PHILIPS

MRI Magazine

Publication for the Philips MRI Community **Issue 57 – 2020**

FieldStrength

Fast scanning, fast workflow, high quality

More time for **advanced MRI** in neurology clinic

Institute boosts MRI **quality and speed** with Ambition

UBC advances their **MS imaging** with Elition 3.0T

Up to **20 extra patients per week** at Cobalt

Dear Friends,

Our vision for MR builds on the quadruple aim of healthcare which strives to reduce cost, improve outcomes, and improve patient- and staff satisfaction. In MRI, we therefore develop products that can help reduce cost per procedure, allow to serve more patients, help reduce pressure on staff and support more confident diagnoses.

It's inspiring to see how our customers use our technology to help them advance on this quadruple aim. In this issue of FieldStrength you can read about the Miami Cardiac & Vascular Institute seeing a boost in MRI quality, speed and patient comfort after installing an Ingenia Ambition 1.5T scanner with the BlueSeal magnet, that contains only 7 liters of helium and is designed for helium-free operation.

In the article about University of British Columbia you can read how switching to Ingenia Elition 3.0T has created many new opportunities for the researchers to advance their imaging of multiple sclerosis. Ingenia Elition helped Fondation Rothschild to shorten scans, allowing them to add advanced sequences or switch to higher resolution for improving diagnostic confidence.

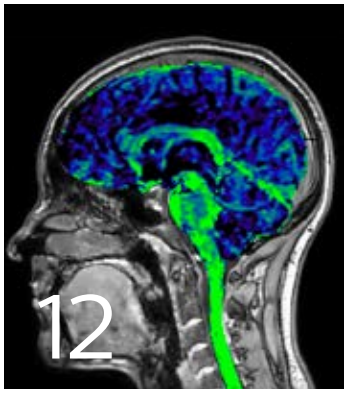
Over the past two years, many customers started to use our Compressed SENSE acceleration technology and experienced how it helped them improve in many ways, ranging from scanning more patients to reduced staff over time, technologists having more time with their patient or improved diagnostic confidence thanks to improved resolution or the ability to add more sequences in the same time slot. Read more in the articles about Cobalt in the UK and about Ikazia Hospital in the Netherlands. There is also an educational article that can help you understand what makes Compressed SENSE so powerful.

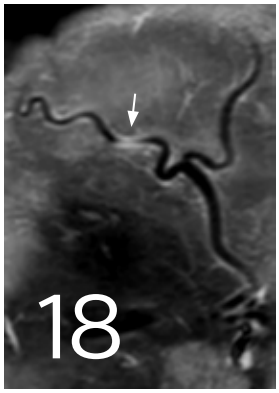
I am proud that together with our customers we are making this impact in healthcare and we constantly strive to improve patient care.

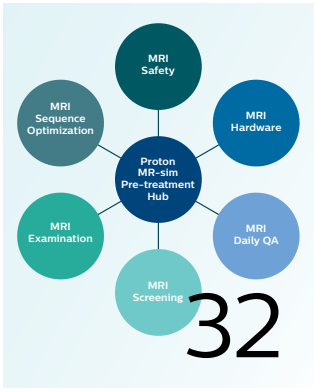
Enjoy reading!

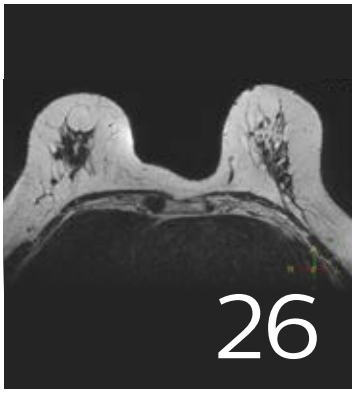
Martijn Hartjes
Head of Global Product Marketing MR, Philips

Fast scanning, fast workflow, high quality









News

Users experience speed, comfort, confidence

Education

Research

*Compared to Philips scans without Compressed SENSE

Results from case studies are not predictive of results in other cases. Results in other cases may vary.
Results obtained by facilities described in this issue may not be typical for all facilities.

Philips demonstrates innovation leadership in MRI

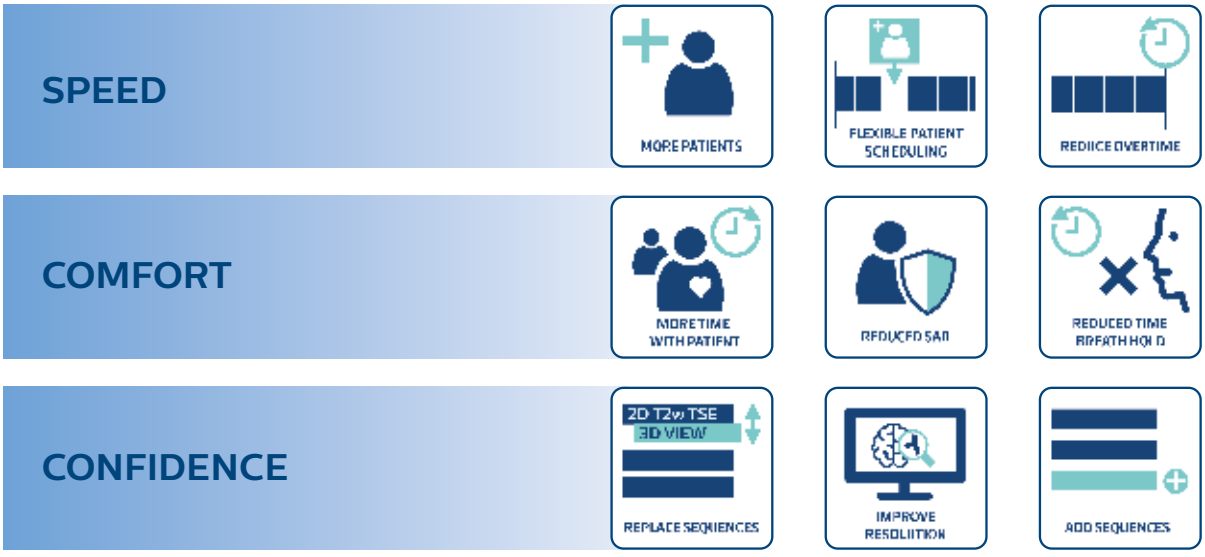
At the most recent RSNA, Philips highlighted the success of its Compressed SENSE MRI acceleration technology as well as additional features to save time and enhance workflow. Also in the spotlight was the Ambition 1.5T MRI scanner, the industry's first and only commercially available, fully sealed magnet for productive, helium-free operations [1]. User results illustrate its excellent imaging capabilities.

Faster scanning times can increase productivity while benefitting patients and staff

Improving MRI speed and workflow is a key area of attention for many imaging providers. Compressed SENSE is an advanced solution that can reduce scan times by up to 50% [2]. It can be used for all anatomical scans throughout the body, both 2D and 3D. Philips recently marked that one million patients were already scanned with Compressed SENSE acceleration. The User experience articles in this issue provide examples of results obtained at different facilities.

"Our accelerated Compressed SENSE scanning technology, combined with a host of smart innovations, enables a step-change in MR speed, productivity and workflow, while improving the experience for patients and staff."

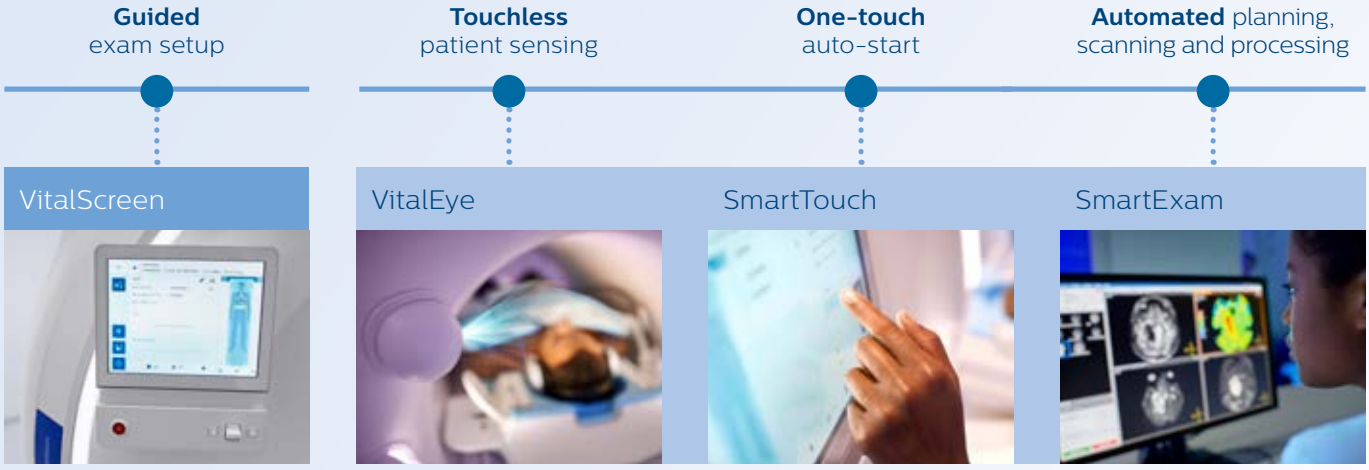
Arjen Radder, General Manager for MR at Philips



Driving a breakthrough in workflow experience

Combining powerfully with Compressed SENSE, our latest SmartWorkflow solution integrates guided patient setup and scanning automation, along with technology such as VitalEye, VitalScreen and SmartExam [3], helping to save time and reduce staff stress by simplifying the number of workflow steps.

The technologist can initiate the exam with a single touch. Scanning begins immediately after the door is closed, and the system automatically centers, plans, scans and processes the resulting images. As a result, patient setup can be done in less than one minute, even for less experienced operators [4]. With this breakthrough in workflow, a fully automated MR exam is now one step closer.



Workflow innovations key to improving the experience of staff and patients

Research commissioned by Philips highlights the need for radiology staff empowerment and workflow-focused innovation. With pressure on imaging departments mounting amid rising patient volumes and a global shortage of qualified staff, improvements in workflow and efficiency, supported by data integration and AI, can improve the experience of staff and patients and, more broadly, enhance clinical outcomes while reducing costs.

Our evidence-based research approach and people-centric design thinking help facilities uncover new opportunities to improve the patient, family and staff experience. With over 1500 installations worldwide, Ambient Experience solutions can benefit many areas – from waiting areas and uptake rooms to procedure and recovery rooms and even entire departments.

Only MRI scanner with fully sealed magnet receives customer and industry recognition

The Ambition 1.5T MRI scanner is the industry's first and only commercially available fully sealed magnet for more productive, helium-free operations [1]. Since its launch last year, the breakthrough technology has received an enthusiastic reception from healthcare providers worldwide, reducing the chance of potentially lengthy and costly disruptions, and virtually eliminating dependency on a commodity with an unpredictable supply.

The fully-sealed system does not require a vent pipe and is around 900 kg lighter than its predecessor [5]. This significantly reduces the siting challenges presented by conventional magnets and is lowering construction costs.

The Ambition 1.5T MR was recently recognized by the U.S. Association for Medical Imaging Management (AHRA), winning its inaugural Innovation Award. Refer to page 6 to read about the excellent imaging results with Ambition at Miami Cardiac & Vascular Insitute. «

1 The Ambition 1.5T MR contains less than 0.5% of the helium of a conventional system and this is permanently sealed inside the device.
2 Using Compressed SENSE technology and compared to Philips exams without Compressed SENSE.
3 SmartExam is not available to patients with MR Conditional Implants.
4 Based on in-house testing.
5 Compared to the 1.5T ZBO magnet.

Miami Cardiac & Vascular Institute benefits from the advantages of Ingenia Ambition with BlueSeal magnet, designed for helium-free operation

Institute sees boost in MRI **quality, speed and patient comfort**

When it was time to replace its old MRI system, Miami Cardiac & Vascular Institute chose the Ingenia Ambition 1.5T scanner after evaluating several MRI systems. This "7-liter liquid helium MRI system" has delivered simple siting, workflow efficiency and many patient comfort features. Most important, however, was the superb quality of the images. Since its installation in 2018, the exceptional image quality provided by Ingenia Ambition has offered diagnostic confidence to the Institute's radiologists. The machine's outstanding performance has more than justified their choice.

"Compressed SENSE is not just faster imaging, it's a way to improve both image quality and scan time"

Quality, patient comfort and workflow drive purchase decision

"After scanning many thousands of patients with our Achieva MRI system, a 16-year-old magnet, it was time to investigate the latest technology," says Carol Melvin, Chief Operating Officer at Miami Cardiac & Vascular Institute, part of Baptist Health South Florida.

"Our aim is to offer patients the care that they need in a less invasive way, which is why diagnostic imaging is key to us," Melvin says. "Among our biggest challenges is staying current with technology that will enable us to maintain world-class care. But just because we had used a Philips system before didn't compel us to automatically acquire Philips again. We went through our due diligence and evaluated the MRIs of multiple vendors to ensure an informed decision. It was important that our physicians and technologists embrace the new system."

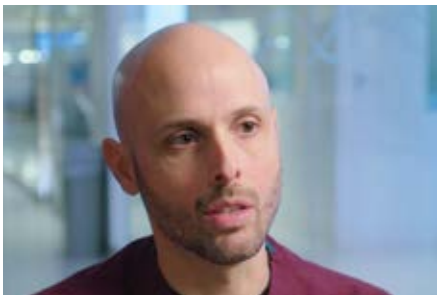
"Challenges facing us every day are how to maximize our image quality in order to answer diagnostic questions for our patients," says interventional radiologist Constantino Peña, MD, the Institute's Medical Director of Vascular Imaging. "In selecting an MRI machine, we wanted state-of-the-art technology that was easy to install, easy to use, and that would be easy on the patient. But most definitely, it had to give us high quality images. That's how we how we settled on the Ingenia Ambition."

Apart from its excellent imaging capabilities, several other factors ultimately led Miami Cardiac & Vascular Institute to select Ingenia Ambition. The industry-first fully sealed BlueSeal magnet contains just seven liters (v. 1,500 liters) of liquid helium and is completely sealed, so helium cannot escape, which helps increase operational efficiency. In addition, its light weight, small footprint and no need for a vent pipe simplify system siting.

According to the Institute's team, however, the most impressive attribute of Ingenia Ambition is a combination of speed and exceptional quality of imaging, workflow enhancers and patient comfort solutions that have been particularly beneficial in its first six months of operation.

Constantino Peña, MD

Interventional radiologist at Miami Cardiac & Vascular Institute who, as Medical Director of Vascular Imaging, also performs CTA, MRA, and noninvasive arterial examinations.



Carlos Avila, RT

Technologist at Miami Cardiac & Vascular Institute since 2004, who has been involved in building cardiac and vascular MRI for 11 years.

Carol Melvin

Chief Operating Officer for Miami Cardiac & Vascular Institute, Baptist Health South Florida.

"The ability to adjust Compressed SENSE to enable shorter breath-holds translates to a much smoother cine"

Compressed SENSE acceleration helps clinicians to balance speed vs. image detail

When asked about the most remarkable features of Ingenia Ambition, Carlos Avila, the Institute's Lead Technologist responds without hesitation: "The most impactful changes come from Compressed SENSE and mDIXON XD."

Compressed SENSE allows up to 50% faster* scanning. It works for all anatomical scan sequences and in all body areas. And, as always in MRI, scanning speed may be traded to obtain more anatomical detail, which may have even more impact at the Institute. The mDIXON XD methods provides robust fat-free, high SNR imaging and significant time savings in MR angiography (MRA).

