SIGNA

Pulse of MR

Autumn 2013

RSNA Edition

Volume Fifteen

MR UNLIMITED 1983 30 2013 30 YEARS OF INNOVATION

IMAGINE WHAT MR CAN BE

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WELCOME

IMAGINE WHAT MR CAN BE

This is a landmark year for GE Healthcare MR. Not only are we celebrating our 30th anniversary, but our development teams are buzzing with significant innovations in the areas of MR technology, efficiency, and patient comfort. As a seasoned leader, we know that to be successful we must always be innovating to stay one step ahead. And as we look to our next 30 years, Imagine What MR Can Be.

RSNA is always a great time for GE Healthcare MR. You may know that it was at RSNA in 1983 that GE introduced the first 1.5T whole body MR scanner, the SIGNA™ 1.0. And just look how far we've come since then: Phased array RF coils, shielded MR gradients, snapshot echo-planar imaging, the first clinical 3.0T system, Silent Scan and advanced applications like PROPELLER, VIBRANT, TRICKS, BrainWave, FSE, MR Angio, and MAVRIC SL. It truly is amazing.

So getting back to RSNA, for this year's show, the GE Healthcare theme is "Advancing healthcare . . . together," and several of our new products echo this theme. For example, we'll be showcasing the DV24.0 Continuum™ Pak suite of applications—GE Healthcare's latest response to our customers' ever-changing diagnostic needs. This collection of solutions is designed to improve patient comfort, with innovations such as Silent Scan to enhance producitivity and efficiency, and improve quality and diagnostic confidence. Essentially, the DV24.0 Continuum Pak is designed to give our customers the power to be more efficient and elevate patient care.

With the DV24.0 Continuum Pak, GE MR is pleased to deliver productivity improvements of up to 30% compared to existing platforms. These improvements are possible with new features such as the eXpress PreScan and Workflow 2.0. These enhancements will also drive efficiency by greatly reducing the number of mouse clicks for technologists. The DV24.0 Continuum Pak also features MAVRIC SL, a new technique designed for imaging the joints of patients with MR conditional implants that redefines standards in musculoskeletal radiology. It was developed in response to a growing clinical need for assessing soft tissues in the vicinity of arthroplasty (joint replacements) and MR conditional instrumentation.

Additionally, we're excited to once again demonstrate Silent Scan at the show. At last year's RSNA, we introduced this revolutionary technology, which allows us to perform neuro scans at near ambient noise levels, and frankly the healthcare community can't get enough of it. To help give everyone the opportunity to hear or "not hear" Silent Scan, we will again have a live demo room so attendees can hear the new sound of patient comfort. Even though it debuted last year, our exclusive Silent Scan technology is expected

to be the star of RSNA for the second straight year. Silent Scan has been expanded to include T2, FLAIR, proton density, and angiographic contrasts while adding motion correction with techniques such as PROPELLER. It truly is a monumental step toward changing how patients feel, see, hear, and experience MR for the better.

Personally, I believe the only thing more important than being a leader of technological innovation is being a leader that keeps innovating. At GE Healthcare MR, we keep our customers' needs top of mind, so that when they're ready to enhance their capabilities, we're ready to provide the right solution. We see MR as having unlimited potential, and we are hard at work to push the limits even further.

As you read the pages of this issue, you'll learn more about our new technologies. Enjoy the issue and if you are attending the show, we encourage you to stop by.

Richard Hausmann, PhD
President and CEO
Global MR, GE Healthcare

WE WANT TO HEAR FROM YOU

The SIGNA Pulse of MR Editorial Board welcomes your feedback. In each issue, we'll feature a selection of reader comments on the magazine and questions about GE MR products and services. Write to us at **signa.pulseofmr@ge.com.**

Q I'm a technologist at a facility that just purchased MAVRIC SL. We see a lot of geriatric patients with implants so I am thrilled to be getting this technology. I haven't attended training yet, but another tech at my facility said she heard you could only use MAVRIC SL with receive-only coils. Is this accurate?

A This is not accurate. MAVRIC SL can be used with any coil that is compatible with the system. It has been indicated for use in scanning MR conditional implants, and MR imaging of those patients should adhere to restrictions provided by the implant manufacturer.

DIGITAL DIVE
For more information on MAVRIC SL, view the brochure at http://tiny.cc/spa133

Q I was at RSNA last year when you introduced Silent Scan, and I remember seeing the demonstration and having my jaw drop. Congratulations! This truly is amazing technology. During the demo I attended, you pointed out that Silent Scan was only used for T1 imaging. Is Silent Scan only available for T1 imaging? If not, what else is available?

A Significant advancements in GE's Silent Scan technology have been made since last year's RSNA. GE has worked hard to develop a complete Silent Neuro Package that includes T1, T2, and FLAIR contrasts at near ambient noise levels. At 3.0T, a silent non-contrast MR angiography technique is available that benefits from the ultra-short echo times and isotropic resolution of the silent acquisition.

Q Diffusion imaging is becoming increasingly important for characterizing lesions. What is GE doing to address this growing need?

A The DV24.0 Continuum™ Pak release introduces new functionality to improve diffusion imaging across all body parts. First, GE is introducing new technology that automatically compensates for gradient field errors that often cause image distortion in diffusion-weighted images. The technology accounts for "higher-order" effects that until now have required sequence modifications that prolonged echo-times and reduced SNR in diffusion-weighted images. The second technology is FOCUS. This technology reduces the FOV by utilizing a 2-dimensional excitation pulse to limit the FOV in the slice and phase-encode direction. This allows the operator to acquire much higher spatial resolution than can be achieved with conventional DWI techniques and is particularly useful in imaging of the spine, prostate, pancreas, and small bowel. Both technologies are available at 1.5T and 3.0T and do not require the addition of new hardware to the systems.

Answers to all questions provided by:
Bryan Mock,
MR Global Product Marketing Manager at GE Healthcare.

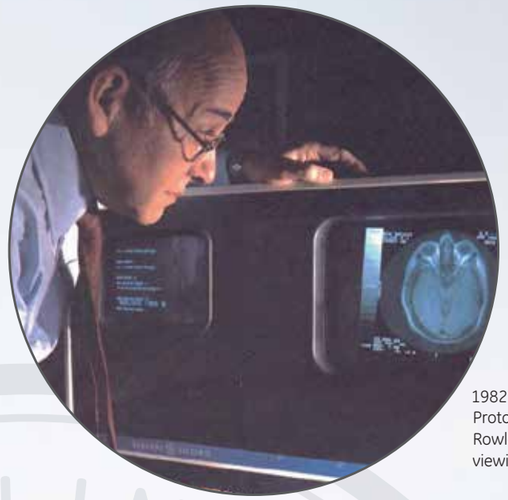
MR NEWS

CHEERS TO 30 GROUNDBREAKING YEARS

If the saying, "To know where you're going, you've got to know where you've been" holds true, then few companies can be as proud or as well positioned for a bright future than GE Healthcare MR. This year marks the anniversary of 30 years of groundbreaking innovation for GE MR, and what an incredible trip it has been.

1982 – John Schenck with physicist Bill Edelstein, as a volunteer.

1982 – Rowland "Red" Redington, MR pioneer and John Schneck.



1982 – First MR console – Prototype: CT8800 console. Rowland 'Red' Redington viewing 1.5T brain images.

The days of X-rays

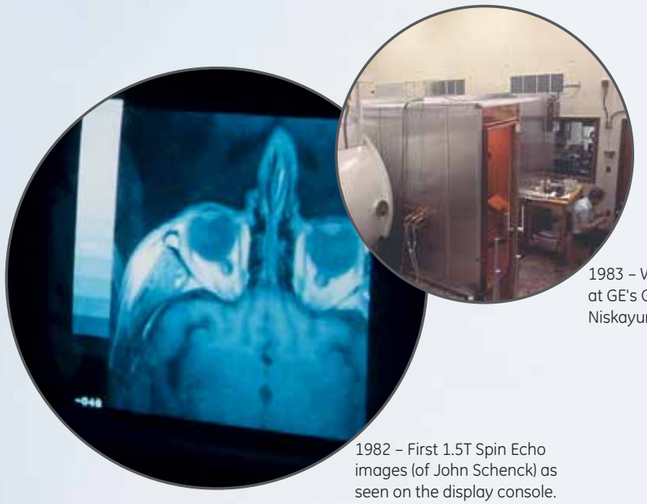
To really appreciate GE Healthcare's MR innovation, it's important to start with a look back. The discovery of X-ray in 1895 started a period in which imaging of the human body became associated with GE's innovation and boundary pushing. In the 1970s, the company became the first equipment leader to make a strong move into the X-ray CT market.

In 1974 and 1975, respectively, GE designed a mammography research prototype and introduced the fast-scan, rotate-only CT system. In 1976 this was followed up with the first installation of what was ultimately known as the CT8800. And while the achievments in these modalities set the foundation for GE to be known as the world imaging leader, as you know, the innovation didn't stop there.

The birth of MR

In the early '80s, Dr. John Schenck, a GE scientist and his research team were hard at work developing a commercially viable MR system. Through their efforts, in 1983, GE was able to launch the Signa™ 1.0, a 1.5T whole body system, which made history as the first commercially available MR scanner. This square-shaped scanner barely resembles the scanners of today, but it marked an enormous healthcare milestone. "In 30 years of GE MR, together with our customers and collaboration partners, we have helped to define the MR experience of today. Considering how many lives have been saved by this technology over those years only increases our determination to work harder, identifying and introducing new clinical applications and technologies, while we are innovating to provide the best economics for our customers and their clinical outcomes, bringing MR to more people all around the world." said Richard Hausmann, President and CEO of GE MR.

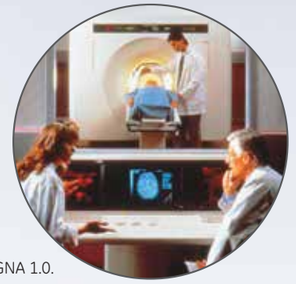
GE's first scanner was built in Florence, S.C. and since that launch, the site has designed and built over 15,000 magnets at field strengths from .5T to 3.0T. One important thing to note is that for over 30 years, GE has designed and manufactured superconducting magnets at their magnet facility in Florence. This strategic R&D decision was based on the magnet being the technological heart of an MR system, and it is crucially and inextricably linked to the overall performance of the system.



1983 – World's first 1.5T scanner at GE's Global Research Labs in Niskayuna, NY.

1982 – First 1.5T Spin Echo images (of John Schenck) as seen on the display console.

1983 – Launch of 1.5T whole body MR scanner, the SIGNA 1.0 – RSNA, Chicago Ill.



SIGNA 1.0.

By cultivating magnet expertise in-house for nearly 30 years, GE has been able to carefully and methodically add new benefits to the scanners without compromising on the essential principles of stability and broad, homogeneous magnetic fields. Take a look at the list of GE MR accomplishments below.

Cheers to the next 30 groundbreaking years

With such a long history of achievements and scientific firsts, the future of MR is very bright at GE. According to Jason Polzin, General Manager, MR Applications and Workflow, GE Healthcare is constantly researching ways to stay one step ahead when it comes to providing customers and patients with the most innovative MR technology. "What's interesting is that 30 years later, while MR has become a more mature technology, we're still pushing the envelope with technical achievements in new ways. Much of the future innovation will be in the areas of patient focus and ways of making the system easier to use."

When asked what GE has in store for the future, Polzin stated, "You'll have to stay tuned, but rest assured, GE MR is constantly surprising."

Insight...

GE Healthcare MR is proud to boast the following "World's First" accomplishments that occurred in the early '80s:

- 1.5T scanner at GE Global Research Labs in Niskayuna, NY.
- 1.5T high-field, Spin Echo MR images of John Schenck, who is still hard at work at the GE Research Lab in NY.
- MR console, resulting from a prototype of the old CT8800 console.

1983
First High-field 1.5T Scanner

1986
First Actively Shielded Gradients

1991
First Phased Array Coils

1993
First Actively Shielded Magnet

1994
First Fast Gradients

1995
First Interventional System

1999
First High-field 3.0T Scanner

2002
First 32-channel MR Scanner

2003
First Motion Correction Technique: PROPELLER

2012
First Silent Scan Acquisition

HIGH PARTICIPATION IN SIGNA PULSE OF MR SURVEY

SIGNA Pulse of MR is your connection to the GE Healthcare MR community, and the entire editorial staff is committed to making the magazine more pertinent and user-friendly for you. That's why this past August, we reached out to our subscribers who supplied email addresses and asked them to participate in a short survey that would help us tailor the content, layout, and usability of the magazine to our readers' needs. We were very pleased with the response rate to this survey with readers from 26 different countries represented in that response. We can't thank you enough. Your input is invaluable and is what we will use to direct future issues of the magazine.

There were many insights gained from the reader survey, and one of the questions we posed concerned the delivery process of SIGNA Pulse of MR. Specifically, we wanted to know if we should continue to provide the magazine in both print and digital formats. We learned that 40% of our readers currently receive both the print edition and the digital formats, 37% receive the printed copy only, and 28% receive only the digital format. This answered our question and we will continue to publish both formats. This also made us wonder if the 60% receiving only one format would like to receive the magazine in the other format. Therefore, to facilitate getting both editions, we thought it might be helpful to review the ways to subscribe to the magazine.

- Become a subscriber for complimentary editions of SIGNA Pulse of MR. Visit: http://tiny.cc/spa137 or the SIGNA Pulse of MR web page on GE Healthcare's website.
- To download the free tablet and smartphone applications, visit the App Store, Google Play, or Amazon.com and search for the SIGNA Pulse of MR app.
- And don't forget, you can always view the current publication and back issues online. Visit: http://tiny.cc/spa138 or the SIGNA Pulse of MR web page on GE Healthcare's website.

In addition to other valuable insights gleaned from the survey, we were proud to learn that 40% of respondents mentioned "New and Up-to-Date information and protocols" as a top-of-mind thought about SIGNA Pulse of MR. We were extremely pleased with this feedback, and we want you to know that we are committed to continuing to bring you the latest information about MR and relaying protocols you can use on the job.

One more exciting finding from our survey was learning that many of those who answered the survey (an impressive 56%) are interested in contributing an article to SIGNA Pulse of MR. We are always looking for interesting stories, so if you have an article idea, please send us a synopsis at signa.pulseofmr@ge.com.

STARTING WHERE OTHERS STOP AT RSNA

GE Healthcare's theme for the 2013 Radiological Society of North America (RSNA) conference, "Advancing healthcare...together," underscores the company's commitment to the future of MR. One example of that dedication, which will be showcased at RSNA, is the new and customizable DV24.0 Continuum™ Pak—GE Healthcare's latest response to customers' ever-changing diagnostic needs. It offers a robust collection of solutions, including Silent Scan, to improve workflow and supercharge applications.

Speaking of GE-exclusive Silent Scan, revolutionary technology designed to address excessive acoustic noise generated during an MR scan, it's expected to be the star of the show for the second straight year. There will be a live demo room so attendees can hear the new sound of patient comfort: neuro scans at near ambient noise levels. For more information about both technologies, see pages 22 and 26.

Another future-forward advancement being unveiled is the new Pediatric Positioner Pad Set—GE Healthcare's first pediatric offering to receive FDA 510(k) clearance for marketing in the US. The pads facilitate MR exam preparation for newborns and infants, up to two years of age or 12 kg, when performing pediatric MR neural examinations using standard MR brain and spine coils designed for adults. See page 80.

DIGITAL DIVE
For more information:
www.GEHealthcare.com

GE HEALTHCARE MR WELCOMES NEW CMO

We are very excited to announce that Ioannis Panagiotelis has been named Chief Marketing Officer of GE Healthcare MR. Ioannis joins GE from Siemens where he was most recently Vice President of MR in the US, overseeing sales and marketing, as well as R&D and research collaborations.

Prior to that, he served as the General Manager for Siemens Healthcare in Greece. From 2004-2008 he was the Global Marketing Manager for the Premium MRI Segment in Erlangen, Germany. Before joining Siemens, Ioannis was an MR Applications/ Systems Integration Scientist at BRUKER-Biospin MRI GmbH.

Ioannis holds a bachelor's degree in Physics from Aristotle University of Thessaloniki, Greece; a master's degree in Medical Physics from University of Aberdeen, UK; a PhD in Biomedical Physics and Bioengineering from University of Aberdeen, UK; and an MBA from IESE Business School in Barcelona, Spain. Stop by the RSNA booth to say, "hello" to Ioannis!

SILENT SCAN STORY REACHES OVER 3 MILLION PEOPLE IN THE US ALONE

GE Healthcare's Silent Scan is revolutionary technology designed to address one of the most significant impediments to patient comfort—excessive acoustic noise generated during an MR scan. Conventional MR scanners can generate noise in excess of 110 decibels, roughly equivalent to a rock concert. Silent Scan's technology is designed to reduce MR scanner noise to background sound levels, and thus, can improve a patient's MR experience.

Not surprisingly, Silent Scan has made the news—big time. Between being the belle of the ball at RSNA 2012 and exceptional feedback from customers who were the first to have the GE-exclusive technology, the newsworthy Silent Scan story has reached over 3 million people (including traditional media coverage, Twitter, and YouTube) in the US. Additionally, it has been featured in nearly 70 media outlets in Asia. See page 22 to read about one of the first facilities in the world to test Silent Scan.

FIRST US USER OF MR + PET/CT TRIMODALITY IMAGING SYSTEM

Decatur Memorial Hospital in Decatur, Ill. is the first user in the U.S. of GE Healthcare's Trimodality imaging system, designed to capture high-quality images from MR and PET/CT scanners—then fuse them with Integrated Registration software. Trimodality imaging is intended to be a sound investment for researchers and multi-specialty hospitals interested in combining functional and structural information to enhance patient care.

> "GE Healthcare's Trimodality solution combines all three modalities to make the most complete and accurate diagnosis in one test."

"GE Healthcare's Trimodality solution combines all three modalities to make the most complete and accurate diagnosis in one test," says Mark Muscato, MD, Diagnostic Radiologist, Decatur Memorial Hospital. "We are using it for improved treatment planning and to target different lesions for biopsy or tissue mapping. With the vast array of applications, the potential is endless."

According to David Overlot, Executive Director of Radiology at Decatur Memorial Hospital, his department is constantly striving for the next advancement in imaging. "Our new Trimodality imaging system is so valuable and versatile—we think it's going to be a big part of our growth in areas such as molecular medicine."

Photo courtesy of Decatur Memorial Hospital.

Decatur Memorial Hospital is the first US hospital to install GE Healthcare's Trimodality imaging system, which captures high-quality images from an MR scanner (foreground) and a PET/CT scanner (background).

GE MR SYSTEM TO SCAN ATHLETES AT SOCHI WINTER OLYMPIC GAMES

The XXII Winter Olympic Games are scheduled to take place Feb. 7-23, 2014, in Sochi, Russia. As a Worldwide Olympic Partner, GE is the exclusive provider of a wide range of innovative products and services that are integral to staging a successful Olympic and Paralympic Games.

In Sochi, GE's contribution to healthcare technologies and infrastructure will include a wide range of digital imaging equipment at the Olympic Village Polyclinic, including MR—allowing diagnosis of even the smallest strains and sprains. A mobile Signa™ HDxt 1.5T will provide Olympic athletes and their doctors with precise information to evaluate injuries, and help determine if an athlete can continue to compete.

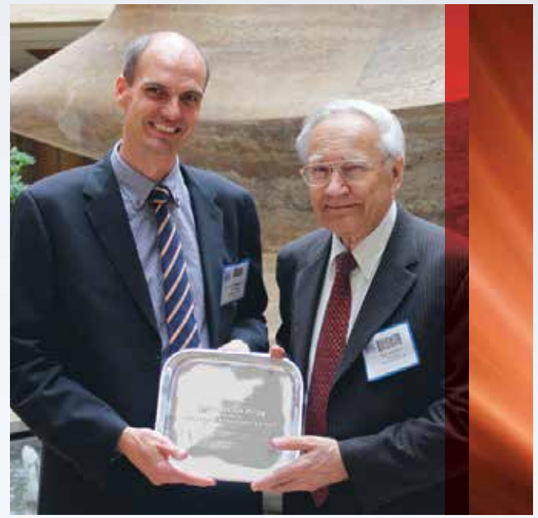
With an optimized workflow, high-density surface coils and advanced clinical applications, GE Healthcare's Signa HDxt continues to represent the next level of performance in imaging. The system is expected to provide exceptional care to the athletes, as it offers a robust suite of neuro applications that includes 2D MERGE/3D COSMIC for enhanced axial cervical spine imaging; PROPELLER for artifact-free and motion-free brain imaging; and Cube for 3D high-definition imaging customized for specific brain, body, and MSK imaging.

GE is looking forward to the Rio de Janeiro 2016 Summer Olympic Games and Pyeongchang 2018 Winter Olympic Games, where they are already working with the organizing committee and government to provide technologies for the infrastructure built for the Games.

GE HEALTHCARE SCIENTIST WINS GÜNTHER LAUKIEN PRIZE FOR HYPERPOLARIZATION

Jan Henrik Ardenkjaer-Larsen, principal scientist at GE Healthcare in Denmark and head of the Danish Research Centre for Magnetic Resonance (DRCMR) hyperpolarization group, was awarded the Günther Laukien Prize by Nobel laureate Richard Ernst. This is the most prestigious prize given for advances in NMR spectroscopy.

Ardenkjaer-Larsen and Klaes Golman were recognized for their seminal work on the hyperpolarization technique, which in certain situations can improve the MR signal by a factor of 10,000.[1] The technique is used at the DRCMR and elsewhere for studies of cancer development and treatment response.



Reference

1. www.drcmr.dk/AllNews/345-ArdenkjaerLarsenLaukienPrize2012

Vitals...

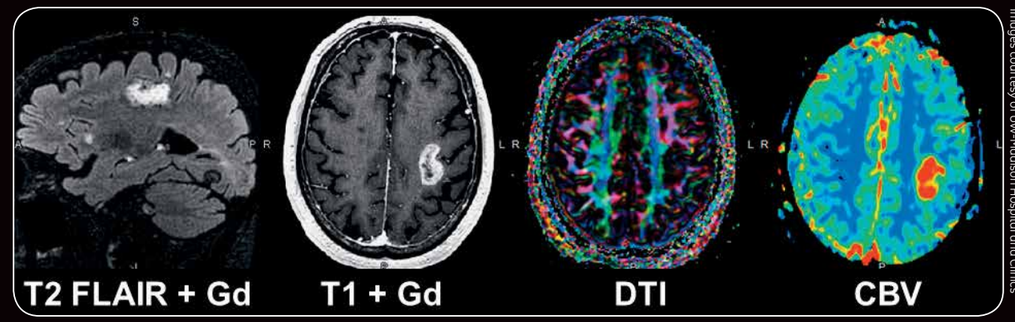
Sales of the Optima™ MR360 Advance and Brivo™ MR355 Inspire product line have hit the 1,000 mark. Both 1.5T MR systems represent GE Healthcare's ongoing focus on the human element in MR, and each is designed to offer different benefits to fulfill the needs of facilities and patients.

iMRI SURGICAL SUITE HELPS WITH MORE COMPLETE RESECTIONS

Since the introduction of GE Healthcare's first intra-operative MRI (iMRI) suite at Brigham and Women's Hospital in Boston 20 years ago,[1] key advancements in MR technology and surgical tools/devices have propelled the success of combination imaging and surgical suites. Namely, the introduction of wide bore MR has provided clinicians with greater access to the patient while they are in the bore. Surgical device manufacturers continue to invest in MR-compatible equipment that can be used for interventional or intra-operative procedures.

While imaging typically helps guide the surgical planning, leading institutions have recognized the value of intra-operative imaging to help clinicians confidently and more completely resect tumors that previously may have been deemed inoperable due to the tumor's location on or near critical structures. GE Healthcare has answered this growing need for iMRI with its MR Surgical Suite and has implemented over 22 systems worldwide, with an additional 8 scheduled for installment.

iMRI offers several clinical advantages for brain tumor resections and in some centers specializing in epilepsy surgery and deep brain stimulation (DBS). Four hospitals utilizing GE's MR Surgical Suite solution shared their clinical experience with SIGNA Pulse of MR: the University Hospital Bonn, Baptist Medical Center Jacksonville, University of Wisconsin Hospital, Madison, and Yamagata University Hospital.



Images courtesy of UW-Madison Hospital and Clinics

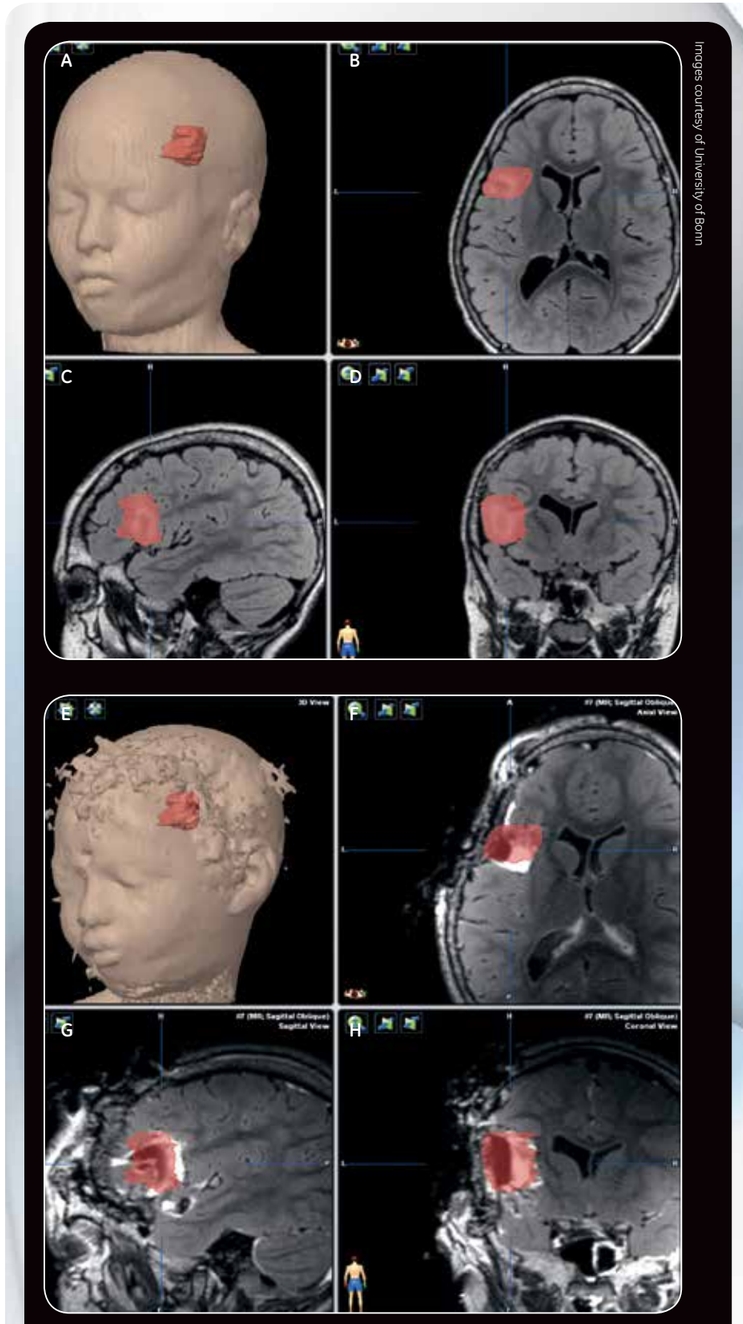
Figure 1. Pre-operative MR images (top row) used for surgical planning; intra-operative MR images (bottom row) showing active contrast leakage into the surgical bed.

Surgical cases–resection of tumor and epilepsy

Without question, the most significant clinical impact of an iMRI suite is to enable the neurosurgeon to more completely resect brain tumors. In the case of low grade gliomas, extent of resection plays a role in patient outcomes.[2] However, in children this can be an even more important factor, says Philipp Aldana, MD, pediatric neurosurgeon, Wolfson Children's Hospital, part of Baptist Medical Center (Jacksonville, Fla).

"The majority of tumors in children are low grade tumors. Therefore, completeness of resection plays a larger role in children, as these low grade tumors can be less responsive to other non-surgical, adjuvant treatments such as chemotherapy and radiation therapy," Dr. Aldana explains. Also, tumors in the posterior fossa are more common in children; therefore, approximately half of his cases are performed with the patient in a prone position.

