

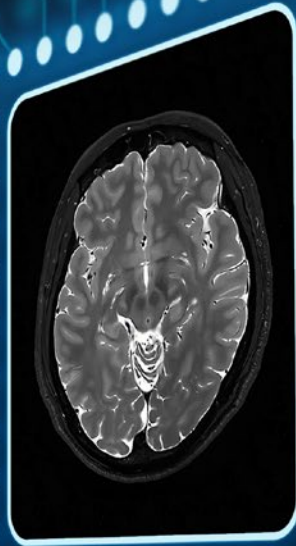
visions

SPECIAL

MAGAZINE FOR HEALTH PROFESSIONALS // MR SPECIAL // MAY 2020

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**Cover Image:**

Stockphoto and Canon Medical's clinical MR images, with Advanced intelligent Clear-IQ Engine (AiCE). AiCE is the world's first fully integrated Deep Learning Reconstruction (DLR) technology for MR. Read more about this technology in this MR Special of VISIONS magazine.

This MR Special edition of VISIONS magazine is a publication of Canon Medical Europe and is offered free of charge to health professionals. To download the digital edition of this MR Special, please visit: <https://eu.medical.canon/visions>.

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// EDITORIAL

Dear Healthcare Partners and MR Users,

I am delighted to welcome the readers of this special MR edition of VISIONS Magazine. We would like to thank our valued customers and partners for their continued interest in, and contributions to our Magnetic Resonance (MR) solutions.

This VISIONS MR Special is our platform to highlight some of our recent MR success stories. It shows how MR can help improve clinical outcomes through increased image quality, reduced scan time, or simplified workflows.

Canon Medical's "Made for Life" philosophy is illustrated through the way that our MR solutions continually deliver valuable outcomes for clinicians and patients. Matching customers' expectations to solve their daily challenges, is key in driving technological innovation. This is one of our goals. In achieving this, we are proud and delighted to collaborate with a wide range of partners, from famous sport medicine teams to well-known institutions, and renowned academic- and university partners.

Artificial Intelligence (AI) is a key theme that we can address in healthcare. Applying Canon Medical's experience in CT, we developed the world's first MR Deep Learning Reconstruction (DLR) technology with Advanced intelligent Clear-IQ Engine (AiCE). AiCE is used to remove the noise from MR images intelligently. It allows us to obtain clearer MR images with higher resolution while maintaining and/or reducing scan time. AiCE enables 'scanning as fast as possible' and delivers noise-free MR images.

Delivering technology for higher clinical confidence is a crucial target for Canon Medical, which is derived from our clinically-focused mindset, and is aligned with our partners and customers. We continuously improve the MR experience for the patient, as acceptance is vital for a successful and efficient MR examination, whichever technology is used. We offer world-class solutions to make MR examination more accepted by patients. These include in-bore entertainment solutions with MR-Theater, quieter MR scans, achievable with Pianissimo and Pianissimo Zen, and contrast-free solutions for MR angiography.

We thank the customers and partners that have contributed to the articles, interviews, and case studies in this MR Special. These articles demonstrate our unique technology features that benefit procedures leading to better patient outcomes.

Enjoy reading this exciting VISIONS MR Special!

Kind regards,

THIERRY MUNIER

*European Director – Magnetic Resonance
Canon Medical Systems Europe*

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Artificial Intelligence to Boost
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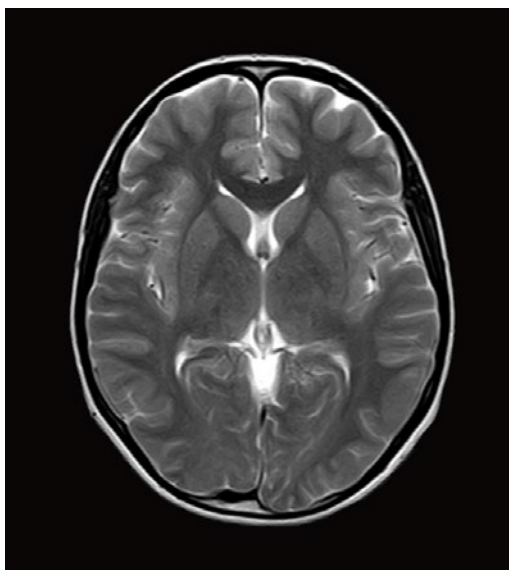
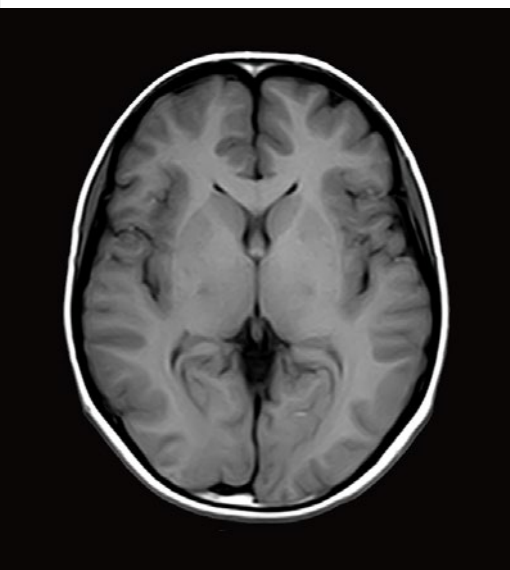
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MR-PHYSICS

First MR Theater installed in Europe

| The Netherlands

In January 2020, the MR Theater was installed at diagnostic center, Open MRI Zen in Sluis in The Netherlands. This is the first MR Theater installed in Europe.



The imaging center focuses on claustrophobic patients. Canon Medical's Vantage Galan 3T already provided them with a range of options to make examinations as comfortable as possible for every patient. This will be maximized with their latest upgrade. The Open MRI Zen Center will now be able to provide patients with a calming and immersive experience, thus reducing patient anxiety and improving patient comfort.

Calmness not only improves the experience of the patient, but also helps patients remain physically still during an examination, and, therefore, improves image quality. The MR Theater is provided with a suite of beautiful and calming films that can be played to patients, but can be used to screen whatever is desired. In the near future, specialists at the Sluis Center plan to use the MR Theater to display visual stimuli during a functional MRI examination.

With a 71 cm wide bore scanner equipped with Pianissimo and Pianissimo Zen sequences within the MR Theater, Canon Medical's Vantage Galan is the optimal 3T system, delivering unsurpassed image quality and outstanding patient comfort. //

First MRI Workshop in Poland

On October 18 and 19 2019, TMS Sp. z o. o. (the official distributor of Canon Medical Systems Europe in Poland) organized the first international Canon Medical System's MRI workshop for radiographers based in Poland. The two-day event was a great success and attracted 70 participants.

An Introduction to the future of MRI

The first day of the workshop was tailored to basic- to intermediate-level radiographers. An introduction about the future of MRI was given by Prof. Piotr Bogorodzki, who is one of the best experts in MR imaging in Poland.

Following this, quality and safety in MRI rooms was explored, as well as MR fundamentals of Multiple Sclerosis and stroke imaging, contrast agents, recognizing tumor and fetal imaging. One lecture, entitled "MRI Encyclopedia", compared differences in MRI sequences between manufacturers, and in particular highlighted the unique capabilities of Canon Medical Systems' MRI. Dr Jacek Wakuliński from the Institute of Tuberculosis and Lung Diseases in Warsaw, Poland, contributed a presentation on Artificial Intelligence in medical imaging. There was also large panel discussion? related to MR Spectroscopy, Breast Imaging and Chest Imaging with ultrashort echo time (UTE).

Hands-on experience

The second day was dedicated to practical activities. Participants had a chance to work on Olea workstations with Olea Sphere. This enabled them to observe changes in DCE/DSC perfusion, performing oncology follow-up and the use of Olea Nova+ helped them to understand how basic sequence parameters (TR, TE, TI) affect final image. . One of the more exciting elements of the day was an opportunity to get familiar with various Canon MRI coils and gain experience in positioning patients. As a demonstration for the workshop, three MRI positioning simulators were built – each one with different bore diameter (60 cm, 63 cm and 70 cm), patient table-top and sliding transparent gantry, from which the operator could see where examined anatomy is located in relation to field of view (FOV) and radiographic isocenter.

Impressive capabilities

The workshop gave an insight into the impressive MRI capabilities of Canon Medical and a second workshop is in the planning. //



First Vantage Orian orders in the UK

Imaging procedures at The National Spinal Injuries Centre, 24 hour A&E, cancer care, cardiac & stroke unit to be enhanced & future-proofed at Buckinghamshire Healthcare NHS Trust.

Buckinghamshire Healthcare NHS Trust has placed an order for two Vantage Orian 1.5T MRI scanners to future-proof its imaging services. This represents the first UK orders of the premier MRI system. One MRI has already been installed at High Wycombe Hospital and is in working action, whilst the second is due for installation at Stoke Mandeville later this year. The system will provide patients with the latest techniques for cancer, stroke, heart, spine and wider frontline imaging. The purchase of the scanners will be funded by the Buckinghamshire based charity 'Scannappeal'.

Wycombe Hospital received the new scanner in January 2020 and was up and running in March 2020, which has replaced an ageing system and support its busy district general imaging needs such as stroke and MSK research work. The Vantage Orian will facilitate shorter patient scan times and thus reduce appointment times for some examinations and enhance the patient experience. This will help to drive improved throughput and meet the 13% year-on-year increase in demand at the Trust for MRI examinations.

Stoke Mandeville Hospital, which includes the internationally recognised National Spinal Injuries Centre and a busy 24 hour A&E department, will also take delivery of its Vantage Orian in 2020. The benefits of high productivity, patient comfort and greater clinical confidence will boost the standard of care delivered to patients, increase capacity and enable new research projects to be undertaken.

Deborah King, Lead Radiographer MRI at Buckinghamshire Healthcare NHS Trust states, "We have a great CT



Vantage Orian 1.5T.

support service from Canon Medical Systems UK so they were a natural choice to help us modernise our MRI facilities. With 22,000 MRI scans each year, and growing by double digits annually, we needed to replace old systems and get ourselves fighting fit to support patients into the future. Canon Medical Systems listened closely to our needs and supported us on our brief."

Scannappeal Chairman, William Baxter CBE states, "Scannappeal has been proudly supporting and working with communities across Buckinghamshire since 1987 and this is the biggest appeal that we have run in our history. It is a tremendous

commitment, but the new Bucks MRI Appeal provides a wonderful opportunity for the local community to work with us to ensure we have the best possible equipment available at our hospitals."

"It's great that the UK's first orders of the Vantage Orian will be going to hospitals that are so focused on improving the clinical services to the patients they serve," states Vanessa Ellis, MR Modality Manager at Canon Medical Systems. "From the amazing Scannappeal charity, the committed staff in the departments and the enthusiastic research Radiologists, everyone is determined to make a difference, which we will support in partnership with all of them." //

First European MRI Safety Course & Certification

| UK

UK joins the USA and Australia with introduction of MRI safety accreditations to safeguard users and deliver higher standard of imaging patient care.

Almost 200 radiologists, radiographers and medical physicists have attended the first European MRI Safety Matters® training seminar. The 2-day event, held August 2019 in London and sponsored by Canon Medical Systems UK, was a platform to call for greater collaboration between industry and healthcare, and for a standardised approach to MRI user and patient safety. It was delivered by the internationally renowned MRSO/MRMD safety luminary Dr. Emanuel Kanal.

At the event there was overwhelming support from delegates to bring MRI safety standardisation and certification to Europe, with many delegates surprised that there is not a regulated minimum MRI safety standard nor standardised mandatory training already in place in the UK. Topics

covered during the event included: understanding static magnetic fields; time varying RF and Gradient fields; focal power deposition, auditory concerns; neurostimulation; implant and foreign body safety assessments; and overall peer-to-peer best practice discussions on all aspects of MRI safety.

In a European first, the event was followed by UK relevant examinations leading to MR Safety certification, administered by The American Board of MR Safety (ABMRS). Radiographers, Physicists and Radiologists sat the exams and successful candidates were the first UK MRI cohort to obtain an accreditation for MRI safety. These individuals are expected to influence and shape the safety culture of the UK MRI industry by embracing the certification.

certification mandated for or even available for MRI staff. A big challenge is the disparity in the reporting of accidents which hampers learning.

Whilst many healthcare organisations are great at ensuring safety practices and policies, there is nothing guiding a mandatory safety framework and so it remains a grey area in terms of managing radiology workforces. We were delighted with the positive feedback this year and look forward to championing more safety certifications and discussions at next year's event."

"When we launched our latest MRI system, the Vantage Orian, into the UK last year, we reviewed our commitment to the duty of care delivered to the MRI imaging community," states Vanessa Ellis, MR Modality Manager at Canon Medical Systems UK. "In addition to delivering high productivity and enhanced clinical confidence, its design is also about the safety of people operating and maintaining the systems, and of course, the patients being examined. MRI safety is of the utmost importance in all healthcare organisations and we strongly support the aims of the MRI Safety Matters® team and the roll out of a standardised UK safety standard." //



Barbara Nugent, Founder of MRI Safety Matters®, MRI safety specialist and MRI & CT Radiographer states, "The busier MRI modalities are becoming for frontline imaging care, the more accidents there are. Yet despite every incident being preventable, there is still no standardised MRI safety training or safety

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Vantage Galan 3T / Saturn X Gradient Inaugurated for New Research Collaboration

| France

The new Canon Medical Vantage Galan 3T / Saturn X Gradient system was inaugurated at Centre Hospitalier Sainte Anne, Paris, France, during October 2019. The new system will consolidate and expand this renowned hospital's expertise in in Neuro-Imaging

Sainte Anne is one of France's most well-known hospitals for expertise in Psychiatry, Neurology, Neurosurgery, Neuro-imaging and Addictology. It is part of the GHUPPN (Groupe Hospitalier Universitaire Paris - Psychiatrie et Neurosciences) - a leading medical academic institution in Paris in the field of neurosciences in both clinical and research specialisms.

The Vantage Galan 3T / Saturn X Gradient has been installed as a research partnership and collaboration between GHUPPN, Canon Medical and Olea Medical. The partnership's main objective is to support GHUPPN's research project and improve understanding of MR's contribution to Neuro-Imaging, and especially for mental-, neuro-vascular, neuro-oncology and epileptogenic networks.

GHUPPN will evaluate specific MR sequences for brain tumor and acquire a better understanding of the evolution of brain gliomas by deeply analyzing their spatial organization and get a better delineation between tumors and surrounding benign brain parenchyma. A second research priority is to develop and evaluate contribution of contrast-free MR angiography for head and neck vessels and compare to current gold-standard MR angiography with contrast-media injection. Leveraging its extensive expertise in Psychiatry, GHUPPN is also planning to use the Vantage Galan 3T / Saturn X Gradient to evaluate the contribution of dedicated MR pulse sequences for children and teenagers with psychiatric disorders and cognitive development limitation.



From left to right: Mr. Adachi (Canon Medical Systems Corporation), Mr. Kamijima (Canon Medical Systems Corporation), Mr. Vorms (Canon Medical Systems France), Prof. Oppenheim (Sainte Anne Hospital), Mr. Chassaniol (Sainte Anne Hospital)



The Vantage Galan 3T operator room in Sainte Anne Hospital.