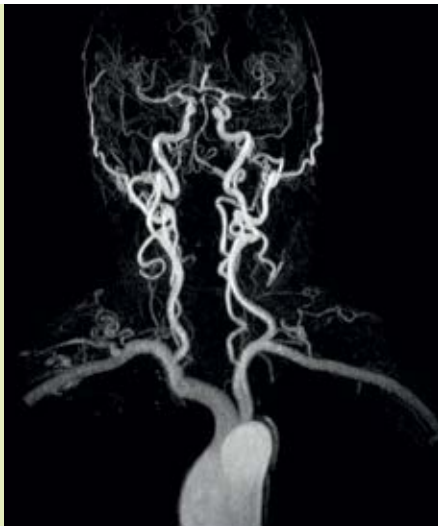
"High quality imaging has allowed us to move away from invasive angiography to noninvasive methods such as MRA. When relying on these types of images, it's important to have the best possible image quality," Dr. Peña says. "That makes the difference and allows us to determine whether someone needs to proceed to therapy or treatment and prevents us from needing a significant number of invasive procedures."

"Compressed SENSE is not just faster imaging, it's a way to improve both image quality and scan time – the user controls how to balance that. In some scans, we may want to acquire images quicker, while for other scans we want to use Compressed SENSE to increase resolution so that we see more detail," Dr. Peña says.

*Compared to Philips scans without Compressed SENSE

3D dynamic MRA of head and neck

Excellent image quality is obtained in this dynamic scan., C-SENSE factor 5.4, scan time is 1:20 min, voxel size is 0.8 x 0.8 x 1.6 mm, Ingenia Ambition, 1.5T.



Shorter breath-holds help patients and benefit diagnostic confidence

Owing to their condition, many patients at Miami Cardiac & Vascular Institute have difficulty performing breath-holds as needed, for instance in MRI cine scans of the heart and in MRA examinations.

Avila says that Compressed SENSE allows them to reduce breath-hold time to 3 to 4 seconds in cardiac cine scans. "At the same time, we can now – based on cardiac frequency – obtain as many as 30 to 40 cardiac phases without sacrificing resolution, while before Ingenia Ambition, we were acquiring only 20 phases.

"This ability to use Compressed SENSE for obtaining higher temporal resolution translates to a much smoother cine. This allows me to better assess heart function," Dr. Peña says.

"In MRA, the capacity to acquire a sequence in a single breath-hold provides images that are motion-free and high in contrast and detail, advantages that aid in diagnosis," he says. "With Compressed SENSE, we can reduce the time for the single breath-hold to just 2-3 seconds. Before Ingenia Ambition and Compressed SENSE, the breath-hold requirement was about 8 to 9 seconds, which was too long for some patients." »

MRA run-off study with mDIXON

The subtractionless peripheral MR angiography shows improved vessel-to-background contrast and high resolution. Ingenia Ambition 1.5T.

Station	Ingenia Ambition
Pelvis	Voxels 1.3 x 1.3 x 3.2 mm, FOV 430 mm, 125 slices
Upper legs	Voxels 1.3 x 1.3 x 3.2 mm, FOV 430 mm, 125 slices
Lower legs	Voxels 1.0 x 1.0 x 2.0 mm, FOV 430 mm, 125 slices

Subtractionless MRA run-off studies with exceptional spatial and temporal resolution

"In our peripheral MRA run-off studies with Ambition we realize key benefits, including outstanding image quality and significantly reduced breath-hold and scan times, which not only benefit the patient, but also provide the opportunity to add sequences that could aid in diagnosis," Dr. Peña says.

"Before we had Ingenia Ambition, our CE-MRA run-off studies would first acquire a dynamic pre-contrast scan with 20-25-second breath-holds, then inject the contrast, do another acquisition and then subtract the two," says Avila. "Now, mDIXON XD allows us to complete the study in just one single pass – without need for a pre-exam – which eliminates subtraction artifacts and almost halves the scan time. In addition, mDIXON provides much better background suppression, which really improves vessel-to-background contrast. And, thanks to Compressed SENSE, the single breath-hold is not long and we improve image resolution."

Time saved enables addition of useful diagnostic sequences

The time saved by Compressed SENSE and mDIXON XD is sometimes used to include additional sequences. An example are peripheral MRA studies, in which Compressed SENSE and mDIXON XD help achieve a 5- to 10-minute reduction in scanning time. This brings the total time down, from the 45 minutes needed with their previous system to about 30 to 35 minutes on Ingenia Ambition, thus providing ample time to include additional sequences.

"These scans are so fast now that we have been able to add a non-contrast MRA sequence within the same timeslot. We compare the respective image quality with the goal to determine whether the non-contrast sequence could be an alternative for patients who can't tolerate gadolinium contrast agents due to poor kidney function," says Avila. "We find the image quality of the non-contrast sequence so good that we can now also offer peripheral MRA to these patients whom we had been unable to serve before Ambition, so that has been great."

Another example is the foot examination for diabetic patients, which has improved dramatically. "The forefoot is generally difficult to image with MRI because of the inhomogeneities that the toes create – it's hard to obtain good fat saturation in that area. Here, mDIXON made a huge difference right away, we obtain much better image quality," Dr. Peña says.

"Because mDIXON XD provides subtractionless fat-free imaging, we get much better background suppression, which really helps the vessels stand out"

"Using mDIXON, Compressed SENSE and the dS FootAnkle coil, we have been able to reduce the scan time, so that we can now also include an additional 3D STIR sequence to visualize both arteries and veins in the foot."

Avila adds: "In addition, since most of these patients are in a significant amount of pain, it's important to perform the examination as quickly as possible. With Compressed SENSE and mDIXON we have been able to reduce the scan time from about 45 minutes to just 15 minutes. Not only does this improve patient comfort, we see that it also helps us acquire images without motion artifacts, which is critical to making a confident diagnosis."

High temporal resolution for detailed timing in MRA

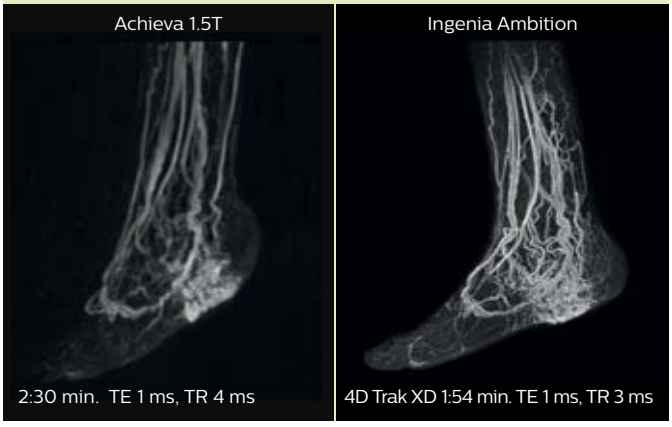
The team at Miami Cardiac & Vascular Institute also appreciates Ingenia Ambition's capabilities for fast dynamic CE-MRA. "With 4D TRAK XD, we get much better temporal and spatial resolution. Previously, with the Achieva we needed 6 seconds per dynamic, but now we can shorten that to 2 seconds per dynamic," Avila says. "As a result, we can see the transition from arterial to venous phase with much higher temporal resolution. This is important, for example, for imaging arteriovenous malformations, which are quite vascular."

"On our previous system we really had to sacrifice image resolution to get to 5- or 6-second temporal resolution, while now – using 4D TRAK XD on Ambition – we no longer have to sacrifice image quality," Dr. Peña says. »

"On our previous system we had to sacrifice image resolution to get to 5- or 6-second temporal resolution, while on Ambition, we don't have to sacrifice image quality"

MRA of foot using 4D-TRAK XD

The images obtained with Ingenia Ambition show large coverage and high, uniform signal. More vessels are visible than in a previous exam of the same patient on Achieva. The movies show a higher temporal resolution in the Ambition acquisition than in a previous Achieva 1.5T exam. Both exams use a FOV of 300 mm and voxel height and width of 0.78 mm.

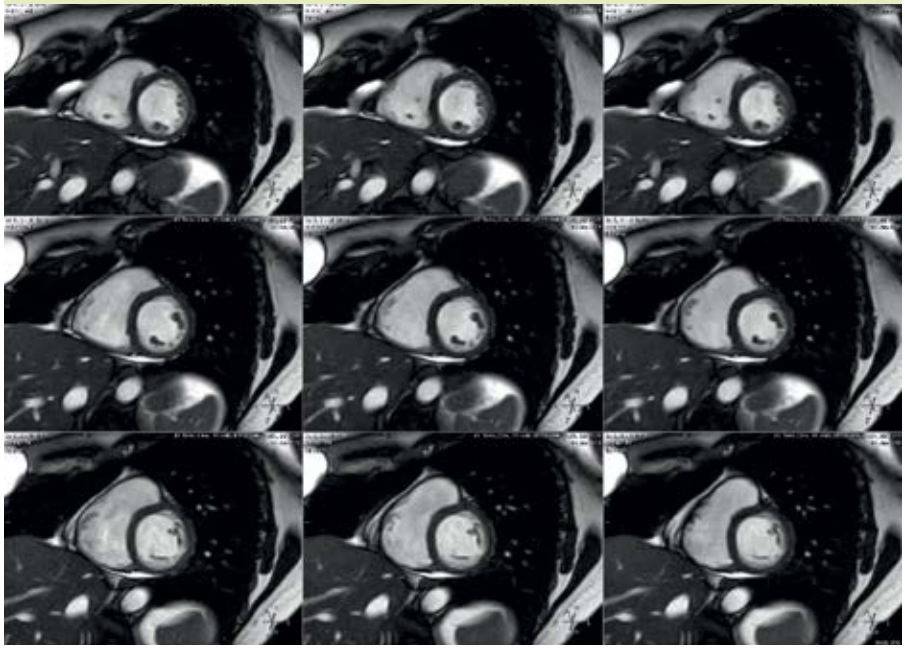


mDIXON MRA in chest

Performed on Ingenia Ambition.
FOV 430 mm, voxels 1.3 x 1.3 x3.0 mm,
130 slices, Breath hold 16.6 sec

Short breath hold cardiac cine

These are some images of a cardiac cine scan with a short breath-hold time. A high temporal resolution provides a smooth cine, which helps in assessing heart function. Ingenia Ambition.



"We used to have maybe two patients each week who we had to convince to have the scan. With Ambition that has become the exception"

VitalEye

VitalScreen

So many features that enhance patient comfort

"The ambient lighting, the wide bore diameter, the comfort mattress, the monitor in the back offering video and information during the scan, the sound reduction – all of it has made a big difference for our patients," Avila says. "Before Ambition, we would have maybe two patients each week for whom we had to take time to convince them to have the scan. That has become the exception now. Once we lay them down on the support, I can see it in their eyes – their anxiety level drops. I haven't turned away a patient yet."

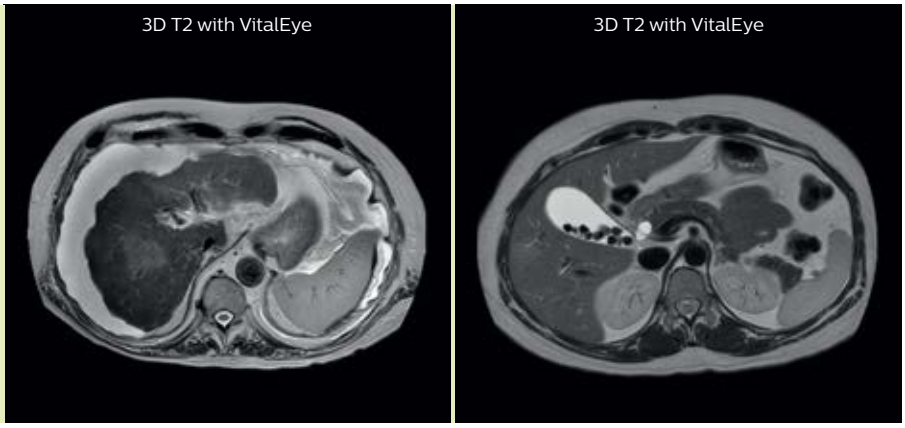
According to Avila, patients have been very positive across the board. "Many patients at the Institute require repeated MRI scanning. Some of them may have had an experience of feeling terrified in a previous MRI exam, but when they come to this new room, it's like a new post. Patients often spontaneously share comments about the comfort of the room and the system. They are happy about the conditions, the path through the machine and the visual experience."

He adds that the coil's tilting device also often helps to make the exam easier to undergo. "For patients who have shortness of breath, being able to elevate their head often helps them a lot. We can lift that tilt device all the way up and still put the mirror on, so patients can see outside of the bore," Avila says.

"Never before have we gotten so many comments from patients about how good their MRI experience was"

Free breathing abdominal MRI with VitalEye

Ascites can be hard to image, but excellent result is obtained with Ingenia Ambition. This high resolution image demonstrates the high quality that can be obtained with VitalEye and the patient just breathing normally. The acquisition time is fast thanks to the accuracy of the respiratory gating with VitalEye** and it also saves the time needed to put a respiratory belt on the patient.



Workflow tools for a challenging clinical environment

Ingenia Ambition came with tools that help Miami Cardiac & Vascular Institute technologists in streamlining their workflow. Both technologist and patient comfort benefit from VitalEye, a solution for detecting patient physiology and breathing movement, according to Avila.

"With VitalEye, we can get high-resolution acquisitions with the patient free-breathing. This is much easier for the patient than breath-holds. Moreover, it eliminates the longer set-up times needed for putting a respiratory belt on the patient and provides superior image quality**," Avila says. "VitalEye serves as a guide for us to trigger the acquisition and for the scanner to trigger the AutoVoice commands. Its high-quality reading of the patient's breathing patterns translates into sharper** images without breathing motion artifacts."

The Institute's technologists also save time by initiating scans with VitalScreen, the interactive touchscreen on the scanner that provides guidance and insights on the current patient study, such as exam duration, coil selection and patient positioning. "We can verify the patient's name, scanning orientation and the accuracy of cardiac gating," Avila says. "In addition to being able to control the bore lighting and fan, VitalScreen increases our efficiency by enabling us to start acquiring the initial reference images and scouts before we even walk out of the room."

Technologists are also happy with AutoVoice guiding patients through the MR study. "AutoVoice removes the task of giving breathing instructions from the technologist and thus allows us to focus on planning the exam," Avila says. "It's almost like the study is on auto-pilot – Ambition is doing the work. Plus, a diversity of languages is available, which is important in a large metropolitan area like Miami."

For Miami Cardiac & Vascular Institute, Ingenia Ambition excels with diagnostic quality and patient comfort

The Ingenia Ambition experiences at Miami Cardiac & Vascular Institute demonstrate that exceptional diagnostic capabilities, outstanding patient comfort and productivity attributes can co-exist on a single imaging platform.

"We've been pleasantly surprised with Ingenia Ambition – it's next-generation MR technology," Dr. Peña says. "When comparing it to our previous MR system, we notice that we improved by being able to include more sequences in a study and we see improved quality of many sequences."

"It's also remarkable that while Baptist Health has installed multiple different MRIs throughout the system, never before have we gotten so many comments from patients about how good their MRI experience was," Dr. Peña adds. "And, the combination of things like VitalEye, the comfort mattress and sequences such as Compressed SENSE and mDIXON have really made our patients' lives and our lives easier in this complex cardiovascular imaging environment. Ambition truly brings together all the most important aspects of a successful MRI service."

