 min; (C, D) T1 FSE FLEX 3:20 min; (E, F) T1 FSE FLEX 3:03 min, in-phase and water only; and (G, H) T2 FSE FLEX 3:55 min, in-phase and water only.
Jill also feels rather “spoiled” by GE Healthcare and its support teams given the geography of New Zealand being separate from other countries. Anytime Jill has a question she can pick up the phone and get an answer right away—and that filters right down to a higher quality of patient care.

“The SIGNA Artist allows us to help more patients that we might otherwise not be able to help. It really lowers the barrier for patients who have difficulty tolerating MR so we can do what we need to get done on a daily basis, and that has been great for our patients and our clinicians.”

Dr. David Smit

quality. Based on this success, Jill intends to utilize it in smaller FOVs such as the hand, foot and wrist. The Proton Density (PD) sequence—both with and without FatSat—has produced very good, high-resolution images and is useful for differentiating bone infarction from osteomyelitis while also helping to shorten scan times.

Whole-body MR in rheumatology patients is another area where the SIGNA Artist shines. Although the exam includes the use of multiple integrated coils, patients have tolerated it well and Jill says they are getting really good images using whole-body STIR and whole-body T1 sequences.

“The key improvement is the uniformity over large FOVs, and that is really why the whole-body imaging on this system is so much better—it is predictable and that enhances clinical confidence,” Jill says.

Adds Dr. Smit, “Rheumatologists rely on MR for determining the best area to biopsy. As a radiologist, we don’t want to review MR images with a lot of flare as we are looking for brightness in the muscle. With this system and using many of these new imaging techniques, we are now much more confident that the signal in the muscle is truly abnormal. In the past, we didn’t always have that clarity of identification.”

Thanks to the speed and precision of SIGNA Artist and SIGNA™Works, patients are more comfortable and there has been a noticeable reduction in the use of sedation and general anesthesia. The ability to image a patient feet first has also enhanced satisfaction.

“Feet-first imaging is a real plus for our patients,” says Jill. “They have tolerated it so much better.”
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.
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).

<table>
<thead>
<tr>
<th>Before</th>
<th>Sequence</th>
<th>Scan time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SSFSE 3P</td>
<td>0:06</td>
</tr>
<tr>
<td>2</td>
<td>DWI Axial</td>
<td>1:30</td>
</tr>
<tr>
<td>3</td>
<td>Head TOF-MRA</td>
<td>5:04</td>
</tr>
<tr>
<td>4</td>
<td>FLAIR Axial</td>
<td>2:44</td>
</tr>
<tr>
<td>5</td>
<td>T2*w Axial</td>
<td>3:25</td>
</tr>
<tr>
<td>6</td>
<td>T1w Axial</td>
<td>3:21</td>
</tr>
<tr>
<td>7 (opt.)</td>
<td>Neck TOF-MRA</td>
<td>9:01</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>27:40</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>After</th>
<th>Sequence</th>
<th>Scan time (min)</th>
<th>Advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SSFSE 3P</td>
<td>0:09</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>HB DWI Axial</td>
<td>0:45</td>
<td>50% scan time reduction by HyperBand</td>
</tr>
<tr>
<td>3</td>
<td>Head HS TOF-MRA</td>
<td>3:13</td>
<td>40% scan time reduction by HyperSense</td>
</tr>
<tr>
<td>4</td>
<td>FLAIR Axial</td>
<td>2:44</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>T2*w Axial</td>
<td>3:25</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>T1w Axial</td>
<td>3:21</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>T2w Axial</td>
<td>2:30</td>
<td></td>
</tr>
<tr>
<td>8 (opt.)</td>
<td>Neck HS TOF-MRA</td>
<td>4:51</td>
<td>45% scan time reduction by HyperSense</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>20:58</td>
<td></td>
</tr>
</tbody>
</table>

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

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
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.

**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.

**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).

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%.
Case Studies

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. 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

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

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.