"We are more confident that we've completely resected the tumor, based on our iMRI images," he adds. He recalls two recent cases in his institution where the surgeon thought the tumor was completely removed, but the iMRI showed residual tumor. The patient had further resection during the same operative session, saving these patients from another trip to the OR post-op. The MR Surgical Suite has also helped in cases where the tumor has a similar appearance to the brain matter, and the images help in the differentiation, he says.



Images courtesy of University of Bonn

Figure 2. Pre-operative MR (A-D) and intra-operative MR (E-H) of patient with focal cortical dysplasia. Intra-operative imaging enables the neurosurgeon to tailor the procedure to the patient.

For any patient undergoing brain tumor resection, there is always a balance between safety and the aggressiveness of surgery, says Professor Hartmut Vatter, MD, Neurosurgeon, University Hospital Bonn (Germany). The Discovery™ MR750w intra-operative surgical solution at Bonn is used for resecting both tumor and epilepsy patients. "For the epilepsy surgery, it is also a question of accurateness or resecting exactly the area that you want," he explains. Since these are elective cases, it is absolutely necessary for higher brain functions to be unaffected as the goal of the surgery is to enhance the patient's quality of life, not prolong it in the case of tumor resection. "It is a matter of tailoring the surgery so that function is preserved as long as possible."

In fact, Professor Vatter and his colleague, Professor Matthias Simon, MD, neurosurgeon, see a higher value in the ability to use iMRI to tailor neurosurgery to the individual patient. Professor Vatter asked, "Is it better for a particular patient to risk a decrease in memory function yet gain additional years of life? Considering the last 5% of a resection leads to 90% of reported complications, would it be better for the patient if we change the operative strategy and ask the radiosurgeon/oncologist if the remaining tumor is suitable for radiation therapy or stereotactic radiosurgery?" While today these questions cannot be answered definitively, Professor Vatter is excited at the possibility of how iMRI can help tailor the surgical approach to the individual—an area that he hopes to investigate.

John S. Kuo, MD, PhD, FAANS, FACS
is Associate Professor of Neurological Surgery and Human Oncology Director, Comprehensive Brain Tumor Program Chair, CNS Tumors Group, Carbone Cancer Center

At the University of Wisconsin-Madison, the MR Surgical Suite with the Optima™ MR450w has "lived up to its promise," says John Kuo, MD, neurosurgeon, although it has been a learning experience. "We've learned things about the pooling of blood, or other hyper acute changes," he explains. "Our neuroradiologists conservatively called residual or enhancing tissue on MRIs that are now understood to be hyper-acute residual blood." As Dr. Kuo and his colleagues used the intra-operative MR, they learned to distinguish the post-op blood/hyper acute blood pooling as it appears on the MR images and not go back in search of residual tumor.

The MR Surgical Suite at UW Madison was installed in the spring of 2011. In addition to using the solution for brain tumor resection, he says there are other clinical areas that his colleagues are exploring for iMRI use, including DBS.

Yamagata University Hospital (Japan) has been utilizing its MR Surgical Suite with the Signa™ HDxt 1.5T since 2008. Nearly 300 cases have been completed using the system. It is used not only for brain tumor operations but also for epilepsy, blood vessel obstacle cases, arteriovenous malformations, and cerebral aneurysm surgeries. The advantages of the system are numerous, says Kaori Sakurada, MD, PhD, Neurosurgeon and Assistant Professor, Department of Neurosurgery, Yamagata University. In addition to looking for any residual tumor, the solution also "raises the accuracy of the navigation under operation by updating the brain shift, or brain modification, that occurs during surgery and helps detect unexpected intraoperative complications that may occur inside and outside of the operative field."

The typical sequences used at Yamagata University Hospital include Gadolinium-enhanced T1-weighted T1 (WI), diffusion-weighted (DWI), T2* (WI), T1 (WI), T2 (WI), and FLAIR to evaluate the completeness of resection and detect intra-operative complications. "By creating a tractography of the pyramidal tract and the optic radiation based on the data from diffusion tensor imaging, we can perform subcortical monitoring efficiently and safely," says Dr. Sakurada.

In one particular case, the MR Surgical Suite was also useful for early diagnosis of an unexpected complication. "While there are reports of subdural hematoma and epidural hematoma outside the operative field, we experienced a case in which a subdural hematoma formed at the opposite side during resection of glioblastoma. Although slight bulging of the operative field was suspected during surgery after removal of a large tumor and dural closure, the hematoma may not have been noticed until the patient experienced anesthesia awakening delay." With the MR Surgical Suite, the hematoma was diagnosed and promptly removed before the patient left the OR.

Professor Hartmut Vatter, MD
is Chairman of the Department of Neurosurgery, University of Bonn, Germany.

Dr. Sakurada shares that additional resection was performed in approximately 20% of intracerebral malignant tumor cases and in 5% of endoscopic removal of lesions near the hypophysis at Yamagata University Hospital. For primary gliomas, the resection rate before iMRI was 91.7% and rose to 93.5% after system implementation.

Shared resource model

GE's MR Surgical Suite solution has the OR and the MRI in two different suites with an RF shielded door connecting them. The patient is safely and securely moved from the OR to the MR, imaged, and then moved back into the OR. "From a pure intraoperative situation, this (set-up) is nearly perfect," says Professor Vatter. He's had some experience with other configurations that have a moveable MR into the OR.

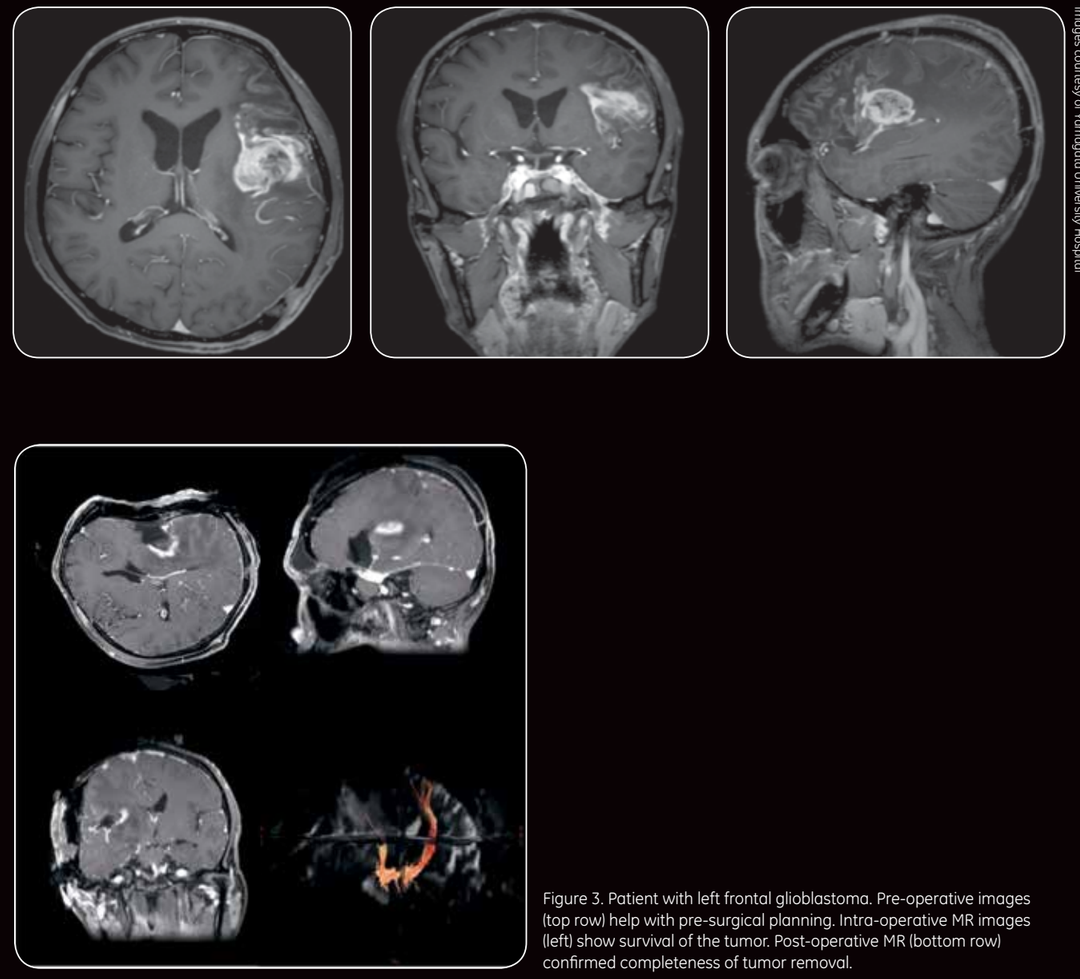
With a two suite configuration, the surgeon can use their traditional surgical tools during the operation, he says, reducing the need and cost of special MR-compatible instruments. Another advantage of the separate room is that it facilitates the ability to capture MR images on the same system before, during, and after surgery. This is also useful, Professor Vatter adds, for patients post-surgery who develop necrosis or other complications and require an MR scan. The unit is more available for these types of cases since access to it is not dependent upon the OR suite—which is often utilized throughout the day for many types of surgeries other than brain resection.

Professor Vatter adds that there is a difference in physician positioning between the two different concepts of an iMRI suite. He found that when the MR was moved into the OR suite, it made his surgical positioning more uncomfortable as it is typically stored under the operation rack during the procedure. "With the MR Surgical Suite in Bonn, a further advantage is that I can position myself in the same manner as with any other surgery; I don't have to position around the MR during the surgery."

Dr. Aldana agrees that the two-room configuration is a convenient approach to obtaining the MR in an operative environment. "We don't have to consider additional precautions that are needed when bringing an MR into the OR suite," he says. There is also a financial consideration, he says, in that there are no special design requirements for the OR when the MR is housed in a separate room. "We can design the surgical suite like a regular OR. That is the biggest factor as there is a significant difference in the infrastructure cost of an MR that travels to the patient versus the patient traveling to the MR."

The clinicians agree that having a separate MR and surgical suite just makes economic sense. At the University of Bonn, the MR Surgical Suite system is now being used to image intubated patients. At UW Madison, the MR suite is often used for inpatient and outpatient diagnostic imaging. Dr. Kuo and his colleagues typically performs one to two iMRI procedures each week—a rate that is similar across all four sites—and when the MR is not being used intra-operatively it handles imaging exams scheduled by UW Madison's radiology department. In fact, the MR suite utilization is on par with the other MR systems at UW Madison. Similarly, at Yamagata University Hospital, having another MR solution is important as the hospital performs over 1,300 MR studies each year compared to 80 iMRI cases.

Philipp Aldana, MD, FAANS, FAAP
is Chief, Division of Pediatric Neurosurgery, University of Florida, Jacksonville, and Chief of Service, Pediatric Neurosurgery, Wolfson Children's Hospital.



Images courtesy of Yamagata University Hospital

Figure 3. Patient with left frontal glioblastoma. Pre-operative images (top row) help with pre-surgical planning. Intra-operative MR images (left) show survival of the tumor. Post-operative MR (bottom row) confirmed completeness of tumor removal.

Patient safety

In terms of safely transporting the patient, Dr. Aldana explains that anesthesiologists are already accustomed to bringing non-operative, sedated patients to an MR so the surgical team has adopted a similar workflow. New protocols were developed to ensure any ferro-magnetic materials are removed from the patient, Dr. Aldana adds. "When we prepare the patient for the MR, we have a safety checklist that the nurses and MR tech go over to remove all instruments that are not MR safe." Additionally, the hospital invested in MR-compatible remote patient monitors and instruments. "Paying attention to these details is important," he says, "and it requires a team effort—the surgeon, nurse, technologist, radiologist, and anesthesiologist to make it safe and efficient."

Professor Vatter agrees that the safety of the patient is dependent upon ensuring there are no ferro-magnetic tools rather than patient transport. "There is no difference in safety if you move the patient or move the MR," he says. Also, he reports no increase in infections resulting from moving the patient to the MR suite compared to any other surgical cases. The MR suite is a sterile environment at all four facilities and is re-sterilized prior to any iMRI case.

Dr. Sakurada also confirms that while initially there may have been concerns regarding infection risk accompanying an iMRI suite, there has been no case in her institution where infection has been caused by the MR Surgical Suite.

Many neurosurgeries utilize head clamps to help ensure the cranium remains in a fixed—stable position throughout the surgery, another important patient safety consideration. All four hospitals use the GE exclusive Mayfield® Skull Clamp (Integra Lifesciences Corporation) which is MR and X-ray compatible. Designed to provide full range of motion capability, it gives neurosurgeons the flexibility to position their patients for optimal surgical planning. In addition, with pin options of titanium and sapphire, the clamp minimizes any disruption to the imaging capability. GE also ensured that this clamp was designed to accommodate coils without compromising flexibility. Professor Simon says that while the neurosurgeons at University Hospital Bonn had to become familiar with placing coils over the clamp, it didn't create any issues. "It has worked on all the cases where we've used it and was less difficult than we had feared," he adds.

Dr. Aldana agrees the skull clamp is easy to use and work around once one has learned to use it, although there are certain pediatric patients who are not suitable for clamping. "We can still do surgery without the clamp," he adds.

Conclusion

Looking forward, Dr. Kuo hopes to perform more advanced imaging in the MR Surgical Suite, such as tractography or overlaying functional imaging. Professor Vatter also hopes to begin using these same techniques to learn more about brain function. "Our next steps will be to use functional MRI in the intra-operative MRI and also to determine metabolites, for example, to see changes in brain perfusion that occur during or after surgery."

Professor Vatter explains, "In many tumor resections, we have an edema and we do not really understand why it occurs. Probably it is due to changes in the blood flow during or after the operation. There are also other phenomena that occur peri-operatively that we do not really understand; if we can recognize it during the operation we can do something about it." iMRI, he adds, is only in its infancy and there is still much to learn and understand how it can be used peri-operatively.

Ultimately, the success of an iMRI solution depends on the planning, the staff, and the quality of images. In addition to image quality, Dr. Aldana found that the technical support provided by GE was invaluable, including helping with protocols and pre-implementation planning. Dr. Kuo shares that hospitals seeking to implement an iMRI must first know what their goals are, and have the entire staff—from the clinicians to the support staff—involved in the planning.

Creating a successful iMRI program takes dedication from the entire surgical and radiology teams, extensive planning for workflow, and a solution that is economically viable for hospitals in uncertain economic times. With the solution from GE Healthcare, the neurosurgeons at University Hospital Bonn, UW-Madison, Baptist Medical Center Jacksonville, and Yamagata University Hospital can more confidently resect brain tumors and save patients from additional surgeries to remove residual tumors.

While research is needed to further determine the long-term impact on patient outcomes, one thing is clear to Professor Vatter. "iMRI can improve the immediate surgical outcome because resection is more complete."

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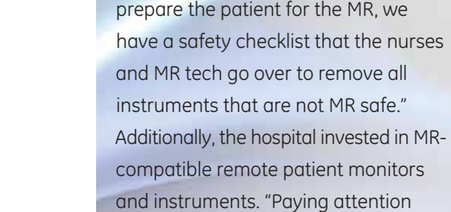

Kaori Sakurada, MD, PhD
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Professor Matthias Simon, MD,
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> "iMRI can improve the immediate surgical outcome because resection is more complete."
>
> *Professor Hartmut Vatter*

John S. Kuo, MD, PhD, FAANS, FACS, *is a tenured Associate Professor of Neurological Surgery and Human Oncology, and Director of the Comprehensive Brain Tumor Program at University of Wisconsin-Madison. He graduated with MD and PhD degrees on a fully funded MSTP fellowship from Harvard Medical School and MIT, then completed neurosurgery training at University of Southern California and a postdoctoral fellowship at University of Toronto's Hospital for Sick Children-Labatt Brain Tumor Research Centre. In addition to specializing In neurosurgical oncology, Dr. Kuo chairs the Carbone Cancer Center's CNS Tumors group for clinical trials, and leads an NIH-funded lab studying cancer stem cell biology and developing novel cancer therapies.*

University of Wisconsin Hospital and Clinics *is a 566-bed facility that ranks among the finest academic medical centers in the United States. Frequently cited in publications listing the nation's best health care providers, UW Hospital and Clinics is recognized as a national leader in fields such as cancer treatment, pediatrics, ophthalmology, surgical specialties and organ transplantation.*

Professor Hartmut Vatter, MD, *is Chairman of the Department of Neurosurgery, University of Bonn, Germany. Dr. Vatter received his medical degree from the University of Heidelberg and completed his residency in the Department of Neurosurgery, Goethe University Frankfurt. He is a reviewer for Neurosurgery, Journal of Neurotrauma, Neurosurgical Reviews, Acta Neurochirurgica, Journal of Neurological Sciences, Experimental Neurology, Stroke, Critical Care Medicine. He has published numerous clinical and scientific papers on topics relating to neurosurgery, including aneurysms, traumatic brain injury, tumor resection, and cerebral vasospasm after subarachnoid haemorrhage.*

Professor Matthias Simon, MD, *is Vice Chairman in the Department of Neurosurgery at the University of Bonn. Dr. Simon received his medical degree from the University of Hamburg, graduating magna cum laude. His current clinical interests are in aneurysm, complex spine, and brain tumor surgery (including intraoperative monitoring/mapping), and neurosurgical intensive care medicine.*

The University Hospital Bonn *is the tertiary referral academic teaching hospital associated with the University of Bonn. It is among the leading hospitals in Germany and Europe, providing excellent patient care and research. In 2008 the German Center for Neurodegenerative Diseases (DZNE) was established on the hospital site. The Faculty of Medicine is part of the Rheinische Friedrich-Wilhelms University of Bonn.*

Philipp Aldana, MD, FAANS, FAAP, *is Chief, Division of Pediatric Neurosurgery, University of Florida, Jacksonville, and Chief of Service, Pediatric Neurosurgery,* **Wolfson Children's Hospital** *(Jacksonville, Fla). He received his medical degree from the St. Louis University School of Medicine in St. Louis, MO. He co-founded and is President of the Neurosurgery Outreach Foundation, a charity that advances neurosurgical care in underserved communities. He is active in the American Academy of Pediatrics, where he serves as secretary of the Executive Committee of the Section of Neurological Surgeons.*

For more than 20 years, healthcare consumers have named ***Baptist Medical Center Jacksonville*** *the "most preferred healthcare provider" in the region. As the central hub of the Baptist Health system, Baptist Jacksonville provides the highest level of medical and surgical care using the latest technologies. At the region's only children's hospital, Wolfson Children's Hospitals' skilled pediatric specialists, advanced technology and evidence-based practices help children overcome illnesses like serious heart conditions, brain tumors and diabetes.*

Kaori Sakurada, MD, PhD, *is an Assistant Professor, Department of Neurosurgery at Yamagata University. Dr. Sakurada received her medical and doctorate degrees from Yamagata University and completed her residency at the National Cancer Center Research Institute in Japan. Her current clinical and research interests include surgery for brain malignancy using high-field magnetic resonance surgical suite MRI system.*

Yamagata University Hospital *is part of Yamagata University, a national university established in 1949 but with roots back to 1878 as Yamagata Normal School. In 1973, the Faculty of Medicine and a Department of Medicine was established. Yamagata University is the second largest university in the Tohoku Region of Japan.*

DYNAMIC NEW SET OF ENHANCEMENTS IMPROVES PATIENT COMFORT AND WORKFLOW WHILE SUPERCHARGING APPLICATIONS

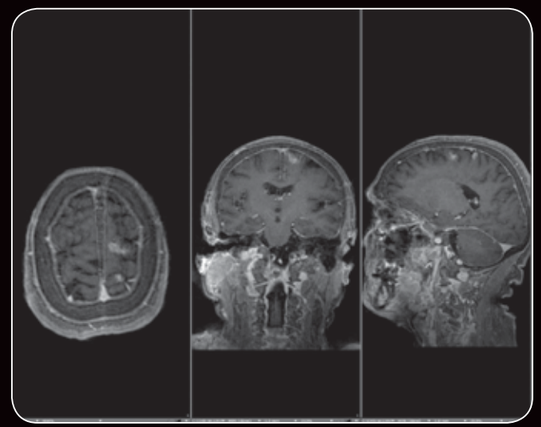
Aristotle once said, "For the things we have to learn before we can do them, we learn by doing them".[1] MVZ Radiologie & Nuklearmedizin in Furth, Germany is doing just that with new imaging technology from GE Healthcare—the DV24.0 Continuum Pak, featuring the ability to perform neuro scans at near ambient noise levels with Silent Scan.

Sedat Alibek, MD
is an Associate Professor of Radiology and Head of Radiology at MVZ Radiologie & Nuklearmedizin in Fürth, Germany.

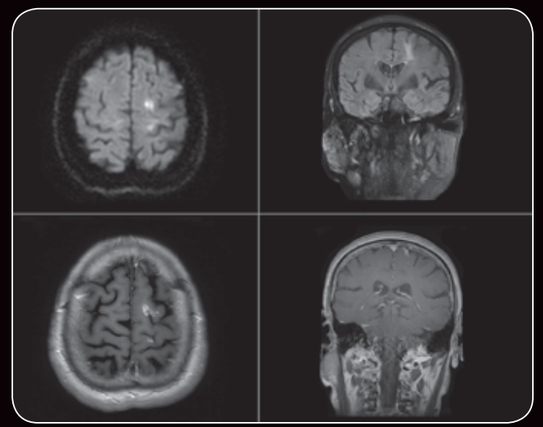
At MVZ Radiologie & Nuklearmedizin, patient care standards are a high priority. Due to the large number of MR patients served daily, on 15 GE Healthcare MR scanners across 17 centers, it's necessary to accommodate a wide variety of patient needs. Patient populations such as pediatric and the elderly can be especially sensitive to noise, and the anxiety, confusion, and movement that often result, can decrease image quality. Loud MR scanner noise can also lead to halting of the scan, especially with neuro exams where the patient's head is positioned inside the bore.

Because the facility scans a large number of these patients, Sedat Alibek, MD, Associate Professor of Radiology and Head of Radiology at MVZ Radiologie & Nuklearmedizin, was especially pleased to be one of the first in the world to test Silent Scan as an upgrade to its Discovery™ MR750w 3.0T as part of a research collaboration with GE Healthcare.

Silent Scan, introduced by GE Healthcare in 2012, is revolutionary technology designed to address one of the most significant impediments to patient comfort—excessive acoustic noise generated during an MR scan. Conventional MR scanners can generate noise in excess of 110 dBA (decibel) levels, roughly equivalent to a rock concert. GE's exclusive Silent Scan technology is designed to reduce MR scanner noise to background sound levels, and thus, can improve a patient's MR experience.



Multiplanar reconstruction of a 3D T1w Silent MR after i.v. contrast injection. Note the contrast up taking areas, which represent the ischemic changes in the subacute phase (approx. 1 week). Also note that the patient moved during the scan, but only the falx appears as a double lined structure, no classic motion artifacts like blurring are noted.

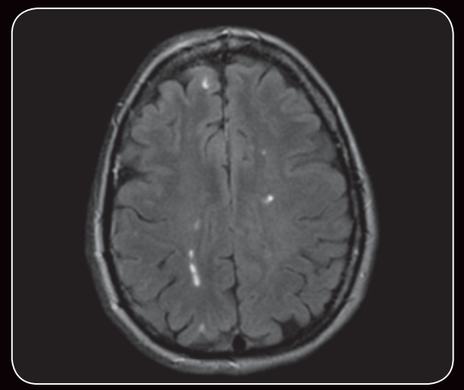


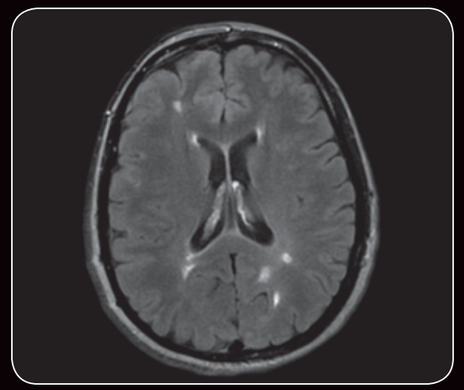
Left upper image: conventional DWI image showing areas of ischemia in the left hemisphere (bright dots).

Right upper image: conventional T2 FLAIR showing periventricular ischemic changes (bright area).

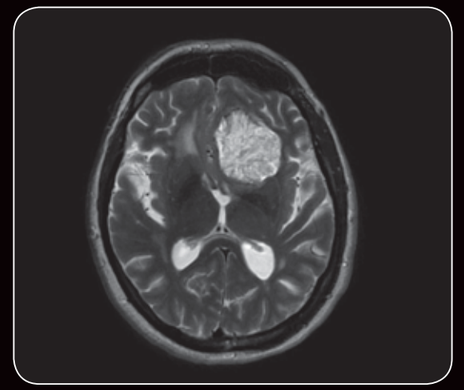
Left lower image: conventional T1 FLAIR after i.v. contrast showing ischemic changes in the subacute phase.

Right lower image: conventional T1 FLAIR after i.v. contrast showing ischemic changes in the subcortical region in the left hemisphere.





Axial image of a Silent T2 FLAIR PROPELLER showing bright spots bilaterally in the periventricular area in a 30 y/o patient with known encephalomyelitis disseminata.



Axial Silent T2 PROPELLER showing a mass in the left frontal lobe with midline shift to the right and compression of the left ventricle (ruptured dermoid).

First impressions mean everything

Silent Scan is a unique combination of innovative technologies that make the sound of an MR near ambient level, while still providing the diagnostic image quality necessary to make a confident diagnosis. It was installed at MVZ Radiologie & Nuklearmedizin in March of 2013, and already, Dr. Alibek and his staff have very positive impressions to report.

"Quite a lot of things have changed in MR. But one thing that hadn't changed until Silent Scan was an impactful reduction of scan noise," comments Dr. Alibek, who has been a radiologist and MR user for more than 10 years. "I always ask patients, 'How was your wide bore MR scan experience?' Before Silent Scan, most said it was very spacious but extremely loud. I always answered the patients with, 'Well, that's physics, we can't change that.' So I didn't believe it when I first heard, or didn't hear, Silent Scan."

MVZ Radiologie & Nuklearmedizin was so impressed that the staff conducted a feasibility study. After local ethical committee approval, 75 patients referred for a brain MR scan were invited to participate. As asked by the study protocol, before the scan, each patient received a survey to ascertain whether they'd had an MR scan previously—and asked them to rate the noise level from previous scans on a subjective scale. Next, patients had the scans—first conventional, then with Silent Scan. They were then asked to rate the noise level of Silent Scan and asked if they would prefer Silent Scan in the future. The result: on a scale of 0-5, with 0 being the quietest, the respondents rated the conventional scan around 3 and the Silent Scan 1—a statistically significant decrease in Silent Scan. 98% of patients also said they would prefer Silent Scan.

Scanning more patients

According to Dr. Alibek, the technology provides an opportunity to scan patients who couldn't have been scanned previously. For example, children are prone to motion because of sickness and anxiety when hearing very loud noises. With Silent Scan, anxiety in pediatric patients is often alleviated. Additionally, the elderly, and patients with dementia or other illness that prohibit talking and cooperating, get especially anxious from noise. "Because of Silent Scan, I definitely think we can lower the rate of failure. We expect a high rate of reduction of non-diagnostic scans," he offers.

Additionally, for Dr. Alibek, another plus is that Silent Scan doesn't require measurably longer scan times to maintain diagnostic image quality. "Typically, for better images, we need to scan a bit longer. Silent Scan requires just a little more scanning time compared to a conventional scan, but getting an accurate diagnosis makes it worth it." Furthermore, he reports that workflow has not changed for the technologists, as they don't have to do anything differently.

More first impressions

MVZ Radiologie & Nuklearmedizin was one of the first sites worldwide to have the brand new DV24.0 Continuum™ Pak installed on its Discovery MR750w 3.0T in September of 2013. As GE Healthcare's latest response to customers' ever-changing diagnostic needs, the DV24.0 Continuum Pak offers a robust collection of solutions—in addition to Silent Scan—to improve workflow and supercharge applications.

The DV24.0 Continuum Pak has a range of customizable offerings, so an upgrade package can be tailored to meet the specific needs of the facility. "My first impression was positive. We wouldn't have the DV24.0 Continuum Pak if we weren't sure it was better than what we had before," Dr. Alibek comments. "So far, it's an amazing set of enhancements."