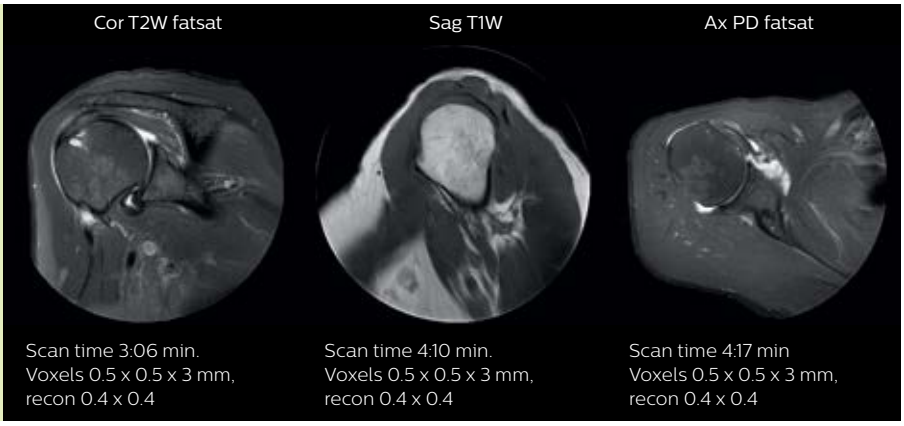
Avila echoes Dr. Peña's impressions and adds: "Our workflow has become much more efficient by replacing our former system with Ambition. We have faster exams, higher quality images, and less time inside the magnet overall."

COO Carol Melvin concludes: "We're thrilled to be the first in North America to have Ingenia Ambition. From what we've seen and demonstrated, Ambition enables us to perform really high-quality imaging, which is allowing us to take this institute to a higher level. It also has helped us decrease procedure time, which allows us to have slots open for additional patients." «

**Compared to Philips belt-based signal. Requires an unobstructed line-of-sight.

Shoulder with MultiVane motion reduction

MultiVane was used for motion reduction in this shoulder examination, providing excellent detail that is not obscured by motion artifacts, as happens quite commonly when no proper motion reduction method is available. Images from Ingenia Ambition.



Switching to Ingenia Elition has created new opportunities for MS imaging at the University of British Columbia

UBC researchers advance their **multiple sclerosis imaging**

One of the main research areas at the MRI Research Centre at the University of British Columbia (UBC), in Vancouver, Canada, is imaging of multiple sclerosis (MS). The center runs many studies and trials, and its researchers continually strive to improve and expand imaging methods to help in visualizing the disease and support diagnosis and monitoring. In this article, UBC researchers explain how their recently installed 3.0T MRI system, a Philips Ingenia Elition, helps them advance their MS-related research studies. At the same time, they feel this scanner makes their lives easier and surprises them with the impact it has on patients and volunteers.

Alex MacKay, DPhil

Professor of Physics, with a joint appointment in the Department of Radiology and the Department of Physics and Astronomy at the University of British Columbia, and Director of the UBC MRI Research Centre. He has been working with MRI since about 1988 with a main research focus on neuro.

Alex Rauscher, PhD

Associate Professor and physicist at the University of British Columbia. His research focus is on quantitative brain MRI and includes mapping tissue susceptibility, myelin mapping, and studying the effects of anisotropic tissue orientation on MRI.

Shannon Kolind, PhD

Assistant Professor and physicist at the University of British Columbia, currently working in the Department of Medicine, Division of Neurology. Her main goal is translating current quantitative- and biologicallyspecific MRI methods for use in clinical environment, in particular myelin imaging for MS.

Laura Barlow, RTMR

MRI Technologist Supervisor at the University of British Columbia MRI Research Centre, 3T facilities. She has been working with MRI for a decade. Her current role focuses on the field of advanced neuro research.

"Switching from our old scanner to Elition is like jumping from a flip phone to the latest smart phone"

Trends in visualizing and identifying MS lesions with MRI

At the UBC MRI Research Centre, which is currently staffed by 70 principal investigators, the majority of studies and clinical trials are brain research, with MS-related research as a principle area of interest. The center installed a 3.0T Ingenia Elition scanner in December 2018 as a successor of their Achieva 3.0T, with the intention to use it for all future research studies.

Multiple sclerosis or MS is a neurodegenerative disease that is characterized by myelin degradation, resulting in cognitive and motor deficits. According to Dr. Shannon Kolind, MR imaging for diagnosis and monitoring of MS is moving to higher field strength and using more 3D sequences, as reflected in the CMSC guidelines [1-3].

"In addition to traditional imaging like FLAIR for lesion identification, we see a real push towards techniques that weren't normally required for MS, including good high-resolution 3D T1-weighted images to do volumetrics. We've also started looking at spinal cord imaging again, since techniques have improved in terms of acquisition and analysis. Another important technique is susceptibility weighted imaging (SWI), particularly if we are looking for central veins in lesions, which is extremely helpful for diagnosis."

Boosting myelin imaging capabilities to help visualize MS progression

At UBC, a lot of the MS-related work focuses on myelin imaging. "We're born with very little myelin and that increases as the brain grows, which is important for nerve signal propagation. Multiple sclerosis on the other hand, degenerates the myelin with the opposite effect. So, myelin has a really important role in brain function, and having a tool that measures myelin can be extremely useful, we feel," says Dr. MacKay.

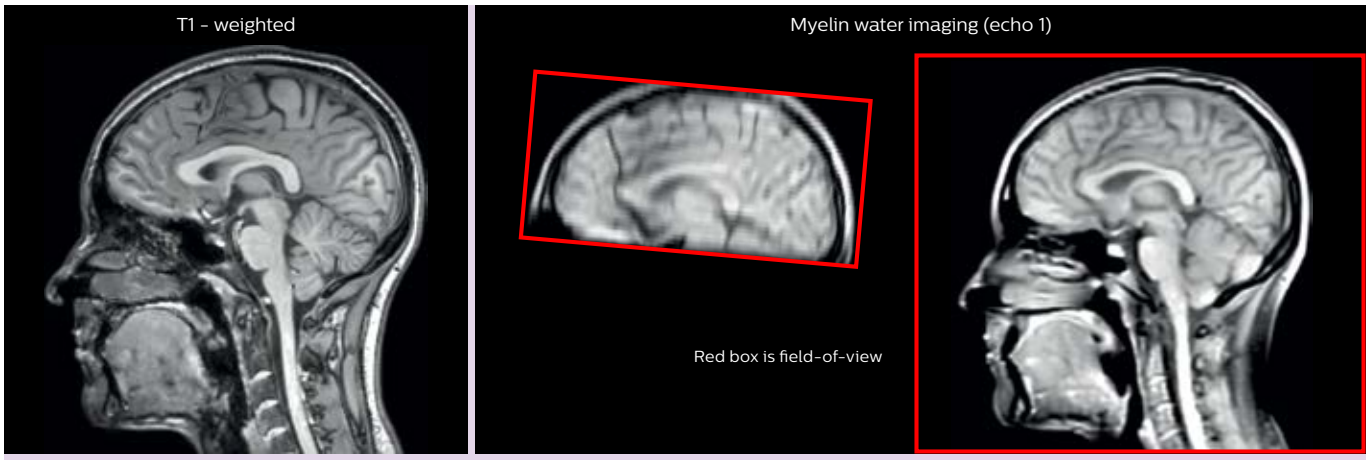
Myelin water imaging (MWI) is a breakthrough technique that was pioneered at UBC for measuring myelin content in the brain, in vivo. "Because the T2 time of water in myelin is much shorter than the T2 of water in the intra- and extracellular spaces, we can separate out the myelin water signal."

The techniques for measuring myelin have changed a lot over the years. "Since we are using the Elition, our myelin water images are much better. We're now acquiring 1 x 2 x 5 mm voxels and displaying at 1 x 1 x 2.5 mm. For a whole brain we can now measure the fraction of water in the myelin component in only about five or six minutes," Dr. MacKay says.

"We are actually starting to apply this technique in clinical trials," says Dr. Kolind. "And I'm really hopeful that this is going to give us more clues about the underlying disability progression in MS and move us towards some treatment options for that aspect of the disease."

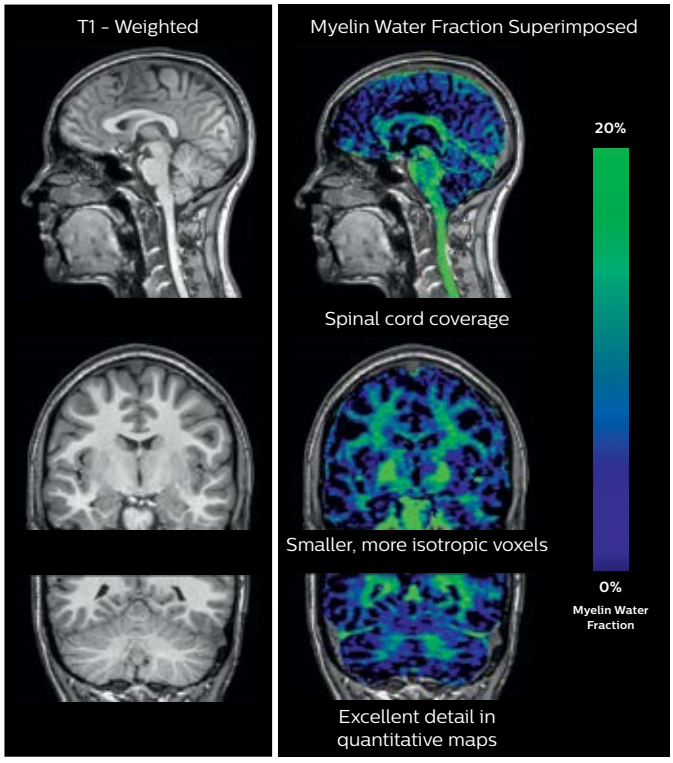
Dr. MacKay adds that researchers at UBC are also involved in trials to examine the effects of MS drug treatments on myelination. "In a way, we're providing a validation of the drug mechanism," he says. "Some treatments are designed to promote myelination and unpromote demyelination. We can see that some of these drugs are definitely having an effect on myelin water fraction in the cohorts we've been studying, and that's really exciting for us." »

"Since we are using the Elition, our myelin water images are much better"



Increasing resolution and coverage.
These images illustrate that instead of limiting MWI to the brain, even without the cerebellum, the team can now spend about the same amount of time and scan the whole brain and the cervical spinal cord, which is a huge boost for them.

Myelin water imaging	With SENSE		With Compressed SENSE
Acquired resolution	1 x 2 x 5 mm^3	→	1.5 x 2 x 3 mm^3
Number of echoes	32 or 48	→	56
Echo spacing	10 ms or 8 ms	→	7 ms



Images courtesy of Adam Dvorak, Department of Physics and Astronomy, University of British Columbia

Fast MWI scans with full brain coverage

Dr. Kolind says that Ingenia Elition has opened up a world of different options and features and it has been tremendously exciting to discover how these can benefit their protocols. "Switching from our old scanner to Elition is like jumping from a flip phone to the latest smart phone," she adds.

"The biggest jump is being able to turn on Compressed SENSE; it has definitely made sequences faster, allowing us to fit in more types of images. However, in most studies one or two scans are the main focus, so we can also stick to the time and apply Compressed SENSE to improve the resolution or even the coverage. For example, instead of limiting MWI to the brain, even without the cerebellum, we can now spend about the same amount of time and scan the whole brain and the cervical spinal cord, which is a huge boost for us."

Dr. Rauscher says, "For MWI we perform 3D T2 with 32 or more echoes. This used to take a long time, but with Compressed SENSE we can decrease this to ten minutes for the whole head. Because of the large field of view (FOV) on the readout direction, we even get information from the brainstem, which we previously missed when we were using the GRASE approach. Having the whole head scan is nice because it has spatial resolution, orientation and FOV that are comparable to the standard 3D clinical MS scans, including the FLAIR and 3D T2, and a 3D T1 for brain volume."

Researchers enjoy flexibility in adjusting sequences, even without pulse programming

The flexibility of the Elition scanner stands out in particular for Dr. MacKay. "Researchers want broad possibilities for manipulating pulse sequences, but getting into pulse programming takes a lot of time and training. Fortunately, the Elition console allows us to do an amazing number of things without going into pulse programming. Technologists or scientists who know the scanner well, can perform scans very quickly, faster

"Researchers want broad possibilities to manipulate pulse sequences. Fortunately, the Elition allows us to do an amazing number of things without going into pulse programming"

than on either of the other scanners we have." Technologist Laura Barlow agrees: "This system is far more intuitive than our Achieva in terms of navigating operator software; it's much faster."

Also Dr. Rauscher considers it a huge advantage that he can simply try things on the Elition that would require pulse programming on different MRI systems, such as their old Achieva system. "For example, adding pre-pulses or turning a conventional 3D T2 scan into an accelerated GRASE scan with multiple echoes have been very easy thanks to the enormous flexibility with the Elition's graphic user interface," he says.

"In the past, MWI scans were often limited due to time constraints," says Dr. Kolind, "because it was a difficult acquisition and complicated analysis. But with the Elition, we can perform MWI without having to do any programming modifications."

Gradient enhancements have a substantial impact on myelin imaging

For Dr. Kolind, the Elition excels in advanced neuroimaging for two main reasons. "It's image quality and access to so many different imaging parameters. We're involved in several multi-center studies, and we can always easily identify the images that came from our Elition scanner, because they are just so beautiful – even though it seems like we've set our parameters similarly to other study participants. And as a physicist, being able to do many things, for instance to push resolution and save time, is really helpful."

According to Dr. MacKay, MWI images benefit from Elition's high quality gradients. "We need good gradients because we want to be able to do multi-echo sequences that have short TE times."

Dr. Rauscher says, "With better gradients we can use a shorter echo spacing on the spin echo, so we get better sampling of the rapidly decaying myelin signal, which typically has T2 of around 10-20 milliseconds at 3 Tesla. If we can reduce echo spacing from about 8 to 5-6 milliseconds, we get a much better sampling of the short decay component and increase our SNR, which is a big advantage. The same is true for multi-echo gradient echo which we use for susceptibility mapping and for mapping venous vessels in MS."

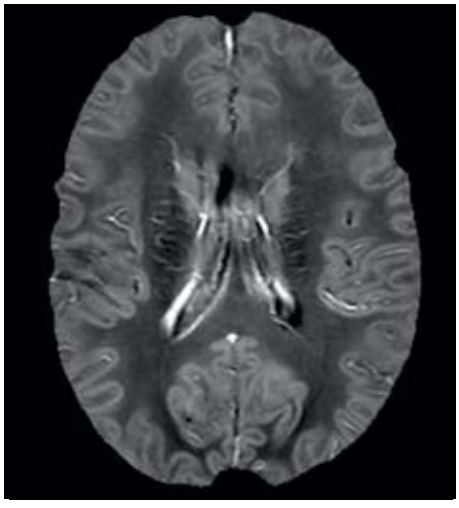
In practice, Ingenia Elition allows the team to do things now that were not possible before: "There are some scans that we didn't do before, because the scans were taking too long. With Elition we can combine scans that would have been prohibitively long on the old scanner. For instance, we can get the combined information from looking at advanced diffusion, multi-shell diffusion combined with myelin water, and then also add quantitative susceptibility mapping and get a better idea of tissue micro structure effects from all three combined. On the old scanner we only had time to run maybe one or two of these sequences in addition to the conventional scans," says Dr. Rauscher.

Accelerating scans helps researchers achieve their imaging goals

The Elition scanner at UBC has helped researchers decrease scan times and has paved the way for extended scanning possibilities. "We can now achieve more of our scanning goals in the same time," says Dr. Rauscher. "Patients can typically stay in the scanner for about 45 minutes. So, with the faster scan times, we can now add more scans into one session. »

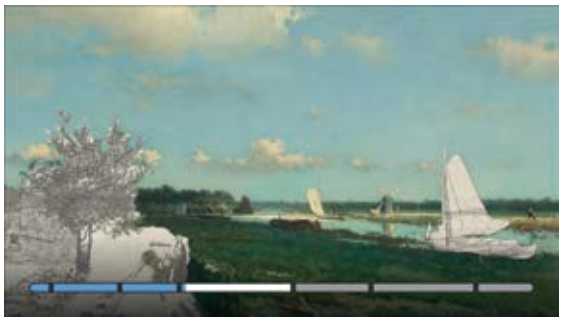
"We can now achieve more of our scanning goals in the same time"

Sagittal 3D FLAIR with 0.3 mm3 voxel volume acquired in 5:12 min. using Compressed SENSE showing a (juxta)cortical MS lesion.