**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 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.

References
5. The figures in this article will be used in future journal publications, for which the manuscript is in preparation.
Pediatric brain tumor assessment using MAGiC

By Hernan Chaves, MD, and Maria Mercedes Serra, MD, staff radiologists, Foundation for the Fight against Neurological Diseases of Children (FLENI), Buenos Aires, Argentina

Introduction
It is often difficult for adolescent and pediatric patients to undergo a typical 20- to 40-minute neuro MR exam, especially taking into account their emotional state and health condition that requires an imaging study. As a result, pediatric patients have a difficult time complying with a technologist’s request to remain still and usually end up moving during an examination. This often leads to the use of anesthesia or sedation to conduct the MR exam. Techniques such as MAGnetic resonance image Compilation (MAGiC) may allow clinicians to shorten examination time for these patients, which can increase patient comfort and reduce potential motion artifacts without losing image quality.¹

Patient history
A 14-year-old patient with a history of drug-resistant epilepsy. Previous CT showed a frontal space occupying lesion. They were referred to our institution for a brain MR with and without contrast to better characterize this finding.

MR technique
Our conventional MR protocol for brain tumors was performed on a Discovery™ MR750 3.0T scanner with a 32-channel Brain Coil. We included Sagittal T1 FLAIR, Axial T1 FLAIR, T2 PROPELLER, T2 FLAIR, DWI, SWAN and FSPGR after intravenous injection of gadolinium. We additionally acquired pre-contrast Axial MAGiC with 3 mm slice thickness. Comparison scan times for the brain tumor MR protocols with and without MAGiC are shown in Table 1.

---

### Table 1. Comparison times between brain tumor MR protocols without and with MAGiC.

<table>
<thead>
<tr>
<th>Brain tumor MR protocol without MAGIC</th>
<th>Brain tumor MR protocol with MAGIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sequence</td>
<td>Scan time (min)</td>
</tr>
<tr>
<td>Sagittal T1</td>
<td>1:58</td>
</tr>
<tr>
<td>Axial T1 FLAIR</td>
<td>1:55</td>
</tr>
<tr>
<td>Axial T2 PROPELLER</td>
<td>1:48</td>
</tr>
<tr>
<td>T2 FLAIR</td>
<td>4:58</td>
</tr>
<tr>
<td>SWAN</td>
<td>2:37</td>
</tr>
<tr>
<td>DWI</td>
<td>1:09</td>
</tr>
<tr>
<td>FSPGR</td>
<td>4:40</td>
</tr>
<tr>
<td>Total time</td>
<td>19:05</td>
</tr>
</tbody>
</table>

¹ Techniques such as MAGnetic resonance image Compilation (MAGiC) may allow clinicians to shorten examination time for these patients, which can increase patient comfort and reduce potential motion artifacts without losing image quality.
Figure 1. (A) Conventional T1, (B) T2 and (C) FLAIR sequences. (D) MAGIC T1, (E) T2 and (F) FLAIR sequences.

Figure 2. Additional sequences reconstructed from MAGIC. (A) PSIR, (B) PD and (C) STIR. Some tumor features can be better depicted with these sequences, including vascular encasement (yellow arrows), intratumoral cysts (red arrows) and septa (green arrows).

Maria Mercedes Serra, MD
Foundation for the Fight against Neurological Diseases of Children (FLENI), Buenos Aires, Argentina
MR findings

A cortical expansive lesion was identified in the left mesial frontal region. It presented with markedly increased signal on T2-weighted and decreased signal on T1-weighted images with a bubbly appearance in both the synthetic and conventional images. On the synthetic FLAIR and STIR images, internal septations and multi-microcysts were observed with better definition (Figures 1 and 2) than on the conventional images. Diffusion-weighted imaging (DWI) was facilitated within the lesion and no coarse calcifications or blood products were identified on SWAN. After intravenous contrast administration, isolated nodules and rings of enhancement were identified within the lesion. These features suggested the diagnosis of Dysembryoplastic Neuroepithelial Tumor (DNET), which was pathologically confirmed after surgery.

Discussion

MR scan duration in adolescents and pediatrics is a primary concern due to the difficulty in compliance with these patients and the desire to avoid or minimize sedation. Even when optimized, simple brain protocols will usually require at least 20 minutes to complete the study. By replacing conventional techniques with synthetic images, such as those processed with MAGIC, we could reduce the total exam time while maintaining image quality with similar diagnostic utility. Specifically, MAGIC could replace Axial T1-weighted, T2-weighted and T2 FLAIR acquisitions and can be acquired in any plane if desired. Additional sequences reconstructed from MAGIC, such as Phase Sensitive Inversion Recovery (PSIR), double IR, Proton Density (PD) and Short Tau Inversion Recovery (STIR), which are not typically acquired on conventional brain tumor protocols, could provide additional information for further analysis of MR acquisition data. PSIR is a phase sensitive reconstruction contrast technique that allows for the differentiation of fluid from tissue.