The Vantage Galan 3T, with powerful gradients and high-end RF coils technology, is the perfect device to support such research project and objectives. The wide range of advanced pulse sequences, including the latest innovation, such as Advanced intelligent Clear-IQ Engine (AiCE) and Compressed SPEEDER, provide the most efficient solutions to the researchers, while bringing outstanding image quality and resolution. Alongside scanning, advanced post-processing software for both qualitative and quantitative analysis is provided through Olea Medical solutions.

As part of the partnership agreement, Canon Medical and Olea Medical provide regular support from Clinical Scientists and Development Engineers, who work closely with the Hospital's research team. A real teamwork to benefit from each other's expertise: analyze challenges, think together, share knowledge, propose and test improvements towards achieving the research objectives.

The inauguration was directed by Jean Luc Chassaniol (Director of Sainte Anne Hospital), Prof. Jean François Meder (Neurosciences Chief of Staff at Sainte Anne Hospital) and Prof. Catherine Oppenheim (Head of Neuro research Staff at Sainte Anne Hospital).

Mr. C. Kamijima (Senior Vice President, Canon Medical Systems Corporation), Mr. A. Adachi (General Manager CT-MR Division, Canon Medical Systems Corporation) and Mr. F. Vorms (Managing Director, Canon Medical Systems France) represented Canon Medical. //

Great Collective Cross-Modality Achievement

Luz Saude | Portugal

Great collective cross-modality achievement in Luz Saude (Siemens install-base), one of the largest health care groups in the Portuguese market. //



Vantage Galan 3T / Saturn X Gradient



Alphenix 4D CT



Alphenix BP HD



3 x Aplio i-800



Collaboration with CMCiB for R&D in Cardiology, Neurology and Oncology

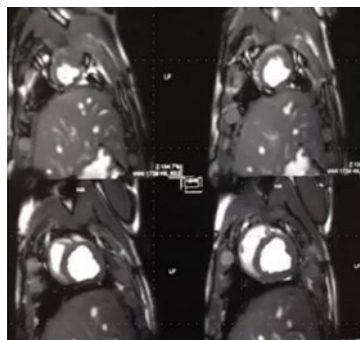
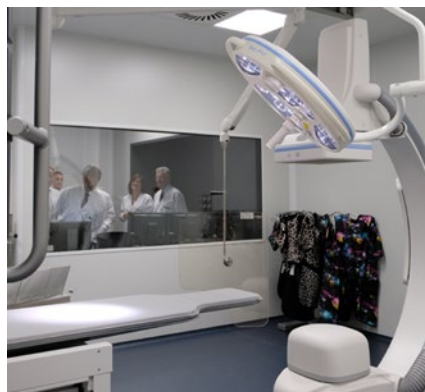
Badalona | Spain

The Comparative Medicine and Bioimage Center of Catalonia (CMCiB) is an unique new facility for research and training in Europe.

The latest technology and tailor-made facilities are available for a full range of biomedical examinations, from pre-clinical models to new surgical techniques, all conforming to European standards for responsible research.

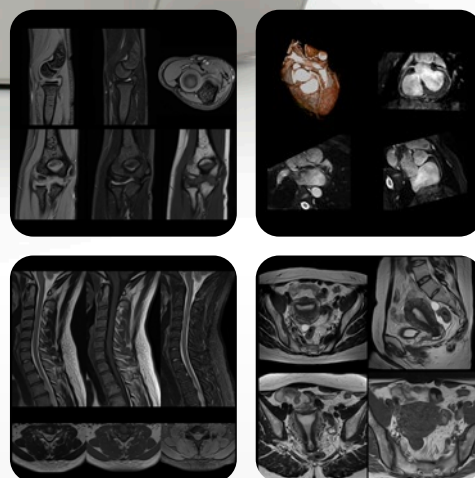
The CMCiB has setup a real Imaging environment with the Vantage Galan 3T / Saturn X Gradient and the Alphenix Core +, with Vital & Olea post-processing.

The CMCiB is a facility of the Germans Trias i Pujol Research Institute (IGTP), located on the Can Ruti Campus, in the Barcelona region, Spain. //



Vantage Galan 3T / Saturn X Gradient

Canon



Vantage Elan

Superior Imaging From Head to Toe

Comfortable

Vantage Elan's unique Pianissimo technology significantly reduces the noise in and around the MRI environment for every patient, every sequence, and every time.

Effortless

Optimize daily workflow and productivity with Vantage Elan's intuitive user interface, M-Power. Designed to enhance daily productivity and make MR operations remarkably easy to learn and use.

Efficient

This extremely compact system meets the operational needs by reducing construction and running costs. Vantage Elan utilizes original hardware technologies to achieve excellent image quality.



From left to right: Valentin Prevost (Canon Medical Systems Corporation), Bei Zhang (Canon Medical Systems Europe), Prof. Tourdias (Bordeaux University Hospital), Prof. Dousset (Bordeaux University Hospital), Bruno Triaire and Nobuyasu Ichinose (Canon Medical Systems Corporation).

*VISIONS spoke with Prof. Dousset
and Prof. Tourdias, from the
Bordeaux University, France.*

Deep Learning Reconstruction in Magnetic Resonance

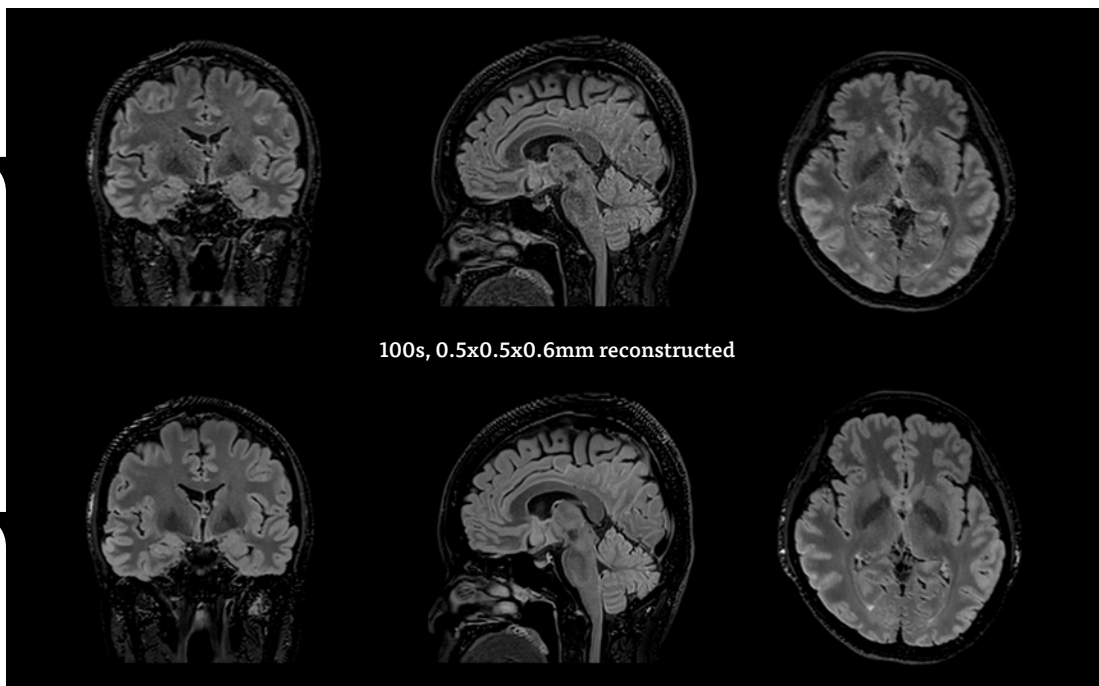
Artificial intelligence continues to expand the possibilities brought by medical imaging and advance healthcare. In particular Deep Learning Reconstruction (DLR) used in combination with Magnetic Resonance Imaging has the potential to help diagnose diseases earlier, faster and better. In France, Bordeaux University is working with Canon Medical's DLR solution to fulfill these promises and take the best out of the technology in numerous applications in research and clinical practise.

DLR has the ability to improve image quality by eliminating noise. Removing noise from images with DLR increases signal to noise ratio, helping to obtain ultra high-resolution images. Based on the experience from Bordeaux University, this has provided the opportunity to see anatomy previously not possible on 3T systems.

Applications in research and clinical work

With the help of Canon Medical, the future has already started at the Bio Imaging Institute (French: IBIO¹), an unique structure that serves as an interface between the clinical work performed at Bordeaux hospital and the research done at Bordeaux University.

3D FLAIR
Original image.



3D FLAIR
with DLR.

IBIO started integrating Canon Medical's DLR solution in November 2017. The workload progressively increased during the first six months, to find the optimal parameters and fine-tune the "denoising". The team has been using the system routinely for about a year now and is working on validating the tool scientifically.

Prof. Thomas Tourdias, Radiologist at Bordeaux University, uses DLR in almost all his research projects. "DLR helps to remove noise and obtain better image quality, which assists us to collect more information to answer

research questions. Removing noise also helps us to reach a very high resolution that we previously couldn't achieve, which is very helpful for specific research areas," he said.

DLR can be implemented in a myriad of clinical scenarios, for example to help expedite workflow. "In our daily routine, we are challenged with a growing number of requests and the difficult task of examining all these patients. So probably the major clinical application for DLR is going to help us work faster. Many more patients could undergo examinations when

we decrease the acquisition time," Prof. Tourdias explained.

DLR is easily integrated into the image reconstruction chain. Radiologists only have to plug in the option to improve the image quality. Switching to this new routine is effortless and brings real benefits, according to Prof. Vincent Dousset, Head of the diagnostic and therapeutic Neuro Radiology department at Bordeaux University Hospital.

"The first advantage is that we can achieve high resolution images with-



"Removing noise also helps us to reach a very high resolution that we previously couldn't achieve."

Prof. Thomas Tourdias, Radiologist at Bordeaux University and Hospital, Practitioner at Bordeaux University Hospital. Also member of INSERM Unit U1215 Pathophysiology of neural plasticity" at the Magendie Neurocentre.



“With DLR we can achieve both high resolution images without losing time or signal and reduce the image acquisition time.”

Prof. Vincent Dousset, Head of the diagnostic and therapeutic Neuro Radiology department at Bordeaux University Hospital.

out losing time or signal. The second advantage is the reduction of image acquisition time, as we care less about the signal quality because the noise can be eliminated following the scan,” Prof. Dousset said.

DLR is more than just a new tool, it’s a major change in medical imaging history, Prof. Dousset believes. “Because the DLR will allow us to correct afterwards what couldn’t be corrected at the outset, the first application is that we no longer have to improve the signal or the spatial resolution. This is revolutionary in medical imaging history.

This is the main advantage I think: the image “denoising” technique.”

In particular DLR has an important clinical impact in anatomical regions that require a very high resolution, for example parts of the hippocampus and the claustrum.

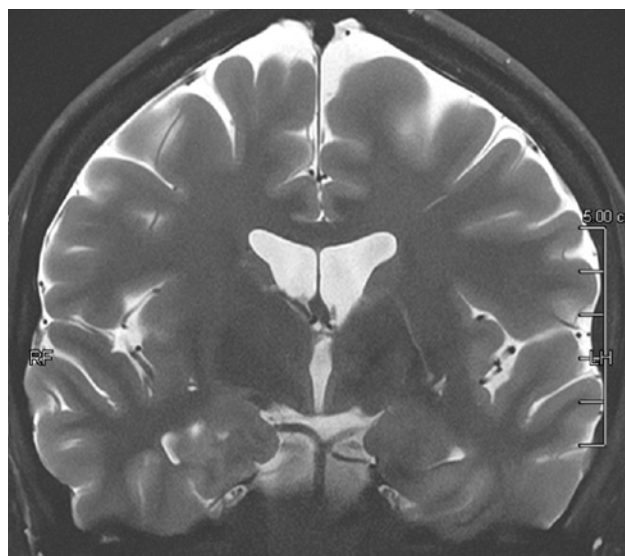
“The DLR brings a spatial resolution that I have never seen before in neurologic imaging. I recently pointed out a brain area, for example the claustrum, that is almost invisible on standard MRI images even with very high resolution or high field devices. However, thanks

to the DLR we could highlight this kind of brain anatomy. So, indeed, there is a considerable advantage to using this technique.” Prof. Dousset said.

Prof. Tourdias worked at 7T to visualise extremely fine structures of the hippocampus while at Stanford. With DLR, he can now do this task with a 3T. “When we compared the images we realized that by pushing the 3T machine and processing with DLR that we were able to achieve a similar result to what we could achieve with 7T. I think this is the main surprise of the technology.” he said.



Original Coronal T2w image.



Coronal T2w image with DLR.



Bordeaux University Hospital.

Mutual benefits

The synergy between the hospital and Canon Medical creates opportunities to find solutions for the patient, also in areas that had never been explored before. Working with Canon Medical enables physicians at IBIO to work with the most advanced technology on the company's latest MRI scanner for on-going clinical research, but benefits spread beyond the institute, Prof. Tourdias explained.

"There is an interest in transferring the technology back to the manufacturer, and we hope that the results of this research will quickly spread to the industry. And then it's interesting to put together research projects. So, there are multiple facets to our collaboration," he said.

The strong cooperation between Canon Medical and the medical team at IBIO has also placed the institute among the top, most competitive imaging centres in Europe.

"Canon Medical's collaboration with Bordeaux University helps us position ourselves internationally among the important European academic teams who work with major medical imaging manufacturers. This is a huge benefit," Prof. Dousset said.

Canon Medical's cooperation was essential in installing and becoming familiar with the system and more generally with AI. With Canon Medical's clinical scientists involved all through the process and visiting regularly, the medical team was able to find the optimal settings and make the most of DLR.

"There were a lot of questions about DLR's relevance and benefits, and the different technical parameters that it features. We proceeded to analyse a lot of images, so that we could make choices that had been transcribed by Canon Medical. The manufacturer's contribution was very significant to DLR's development at our site," Prof. Dousset said.

Innovating hand in hand with Canon Medical benefits not only the patient, but also the next generation of radiologists. "It's very important to integrate the industry in education, to prepare students for their future professions," he concluded. //

Reference

¹ The Bio Imaging Institute (French: IBIO) project was initiated ten years ago to be the interface between Bordeaux Hospital and Bordeaux University. The building hosts research on both animals and humans, with a particular focus on MR imaging, but there are also on-going projects in X-Ray and optical imaging. The IBIO welcomes several academic teams from Bordeaux University and the French National Centre for Scientific Research (French: CNRS), who work on MRI biologic imaging development and neuroscience studies, as well as industrial teams, such as the Canon team for MR work.

Vantage Orian 1.5T



The Vantage Orian 1.5T steps into the era of Artificial Intelligence to boost MR imaging performance and productivity. With its outstanding patient comfort, optimized workflow solutions and uncompromised clinical confidence, Vantage Orian 1.5T is the perfect fit to MRI business and clinical requirements.

Artificial intelligent Clear-IQ Engine (AiCE)

Artificial Intelligence (AI) is undeniably entering the radiology domain. One area of AI is Deep Learning Reconstruction (DLR), where the enormous computational powers of a Deep Convolutional Neural Network (DCNN) are used to produce high quality MR Images. The power of AI is brought to routine MR imaging by Canon Medical's DLR technology: Advanced intelligent Clear-IQ Engine (AiCE). AiCE is the world's first fully integrated DLR technology for MRI. AiCE was trained on vast amounts of low and high signal-to-noise ratio (SNR)

MR images to distinguish true signal from noise. The results were validated by a team of radiologists, medical physicists, AI scientists, and clinical researchers, producing a fast, fully-trained reconstruction algorithm ready for clinical use.