QSM based on a Compressed SENSE multi-echo SWI.

"The progress bar tells patients how much time is left, the little clock shows when to do a breath hold. These may seem little things, but they make a big difference"



Ambient experience in-bore Connect

He says the accelerated scanning is achieved via the use of Compressed SENSE and MultiBand SENSE. "We can use Compressed SENSE acceleration factors of about 10 on a 3D FLAIR for instance, which is quite remarkable compared with what we saw with the Achieva. With 3D FLAIR, we can push the spatial resolution to 0.3 cubic mm and it works. Previously, our 3D FLAIR scans lasted about 8 minutes, but now with Elition they are five minutes. The SNR is also visibly better. Our SWI and QSM scans look fantastic. Also, since a lot of neuroimaging is EPI based, using the MultiBand SENSE technique can increase temporal resolution and make it possible to run complicated DTI scans relatively quickly."

Surprised by big impact on patient and volunteer comfort

The great impact of Elition's patient comfort features was a surprise for Dr. Kolind. "In our research projects we are working with many patients and volunteers. Their universal feedback has really been that it's just such a better experience than the previous scanner." Dr. Kolind thinks that the comfortable bed and the Ambient system all contribute to patient comfort. "Having control over the lighting and environment with the Ambient Experience seems to really give the patients a feeling that they have more power during the scanning process."

According to technologist Laura Barlow, many people are quite relaxed when they get off the table. Some explicitly mention that the comfortable mattress and added features, such as ability to see the scan's progress bar, also keep patients feeling satisfied with their experiences.

"One of our patients admitted to being very uncomfortable in previous MRI scans and had actually tried to avoid having clinical MRIs for four years. She had decreased mobility, so we brought her into the room using the FlexTrak trolley, and she remarked on how comfortable the mattress was. After her scan, she said it was the best MRI she'd ever had, and she would definitely come back and volunteer again."

Smart features help contribute to a quick workflow for patient preparation and scanning

According to Laura Barlow, the addition of the Elition scanner at UBC has resulted in impressive changes in daily workflow. "It's really easy to operate the scanner," she says. "Being able to drag-and-drop, having the middle mouse to scroll through the images, it's just so much faster than our previous system."

The staff also notices enhancements in patient preparation prior to scanning. "Bringing patients into the room and positioning them on the table is certainly fast now, since we can move the table without having to landmark with certain coils, and having the FlexTrak makes it easier to help patients on and off the table," Ms. Barlow says.

"The VitalEye wireless gating system makes things much easier, too. We tested it with volunteers who were instructed to move around during scanning, and it still performed very well, which was a nice surprise. Being able to set the scan to start as soon as we shut the door also improves the flow. The AutoVoice and progress bar cuts down on the amount of time we need to communicate with the patient, which also helps accelerate the scan time."

An excellent scanner for researchers and their study subjects

"Our decision to purchase Ingenia Elition was based on the image quality and ease of use," says Dr. MacKay. "We really feel that the images we get from the Elition 3.0T scanner are high quality and more artifact-free than what we see from other systems. Also, the console of the Elition allows our techs and

researchers to do an amazing amount of things without having to get into pulse programming. Just sitting at the console, you can do a remarkable number of things with this scanner."

"What we didn't foresee beforehand was how much patients would love the scanner," says Dr. MacKay. "They find it so much nicer to be inside the wide bore Elition with its Ambient and In-bore experience. They can see the progress bar that tells them how far they are in the protocol and how much time is left, or the little clock when they have to do a breath hold. These may seem little things, but they make a big difference, particularly because patients participating in trials or research studies often have to stay quite long in the scanner." «

References

1 Consortium of MS Centers, 2018 MRI guidelines, MRI protocol for the Diagnosis and Follow-up of MS, www.mscare.org

2 Hu XY, Rajendran L, Lapointe E, Tam R, Li D, Traboulsee A, Rauscher A. *Three-dimensional MRI sequences in MS diagnosis and research.* Mult Scler 2019 May 22:1352458519848100. doi: 10.1177/1352458519848100

3 Wiggermann V, Hernandez-Torres E, Traboulsee A, Li DKB, Rauscher A. *FLAIR2: A Combination of FLAIR and T2 for Improved MS Lesion Detection.* AJNR Am J Neuroradiol 37:259–65

4 Kames C, Wiggermann V, Rauscher *A Rapid two-step dipole inversion for susceptibility mapping with sparsity priors.* Neuroimage. 2018 Feb 15;167:276-283

Summary of experiences with Ingenia Elition at UBC:

- Compressed SENSE and Multiband SENSE allow acceleration of virtually every sequence
- Shorter scan times allow for additional sequences in an examination to provide more information
- Faster scanning allows for the use of 3D instead of 2D sequences to benefit diagnostic confidence
- Comfort features, such as the mattress, the progress bar and Ambient Experience help patients and study participants have a more enjoyable experience
- The FlexTrak, VitalEye, and AutoVoice features help streamline workflow

"Bringing patients into the room and positioning them on the table is certainly fast now, since we can move the table without having to landmark with certain coils"

Fondation Rothschild creates more time for advanced neuro exams by faster* scanning, thus boosting diagnostic confidence

Scanning faster* and have **more time for advanced MRI** techniques

When faced with the task of selecting two MRI scanners for a busy neurology clinic, Dr. Julien Savatovsky and his team looked for a system that could help them meet the increasing demand for MRI exams, and deal with declining reimbursements in France. After a balanced assessment of several systems, the quality of the images and the fast acquisition times of Ingenia Elition 3.0T led to the decision to purchase two Elition scanners. These have allowed the team to shorten scan times, and that enables Dr. Savatovsky to include more advanced sequences to boost diagnostic confidence.

The need for flexibility while maintaining a steady workflow

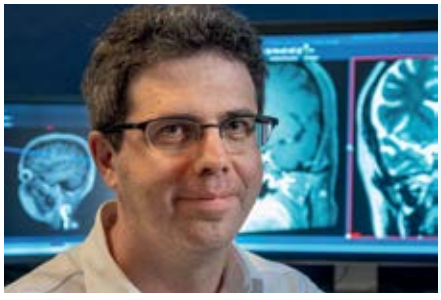
Fondation Rothschild, based in Paris, France, is a tertiary care hospital that performs specialized workups for patients presenting with neurologic, ophthalmologic, and head-and-neck diseases. They also provide first-line treatment for patients, as well as emergency care for acute stroke, ophthalmologic, and neurologic cases. The radiology department has been using four MRI scanners, including two Ingenia Elition 3.0T machines, since November 2018.

According to Dr. Julien Savatovsky, a diagnostic neuroradiologist at Fondation Rothschild, the increasing demands for MRI exams, decreasing reimbursements in France, and the need to perform advanced exams for complex patients requires fast, high quality scanning and efficient workflow. These challenges drove the decision to buy two Ingenia Elition 3.0T scanners.

From the beginning, the intention was to acquire two of the same machines. “We like the two MRIs to be interchangeable, so that we can easily switch a patient to the other device when we have to accommodate emergencies during the day”, says Dr. Savatovsky. “Another reason is that this allows our technologists to use both devices in exactly the same way and they only need to learn one user interface.”

Image quality and speed driving the Elition purchase

The choice for two Elition scanners was not made lightly. Dr. Savatovsky and his team compared devices from different vendors before making the decision. “Part of this process was our assessment of the image quality of different devices. We put together a list of sequences with detailed requirements, including limited acquisition times, to allow a fair comparison. We even put the same volunteer in each scanner. Our assessment was that the image quality was better with the



Julien Savatovsky, MD

Diagnostic neuroradiologist at Fondation Rothschild, Paris, since 2006. His clinical interests include advanced diagnostic imaging in neuro, head and neck, and ophthalmology.

“The main breakthrough for us was that Compressed SENSE and Multiband SENSE have allowed us to accelerate our examinations.”

Elition scanner. Compressed SENSE or Multiband SENSE was used for almost every sequence, and I think this helped a lot to maintain a great image quality in the shorter acquisition time."

Using speed for shorter exams or more information in the same acquisition time

According to Dr. Savatovsky, Ingenia Elition has an impact in virtually all examinations. "We can either make the scanning faster compared to our older Ingenia 3.0T, or we save enough time so that we can add sequences we wouldn't perform otherwise, or increase resolution. So, I think it has benefits for most of our patients."

"Some routine exams that we use every day have been shortened since we started using Elition. For example, we now use mostly a comprehensive stroke protocol (high b-value diffusion, fast 3D FLAIR, TOF, supra-aortic vessels angiography, SWIp, T1 post gad) that lasts 10 to 11 minutes, but our fast stroke protocol takes only 7 minutes. Our routine IAC needs about 10 minutes scan time and our comprehensive brain MS examination requires no longer than 13 minutes of scan time. Our ability to reduce acquisition times of most sequences helps to shorten total examination times, which in turn helps us to increase the number of patients we scan per day.

"The main breakthrough for us was that Compressed SENSE and Multiband SENSE have allowed us to accelerate our examinations. Alternatively, we can invest the time gained in obtaining higher spatial resolution to see more details, or we can add additional sequences," says Dr. Savatovsky. "That's a big improvement from what we did before."

Enriching examinations to boost diagnostic confidence

"We used to have long examination times for certain types of patients, a few lasting more than 40 minutes," says Dr. Savatovsky. "What is remarkable, is that now all these examinations are below 30 minutes, which opens up opportunity to add more sequences when needed. It's really hard to keep a patient for more than 40 minutes in the scanner, but because we have now cut scan times by at least 10 minutes, we can add more sequences without making the exam too long. And this is where the new system helps us make a difference. Examples include our examinations for informing brain tumor classification or giant cell arteritis workup, or for intracranial wall imaging – so in patients where we need several advanced sequences or high resolution sequences."

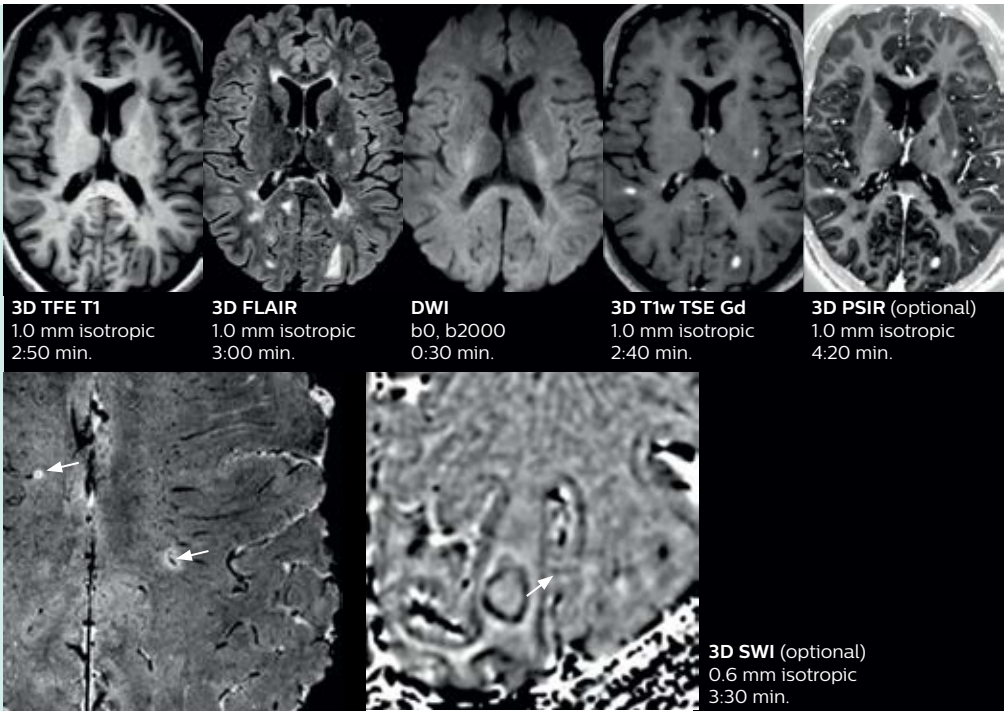
"We added three additional sequences in our brain neoplasm classification exam: a 3D SWI sequence, APT and ASL on top of 3D morphologic sequences, an isotropic DSC (dynamic susceptibility contrast) and multivoxel spectroscopy. I think that in patients that need a classification for brain mass, for example, we can provide a more detailed and confident diagnosis than before, allowing the clinicians to decide for either a medical workup if no tumor is suspected, or for neurosurgery as soon as possible if a neoplasm is suspected."

"In multiple sclerosis patients, we increasingly include a multishot susceptibility sequence [3] in our routine cases, thanks to the shorter scan times. Our abbreviated MS protocol for brain is »

Fast MS protocol with optional sequences

The abbreviated MS protocol for brain is only around 9 minutes, so in case of suspected multiple sclerosis, one or two more advanced sequences may be added, such as PSIR (phase sensitive inversion recovery) or susceptibility-weighted sequences to help us make more confident diagnoses in these inflammatory cases.

In this example, the optional 3D multishot susceptibility weighted sequence with 0.6 mm isotropic voxels is 2 lesions with a central vein sign (arrows) and one lesion with a phase-rim sign (arrowhead). The total scan time, including SmartBrain and axial PD/T2 3mm, is 11:10 min. and is 18:30 min. with the optional 3D PSIR and 3D SWI multishot included.



around 8 to 9 minutes, so we can ask for one or two additional sequences to visualize the central veins, or to get an additional contrast to better depict posterior fossa lesions. In cases of white matter lesions of unknown significance on FLAIR images, for example when we see high signal hyperintensities in the brain, we can add on more advanced sequences such as PSIR (phase sensitive inversion recovery) or susceptibility-weighted sequences to help us in distinguishing between MS and nonspecific or vascular abnormalities in these inflammatory cases."

Performing advanced techniques has a direct impact on hospitalizations

So, what is the actual impact of having more information and more diagnostic confidence? According to Dr. Savatovsky, "One of the indications I've seen where using Elition is most impactful is in patients with suspected giant cell arteritis. As an ophthalmologic hospital, we see many patients with suspected giant cell arteritis. Usually we were performing MRI to help us rule out an ischemic stroke, and to verify that the supra aortic vessels are undamaged. With Elition, we still do this, but now we can add on more detailed high-resolution black-blood sequences on superficial arteries. This provides us with high confidence levels for diagnosis of giant cell arteritis (GCA) and as a result, some patients are not sent for a biopsy anymore. A patient who has a normal MRI will not require a biopsy and can be discharged from the hospital in the same day. Before, such a patient would have to stay for about a week, just to find that their biopsy results were negative. We have at least three or four patients a week with suspected giant cell arteritis. For a great deal of these patients we can have a direct impact on their hospital stay."

A good workflow for excellent patient management

Dr. Savatovsky recognizes that throughput in an MRI center not only depends on scanning time, but also on the time needed by the technologist to position the patient and operate the MRI scanner. "Scan time in very short exams will last from 5 to 9 minutes. Our goal is to keep our average scan time under 15 minutes."

"The time needed for positioning the patient and the technologist's workflow depends on the device. We particularly benefit from the lightweight FlexTrak dockable patient transport system for patient preparation outside the MRI room, which we purchased with the Elition. Currently, patient positioning is quite fast, even for heavy or bedridden patients, because with FlexTrak the patient and coils can be installed in the preparation room and then be brought into the scanner room immediately after the previous examination ended." Other Elition features that support a fast workflow include the auto-start function that starts the scan as soon as the technologist closes the scanner room door.