Figure 3. Additional conventional sequences. (A) Sagittal T1; (B) Axial post-contrast FSPGR; (C) DWI; (D) Sagittal reconstruction post-contrast FSPGR; (E) SWAN; and (F) ADC map. Areas of nodular and ring-like enhancement can be clearly depicted on post-contrast FSPGR (B, D, yellow arrows). (E) No coarse calcifications or blood products can be seen on SWAN. (C, F) Tumor diffusion was facilitated.
that greatly improves T1 contrast as it displays both negative and positive longitudinal magnetization amplitudes rather than normal magnitude reconstruction. In our case, we also used MAGIC T1 with a 100 ms TR and a 5 ms TE, improving contrast of normal T1 FSE.

The MR workstation enables immediate and automatic reconstruction of all MAGIC-derived series, which can then be sent to PACS for reading. For further inspection, radiologists have access to raw data and can change the TR, TE and TI of the derived. Quantitative maps are also available for T1, T2 and PD and can be used for further evaluation of tissues.

In conclusion, MAGIC may be acceptable for clinical use in children; however, users should be aware of its limitations. Noteworthy synthetic reconstructions rely on the quality of a single scan, so special care should be taken to minimize motion artifacts during this acquisition.

References

Figure 4. MAGIC quantitative maps (T1, R1, T2, R2 and PD) allow direct visualization as well as information of T1, T2 and PD for enhanced evaluation of tissues inside the ROI.
Pediatric imaging with MAGiC

By So Mi Lee, MD, Assistant Professor, Department of Radiology, Kyungpook National University Medical Center, Daegu, South Korea

Introduction
Contrast-enhanced MR studies are a sensitive imaging study for the evaluation of brain pathology. Despite the diagnostic utility of using an MR contrast agent, there is concern regarding the accumulation of gadolinium in neuronal tissues.² As a result, many experts suggest if gadolinium is not needed for a particular exam, especially in pediatric patients, then it should not be administered.

Our institution has evaluated MAGnetic resonance image Compilation (MAGiC) for use in non-contrast imaging of pediatric patients with neurological disorders. Many of these young patients will require multiple follow-up MR scans and, therefore, the avoidance of MR contrast is desirable.

Sturge-Weber Syndrome (SWS) is a rare neurological disorder present at birth marked by a distinctive port-wine stain (facial nevus flammeus) on the forehead, scalp or around the eye. Many people afflicted with SWS experience seizures or convulsions. Other complications may include eye abnormalities, developmental delays and weakness on one side of the body. This disease usually worsens over time with clinical symptoms such as hemiparesis, mental retardation and seizures. Specific pathologies resulting from this disorder include leptomeningeal angioma and enlarged collateral vessels, such as transmedullary and subependymal veins. Demonstration of the extent of the angioma is critical in determining the patient’s prognosis and the necessary extent of cortical resection for seizure management.

In the following case, the patient underwent conventional and synthetic imaging (with MAGiC), to determine the extent of disease and evaluate if the use of MAGiC without contrast may be utilized to replace conventional contrast-enhanced scans for the evaluation of SWS.
**Patient history**
A nine-month-old patient with an episode of focal seizure was referred for evaluation. The patient also had facial nevus flammeus (left side) and angioma involving the choroid of the eye.

**MR findings**
Both conventional and synthetic imaging with MAGIC were performed on this patient.

Conventional: Axial T2-weighted image (Figure 1A) shows minimal hypointensity of the left hemispheric white matter and dilated medullary and subependymal veins. The ipsilateral cerebral hemisphere shows mild atrophic change. On the contrast-enhanced image (Figure 1B) the leptomeningeal angioma especially involves the parieto-occipital region.

Enlarged collateral vessels, such as subependymal and transmedullary veins, enlarged choroid plexus and marked enhancement of the choroid of the ocular globe are shown in the left side. These imaging features are consistent with SWS.

Using synthetic imaging (Figure 2B), the leptomeningeal angioma—the pathognomonic feature of this pathology being most clearly depicted on contrast exam—can be demonstrated without the use of an MR contrast agent.