In MR, there is always a tradeoff between scan time and resolution as SNR depends heavily on these parameters. As AiCE intelligently removes the noise from the images, the SNR of the image will increase, enabling an increase in resolution or decrease in scan time.

Vantage Orian



- ✓ Intelligent
- ✓ High Productivity
- ✓ Patient Comfort
- ✓ Clinical Confidence

High productivity

With the increasing demand for shorter examinations, the Vantage Orian 1.5T is equipped with intelligent technologies to advance productivity. Next to fast scan techniques as MultiBand SPEEDER, Fast 3D for mVox and k-t SPEEDER, our latest acceleration technique, Compressed SPEEDER, is now available. Compressed SPEEDER is a new imaging technique that can accelerate scan times across the whole body. This unique imaging approach enables accelerating scan times up to four times by acquiring less data in a random fashion. Reducing scan time not only increases throughput, but also improves the patient experience and diminishes motion-related artifacts.

Another technique that can reduce scan times is WFS (Water Fat Separation). WFS achieves consistent and homogeneous fat suppression and acquires four different tissue contrasts in one scan. This technique is available for T1, T2, and PD sequence and can be acquired in any area of the body. By acquiring multiple contrast in one scan, the total number of scans that needs to be acquired is reduced.

Next to improvement in scan times, Canon Medical aims to reduce the time for planning as well. With every Vantage Orian 1.5T, ForeSee View is included, which is Canon Medical's unique feature to increase the efficiency of planning. It provides a preview of the slice one is planning in real time. This tool is particularly useful in anatomies that can be difficult to plan such as the pancreas, the heart, and certain orthopedic joints. This excellent feature reduces the need for re-scanning and saves time on scan planning for all body regions.

To further assist in the planning, the operating assisting EasyTech solutions are available for the head, spine, knee and heart. With the complexity of scan planning, achieving scan plane reproducibility can be challenging and time-consuming. EasyTech technology takes away the variability and helps to improve workflow. The Vantage Orian 1.5T can be equipped with a Dockable Table to further improve workflow.

The innovative and workflow-oriented MR post-processing solutions by Olea Medical, a subsidiary of Canon Medical Systems, are available in the Vitrea Advanced Visualization platform and in Olea Sphere®, the post-processing platform by Olea Medical. Both platforms provide multi-modal, multi-vendor and modular solutions to meet the needs of every user. Complete post-processing solutions are available for e.g. stroke, prostate (PI-RADS v1 and v2) and breast (BI-RADS), including generation of automatic compliant reports.

Patient comfort

To maximize patient comfort, the Vantage Orian 1.5T has a 71 cm wide bore, is equipped with Pianissimo and has options like MR Theater and dedicated free breathing and contrast free sequences to ensure easier examinations for every patient.

The unique noise-reducing Pianissimo technology is active during every scan and for every patient. The patented technology of acoustically active decoupled gradients is much quieter than other gradient systems, without any loss of efficiency for the sequences.

Coronal PD FatSat of the Shoulder, Res: 0.3 x 0.3 x 3 mm, Scan time: 3:25



Original.



Same image after AiCE Reconstruction.

In addition, the silent Pianissimo Zen technologies are offered with a volume of only <2 dBA greater than the ambient noise. MR Theater, Canon Medicals in-bore entertainment system - encourages patients to relax and stay still, enabling clinicians to produce, high-quality imaging.

An increasing awareness of the potential risks associated with gadolinium-based contrast agents has revealed the need for alternative, contrast-free MR angiography techniques. Canon Medical offers a full range of non-contrast MRA sequences to minimize risk to patients with sensitivity to contrast while producing exceptional diagnostic images. Furthermore, free-breathing images can be acquired using Quick Star or k-t SPEEDER or using navigator-triggered sequences.

Clinical confidence

To achieve good and consistent image quality, state-of-the-art technologies are implemented in the Vantage Orian 1.5T. Most important parts of MR hardware are the magnet, gradient coils and RF components. The zero boil-off magnet features excellent homogeneity even for large field-of-views. The high-pressure-produced slim gradients, have a gradient strength up to 45 mT/m and a slew rate up to 200 T/m/s. These enable faster imaging and reduction of motion

artefacts, in particular in neurological- and cardiological imaging. At the same time, image sharpness is increased, especially for demanding sequences.

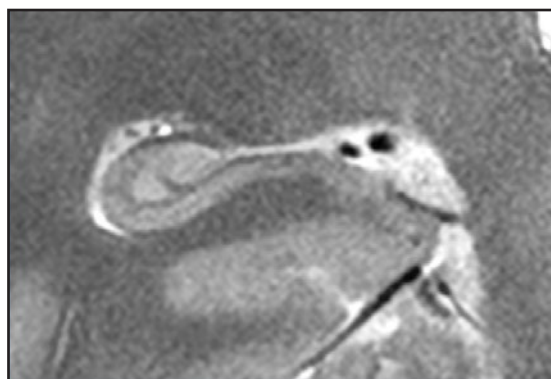
The ^{PURE}RF technology with up to 38% improvement in SNR is a technological feature of the Vantage Orian 1.5T. ^{PURE}RF Rx works similarly to noise cancellation in headphones; electrical noise is detected and reduced during digitalization of the signal. This technology offers full digitalization of the signal by means of independent AD converters and ensure processing is as efficient as possible.

The hardware is designed for efficient installation and energy-efficient operation. The minimum installation area of 25 m² (if necessary, without the additional technical room) enables space-saving installation. The new two-step technology Eco Mode Plus is a basic technological feature of the Vantage Orian 1.5T. The first step is activated when the table is lowered and the second step, when the MRI is idle, such as during the night. With the Eco Mode Plus, energy consumption of the cold head is decreased by a solid one-third. High energy-efficiency during examinations is achieved thanks to the use of lightweight, combinable matrix coils and automated examination sequences. //

AiCE - High resolution imaging

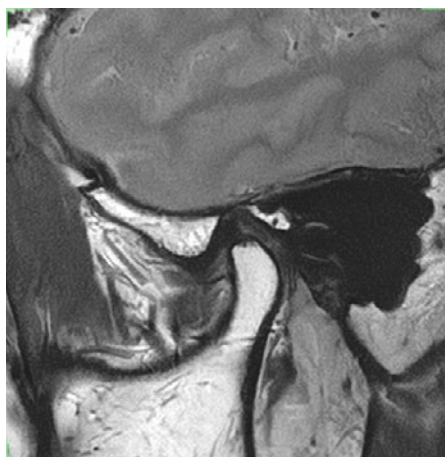
Brain – Hippocampus

Atlas SPEEDER Head/Neck, T2, AiCE,
Res: 0.2 x 0.2 x 2 mm, Scan time: 6:35 min.

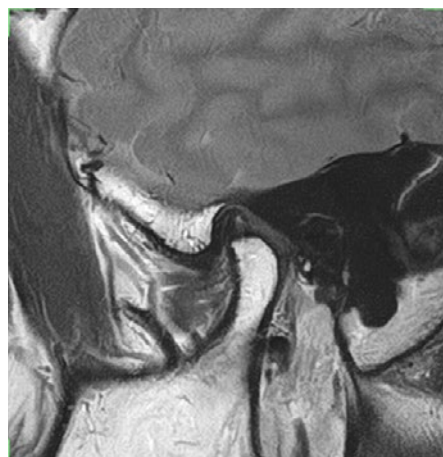


TMJ

16ch Flex SPEEDER, PD,
AiCE + Compressed SPEEDER,
Res: 0.16 x 0.16 x 2 mm,
Scan time: 1:09 min per side.



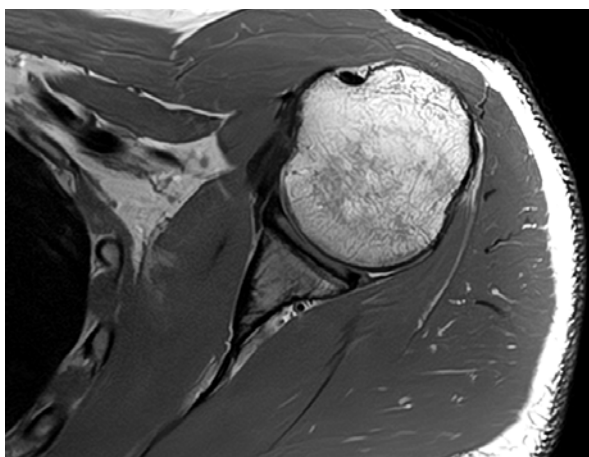
Left.



Right.

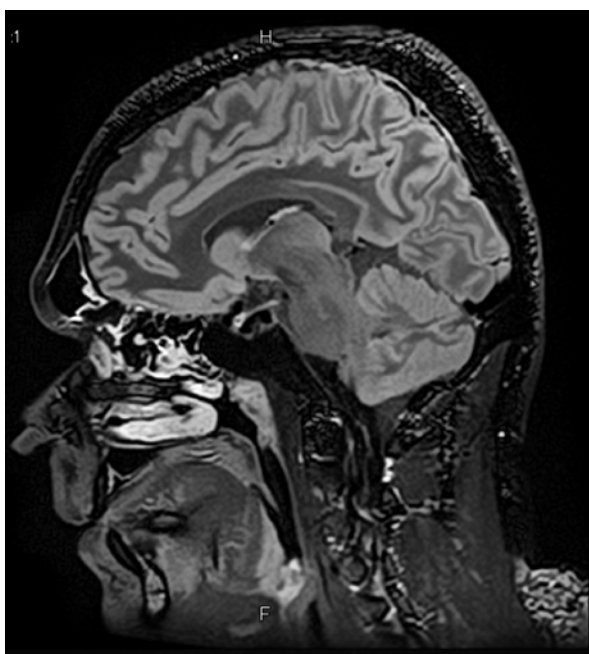
Shoulder

16ch Flex SPEEDER, PD,
AiCE + Compressed SPEEDER,
Res: 0.3 x 0.3 x 3 mm,
Scan time: 3:23 min.



Brain

Atlas SPEEDER Head/Neck,
3D FLAIR, AiCE,
Res: 1 x 1 x 1.1 mm,
Scan time: 4:55 min.



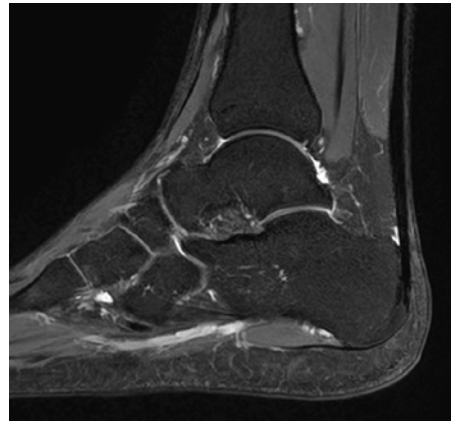
AiCE - High resolution imaging with short scan times

Ankle

16ch Flex SPEEDER, WFS
(Water Fat Separation), AiCE,
Res: $0.3 \times 0.3 \times 3$ mm,
Scan time: 3:13 min.



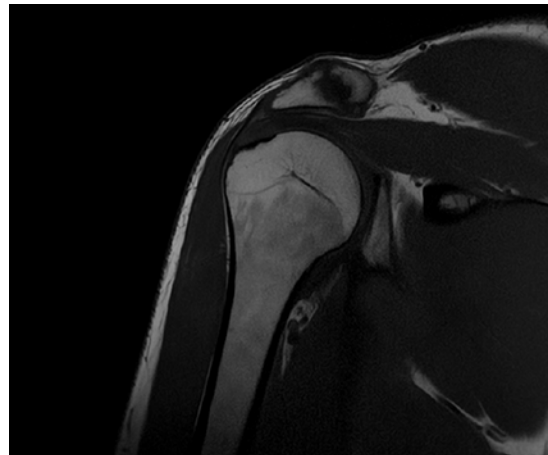
PD - In Phase.



PD - Water Only.

Shoulder

16ch Flex SPEEDER, T1,
AiCE + Compressed SPEEDER,
Res: $0.26 \times 0.26 \times 4$ mm (interp),
Scan time: 1:00 min.



Lumbar Spine T1

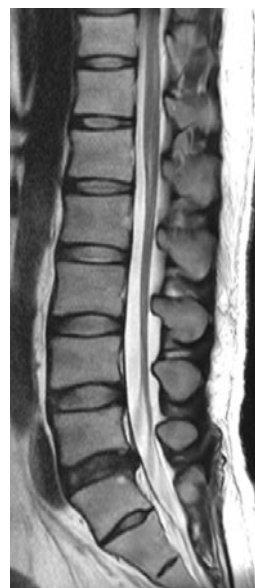
Atlas SPEEDER Spine,
AiCE + Compressed SPEEDER,
Res: 0.35×0.35 mm,
Scan time: 0:59 min.

Lumbar Spine T2

Atlas SPEEDER Spine,
AiCE + Compressed SPEEDER,
Res: 0.3×0.3 mm,
Scan time: 0:57 min.



T1.



T2.

The Future in Magnetic Resonance: Vantage Galan 3T

Cross over to a new era of MRI with a 3T system fully capable of meeting the imaging needs of a cutting-edge healthcare facility. Vantage Galan 3T from Canon Medical evolves into the AI era with Advanced intelligent Clear-IQ Engine (AiCE) technology and fast scanning without compromise with Compressed SPEEDER. Combined with outstanding automated workflow, pure digital image quality, and industry leading patient focused design, Vantage Galan 3T is the MRI system you need now, and into the future.



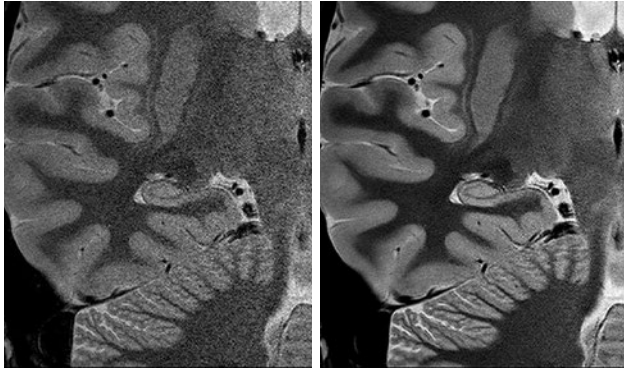
Vantage Galan 3T



- ✓ *Intelligent*
- ✓ *Quiet*
- ✓ *Digital*
- ✓ *Quick*



Scan the QR code to view the video



Intelligent

Advanced intelligent Clear-IQ Engine (AiCE) intelligently removes noise from images which results in higher SNR and enables increased resolution or decreased scan times. Achieve sharp, clear and distinct images utilizing the power of Deep Learning, allowing you to see through the noise.



Scan the QR code to view the video and discover how quiet the Vantage Galan 3T really is!