Dr. Alibek has observed expanded productivity features. For example, technologists can perform the same scan more quickly than with the previous version, so more patients can receive a scan in the same timeframe. Additionally, he is impressed with the intuitive applications that enhance the staff's daily work and enable them to do more during exams. "For example, the image quality in the DV24.0 Continuum Pak diffusion-weighted imaging is much better with less distortion than the previous version, which is important to me as I do diffusion-weighted imaging (DWI) in not only neuro but also in other body parts; for example, to determine if a tumor is benign or malignant."

Dr. Alibek continues, "Also, FOCUS delivers a highly efficient method for increasing the resolution in Single Shot DW EPI sequences. Utilizing a multi-dimensional selective excitation, FOCUS supports zoomed, small field-of-view imaging of specific organs—such as the prostate and pelvis—with higher diagnostic quality, lower artifacts, and faster exam times compared to conventional diffusion imaging."

Learning from experience

Dr. Alibek's advice to his peers is this: "If you'd like your patients to feel as comfortable as possible during MR scans, GE's DV24.0 Continuum Pak with Silent Scan is enormously important. Being able to use the technologies on the whole body improves our work and helps make our center even better. Make sure your patients understand what a difference these enhancements make, and they will possibly choose you as an imaging center again."

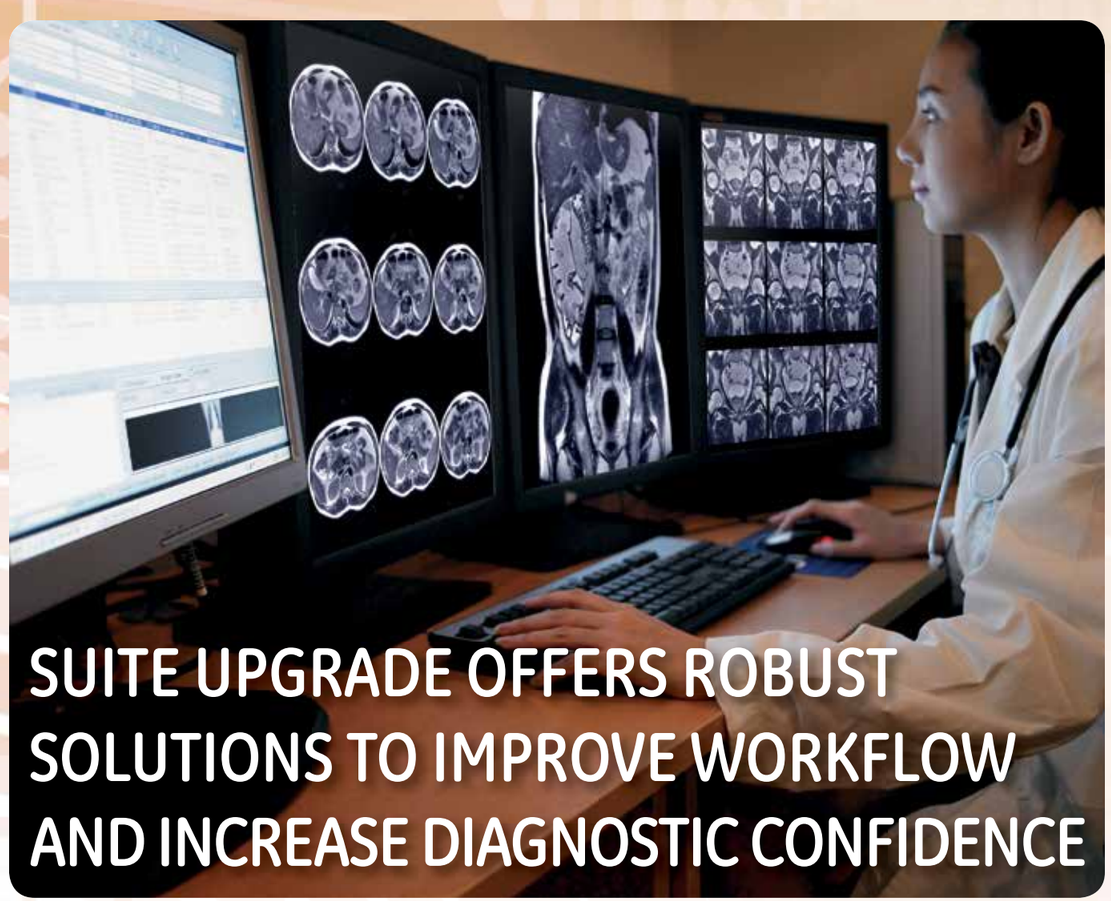
Dr. Alibek says experiencing the technologies in their early stages has been special. With the enhancements, he hopes to improve the quality of MR imaging for patients in any given situation, whether they are healthy, sick, young, or old.

Reference

1. Bynum, W. F. and Porter, R. (eds) (2005) Oxford Dictionary of Scientific Quotations. Oxford University Press. 21:9.

Sedat Alibek, MD, *is an Associate Professor of Radiology and Head of Radiology at MVZ Radiologie & Nuklearmedizin in Fürth, Germany. Dr. Alibek attended the University of Erlangen-Nuremberg Medical School and has been published in more than 25 peer-reviewed journals.*

The radiology department at ***MVZ Radiologie & Nuklearmedizin*** *is part of the Competence Network Radiology and Nuclear Medicine Franconia, located in the northern part of Bavaria (mainly in the cities of Nuremberg and Fürth). The department offers advanced diagnostics and a high level of modern imaging technique expertise in diagnostic radiology and nuclear medicine.*

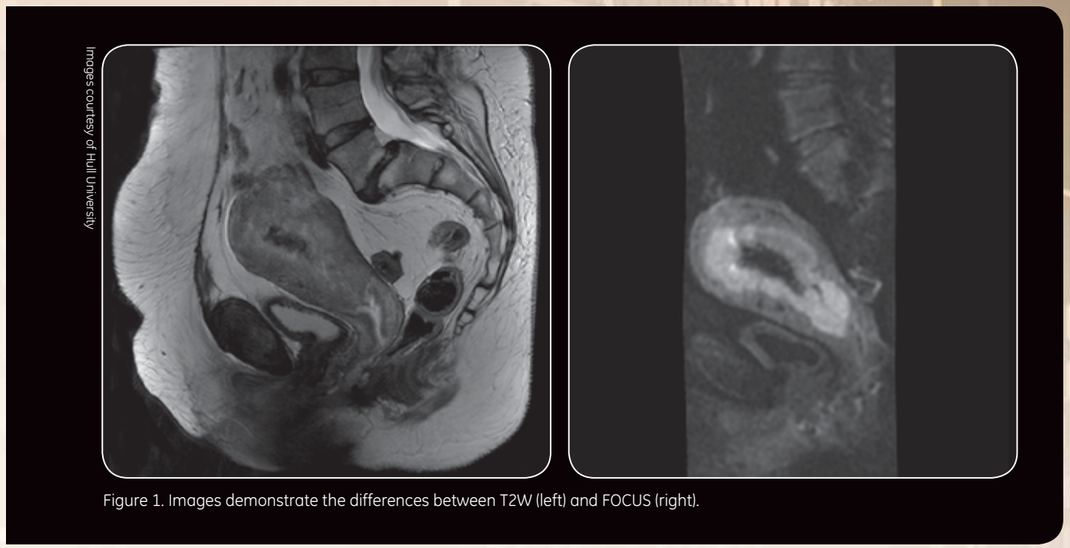


SUITE UPGRADE OFFERS ROBUST SOLUTIONS TO IMPROVE WORKFLOW AND INCREASE DIAGNOSTIC CONFIDENCE

The DV24.0 Continuum Pak is GE Healthcare's latest response to customers' ever-changing diagnostic needs. It starts with the innovative Silent Scan technology that enables routine neuro scans at ambient noise levels. Yet, this upgrade package doesn't stop there—it offers a robust collection of solutions designed to improve workflow and increase diagnostic confidence across the full spectrum of clinical applications.

Jean-Marc Pinon
is the Imaging Department Manager at the CT and MR imaging center based at the regional hospital CHR Laennec of Creil, France.

Several early users of the DV24.0 Continuum™ Pak have shared their feedback on a number of the enhancements with which they have gained experience, including Silent Scan, FOCUS, Body Navigators, GE's new diffusion imaging correction technology (Real Time Field Adjustment), and SWAN 2.0 (for more on Silent Scan, see page 22. A full description of the DV24.0 Continuum Pak is included on page 76).



Images courtesy of Hull University

Figure 1. Images demonstrate the differences between T2W (left) and FOCUS (right).

The sound of Silenz

Patients have long complained about the noise of an MR study—a typical MR scan can reach 100 decibels, or equivalent to the sound of a jackhammer, a speeding train, or a rock concert. With Silent Scan, GE Healthcare has changed the way patients hear MR forever. That is perhaps the most immediate difference that Jean-Marc Pinon, Imaging Manager, Creil Hospital, has noticed.

"At first, the most impressive contribution of this upgrade is the Silenz sequence," Pinon says. "It brings a new level of comfort to the patient and that helps us generate a quality examination." A more comfortable patient is also less likely to move, causing fewer artifacts. Patients noticed the difference immediately, he adds.

Silenz offers more than just decreased noise levels, however. The clinicians at Creil have noticed that it improves tissue differentiation in neuro exams. That's due to the very short echo time, which improves image quality and signal from all tissues of interest. Additionally, Silenz technology acquires 3D MR data, resulting in isotropic resolution.

Enhanced sequences for confident diagnosis

At Hull University, Professor Lindsay Turnbull, MD, Scientific Director at the Centre for MR Investigations, has utilized FOCUS diffusion-weighted imaging (DWI) for female pelvic and prostate imaging. FOCUS delivers a highly efficient method for increasing the resolution in single-shot DW EPI sequences. By utilizing a multi-dimensional selective excitation, FOCUS supports zoomed, small field-of-view imaging of specific organs with higher diagnostic quality and fewer artifacts, compared to conventional diffusion imaging.

"We routinely acquire FOCUS DWI in the axial plane for prostate and vaginal vault but acquire the sequence in the sagittal plane for the uterus and cervix," Professor Turnbull explains. "Image quality is dependent on rectal filling but the majority of the cases seen to date have been impressive and the additional information obtained is clinically very useful."

Lindsay Turnbull, MD
is Professor of Radiology at Hull-York Medical School and Scientific Director of the Centre for MR Investigations.

Images courtesy of Creil Hospital

Figure 2. Two station spine IDEAL and FOCUS on a patient with metastatic breast cancer.

While image quality in the pelvic region can vary depending on the surrounding materials and structures, Professor Turnbull is impressed with the results. "There is improvement in spatial resolution, better fat suppression, and hence no degradation of the image by ghosting artifact from abdominal wall signal," she adds. "The FOCUS DW images are certainly the best DW images we have ever obtained and the sequence has been adopted into our routine protocols for male and female pelvic imaging."

Thus, FOCUS helps increase Professor Turnbull's clinical confidence in the detection of abnormalities in the prostate. This is important, she says, for multiparametric MR and the detection of small lesions. Similarly, FOCUS is being used at Hull to determine the depth of invasion of the junctional zone/myometrium and the presence of lesions in the endocervical canal and surrounding cervical stroma in patients with endometrial cancer. With prior techniques, it was problematic for axial imaging to capture the organ of interest as it is often oblique to the imaging plane. She has found similar advantages using FOCUS in patients with primary cancer of the cervix.

"We have also used FOCUS for patients with potential recurrence of endometrial cancer to the vaginal vault, picking up recurrences of 3 to 4 mm," Professor Turnbull adds. "The sequence will also be very useful for imaging the vagina and also the perineum for patients with vulval and anal margin malignancies."

The DV24.0 Continuum Pak also offers a full complement of navigated sequences to reduce the dependence on respiratory bellows. These Body Navigators are designed for free breathing, motion-controlled acquisitions. "Our use of Body Navigators for respiratory gating is working very well," says Professor Turnbull. "The process is simple to perform and reliable, and is resulting in an improvement in image quality in the SSFSE sequence."

She did have one problematic case in a patient whose liver was of such low signal intensity that there was no contrast difference between the liver and lung. "Instead we used the spleen/lung interface and this worked just as well," she adds.

"Both sequences—FOCUS and navigated SSFSE—have resulted in better image quality," Professor Turnbull says, "and to date have allowed us to detect several small lesions, some less than 5 mm, which may have an impact on treatment decisions."

Jérôme Hodel, MD, PhD

serves as radiologist at Saint Joseph Hospital. He is a member of the French Society of Radiology and European Society of Radiology.

Jerome Hodel, MD, at St. Joseph Hospital in Paris, has utilized two enhanced sequences in the DV24.0 Continuum Pak. SWAN 2.0 introduces phase images to help differentiate between paramagnetic (iron) and diamagnetic (calcium) and RTFA reduces distortions in diffusion imaging.

"Compared to our standard diffusion protocol, GE's new diffusion imaging correction technology (RTFA) significantly increases signal-to-noise, providing a real improvement for both diffusion weighted and diffusion tensor imaging," Dr. Hodel explains. He sees this as a promising tool for imaging of optic nerves and the brainstem and, potentially, also to positively impact EPI-based fMRI. In fact, he would recommend the use of RTFA to his colleagues for all EPI-based MR sequences.

The susceptibility effects of SWAN 2.0 generate impressive phase maps that are very useful in clinical practice. "The signal homogeneity obtained on phase maps is always satisfactory," he says. "Phase maps increase our clinical confidence, allowing us to recognize diamagnetic and paramagnetic dipoles in the daily practice. Aliasing on the phase maps may also be useful for the diagnosis of subarachnoid hemorrhage."

Additionally, Dr. Hodel believes the phase maps may be useful to further improve the contrast of SWAN magnitude images, which are necessary to detect ToF effects within brain vessels. The use of these maps is important for a better understanding of signal abnormalities on magnitude images.

When combined with 3D ASL, a non-contrast, whole brain, quantitative perfusion assessment sequence, Dr. Hodel finds that SWAN 2.0 "significantly improves the diagnostic performance for patients with stroke and brain vascular malformations. Both SWAN and ASL can have a major impact in clinical management."

Images courtesy of ST Joseph Hospital

Figure 3. Using eSWAN, the phase increased at the two lobes (bright) and decreased at the equatorial rim (dark) (A, B); the phase is decreased at both lobes (dark) and increased (bright) at the equator (C, D).

Images courtesy of Hull-York Medical School

Figure 4. Matched T2W/diffusion/perfusion abnormality posterior aspect left PZ, consistent with malignancy. Lesion, capsule, and neurovascular bundle are well visualized with FOCUS.

Efficient, flexible workflow

Several workflow enhancements in the DV24.0 Continuum Pak are helping to simplify use of the MR system and create new efficiencies. For example, Pinon points out that the prescan time is decreased and there is an improvement in the user interface for programming the examination. These two enhancements, along with the new sequences, bring a new flexibility that has helped Creil increase the number and type of examinations.

A very useful complement to high image quality is the greater ease of scrolling through images on the DV24.0 Continuum Pak, adds Professor Turnbull. "The enhanced image navigation tools make the case review much more straightforward," she says.

Also, the improvement in prescan times has allowed Professor Turnbull and her colleagues to add FOCUS scans without any significant impact in the total exam duration. "We have replaced non-informative calibrations with diagnostic valuable acquisitions," she adds.

Overall, the experience with the new DV24.0 Continuum Pak has been a positive one at Creil, Hull and St. Joseph's hospitals. Professor Turnbull was impressed with the implementation. "The DV24.0 Continuum Pak was installed almost seamlessly," she says. "There has been no significant system downtime and the new functionality has been easy to implement into clinical practice. It is a significant improvement."

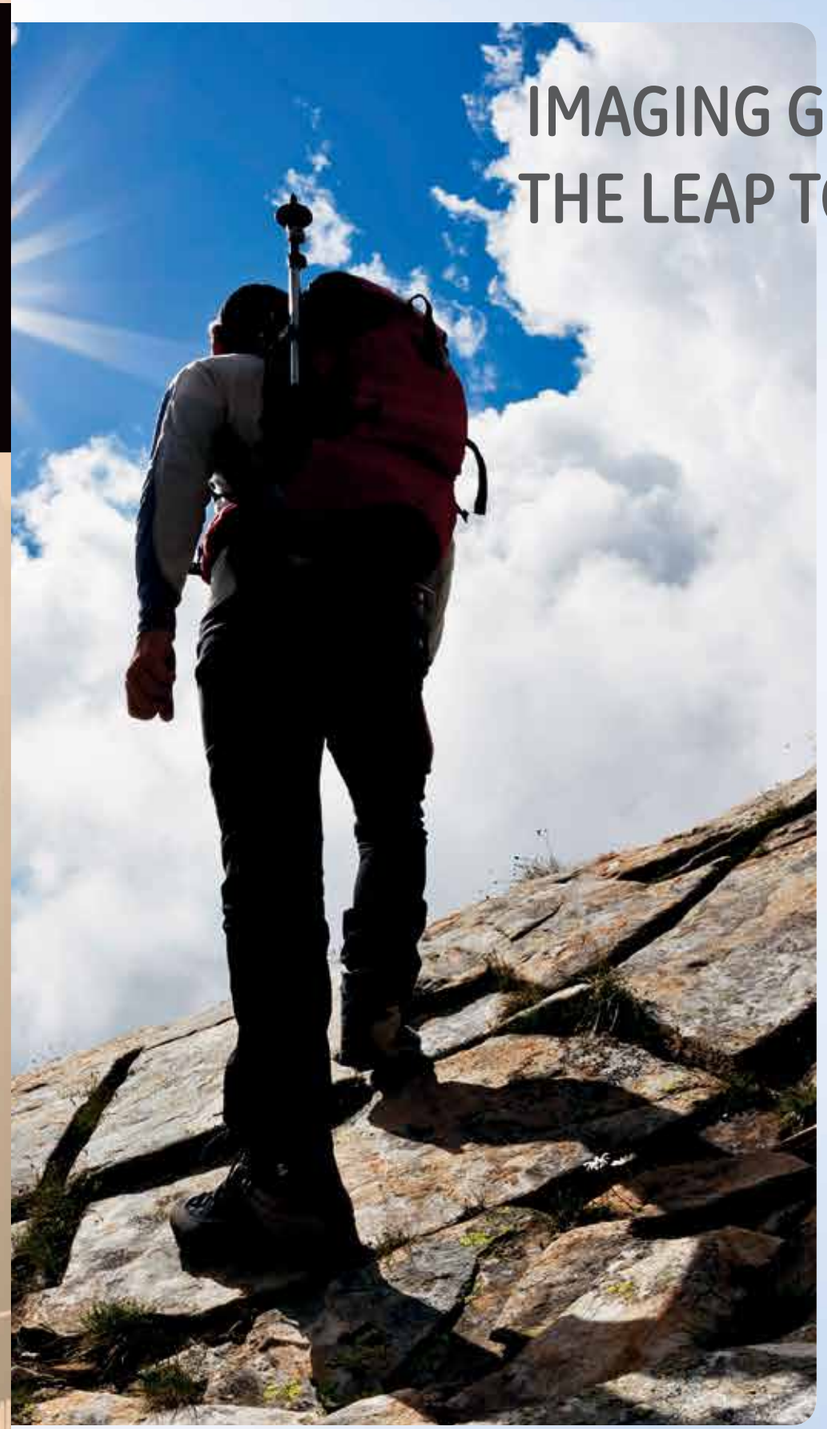
For the technologists at Creil, the addition of new sequences and provision of new techniques has enabled them to increase image quality and significantly contribute to the radiologists' diagnostic abilities. He concludes, "The DV24.0 Continuum Pak upgrade that includes Silent Scan is, in my opinion, the most innovative approach in MR in the last few years that will make a significant contribution in the chain of diagnosis."

Jérôme Hodel, MD, PhD *serves as radiologist at Saint Joseph Hospital. He is a member of the French Society of Radiology and European Society of Radiology. He specializes in neuro-imaging and has a strong focus on clinical applications of advanced MR techniques.*

The imaging department of ***Saint Joseph Hospital*** *in Paris, France, investigates patients with suspected brain disorders, such as stroke. The hospital offers 24/7 access to MR and CT imaging.*

Jean-Marc Pinon *is the Imaging Department Manager at the CT and MR imaging center based at the regional hospital CHR Laennec of Creil, France. He holds a national degree in electroradiology. Mr. Pinon started his career in radiology in 1986 at CCN where he spent 14 years. After CCN, he served in different private imaging centers in France as a consultant and applications engineer.*

Lindsay W. Turnbull, MD *is Professor of Radiology at Hull-York Medical School and Scientific Director of the Centre for MR Investigations, University of Hull. Prof. Turnbull received her medical degree from the University of Edinburgh after earning an Honors degree in pathology and subsequently obtained the FRCR and MD. She is Chairman of the Diagnostic Technologies and Screening Panel for the National Institute for Health Research, Health Technology Assessment Programme, a member of the regional Experimental Cancer Medicine Centre and has previously served on the Scientific Advisory committees for Yorkshire Cancer Research and the Breast Cancer Campaign.*



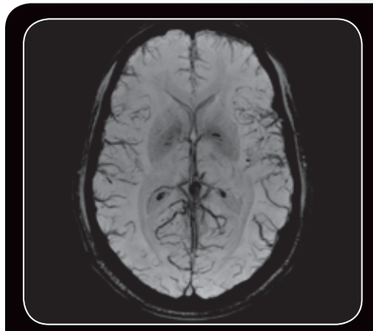
IMAGING GROUP MAKES THE LEAP TO 3.0T MR

Acquiring a new MR scanner is a significant investment for most imaging providers, regardless of whether it's a hospital, imaging center, or radiology practice. Today, a key consideration for many sites is whether to make the leap from 1.5T to 3.0T.

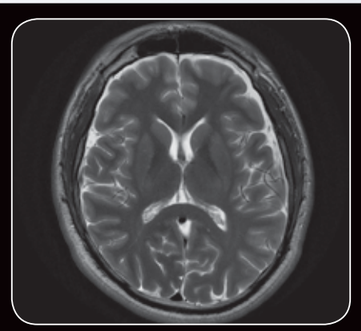
As a senior member of the American Society of Neuroradiology, Frederick Cohn, MD, FACR, President and CEO of Borg and Ide Imaging (Rochester, NY), knew the advantages of 3.0T imaging. Borg and Ide Imaging is partnered with RadNet, Inc., a national leader in providing high-quality, cost-effective diagnostic imaging services through a network of 250 owned and/or operated outpatient imaging centers.

In addition to a high signal-to-noise (SNR) ratio, 3.0T MR increases image resolution and enables the clinician to obtain more information, such as viewing subtle lesions that may not be visible at lower field strengths. "It allows a panoply of different options to add to your armamentarium on how to take care of your patients."

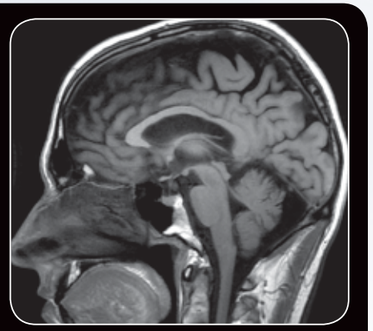
On that note, Joyce Doll, Director of Clinical Operations at Borg and Ide Imaging, points out the facility's strong emphasis on the patient. "The patient experience here is truly the number one priority. Patients come in for their study, they expect prompt,



SWAN is a gradient echo sequence that referring physicians like for visualizing lesions or subdural hematomas.



PROPELLER 3.0 is useful for helping obscure any patient motion artifacts for great motion-free imaging.



FLAIR is often used for imaging patients with MS.

courteous service, and they want to be comfortable in their environment." So, in addition to 3.0T, the facility was interested in a wide bore solution.

Initially, Dr. Cohn and his colleagues were concerned about the trade-off in moving to a wide bore scanner, especially at 3.0T. Specifically, they were concerned about key performance criteria including specific absorption rate (SAR), field homogeneity, and field-of-view (FOV) capability. They turned to GE Healthcare and, after learning how GE addressed these issues, selected the Discovery™ MR750w 3.0T wide bore system.

"In the past, we've had issues with SAR in that we would have to terminate or stop an examination, wait for significant cooling, and then restart the examination to complete it," says Chris Schaeffer, MD, PhD, Neuroradiologist at Borg and Ide Imaging. "With the GE Discovery MR750w, we don't have that problem; with most patients we complete an examination without the significant pauses that we experienced with earlier magnets."

The scanner offers numerous algorithms that enable the technologist to tailor the study to the patient's body habitus, not just his or her weight, to further decrease SAR. As a result, adds Technologist Patty Marianetti, "We've had no SAR issues whatsoever."

A decrease in a homogeneous field has historically been an issue with wide bore MR systems, resulting in a decreased FOV. That's not the case with the Discovery MR750w. "Because the homogeneity is so pure and uniform, we can perform significant imaging off isocenter, particularly for joints or shoulders in large patients," says Dr. Cohn. Plus, with the larger bore, Marianetti finds that she can position the patient so that the region of interest is isocenter in most cases and capitalize on the benefit of a large 50 cm FOV.

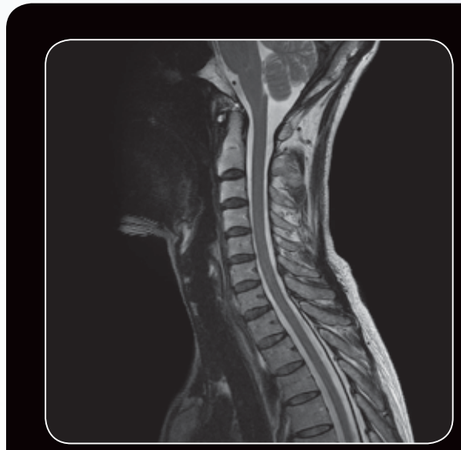
More referrals and comfortable patients

Staff at Borg and Ide Imaging saw the need for a 3.0T MR scanner in the surrounding community they serve—the west side of Rochester, New York. "Referral patterns have gravitated toward the 3.0T, especially for neurologists, neurosurgeons, and orthopedics," says Doll. Marianetti has also noticed an increase in referrals for neuro applications. "We didn't have these referrals before the 3.0T."

One of the most important aspects of Borg and Ide's new scanner is that the patient is significantly more comfortable and less claustrophobic compared to prior 60 cm bore scanners, which means less patient movement and fewer motion artifacts. Dr. Schaeffer explains that if the patient is more comfortable, then he or she

Frederick Cohn, MD, FACR

is President and CEO of Borg and Ide Imaging and a Clinical Associate Professor of Radiology at the University of Rochester School of Medicine.



The Sagittal T2 sequence highlights the spinal cord for disc disease.

T1 helps with evaluations of the vertebral body.

can withstand the magnet longer, and that positively impacts image quality.

Not only are patients less intimidated by the wider bore, but other capabilities such as feet-first imaging further enhance comfort. "With the Discovery MR750w, we can essentially perform all scans with the patient in the gantry feet first, and that dramatically decreases claustrophobia," says Dr. Cohn. "That, along with more room, reduces motion which improves image quality, lesion conspicuity, and our diagnostic confidence."

Another key feature is the detachable Express patient table. Marianetti explains that this is a benefit to all patients, but specifically with disabled patients. "Patients with disabilities like the fact that the table comes out and they can get on it themselves. Again, it's less intimidating yet easier to use." The Discovery MR750w also provides a large FOV, so Marianetti can get good resolution with the high SNR on larger patients.

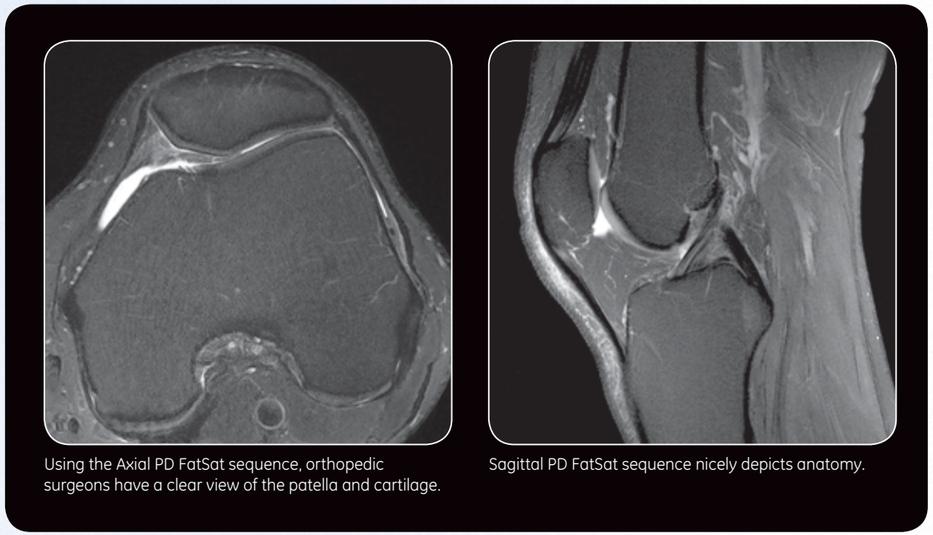
More information for a confident diagnosis

Both Dr. Cohn and Dr. Schaeffer agree that the power of 3.0T is evident in neuro imaging. "I request 3.0T for our patients who have Multiple Sclerosis (MS), strokes, seizures, or any lesions that would require very subtle, intricate imaging," says Dr. Schaeffer. It is also ideal, he says, for heterotopias and medial temporal sclerosis due to the higher SNR and image resolution. "Lesions at the cortical interface become much more prominent at higher fields and this can guide treatment planning," he adds. Isotropic imaging with Cube also provides several planes for lesion or injury evaluation.