Accommodating multiple emergencies per day

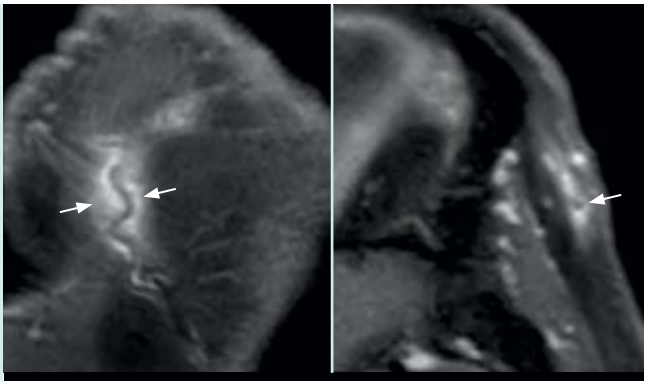
The MRI center at Fondation Rothschild receives several neuro and head/neck emergency cases per day. On weekdays, an average of 7 unscheduled patients will require scanning, with approximately 4 to 5 patients actually requiring an urgent MRI scan, according to Dr. Savatovsky. He notes that the ability to accelerate sequences while maintaining image quality is particularly important in the emergency setting.

"The fast scanning capabilities that came with Elition allow us to do a really quick examination and answer a lot of questions within a short time. We use every tool available to accelerate image acquisition while maintaining a reasonable image quality. So, for most of the sequences we use Compressed SENSE, for example, in our 3D FLAIR, in contrast-enhanced and noncontrast MR angiography, and for susceptibility-weighted sequences."

Among the emergencies that are routed to the MRI department at Fondation Rothschild, stroke is seen almost daily. "After arriving, acute stroke patients are immediately brought to the MRI preparation room and positioned on the FlexTrak table. There, the neurologist examines the patient and the biological workup is performed. Once this is finished, we can immediately move the patient with FlexTrak into the MRI and begin the scanning within one or two minutes. So, having the FlexTrak is a big advantage for us."

Giant cell arteritis

The 3D TSE T1w black blood MSDE sequence with fat suppression has an isotropic 0.8 mm voxel size and sagittal oblique and axial reformats are made. The images show superficial temporal artery thickening and peri-arterial fat infiltration. The 3D TSE PDw black blood MSDE with fat suppression has 0.55 mm isotropic voxels. The images shows focal involvement of the frontal branch of the superficial temporal artery.

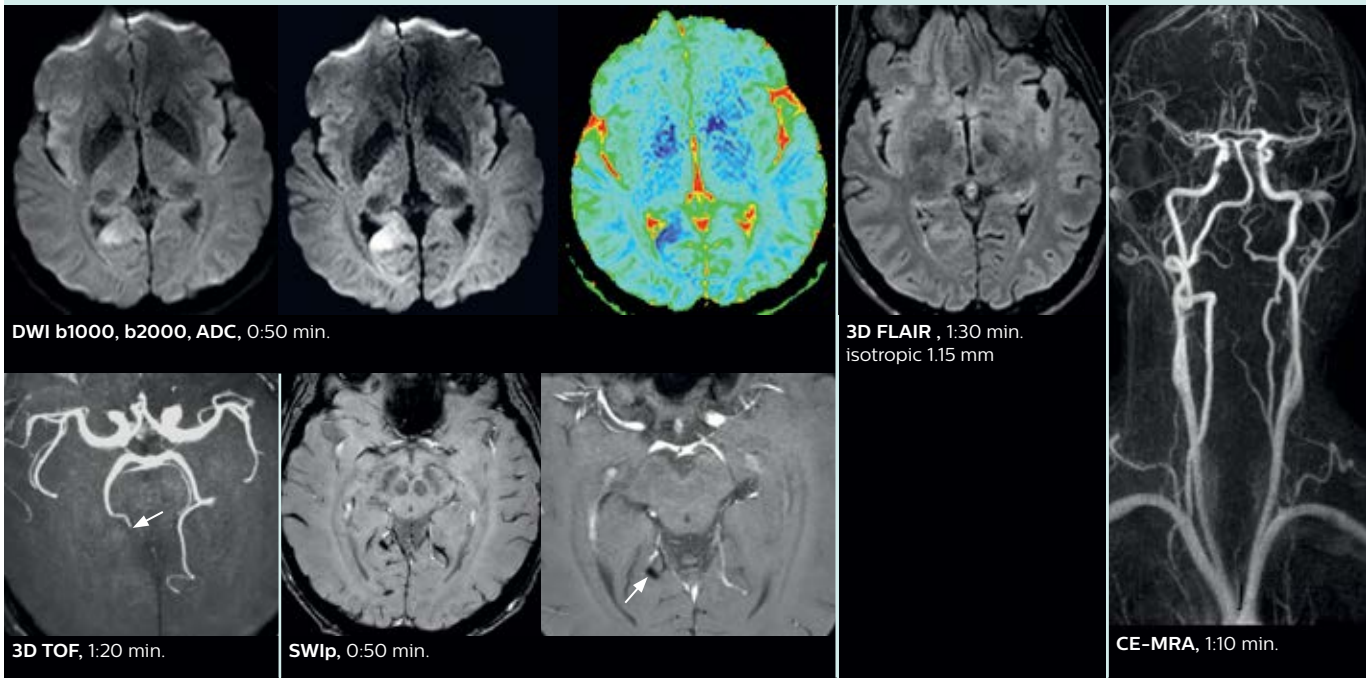


3D TSE T1w BB MSDE
0.8 mm isotropic, 4:40 min.

3D TSE PDw BB MSDE
0.55 mm isotropic, 4:30 min.

Fast acute stroke protocol

This is an example of acute ischemic stroke with distal occlusion of the right posterior cerebral artery. Note the improved visibility of the ischemic territory on the diffusion weighted image with high b-value. The 3D FLAIR shows a distal PCA occlusion. The fast SWIp depicts the thrombus on the isolated second echo image. The total scan time (including SmartBrain, preparations and a fast 3D T1w TSE Gd) is 8:00 minutes.



Comprehensive stroke MRI within acceptable time

Dr. Savatovsky appreciates the improvements and flexibility that Elition with Compressed SENSE and MultiBand SENSE provides, particularly for stroke patients. "For stroke, it allows us to cut about 5 minutes off of our stroke protocol, or to keep the same acquisition time and get more insights."

The ability to perform more sequences can help in making a swift and confident diagnosis. "For example, our stroke cases usually include the regular sequences that every center does (b1000 diffusion, FLAIR, time-of-flight angiography), but we also image supra aortic vessels, and we can replace a gradient echo sequence with a fast 50-second susceptibility-weighted sequence, and all of this doesn't add much time. because all the regular sequences are accelerated on Elition."

"The time savings with Compressed SENSE and MultiBand SENSE make it easier to add sequences to give us additional insights. Depending on the context and the first results, we might add a DSC perfusion to assess the ischemic penumbra, an ASL perfusion to help find an alternative cause in case of normal diffusion, or add a high-resolution T1 sequence for a stroke patient, to quickly assess wall imaging in emergency cases. The additional sequences can help improve patient management, because we can already consider some alternative diagnoses if the morphological MRI is normal."

Improved diffusion imaging in stroke patients

Using MultiBand SENSE allowed the staff to improve their diffusion quality. "Our diffusion sequence was already fast before, about 40 seconds. Now with Elition, it still lasts 40 seconds, but we improved the spatial resolution by 0.2 mm and use high b-values to be more sensitive to visualize changes related to acute stroke," says Dr. Savatovsky.

"We now also developed a high resolution DTI sequence (1.3 x 1.3 x 2 mm) that can be reformatted and takes 2 to 5 minutes depending on the coverage. We use it every time we have a doubt, or when we expect the diffusion to be abnormal but don't see that on the fast sequence. We occasionally spot small ischemic infarctions that would not have been visible with the regular diffusion sequence."

Excellent spine and spinal cord imaging

Looking for inflammatory lesions of the spinal cord is usually challenging with MRI, says Dr. Savatovsky. "We solved some of the challenges by implementing sequences such as 3D PSIR, which allows us to see far more lesions than the usual T2 imaging. We are starting to see cases where the MRI images at 1.5T were normal, but then we do see lesions when performing the PSIR at 3.0T." [1]

"Elition also performs very well in imaging of the bony spine, the discs and degenerative disease, especially now that we can include at least one 3D sequence in every scan. For example, »

we perform a lot of 3D spin-echo (TSE) sequences when imaging degenerative lumbar spines. Thanks to Compressed SENSE and the 3D SpineVIEW protocols, we have a very high signal intensity with no flow voids, so the image quality is very good. The possibility to reformat the images in every plane raises the diagnostic confidence, especially in patients who have to undergo surgery."

Increased patient throughput with higher resolution

Previously, about 30 patients a day were scanned on their Ingenia 3.0T, during a 15-hour opening period. With the Elition system, the average number of patients scanned per day increased by approximately 10%. "On a day where we only scan outpatients, we can scan 35 to 40 patients a day. Also, routine MRI cases, such as IAC, headaches workup, memory impairment, acute neurological deficit, and multiple sclerosis, last less than 15 minutes, which is appreciated by patients who prefer short examination times," says Dr. Savatovsky.

"Elition really makes a difference. For example, sequences that lasted 6 minutes a few months ago are now completed in 3.5 minutes."

Purchasing Elition was a wise decision

In conclusion, Dr. Savatovsky recaps the advances made possible by having the Elition scanners: "Many examinations are shortened, for more complex cases we can add advanced sequences or switch to higher resolution for improving diagnostic confidence. Emergency patients in particular benefit from the speed and efficient workflow associated with the FlexTrak patient transport system."

"The image quality for neurological cases is the most robust we've seen. If we compare examination time and image quality of a given sequence, like 3D TSE FLAIR, there is no question that the Elition performs really well. We are now also capable of performing multishot susceptibility and can perform PSIR sequences for spine and brain, which are not available on all systems. We can use Compressed SENSE for every sequence, whereas with other vendors this might be limited to a few sequences, only."

Looking back at the economic factors that contributed to his hospital's decision to purchase two Elition MRI devices, he notes: "Since reimbursement costs are decreasing, we had to calculate the number of patients needed to make an economically sound investment. Now we know that also from an economic perspective, purchasing the Elition MRI machines was a wise decision." «

References

1. Mirafzal S, Goujon A, Deschamps R, Zuber K, Sadik JC, Gout O, Lecler A, Savatovsky J.. *3D PSIR MRI at 3 Tesla improves detection of spinal cord lesions in multiple sclerosis.* J Neurol. 2020 Feb;267(2):406-414. doi: 10.1007/s00415-019-09591-8. Epub 2019 Oct 26.

2. Mohammed-Brahim N, Clavel G, Charbonneau F, Duron L, Picard H, Zuber K, Savatovsky J, Lecler A. *Three Tesla 3D High-Resolution Vessel Wall MRI of the Orbit may Differentiate Arteritic From Nonarteritic Anterior Ischemic Optic Neuropathy.* Invest Radiol. 2019 Jul 16. doi: 10.1097/RLI.0000000000000595. [Epub ahead of print] PMID:31335635

3. Sati P, et al; NAIMS Cooperative. *The central vein sign and its clinical evaluation for the diagnosis of multiple sclerosis: a consensus statement from the North American Imaging in Multiple Sclerosis Cooperative.* Nat Rev Neurol. 2016 Dec;12(12):714-722. doi: 10.1038/nrneurol.2016.166. Epub 2016 Nov 11. Review.

Summary of Dr. Savatovsky's experiences with Ingenia Elition 3.0T:

- Compressed SENSE and Multiband SENSE allow acceleration in virtually every Elition exam
- Scan times of most sequences were reduced with Elition without sacrificing diagnostic confidence*
- Workflow is fast and efficient, particularly in emergency cases
- More patients are scanned per system per day with Elition**
- Shorter scan times allow for additional sequences in an examination to provide more information and benefit diagnostic confidence
- Faster* scanning allows for the use of 3D instead of 2D sequences to benefit diagnostic confidence

*Compared to Philips scans without Compressed SENSE
**Compared to the Ingenia 3.0T

Faster* MRI examinations and **more comfort for patients**

Compressed SENSE acceleration helps Ikazia Hospital scan more patients

When their MRI waiting times continued to increase, Ikazia Hospital Rotterdam added Compressed SENSE software to their existing MRI scanner. This technology can accelerate MRI scans. It can be used for virtually all anatomical areas and with most sequences and contrast types. The team at the Ikazia Department of Radiology is delighted with the significantly shorter examination times, without loss of image quality. The radiology staff also noticed the impact on their workflow and on their patient's experience. »

*Compared to examinations without Compressed SENSE.

Mark Stoutjesdijk, MD

Has been a radiologist at Ikazia Hospital Rotterdam for 12 years.

Wim Boon

Has worked as MRI technologist at Ikazia Hospital for over 19 years.

Marieke van Noort

Is Head of the Radiology department at Ikazia. She has been working in radiology for 32 years.

"I believe Compressed SENSE is a must-have for every hospital"

Wim Boon, MRI technologist

Addressing the continuously increasing waiting times for MRI

According to radiologist Mark Stoutjesdijk, the hospital was facing an enormous capacity challenge for MRI in 2018. "We have one MRI scanner and our waiting times continued to increase, which made us quite uncomfortable. We were thinking about adding a second MRI scanner, but such purchase processes typically take at least one year."

However, technologist Wim Boon learned from a Philips application specialist that new scan acceleration software could be installed on their system. "The Compressed SENSE software is also available for older MRI scanners like our Achieva 1.5T dStream. That would allow us to scan much faster* without losing our image quality."

"We immediately recognized the potential to help us scan more patients," says Marieke van Noort, Head of Radiology at Ikazia. "During a demo, based on our own protocols, Philips showed us where we could save time, and that was very convincing. I immediately set up a working group, also involving radiologists, to thoroughly discuss the steps we would take."

A well-planned, step-by-step implementation

In December 2018, Ikazia Hospital Rotterdam was the first hospital in the Netherlands to add Compressed SENSE software to their existing MRI scanner. Compressed SENSE is an acceleration technology that combines 'compressed sensing' and 'sensitivity encoding'. It can reduce scan time for most MRI sequences and can therefore also shorten examination times. Although Compressed SENSE can also be used to improve quality, Mark Stoutjesdijk says that the team jointly made a clear decision to choose for time savings. "We could have exploited the other capabilities of Compressed SENSE, for example for increasing image quality, but that was already excellent. We really wanted to increase patient throughput, and we set specific goals for that."

"We have more than achieved our goals regarding patient throughput, it's really beyond our expectations."

"We first looked for the quick wins, the low-hanging fruit. For us, those were the knee examinations, which we had already clustered in the evenings and on Saturdays," says Wim Boon.

Mark Stoutjesdijk continues: "Together with my fellow radiologists, I mainly looked at the quality of the images in relation to the acceleration. It was important that we, as team, reached a consensus on what level of image quality was acceptable."

Knee exam time halved, more patients scanned

When asked whether the waiting list had disappeared six months after installing Compressed SENSE, the team was quite amused. Mark Stoutjesdijk explains, "We have more than achieved our goals regarding patient throughput, it's really beyond our expectations. Our knee examination times have been reduced from 30 minutes to only 15 minutes, and other examinations also take less time. On some Saturdays we scan as many as 26 to 30 patients. However, apparently increased capacity also creates new demand, so our waiting times are still the same, even though we scan many more patients."

Patients appreciate shorter exams

Although the main aim was to save time, the shorter study duration also benefits patients, according to Wim Boon. “Especially for patients who are anxious, a shorter time in the scanner is much more comfortable. Patients who have experienced the difference between an ’old‘ exam and our current exam with Compressed SENSE indicate that they find it much more pleasant.”