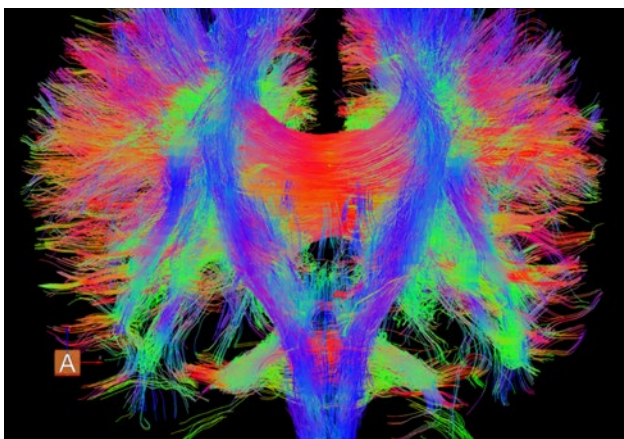


Quiet

The short magnet and 71 cm bore offers an open MRI scanning environment. Our Pianissimo technology delivers whisper quiet scanning and the new MR Theater relaxes patients with a virtual immersive experience.



Scan the QR code to view the video



Digital

The crisp digitized signals offer 20% increased SNR through ^{PURE}RF Technology and our ^{PURE}Gradient technology improves SNR for diffusion weighted imaging.

For post-processing, advanced Olea Medical solutions are available, integrated in the Olea or Vitrea platform.



Scan the QR code to view the video



3:55 min.

1:25 min CSx3.

Quick

Compressed SPEEDER, the new rapid scan technology to reduce scan time, is now available for the Vantage Galan 3T. To improve your workflow even more, we can offer the new Dockable Table (Capital), operator assisting planning with automated EasyTech solutions and ForeSee View, showing a preview of the slice you're planning.

Artificial Intelligence to Boost MR Imaging Quality and Productivity

The power of AI is brought to routine MR imaging by Canon Medical's Deep Learning Reconstruction (DLR) technology: Advanced intelligent Clear-IQ Engine (AiCE). AiCE is the world's first fully integrated DLR technology for MRI.

One of the main challenges in MRI is finding the optimal balance between the signal-to-noise ratio (SNR) and image resolution. A higher spatial resolution

could improve visualization of structures, but when spatial resolution is increased, SNR drops. To regain SNR, typically scan times need to be increased, reducing patient comfort and decreasing throughput.

signal-to-noise MR images to detect noise and remove it from the MR images. By removing noise, AiCE enables spatial resolution to be increased or acquisition time to be reduced.

“AiCE changes the way we think about MRI.”

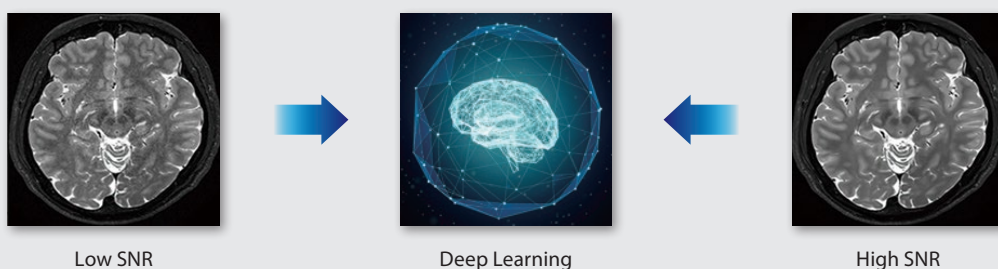
Prof. Garry E. Gold.

Canon Medical found a solution in artificial intelligence: AiCE. AiCE is a deep-learning based solution trained on vast amounts of low and high

AiCE expands diagnostic capabilities, enriches radiologist's confidence and reduces examination times and thus improves patient comfort. With AiCE we enter a new era in MRI.

Training Phase

Using high SNR images, Advanced intelligent Clear-IQ Engine (AiCE) learns to differentiate between signal and noise in low SNR images.



Operational Phase

Using the intelligence from the Training Phase, AiCE removes noise from images which results in high SNR.





“With DLR we can achieve both high resolution images without losing time or signal and reduce the image acquisition time.”

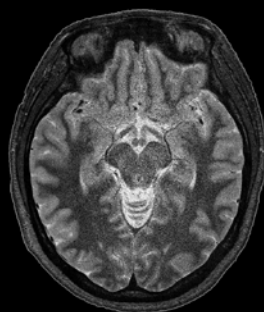
Prof. Vincent Dousset,
Head of the diagnostic and therapeutic
Neuro Radiology department at
Bordeaux University Hospital.



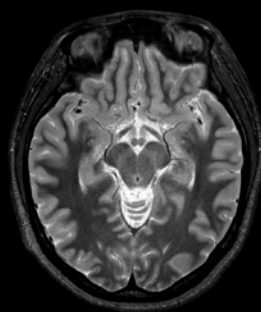
“I’m impressed by the ease-of-use, how it maintains image contrast and structural detail, while at the same time eliminating noise.”

Prof. Garry E. Gold,
Clinical radiologist and researcher, Past
president of the International Society for
Magnetic Resonance in Medicine (ISMRM)
and the Society of Computed Body Tomography
and Magnetic Resonance (SCBT/MR)

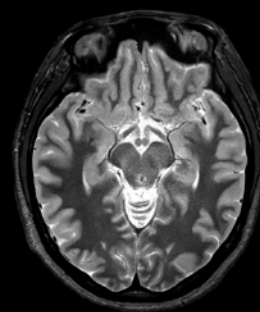
PD STIR - 1024 x 1024 matrix - 3mm slice thickness



Standard Image
1 Average - 1:45 min

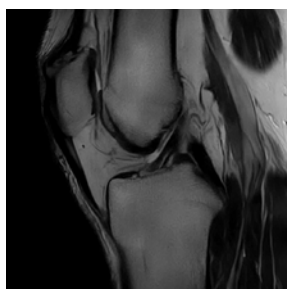


Improved quality by long scan times
10 Averages - 16:49 min

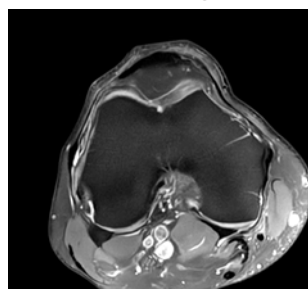


Improved quality by AiCE
1 Average - 1:45 min

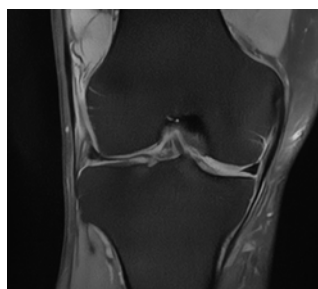
Fast knee protocol with AiCE on Vantage Orian 1.5T



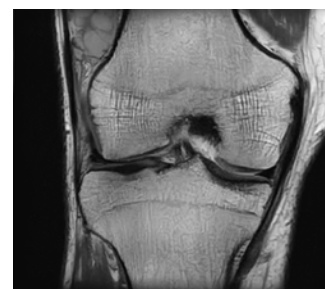
Sag T2 - 0.5 x 0.5 min - 0:56 min



Ax PD FatSat - 0.6 x 0.6 mm - 1:30 min



Cor PD FatSat - 0.6 x 0.6 mm - 1:15 min



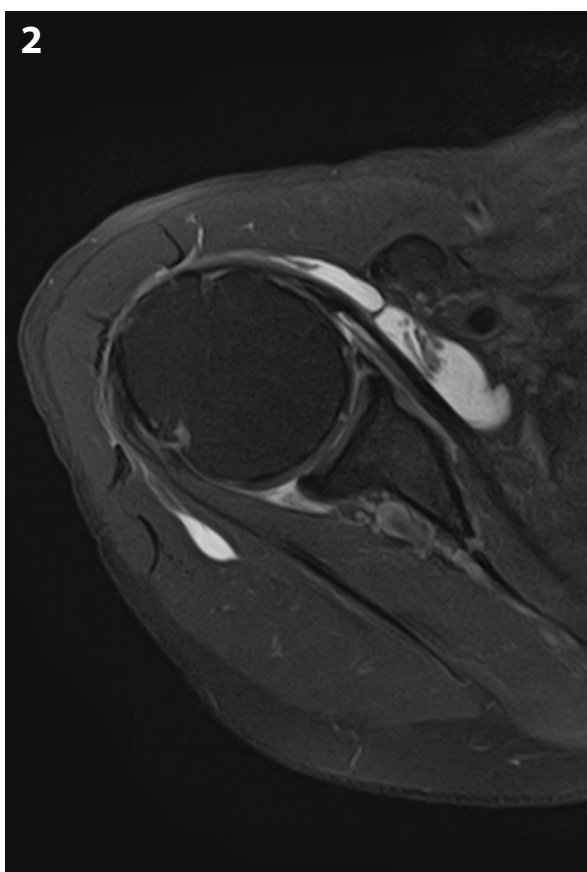
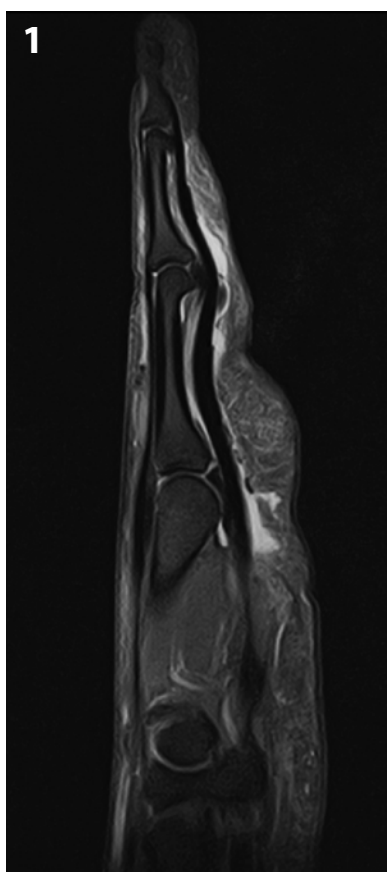
Cor PD - 0.5 x 0.5 mm - 0:58 min

First Vantage Orian 1.5T / Encore Upgrade Installed in Europe

In November 2019, the Encore Upgrade of the Vantage Titan to Vantage Orian 1.5T started at Helsingin Magneettikuvaus, in Helsinki, Finland. Helsingin Magneettikuvaus is a 9 years old company, where they had the so called first generation Vantage Titan. This installation is the first Encore Upgrade in Europe. The Encore Upgrade enables users of Canon Medical's EXCELART Vantage, EXCELART Vantage Atlas and Vantage Titan MR systems to convert their system to the new Vantage Orian 1.5T system, with lower costs and minimal construction work compared to purchasing a new system.

With the Encore Upgrade, the customers now have access to the Vantage Orian 1.5T hardware and digital software platform that can help improve workflow and deliver clinical confidence. Depending on the current platform, new options become available like contrast-free MR angiography, ultrashort echo time (UTE) imaging and Water Fat Separation (WFS), a technique that provides homogenous fat suppression while acquiring four different tissue contrasts in one scan.

After the installation, Jari Erkkila, Clinical application specialist at Tromp Medical (official distributor of Canon Medical in Finland), gave a training to explain about the new features that are now available. As the site had much experience working on the Vantage Titan, it was rather straightforward to rebuild new imaging protocols and learn to use Vantage Orian 1.5T in a smooth and optimal fashion. With the upgrade, they now have the option for new coils like the 16ch Flex SPEEDER coils and the dedicated Knee/Foot SPEEDER coil.



1

Finger scanned with 16ch Flex SPEEDER coil

- Sagittal PD with FatSat
- Resolution: 0.6 x 0.6 mm
- Slice Thickness: 2.5 mm

2

Shoulder scanned with Shoulder SPEEDER Coil

- Axial PD with FatSat
- Resolution: 0.6 x 0.6 mm
- Slice thickness: 3 mm



Jukka Mäntylä (Radiographer), Martti Kuusisto (Radiographer), Tommi Jauhiainen (Radiologist).

Tommi Jauhiainen, owner and chief radiologist at Helsingin Magneettikuvaus, closely followed the initializing phase and is excited about new methods like WFS and 3D mVox imaging, but especially he likes the flexibility in the scan environment.

He has achieved good understanding of Canon Medical MRI functions and he often tunes the protocols to get full potential out from the system. So the protocols are well validated.

“Thanks to new possibilities in scan environment and new coils the general image quality is better than before using approximately the same scan time. While overall image quality is excellent, the Knee/Foot SPEEDER coil gave us best improvement in image quality compared to the old system. Foot, ankle and knee images are excellent”, said Tommi Jauhiainen. With the new software we were also able to start abdominal scans. Water Fat Separation (Dixon, WFS) helps when fat saturation is for some reason difficult”, he concluded. //



3

Lumbar Spine

- Sagittal T2
- Resolution: 1.0 x 1.0 mm
- Slice Thickness: 3.5 mm

4

Cervical Spine

- Sagittal T2
- Resolution: 0.9 x 0.9 mm
- Slice Thickness: 3.0 mm



VISIONS spoke with
Thierry Munier, Senior Manager
for the European MR Business Unit,
Canon Medical Systems Europe.

Understand our Customers and Anticipate their Needs

With the recent introduction of Deep Learning Reconstruction and new systems in the pipeline, Canon Medical is completing its impressive portfolio and confirming its leading role in MRI innovation. And with the nomination of Thierry Munier as Senior Manager for the European MR Business Unit last summer, the group is all set to answer and anticipate the end users' needs.

Thierry Munier started his career caring for patients directly, by manipulating the imaging equipment as a radiographer. This experience has given him invaluable insight of what customers need from equipment manufacturers, and a unique opportunity to witness all the technological advances in the field.

"I started as a radiographer in 1987, the same year MRI became widely implemented in clinical practice. So I sort of grew with MRI and had time to assimilate the developments. This knowledge became very useful when I switched to the industry 15 years later," he said.

Thierry is now responsible for Canon Medical's MR business in 50 countries, a mission that is both complex and exciting. "We're dealing with different

organisations and distributors in many countries, languages, cultures and various healthcare systems. Our partners also have different levels of maturity in medical imaging, so we have to adapt our offer to each and every scenario while matching the needs of every end user. It's exhilarating," he said.

A leader in patient comfort

To match the wide disparity in its customer base, Canon Medical Systems Europe has developed a set of solutions based on efficiency, with an emphasis on patient comfort.

"MRI examinations are known to be long and noisy, so we must offer appropriate strategies to make the patients feel as much as possible at ease. They must overall have a positive experience and be calm during the examination," Thierry said.

The quality of images acquired with MR heavily depends on patient cooperation. To augment patient well being, Canon Medical's MR systems all feature ultra-short open bores and feet-first imaging.

A few years ago, Canon Medical introduced the MR Theater, an immersive entertainment system that helps patients focus their attention on elements other than the examination. The MR Theater uses sounds and videos of peaceful surroundings that are being projected on a screen and onto the bore's walls to soothe any potential patient anxiety.

Canon Medical has also pioneered and the Pianissimo technology to reduce the level of noise in and around the MRI environment and improve comfort. Users have reported high levels of satisfaction and quiet with this unrivalled solution, which uses space at the heart of hardware. "Pianissimo has made our reputation. It has 0 impact on workflow and it's unique on the market. It's deeply rooted inside the equipment," Thierry explained.

Canon Medical is also increasingly equipping its new MR scanners with wider bores (71 cm vs. 60 cm), as these can improve patient experience and accommodate larger patients.

Different customers/ users, different offer

Canon Medical's MR systems offer wide field of view and extensive range of standard and specialty coils, to ensure accurate diagnosis in a variety of clinical and research scenarios.