"In my world of neuroradiology, the conspicuity of MS lesions in the brain or the spine, or other subtle lesions, becomes much more evident and that's been a huge improvement. That also improves our confidence in the diagnosis and patient management," says Dr. Cohn.

New applications, such as diffusion tensor imaging (DTI) for imaging concussions in athletes or tractology for pre-operative planning of brain tumors, are very helpful. According to Dr. Cohn, "We can determine the important fiber tracts in eloquent areas in relationship to the tumor. Also, we use spectroscopy for tissue characterization." For vascular interventional radiology, the Inhance package is an important addition. He continues, "It's the first time we can image the entire vascular system, from head to toe, without any Gadolinium. That's been an enormous advantage."

PROPELLER 3.0 has also dramatically affected the way patients are imaged, explains Dr. Schaeffer. Patients who become uncomfortable during the examination will often move, creating motion artifacts. "With PROPELLER 3.0, we can image these patients and get very high quality, reasonably motion-free images that allow us to diagnose them at a much higher confidence level."



Using the Axial PD FatSat sequence, orthopedic surgeons have a clear view of the patella and cartilage.

Sagittal PD FatSat sequence nicely depicts anatomy.

MR perfusion studies of the brain are another often used sequence. These are helpful for treatment planning in patients with gliomas and glioblastoma multiforme, metastatic disease, and resections. "These patients undergo an MR perfusion to tell whether the enhancement pattern is a recurrence or radiation necrosis due to the treatment," says Dr. Schaeffer. "That information can guide treatment to determine whether there is disease progression or if the current treatment plan is working and can be continued."

Marianetti adds, "The SWAN sequence is also a big plus for the clinicians' diagnoses, and when we first got it, doctors were actually putting SWAN on their requisitions so now it is part of our stroke assessment protocol." In breast imaging, she has noticed that VIBRANT Flex is providing complete fat saturation images. "This was almost always a problem, depending upon the patient's anatomical structure. VIBRANT Flex takes that all away."

Dr. Schaeffer also sees a significant improvement in T1-weighted and T2-weighted images. "By using T2 for FatSat of the spine, we can get higher resolution images without very long scan times. In terms of image quality for spine imaging, ours are probably the best in the area."

In fact, the image quality is so good on the Discovery MR750w that neurologists tell Dr. Schaeffer they're sending all their patients to Borg and Ide Imaging.

Efficient workflow, extraordinary support

The Discovery MR750w includes GE's latest innovation in MR coil technology—the Geometry Embracing Method (GEM) Suite of coils. The GEM coils are user friendly, Marianetti says, with a longer length for anatomical scanning so she doesn't have to change coils to image different body parts. "I can image a head, neck, thoracic spine, and lumbar spine without having to change patient orientation or move them off the table to change coils," she adds.

She also finds the "pause scan" feature helpful with patients who may experience difficulty during the scan.

DIGITAL DIVE
Watch customers from Borg & Ide Imaging, P.C., weigh in on the advantages of the Discovery MR750w 3.0T scanner when you visit http://tiny.cc/spa136

Chris Schaeffer, MD, PhD
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Joyce Doll, RT,
is Director of Clinical Operations.

"I request 3.0T for our patients who have Multiple Sclerosis (MS), strokes, seizures, or any lesions that would require very subtle, intricate imaging."

Dr. Chris Schaeffer

"We can use pause scan and talk to the patient to find out what is going on. I don't have to stop and restart the scan. It's one button, and we resume the scan, so it increases productivity." Another feature that helps reassure patients is the GEM head coil comfort tilt feature—the patient is more comfortable which helps him or her get through the exam quicker.

IntelliTouch is another feature that helps Marianetti do more in the time she has. "It's one button... you don't have to worry about laser lights and you have the freedom to actually interact with the patient more."

An advanced MR imaging system relies on optimized protocols to maximize performance and reduce operator dependence. That's where GE's strength in service and support are helping Borg and Ide Imaging take MR imaging to a new level of quality.

"One of the most important things after installation is the ongoing communication of our radiology and technologist teams with GE applications to continue improving the image quality," says Dr. Cohn. Dr. Schaeffer is equally impressed with the level of support and dedication shown by GE's applications specialists. "We all sat down together on several occasions and oversaw patients being scanned; we focused on workflow and protocols, making modifications on the fly. The day, we would have a meeting to assess what was done and then, moving forward, made changes to increase efficiency and optimize the system."

Overall, the Borg and Ide Imaging group found its experience with GE applications training to be a great one. The new MR scanner was a big investment for the facility—one that they intend to keep for as long as possible. Doll sums it up by concluding, "It's definitely advantageous to have a system like this that will stand the test of time."

Frederick S. Cohn, MD, FACR, *is President and CEO of Borg and Ide Imaging and a Clinical Associate Professor of Radiology at the University of Rochester School of Medicine. He received his medical degree from the University of Rochester, where he also completed his residency in radiology and neurosurgery and a fellowship in neuroradiology. Prior to Borg and Ide, Dr. Cohn served as Chief, Vascular/Interventional Radiology and Chair, Department of Radiology at St Mary's Hospital (Rochester, NY).*

Christopher J. Schaeffer, MD, PhD, *is a partner and Medical Director of Borg and Ide Imaging. He received his medical degree from the University of Cincinnati College of Medicine and completed a pediatric internship at Cincinnati's Children's Hospital and a diagnostic radiology residency and neuroradiology fellowship at Cleveland Clinic Foundation. Prior to pursuing his degree in medicine, Dr. Schaeffer earned his PhD in biochemistry from Ohio State University.*

Joyce Doll, RT, Director of Clinical Operations, *graduated from Hudson Valley Community College with an AAS in Applied Science. She began employment at Rochester General Hospital as a Radiologic Technologist, and then she joined Borg and Ide Imaging as a CT Technologist. Joyce has also been the Lead CT Technologist and Imaging Center Manager for the practice.*

Patricia Marianetti, RT(R), CT, MRI Technologist, *graduated from Monroe Community College with an AAS in Applied Science. She began employment at Rochester General Hospital as a Radiologic Technologist. She then became a departmental Supervisor in CT, Special Procedures, Diagnostic, and Mammography. She joined Borg & Ide Imaging in 2006 and is currently the Lead MRI Technologist at the Ridgeway Office.*

As one of the largest imaging providers in the Rochester area, ***Borg & Ide Imaging*** *offers a complete range of imaging services including Digital Mammography, X-Ray, MRI/MRA, CT/CTA, PET/CT, Nuclear Medicine, DEXA for bone density measurement, and more. The practice operates 11 outpatient locations around the Rochester area and brings the expertise of 25 board certified radiologists and 87 years of service to the Rochester area. Today Borg & Ide Imaging is partnered with* ***RadNet, Inc.****, a national leader in diagnostic imaging and comprehensive radiology solutions. With this partnership, Borg & Ide Imaging is affiliated with 250 centers in California, New Jersey, New York, Maryland, Florida, Delaware, Rhode Island, and Kansas.*

High Spatial Resolution DWI With FOCUS in the Body

By Takayuki Masui, MD, PhD, Chief of the Department of Radiology, Associate Director of Health Information Center, Director of PET Center at Seirei Hamamatsu General Hospital, Hamamatsu, Japan

Discovery™ MR750w 3.0T

Diffusion-weighted imaging (DWI) is now widely used for detection and characterization of lesions, staging of malignant tumors, and evaluation of oncology patient treatments. Single shot Echo planar imaging (EPI) is frequently used for body DWI, which is susceptible to inhomogeneity of the magnetic field. Smaller field-of-view (FOV) in the phase encoding direction can be obtained with the recently available FOCUS (FOV Optimized and Constrained Undistorted Single Shot) technique, which is based on the use of a 2D spatially selective RF excitation pulse and 180° refocusing pulse, resulting in shorter readout duration of the method.[1] Accordingly, with higher spatial resolution, distortion of the images and loss of signal intensity due to magnetic susceptibility effects can be significantly reduced.

These two cases demonstrate the use of DWI with FOCUS.

References

1. Saritas EU, Cunningham CH, Lee JH, Han ET, Nishimura DG. DWI of the spinal cord with reduced FOV single-shot EPI. Magn Reson Med, August 2008; 60(2):468-473.

Case one: Urinary bladder cancer

Patient history

A 71-year-old patient was referred for MR imaging with hematuria.

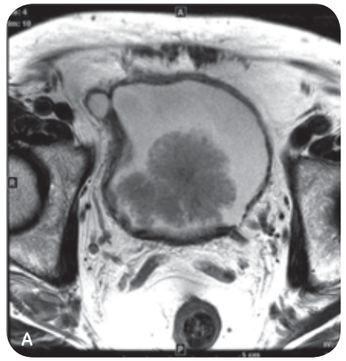
MR findings

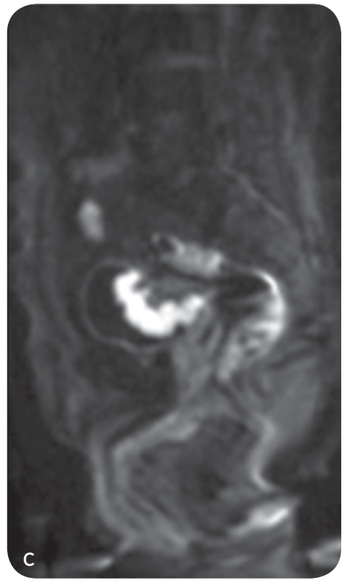
T2-weighted image showed a large lobulated tumor at the right lateral posterior wall of the urinary bladder (Figure 1A). Both conventional DWI (Figure 1B) and DWI with FOCUS (Figure 1C) demonstrated a tumor depicted by the high signal intensity area, measuring 5.3 x 4.6 cm with a broad submucosal thickening and low signal intensity. Axial and sagittal DWI with FOCUS depicted intra-tumoral structures with clear delineation of the tumor margin due to high spatial resolution compared with conventional DWI. With the muscular layer of the urinary bladder intact and showing relatively low signal intensity, tumor staging of T1 and lower was suggested.

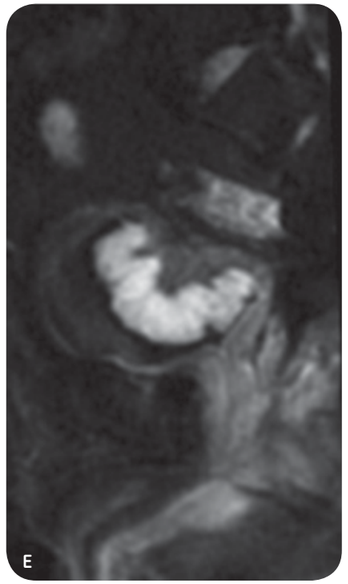
MR Parameters		
	DWI with FOCUS	Conventional DWI
Plane:	Axial, Saggital	Axial, Saggital
FOV:	24 x 12 cm	40 cm
Matrix:	160 x 80	128 x 160
Slice thickness:	4-5 mm	4 mm
B value (s/mm²):	800	800
ASSET:	-	Factor 2
Navigator :	-	-
TR:	6,000 ms	10,000 ms
TE:	63 ms	70 ms

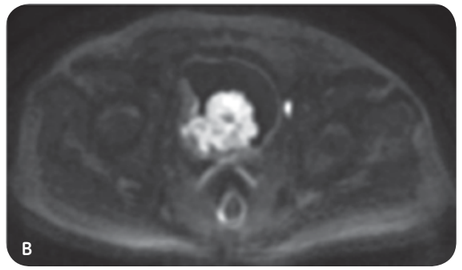
Case one: Urinary bladder cancer (continued)

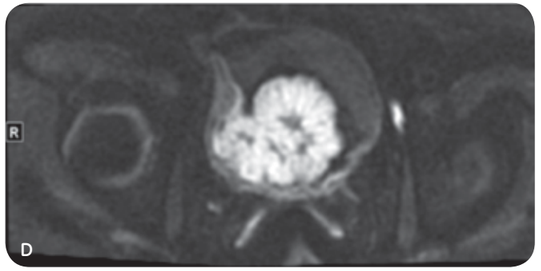
Figure 1. T2-weighted image (A); conventional DWI, Axial (B); Sagittal (C); DWI with FOCUS, Axial (D); and Sagittal (E).











Discussion

Staging of the urinary bladder cancer can be made using DWI. The submucosal thickening simulating broad stalk is recognized as relatively low signal intensity, likely composed of edematous submucosal layer, fibrotic changes, and capillary structures. Without disruption of the muscular layer, tumor staging of T1 or lower was suggested. In combined use of Real Time Field Adjustment (RTFA) with conventional DWI and DWI with FOCUS, single spin echo can be used instead of dual spin echo due to a reduction of Eddy current. Optimization with RTFA can shorten echo time (TE) and overall image quality of both the conventional DWI and DWI with FOCUS is improved.

Further, DWI with FOCUS provides anatomical detail such as fine intra-tumoral structures with higher spatial resolution and less susceptibility effects compared with conventional DWI.

Case two: Pancreatic neuroendocrine tumor

Patient history

A 65-year-old patient with suspicion of lung cancer underwent FDG-PET; pancreatic tumor was detected. MR imaging of the pancreas was performed.

MR findings

Single shot fast spin echo (SSFSE) T2-weighted image (Figure 2A) shows a 1.5 cm lesion as a high signal intensity area in the pancreatic head and a focal 4 mm high signal intensity spot is noted in the tumor (arrow). The tumor is strongly enhanced on the dynamic contrast image in the arterial phase (Figure 2B). The cystic change is recognized as focal unenhanced area in the tumor (arrow).

Free breathing conventional DWI (Figure 2C) and DWI with FOCUS (Figure 2D) combined with the use of navigator triggering can visualize the lesion in the pancreatic head as a high signal intensity area. The pancreatic head is well demarcated without distortion on both DWIs. On the DWI with FOCUS, sharp delineation of the tumor in the pancreatic head and focal low signal intensity area in the tumor (arrow) is noted, which cannot be recognized on conventional DWI. Pancreatic neuroendocrine tumor was suggested. Without metastatic lesions in the body, surgical resection of the tumor was planned.

MR Parameters		
	DWI with FOCUS	Conventional DWI
Plane:	Axial	Axial
FOV:	24 x 12 cm	40 cm
Matrix:	128 x 64	128 x 128
Slice thickness:	4-5 mm	4 mm
B value (s/mm²):	800	800
ASSET:	-	Factor 2
Navigator :	+	+
TR:	3,750 ms	15,000 ms
TE:	57 ms	64 ms

Discussion

Both conventional DWI and DWI with FOCUS can demonstrate the tumor in the pancreatic head as a high signal intensity area. Successful recognition of the tumor in the pancreas can be made with navigator technique and available short TE with RTFA.

High spatial resolution DWI can be obtained with FOCUS, demonstrating a small spot of cystic change in the tumor. Information of anatomical detail and high tissue contrast can be obtained with free breathing FOCUS DWI utilizing navigator triggering. S

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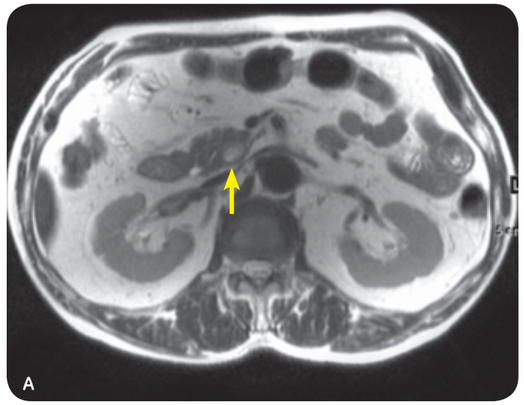
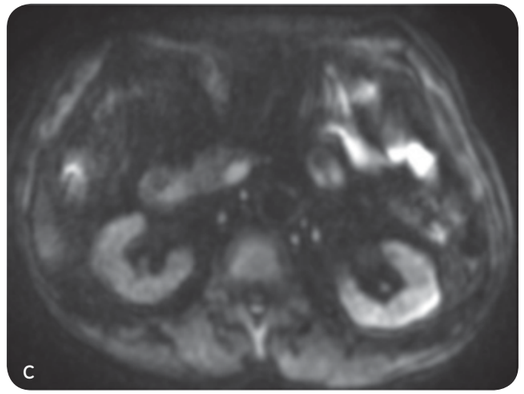
is Chief of the Department of Radiology, Associate Director of the Health Information Center, and Director of the PET Center at Seirei Hamamatsu General Hospital (Hamamatsu, Japan); and Clinical Professor at Hamamatsu University School of Medicine (Hamamatsu, Japan).

Case two: Pancreatic neuroendocrine tumor (continued)





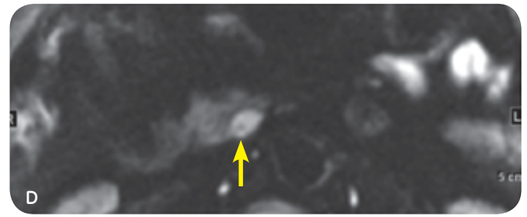


Figure 2. SSFSE T2-weighted image (A); dynamic contrast enhanced LAVA (1st phase) (B); conventional DWI (C); DWI with FOCUS (D).

Takayuki Masui, MD, PhD, *is Chief of the Department of Radiology, Associate Director of the Health Information Center, and Director of the PET Center at Seirei Hamamatsu General Hospital (Hamamatsu, Japan); and Clinical Professor at Hamamatsu University School of Medicine (Hamamatsu, Japan).*

He received his medical and doctor of philosophy degrees from Hamamatsu University School of Medicine and was an MR research fellow at the University of California, San Francisco. His research is focused on the abdomen, pelvis, and vascular MR.

Seirei Hamamatsu General Hospital *is one of the core hospitals of the Seirei Social Welfare Community, which is the largest community in Japan. Established in 1930, it offers more than 100 facilities, and 200 services throughout Japan. Five MR scanners, including the Discovery™ MR750 3.0T and Discovery™ MR750w 3.0T from GE Healthcare, are installed at the hospital.*

Using DWI to Non-invasively Differentiate Between Benign and Malignant Lesions of Bone and Soft Tissue

By O. P. Gupta, MD, Director & Consultant Radiologist, and Muhammad Qasim, MBBS, DMRD, Chief Reporting Radiologist, Dr. O. P. Gupta Imaging Centre, Meerut, India

Optima™ MR360 Advance 16ch

Introduction

DWI can provide structural and functional information without any IV contrast administration. The most important application of DWI is to differentiate benign and malignant lesions of bone and soft tissues of the body. It has the ability to delineate pathological lesions against generally suppressed background signals, to produce excellent contrast resolution.

MR Parameters	
Imaging mode:	2D
Pulse sequence:	Spin Echo DWI
Slice thickness:	6 mm
Spacing:	1 mm
Frequency:	128
Phase:	192
B value:	600
NEX:	8
Respiratory gating:	On

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Case One: Ewing's sarcoma DWI

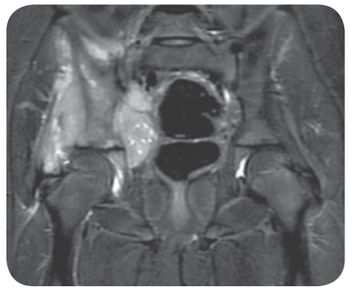
Patient history

An 11-year-old patient complained of severe pain in right hip joint over the last 15 days.

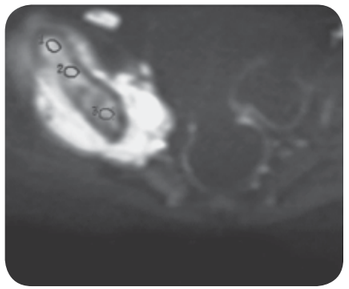
Findings

T2, STIR images revealed heterogeneous intermediate signals with permeative destruction. DWI imaging of the lesion revealed restriction and low ADC value in right iliac bone and surrounding soft tissue component. Average ADC value of the iliac bone was 0.594×10^{-3} mm²/s. Average ADC value of soft tissue components was 0.467×10^{-3} mm²/s. The findings suggested a high-grade malignant lesion. The low ADC value as described above suggested RPF. A value lower than 0.9 suggested lymphoma.

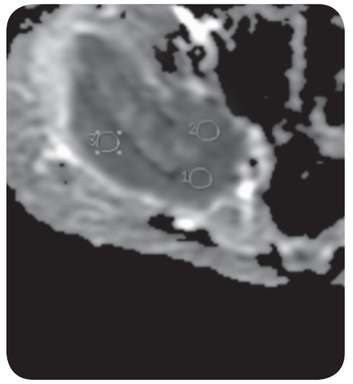
Corroborative CT findings include: permeative destruction of the bone, onion peal periosteal reaction, and large surrounding soft tissue, further indicating the neoplastic process and suggestive of Ewing's sarcoma.



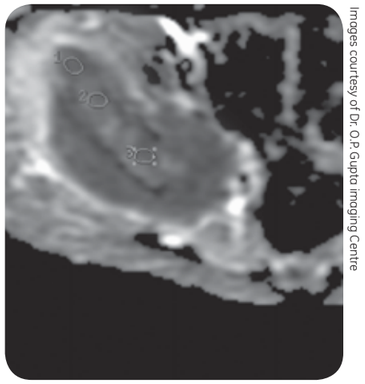
STIR



DWI



ADC - Soft tissue component
ADC value = 0.467×10^{-3} mm²/s



ADC - RT iliac bone
ADC value = 0.594×10^{-3} mm²/s

Images courtesy of Dr. O.P. Gupta Imaging Centre

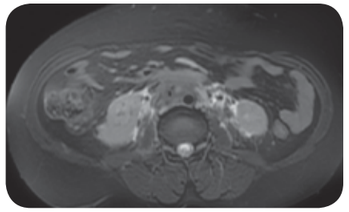
Case Two: Retroperitoneal fibrosis DWI

Patient history

A 37-year-old patient presented with bilateral hydroureteronephrosis.

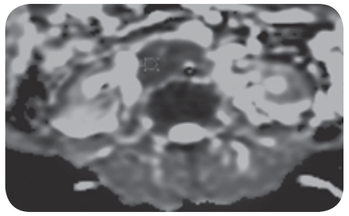
Findings

T2, STIR images revealed large intermediate signal retroperitoneal lesion extending from renal hila to the pelvis encircling the vessels and the ureters. DWI imaging of the lesion demonstrated high signal intensity of T2/STIR bright mass. ADC value of the lesion was low, measuring 1.1 x 10^{-3} mm^2/s. The low ADC value is suggestive of retroperitoneal fibrosis. A value lower than 0.9 suggests lymphoma.



Images courtesy of Dr. O.P. Gupta Imaging Centre

Axial T2



ADC value 1.12 x 10^{-3} mm^2/sec excluding lymphoma ADC value of lymphoma <0.9 x 10^{-3} mm^2/sec

Discussion

DWI is an excellent diagnostic tool that helps to differentiate between benign and malignant lesions of the bone and soft tissue non-invasively.

O.P. Gupta, MD, *is Director & Consultant Radiologist at Dr. O.P. Gupta Imaging Centre in Meerut, India. He earned his MBBS and MD at G.R. Medical College in Gwalior, India. As a consultant radiologist for 25 years, Dr. Gupta has contributed to many radiology books and has written numerous presentation papers, winning various Conference & Best Paper Awards.*

Muhammad Qasim, MBBS, DMRD, *is Chief Reporting Radiologist at Dr. O.P. Gupta Imaging Centre in Meerut, India. He received his MBBS and DMRD from LLRM Medical College in Meerut. Dr. Qasim is currently working on the Optima™ MR360 Advance from GE Healthcare with a special interest in body diffusion imaging.*

Dr. O.P. Gupta Imaging Centre *in Meerut, India has been one of biggest MR facilities of the Western U.P. since 1989. The facility's vision is to offer diagnostic service with a reputation for superior quality, speed of service, and convenience. Modern technology blends with a culture of care, serving as a platform to fill a void that exists in the Indian diagnostic industry.*

Clinical Utility of IDEAL IQ for Pediatric and Adult Patients

By O. P. Gupta, MD, Director & Consultant Radiologist, and Muhammad Qasim, MBBS, DMRD, Chief Reporting Radiologist, Dr. O. P. Gupta Imaging Centre, Meerut, India

Optima™ MR360 Advance 16ch

Introduction

Fatty liver disease is a growing cause of concern. An estimated 20 to 80 million Americans have non-alcoholic fatty liver disease (NAFLD)—the most common chronic liver disease in the United States.[1] Recent evidence has shown that 5% to 15% of patients with NAFLD present with established cirrhosis on liver biopsy and 4% to 5% of individuals with isolated steatosis eventually develop cirrhosis.[2] Therefore, it is imperative that these conditions are diagnosed early.

MR technique

IDEAL IQ is a promising MR-based technique. It provides volumetric whole-liver coverage in a single breath-hold and generates estimated T2* and triglyceride fat-fraction maps in a non-invasive manner. It is intended for breath-held abdominal imaging to evaluate diffuse liver diseases such as hepatic steatosis of the liver and corrects for challenging confounding factors such as T2* decay. It's designed for water-triglyceride fat separation with simultaneous T2* correction and estimation based on the IDEAL technique. Our liver protocol includes Axial T1, T2, FIESTA, STIR, DWI, and IDEAL IQ. IDEAL IQ provides four sets of an image (FF, R2*, in-phase, out-of-phase).

Acquisition Protocol	
Scanner:	Optima MR360 Advance
Imaging mode:	3D
Sequence:	Fast SPGR
Slice thickness:	8 mm
Frequency:	160
Phase:	160
Bandwidth:	111.11 NEX-1
No of echoes:	6
Scan time:	14 sec in breath-hold
Location per slab:	32

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Case One: Thalassemia

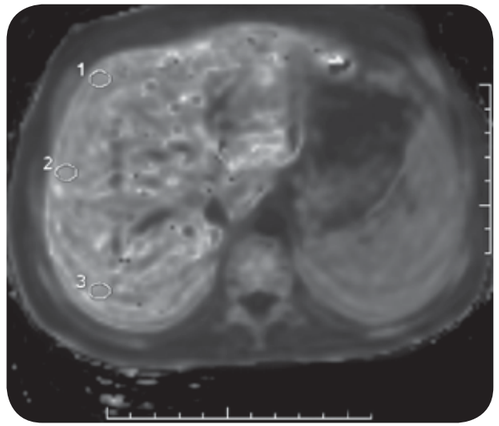
Patient history

A five-year-old patient presented with complaints of abdominal pain and anemia.

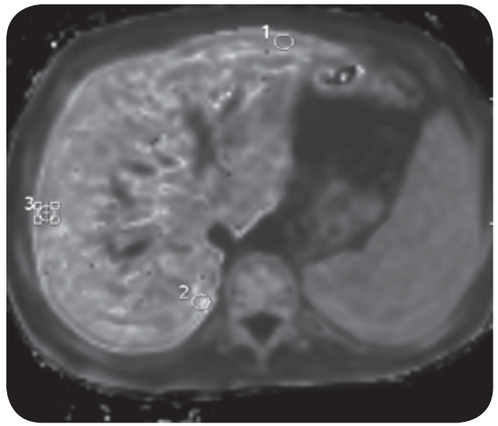
Findings

R2* revealed high iron content with average value max up to 546.57, suggestive of severe iron overload. The patient received an additional work up, including blood work, and was diagnosed with Thalassemia.