Impact is broader than just scan times

Installing the acceleration software on the MRI scanner has also brought about major changes in other areas. According to Marieke van Noort: “All of a sudden we see that patient change times play a role. In the past, our examination times were so long that the time required for taking the patient on and off the table didn't matter so much. Now, switching patients needs to happen quickly – the entire workflow has changed. We have also adjusted our patient information brochures accordingly.”

The introduction of Compressed SENSE also encouraged the radiologists to review the scan protocols, tells Mark Stoutjesdijk. “We went through our protocols to determine what we really needed to keep, and what we could possibly eliminate, which also resulted in time savings”, he says. “It is also important to involve the referring clinicians in such a process. After all, they need to be aware that the examination times have changed, and that they may have to request a different type of examination in some cases.”

Wim Boon adds: “It is important to realize that implementing this application has had a great impact on our patient flow. My job as a technologist has really changed. If a hospital is buying Compressed SENSE, the department should be aware of the broader influence it can have.”

Caring for patients paired with productivity

Despite high pressure on the department to limit waiting times and increase productivity, the interests of patients remain paramount at Ikazia. “That’s what I like about my job,” says Wim Boon. “It is technical, but the success of an examination largely depends on how we guide patients through it – because they are often quite tense.”

“Our patients should not notice that we are very busy. When patients are quite anxious or stressed, we take the time to help them feel comfortable enough to undergo the scan,” says Marieke van Noort. Wim Boon adds “The fact that examination times are now considerably shorter also helps.”

“I think that in our hospital, we look carefully at how we can deliver good care in an efficient way,” says Mark Stoutjesdijk.

Highly recommended to others

When asked whether they would recommend the Compressed SENSE acceleration software to others, the three interviewees were unanimously enthusiastic. “I have already been consulted by another hospital and I could only confirm that we achieved everything that we expected,” says Marieke van Noort. Wim Boon thinks that “It is a must-have for every hospital” and Mark Stoutjesdijk concludes by saying “The quality of the images is excellent. And every minute in the MRI room is valuable, so the less time spent, the better.” «

“We look carefully at how we can deliver good care in an efficient way”

Karen Hackling-Searle,
Head of MRI

Ruth Pearson,
Training Facilitator, MRI Radiographer

Zoe Wray,
MRI Senior Radiographer

Accelerated MRI examinations helped to increase productivity, allowing up to 20 additional patients to be scanned each week.

Compressed SENSE pilot reaps rewards for Cobalt

In September 2018, Cobalt was the first imaging facility in the UK to install Compressed SENSE in a clinical setting. Over a three month trial period, the team has been able to scan an additional 17-20 patients per week compared to the same period in the previous year, using the same Ingenia 3.0T scanner. The time gain with Compressed SENSE was also used to increase spatial resolution in anatomies where this matters, for instance in breast imaging.

"Cobalt saw its diagnostic imaging services reduce their MRI examination times by up to 30–50%, accommodating up to 20 additional patients per week as a result."

Cobalt: innovation in imaging

Cobalt is a charity that invests in equipment, research and education to enable patient access to the best technology and medical imaging services. Cobalt and Philips have enjoyed a strong collaboration since 1993 when the first 0.5T MRI scanner in a mobile unit was provided to support patients in Gloucestershire, Herefordshire and Worcestershire. Since then Cobalt and Philips have collaborated on a number of memorable firsts, including the UK's first 1.5T MRI in a mobile unit, first 1.5T Ingenia mobile, and first 3.0T Achieva TX and Ingenia MRI mobiles. The team at Cobalt is primarily focused on medical diagnostic imaging and believes that all patients should have access to the very best equipment while helping doctors to make a clear diagnosis, and an appropriately personalized treatment plan. The Imaging Centre in Cheltenham remains at the forefront of diagnostic imaging technology.

Over 75,000 patients are seen each year, both at the Imaging Centre in Cheltenham, at the Institute of Translational Medicine (ITM) Imaging Centre in Birmingham and with the mobile MRI and CT scanners that travel nationally. To meet the increasing demand for MRI capacity within the clinic, Cobalt introduced the Philips Compressed SENSE technology on their Ingenia 3.0T during September 2018. This made Cobalt the first imaging facility in the UK to use Compressed SENSE in a clinical setting, over a three month period.

Adapting to the acceleration software and steps taken to increase impact

News regarding the Compressed SENSE pilot generated excitement amongst the team. Karen Hackling-Searle, Head of MRI, says: "We discussed Compressed SENSE with the radiographers and highlighted this was something new with the potential for measurable benefits for our patients. A core group of radiographers really embraced the trial, in the hope that we'd see some tangible benefits."

"In fact, the transition was indeed seamless, as the radiologists did not notice the changes made, and continued to report as if nothing has changed."

Rather than changing all the scanning protocols immediately, several routine body areas were chosen for dedicated Compressed SENSE scanning sessions. Where possible, body areas were block-booked to reduce set-up time and increase the throughput.

Dedicated sessions also gave the team time to review the patient pathway from reception arrival, through preparation to scanning and patient release. This was to arrive at efficient workflows to turn patients around in shorter appointment slots, whilst continuing to maintain the same level of care and support.

Patients were asked to arrive earlier at the clinic and measures were taken to accommodate additional car parking requirements, owing to the increase in patients arriving during the Compressed SENSE sessions. The team recognized a need for additional staff to guide the patients through the pathway and arranged for a dedicated Imaging Assistant to the Ingenia 3.0T scanner.

A core team was established to set up and optimize scanning protocols. This gave them ownership of the task, and authority to develop the protocol as was necessary, whilst maintaining high image quality.

When developing protocols, the team had to take care that there was no compromise on image quality and that the transition to new protocols was seamless. In fact, the transition was indeed seamless, as the radiologists did not notice the changes made, and continued to report as if nothing has changed.

"Cobalt strive for innovation and improving the patient pathway. With that in mind, we always have our eye open for anything new to achieve this. With Compressed SENSE there will be a lot of discussions across the whole MR world about this technological advance in MRI acceleration technique," says Karen Hackling-Searle. »

"Now with the Compressed SENSE technology, we can get more detail and scan faster"

Growing pressure on imaging services

Over a four-year period, the number of Magnetic Resonance Imaging (MRI) scans being performed annually in England has grown by 8.9% (from 2.35 million in2012/13 to 3.36 million in 2016/17)[1]. This is compounding pressures on radiologists. Figures suggest their workload has increased by 30% during a similar period (2012–2017) [2]. There is also an ongoing, nationally recognized shortage of diagnostic radiographers, particularly those specializing in MRI and CT [3,4].

This increased workload is having detrimental impacts on the radiology workforce, with radiologists and radiographers showing signs of stress and burnout, in part due to longer working hours – a factor in taking an early retirement or a change in career [5]. The use of MRI is predicted to increase further, owing to an increase in chronic conditions and continuous pressures on healthcare systems [6]. These findings underline a need for increased efficiencies in imaging services in the UK.

The Ingenia 3.0T with Ambient Experience lighting in situ at the Cobalt centre. The Ingenia 3.0T provides an immersive in-bore visual experience.

References

1. NHS England, 23 November 2017. *Diagnostic Imaging Dataset Annual Statistical Release 2016/17.* Available at: Diagnostic Imaging Dataset Annual Statistical Release 2016/17

2. BBC, 22 August 2018. *Radiologist shortage 'affecting cancer care' in the UK*. Available at: bbc.com/news/health-45275071 (accessed 2 July 2019)

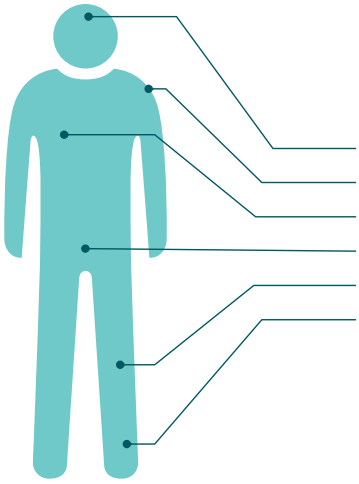
3. The Society and College of Radiographers, May 2019. *UK Workforce Census 2018 report.* Available at: www.sor.org/learning/document-library/diagnostic-radiography-workforce-uk-census-2018 (accessed 2 July 2019)

4. The Society and College of Radiographers, 6th November 2018. *BBC interview with Society CEO highlights radiographer workforce shortage.* (accessed 2 July 2019)

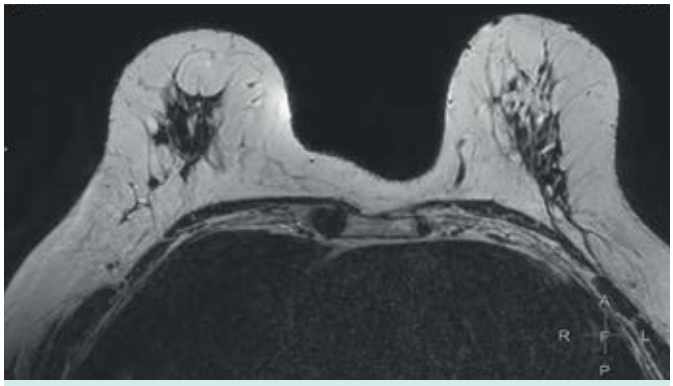
5. Royal College of Radiologists, April 2019. UK Workforce Census 2018 report.

6. www.businesswire.com/news/home/20190801005481/en/Global-Magnetic-Resonance-Imaging-Market-Drivers-Restraints

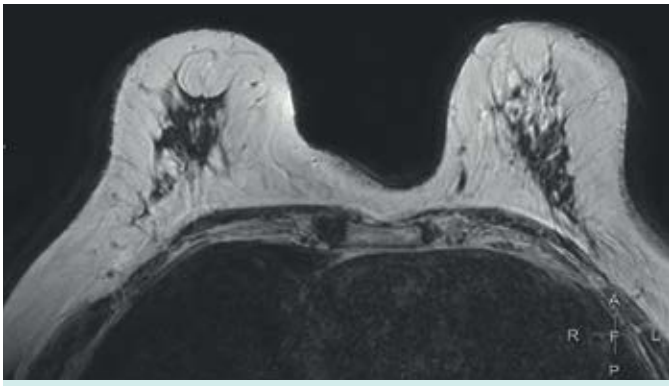
7. *Cobalt.* Available at: www.cobalthealth.co.uk (accessed 2 July 2019)



	Original examination time	With Compressed SENSE	Time saving [%]
Brain	13:45 min	8 min	5:45 min [42%]
Shoulder	17 min	9 min	8 min [47%]
Breast	6:32 min	3:54 min	2:38 min [40%]
Lumbar spine	21 min	16 min	5 min [24%]
Knee	11:42 min	5:57 min	5:45 min [49%]
Ankle	22 min	13 min	9 min [41%]



Compressed SENSE, scan time 3:54 min, C-SENSE factor 12
Voxels acq 0.8 x 0.72 x 1.8 mm, recon 0.63 x 0.63 x 0.9 mm



SENSE, scan time 6:32 min, SENSE factor 3
Voxels acq 0.8 x 0.8 x 1.8 mm, recon 0.63 x 0.63 x 0.9 mm

Increasing productivity and diagnostic confidence

The team were able to scan an additional 17–20 patients per week, compared with the same period in the previous year. The increased throughput meant that the staff had to be more prepared in terms of moving the patients through the system efficiently.

"I would definitely say that throughput has been helpful to our breast list. Prior to Compressed SENSE we were scanning up to seven patients, we're now able to scan up to nine patients within the same time period," says Zoe Wray.

The time gain with Compressed SENSE was also used to increase resolution in order to help radiologists identify the tumor characteristics more confidently which may be used for a more personalized treatment. For example, in breast imaging, resolution is crucial for visualization of very small lesions. Compressed SENSE allows to scan thinner slices, allowing a 3D isotropic sequence which can provide increased diagnostic confidence for the radiologists.

"The 3D-THRIVE sequence has proven to be important in providing detailed post-processing data to inform on diagnosis and how we care for the patient," says Ruth Pearson. "Normally, if you want more detail on an MRI scan, the scan takes longer. Previously we've had to balance between getting the detail required and how long the patient can lie still. Now with the Compressed SENSE technology, we can get more detail and scan faster."

Enhanced patient experience

Compressed SENSE in combination with In-bore experience and the Ambient lighting is a combined approach that can help relax patients, supporting the high levels of compliance and a successful scanning to support confident diagnosis. The radiographers feel they did not need to spend so much time encouraging anxious patients on and into the scanner during set up, which allows a quicker examination, often with less movement issues, which helped in keeping the day list schedule on-track.

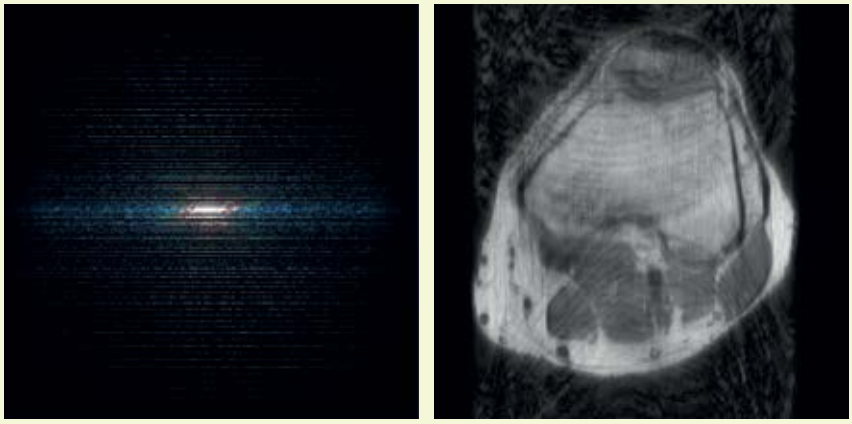
Zoe Wray, also adds: "It's better for the patient in that they're not having to stay still as long and they're not having to stay in the scanner longer than required either, which can help improve the experience." Other groups who are likely to benefit include those suffering with pain, and children where keeping still for an examination is challenging. «

Understanding how Compressed SENSE makes **MRI faster**

Compressed SENSE is the latest Philips MRI acceleration method, based on our industry leading dStream architecture. Compressed SENSE further expands the performance of dS SENSE, making MRI scans up to an additional 50% faster*, with virtually identical image quality. Alternatively, Compressed SENSE can increase the image resolution up to 40% within the same scan time. Compressed SENSE can be applied to all anatomies and works for both 3D as well as for 2D MRI acquisitions, making it a powerful asset for almost all clinical MRI exams.

The Compressed SENSE principle in pictures

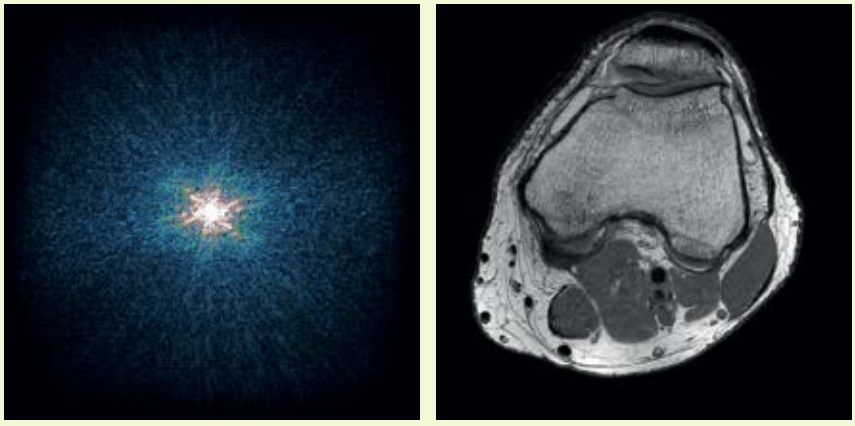
Basic compressed sensing principle



k-space | image

In this example, only one fifth of the required MR radiofrequency signals is recorded. This results in a five times faster acquisition, with a subsampled k-space (left) and inherent image artifacts after standard reconstruction (right).