The 1.5T Vantage Elan provides standard, high quality imaging. It's easy to install and useful in many settings including paediatric, cardiac, vascular, breast and quantitative imaging. But this market segment is continuously dropping for the past few years in Europe because buyers focus more on wide bore scanners which increase comfort and patient acceptance during the examination.

"The market demands more efficient and faster systems, which reflect the evolution in MR in terms of resolution, scanning time and diagnosis accuracy/ reliability, but also comfort and ease-of-use. So we now have the 1.5 T Vantage Orian, which offers much more technical possibilities with a 71 cm-wide bore," Thierry said.

The Vantage Galan 3T enables to expedite examinations with cutting edge acquisition techniques such as DTI or fMRI. Recent technological advances in 3T MRI have enabled its wider adoption in clinical practise. "With 3T

we can now have very versatile equipment and well known 3T artefacts are now far away," he said.

Our strategy is to match the end users' needs, as the current trend is to decrement, with the majority of healthcare systems experiencing budget cuts. Strategies that help to do more with less have therefore been explored.

A precursor with DLR and vendor versatility

Artificial intelligence (AI) has emerged as a potential solution in many applications that could enable to save costs in the future. Canon Medical has taken the lead with the recent launch of a Deep Learning Reconstruction (DLR) solution, the Advanced intelligent Clear-IQ Engine (AiCE) software, which helps to 'see through the noise' combined with the Vantage Galan 3T and Vantage Orian.

"We are the first on the market to offer a validated tool that enables to reconstruct and eliminate noise from an image, even a very noisy one. This is called denoising; we're just taking the noise away, not the useful information. Some preliminary users have even noticed that images acquired with 3T and AiCE look similar to those acquired with 7T."

AI will continue to play a leading role in MR workflow and help stabilize image quality, an ever challenging task with MR. "AI will enable to anticipate these situations and correct an image whenever necessary, in order to obtain optimal quality and reproducibility. Manufacturers will help a lot in this regard," he said.

To improve reproducibility between exams, Canon Medical has developed EasyTech, a machine learning-fed software which positions slices according to patient's anatomy using automatic detection. The solution enables to obtain the same slice positioning in different examinations, which can be useful for radiologists doing follow-up imaging but also for radiographers, by providing easy, automatic and reproducible slice positioning for every patient.





“We have a very complete portfolio to help our users take MR to the best of its abilities.”

Thierry Munier, Senior Manager for the European MR Business Unit, Canon Medical Systems Europe.

In spite of the tremendous possibilities, many hospitals are still reluctant to use AI because of vendor dependence issues. There is still a trend for manufacturers to only enable to run algorithms that have been purchased with their equipment, which limits the widespread use of AI technology in clinical practise.

Canon Medical has already addressed the problem during RSNA 2018, by launching, Collaborative imaging, an initiative to allow a transversal and multi solution-based approach in the management of particular anatomies or pathological scenarios, from diagnosis to treatment, analysis and information sharing.

“It’s one of the main questions right now: what is the place for AI? We think it will be everywhere. We already use the Collaborative imaging approach on our different modalities, but we could also do it in image post processing, analysis and reporting. Unleashing the power of AI regardless of the acquisition modality will be paramount and we need a global solution,” Thierry said.

Canon Medical works with Vital and Olea Medical on post processing solutions that can easily be shaped depending on customers’ needs - a single stand-alone console, a light server, a larger server for major institutions with many users for image analysis and reporting - regardless of the manufacturer.

“Compatibility is often an obstacle, however, you need to be able to work with others to grow. We therefore offer a post processing solution that can adapt to any system or setting.”

Future directions

Canon Medical Systems Europe aims for 15-20% of the MRI market share and is actively working towards that goal, by taking part in impacting research projects at Bordeaux University and Sainte Anne Hospital, Paris Descartes University in France.

The Vantage Galan 3T is instrumental in setting future clinical practise and offers two versions of magnetic fields gradients to step up cardiac and oncology imaging quality, by notably working with acquired and synthetic images, which help speed up acquisition times.

The Vantage Galan 3T is the technology used by the medical teams of prestigious football clubs such as Manchester United, Real Madrid and FC Barcelona. “These partnerships already demonstrated our strength in matching high image quality expectations in MSK imaging of professional players, anytime clinicians need immediate diagnosis for: acute injury or long term follow-up for physical load programme during training,” Thierry said.

Canon Medical’s MR product line also helps improve breast MRI, a

fast developing field with major on-going screening campaigns. In dense breast mammography, this technology can be a complementary solution, especially in difficult cases, as recent studies highlighted.

One machine in the pipeline that should obtain CE mark early 2020 is the 3T Vantage Centurian, which will be deployed in the research setting. The technology has the most performing gradients available on the market and is currently being implemented at Bordeaux University.

Be it for general or high-end MR systems, Canon Medical continues to invest massively to provide the fastest and easiest user experience, and match a common expectation: make MRI simple, fast and reliable, regardless of the operator’s knowledge and skills.

Customer satisfaction is reportedly very high on all devices and Canon Medical wants to set the bar higher.

“For us, it’s all about placing health-care professionals and patients at the centre of our activity. We cater to our end users’ needs; be they in daily practice workflow, post treatment, analysis or system optimisation. We have a very complete portfolio, with guaranteed ease of use, to help our users take MR to the best of its abilities,” Thierry concluded. //

Sports MRI - How Next Generation Imaging Systems are Giving Greater Insights

Dr. Steve McNally

Dr. Steve McNally, Head of Football Medicine & Science at Manchester United Football Club, examines how the rich depth of innovative MRI imaging better supports health surveillance, performance management & injury grading, with the ultimate aim of improving sporting outcomes.

There has been a long standing need for diagnostic imaging information to help quickly identify, prevent and treat injury in valuable elite athletic assets, such as footballers in the Premier League. Demand to pre-empt future conditions and manage the long-term performance of players through proactive health surveillance is now on the increase. The long-term value of a sports person impacts the bottom line at many sporting organisations, and therefore a breadth of medical imaging modalities and technologies is required to unlock information from deep within the body.

We are lucky in sports medicine that the pace of innovation in next generation imaging systems is evolving swiftly. Whilst ultrasound has to date been the quick de-facto choice, the depth of information delivered by the larger modalities such as MRI is expanding through next generation developments, giving much more data to base decisions on. The procedural times of MRI, for example, were once considered a negative factor but are now discernibly quicker as innovative software applications automate operational and clinical processes. In addition, image outputs are greatly improved to give rich clarity of detail to assist with sports science management.

MRI in sports health surveillance

Cardiac screening for proactive health surveillance is firmly on the radar for all sporting organisations. This is not only to identify undetected anomalies that could put life and health at risk, but also to monitor for the onset of coronary artery disease as players age. Indeed, from youth teams to the veteran professional footballer, anyone undertaking vigorous training and competitive matches is regulated to receive cardiology profiling every 2 years¹.

The imaging tool that has traditionally been used is ultrasound echocardiography, looking at the structure of the heart at rest and during stress exercise. Now, and increasingly, the structure and functionality of the heart is examined via the latest generation in MRI.

For example, new developments have accelerated the examination time for cardiac MRI, with fewer patient breath holds needed to deliver much more detailed, richer image outputs that give another level of screening and profiling of the more subtle presentations of cardiac anatomy.

MRI is also an excellent choice of tool for the diagnosing and monitoring of Chronic Traumatic Encephalopathy (CTE), the result of repetitive brain trauma from blows to the head and repeated episodes of concussion, which in football may have come from player contact or heading the ball. It is a hot topic in all contact sports such as boxing, rugby and martial arts and follows research at the University of California, Los Angeles (UCLA) using MRI as the option to explore CTE without any dose implications to patients².

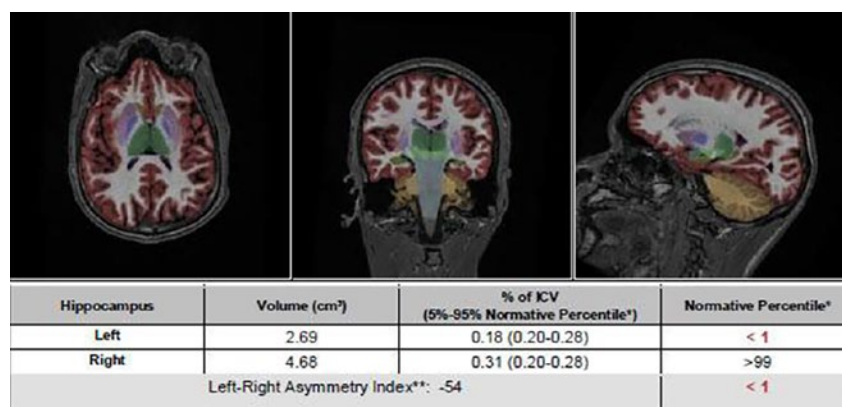


Fig 1: Next generation MRI is being used to gather data on brain tissue volumes



Canon

CANON MEDICAL SYSTEMS

From this season at Manchester United Football Club, we have started to gather data by using MRI (see fig 1) to measure volumes of brain tissue in specific areas, to monitor for a decrease in volumes over time. If the volumes become unusual or deviate from the norms that we would expect, it may help us identify early changes of CTE that need closer monitoring. This is a new, long-term data gathering study in our cohort of players that has been facilitated with the new next generation MRI³ now in place at our medical centre.

Advanced MRI applications will also assist in the surveillance of joint and articular cartilage health, a key consideration in athletic populations, that could limit and impede sporting careers or restrict performance capacity. New generation MRI will also assist alongside ultrasound in primary and secondary muscle injury prevention.

Managing player performance using imaging innovations

Using MRI Spectroscopy over the last four years we have been able to

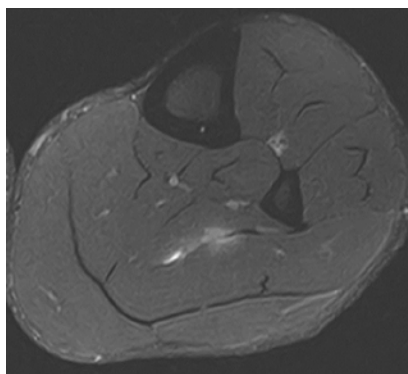


Fig 2: Very small fibre tears identified using high resolution MRI

undertake 'muscle talent scans' as part of managing player performance. This has enabled us to code the muscle fibre type of all our young professional players and estimate the measures of carnosine content in soleus and gastrocnemius muscles. This is a much more accepted and non-invasive approach to muscle fibre typing than undertaking muscle biopsies.

Muscle fibre typing tells us who can twitch their calf muscles quickly or more slowly. We know that this can correlate to performance characteristics indicating those that are sharp and quick versus those that are more endurance based. This information helps us manage the players and the squad's performance over the long term. For example, a very fast twitcher would suggest that muscles will fatigue more readily and require extra rest or nutrition, so informing our care plan.

The power of MRI to pick up subtle injuries

Even the smallest injury in elite sports has implications. Having the right diagnostic tool at the peak of its development is vital to diagnosing subtle injuries that could impact player health. Using high resolution MRI therefore helps to identify very minute intra-articular joint injuries, muscle oedema changes or very small fibre tears (see fig 2).

Detailed diagnostic information is crucial to then accurately give the injury a grading using classification systems⁴. This grading severity then translates into an estimate of the mean number of player and training days that will be lost.

Although there is conflicting research about the value of using MRI to determine time out, undoubtedly having higher clinical confidence in injury analysis by using high clarity imaging outputs from new generation systems has the potential to be intrinsically linked to the rehabilitation and recovery time of the player. This, of course, also impacts long term asset performance and financial value.

The advancement of sports imaging techniques

The ongoing advancement in research and development of imaging systems, in part due to clinical research partnerships pushing systems further than ever before, is an exciting time for us sports clinicians. Gaining wider diagnostic information about the structure and function of the body will steer our decision making to improve and speed up accuracy and expand surveillance of elite sports people. Next generation MRI is undoubtedly an increasingly vital tool in elite sports medicine management. //

References

- ¹ The European Society of Cardiology
- ² The American Journal of Geriatric Psychiatry, Volume 24, issue 10, Oct 2016, pages 784-790, <https://tinyurl.com/yj9fanje>
- ³ Canon Medical Systems Galan 3T MRI Injury grading systems used: Munich Consensus
- ⁴ Statement; FCBarcelona; and British Athletics.

EasyTech Solutions

Increase Throughput in MR

Frédéric Martin, Dr. Marie Dominique Boespflug, Patrick Andres

The EasyTech functions guide the operator through the scan process, from beginning until end. This reduces idle-time between the sequences, improves the workflow and enhances reproducibility for longitudinal follow-up examinations.

EasyTech Knee Package

The EasyTech Knee Package consists of the ^{SURE}VOI Knee and KneeLine+ applications and supports the operator in automatically centering the volume of interest (VOI) and position slices for knee examinations. The application also detects when the knee is incorrectly placed in the RF coil. It enables a knee examination with just one mouse click.

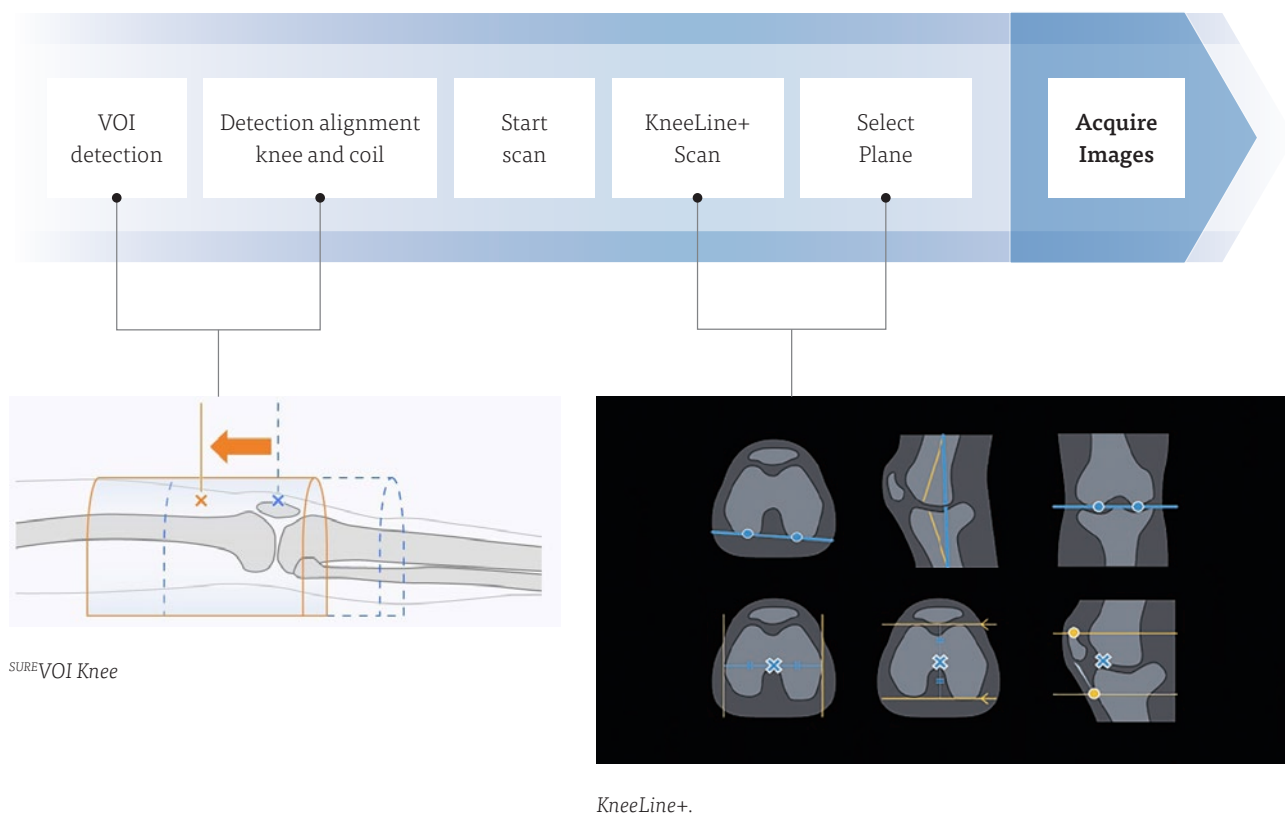
^{SURE}VOI Knee

^{SURE}VOI Knee is a positioning support function that automatically detects the knee and places the VOI and pre-saturation zones (if necessary) to eliminate wrap-around and flow artifacts. Using anatomical recognition, ^{SURE}VOI detects if the center of the knee and the center of the RF coil are aligned, and instructs the operator if repositioning is needed.