IDEAL IQ (R2* map)



R2* map
R2* average value max = 546.57



R2* map
R2* average value max = 546.57

Images courtesy of Dr. O.P. Gupta Imaging Centre

Case Two: Fatty liver disease

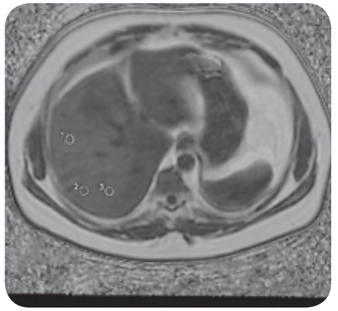
Patient history

A 41-year-old patient presented with complaints of abdominal pain and indigestion. The patient was fond of eating fatty and spicy foods.

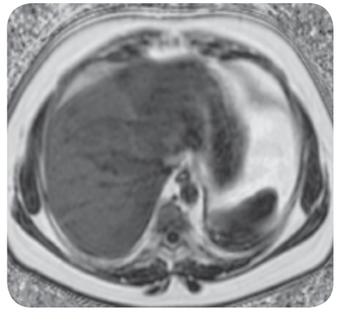
Findings

Fat fraction revealed high percentage of triglycerides in the liver parenchyma with average value max up to 25%, suggestive of fatty liver disease.

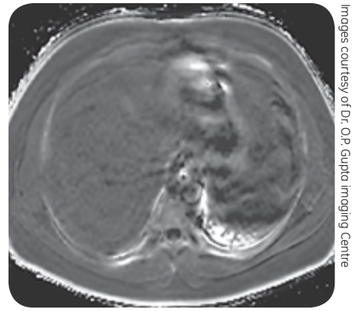
IDEAL IQ (fat fraction)



Fat fraction
Fat fraction average value max = 25.0



Fat fraction



R2* map

Images courtesy of Dr. O.P. Gupta Imaging Centre

Discussion

IDEAL IQ is an excellent diagnostic tool in the diagnosis of various liver diseases. It is an effective technique to estimate the fat fraction in a non-invasive manner.

References:

1. Clark JM, Diehl AM. Defining nonalcoholic fatty liver disease: implications for epidemiologic studies. Gastroenterology 2003;124(1):248-50.
2. Matteoni CA, Younossi ZM, Gramlich T, et al. Nonalcoholic fatty liver disease: a spectrum of clinical and pathological severity. Gastroenterology 1999;116(6):1413-9.

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3.0T MR Provides Details of Prostate Anatomy to Assist in Accurately Predicting Staging

By Robert Princenthal, MD, Radiologist, President of Rolling Oaks Radiology, Medical Co-director of RadNet Prostate MRI Program

Introduction

Early MR prostate imaging (circa early 2000s) was difficult to replicate across clinical sites and suffered from low specificity and sensitivity for accurately detecting the presence of cancer and tumors. Beginning in 2009, clinical studies began to demonstrate the utility of prostate imaging using a multiparametric MR approach.[1,2]

Multiparametric MR includes high-resolution T2 axial, DWI, dynamic contrast, and optional MR spectroscopy. When the anatomic and functional imaging data is analyzed and blended into a Pi-Rads structured report, the radiologist can begin to answer key clinical questions. In cancer detection protocols, the explanation of why a particular patient's PSA is elevated can often be identified. For men diagnosed with prostate cancer, the exact anatomic size, aggressiveness, and staging information becomes apparent. The utility of multiparametric MRI then allows for determination of optimal treatment discussions with the patient.

A 3.0T MR has appealing properties for prostate imaging due to the higher signal-to-noise ratios, excellent soft tissue contrast, and high image quality. It provides additional details of the prostate anatomy that assist the clinicians in accurately predicting staging, specifically by the ability to provide clear images of the capsule and neurovascular bundle.

Also, the majority of men needing prostate MR imaging are middle-aged or older and tend to be larger. As a result, we have found that they are more comfortable in a wide bore MR.

Currently, the prostate is the only organ biopsied without direct guidance. The current practice of trans-rectal ultrasound, or TRUS, guided biopsy does not permit specific target visualization, and only helps guide the urologist to target regions within the gland. MRI guidance can result in fewer biopsy needles, and higher yields of cancer detection. MR has the potential to guide an appropriate selection of biopsy candidates and, when fused with ultrasound, guide needle placement.

Discovery™ MR750w 3.0T

MR Parameters	
T2 frFSE	
TR:	2500
TE:	128
FOV:	24
Slice thickness:	3 mm
In-plane resolution:	320 x 320
NEX:	4
Options:	NPW, SPF, FC, TRF
Scan time:	3:47 min
eDWI	
b-values:	10, 200, 800, 1000
TR:	5550
TE:	Min
FOV:	28
Slice thickness:	4 mm
In-plane resolution:	80 x 128
SmartNEX:	2, 1, 6, 9
Scan time:	6:45 min
LAVA	
TR:	Min
TE:	Min
FOV:	32 x 25
Slice thickness:	4 mm
In-plane resolution:	192 x 160
Scan time:	0:05 sec x 50 phases

Patient history

A 72-year-old presented to his urologist with an elevated PSA of 18.1. His biopsy showed high grade PC, Gleason Score 9. The patient has no family history, and the patient denies being on prostate specific medications. He receives a staging MRI four weeks following his biopsy.

Robert Princenthal, MD
is President and founding partner of Rolling Oaks Radiology, a network of outpatient imaging centers in Ventura County, California.

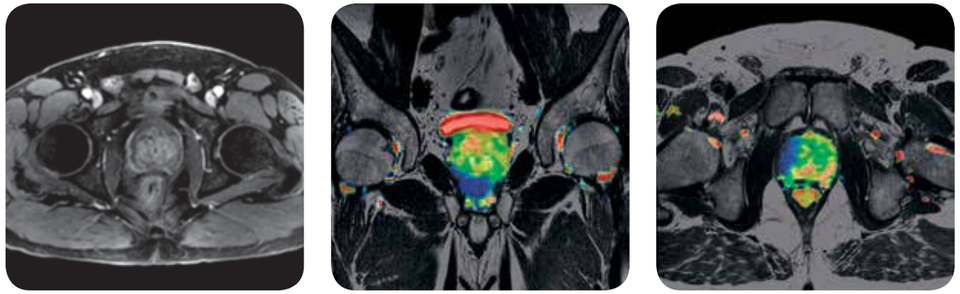

Figure 1. Fat suppressed LAVA (left) and high-resolution Axial and Coronal T2-weighted FSE with ADC overlaid using READY View, demonstrating area of low ADC in apex of the prostate.

Findings

Multiparametric MR was performed using high-resolution FSE T2s in axial, coronal, and sagittal plane, a multi-b value DWI (b=10, 200, 800, 1000), and a fat suppressed dynamic LAVA with 5 sec/phase. The prostate protocol for functional acquisitions was optimized to remove confounding factors such as fat signal interference. We find the fat suppression with dynamic scan is quite useful to reduce the respiratory motion in relation to subcutaneous fat signal contamination into the prostate area. For DWI images, SAT bands are utilized in addition to fat suppression and spectral spatial excitation to eliminate fat signal and any potential contamination to the ADC maps from fat signal ghosting. Functional assessment using ADC maps and dynamic contrast enhanced scan confirmed the lesion measuring 3.19 cm. ADC values were 600, indicating an aggressive lesion consistent with the Gleason score. MR detected bulging of the capsule, crossed from left to right side, and larger volume, indicating advanced disease. A small component of the tumor on the opposite side previously undetected was also noted. No abnormal lymph nodes or bony involvement detected. MR study clarified stage of disease and provided additional useful information.

Discussion

High-quality, 3.0T MR has value as a diagnostic and staging tool for prostate cancer. It may open the door to enable focal therapy with precise lesion targeting. There is a growing body of research demonstrating the efficacy of focal therapy for tumors contained to one lobe of the prostate gland. In addition to keeping the gland intact, focal therapy can help men avoid the side effects of radical prostectomy.

With MR imaging, the entire prostate gland can be mapped out in terms of grade and stage of disease. As a result, MR-guided therapies, such as ablation, need further investigation as a potential treatment alternative. MR imaging of the prostate provides a large clinical benefit and, as education and training continue, it creates a demand for radiologists with the skill set for prostate imaging. S

References:

1. Langer DL, van der Kwast TH, Evans AJ, et al. Prostate cancer detection with multi-parametric MRI: logistic regression analysis of quantitative T2, diffusion-weighted imaging, and dynamic contrast-enhanced MRI. J Magn Reson Imaging, 2009 Aug;30(2):327-34.
2. Rais-Bahrami S, Siddiqui MM, Turkbey B, et al. Utility of multiparametric magnetic resonance imaging suspicion levels for detecting prostate cancer. J Urol, 2013 Nov;190(5):1721-7.

Robert Princenthal, MD, *is President and founding partner of Rolling Oaks Radiology, a network of outpatient imaging centers in Ventura County, Cal. He also serves as the medical Co-Director for RadNet's Prostate MRI Program. Dr. Robert Princenthal has been instrumental in establishing one of the most robust prostate MRI practices in the nation. As of July, 2013, the program has read more than 3,000 prostate MRI studies and has grown to become one of the largest, most experienced practices in the country.*

Dr. Princenthal's prostate program has grown rapidly since its inception in 2009, and now performs around 125 prostate MRI's/month. Their program also performs many MRI targeted in bore prostate biopsies. Dr. Princenthal has provided a webinar for Applied Radiology on the role of prostate MRI and targeted biopsy. He has been invited to present at imaging grand rounds at several of the local universities and hospitals to share his experience in establishing a prostate MRI program. He also enjoys bringing this information directly to patients, and supports the local prostate cancer support groups of Us 2, Men 2 Men, Admetech, and PCRI. He has published several case reports on the role of mpMRI of the prostate, and unexpected findings. His mentors for teaching him these techniques are Drs. Jelle Barentz of Holland, and Peter Choyke, of NIH.

The RadNet Prostate MRI Program *currently offers MRI for prostate cancer imaging services in four locations in Southern California (Beverly Hills, Encino (San Fernando Valley), Oxnard and Thousand Oaks). The Program's direct connection with RadNet, a national network of outpatient imaging centers, allows RadNet centers that offer MRI for prostate cancer screening and staging to invest in some of the most advanced MRI and biopsy equipment available.*

Diagnosing NAFLD and NASH With IDEAL IQ and MR Touch

By Benjamin E. Tubb, MD, South Texas Radiology Group

Introduction

Over the past several decades, the prevalence of fatty liver disease in the American population has markedly increased, closely related to increasing prevalence of obesity and diabetes. Nonalcoholic fatty liver disease (NAFLD) is a broad category defined as elevated hepatic lipid deposition without significant history of alcohol use. The majority of patients with NAFLD have preserved hepatic function and absent or minimal hepatic inflammation, with normal or minimally elevated liver enzymes; this condition is described as benign hepatic steatosis.

However, approximately 10-20% of patients with NAFLD have chronic active hepatic inflammation which can cause progressive hepatic fibrosis and eventual cirrhosis. This condition is described as nonalcoholic steatohepatitis (NASH) and now represents one of the leading causes of progressive liver disease and cirrhosis in Western countries. NASH is also associated with increased risk of hepatocellular carcinoma.[1]

Early diagnosis of NAFLD and discrimination of benign steatosis from NASH impacts a patient's prognosis and may alter his or her treatment. Those patients with steatohepatitis may benefit from more aggressive treatment to slow or prevent their progressive liver disease. Current treatment for steatohepatitis is largely focused on weight loss and control of diabetes and hyperlipidemia. Anti-fibrosis drugs are under development and may contribute to treatment of NASH patients in the future.

In clinical practice, many patients with the "metabolic syndrome" of obesity, hyperlipidemia, and insulin-resistance or diabetes are found to have mildly elevated liver enzymes. Clinicians often use liver ultrasound exams to evaluate these patients for fatty liver disease, which is suggested by increased echogenicity of the liver parenchyma. However, this ultrasound finding is nonspecific and somewhat subjective, and exams are often limited due to obesity.

Most importantly, ultrasound does not differentiate the majority of patients with benign steatosis from the smaller group of patients with steatohepatitis and early hepatic fibrosis. Ultrasound exams can sometimes identify morphologic features of early cirrhosis such as irregular liver contour, however these features are not present until patients with NASH have progressed to more severe hepatic fibrosis. Liver biopsy is a more sensitive and specific test, but it entails greater cost and risk, limiting its use in initial evaluation of the large number of patients with NAFLD.

Discovery™ MR750w 3.0T

MR Parameters	
MR Touch	
Patient position:	feet first, supine
Coil:	8US TORSOPA
Plane:	Axial
Scan time:	38 sec
IDEAL IQ	
Sequence:	MFGR
TR:	175
ET:	8
TE:	2.9, 5.2, 7.5, 9.8, 12.1, 14.4, 16.7, and 19.0
Flip angle:	80 degrees
Bandwidth:	62.5 kHz
Matrix:	256 x 192
Slice thickness:	8 mm
Slice spacing:	2 mm
Scan time:	15 sec in breath-hold

Currently available MR fat quantification and MR elastography tools such as IDEAL IQ and MR Touch provide highly valuable tools for the quantitation of hepatic steatosis and the sensitive identification of hepatic fibrosis.

MR elastography techniques allow noninvasive measurement of liver tissue stiffness as an index of hepatic inflammation and fibrosis. Currently available MR fat quantification and MR elastography applications such as IDEAL IQ and MR Touch provide highly valuable tools for the quantitation of hepatic steatosis and the sensitive identification of hepatic fibrosis. Importantly, studies have shown that MR elastography is sensitive for early hepatic fibrosis (before morphologic changes occur) and has high negative predictive value, meaning that identification of normal liver tissue stiffness indicates a very low likelihood of hepatic fibrosis.[3,4] Thus, MR elastography can differentiate patients with benign steatosis from those with steatohepatitis, allowing clinicians to risk stratify these groups of patients and potentially target those with suspected early NASH for more aggressive management, including potential liver biopsy.

MR implementation and technique

In our practice, we have implemented a comprehensive liver MR exam using IDEAL IQ and MR Touch, including MR elastography, fat and iron quantification sequences, and diffusion-weighted imaging. We have designated a group of specialized radiologists to interpret these exams and standardized their reporting. In addition to the radiologist's report, we have created standardized information pages for quantitative results of liver fat content, liver iron content, and liver shear stiffness, which are appended to each exam in our PACS. These provide our referring clinicians with single printable pages for each quantitative result, including relevant image(s) from which that result was derived, a table of normal and abnormal ranges for this result, and references regarding their clinical significance.

We introduced this new comprehensive liver MR exam to our referring clinicians in San Antonio at the start of this year. Subspecialized radiologists from our body imaging division made visits to clinician offices to explain the utility of this exam, especially the MR elastography component and improved liver fat and iron quantitation sequences. We initially visited gastroenterology and hepatology groups in our area, expecting that these physicians would be the most interested. However, as we gained experience and continued our visits to clinician offices, we learned that many primary care and internal medicine groups were also very interested in this exam.

During the past nine months, the majority of these comprehensive liver MR exams have been requested by primary care physicians for their patients with hepatic steatosis and concern for possible early NASH. Case 1 in this article represents this clinical scenario, in which a primary care physician learned that her patient had moderate hepatic steatosis and mildly elevated liver enzymes. Using the new comprehensive liver MR exam including MR Touch, we demonstrated that this patient has moderate steatosis but normal liver tissue stiffness, indicating no evidence of hepatic fibrosis or NASH.

We have also received strong interest in MR Touch from the transplant physicians in San Antonio. They have found this exam to be useful in multiple clinical scenarios, including (1) serial monitoring of liver transplant recipients with recurrent viral hepatitis, and (2) preoperative evaluation of renal transplant candidates with end-stage renal disease but also abnormal liver enzymes and uncertain degree of liver disease. Case 2 in this article illustrates the second scenario, in which a renal transplant candidate was found to have splenomegaly and mildly abnormal liver function tests. The transplant physicians wanted to evaluate for presence and degree of hepatic fibrosis before proceeding with renal transplantation. We demonstrated that this patient has only mild hepatic fibrosis, which was confirmed on subsequent biopsy.

Our comprehensive liver MR protocol employs IDEAL IQ and iron quantification techniques to deliver whole liver coverage in single breath-holds. IDEAL IQ provides quantitative assessment of triglyceride fat content in the liver parenchyma, allowing diagnosis and quantitation of hepatic steatosis. IDEAL IQ produces a volumetric fat-fraction map for the entire liver that is corrected for R2* confounding factors, so fat quantitation is not affected by liver iron content. Fat fraction corresponds to percentage fat content in the liver parenchyma. Normal range is less than 6-8% fat content, whereas mild, moderate, and severe steatosis are defined as fat fraction measurements of 8-15%, 15-25%, and greater than 25%.

Similarly, we employ iron quantitation sequences which derive T2* measurements from single breath-hold acquisitions at multiple TE values, so liver iron concentration estimates are relatively independent of liver fat content. This is a significant improvement from use of in-phase and opposed-phase T1 sequences to detect liver fat or iron content. We convert the calculated liver T2* measurements using a standard curve, and we report liver iron concentration to clinicans as an estimate in milligrams of iron per gram dry weight liver tissue, matching the units for reporting of liver iron concentration from biopsy samples. Normal range for liver iron concentration is less than 2.0 mg/g. Mild, moderate, and severe iron overload are defined as estimated liver concentrations of 2-7 mg/g, 7-15 mg/g, and greater than 15 mg/g respectively.

The MR Touch acquisition requires less than three minutes at the start of our exam, including preparation time for technologists to apply the acoustic transducer to the patient's upper abdomen over the right costal margin.

The MR Touch elastography acquisition uses acoustic waves to identify variations in tissue stiffness. This provides an elastogram, an anatomic map of tissue stiffness throughout the liver parenchyma that has been shown to correspond to the degree of hepatic inflammation and fibrosis in corresponding liver biopsy samples.[2,3,4] The MR Touch acquisition requires less than 3 minutes at the start of our exam, including preparation time for technologists to apply the acoustic transducer to the patient's upper abdomen over the right costal margin. Importantly, we have found that the MR Touch acquisition reliably provides diagnostic images of wave transduction through liver tissue, without significant degradation due to patient motion or obesity or mildly elevated liver iron content.

MR elastography requires specialized equipment and software. The necessary equipment is relatively simple: a small disc-shaped transducer is placed over the patient's upper abdomen at the start of the exam, connected through a flexible plastic tube to a subwoofer-like device, which creates low frequency sound waves. These waves cause small repetitive vibrations within the patient's abdomen, sending pressure waves through liver tissue which are detectable through sensitive phase contrast MR sequences. In patients with liver disease and hepatic fibrosis, their liver tissue becomes stiffer, and the wavelength of induced pressure waves becomes longer. These pressure waves can be visualized in color-coded images and their wavelength can be measured, providing quantitative estimates of liver tissue stiffness. Wavelength measurements are converted to units of elasticity called kilopascals (kPa), and these units are used for reporting.

Studies have demonstrated that MR elastography provides highly reliable measurements, with little test-retest variation.[5] Normal subjects demonstrate consistent liver stiffness measurements with a mean of 2.2 kPa and standard deviation of 0.3 kPa, corresponding to normal soft liver tissue. Patients with increasing degrees of liver fibrosis demonstrate a direct correlation between MR measurements of liver stiffness and stage of fibrosis in corresponding liver biopsy specimens. Importantly, patients with early liver disease and stage 0 or stage 1 fibrosis demonstrate elevated liver stiffness measurements of approximately 3.0-4.0 kPa. Using a cut-off value of 2.93 kPa.[2] achieved sensitivity of 98% and specificity of more than 99% for differentiating any stage of liver fibrosis from normal liver tissue.[2] Using a cut-off value of 4.89 kPa, these researchers were able to differentiate early stage 0-1 fibrosis from more advanced stage 2-4 fibrosis, with 86% sensitivity and 85% specificity. More recent studies have established a threshold of 4.15 kPa for distinction of mild fibrosis from moderate and severe fibrosis.[4] We have adopted these thresholds in our reporting. We define a normal range of liver tissue stiffness as below 2.9 kPa, mild elevated liver stiffness as 2.9-4.2 kPa, and moderate to severe elevated liver stiffness as greater than 4.2 kPa.

To interpret MR Touch results, we start by reviewing the source images to identify the region of liver parenchyma included on each of the 3 axial slices obtained. We then review the colorized wave images, which include 8 sequential timepoints for each slice, showing progression of pressure waves through the liver parenchyma. We try to assess the approximate width of these pressure waves, accounting for their interference patterns and other artifacts at tissue boundaries. In some cases, we may measure groups of two to four waves to estimate the underlying width of single waves. As a rough measure, we have found that average wavelengths of less than 1.25 cm (i.e. four waves measuring less than 5 cm) correspond to normal range of liver tissue stiffness. We then review the quantitative analysis, in which regions of interest (ROIs) are applied within areas of liver parenchyma, and software analysis of waves passing through these ROIs yields quantitative stiffness measurements in kilopascals (kPa). We have found that when large ROIs are used (preferably larger than single wavelength), we obtain excellent agreement between separate measurements within the liver parenchyma. As we have gained experience with the MR Touch images and software analysis tool, the subspecialized readers in our practice who interpret these exams have gained confidence in their accuracy and repeatability. We have collected our cases into a reference set for review and have correlated with liver biopsy results when available.

Benjamin E. Tubb, MD, PhD

is a diagnostic and interventional radiologist with South Texas Radiology Group in San Antonio, Tex, where he is actively involved with designing and interpreting the imaging components for clinical trials and implementing new imaging technology in clinical practice.

Case One

Patient history

A 41-year-old with recently identified moderate hepatic steatosis identified on unenhanced CT exam, mildly elevated liver enzymes, and no history of significant alcohol abuse.

Technique

Complete liver MR exam on the Discovery MR750w, including fat quantification, iron quantification, MR elastography, diffusion-weighted, and post-contrast sequences after administration of 20 mL Magnevist Gadolinium contrast.

Findings

Exam confirmed diffuse moderate hepatic steatosis with estimated liver fat fraction of 20%. MR elastography demonstrated normal liver shear stiffness of 2.2 kPa and indicated no evidence of hepatic fibrosis. Exam also demonstrated normal liver size and contour, borderline elevated liver iron concentration of 2.2 mg/g, and no focal hepatic lesion.

This patient has moderate hepatic steatosis but no current evidence of hepatic fibrosis to suggest NASH.

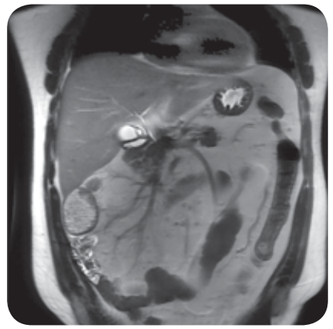

Figure 1. Coronal SSFSE, showing normal liver size and contour.

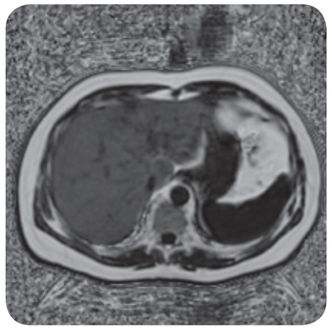

Figure 2. Axial IDEAL IQ fat quantitation image showing moderate hepatic steatosis, fat fraction 20%; signal corresponds to calculated tissue fat fraction.

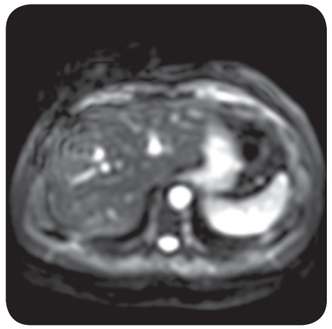

Figure 3. Axial MR Touch source image for anatomic correlation.

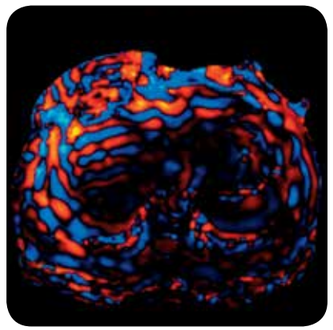

Figure 4. Axial MR Touch elastogram wave image.

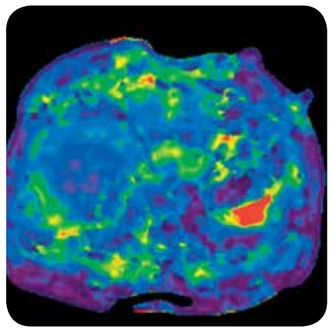

Figure 5. Corresponding MR Touch elastogram with color scale from 1-8 kPa.

Case Two

Patient history

A 49-year-old with end-stage renal disease and known chronic Hepatitis C viral infection, being evaluated as a potential renal transplant recipient. Recent imaging identified splenomegaly, of uncertain etiology but raising concern for possible cirrhosis and portal hypertension. Transplant physicians requested liver MR exam including elastography to evaluate for presence and degree of hepatic fibrosis.

Technique

Unenhanced liver MR exam on the Discovery MR750w including fat quantification with IDEAL IQ, MR elastography with MR Touch, and diffusion-weighted sequences. Gadolinium contrast was not administered due to renal failure.

Findings

Exam demonstrated normal liver size with slightly prominent lateral left hepatic lobe and minimally lobulated liver contour, however no frank morphologic evidence of cirrhosis. MR elastography demonstrated mild increased shear stiffness of liver parenchyma, measuring approximately 3.5 kPa, suggesting mild hepatic fibrosis. Liver demonstrated normal fat content, with estimated fat fraction 1.1%. No focal hepatic lesion was identified on this unenhanced exam. Again noted was splenomegaly with spleen measuring 15 cm craniocaudal, with no portosystemic varices identified to suggest portal hypertension. Small loculated collections of simple fluid were noted near the left hepatic lobe and stomach, likely chronic and related to previous peritoneal dialysis, with no evidence of generalized ascites.

This patient has mild hepatic fibrosis, likely related to chronic Hepatitis C infection, but no evidence of advanced fibrosis or cirrhosis. Patient's splenomegaly is likely unrelated to liver disease, with no definite findings to suggest portal hypertension. Patient had subsequent liver biopsy within one month of this MR exam, confirming only mild hepatic fibrosis.

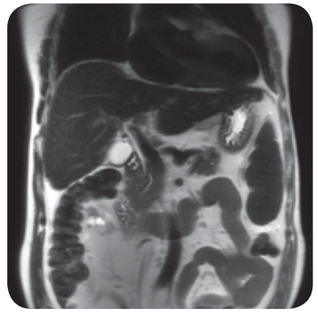

Figure 6. Coronal SSFSE, showing normal liver size and mildly prominent lateral left hepatic lobe.

Figure 7. Coronal SSFSE, showing splenomegaly and end-stage renal disease with extensive renal cystic change.

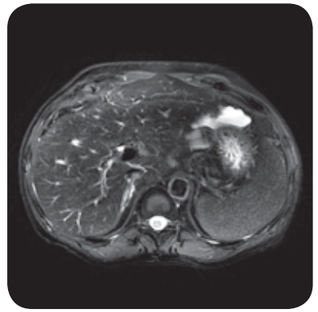

Figure 8. Axial T2 fat-saturated PROPELLER 3.0 image showing splenomegaly with small loculated fluid collections in left upper abdomen.

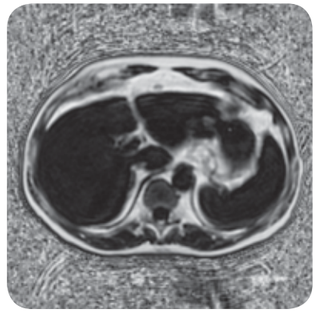

Figure 9. Axial IDEAL IQ fat quantitation image showing normal minimal fat content in liver, fat fraction 1.1%. Signal corresponds to calculated tissue fat fraction.

Case Two continued

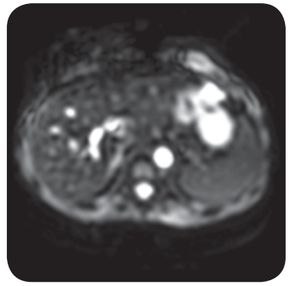

Figure 10. Axial MR Touch source image for anatomic correlation.

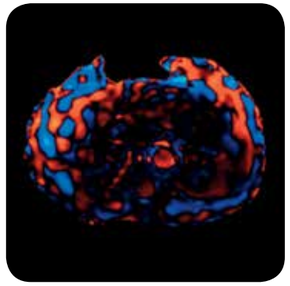

Figure 11. Axial MR Touch elastogram wave image, showing mildly increased wavelengths of pressure waves in right hepatic lobe.