Philips Compressed SENSE



k-space | image

The Compressed SENSE reconstruction uses iterative, knowledge-based algorithms to fill in the empty lines in k-space (left). This removes the artifacts while keeping the final image fully consistent with the acquired data (right).

*Compared to Philips MR exams without Compressed SENSE

Compressed sensing vs other acceleration methods

Compressed sensing is a term from the field of digital signal processing. When a signal is digitally sampled, like it happens in an MRI scanner, the signal is not recorded continuously (like old cassette players used to do) but at intervals. A famous theorem from digital signal analysis, the Nyquist theorem, states that for constructing a perfect MR image of 256 x 256 pixels, it is required to sample 256 lines in k-space, each sampled in 256 positions. By doing less, the acquisition will be faster, but the reconstructed image will always be distorted one way or another.

This is exactly what happens with traditional acceleration techniques in MRI, such as halfscan, radial, spiral, increased voxel size and parallel imaging. All of these methods skip parts of k-space during acquisition in order to reduce acquisition time. However, there will always be a penalty: either a reduced signal-to-noise ratio (halfscan, parallel imaging), lower image resolution (increased voxel size) or image artifacts (spiral, radial).

Compressed sensing is not different, but in practice it is often more forgiving than other acceleration techniques in terms of image distortion and SNR, because it can be designed to primarily sample the MR signals that matter most, while leaving out the rest. A unique aspect about compressed sensing is that it can bypass the aforementioned Nyquist theorem: although not enough samples are taken for perfect image reconstruction, a good compressed sensing reconstruction can successfully remove the inherent artifacts and produce excellent diagnostic images.

Philips Compressed SENSE for faster MRI without sacrificing image quality*

Compressed SENSE is the Philips implementation of the compressed sensing principle. It combines dS SENSE, our industry leading parallel imaging method, with compressed sensing. As a result, it can reduce the scan times by up to 50% compared to current examinations without Compressed SENSE.

Philips Compressed SENSE is unique for various reasons:

- Compressed sensing reconstructions can be done in many different ways. Our algorithm uses a priori information from system calibration data, anatomical knowledge and general MRI principles. All of this information is carefully balanced to reconstruct the best possible MRI image quality, whilst keeping it consistent with the measured MRI data.
- Traditionally, the time gained with a compressed sensing acquisition is lost again during image reconstruction, which is typically very long, and requires careful parameter optimization by the user. Not so for Compressed SENSE, which typically reconstructs under a minute, without the need for complex user interactions, nor dedicated reconstruction hardware. This pulls it out of the research realm straight into clinical practice.
- Thanks to our unique dS SENSE infrastructure we have full k-space sampling flexibility for our compressed sensing algorithms. This means that Compressed SENSE, unlike other solutions on the market, has the full freedom to optimize k-space sampling for best SNR and sharpness, without any restrictions whatsoever.
- As a result of this flexibility, Philips Compressed SENSE can be applied to both 3D and 2D MRI acquisitions, making it applicable to most clinical routine MRI scans. «

Building **MR-simulation competency** in radiotherapy

Starting from scratch, The Christie develops a MR-sim education and training program for proton beam radiotherapy service

In the development of the National Health Services' first high energy proton beam therapy (PBT) center at Manchester's The Christie Hospital, acquisition of a dedicated MRI system for PBT planning was essential. MRI can provide exceptional soft tissue visualization for precise target and organs-at-risk (OAR) delineation for treatment planning and monitoring on-treatment variation – an imperative for safely delivering proton therapy.

However, integrating MRI in a radiotherapy department presented a challenge – radiotherapy personnel typically have little or no experience in safely and effectively operating in an MRI environment, while diagnostic radiographers have no or limited exposure to the needs of pre-treatment radiotherapy. To enable the safe, smooth implementation of an MR-sim Service, the Christie team developed and executed a training and education program for all PBT employees.

Starting at ground zero with MRI

While The Christie's Ingenia MR-RT 1.5T system was to be the centerpiece of the new PBT facility's pre-treatment workflow, establishing an imaging staffing model for the department and training those who would operate the MRI were major hurdles that department administration would need to overcome. "The biggest problem was a lack of knowledge, experience and training," says Thomas Edwards, Principal Radiographer at The Christie, who led the team in developing education and training. "Therapeutic and Diagnostic Radiographers in the UK are on completely different educational paths so each group knew little about the other's profession, yet the expertise of both roles was required for safe, competent pre-treatment imaging. Cross-training was clearly needed."

This challenge is further complicated by the fact that although in the UK there are non-compulsory post-graduate MRI qualifications, the approach to educating even diagnostic radiographers in MRI falls heavily on individual departments to set standards in MRI training and education. This makes it difficult to know where to start in a radiotherapy department. "The Society of Radiographers (SCoR) indicates, for example, that an individual who can scan with MRI is 'An authorized person deemed to have sufficient experience (knowledge and skills) and appropriate training and is responsible for operating the scanner in a safe and appropriate manner,'" he says. "The challenge was, that there was no guidance as to what defines that 'knowledge' during the development of our service. However, this is changing, and a working party has been developed by the Society to publish guidance and an overview of the educational and professional requirements for safe, effective use of MRI in radiotherapy for the purposes of simulation and on-board radiotherapy guidance."

"The biggest problem in ensuring the safe and smooth implementation of an MR-sim service was a lack of knowledge, experience and training"

Thomas Edwards is pre-treatment principal radiographer for protons at the Christie NHS Foundation Trust. He has worked in radiotherapy for 16 years, specializing in radiotherapy imaging. He was involved in the development of the Christie Proton service and supported various aspects of the implementation, including procurement of the service's Ingenia MR-RT 1.5T system, service development, recruitment, training and service provision.

The Christie NHS Foundation Trust in Manchester, UK, is the largest single site cancer centre in Europe, treating more than 44,000 patients a year. The centre has access to 15 linear accelerators and offers both proton beam therapy and MR-guided therapy.

"Therapeutic and Diagnostic Radiographers in the UK are on completely different educational paths so each group knew little about the other's profession"

First steps in building MR-sim competence

A full year before the complete pre-treatment staff were hired and ready for training, Edwards became involved in acquiring the MRI system in a competitive tender process. To facilitate this process, Edwards recruited Lisa McDaid, a diagnostic radiographer with abundant MRI experience to join the standard procurement team, which included a physics lead, radiotherapy engineer, MR physicist, radiologist and a project manager.

"Since I had very little MRI experience, we needed to hire someone to help us procure the system," he says. "Lisa's MR oncology experience and her familiarity with a variety of MRI systems was invaluable in evaluating modern MRI scanners."McDaid also played several other key roles after the Ingenia acquisition and prior to recruitment of the PBT diagnostic superintendent radiographer and MR responsible person.

These included ensuring that The Christie was aligned with "MR local rules" governing regulatory requirements for safety in the PBT department; helping recruit the therapeutic and diagnostic radiographers comprising the permanent PBT pre-treatment team; assisting in identifying training needs; safety training; and developing the initial sequences with the Philips applications training team and other pre-treatment team radiographers.

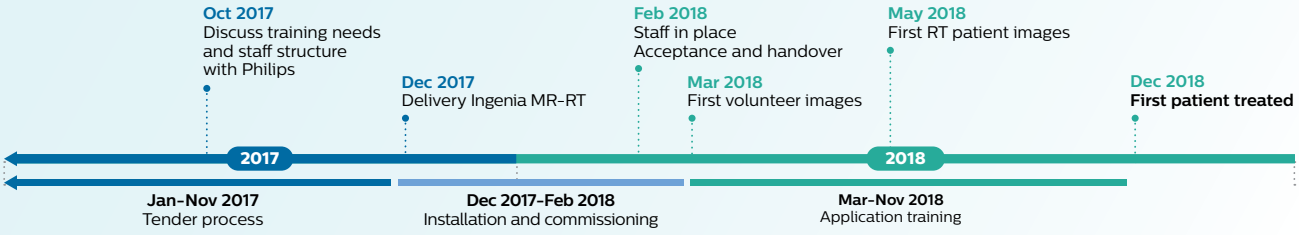
With the delivery of the Ingenia MR-RT in December 2017, the clock started for the clinical go-live of the PBT center. "The machine had to be installed, tested and commissioned and we still had to recruit many of the pre-treatment staff members before we could start applications training," Edwards says."The schedule was very tight. Our first patient was planned for December 2018, which left only nine months to complete training."

Determining a staffing model

The Christie proton project team and NHS had worked together to define the PBT center's staffing model, including the make-up of the pre-treatment staff who would operate the MRI system.

"We decided that we should always have a 50-50 split of diagnostic and therapeutic staff," Edwards says. "And, as we came to post and started looking at staffing and anticipated workload, The Christie team agreed that we needed to have a mix of both professions, and that ideally each group needed to be cross-trained in MRI and radiotherapy to create hybrid MR-RT radiographers. We always assumed that MR scanning would require a collaborative practice, so at minimum there would be one diagnostic radiographer and one therapeutic radiographer at any time to scan the patients." »

Timeline of building MR-sim service at The Christie



"The didactic and hands-on Philips applications training was really well structured"

View the extended online article for more detailed information

MR-RT applications training: the first form of competence

Two months before the delivery of the Ingenia MR-RT, The Christie team met with Philips representatives to confer on staff structure and training needs for the diagnostic and therapeutic radiographers.

By February 2018, the Ingenia system was commissioned, fully accepted and handed over, and the staff had been recruited and hired – a complement of three therapeutic and three diagnostic radiographers. Philips application training began in March, first for the physicists, engineers and dosimetrists, then for the permanent pre-treatment staff.

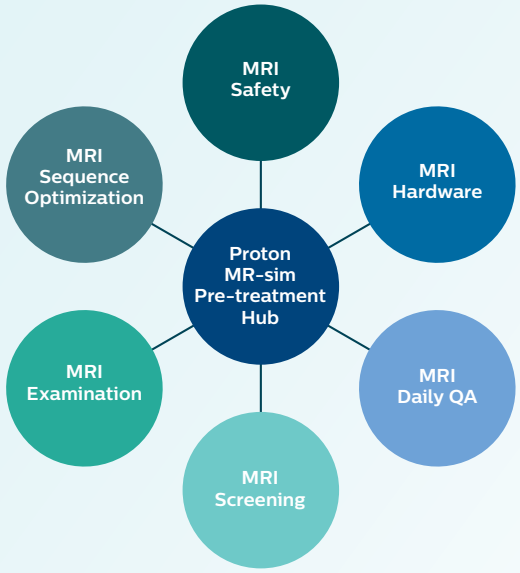
"The didactic and hands-on Philips applications training was really well structured, with a modular setup in chapters, key stages and key points of the process," Edwards observes.

"It was quite comprehensive as well, including everything from safety and basic operations to developing and modifying protocols. Over a six-week period, they led us through what we needed to know about Ingenia MR-RT. And, although the training was very well aimed at the therapeutic radiographers, the diagnostic radiographers also benefited because they had limited understanding of this particular system.

"Since the applications training was the first form of competence, it was extremely important that it was well-documented and assessed, to enable us to show evidence of the training – especially in lieu of other formal accredited training," he adds.

"The training was excellent. The Philips applications specialist, Lynsey Cameron-Clark, and The Christie team developed a fantastic relationship, which was reassuring. And we felt comfortable calling on her repeatedly – in fact, we still do."

Overview of The Christie hub-and-spoke training model on proton MR-sim pre-treatment.



Hub

Proton Pre-treatment Hub includes training for MR-sim pre-treatment staff and is based on MHRA guidelines:

- Safety
- Environment
- Local rules
- Equipment

Spoke

Each spoke includes the additional, specific content for the radiographers and consists of:

- A competency profile
- A guide for trainers
- A guide for assessors

Hub-and-spoke model provides tailored training for different groups

Following applications training, The Christie MR radiographer and Education Team worked together in order to develop the in-house training of the pre-treatment staff. They started by investigating how the Diagnostic Imaging service trains its radiographers and documents this program, and then developed the hub-and-spoke training model for MR simulation.

"We knew what we knew, but we didn't know what we didn't know," Edwards says. "So we also wanted to find out where our gaps in knowledge were by relying on the Philips application specialist and our team of therapeutic and diagnostic radiographers.

We also relied on them to identify their gaps in knowledge. For example, for diagnostic radiographers, radiotherapy patient positioning is not part of their usual scope of practice, while the therapeutic radiographers – though they were aware of radiation hazards – had little previous knowledge about the risks of projectiles in a magnetic field or the danger of scanning a patient that has an implanted medical device. Upskilling both groups presented a major challenge."

The hub-and-spoke model consists of a core module (hub), which comprises of the important parts of the UK's Medicines and Healthcare Products Regulatory Agency (MHRA) MR safety guidelines.

Overview of the main learning objectives identified per job role

For diagnostic radiographers
- Treatment position and coverage for treatment planning purposes (PBT requires greater accuracy)
- Reproducibility and registration requirements
- Purpose of images for treatment planning (target v. OAR delineation v. synthetic CT generation)
- Differences in requirements of diagnostic and treatment planning imaging (acquired orthogonal to system, geometric fidelity, MP imaging on the same isocenter for better registration accuracy)

For therapeutic radiographers
- MRI safety
- Basic MR physics
- Image acquisition (including parameters and tradeoffs, artifact recognition and reduction)
- Image interpretation (e.g., understanding which sequences are used for target v. OAR delineation, anatomy)

For treatment planners/radiation (clinical) oncologists/dosimetrists
- Image interpretation
- Image registration (cross-sectional/cross-modality anatomy)

The spokes represent additional learning modules for specific job roles, and include modules on safety, screening, scanning, daily QA and image contrast.

"We can choose which training modules are required for any role in the PBT department, and these are mapped out in the training needs analysis performed by the education team," Edwards says. "The training priorities were safety and instilling confidence, with the ultimate goal to have the diagnostic and therapeutic radiographers be equally proficient regardless of their professional designation. In short, we wanted to create hybrid MR-RT radiographers."

Detailed training guides ensure consistency

The identified training needs for each group were compiled in training guides, a guide for the trainer, and an assessor's guide. An example of a trainer's guide is available in the online version of this article.

"This model ensures that all learners receive the same information, and that it's delivered and assessed in a consistent manner," Edwards says. "The training guide contains the information to be taught, the trainer's guide instructs how to teach the material and the assessor's guide shows how to evaluate each learner's competence. They simply ask an individual being trained to demonstrate the knowledge and hands-on skills that the trainers had presented them. We said: 'You need to know XYZ and if you say you do, then provide evidence that you know XYZ either verbally, in writing or by a hands-on demonstration."

"This model ensures that all learners receive the same information, and that it's delivered and assessed in a consistent manner"

Safety in an MRI environment

Integrating MR-sim into a new department was a big change for the whole PBT service, necessitating education of more than just the pre-treatment staff. The most important aspect of this training was safety, Edwards adds. "The scanner is surrounded by 150 team members who haven't necessarily worked adjacent to an MR scanner before," he says. "We developed a general MRI safety program, as part of the training hub, to teach everyone working in the building about the risks associated with a strong magnetic field. Awareness of the consequences of going through a particular door or taking certain equipment into the magnet room was felt to be very important to ensure staff, patient and visitor safety."
(See sidebar below on MRI Safety). »

Key aspects of MHRA guidelines

MR safety
"It's not just about screening for ferrous material or implants"

Noise
- Know acceptable levels and how to limit

Specific Absorption Rates (SARs)
- Know the effects of high SAR sequences
- Know recommended limitations

Patient positioning and immobilization devices
- Just because it's not metal doesn't mean it's MRI-safe
- Hidden screws and hinges
- Heating effects

Anti-peristaltic and contrast agents
- Training and awareness

"They are a very competent team of radiographers working in MR-RT and they work fairly independently now"

Developing Radiotherapy-specific ExamCards for PBT Patients

The Christie team and the Philips application specialist worked with the center's radiologists and radiation oncologists to develop PBT-specific radiotherapy planning imaging protocols (ExamCards). The process started with soliciting suggestions from the radiation oncologists regarding their image quality and contrast requirements for PBT planning.