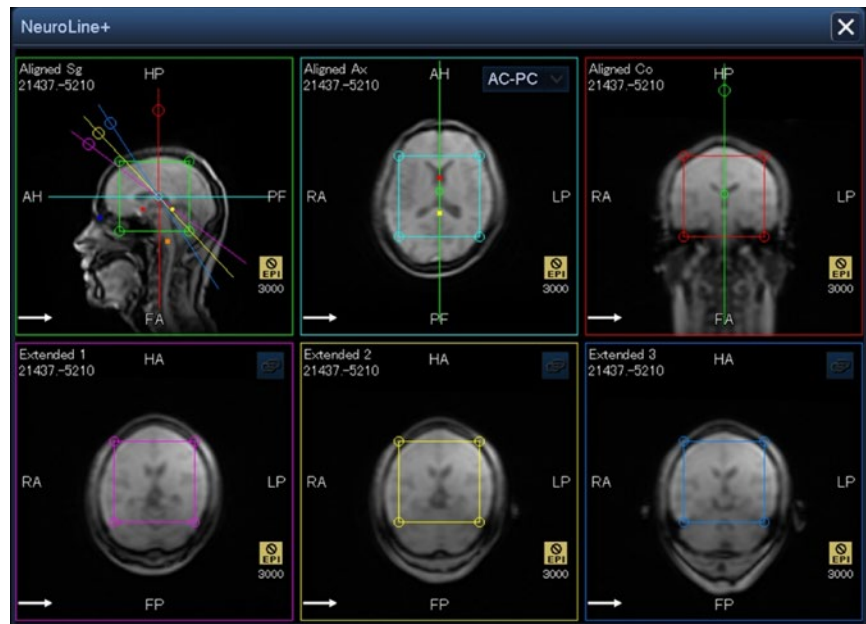
KneeLine+

KneeLine+ automatically defines the standard scan planes of the knee (axial, sagittal and coronal). If necessary, the orientation and position of the standard planes can be adjusted.

Workflow EasyTech Knee Package:



NeuroLine+
window.



The G.I.E VAR OUEST private center in Ollioules, France, has a Vantage Orian with M-Power V4.5. Most of the center's work is based on musculoskeletal- (frequently of the knee) and neurological examinations (of the brain).

Using the EasyTech Knee Package, the sequences follow each other automatically without wasting time. The operator can register and prepare the next patient. Looking for musculoskeletal examinations, the EasyTech Knee Package enables an increase in efficiency and scanning of an additional 1.5 patients extra per day on average.

"After 2 to 3 days of adaptation, the team acquired the utmost confidence in the AI automatic positioning techniques, which allow them to concentrate on other, more rewarding tasks, such as post-processing tasks. Examination time is optimized, and no time is wasted. Today, 85% of knee exams are performed using this technique.", explained Mr Martin.

NeuroLine+

The NeuroLine+ application is used to automatically plan brain scans. The three standard planes are detected: (1) the mid-sagittal plane, (2) the axial plane (either parallel to the anterior commissure - posterior commissure (AC-PC) line, or to the orbitomeatal (OM) line) and (3) the coronal plane. Alongside these planes, the user can define his/her own scan planes.

Initial results from G.I.E VAR OUEST demonstrate the efficiency of this technique, both from the point of view of reproducibility of longitudinal lesion follow-up and from a smooth workflow. Regarding the time taken to perform neurological examinations, they have increased efficiency by one more patient a day on average. In patients suffering from Multiple Sclerosis, the radiologist will not only be able to count the number of plaques, but will also be able to compare their sizes, because the follow-up examination is acquired in exactly the same plane. The same applies for the follow-up of patients with 'tumor-like' lesions, enabling better treatment adjustment.

"Using this technique allows us to carry out a real follow-up of patients with Multiple Sclerosis and brain tumors. The reproducibility of the scan planes enables us to compare both the number of macrophages and their size. Measurements can also be replicated in the case of brain tumor treatment, and we can judge the effectiveness of the treatment. Today, 97% of exams for MS and tumors are carried out using this technique.", explained Dr. Boespflug. //



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Radiographer,
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**Dr. Marie Dominique
Boespflug**
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MRI Clinical
Application Specialist,
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France.

What is Synthetic MRI?

Olea Nova+ is the Future

Thiele Kobus

Synthetic MRI is generated through calculation from acquired images and this MRI technology is gaining increasing interest. While the technique was already described in the 1980s, the high computational powers of current PCs make it possible to generate Synthetic MRI in real-time, extending its potential for clinical applications tremendously. Canon Medical together with Olea Medical offer a complete package for Synthetic MRI: Olea Nova+. VISIONS explains the technical background behind this.

Relaxation: The basis for MR contrast

To make an MR image, differences in magnetic properties between tissues are leveraged. Two important magnetic properties are the longitudinal (T1) relaxation time and transverse (T2) relaxation time.

Transverse relaxation time

T2-relaxation time is related to transverse magnetization. When no excitation pulse is applied, there is no transverse magnetization. By applying an excitation pulse, transverse magnetization is created. This transverse magnetization decays again over time. The speed at which the transverse magnetization decays defines the T2-relaxation time (Figure 1).

Longitudinal relaxation time

Although there is no transverse magnetization without excitation pulses, there always is longitudinal magnetization. The longitudinal magnetization is in 'thermal equilibrium'. By applying a 90-degree excitation pulse, the longitudinal magnetization is temporarily lost. After the pulse, the longitudinal magnetization will regrow to thermal equilibrium at a speed known as T1-relaxation time (Figure 1).

Tissue differences = contrast

Following a certain time after the excitation pulse, a difference in longitudinal and transverse magnetization occurs for tissues with short- and long T1 and T2 relaxation times. This tissue property is utilized to obtain contrast in MR images (Table 1).

Imaging parameters

As well as differences in the relaxation times, imaging parameters contribute to MR contrast. Echo time (TE) and repetition time (TR) have the biggest influence. With these parameters, the time between the excitation pulse and the

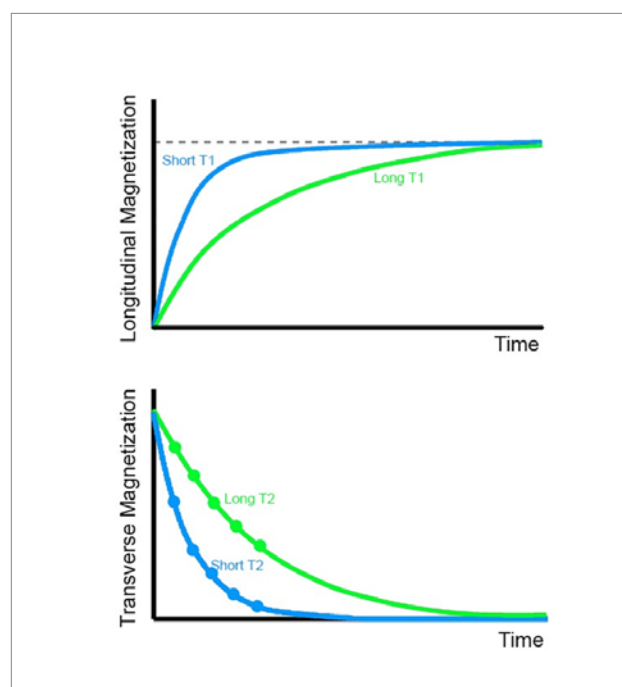


Figure 1, A fast return or magnetization drop means a short T1 or T2 relaxation time (blue lines) and the slow return or slow magnetization decay has a long T1 or T2 relaxation time (green lines).

Tissue	T1 (ms)	T2 (ms)
Water/CSF	4000	2000
Grey matter	900	90
Muscle	900	50
Fat	250	70

Table 1, Approximate relaxation times for different tissues at a field strength of 1.5T.

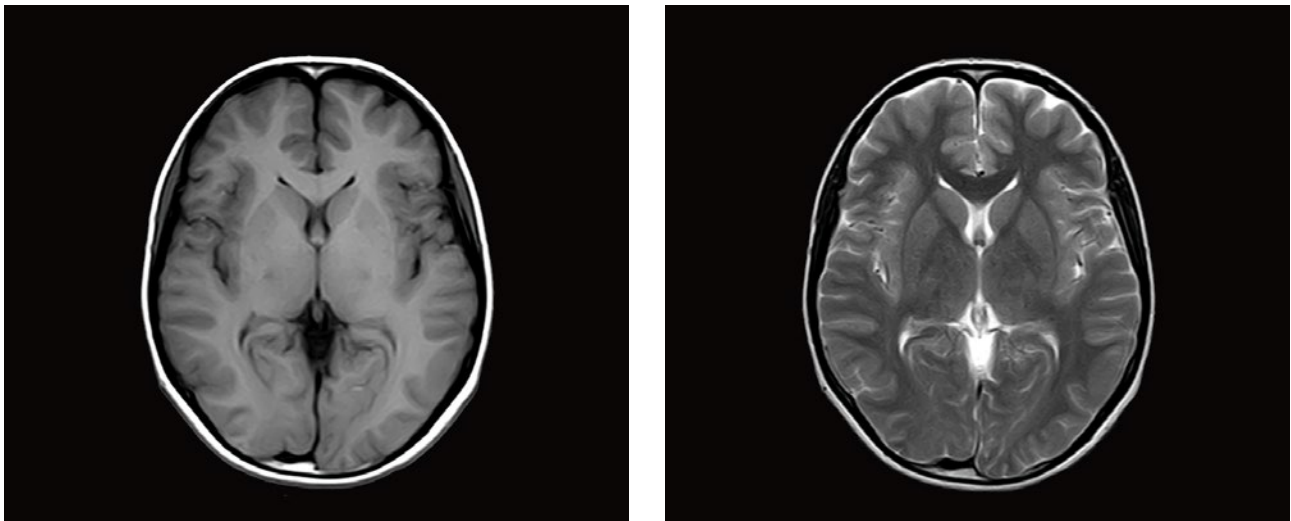


Figure 2, Axial MRIs of the brain. Left: T1-weighted image (short TE and TR). Right: T2-weighted image (long TE and TR).

sampling (TE) or time till the next excitation pulse (TR) is set. The operator can select these imaging parameters to give optimal contrast between two or more tissues.

Figure 2 shows differences in T1 and T2 relaxation times. For a T1-weighted image, we choose a short TE and TR, while for the T2-weighted images, both TE and TR are long. Many combinations in TE and TR are possible; however, to acquire many different contrasts, MR examinations can

become very lengthy. Furthermore, different pathologies can alter the relaxation times of the tissue, which could lead to a sub-optimal image contrast for diagnosis. To overcome this, it would be desirable if the imaging parameters could be altered retrospectively. This is possible if you know the actual T1 and T2 relaxation times. Based on these values, you can calculate how the tissues would behave under different imaging conditions. The method to create new images from these calculations is called Synthetic MRI.

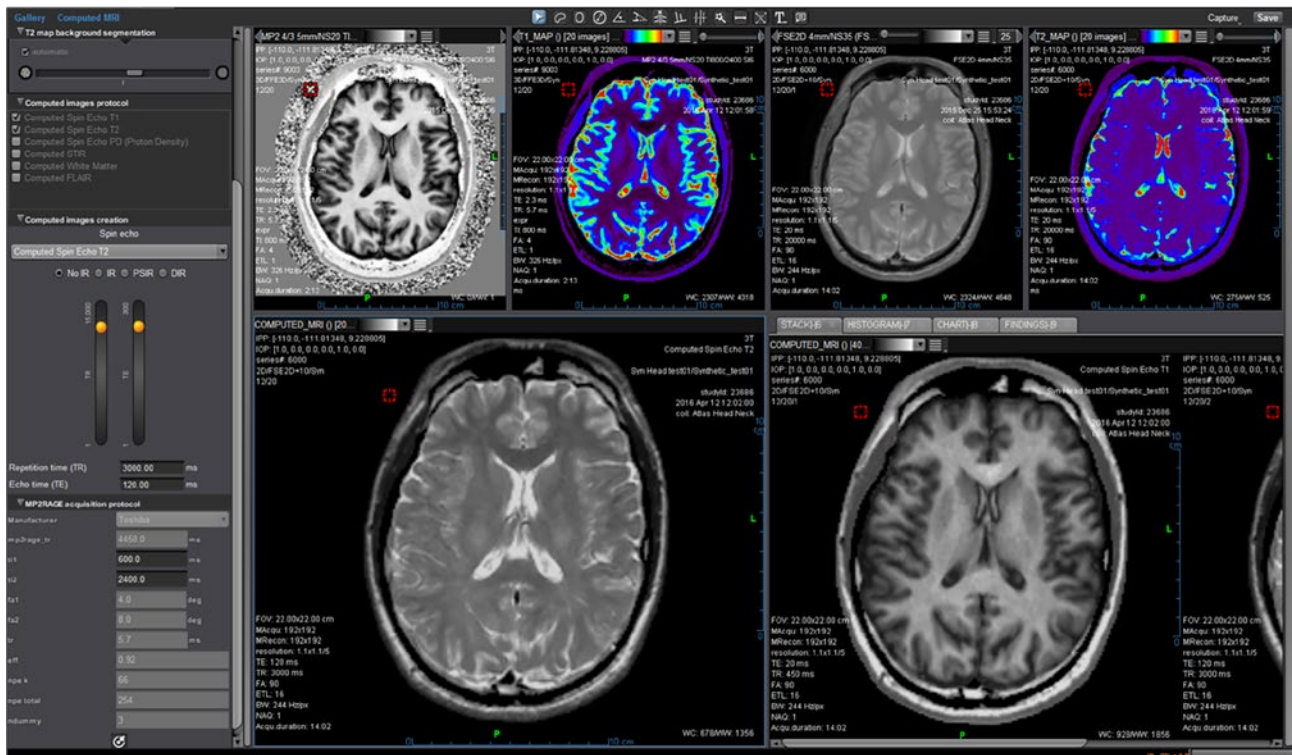


Figure 3, Olea Nova + software. Top row: MP2RAGE images from which the T1-map is calculated and FSE mEcho images used to calculate the T2-map. Bottom row: Two synthetic images with different imaging parameters.