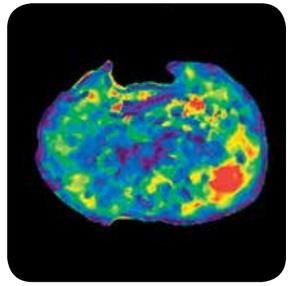

Figure 12. Corresponding MR Touch elastogram with color scale from 1-8 kPa; green areas correspond to mild elevated liver stiffness.

Discussion

The MR Touch elastography technique enables us to noninvasively detect and quantify hepatic fibrosis at an early stage of disease, before the morphologic changes of more advanced fibrosis and cirrhosis. We have incorporated MR Touch into a comprehensive liver MR exam which also includes quantitative assessment of liver fat fraction and liver iron content. For our large number of patients with fatty liver disease, this exam allows us to differentiate the subset of patients with early fibrosis and probable NASH from the majority of patients with normal liver stiffness and probable benign steatosis. Those patients with suspected early NASH are candidates for more intensive management of their liver disease, including potential liver biopsy and more aggressive treatment of the other components of their metabolic syndrome such as diabetes and obesity. The strong negative predictive value provided by normal MR Touch results is highly valuable in this risk stratification process.

In addition to detection of early liver disease, the MR Touch elastography technique may allow clinicians to assess progression of hepatic fibrosis in patients with known chronic liver disease, especially those with chronic viral hepatitis. As improved therapies become available, including therapies targeted at slowing, preventing, or even reversing hepatic fibrosis, the repeatable and quantitative measurements obtained by MR Touch may allow assessment of treatment response.

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Dr. Tubb obtained his radiology residency training at Johns Hopkins Hospital after completing the combined MD-PhD program at Baylor College of Medicine in Houston, Tex. His PhD research was in Molecular and Cellular Biology. During residency, Dr. Tubb received a one year RSNA Resident Research Award and designed and conducted a research project involving targeted MR contrast agents and high-resolution pancreatic imaging. He completed a one year MR fellowship at the University of Pennsylvania, with broad experience in body/oncologic, breast, spine, and musculoskeletal imaging.

South Texas Radiology Imaging Centers (STRIC), *a large comprehensive outpatient diagnostic imaging and interventional provider, offers 24 convenient locations throughout San Antonio, Boerne, and Schertz, Texas. Professional interpretation and interventional procedures are provided by South Texas Radiology Group, P.A. (STRG). With over 60 board certified radiologists, most with sub-specialization in fields such as neuroradiology, musculoskeletal, body, cardiac, breast and interventional radiology, STRG has experience and a reputation that spans more than fifty years. With sixteen high field MR scanners, including four 3.0T magnets and five wide bore scanners, STRIC offers the latest high-field MR technology with convenient access. For more information, please visit www.stric.com or ContactUs@stric.com*

ADVANCING HEAD HEALTH

This Issue Spotlight examines how research is providing a better understanding of traumatic brain injury dubbed the “silent epidemic.” It also tackles advancements in diagnosis, screening, and treatment for athletes, military personnel, and the everyday patient.

As recently as five years ago, when football blows to the brain were routinely accepted as "part of the game," the NFL's official position on concussions was that players could go back in after suffering one. Back then, there was not much discussion about this silent epidemic.

PLAYING IT SAFE: LESSONS FROM THE SCIENCE OF SUB-CONCUSSIVE RESEARCH

MR can provide better insights into injury and recovery

Today, the NFL is doing more to protect players by instituting unprecedented new protocols on concussion prevention and treatment. Additionally, the Army—which before 2009 had very loose concussion guidelines—has implemented strict protocols for military personnel in combat.

A concussion is a type of mild traumatic brain injury, or mTBI. While progress has been made with research and management, there's still much to learn. As reported by the Centers for Disease Control and Prevention (CDC), every year, at least 1.7 million TBIs occur either as an isolated injury or along with other injuries.[1] Additionally, TBI is a contributing factor to 30.5% of all injury-related deaths in the United States,[1] and about 75% of TBIs that occur each year are concussions or other forms of mild TBI.[2]

The news does not improve for young people. Children aged 0 to 4, older adolescents aged 15 to 19, and adults aged 65 and older are most likely to sustain a TBI. Furthermore, almost half a million emergency department visits for TBI are made annually by children aged 0 to 14.[3]

> "When it comes to brain injuries, MR can be instrumental in determining the best treatment option. We want patients, parents, and doctors to feel confident about their chosen course of action, and we believe that starts with longitudinal studies."
>
> *Jonathan Murray*

Insight from tragedy

A documented concussion is one thing, but in sports where players may often get their "bell rung", or when military personnel are in active combat and get hit by more than one IED, the true numbers are certainly much higher. In 2009, GE Healthcare collaborated with Purdue University to provide longitudinal data from "healthy through injury and recovery" on a high school football team. The study was largely funded by the Indiana State Department of Health Spinal Cord and Brain Injury Research Fund.

"When it comes to brain injuries, MR can be instrumental in determining the best treatment option. We want patients, parents, and doctors to feel confident about their chosen course of action, and we believe that starts with longitudinal studies," says Jonathan Murray, Managing Director, GE Research Circle Technology, Inc.

The first year focused on collisions to the head in 21 high school football players over the course of a full season. This was the first study to combine MRI, functional MRI (fMRI), biomechanical monitoring, and cognitive testing at multiple times before, during, and after the season to evaluate the effects of hits to the head—including those not leading to a concussion.

There were four stages to the study: baseline assessment, in-game monitoring, in-season follow up, and post-participation follow up. Baseline MRI and fMRI readings were taken before the season started using the Signa™ HDxt 3.0T from GE Healthcare. All hits to the head exceeding 14.4 Gs were then recorded—using monitoring equipment inside the helmets—throughout the season. Based on the number or the magnitude of hits to the head they had experienced, 11 of the 21 participating players were invited back for additional tests during the season. Ten of these 11 players then underwent a post-season assessment, several weeks after the end of the football schedule.

In 2010, Thomas Talavage, PhD, Professor, Co-Director at Purdue MRI Facility, School of Electrical & Computer Engineering, Weldon School of Biomedical Engineering, Purdue University, provided the first direct evidence of subconcussive injury. The year-one study results were published in the Journal of Neurotrauma. Of the 21 high school players, four players who were never diagnosed with concussions were found to exhibit brain impairment that was at least as bad as that of other players who had been deemed concussed and removed from play.

This impairment—observed in players who showed no symptoms of concussion—included significant performance drops on routine cognitive tests and decreased activity during fMRI in parts of the players' brains associated with working memory. Multiple players received more than 1,800 hits to the head during practices and games, some with a force 20 times greater than what a person would feel while riding a roller coaster. According to Professor Talavage, they were not exhibiting any outward signs, yet they were continuing to play. The cognitive impairment they observed was actually worse than the one observed with the concussed players.

Patient (Player 103) was a senior in high school and middle linebacker on a football team. Injured making a tackle, no marked symptoms. MR scan was three days post-injury on a Signa HDxt 3.0T from GE Healthcare. Sat out for one week following concussion.

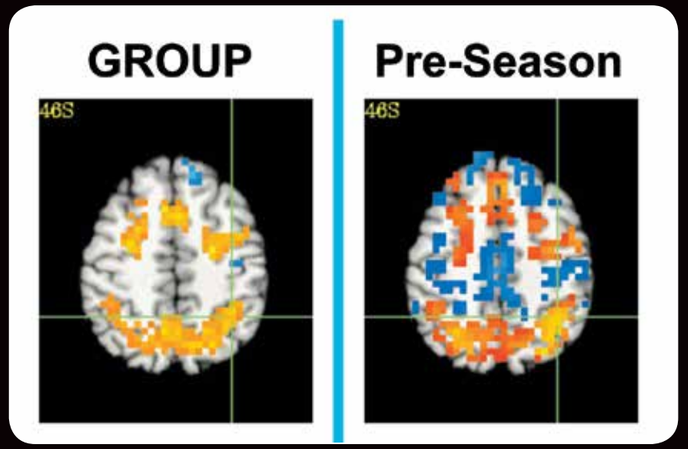

Figure 1. Axial image (including dorsolateral prefrontal cortex/middle frontal gyrus) depicting regions in which activity was greater during 2-back (orange-yellow colorscale) or 1-back (blue-cyan colorscale) during an N-back fMRI task, averaged over a corpus of 20 high school football players before commencement of contact activities. This represents a very normal pattern of activation areas in which the 2-back task is more physiologically demanding than the 1-back task [Ragland et al., 2002].

Figure 2. Same base image, here depicting regions significantly more activated by the 2-back and 1-back tasks when performed by Player 103 during the pre-season evaluation (i.e., before contact practices began; this image depicts a portion of the data averaged to obtain Figure 1. image.)

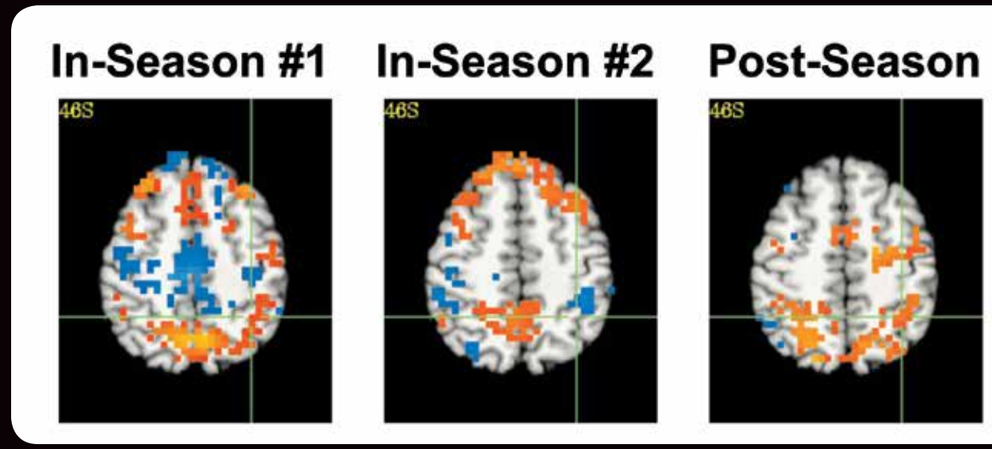

Figure 3. Same base image, but now depicting regions significantly more activated by the 2-back and 1-back tasks when performed three days subsequent to diagnosis of a concussion by the team's athletic trainer and confirmation by the team physician. Note that the regions exhibiting preferential activity for the 2-back task (orange-yellow) in the vicinity of the crosshairs and more anteriorly have been reduced, suggesting that the 1-back task difficulty may have increased.

Figure 4. Same base image, but now depicting activation one month after the diagnosis of a concussion. Regions of preference for the 2-back task have continued to shrink, suggesting that the 1-back and 2-back tasks remain of comparable complexity for the subject.

Figure 5. Same base image, now acquired three months after the concussion, and approximately one month after the end of the football season. Activation has yet to return to normal for this subject, suggesting that while symptoms have been absent for nearly three months, there remains inefficiency in the operation of the subject's brain when performing the relatively simple 1-back and slightly more complex 2-back tasks.

Keeping an eye on the ball

Today, the Purdue study is in the middle of its fifth season. According to Larry Leverenz, PhD, Clinical Professor of Health and Kinesiology and Director of Athletic Training Education Program at Purdue University, the study added a girl's high school soccer team, plus Purdue's freshman football players and the women's soccer team. "It will give us a good comparison between college and high school," says Professor Leverenz. "To my knowledge there is not a lot, if any, concussion research going on with female soccer teams. So it gives us the opportunity to compare the two levels and genders."

According to Professor Talavage, the findings have been essentially the same but in a larger population. Previously, he had been primarily using task-based fMRI, which is not a clinical approach for investigating neurological changes. "In the last couple of years, we've focused on bringing in more MR sequences in an effort to obtain clinically relevant biomarkers that could be useful in identifying and documenting changes in individuals; in fact, physical changes and not just motivational, arousal, or emotional changes."

> "We have added MR spectroscopy, and we've been able to document shorter-term changes in the biochemistry of the brain that is again consistent with previous documentation of TBI—even though these athletes have not been diagnosed with having anything wrong with them."
>
> *Dr. Thomas Talavage*

Recently, the Purdue researchers have used diffusion-weighted and diffusion-tensor MR imaging to identify marked changes in players—consistent with individuals who have experienced diagnosed concussion—as compared with individuals who have not experienced concussion or have not been diagnosed with concussion.

"However, their brains are showing the same structural changes as individuals at comparable ages who have had diagnosed concussions, and both of those populations would be different from a group of like-aged athletes who are not participating in collision sports," offers Professor Talavage. "We have added MR spectroscopy, and we've been able to document shorter-term changes in the biochemistry of the brain that is again consistent with previous documentation of TBI—even though these athletes have not been diagnosed with having anything wrong with them."

Professor Talavage continues by explaining that they've begun adding a functional technique that has potential clinical significance in terms of resting-state functional connectivity. In those cases, the Purdue researchers are finding changes in the players that occur during the season, and persist after the season, that may allow them to investigate the duration of time that is required for a player to recover. "So in other words, how short term are these short-term changes? And what appears to be the boundaries before we become concerned about short-term changes becoming long-term changes?"

Additionally, over the last year, Professor Talavage has added more clinical scans including T2* weighted imaging, or susceptibility weighted imaging, to try and identify the presence or absence of microhemmorages. He has also been utilizing techniques such as a FLAIR sequence to look for edema.

"In our players who are not clinically presenting symptoms, we have yet to see anything in either of those sequences," adds Professor Talavage.

What have we learned?

According to Professor Leverenz, one might assume that the university players would be hitting much harder than the high school players, and there would be more hits or greater magnitude blows at the university level. "However, I think we're going to find that hits at the university level are smaller, and we'll see a lower magnitude and number of blows to the head." He hypothesizes this is because the university players have learned, and they're more seasoned. "Call it a survival mechanism. In order to keep going in a sport, especially a (high contact) sport like football, they have to figure out a way to protect themselves."

One finding that has jumped out: the number of blows taken to the head vs. the severity is what's concerning. For example, "Even with soccer, the players are taking pretty high magnitude blows to the head, but they are not taking as many," explains Professor Leverenz. "Football players practice every day; over a season, they're building up a lot of blows to the head."

Professor Leverenz continues, "We appear to be seeing this data because of the MR sequences we've added. We're continuing to view these changes even though we're not seeing clinical signs that would lead us to believe something's wrong. While we're happy to have this insight, the data continues to be very worrisome."

Advancing the role of MR

Both professors agree that MR has a significant role in furthering their research. Professor Talavage feels that MR is of great interest and has large potential value in the return to play perspective, "MR can provide us with a better understanding of someone's future risk for neurodegenerative or other neurological disorders after suffering a concussion. This is where MR as a screening tool now starts to become extremely valuable."

Professor Talavage provides an example. An individual has had multiple car accidents without any clinical trauma or symptoms, putting him or her at greater risk of future activity resulting in concussion or other diagnosed trauma. By having an MR exam before participating in a sport or other activity, the individual can know the future risk and if there have been other consequences from the car accidents.

GE Healthcare and the NFL are collaborating to improve athlete medical care and safety through the Head Health Initiative. At the core of the partnership is a four-year, $40M initiative to advance the diagnosis and management of TBI using advanced MR technology. Professor Leverenz is on the medical advisory board and says the members are researching new sequences or techniques that could become useable in a clinical sense to diagnose concussions or even subconcussive blows.

Professor Leverenz makes an interesting comparison: "Over the years in athletics, people have had fatalities because of cardiac conditions that were never diagnosed. Today, echocardiograms are routine at the college level. Hopefully, brain MR scans will be just as routine for athletes in the near future."

Thomas Talavage, PhD
is Professor and Co-Director at Purdue MRI Facility, School of Electrical & Computer Engineering, Weldon School of Biomedical Engineering at Purdue University.

Larry Leverenz, PhD
is Clinical Professor of Health and Kinesiology and Director of the Athletic Training Education Program at Purdue University.

Where do we go from here?

There has been much discussion in the news lately about changes made, and being considered, to professional football. Professor Leverenz's goal is to make the game safer. "We should do whatever it takes—pre-participation physical exams, diagnostics during the season, equipment changes, even sideline procedures," he says. "Depending on what comes out of our research, perhaps there is an intervention that might help us help the athletes, soldiers, or person who suffered an auto accident. And just maybe, it can lead to a treatment."

Regarding young boys playing football, Professor Leverenz says the pre-pubescence brain is so much different than the adult brain that it certainly deserves attention. He points out that junior high school football is a new phenomenon. Children who start playing at eight years old have 10 years of football under their belts by the time high school's over. "That's a lot of blows to a young head. To err on the safe side, I would not oppose non-contact football until age 14 or 15."

Professor Talavage is hopeful that the study will continue, as the Purdue researchers have a lot to improve. For example, they would like to get better telemetry data and document whether proposed changes to helmets or padding could have a meaningful impact on brain health. "These issues will require that we collect data with new devices in place to compare the consequences of participation using new technology vs. the consequences of participation without that technology. Long term, this is the best way for us to document any claims of improved health or safety."

> "Over the years in athletics, people have had fatalities because of cardiac conditions that were never diagnosed. Today, echocardiograms are routine at the college level. Hopefully, brain MR scans will be just as routine for athletes in the near future."
>
> *Dr. Larry Leverenz*

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3. www.cdc.gov/TraumaticBrainInjury/statistics.html#A

__Larry Leverenz, PhD,__ is Clinical Professor of Health and Kinesiology and Director of the Athletic Training Education Program at Purdue University. He earned a PhD from The University of Iowa, an Ed.S. and MS from Western Illinois University, and a BS from Southern Illinois University. Professor Leverenz's academic appointments include Assistant Athletic Trainer for Men's Basketball at Purdue University. He has been published many times; for example, "Entry-level Education Committee Tackles Initial Tasks," NATA News.

__Thomas Talavage, PhD,__ Professor, is Co-Director at Purdue MRI Facility, School of Electrical & Computer Engineering, Weldon School of Biomedical Engineering at Purdue University. He earned a BS in Computer and Electrical Engineering and an MS in Electrical Engineering from Purdue University, as well as a PhD in Speech and Hearing Sciences from MIT. Professor Talavage's research includes functional neuroimaging, statistical biomedical image and signal processing, signal detection, audition, speech, language comprehension, and neural prostheses. His areas of interest are biomedical imaging and sensing, as well as communications, networking, signal, and image processing.

__The Purdue Neurotrauma Group's (PNG's)__ current research examines the connection between mild traumatic brain injury (mTBI) biomechanics and the underlying pathophysiology, as well as methods for the prevention of mTBI. Research methods include the use of functional magnetic resonance imaging, neurocognitive testing, sports telemetry, and finite element analysis. By combining these diverse methods, PNG seeks to better understand the nature of mTBI and to develop improved methods of detection and prevention.

INVISIBLE WOUNDS OF WAR

Retired Army Major Ben Richards contemplated how he could hurt himself to get a break from his never-ending concussion symptoms.

> "Trying to figure out how I could break my leg so I could spend two weeks at the hospital was preferable to the idea of having to tell my boss that I could not handle it anymore."
>
> *Retired Army Major Ben Richards*

In recent years, concussions have been dubbed the "silent epidemic." We've learned a lot about the dangers of brain injuries thanks to a greater awareness of mild traumatic brain injuries (mTBI), propelled by new research. Purdue University, for example, has shown that the biggest danger comes from repetitive blows to the head. Contact sports such as football may be the focus of attention in the news, but it's nothing compared to war. On a much vaster scale, the military has also struggled to understand the seriousness of concussions.

From 2000 through the first quarter of 2012, 244,217 service members sustained a TBI according to the Defense Department. The majority of those reported were mTBI, also known as concussion.[1] Tens of thousands—no one knows the exact number—are dealing with lasting brain damage. The Pentagon, which began to recognize the problem as the war in Iraq was winding down, is now implementing changes to treat these invisible wounds.

> "In 2007, I had no idea that traumatic brain injury and post-traumatic stress were the two largest categories of injuries that we had. In some way, we were still listening to our football coaches, who told us as young men that when you got bonked on the head, you shook it off and got back in the game."
>
> *Retired Army General Peter Chiarelli*

One soldier's story

Back in 2007, when Army Major Ben Richards was commanding 100 soldiers and experiencing immediate concussion symptoms after repeatedly hitting improvised explosive devices (IEDs) in Baqubah, Iraq—the most active combat zone in Iraq at the time—the Army did not have a concussion protocol in place. According to Major Richards, in two months of fighting, seven of the 17 armored vehicles under his command were destroyed.

"We were routinely in situations where we were regularly hitting IEDs. About 90% of the guys in my troop hit at least one, and a record holder truck hit five, so we were hitting quite a few," Major Richards recalls. "Many of us were showing severe concussion symptoms, but it didn't seem important at the time to take a break or to investigate our symptoms. It seemed more important to push through and keep on, to stay in the fight as long as possible. Plus, I was responsible for my men, so I had to keep going."

Major Richards' first concussion happened on Mother's Day, 2007 when his armored vehicle was rammed by a suicide car bomber. Everyone walked away with a significant concussion, and Major Richards remembers that his head hurt, he was nauseated for a week, and he literally couldn't see straight. Just weeks later, his vehicle was blown out from beneath by a sedan, driven by a suicide bomber and filled with a few hundred pounds of explosives. They all survived with their "parts and pieces" but Major Richards feels they all suffered another significant concussion.

"The second blast wasn't as big as the first, but it still left us all with damage. In fact, one of my soldiers had to sit out the rest of the war from that explosion because he had been hit too many times. He was very symptomatic," says Major Richards.

Peter Chiarelli, a retired United States Army General and former Army Vice Chief of Staff, served two tours as a combat commander in Iraq. Since retiring and becoming Chief Executive Officer for One Mind for Research, he found that TBI and post-traumatic stress accounted for 67% of the disabling injuries suffered by soldiers in Iraq and Afghanistan, while amputations accounted for only 10%. He has become an advocate of TBI education and management in the military, and he helped implement a new Department of Defense protocol, spearheaded by the Army and Marines.

"In 2007, I had no idea that traumatic brain injury and post-traumatic stress were the two largest categories of injuries that we had. In some way, we were still listening to our football coaches, who told us as young men that when you got bonked on the head, you shook it off and got back in the game," comments Gen. Chiarelli. "If Ben's concussions had happened in 2010 or 2011, he would have been required to do something differently than fighting through the injury. His experience started to change the Army's understanding of TBI and the danger it posed to our troops. As a result, we implemented a new protocol."

Major Ben Richards

education includes the United States Military Academy, Bachelor in Science and Georgetown University, Masters in Global, International, and Comparative History.

> "My wife and kids were not getting the emotional response, love, and care that they deserved. I was struggling as a dad and husband."
>
> *Retired Army Major Ben Richards*

Gen. Chiarelli explains the strict protocol, instituted in 2009-2010: Immediate concussion evaluation is to take place if a vehicle is damaged by an explosion, if an explosion takes place within 50 meters, if a soldier is inside a building where an explosion takes place, or if consciousness is lost for any period of time due to an explosion. Even if a soldier passes the first cognitive test, he or she is held out of the fight for 24 hours. The soldier is required to take the test again, because symptoms often don't appear for 24 hours.

"It's too bad the protocol was not in place in 2007 when Ben was hitting all those IEDs. But we did implement it later—after we understood more about TBI," Gen. Chiarelli offers.

Pushing through the pain

When Major Richards returned home to the US in 2007, he was enduring horrible symptoms. Doctors in Ft. Lewis, Washington said he did not have a TBI problem… he was simply suffering from post-traumatic stress—a diagnosis that would hang over him for four years. "That was a challenge because I wasn't very concerned about post-traumatic stress—the damage was invisible to even me, to some extent, so I hoped it would just get better and go away."

His wife insisted he see a psychologist, so he went to counseling. They didn't see much progress because TBI was part of the problem; however, they didn't know it at the time. "If you have post-traumatic stress and you are not improving through counseling, then you're told it's your fault," adds Major Richards. "But my wife says I was not myself and I spent a lot of time by myself in closed rooms, so clearly, I was not improving."

However, he found a way to endure the suffering and spent the next eight months finishing his command. Major Richards recalls, "At that time, I was one of the worst commanders in the Army… I did a terrible job because of my horrible symptoms." He suffered chronic, disabling post-concussive headaches three or four days a week. He shut down to deal with the pain while taking daily, mega doses of pain reliever to try and keep the edge off. He was not aware of it at time, but he had significant cognitive impairments in memory and functioning. He blanked out during conversations, had no memory of having conversations, and struggled with divided attention, concentration problems, and multi tasking.

"I was emotionally unstable. I'd go from normal to a rage. And I was numb…. I didn't feel emotions like happiness or love," says Major Richards. "My wife and kids were not getting the emotional response, love, and care that they deserved. I was struggling as a dad and husband."

Furthermore, he was experiencing chronic fatigue accompanied by body aches. Simple tasks were difficult. Plus, his sleep was very disrupted, and he began taking medications that made everything worse. "I went from a successful soldier to a lifestyle where I feared everything I attempted," he remembers.

Major Richards then enrolled in graduate school at Georgetown University, a decision he made before he left for Iraq. He moved forward with that plan and dropped off the radar for two years, as he thought the change of venue would help. After his first year, he was directed to withdraw because he was doing so poorly. The administrators decided to let him continue, but he graduated very marginally compared to the expectations he had for himself before Iraq. During this period, he did not seek, or receive, any medical attention.

Not willing to give up on him, in 2010 the Army promoted Major Richards to his dream job: Professor in the Department of History at West Point Military Academy. At this point he was in so much pain and misery, and blanking out in the middle of class, that he resolved to see a doctor. "I was in such a bad place mentally that I was looking for a way out. I don't think I was ever suicidal, but trying to figure out how I could break my leg so I could spend two weeks at the hospital was preferable to the idea of having to tell my boss that I could not handle it anymore," he says.

In the summer of 2010, he saw a sports medicine practitioner who was sensitive to TBI. After their first meeting, the doctor said he was probably having issues with TBI. After three years, this was the first time TBI showed up in his record. Major Richards was referred to a brain injury clinic where he underwent a neurological exam that unveiled his substantial cognitive deficits. His executive function and memory were about 40 IQ points below their expected levels, based on his verbal and non-verbal scores. According to Major Richards, "Statistically, that's three standard deviations below where you'd expect them to be, which I learned is very consistent with TBI."

Meanwhile, Major Richards tried different prescriptions that helped the headaches but at least one promoted suicidal acts. He found the medications to be very "hit or miss," as none of them were designed to treat post-concussive headaches. He gained weight from the drugs, which made him tired, dizzy, and confused. He did not realize it at the time, but he was extremely depressed.

Major Richards was fortunate to have had an exceptional, supportive chain of command at West Point, and at their prompting he went back into counseling. He pushed through for six months but by March of 2011, he reached the breaking point. "All of the problems just broke me. I either needed a break or I was going to hurt myself to go to the hospital so I could get a break."

Help from the heavens

The same month, he was relieved of all duties and put on medical leave. The very same week, something happened that would change Major Richards' life—and his family's life. A representative from the National Intrepid Center of Excellence (NICoE), a Department of Defense organization working to advance the clinical care, diagnosis, research, and education of

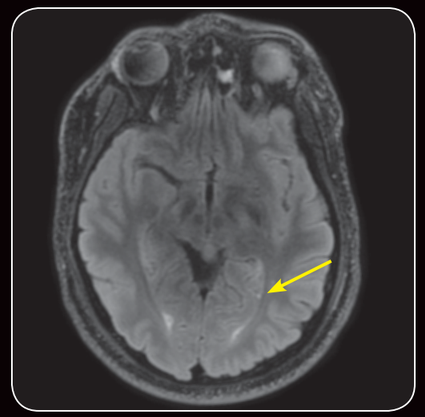

Figure 1

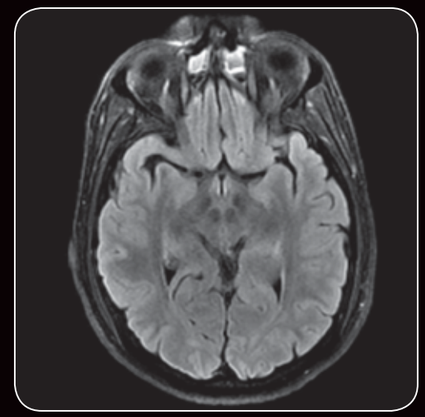

Figure 2

DIGITAL DIVE

NICoE has implemented specific MR sequences that are more sensitive to certain TBI legions than the standard MR sequences. Visit http://tiny.cc/spa132 to view the protocol.