"We used that input to develop the sequences or ExamCards and then test them on a volunteer," Edwards says. "The primary radiologist would critique the images and the team would modify the sequences for more signal, more contrast or a different voxel size if extra detail was needed. Then we would take new images back to the radiologist for another review. It was an iterative process, but ultimately we were happy with the results."

Once the radiation oncologists were satisfied, the center's physicists were consulted on the images' suitability for proton planning, their geometric accuracy and whether they could be fused with CT.

The Christie launches proton therapy service

A journey that began in 2016 with the procurement of Ingenia MR-RT 1.5T – and continued with the recruitment of the PBT pre-treatment staff and development of a training program to transform them into MR-RT radiographers – culminated on December 31, 2018. On that date, a 15-year-old boy with a brain tumor became the PBT service's first patient, the first of some 750 patients The Christie anticipates treating each year.

According to Edwards, the experience of creating a fully staffed PBT service from the ground up was a daunting task, but the result has been quite successful.

"There is still learning to be done, but the pre-treatment team's confidence is growing day by day," he says. "They are a very competent team of radiographers working in MR-RT and they work fairly independently now. They ask fewer questions and are able to make decisions by themselves. The next phase will be to assess the staff again and make sure they know what we have asked them to know. It's a whole process that needs to grow and develop, but we are confident they're a good team of people and they are where they need to be."

On the horizon at The Christie is a pilot program set to begin in late 2019 that consolidates educational programs for MR-sim in proton therapy, MR-sim in radiotherapy and MR-linac operation in a single MR in RT hub. "The program is designed to make sure all Christie radiographers working in MR-sim and MR-linac have enhanced skills," he says. «

References

1. Eccles CL, Campbell M. (2019). *Keeping Up with the Hybrid Magnetic Resonance Linear Accelerators: How.* Journal of Medical Imaging and Radiation Sciences, 50(2).

2. Eccles CL, McNair. HA, Armstrong SEA, Helyer SJ, Scurr ED. (2017). *In response to Westbrook - Opening the debate on MRI practioner education.* Radiograph 23: S75-S76.

3. Eccles CL, NIll S, Herbert T, Scurr E, McNair HA (2019). *Blurring the lines for better visualisation.* Radiography 25: 91-93

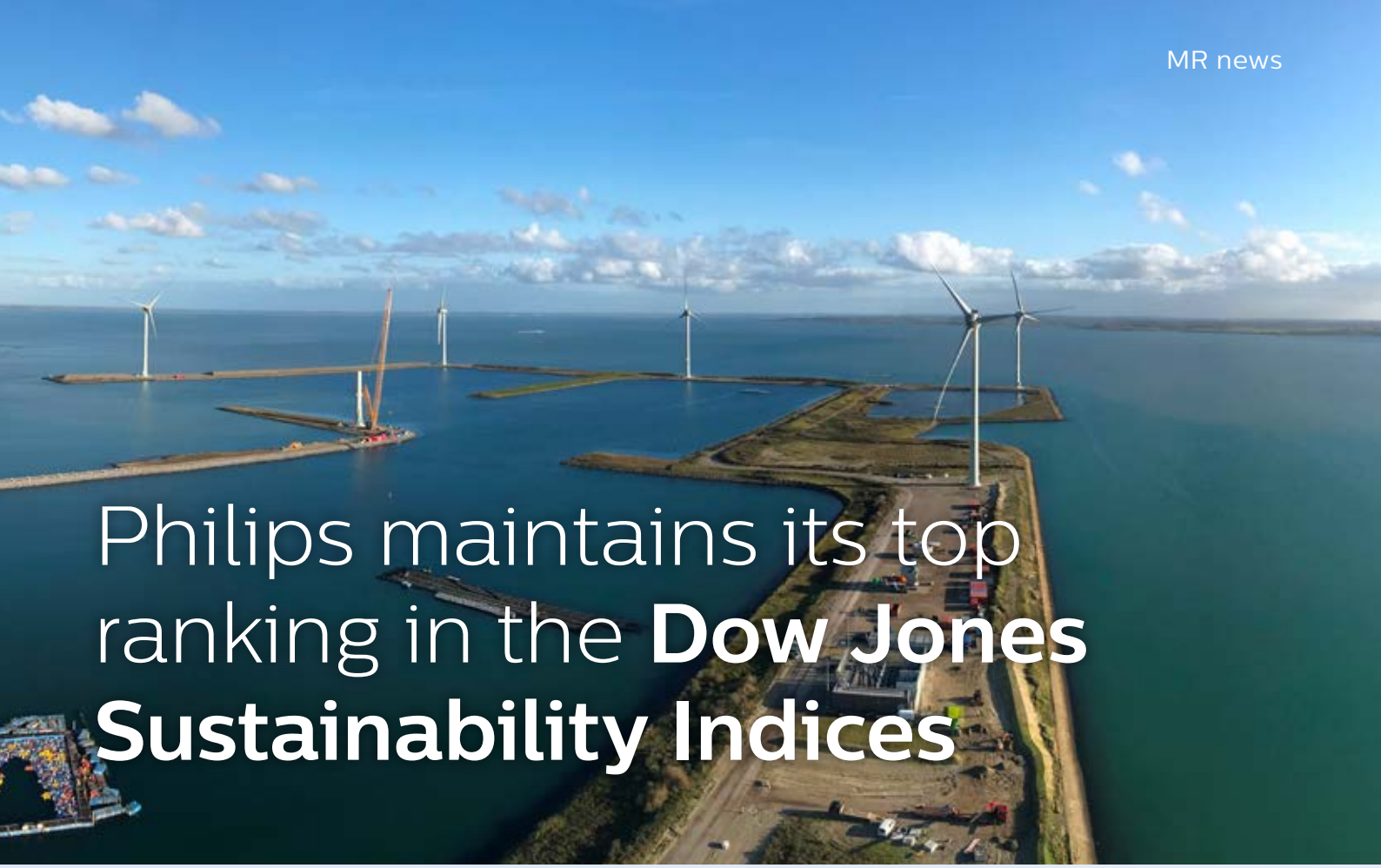
4. Paulson, E., Erickson, B., Schultz, C., Li, A., (2016), Comprehensive MRI simulation methodology using a dedicated MRI scanner in radiation oncology for external beam radiation treatment planning. Magnetic Resonance Physics, Vol 42, pp. 28-39.

5. Speight R, Schmidt MA, Liney GP, Johnstone R, Eccles CL, Dubec M, et al. (2019). IPEM Topical Report: A 2018 IPEM survey of MRI use for external beam radiotherapy treatment planning in the UK. Physics in Medicine and Biology.

6. Rai R, Kumar S, Batumalai V, Elwadia D, Ohanessian L, Juresic E, Cassapi L, Vinod S, Holloway L, Keall P and Liney, G. (2017). *The integration of MRI in radiation therapy: collaboration of radiographers and radiation therapists.* Journal of Medical Radiation Sciences, 64(1), pp.61-68.

7. The Society and College of Radiographers & and the British Association of Magnetic Resonance Radiographers (2013). *Safety in Magnetic Resonance Imaging.* London: SCoR & BAMRR

8. Department of Health (2015). *Safety Guidelines for Magnetic Resonance Imaging Equipment in Clinical Use.* London: Medicines and Healthcare Products Regulatory Agency.



Philips maintains its top ranking in the **Dow Jones Sustainability Indices**

In September 2019 Philips has once again been recognized as one of the top companies for sustainability performance in the global 2019 Dow Jones Sustainability Indices (DJSI)* list. Philips scored 82 out of 100 points in the DJSI Health Care Equipment & Services industry group, further improving on its 2018 score to achieve the #2 ranking in 2019.

Evaluated across the Economic, Environmental and Social dimensions of DJSI's sustainability review, Philips received best-in-class scores in several categories, including the innovation management, climate strategy and contribution to health outcome categories.

Philips continuously strives to make the world healthier and more sustainable through innovation. Its aim is to improve the lives of 3 billion people a year by 2030, via integrated health technology solutions that span the health continuum from healthy living and prevention, to diagnosis, treatment and home care.

With its focus on access to care, the circular economy and climate action, the Philips program *Healthy people, Sustainable planet* is already helping the company to deliver on its 2020 commitments to become carbon neutral in its operations, to grow its Green Revenues to 70% of sales, and to have 15% of its revenues generated through circular economy driven propositions. Philips' efforts have also received notable recognition in other sustainability indexes. The company was ranked #1 on Fortune's inaugural Sustainability All Stars list (August 2019), awarded the Dutch 'Crystal Prize' 2018 for leading change in supply chain sustainability, and in January 2020 it was included in the CDP Climate Change A List for the seventh consecutive time. «

* S&P Dow Jones Indices, one of the world's leading index providers, together with SAM, the business unit within RobecoSAM, which specializes in providing Environmental, Social, and Governance (ESG) data, ratings, and benchmarking, announced the results of the annual DJSI review on September 13, 2019. The SAM Corporate Sustainability Assessment (CSA) is one of the longest standing ESG rating methodologies worldwide, dating back to 1999. It assesses companies based on 80 – 120 industry-specific questions across 61 industries focusing on financially material economic, environmental, and social factors that are relevant to companies' success, but that are under-researched in conventional financial analysis.

How a **co-research** approach tackles MRI challenges with **AI**

Artificial Intelligence (AI) brings promising new possibilities to MRI. It may be applied to many aspects such as automated planning, segmentation and report creation. Also for scan acceleration it offers new possibilities, as AI enables to acquire less data in an MRI examination, which can help to reduce the time that a patient needs to be in the scanner.

Top performers in fastMRI image reconstruction challenge

Last December, it was announced that Philips and the Leiden University Medical Center (LUMC) were together the top performer in the fastMRI image reconstruction challenge in the multi-coil tracks with 8x acceleration category.

A second team in which Philips participated, together with the University of Amsterdam (UvA), the Amsterdam University Medical Center (Amsterdam UMC) and Radboud University, was the top performer in the single-coil track with 4x acceleration category.

The fastMRI challenge is a collaborative research project between Facebook AI Research (FAIR) and NYU Langone Health. The aim is to investigate the use of AI to make MRI scans up to 10 times faster. By producing accurate images from under-sampled data, AI image reconstruction has the potential to improve the patient's experience and make MRI exams accessible for more people.

Thirty-four teams participated from around the world. All teams received the largest publicly available data set of de-identified raw MRI knee measurements that participants could use to train an algorithm that was then used to reconstruct hundred accelerated MRI scans.

To determine the winner, the top five participants with the highest scores on a numerical value were first selected. Their results were then visually assessed by seven expert radiologists with musculoskeletal sub-specialization, paying attention to various aspects: contrast-to-noise ratio, artifacts, sharpness, diagnostic confidence, and overall image quality. The radiologists stressed the importance to visually asses the quality of the image, and to not rely blindly on numerical scores.

The results were presented at the leading AI conference NeurIPS in Vancouver on December 14.

Teamwork makes the dream work

Winning the challenge was not the only reason for our excitement at Philips. The process towards this great achievement made us also extremely proud. Key to our success was a multi-disciplinary team including experts from both Philips and LUMC working fulltime for months on the AI algorithm, leading to this great success. Of particular importance was the involvement of radiologists and clinical scientists who assessed the quality of the reconstructed images from a clinical point of view.

The team demonstrated that it is possible to deliver breakthrough solutions via excellent teamwork. The cooperative working atmosphere and the mutual trust that we now share will definitely pave the way for other innovative projects, including the clear focus in bringing this success to the patients as soon as possible. «

Stay in touch
with Philips MRI

FieldStrength is a professional magazine for users of Philips MR systems. It provides results of MR studies performed by Philips users.

Don't miss an issue

Read more articles or register for your personal email subscription at: **www.philips.com/fieldstrength**

You may also be interested in:

- MR body map to view clinical cases of nearly every anatomy, see **www.philips.com/mrbodymap**
- Philips MRI products, see **www.philips.com/mri**

Printed in Belgium.
4522 991 50971

FieldStrength is also available online:
www.philips.com/fieldstrength
www.philips.com/mri

Editor-in-chief
Karen Janssen

Contributors
Carlos Avila (RT), Laura Barlow (RTMR), Wim Boon, Megan Breuer (PhD), John Brigly, Jerry Duncan, Thomas Edwards, Phil Fritz, Karen Hackling-Searle, Martijn Hartjes, Eltjo Haselhoff (PhD), Frank Hoogenraad (PhD), Karen Janssen, Shannon Kolind (PhD), Alex MacKay (DPhil), Erin MacMillan, Carol Melvin, Kim Mulder, Ruth Pearson, Constantino Peña (MD), Alex Rauscher (PhD), Julien Savatovsky (MD, PhD), Mark Stoutjesdijk (MD), Alexander Vadnais, Joyce van der Valk, Marieke van Grootel, Marieke van Noort, Zoe Wray.

Subscriptions
Please subcribe on www.philips.com/fieldstrength

Correspondence
FieldStrength@philips.com or
FieldStrength, Philips Healthcare, Building QR 0119
P.O. Box 10 000, 5680 DA Best, The Netherlands

Notice
FieldStrength is created for users of Philips MRI systems. It is a professional magazine for users of Philips medical equipment. It provides the healthcare community with results of studies performed by colleagues. Some articles in this magazine may describe research conducted outside the USA on equipment not yet available for commercial distribution in the USA. Some products referenced may not be licensed for sale in Canada.

Results from case studies are not predictive of results in other cases. Results in other cases may vary. Results obtained by facilities described in this issue may not be typical for all facilities. Images that are not part of User experiences articles and that are not labeled otherwise are created by Philips.

PHILIPS

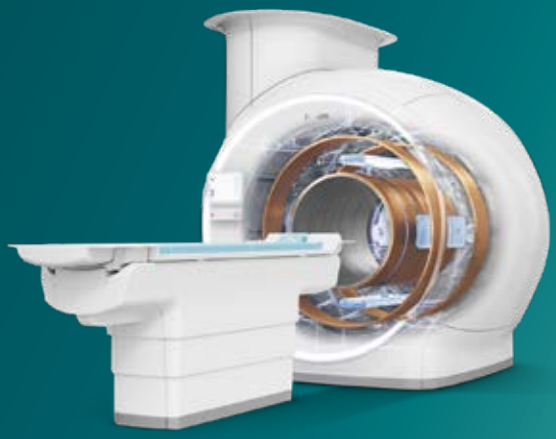
Ingenia Ambition 1.5T

MR services. Helium-free.

The Philips Ingenia Ambition offers cutting-edge MR imaging techniques to help you excel clinically every day. Based on its new, revolutionary fully sealed BlueSeal magnet, the solution lets you experience more productive[1] helium-free MR operations.

Get superb image quality even for challenging patients, and perform your MRI exams up to 50% faster with Compressed SENSE acceleration for all anatomies in both 2D- and 3D scanning[2].

Fast overall exam-time is achieved by simplifying patient handling at the bore with the touchless guided patient setup.
There's always a way to make life better.



Discover more about Ingenia Ambition
www.philips.com/ambition

innovation you

1. Compared to the Ingenia 1.5T ZBO magnet.
2. Compared to Philips scans without Compressed SENSE.