How we do it?

Canon Medical MR systems require two sequences to be able to calculate T1 and T2 relaxation times. To measure the T2-relaxation time, we use a 2D FSE mEcho (2D Fast Spin Echo Multi-Echo) sequence. This sequence acquires the signal multiple times after an excitation pulse (illustrated by dots in the T2-relaxation graph in Figure 1). The longer the time between the excitation and the signal acquisition (TE), the smaller the transverse magnetization becomes. This is an exponential process and the Olea software fits the data points to obtain the T2-relaxation time (Figure 3 – top right).

For the computation of the T1 relaxation time, we use a MP2RAGE sequence (Magnetization Prepared 2 Rapid Gradient Echo). This sequence starts with inverting the longitudinal magnetization of all tissues and samples the regrowth of the magnetization at two different time points after this inversion. In the Olea software, the signal intensity at these two time points is fitted and the T1 relaxation time is determined at each voxel (Figure 3 – top middle). Before the fitting process of both the T1 and T2 relaxation times, motion correction is applied.

Now that the T1 and T2 relaxation time is known at every position in the image, the software can synthesize new contrasts using signal equations that describe the signal intensity based on the T1, T2, TE, TR and TIs (inversion times). To create a T1-weighted image, a short TE and TR can be selected. The software then calculates the contrast obtained with these settings, presenting the result immediately. This new synthetic image can be saved and exported. To change the contrast again, the parameters can be altered (Figure 4) and a new image is created, without the patient needing to be present.

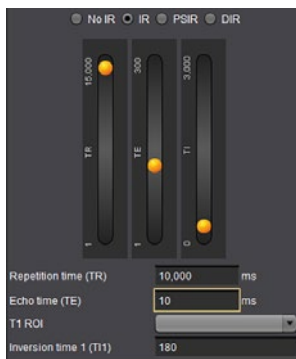


Figure 4, Selection of the imaging parameters.

Advantages and challenges

Synthetic MRI could alter the way MR images are acquired and interpreted. In a typical MR examination, several different contrasts are acquired. Many could be replaced by Synthetic MRI. This could significantly decrease scan time. Much greater flexibility is possible. The radiologist can alter the contrast after the MR examination and make additional contrast images without time penalties. The radiologist can access quantitative images of T1 and T2 relaxation times. This information could be very beneficial for follow-up examinations, as tissue changes can be compared quantitatively. Alongside this, contrasts that are difficult to obtain in vivo can be calculated, (e.g. examinations with long TEs or double inversion recovery (DIR) sequences). When acquired on the scanner, these sequences may have low signal-to-noise ratios, due to decayed magnetization.

A bonus is that the effect of metal artifacts is reduced in synthetic images cf. acquired images, which can improve image interpretation in e.g. MSK exams of patients with implants.

Despite these advantages, routine clinical use of Synthetic MRI will take some time. Radiologists are used to reading weighted images displayed in black-and-white, so it takes time to get a feeling for the quantitative (colored) maps of relaxation time (Figure 3). Furthermore, the contrast of a synthetic image with a certain TE and TR may look different to acquired images with the same settings.

A potential issue are the small partial volume artifacts that can occur at the edge of structures. However, these are easy to recognize by radiologists aware of their existence. Due to the endless contrast options available, radiologists might see structures that they are not as familiar with, requiring a return to their books! //



Thiele Kobus
Product Manager MRI
Canon Medical
Systems Europe.

Towards a Quantitative Era in MRI

Prof. Luca Saba

Professor Luca Saba, Head of the Radiology Department of the University Hospital of Cagliari, Sardinia, Italy, is an established and award-winning international radiology research professional. Enthusiastic about the advantages of Synthetic MRI, he shares his views on this new technique and his experience with Canon Medical's new Olea Nova+ with VISIONS.

Why are you particularly interested in Synthetic MRI?

"There are two levels of interest in Synthetic MRI; research and clinical. I think that the technique could have a significant impact in both."

"Firstly, for research, it is a cutting-edge technology with many advantages. It is easy to define a new hypothesis by using this technique in research, as everything remains to be proven. This is an important point. It's like writing a new book - Right now, we only know the letters, but we are starting to use them to write words, sentences, chapters, and so on.

Secondly, on a more technical basis, is that we can explore the intrinsic properties of the tissues. We can obtain pieces of information that do not depend upon the sequences or the magnetic fields but are intrinsic properties.

In the past, it was not possible to assign a unique number to a specific tissue. This was one of the limiting factors in MRI. When we conduct a study and demonstrate something based on signal intensity, we currently do not use a number, but say that it is brighter, or darker, compared to the muscle, for example.

These are obvious limitations compared to CT, in which we can assess that water is zero and fat is below -80 Hounsfield units. Previously, MRI, has been lacking a quantitative approach. Now, we are moving towards phenotypic and quantitative values - This is a concept of biomarkers. Synthetic MRI is allowing us to move towards a quantitative era of MRI.

With this, thirdly, we can move towards standardization of MRI interpretation. If we can assert that a tissue under examination has a value of 800 signal intensity, and we

know that 800 is the normal value of the grey matter, we can conclude that there is no epilepsy for example, because the grey matter in that region is normal. This means that standardization in interpretation could be applied and a new database in terms of T1 and T2 values of tissues could be created. It is a new language!"

"As mentioned, there is also a clinical impact. With synthetic MRI, we could theoretically reduce acquisition time. As other sequences can be created from only two originals, we can show that the acquisition time could decrease by acquiring both original sequences and comparing the generation time.

Also, the aim of our next studies is to determine if conventional and Synthetic MRI series qualities are similar; if they are, then we can demonstrate that images obtained with Synthetic MRI could, therefore, potentially replace conventional sequences.

In addition, with Synthetic MRI post-processing, it is possible to obtain missing sequences. This is not possible with a conventional approach. After performing a study with the general protocol, we can read the examination 24 hours later, for example.

If, at that time, we realize that one sequence is missing, we can still obtain it if Synthetic MRI sequences have been acquired. This is a strong point from a clinical point of view, and we have already performed this in reality. In one case, a specific sequence was missing, because of a particular approach, but, with Synthetic MRI, we were able to reconstruct it afterwards. It is really useful!

Finally, Synthetic MRI allows standardization of workflow. In the future, if this approach is confirmed as robust, we could only have Synthetic MRI, diffusion and something

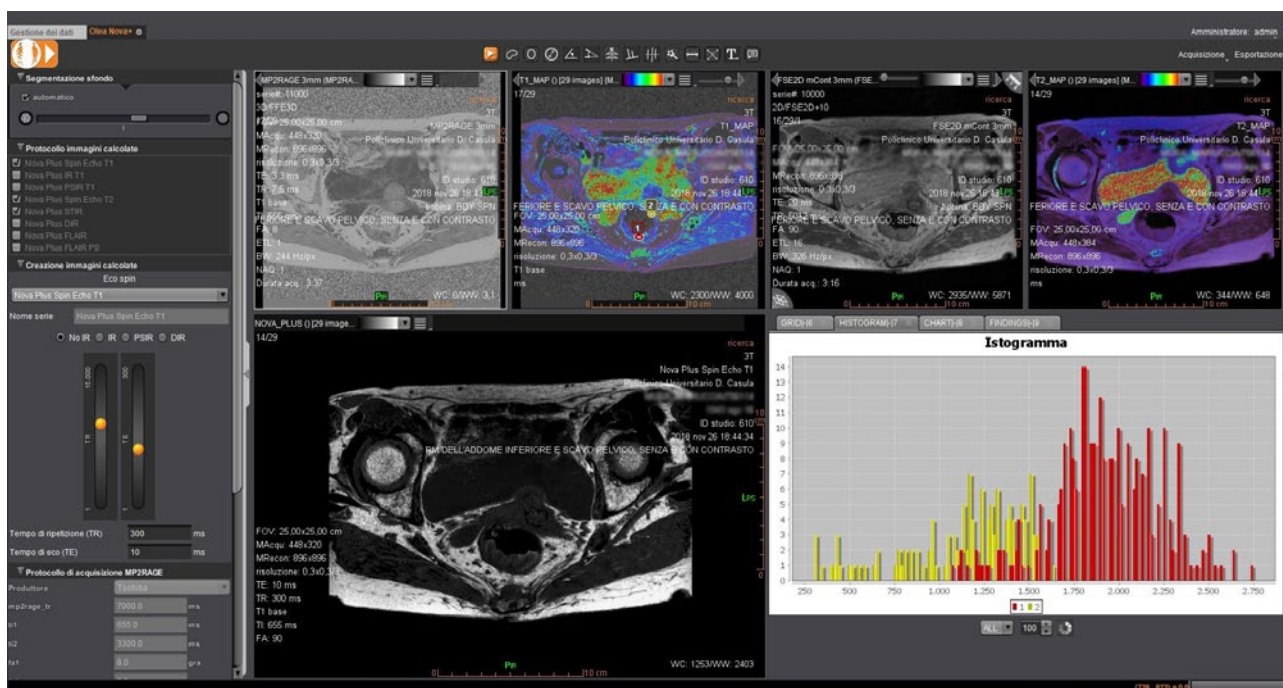


Figure 5, Olea Nova+ application in rectum. First row: MP2RAGE with T1 map and 2D FSE mEcho with T2 map. Second row: synthetic T1w image, histogram shows T1 values of neoplasm (red) and healthy tissue (yellow).

else, which gives us a very simple approach, but provides all the information we need. Moreover, this could avoid errors in the acquisition protocol. Most institutes have a high personnel turnover, however, working with MRI requires time to improve skills and understand techniques. With a simplified approach, we can avoid mistakes.”

What is your experience so far with Olea Nova+?

“We are currently using Olea Nova+ in different organs: brain, rectum, prostate and musculoskeletal (MSK) imaging. For prostate, what is interesting is that we have patients who have undergone biopsy or prostatectomy, so their Gleason score is available.

The protocol is very simple; so, when we have time to perform it, we do so in a general clinical setting. For brain, there are cases with some types of pathologies where we always use Synthetic MRI. Therefore, we have a data bank with control subjects and some groups of patients with pathologies.

That is very important, because if we want to create a database of T1 and T2 values in normal brain – this has not been done yet, we need normal brains.

Ongoing studies concern validation among readers and acquisitions on the reproducibility of the sequences obtained from Synthetic MRI, compared to the conventional sequences in clinical practice of brain MRI. We have made presentations to the European Congress of Radiology (ECR) 2019, in which

we demonstrated the flow charts and the advantage with regard to time, since it theoretically removes about six to seven minutes.

That is important, because compared to the 22 minutes conventional protocol, we could move to 15 minutes for a high throughput center.”

The sequences required for Olea Nova+ provide quantitative information about T1 and T2 relaxation times. Does it bring new relevant information compared to qualitative MRI images?

“Of course, we have also studied the contribution of the quantitative analysis. For example, in rectal and prostate cancers, we analyzed the differences in T1 and T2 values between healthy tissues and tumors and found a significant difference in the distribution of these quantitative values between normal and pathological areas (Figure 5).

This is the future, and it is simple.

What could also be interesting is to combine Olea Nova+ with Olea Texture analysis. The massive approach implies that we use all the available features. If we have 120 features, we should use 120 and test to identify which feature has the best performance. So, we could say at the end: the best thing is to perform MRI with the two sequences required for Synthetic MRI, add the quantitative analysis and use the convolutional matrix inverse feature, for example. There are so many opportunities.”

Prof. Saba graduated in Medicine from the University of Cagliari in 2002. His research interests focus on Multi-Detector-Row Computed Tomography, Magnetic Resonance, Ultrasound, Neuroradiology and Diagnostics in Vascular Sciences.

His work is embodied in more than 250 papers published in high impact scientific journals, including Lancet Neurology, Radiology, the American Journal of Neuroradiology, Atherosclerosis and European Radiology. Prof. Saba's work has been recognized by 18 scientific- and extracurricular awards

during his career. He has presented more than 500 lectures, papers and posters in National- and International Congresses (RSNA, ESGAR, ECR, ISR, AOCR, AINR, JRS, SIRM, AINR); has written 21 book-chapters; is the Editor of 10 books; and reviews more than 60 scientific journals.

Prof. Saba is member of the Italian Society of Radiology (SIRM), European Society of Radiology (ESR), Radiological Society of North America (RSNA), American Roentgen Ray Society (ARRS), and the European Society of Neuroradiology (ESNR).

Synthetic MRI was the first project jointly led by Canon Medical and Olea Medical® teams. What do you think about collaborative imaging?

"I completely share the view that joining forces creates more strength. So, if we can create a connection, a cooperation between different experiences, we will create a greater product. I believe that the best thing I have done in the past was to create connections with my colleagues by identifying the people who could collaborate with different points of view.

This fosters the creation of bigger things. Not alone. Alone, I can do nothing, or not as much. I like this philosophy; it is also mine. I have always thought that it is better to win a game with people than to lose alone." //



Prof. Luca Saba
Head of the Radiology
Department at the
University Hospital of
Cagliari, Sardinia, Italy.

M-Power Version 6.0

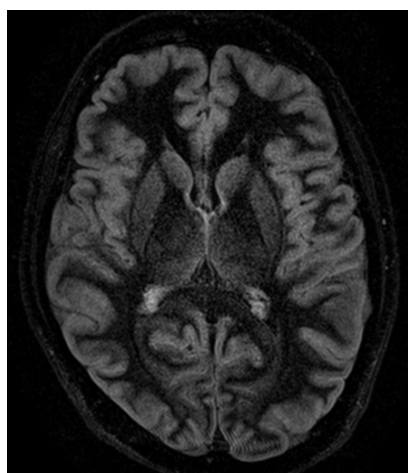
Beginning 2020, M-Power Version 6.0 was introduced for Vantage Galan 3T and Vantage Orian 1.5T and will later also become available for Vantage Elan 1.5T*. In M-Power Version 6.0, new options are available to enhance and improve your productivity, workflow, patient comfort and quantification results - in addition to the rich set features that were introduced with previous software releases.

M-Power - Features to enhance productivity

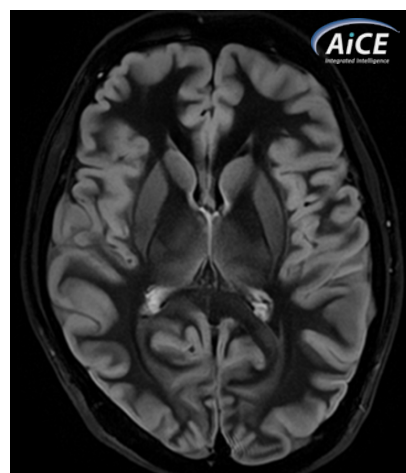
Advanced intelligent Clear-IQ Engine (AiCE)

AiCE is the world's first fully integrated Deep Learning Reconstruction technology for MRI. The engine harnesses the computational powers of a Deep Convolutional Neural Network, which is an artificial network inspired by the functioning of the brain. AiCE was trained on vast amounts of low and high signal-to-noise ratio (SNR) MR images to detect noise and remove it from the MR images. By removing noise, the SNR is increased and this enables spatial resolution to be increased or acquisition time to be reduced. AiCE expands diagnostic capabilities and reduces examination times.