In addition, using MAGIC PSIR (Figure 1D), the dilated and enlarged collateral vessels as well as parenchymal atrophic changes (Figure 2C) can be well visualized without use of an MR contrast agent.

In this case, the white matter underlying the angioma typically shows prominent hypointensity on T2-weighted images compared to the remainder of the brain. This is most likely secondary to abnormal hypermyelination that presumably results from abnormal venous congestion or from repeated seizures. The synthetic imaging that includes myelin partial volume map as well as quantitative imaging such as T1, T2 and PD maps are useful for evaluation of early white matter changes in an infant with SWS.

**Discussion**
The use of synthetic imaging facilitated diagnosis of the patient’s condition as well as the evaluation of the extent of the lesion without the use of a contrast agent. Concerns regarding intracranial...
Image quality of synthetic T2-weighted and T1-weighted sequences were comparable with the conventional images, which is consistent with other findings in our department. If synthetic imaging is used in clinical practice, dural angiomatosis can be depicted with DIR and leptomeningeal enhancement may be useful for evaluation of disease extent. Synthetic T2 FLAIR is still problematic due to partial volume artifacts in the interface between CSF and brain parenchyma, which may influence the evaluation of leptomeningeal angioma. However, PSIR and DIR, two sequences not included in conventional imaging, may compensate for this issue.

References
Pediatric MR enterography

By Hesham Alshaalan, MBBS, FRCPC, dABR, Ped CAQ, Deputy Chairman Medical Imaging Department and Consultant Pediatric Radiology & Pediatric Neuroradiology, King Abdullah Specialist Children’s Hospital Ministry of National Guard, Riyadh, Kingdom of Saudi Arabia

Pediatric MR enterography (MRE) presents additional challenges due to the small body size and small field of view that may come at the expense of SNR. There is often suboptimal oral contrast injection as many children find it tastes unpleasant. Rapid breathing can also create image artifacts from respiratory motion.

The introduction of fast scanning techniques may overcome some of these pediatric MRE obstacles and enable the diagnosis of these patients without the use of ionizing radiation.

Patient history

Three-year-old with suspicion of Crohn’s disease. The patient was prepared with oral contrast for bowel distension and the procedure was done under general anesthesia.

Fast imaging was employed to minimize scanning as well as sedation timing for the patient with a motion correction series. MR was chosen over other modalities to avoid a radiation hazard.

### Parameters

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Slice thickness (mm)</th>
<th>Scan time (min)</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axial FIESTA FatSat – respiratory triggered</td>
<td>4</td>
<td>3:06</td>
<td>224 x 224</td>
</tr>
<tr>
<td>Axial PROPELLER T2 FatSat motion correction</td>
<td>4</td>
<td>6:13</td>
<td>256 x 256</td>
</tr>
<tr>
<td>Axial DWI with multiple b values 0, 50, 150 &amp; 800 with corresponding ADC; respiratory triggered</td>
<td>4</td>
<td>5:07</td>
<td>80 x 192</td>
</tr>
<tr>
<td>Axial LAVA Flex dynamic series, arterial-venous &amp; delayed, with Auto Navigator</td>
<td>3</td>
<td>1:39</td>
<td>256 x 192</td>
</tr>
<tr>
<td>Coronal LAVA Flex post gadolinium injection (delayed)</td>
<td>3</td>
<td>1:22</td>
<td>256 x 224</td>
</tr>
</tbody>
</table>
MR findings
Short segment terminal ileum bowel wall thickening with enhancement, restricted diffusion and prominent mesenteric lymph nodes. The diagnosis was confirmed by colonoscopy biopsy.
Discussion

The use of fast scanning and motion correction sequences with Auto Navigator and respiratory-triggered solutions helped to overcome inherent challenges in imaging pediatric patients. Image quality was excellent. These techniques provided a high level of confidence in my diagnosis and led to appropriate initiation of therapy. Continued development of appropriate respiratory-triggered sequences for pediatrics will help to further overcome inherent challenges in MR imaging of these patients. Our referring pediatric gastroenterologists now rely on our ability to diagnose inflammatory bowel disease utilizing MRE.
At RSNA 2016, GE Healthcare introduced an evolution in MR coil technology: The AIR Technology Suite. AIR Technology Coils were developed to address several clinical needs: clinical coverage with high SNR, optimized geometries for maximum use of parallel imaging, an adaptive design that fits 99.9% of patients and ultra-lightweight for patient comfort.