Figure 1. One of Major Ben Richard's neuro MR images, showing one of at least eight points of damage visible in the MR sections. Some of the numerous scattered white matter T2 hyperintense lesions noted in the thin section T2 FLAIR image.

Figure 2. Neuro MR image of a non-injured brain.

General Peter Chiarelli

retired from the US Army with almost 40 years of experience with the Army and Department of Defense. General Chiarelli commanded at every level from Platoon through Corps for almost four years.

Dr. James Kelly, MA, MD, FAAN

is Director of the National Intrepid Center of Excellence (NICoE), and is one of America's top experts on treating concussions. While serving as the NICoE's Director, Kelly is Clinical Professor at the University of Colorado School of Medicine.

military service members with TBI and psychological health conditions, came to West Point for a briefing on the center's capabilities. The center had very limited space, but he got lucky because someone had just dropped out of treatment.

At the NICoE, Major Richards learned something amazing—something that had eluded him for four years: His brain was physically injured and, combined with the post-traumatic stress, it was the reason for his cognitive problems. After various imaging scans, he could actually see the TBI in areas that control emotional regulation and memory. "It was a eureka moment. I was so relieved to know that there was a physical, tangible reason for my terrible symptoms."

According to Dr. James Kelly, MA, MD, FAAN, and Director of the NICoE, Major Richards was scanned on the Discovery™ MR750 3.0T system from GE Healthcare, using a 32-channel head coil. "We perform 90 minute TBI-specific MR scans on all the NICoE patients, plus TBI patients from the surrounding area. This amounts to about eight TBI-specific brain studies per week. In addition, we do routine MR imaging of the spine and neck."

"We are proud that GE technology is utilized at the NICoE in their critical mission to heal the invisible injuries of war," says Jonathan Murray, Managing Director, GE Research Circle Technology, Inc. "At GE we are trying to make more and more of those injuries visible to caregivers."

Dr. Kelly continues, "In general, we employ very thin section imaging that appears to be more sensitive for the detection of lesions associated with TBI. In addition, our NICoE team has implemented specific sequences on the GE scanner that are more sensitive to certain TBI lesions then the standard MR sequences (see Digital Dive on previous page). We also perform advanced imaging techniques such as fMRI and DTI as part of our NICoE TBI exam." He says that between 40% and 50% of the soldiers at NICoE are seeing for the first time that they have physical damage to their brains.

Major Richards describes his experience at the NICoE as wonderful. "The people there were great. The diversity of what they did to diagnose me was amazing. It allowed all of us to be confident that we had the right diagnosis. The specialists actually talked to each other."

Major Richards underwent various treatments, such as holistic therapy, but the level of damage that had been done was so extensive that the Army retired him. While it was difficult to get resources outside of the NICoE, he felt he had a renewed shot at life. "The experience probably saved my life. I can't imagine where I would have been if I had not had access to the NICoE."

Major Richards and his family moved from New York to Idaho to be closer to his in-laws for support. Today, he is doing much better, as he has put a lot of work into treatment. "I am still frustrated because I miss the old Ben Richards—he was a much better guy than I am. But at least I'm in a place where I feel I can have some kind of future versus two years ago when I saw nothing but failure, pain, discouragement, and ruin." He says his wife and children are the real heroes of this story, because through all of the very tough years, their support never waivered.

"We often focus on the warrior who is wounded, but it also heavily impacts the spouses and children. My wife has suffered because of my service. She did not sign up for the Army, and my kids don't deserve the dad they have now versus the dad they used to have. Our family members are the real heroes, and they need to be remembered."

When asked if he has advice for other soldiers who suspect they have TBI, Major Richards says, "There's great value in getting an early diagnosis because there's a period of natural healing. And do it while you are in active duty, because you'll never get access to that level of care again."

> "We are proud that GE technology is utilized at the NICoE in their critical mission to heal the invisible injuries of war."
>
> *Jonathan Murray*

A long way to go

As Chief Executive Officer of One Mind for Research, Retired General Peter Chiarelli continues his advocacy for eliminating the stigma associated with service members and veterans seeking and receiving the assistance they need for the treatment of the invisible wounds of war. He says much progress has been made with TBI diagnosis and treatment, but there's a disconnect once a soldier leaves the Army. For example, when Retired Major Ben Richards was medically discharged, he was told that some of the drugs prescribed to him at the NICoE were not covered by his veteran's health insurance, or authorized or available through the VA system.

"I am frustrated because there are people like Ben out there who are suffering, and I had no idea this was happening until I retired from the Army. We need to find a way to get to the heart of this to ensure that the drugs prescribed are available from the DoD and the VA," he offers. "The NICoE is a beacon of light, but the system and drug formularies are defeating the good done by the center. They could go so far to help people, but we continue to spend millions and millions of dollars in research and we can't even do the basics."

Additionally, Gen. Chiarelli points out that the protocol used by the NICoE's Dr. Jim Kelly is not accepted everywhere. "In fact, there is not a standard TBI imaging protocol. We need consistent protocols on the military side and on the civilian side. The NICoE could serve as a starting point to develop a standard that would bring us all more in line." Dr. Kelly encourages other physicians to use his TBI protocol (see Digital Dive).

Dr. Kelly adds that satellite NICoEs are being built, but TBI is not just a military problem. As reported by the Centers for Disease Control and Prevention, as many as 3.8 million sports and recreation-related TBIs occur in the United States each year.[2] He suggests that perhaps privately-funded, civilian NICoEs should be created to help more people on the civilian side.

Vitals...

One Mind for Research is an independent, non-profit consortium of a broad international coalition of scientists, advocates, philanthropists, the pharmaceutical and health care industries, and government dedicated to delivering accelerated new treatments and cures for all brain illness and injury. For more information, visit http://1mind4research.org.

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General Peter Chiarelli *retired from the US Army with almost 40 years of experience, commanding at every level from platoon through Corps for the Army and Department of Defense. As the Army's 32nd Vice Chief of Staff for almost four years, General Chiarelli was responsible for the day-to-day operations of the Army and its 1.1 million active and reserve soldiers. This included research, development, and execution of studies followed by the implementation of recommendations related to the Army's behavioral health programs, specifically its Health Promotion, Risk Reduction, and Suicide Prevention Program. As the CEO of One Mind for Research, General Chiarelli continues his advocacy for eliminating the stigma associated with Service Members and Veterans seeking and receiving the assistance they need for the treatment of the invisible wounds of war.*

One Mind for Research *is an independent, non-profit consortium of a broad international coalition of scientists, advocates, philanthropists, the pharmaceutical and health care industries, and government dedicated to delivering accelerated new treatments and cures for all brain illness and injury. For more information, visit http://1mind4research.org.*

Dr. James Kelly, MA, MD, FAAN, *and Director of the National Intrepid Center of Excellence (NICoE), is one of America's top experts on treating concussions. While serving as the NICoE's Director, Dr. Kelly is Clinical Professor of Neurosurgery at the University of Colorado School of Medicine. His past positions include Assistant Dean for graduate medical education at the University of Colorado School of Medicine, and the neurology residency program director at Northwestern University Feinberg School of Medicine.*

The National Intrepid Center of Excellence (NICoE) *is the Military Health System institute for complex, comorbid traumatic brain injury and psychological health conditions. The center delivers comprehensive and holistic care, conduct focused research, and export knowledge to benefit service members, their families and society.*

Robert Benjamin "Ben" Richard's *education includes the United States Military Academy, Bachelor in Science and Georgetown University, Masters in Global, International, and Comparative History. His professional experiences includes Professional Education at the US Army Armor School; Platoon Leader in Germany; Company Executive Officer in the Republic of Korea; Assistant to the US Army Armor School Historian; Professional Education at the US Army Armor School; Operations Staff Officer in the US and Iraq; Cavalry Troop Commander in Iraq; Cavalry Troop Commander in the US; student at Georgetown University assigned to the US Army Student Detachment; and instructor in the Department of History at United States Military Academy, West Point, NY. Presently retired because of combat wounds sustained in Iraq in 2007, Major Richards lives in Idaho with his wife and four children.*

DOCTORS CAN'T TREAT WHAT THEY CAN'T DIAGNOSE

New research is shedding light on traumatic brain injuries

Each year in the US, at least 1.7 million traumatic brain injuries (TBI) occur, either as an isolated injury or in conjunction with other injuries.[1] This is likely an underestimate, as the number of persons who sustain a TBI but do not seek care is not known, but is estimated to account for as much as 25% of TBI.[2] Overall, 75% of TBI is considered to be 'mild' TBI (mTBI), sometimes referred to as concussion.[3] Of the 1.7 million people with a documented TBI each year in the US, 52,000 die, 275,000 are hospitalized, and 1.365 million (80%) are treated and released from an emergency department.[1] TBI is a contributing factor to nearly one-third of all injury-related deaths in the US,[1] and direct and indirect costs for TBI are estimated at $76 billion in the US.[4] Clearly, this is a serious health issue that also has socioeconomic implications.

Fortunately, several leading institutions and clinicians are working toward a better understanding of TBI, including mTBI, and how to more definitively and confidently diagnose it. The Transforming Research and Clinical Knowledge in Traumatic Brain Injury (TRACK-TBI) study is an ongoing clinical trial study funded by the US National Institutes of Health (NIH) and coordinated by the University of California, San Francisco. The purpose of the study is to "test and refine Common Data Elements (CDEs), neuroimaging standards, and best practices for genetics and proteomics in Traumatic Brain Injury (TBI) studies."[5] The investigators will also create and expand data repositories for biomarkers, genetics, neuroimaging, outcomes, and patient demographics to help researchers and clinicians establish multidisciplinary, multicenter research networks and improve clinical research in TBI.

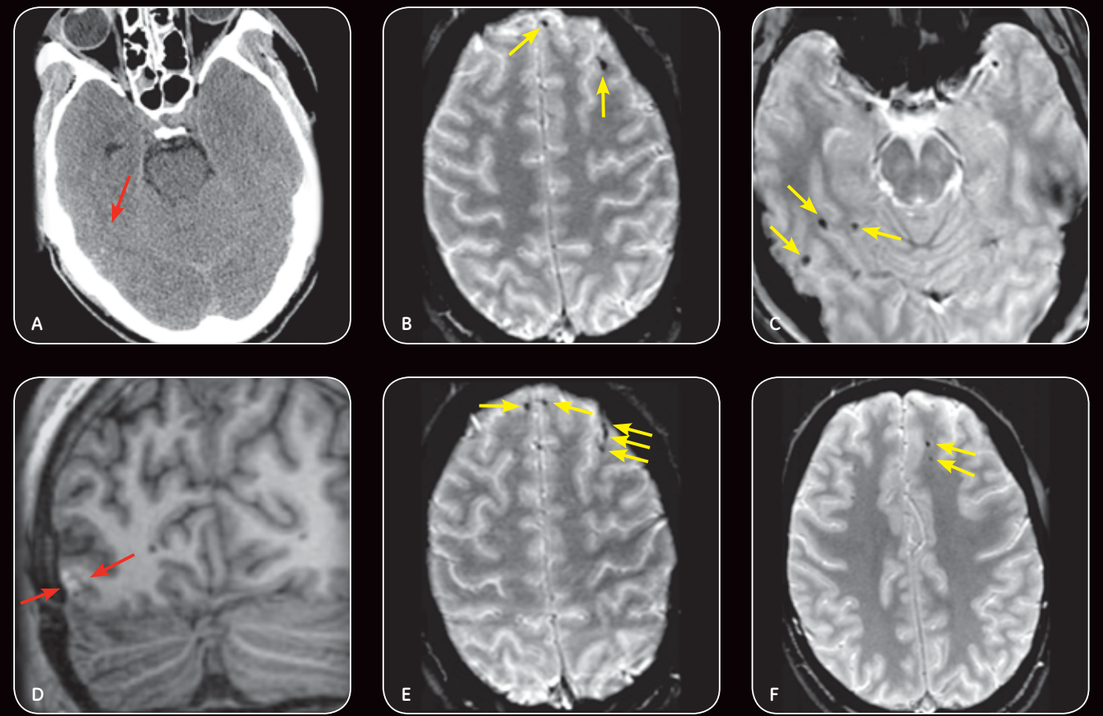

Figure 1. Red arrow in CT (A) demonstrates subtle subarachnoid hemorrhage vs. hemorrhagic contusion in posterior right temporal lobe. 3D T1-weighted fast spoiled gradient echo (FSPGR) MRI (D) demonstrates that this finding represents hemorrhagic contusion (cortical T1 hyperintensity, red arrows) rather than subarachnoid hemorrhage. Yellow arrows in T2*-weighted gradient echo (B,C,E,F) demonstrate innumerable foci of hemorrhage consistent with diffuse axonal injury not detected on CT, even in retrospect.

In the initial pilot phase of the TRACK-TBI study, three TBI centers and one TBI rehabilitation center have been testing and validating the TBI-CDEs. These institutions are San Francisco General Hospital (SFGH), University of Pittsburgh Medical Center (UPMC), University Medical Center Brackenridge (UMCB), and Mount Sinai Rehabilitation Center (MSMC).

In February, 2013, the TRACK-TBI investigators published the first results of the study, which found that in cases of mTBI, sometimes referred to as concussion, MR imaging improves prediction of outcome at three months post-injury. The study evaluated 135 acute mTBI patients at three participating hospitals' Level 1 trauma centers. In addition to a head CT, participants underwent early brain MRI, within three weeks of the injury.[6]

Pratik Mukherjee, MD, PhD
is Professor of Radiology and Biomedical Imaging, Bioengineering and Therapeutic Sciences at the University of California, San Francisco (UCSF) and neuroradiologist at BASIC and SFGH.

Esther Yuh, MD, PhD
is Assistant Professor of Radiology and attending neuroradiologist at UCSF, and has been Assistant Professor of Radiology at the University of California, San Francisco, since July 2009, and a neuroradiologist at the Brain and Spinal Injury Center (BASIC).

> "What we found is a high proportion of people with what appeared to be a relatively mild head injury on the basis of traditional clinical indices, such as a Glasgow Coma Scale score that was perfect or near-perfect, and no loss of consciousness or post-traumatic amnesia, actually had evidence of brain injury when we looked at their imaging studies."
>
> *Dr. Esther L. Yuh*

"What we found is a high proportion of people with what appeared to be a relatively mild head injury on the basis of traditional clinical indices, such as a Glasgow Coma Scale score that was perfect or near-perfect, and no loss of consciousness or post-traumatic amnesia, actually had evidence of brain injury when we looked at their imaging studies," says Esther L. Yuh, MD, PhD, one of the co-investigators on the study, a neuroradiologist at the Brain and Spinal Injury Center (BASIC) and SFGH, and an Assistant Professor in the Department of Radiology and Biomedical Imaging, University of California, San Francisco.

In 2011, SFGH became the first hospital in the US to gain certification for traumatic brain injury (TBI) from The Joint Commission, an independent body that accredits and certifies hospitals nationwide. SFGH is also internationally recognized for its expertise in TBI and spinal cord injury.

In addition to quantifying the frequency of abnormal findings on CT and MRI in the acute to post-acute time frame after mTBI, the researchers also sought to link these findings to outcomes at three months after the injury. "We did show in the TRACK-TBI pilot study that there was a significant correlation between traumatic intracranial findings on initial head CT and early brain MRI, even small or subtle imaging findings, with how people are doing at three months after the injury based on the extended Glasgow Outcome Scale," explains Dr. Yuh. "We need to validate these results in a larger study population, expand our analysis to include more advanced imaging techniques, and work on better understanding the connection between pathophysiology, as seen on CT and MRI, with patient outcome."

A main goal of the new expanded phase of the TRACK-TBI study, involving more than a dozen of the leading academic medical centers across the USA, will be to demonstrate within a much larger study population the relationship between abnormalities seen on acute/post-acute brain MRI and patient outcome. Understanding the significance and potential utility of MRI findings is important, as most people who go to the ER with a head injury typically only receive a head CT, explains Pratik Mukherjee, MD, PhD, principal investigator for neuroimaging and a neuroradiologist at the BASIC, SFGH and the Department of Radiology and Biomedical Imaging, University of California, San Francisco. "A head CT in these cases is usually normal, and typically the patient is told that they are fine, nothing is wrong, and they are sent home. Yet, as Dr. Yuh mentioned, many of them are not fine, even after months or years have passed."

The difference in diagnosing even mild head injuries and providing the appropriate therapy may depend critically on whether imaging is performed, and if so, whether the most appropriate imaging test is administered. "One thing we are discovering is that not all MRIs are created equal," adds Dr. Mukherjee. With 3.0T MR systems that can perform 3D structural imaging with 1 mm isotropic resolution, the researchers could detect very subtle abnormalities such as a small area of scarring or a contusion. With subtle contusions, he explains, there is some residual scarring that is often missed or not even visible on standard 2D protocols on a 1.5T MR. Dr. Mukherjee says what is needed are standard MR imaging protocols optimized for mTBI that would be routinely used for evaluation of people who suffer a concussion. In fact, the TRACK-TBI MR protocols will be disseminated as part of the NIH-funded study and both Dr. Mukherjee and Dr. Yuh hope that more facilities will utilize, validate, and improve upon them. Since the TRACK-TBI study was launched three years ago, additional enhancements to MR technology have been introduced and, therefore, the researchers continue to review and modify the MR protocols used in the study. The current NIH TBI common data element protocols are currently available online.

"It is especially important to have a T2* weighted sequence —preferably high resolution and 3D—to detect small microbleeds or microhemorrhages," says Dr. Mukherjee. These small bleeds are believed to be the result of rotational white matter shearing injury in the brain and are often undetected with standard imaging. "Based on our studies, we have found that the rate of finding these lesions is higher with susceptibility imaging than with conventional, or standard MR protocols. The TRACK-TBI paper showed that having these focal lesions actually does help predict worse outcome in the concussion patient."

Doctors can't treat what they can't diagnose. This is at the heart of the issue with the millions of patients who seek medical treatment for head injuries. By knowing there is an issue, the patient can then seek the appropriate clinical management, rather than suffering from a persistent problem that can lead to cognitive, behavioral, or emotional issues.

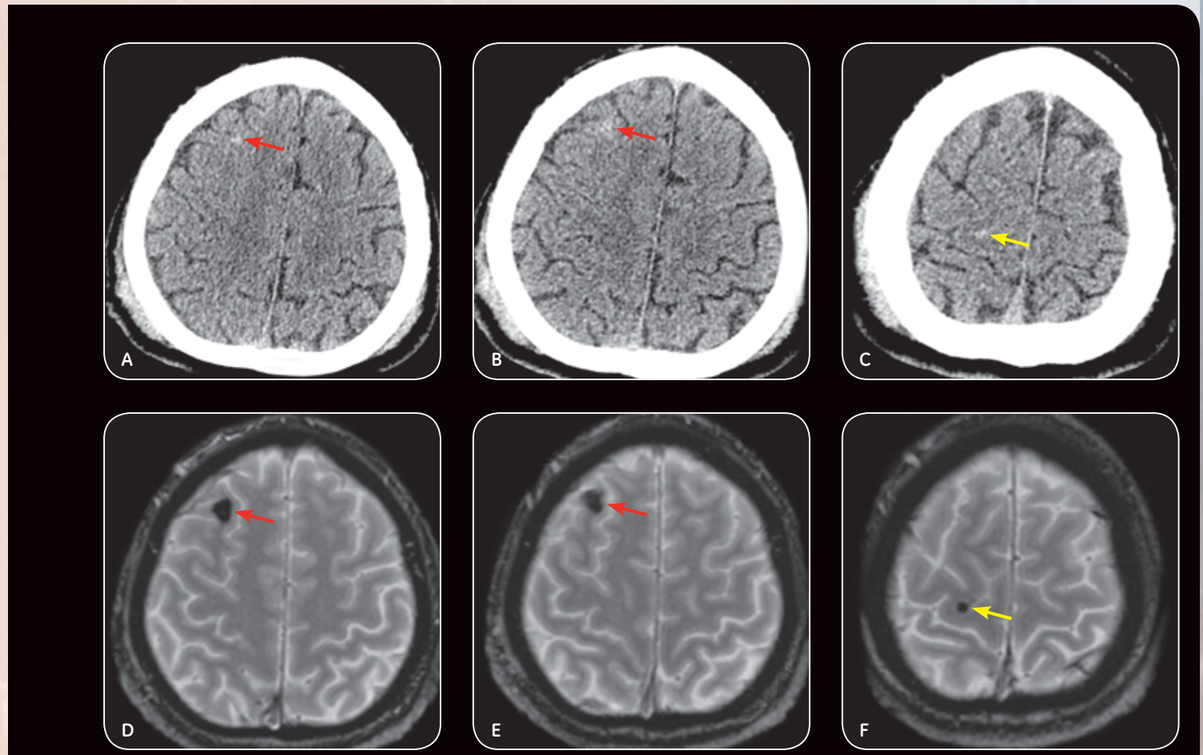

Figure 2. On the CT images (A-C), neuroradiologist interpreted two areas of subtle high density in right frontal sulci (red and yellow arrows) as subarachnoid hemorrhage. No other abnormal CT findings were present. However, T2*-weighted gradient echo (D-F) indicates subcortical hemorrhages signifiying traumatic axonal injury involving the right middle frontal gyrus (red arrows) and right motor gyrus (yellow arrow).

Geoffrey T. Manley, MD, PhD

is the Chief of Neurosurgery at San Francisco General Hospital, Professor and Vice Chairman of Neurosurgery at the University of California San Francisco (UCSF), and co-director of BASIC.

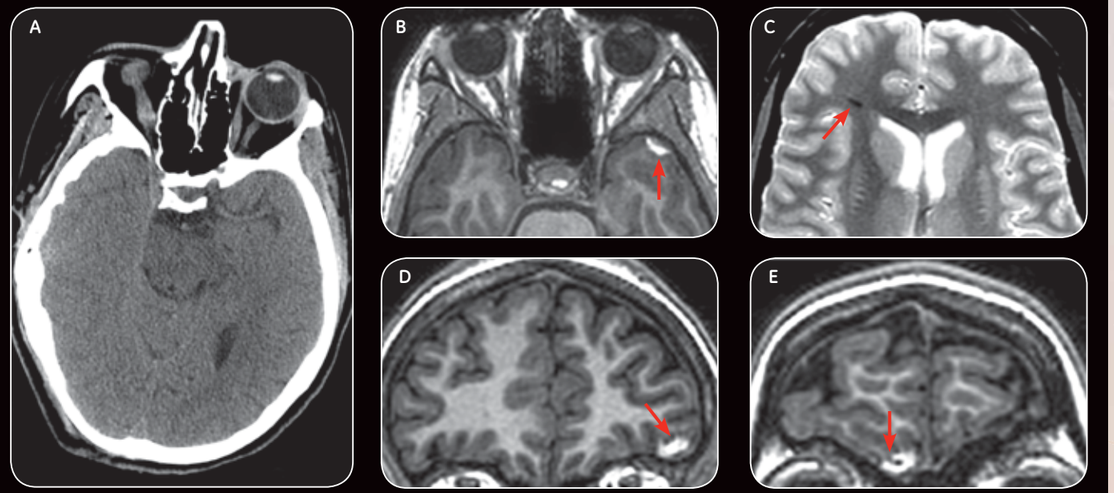

Figure 3. Neuroradiologist reported subtle trace subarachnoid hemorrhage in the right frontal lobe (not shown). CT (A) was otherwise unremarkable. 3D T1-weighted FSPGR MRI (B,D,E) demonstrates unsuspected hemorrhagic cortical contusions involving the left temporal pole (B), left inferior frontal gyrus (D), and right gyrus rectus and medial orbital gyrus (E). T2*-weighted gradient echo (C) also demonstrates microhemorrhage in the deep right frontal white matter signifying traumatic axonal injury.

MR biomarkers and the individual patient

There are other MR biomarkers that the TRACK-TBI researchers will investigate in the next study phase, such as diffusion tensor imaging (DTI) and resting state functional MRI (rs-fMRI). "We believe that mTBI is to a large degree a disorder of connectivity," explains Dr. Mukherjee. "The problem is that (the injury) damages white matter tracts so the patient lacks connections that normally link gray matter regions." Using DTI, the shearing injuries appear as abnormal white matter microstructure and connectivity; on rs-fMRI, it results in impaired functional connectivity between specific brain regions.

This provides the researchers with two key pieces of information. "On a scientific level it helps us understand which neural circuits are affected by the TBI, perhaps on an individualized patient basis, and therefore how that relates to the particular cognitive and behavioral problems that the patient is having," explains Dr. Mukherjee. "On a clinical level, hopefully it will allow us to better diagnose and predict if the patient is at risk of experiencing any deficit and, if they are at risk, to tailor the particular treatment whether it be cognitive training or other rehabilitation approaches, or even medical therapy using cognitive pharmacotherapy."

The difficulty lies in applying this knowledge to the individual, Dr. Yuh adds. Comparing on a group level is currently necessary in order to confidently identify abnormalities using some of the more advanced MRI techniques such as DTI and rs-fMRI, yet the method for applying these techniques to individual patients is still being worked out. She is optimistic that the differences in white matter and microstructural matter detected by DTI will eventually help predict patient outcomes and guide therapy.

"Our study has shown that conventional MR sequences are superior to CT in demonstrating abnormalities in the brain, but we also need to look beyond that, not only to more advanced MRI techniques, but also to what we can do with this information," Dr. Yuh continues. "Can we show that certain types of rehabilitation can benefit patients and if so, which ones? That's another step that still needs to be addressed—to demonstrate therapies that can help these patients."

"What is needed now is better science and better translation of the science into clinical practice," adds Dr. Mukherjee." We classify head injury as mild, moderate, and severe, but those categories are very arbitrary and don't have a lot of prognostic value for how the patients will do." Also, he points out there is not one single definition of concussion, and that further complicates diagnosis and predicting prognosis. This is an area that will also require continued development and collaboration between researchers and clinicians.

> "The problem is that (the injury) damages white matter tracts so the patient lacks connections that normally link gray matter regions."
>
> *Dr. Pratik Mukherjee*

InTBIR

There are new global industry and research efforts focused on TBI of which the TRACK-TBI study is an important part. The umbrella organization is the International Initiative for Traumatic Brain Injury Research (InTBIR), a collaborative effort of the European Commission (EC), the Canadian Institutes of Health Research (CIHR), and the US NIH. Geoff Manley, MD, PhD, Professor and Vice Chairman of Neurological Surgery University of California, San Francisco Chief of Neurosurgery, San Francisco General Hospital Co-Director, Brain and Spinal Injury Center (BASIC), is an InTBIR participant helping to coordinate the large, prospective longitudinal studies on TBI in each of these member nations.

Using similar MR protocols as the TRACK-TBI study, other InTBIR initiatives such as the CENTER-TBI study in the European Union will coordinate clinical research activities across the full spectrum of TBI injuries with the goal of improving outcomes and lessening the global burden by 2020. "We will be focusing on demographic and clinical features, validating imaging and proteomic biomarkers, and looking at genetic risk factors for a detailed and comprehensive assessment beyond the global measure that we currently use, which is the GOS-E," explains Dr. Manley. "Beyond the cognitive deficit, we want to find out how the TBI impaired the individual, including the socioeconomic impact. If we are going to say that everyone with a TBI needs to have an MRI, we need to fully understand what the financial implications are."

While Dr. Manley understands that an MRI is not an inexpensive study, he suggests that the cost of undiagnosed head injuries can have financial implications for society, such as treatments for depression, loss of some cognitive abilities, time off from work, etc. "Someone could be seeking care from up to five different healthcare providers because they had a negative CT and everyone assumes they don't have a head injury. When, in fact, as Dr. Yuh's and Dr. Mukherjee's study pointed out, 25% of people not diagnosed with a brain injury via CT did have a positive MRI.[6] These are the walking wounded seeking healthcare.

"We are learning that mild TBI is not 'mild' in all patients, as we learned (from TRACK-TBI) that there is a lot more disability in this 'mild' TBI group than we have previously appreciated, and that includes those who have a concussion," adds Dr. Manley.

He is also excited about the possibility of a blood biomarker that may detect injury to the brain. The most common

cell in the brain is an astrocyte, which contains a large amount of a protein called glial fibrillary acidic protein (GFAP). When the brain is injured, the GFAP protein is released by the brain into the bloodstream.