Total freedom in coil positioning and handling with the AIR Technology Suite
GE Healthcare scientists developed several new underlying technologies in the new coil design. A multiple resonator conductor arrangement replaces lumped components and circuit boards with an exceptionally durable and flexible loop, named the INCA conductor. AIR Technology also incorporates proprietary E-Mode electronics designed to reduce component volume by more than 60%, decrease coupling flex conductor geometries by 30% and deliver 95% more transparency for MR-based attenuation correction. The E-Mode electronics also help lessen current noise, boost linearity and improve tolerance to varying coil loading conditions. The combination of these technologies makes AIR Technology Coils well suited to work in low- to high-density coil applications.

The University of Wisconsin-Madison recently evaluated the AIR Technology Suite on the SIGNA™ Premier 3.0T system using volunteers in a clinical study which was reviewed and monitored by an Institutional Review Board (IRB). Tammy Heydle, RT(R) (MR), Senior MR Technologist, and Shawn Pulver, RT(R) (MR), Objective MR Technologist, performed a series of scans on the prostate, female pelvis, musculoskeletal, abdomen, ENT (ear, nose and throat), neck, spine and vasculature. They used the Posterior AIR Technology Coil and Anterior AIR Technology Coil for all applications. In addition, Heydle and Pulver also used the AIR Technology Coils simultaneously with conventional coil technology—Head Neck Unit (HNU). When the HNU was combined with the AIR Technology Coil it enabled whole-body imaging without repositioning or re-landmarking the patient. All scanning was performed using existing UW-Madison MR protocols.

“The signal on the images acquired with the AIR Technology Coil appeared greater than the images obtained with the conventional Abdominal Body Array coil. The AIR Technology Coils are also lighter and more flexible so they conform to the body habitus.”

Tammy Heydle

She explains that with traditional coils, the Anterior Abdominal Array does not conform to the patient and needs to be fastened to the table to prevent coil movement. However, with the AIR Technology Coil conforming and molding to a patient’s unique body and size, the issue of coil movement was minimized.

Pulver adds that the material of the coil also makes a difference—it is smoother and more sleek so it is easier to slide the patient into the bore of the magnet. He was also impressed that he could obtain a signal beyond where the AIR Technology Coil is positioned.
The AIR Technology Coil is a vast improvement over the conventional, hard-shell coils that cover the patient’s face,” Heydle says. “It also conforms to the neck providing better comfort.”

Pulver adds, “Since the AIR Technology Coil is lighter, there is less weight on the arms, so the patient doesn’t feel all that pressure on their shoulders when we image them with their arms above their head.”

Another advantage of the AIR Technology Suite in brachial plexus exams is the ability to overlap elements. Pulver used the HNU and the AIR Technology Coil simultaneously.

“We had great signal penetration all the way through with no artifacts or any issues due to the overlap.”

Shawn Pulver
With some coils, an overlap can lead to signal loss or image degradation. He also notes that one nice feature of the SIGNA Premier is the system will alert the technologist if there is too much overlap so they can adjust the coil placement.

Heydle believes the AIR Technology Coils will also help with claustrophobic patients. “The lighter coil will feel more like a blanket, so the patient won’t feel as weighed down,” she says. Plus, the ability to scan feet first on the SIGNA Premier may further lessen claustrophobia.

While the IRB at UW-Madison was only for adult volunteer scanning, Pulver sees an opportunity to use the AIR Technology Coils on pediatric patients.

“You don’t want too much pressure on the patient if they are sedated, so the AIR Technology Coil could be very nice for pediatric imaging.”

In addition to pediatrics, Pulver also sees an opportunity to use the lightweight, flexible AIR Technology Coils for extremity imaging. Both Pulver and Heydle are excited to use the AIR Technology Suite once they are fully implemented at UW-Madison.

Heydle adds, “The AIR Technology Coils are very versatile, which opens up almost endless possibilities for using them.”
Experience freedom.

Designed for freedom in coil positioning, GE Healthcare’s revolutionary AIR Technology is reinventing the way imaging should be. Created with people in mind, the ultra-lightweight design conforms comfortably to all patients, leaving them more at ease during a scan, allowing the technologist to focus more on the patient and not on the technology.

#imagingwithAIR