A recent study found that, similar to troponin for diagnosing heart attacks, the presence of GFAP in the blood was an indicator of a positive CT for head trauma.[7] "It has very favorable receiver operator curve characteristics—sensitivity and specificity—of being able to identify which patients will have a positive finding on head CT," explains Dr. Manley. The importance of this finding is that this blood-based biomarker has the potential to be used as a diagnostic tool on the sidelines or in the ambulance. "With this type of diagnostic tool, it can also help with patient triage that we believe firmly will result in an improved outcome by getting the patient to the right hospital at the right time. We know that if a patient is triaged at the wrong hospital—one that does not have the capabilities to handle a life threatening head injury—that the patient's outcome is worse than if they went to the right hospital—a Level 1 trauma center—the first time."

While Dr. Manley cautions that additional studies are needed for validating GFAP as a blood biomarker of TBI or even mTBI, he is optimistic that with continued effort, answers to these questions will help move the field of head trauma research in a more positive direction.

Applying science to clinical practice

While much remains to be studied in terms of diagnosing and understanding mTBI and TBI, Dr. Manley is optimistic that collectively these studies will propel clinical knowledge of brain injury for an accurate initial diagnosis and treatment evaluation. "We don't yet have a diagnosis—there are over 40 definitions of concussion—so until we have that we cannot pursue clinical trials of targeted treatments that may improve outcomes," he says.

The first step is getting a better diagnostic model and understanding what the prognostic features are of concussion. Secondly, it is clear to Dr. Manley, based on the TRACK-TBI study, that there is a significant role for MR imaging in the diagnosis of brain pathology resulting from even mild brain injury. "Studies have shown that MR has an advantage over CT in detecting all the pathology that exists in these patients and the pathology that we identify is associated with unfavorable outcome," he adds.

As a result, Dr. Manley is more likely to order an MR on a patient than before. "We need to consider adding MR as part of our diagnostic armamentarium when we are trying to rule in and rule out a structural brain lesion, and that doesn't include the potential of diffusion tensor imaging, resting state fMRI, or even PET imaging."

He also believes that the practice of discharging patients from the ER with no follow-up just because they had a negative CT is wrong. "They had an event that brought them to the emergency department and just because we can't see a lesion on a CT scan doesn't mean it is not there," he says. "I think that one of our main objectives is to provide better imaging and diagnostic tools to identify these patients and provide comprehensive follow up care to mitigate the long term effects of this often invisible injury."

> "We need to consider adding MR as part of our diagnostic armamentarium when we are trying to rule in and rule out a structural brain lesion, and that doesn't include the potential of diffusion tensor imaging, resting state fMRI, or even PET imaging."
>
> *Dr. Geoffrey Manley*

To provide that proper follow-up, Dr. Manley and his colleagues at SFGH and BASIC have created a clinic for TBI and mTBI patients to receive the multidisciplinary care they need. These TBI concussion clinics are comprised of multi-disciplinary teams that include neurosurgeons, sports medicine doctors, neurologists, and neuro-psychologists to provide a multi-faceted approach to a very complex problem.

"We, as clinicians, have to be open to new diagnostic models and take a more serious approach at diagnosing and then following TBI and mTBI patients, just like we would with any other disease," Dr. Manley adds. "Much like other recognized diseases—diabetes, coronary artery disease, and cancer—traumatic brain injury is not an event, it is a process. Some people need an MRI, surgery, physical therapy, and follow-up.... so we need to be following these people more carefully like we do with other health issues today."

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DIGITAL DIVE
For more information on NIH TBI protocals:
http://tiny.cc/spa134

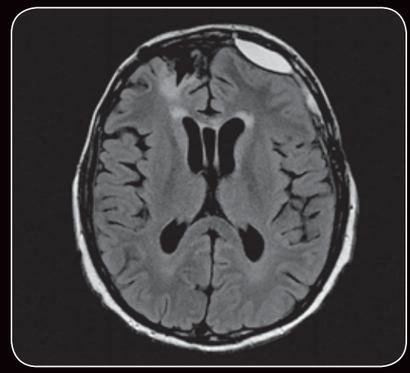
DIGITAL DIVE
To access the NIH MR protocal:
http://tiny.cc/spa135

Pratik Mukherjee, MD, PhD, *is Professor of Radiology and Biomedical Imaging, Bioengineering and Therapeutic Sciences at the University of California, San Francisco (UCSF). He is a practicing clinical attending neuroradiologist at UCSF and also directs a laboratory at the Center for Molecular and Functional Imaging in the UCSF Dept. of Radiology and Biomedical Imaging. Dr. Mukherjee is also the Director of the Center for Imaging of Neurodegenerative Diseases (CIND) at the San Francisco Veterans Affairs Medical Center. For the past three years, he has served as co-Chair of the Research Committee for the American Society of Neuroradiology (ASNR). Dr. Mukherjee currently serves as the Chair of Neuroradiology and Head/Neck Imaging for the Scientific Program Committee of the Radiological Society of North America (RSNA).*

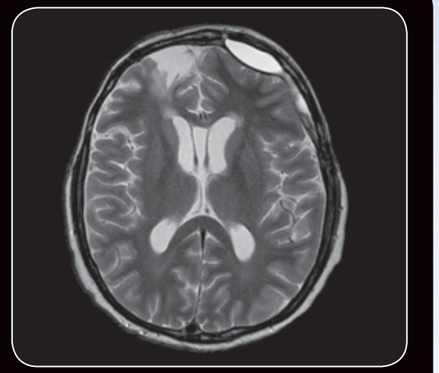
Esther Yuh, MD, PhD, *is Assistant Professor of Radiology and attending neuroradiologist at UCSF. Dr. Yuh completed her MD at Stanford University, and radiology residency and neuroradiology fellowship at UCSF. She has worked closely with the TRACK-TBI investigators to show that abnormalities on early CT and MRI predict poor outcome in mild TBI. Her interests include improvement of image analysis for better classification and treatment of TBI. She was UCSF Radiology's Outstanding Teaching Fellow of the Year in 2009, and a 2010 nominee for UCSF's Exceptional Physician Award. She has 34 peer-reviewed publications in radiology and physics.*

Geoffrey T. Manley, MD, PhD *is the Chief of Neurosurgery at San Francisco General Hospital and Professor and Vice Chairman of Neurosurgery at the University of California San Francisco (UCSF). He also co-directs the UCSF Brain and Spinal Injury Center. Dr. Manley is an internationally recognized expert in neurotrauma. He has published over 150 manuscripts that reflect a wide range of research interests from molecular aspects of brain injury to the clinical care of traumatic brain injury (TBI) patients. He has helped to define new molecular mechanisms and develop advanced neuromonitoring and informatics tools for TBI. He is currently leading national and international efforts to create a modern knowledge warehouse that integrates clinical, imaging, proteomic, genomic, and outcome biomarkers of TBI to drive the development of a new TBI classification system.*

San Francisco General Hospital and Trauma Center (SFGH) *serves some 100,000 patients each year and provides 20% of the city's inpatient care. Recognized as one of the nation's top hospitals, SFGH is the city's busiest emergency room and the only trauma center providing life-saving care to the 1.5 million adults and children of San Francisco and northern San Mateo County. The hospital treats more than 3,900 trauma patients annually with a comprehensive range of resources on hand 24-hours a day, including trauma surgeons specializing in orthopedic, general, and neurosurgery, anesthesiologists and other specialists. In 2011, SFGH became the first hospital in the country to be certified for a Traumatic Brain Injury program. From its inception in 2002, the Brain and Spinal Injury Center (BASIC) at SFGH investigators and clinicians have been pursuing outstanding patient care and world-class research to achieve a better understanding of treatment for traumatic brain and spinal cord injuries.*



Silent Neuro Package
T2 FLAIR PROPELLER Axial
288 x 288
5 mm



Silent Neuro Package
T2 PROPELLER Axial
320 x 320
5 mm

START WHERE OTHERS STOP WITH DV24.0 CONTINUUM PAK

At GE, building a new MR system from the ground up is about creating potential... seeing how far we can push the limits of that potential and enhancing the patient's MR experience. Over the last two years, we've embraced the concept of a caring design and insightful technology. The new DV24.0 Continuum™ Pak is our latest response to clinicians' ever-changing diagnostic needs with a robust collection of solutions to improve workflow and supercharge applications. And, it takes a big step toward increasing patient comfort with Silent Scan technology.

The new sound of patient comfort

Thirty percent of all MR exams are neurological scans where the patient's head is positioned inside the bore. Clinicians and technologists tell us that next to feeling claustrophobic, the loud noise of an MR scan is what patients fear most.

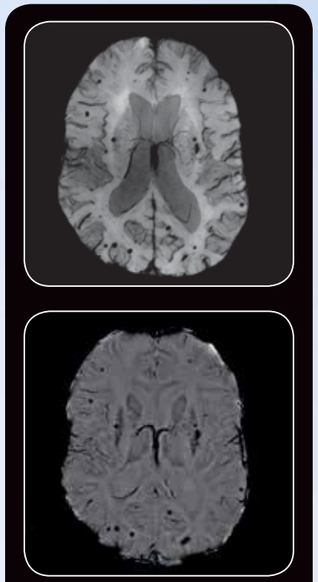
With Silent Scan, patients in need of a routine neuro scan can enjoy decibel levels just above that of ambient noise. Using a unique combination of innovative technologies, we've made MR near silent while still providing the excellent image quality clinicians need for a confident diagnosis.

At the core of Silent Scan is Silenz, a novel data acquisition method in which the gradients are used continuously, but are not rapidly switched on or off. Since the gradients are no longer switched on and off, mechanical vibration is eliminated and no noise is generated during the acquisition. The Silenz technology acquires three-dimensional MR data, resulting in isotropic resolution. Further, Silenz has the unique advantage of a very short echo time, improving image quality and signal from all tissues of interest. Silent Scan includes T1, T2, FLAIR, proton density and angiographic contrasts, while adding motion correction techniques such as PROPELLER.

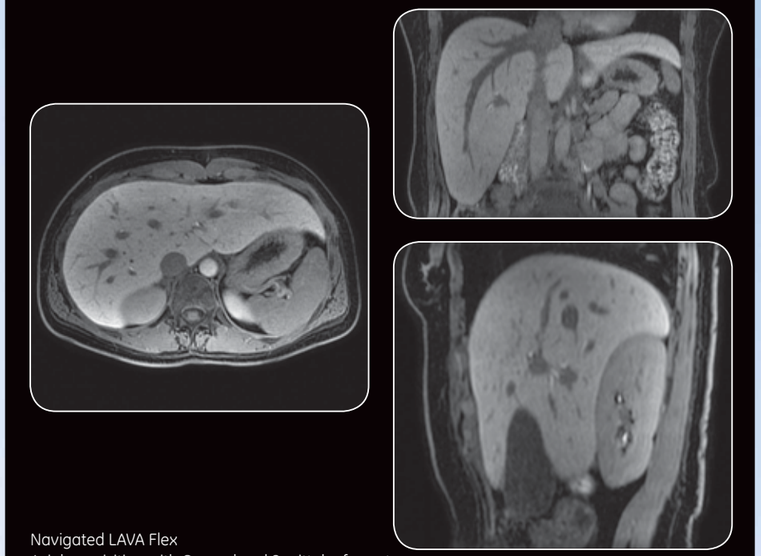
Since Silent Scan technology avoids switching gradients rapidly, it's crucial that the RF coil system be capable of switching from transmit to receive mode within microseconds to maximize signal-to-noise ratios within the images. The GEM Suite of coils is designed to do just that and more—the coils embrace the unique anatomies of each patient, softening pressure points and reducing the need to shift during a scan.

Intuitive applications, customizable approach

With a range of customizable package offerings, hospitals and imaging facilities can tailor an upgrade package to meet their specific needs of today, and plan for future growth tomorrow. The DV24.0 Continuum Pak, available on the Optima™ MR450w and on the Discovery™ MR750 and MR750w systems, includes three different specially configured solutions: the ES, EX, and EL editions.



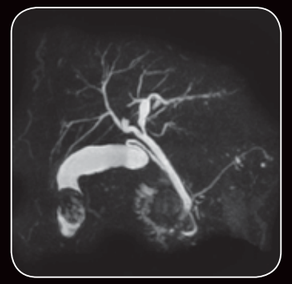
eSWAN
288 x 288
1.8 mm



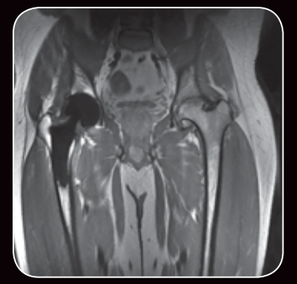
Navigated LAVA Flex
Axial acquisition with Coronal and Sagittal reformats
284 x 224
2.2 mm 36 FOV

Enhanced applications provide an increase in diagnosing power across the full spectrum of clinical applications. Here's a glimpse of what the DV24.0 Continuum Pak has to offer:

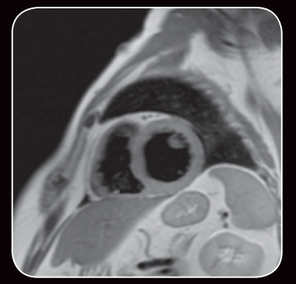
- 3D PROMO corrects motion in real-time for higher quality neuro exams[1]
- FOCUS allows you to zoom in on specific organs using diffusion weighted imaging, providing an improved quality of diagnosis by removing artifacts related to motion, susceptibility and fat common in large field-of-view imaging[2].
- Black Blood SSFSE enables the acquisition of morphologic assessments of the heart in one breath-hold.
- BrainWave 3.0 is a new, simplified solution for functional MRI with support for multi-design paradigms, event-related activity and extensions for diffusion tractography and report generation support.
- Body Navigators are designed to allow for free breathing, motion-controlled acquisitions. DWI, MRCP, T1 and T2 high-resolution images are scanned without a breath-hold and routine liver imaging is performed in less than 15 minutes.
- SWAN 2.0 is a high-resolution 3D multi-echo gradient echo sequence that results in an SNR that is higher than a single echo acquisition. It generates magnitude and phase images from a single acquisition, allowing you to differentiate between microvasculature bleeds and calcified lesions.
- Real Time Field Adjustment (RTFA) technology corrects field imperfections that result in image distortions and loss of resolution in diffusion imaging techniques. RTFA enables large field-of-view coverage in the body, shorter echo times and increased SNR compared with previous techniques.
- Phase Sensitive Inversion Recovery is used to reduce the sensitivity of inversion delay times for enhanced cardiac exams. The result is consistent imaging without worrying about the delay time.



Navigated MRCP
288 x 288
1.4 mm 36 FOV



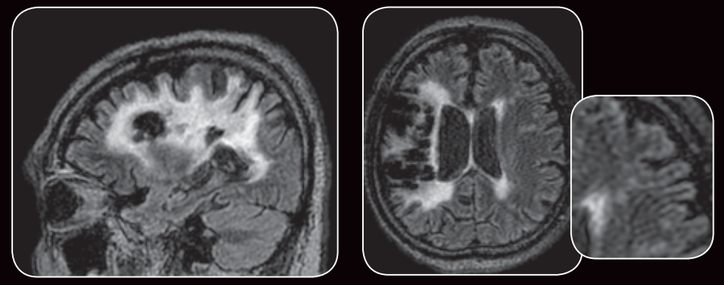
MAVRIC SL
512 x 384
4 mm 38 FOV



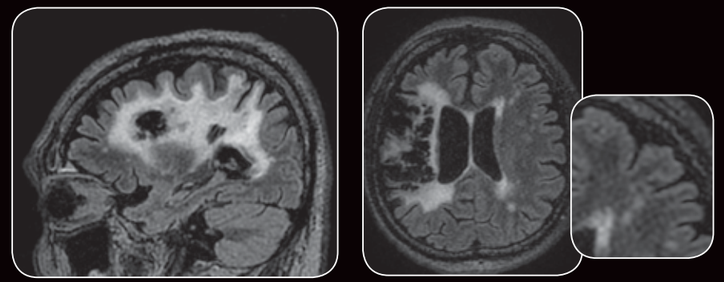
Black Blood SSFSE Short Axis
256 x 192
8 mm

3D PROMO replaces T2 and T2 FLAIR Cube scans with similar scan times and contrast with identical resolution.

T2 FLAIR Cube
224 x 224
27 FOV
1.4 mm
4:28 min



T2 FLAIR Cube with 3D PROMO
224 x 224
27 FOV
1.4 mm
4:34 min



Courtesy CHR Laennec Imaging Center, Creil, France

Also, existing applications such as IDEAL IQ, ASL, MAVRIC SL and MR Touch, are included in the DV24.0 Continuum Pak, bringing more quantitative imaging solutions to routine practice than ever before.

Improve productivity by up to 30%

Efficiency is a good measure of improvement. The ability to perform the same process in a shorter amount of time allows clinicians to be a more effective resource for their patients. With the DV24.0 Continuum Pak, there are fewer clicks and more automation to dramatically improve workflow with features such as the GEM auto-coil selection process, automatic pasting, a unique 'duplicate and set-up' function, and seamless sharing of protocols between GE systems. The new eXpress prescan algorithm increases the efficiency of the calibration process, reducing prescan times by 30% compared to previous generation software. And improved parallel imaging capabilities allow for higher quality images in less time.

The DV24.0 Continuum Pak offers an amazing set of enhancements now available worldwide.

Footnotes

1. Compared to non-motion corrected 3D acquisitions.
2. Compared to conventional diffusion-weighted imaging.

GE HEALTHCARE'S FIRST PEDIATRIC MR OFFERING CLEARED FOR USE

New Pediatric Positioner Pad Set available with standard brain and HNS coils

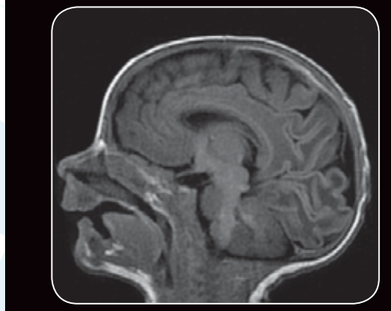
The new Pediatric Positioner Pad Set is GE Healthcare's first pediatric offering to receive FDA 510(k) clearance for marketing in the US. It facilitates MR exam preparation for newborns and infants, up to two years of age or 12 kg, when performing pediatric MR neural examinations using standard MR brain and spine coils designed for adults.

The Pad Set's clinical study was validated by Lucile Packard Children's Hospital (LPCH), which is part of the Stanford University system. The clinical study at LPCH took over one year to complete. With the help of Shreyas Vasanawala, MD, PhD, Professor of Radiology and Director of Pediatric and Abdominal MRI at LPCH, and the MRI staff, more than 20 patients between the ages of 12 days and 22 months were consented into the study.

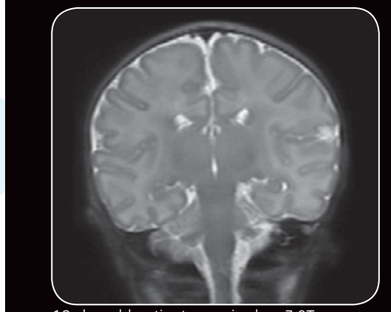
Jessica Buzek, Advanced Applications Specialist at GE Healthcare, explains that, "By conducting a GE-sponsored study with our clinical partners at Stanford, we were able to gather enough data to receive clearance from the FDA to use and market MR imaging with the use of this pad for patients under two years of age."

Shreyas Vasanawala, MD, PhD

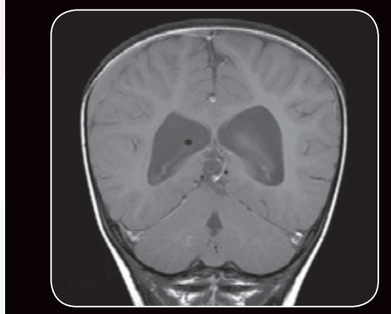
is the Professor of Radiology and Director of Pediatric and Abdominal MRI at Lucile Packard Children's Hospital, part of the Stanford University system.



15-day-old patient, acquired on 3.0T, with the 8ch Brain coil.



12-day-old patient, acquired on 3.0T, with the 16ch HNS coil.



13-month-old patient, acquired on 3.0T, with the 16ch HNS coil.

12-week-old patient, acquired on 1.5T, with the 16ch HNS coil.

Images courtesy of Lucile Packard Children's Hospital

The pad is compatible with the 3.0T and 1.5T HD 8-channel high-resolution Brain Array Coil and the 16-channel Head, Neck, and Spine Coil. When using the Pad Set, the coil-compatible Discovery™ MR750 3.0T and Signa™ HDxt 1.5T MR systems from GE Healthcare are cleared for use with newborns and infants up to two years of age or 12 kg.

> "By conducting a GE-sponsored study with our clinical partners at Stanford, we were able to gather enough data to receive clearance from the FDA to use and market MR imaging with the use of this pad for patients under two years of age."
>
> *Jessica Buzek*

Improves workflow, reproducibility

Additionally, the pad improves workflow, immobilizes the patient, optimizes patient positioning, and facilitates intubation—thereby improving reproducibility of the exam. It provides a simple, low cost solution designed to improve the workflow and reproducibility of pediatric exams, and it is appropriate for use in dedicated pediatric MR centers or clinics that perform occasional pediatric scans.

Buzek says that 90% of all MR coils are designed to fit the 95th percentile adult male. "The pediatric patient is too small to fit into these coils properly. In the clinical environment, it is common practice to use rolled-up towels, blankets, and miscellaneous pads to help fit these small patients into the coils and immobilize them as much as possible. This process takes time and varies amongst clinicians and patients, leading to decreased workflow and inconsistent image quality."

Use of the Pediatric Positioner Pad Set addresses these clinical obstacles by facilitating workflow, improving image quality, and most importantly, providing a perceived sense of increased safety. As the company learns more about the needs of this unique population, its pediatric portfolio will continue to grow. S

Insight…

The new Pediatric Positioner Pad Set coating is strong and easily cleanable, with an anti-skid undersurface that reduces movement. The dimensions are approximately 30 inches long, 20 inches wide, and nine inches high, and it weighs 1.8 kg.

Shreyas Vasanawala, MD, PhD, *is the Professor of Radiology and Director of Pediatric and Abdominal MRI at Lucile Packard Children's Hospital, part of the Stanford University system. Dr. Vasanawala's clinical focuses include diagnostic radiology, pediatric and abdominal MRI, and cardiovascular diagnostic techniques. His current research interests include developing new MRI techniques, and in particular, developing novel applications for children. By taking a comprehensive approach, he explores novel hardware, MRI pulse sequence techniques, and motion correction methods.*

Lucile Packard Children's Hospital (LPCH) *is a world-class, non-profit hospital devoted entirely to the care of babies, children, adolescents, and expectant mothers. LPCH is an academic medical center on the Stanford University campus, with faculty and staff that is recognized as much for their achievements as for their commitment to care. Many of the doctors also serve as professors at the Stanford University School of Medicine. LPCH is ranked in nine specialites in the 2013-2014 Best Children's Hospitals US News & World Report.*

WORLDWIDE TRADE EVENT SCHEDULE

Events Spanning the Globe

GE Healthcare looks forward to seeing you at the following tradeshows:

Event	Date, 2014	Location
Society for Cardiovascular Magnetic Resonance (SCMR)	Jan. 16-19	New Orleans
Indian Radiological & Imaging Association (IRIA)	Jan. 23-26	Agra
Arab Health	Jan. 27-30	Dubai
European Society of Radiology (ECR)	March 6-10	Vienna
KIMES (Korea International Medical & Hospital Equipment Show)	March 13-16	Seoul
SSR (Society of Skeletal Radiology)	March 16-19	San Diego
China Med	March 21-23	Beijing
Korean Society of Magnetic Resonance in Medicine (KSMRM)	March 28-29	Seoul
European Society for Radiotherapy & Oncology (ESTRO)	April 4-8	Vienna
International Technical Exhibition of Medical Imaging (ITEM)	April 11-13	Tokyo
Sao Paulo Radiological Meeting (JPR)	May 1-4	Sao Paulo
Africa Health	May 6-8	Johannesburg
International Society for Magnetic Resonance in Medicine (ISMRM)	May 10-16	Milan
SPR (Society for Pediatric Radiology)	May 13-17	Washington, D.C.
Saudi Health	May 19-21	Riyadh
95th Deutscher Rontgenkongress	May 28-31	Hamburg
American Society for stereotactic and Functional Neurosurgery (ASSFN)	May 31-June 3	Washington, D.C.
Society of Nuclear Medicine and Molecular Imaging (SNMMI)	June 6-11	St. Louis
European Society of Gastrointestinal and Abdominal Radiology (ESGAR)	June 18-21	Salzburg
European Society of Musculoskeletal Radiology (ESSR)	June 26-28	Riga

NEW CUSTOMER INFORMATION CENTER: ADVANCING HEALTHCARE THROUGH COLLABORATION

Helen Keller famously said, "Alone we can do so little. Together we can do so much." GE Healthcare's new MR Customer Information Center (CIC) in Waukesha, Wis. was created with this in mind. The company is dedicated to partnering with customers to address MR growth, quality, operational excellence, and further optimizing the MR experience for all involved. Visits to the CIC are a powerful way to work together to maximize customers' investments—lifting their organizations to a new level of MR performance—while providing important insights into advancing healthcare.

GE aims to connect with customers not just on an academic level, but to better understand their daily business needs and expectations. "We support customers on all levels because efficient patient scanning is not only done with fast sequences and isotropic datasets, but by guiding the patient through an optimized workflow," says Julianna Uresch, CIC and Demo Leader, Global MR at GE Healthcare. "Customers are not just coming to see our advanced MR scanners, or to talk to product managers and scientists, but to experience how differently GE is approaching daily interaction between patients and radiology teams."

Three bays for MR three ways

The CIC accommodates customers in three stunning MR bays: one for the Discovery™ MR750w 3.0T with the GEM Suite of coils, one for the Optima™ MR450w 1.5T with the GEM Suite of coils, and one for the Optima™ MR430s—a specialized extremity system that delivers high-quality 1.5T images. In the Discovery MR750w and Optima MR450w bays, customers will hear the new sound of patient comfort—Silent Scan. This technology allows patients to undergo the MR exam in an even more relaxed fashion because it is engineered to eliminate the typical MR noise at the source.

All of the MR systems are displayed in their own soothing and aesthetically pleasing rooms to further humanize the MR experience through the assuring senses of sight, sound, and touch. This transforms the exam environment from cold and clinical to, for example, a comforting home library and fireside—allowing patients to feel more relaxed and confident.

Every CIC visit is unique and tailored to address the needs of each customer. Upon entry to a suite, customers can choose one of 16 different themes from an iPad coverflow menu, as if they were a patient. Each theme is a serene video or photo collage, with a soothing soundscape and all-embracing mood lighting. Customers can also play music from their own iPods and view photos or videos from their iPads.

Additional features of a CIC visit include specially designed anterooms for each bay and an eye-popping new conference room.

Important insight

According to Uresch, visits to the new bays have been tremendously insightful. Customers from around the globe agree. Esther Nurima, MD and Corporate Managing Director at Eka Hospital in Indonesia, had a great experience. "I was very impressed with GE's humanizing MR concept. The lighting system, video LCD, and Silent Scan technology on the Discovery MR750w 3.0T with the GEM Suite of coils make the scanning experience much more comfortable for patients."

Before her visit, Dr. Nurima was afraid to perform MR scanning alone. While at the CIC, she was able to try it by herself... with the big gantry and the other friendly features of the Discovery MR750w, Dr. Nurima found she's very comfortable scanning on her own. Additionally, she was greatly impressed with GE's hospitality during her visit.

Charilynne Miller, RT(R) (MR) BSRT and MRI North Market Supervisor at Wisconsin's Wheaton Franciscan Healthcare, adds, "In a tight healthcare market, I was most impressed with an MR scanner designed around the patient. All the latest and greatest technology GE has to offer is there, but the focus is on the patient's comfort and reducing anxiety with a calming environment."

Raising the bar

While there has been great interest in and praise about the new CIC, GE Healthcare is already looking into ways to improve the visits—customizing them even more. Additionally, the company plans to add new technology to further underscore its commitment to long-lasting, fruitful relationships with its customers.

Dr. Esther Nurima

Charilynne Miller

The editors thank Esther Nurima, MD, Corporate Managing Director at Eka Hospital in Indonesia and Charilynne Miller, RT (R) (MR) BSRT and MRI North Market Supervisor at Wisconsin's Wheaton Franciscan Healthcare, for their contributions to this story.

GE Healthcare

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