Double Inversion Recovery (DIR) of the brain acquired in 2:18 min



Original image of axial DIR, a scan that is notorious for its low SNR.



Same DIR after AiCE reconstruction showing excellent image quality.

Compressed SPEEDER

Compressed SPEEDER is a new imaging technique that can accelerate scan times across the whole body. This unique imaging approach enables high-speed imaging up to four times compared to standard imaging while maintaining excellent image performance.



Sagittal image of the knee acquired in 3:55 min.



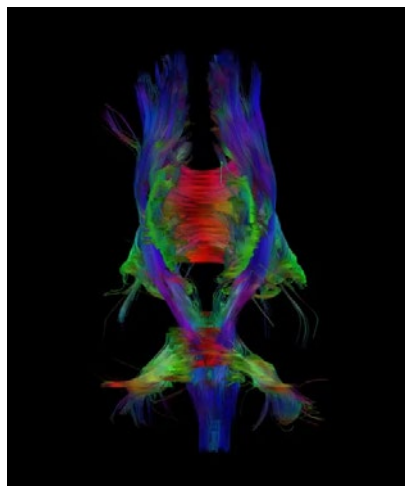
Image of the same slice acquired with Compressed SPEEDER in 1:25 min.



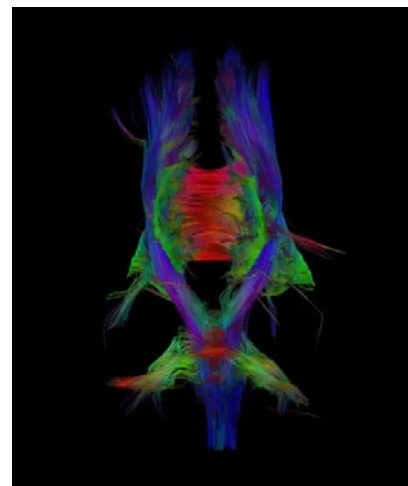
(*) Available options for Vantage Elan 1.5T might differ and are pending CE marking. Regulatory approvals in other regions may be pending.

MultiBand SPEEDER

MultiBand SPEEDER is a technology used to acquire multiple slices at the same time by using simultaneous multiband excitation RF pulses. This technology is especially suited for large-volume diffusion and diffusion tensor imaging examinations, where scan time can often be reduced by half.



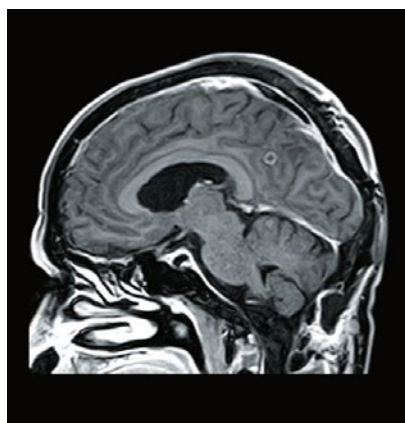
48-direction Diffusion Tensor Imaging with standard acquisition in 10:53 min.



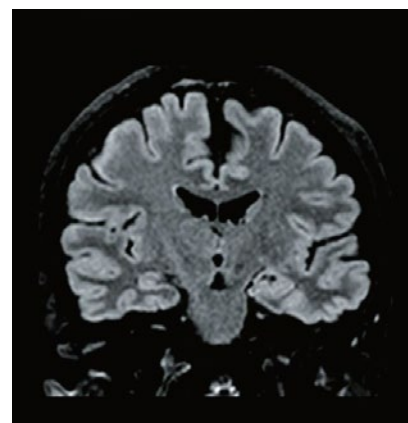
48-direction Diffusion Tensor Imaging with MultiBand SPEEDER acquired in 5:38 min.

Fast 3D mode

Fast 3D reduces scan times for mVox – Canon Medicals technique for isotropic 3D imaging - by up to 50%, allowing you to more quickly collect 3D imaging that can be reformatted into any plane.



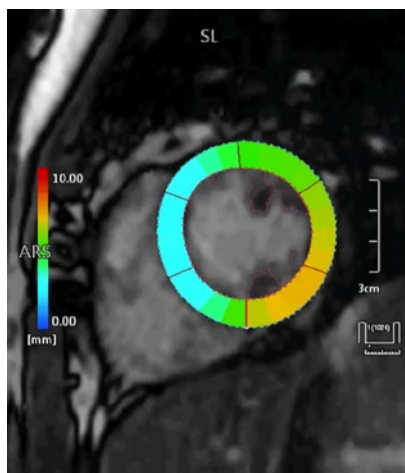
Post-contrast T1 acquired with Fast 3D. Courtesy of Jichi Medical University Saitama Medical Center.



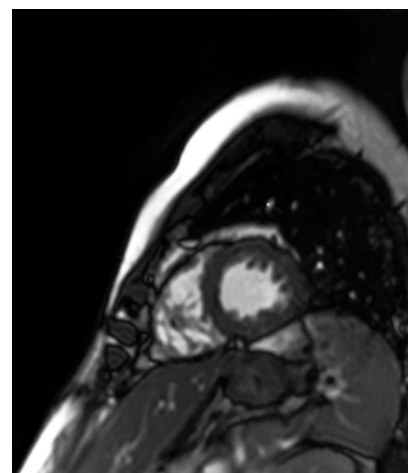
3D FLAIR acquired using Fast 3D.

k-t SPEEDER

k-t SPEEDER provides up to 8x acceleration, enabling you to acquire high temporal resolution cardiac cine. The high acceleration factor enables free-breathing or reduction of breath hold times so patients can be scanned more comfortably.



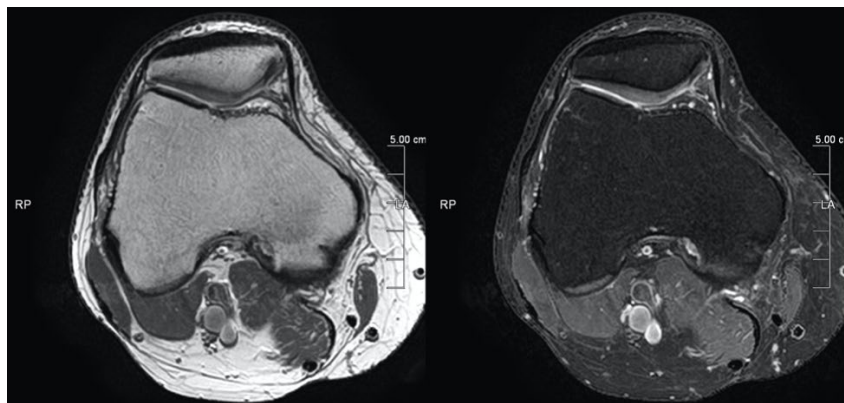
Myocardial analysis using k-t SPEEDER cine images.



Cardiac Cine Imaging acquired with k-t SPEEDER.

Water Fat Separation (WFS)

The technology based on 2D Fast Spin Echo (FSE2D) achieves consistent fat suppression and homogeneity while acquiring four different tissue contrasts in one scan, reducing the total number of scans you need to acquire.



Axial PD WFS - multiple contrasts in one scan, shown here: In-Phase (left) and Water-only (right). The In-Phase image is similar to a PD image and the Water-Only to a PD FatSat.

M-Power - Features to optimize workflow

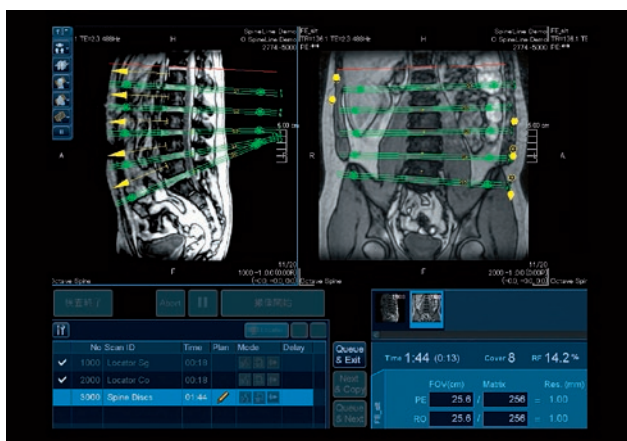
EasyTech

Improve workflow with a suite of auto alignment tools to guide the operator from start till end.

EasyTech offers automatic slice alignment and positioning for cardiac, neuro, knee and spine examinations.

SpineLine+

With its auto-locator functionality, SpineLine+ allows you to plan spine studies quick and easy. The scan positions for three planes (sagittal, coronal and spinal disc planes) are automatically detected and set conforming to the curvature of the spine.



SpineLine+.

NeuroLine+

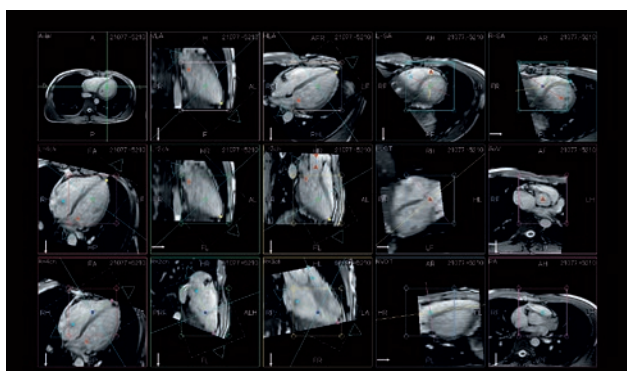
Achieve outstanding scan consistency for all your brain exams with NeuroLine+. The function's intelligent alignment algorithm allows you to automatically set up according to two different axial planes typically used in neuroradiology: AC-PC (Anterior commissure - posterior commissure) line and OM (Orbitomeatal) line.



NeuroLine+.

EasyTech Cardiac

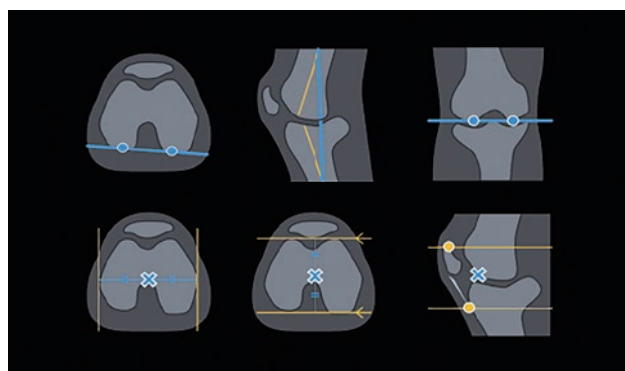
The EasyTech Cardiac Package consists of two functions: SUREVOI Cardiac and CardioLine+. SUREVOI Cardiac automatically detects the heart and moves the table to place the heart of the patient in the iso-centre of the magnet, which is essential for cardiac examinations. Next, CardioLine+ automatically identifies the 14 standard cardiac planes including right and left ventricle, as well as the four cardiac valves. This enables the operator to link the diagnostic scans to one of the detected planes. EasyTech Cardiac greatly simplifies cardiac scanning and helps to maintain consistent quality.



The 14 scan planes detected by CardioLine+.

EasyTech Knee

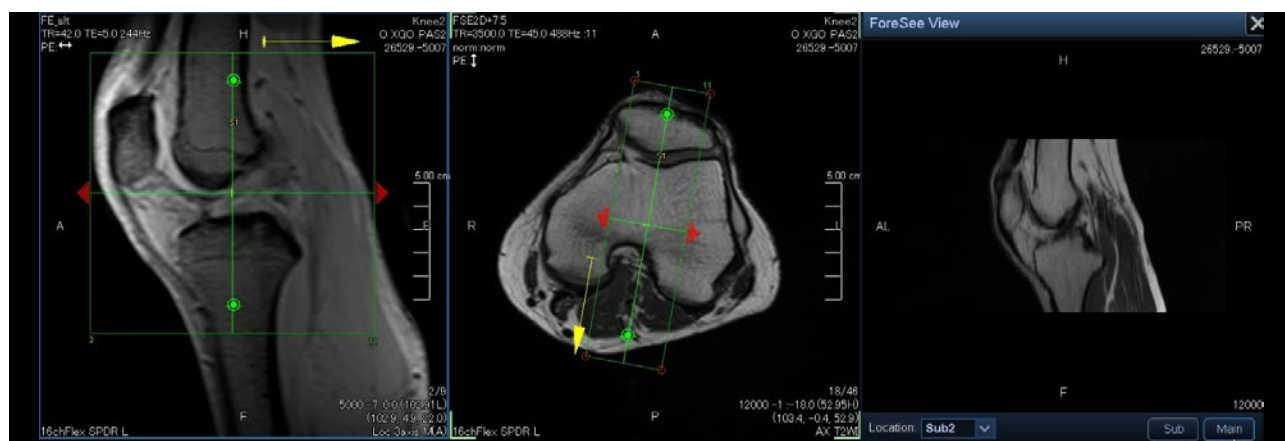
The EasyTech Knee Package consists of SUREVOI Knee and KneeLine+. SUREVOI Knee determines the position of the knee, also with respect to the center of RF coil, and advises repositioning if needed. KneeLine+ automatically defines the standard scan planes of the knee (axial, sagittal and coronal). EasyTech Knee enables a knee examination with just one mouse click.



KneeLine+.

ForeSee View

ForeSee View provides a real-time preview of the current scan plan and allows technologists to have more certainty that difficult to align anatomies, are planned correctly. Like the pancreas, heart, or certain orthopedic joints. By allowing technologists to foresee the scan plan, the need for re-scanning is reduced.



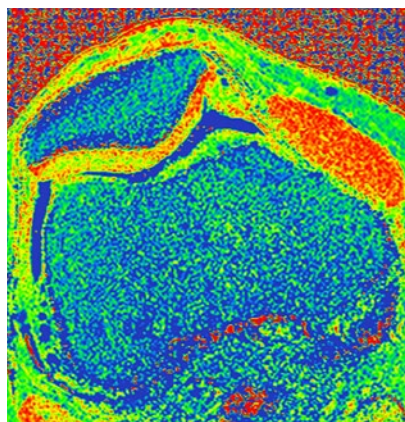
Planning with ForeSee View. In the right window – a preview of the slice you are planning is created, to be sure you have the inner cruciate ligaments correctly visualized.

M-Power - Features for Quantitative Imaging

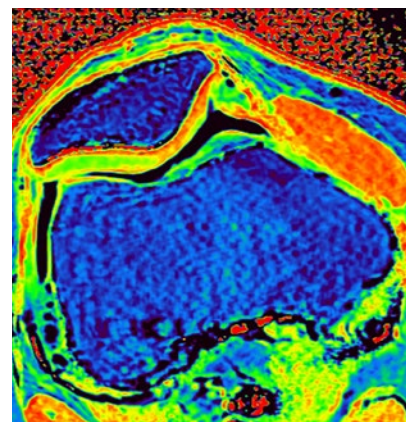
Quantitative MRI

In M-Power, a set of options is available for quantitative MRI. With these tools, it is possible to determine the T1, T2 and T2* relaxation times of different tissues. To do so, data are acquired on the scanner from which the relaxation times can be calculated in the M-Power software. The calculated maps can be saved as DICOM files and send to the PACS or workstation. Alternatively, the acquired data can be exported to Vitrea Advanced Visualization or Olea Sphere for calculation and post-processing.

Furthermore, the datasets can serve as input for Olea Nova+ and used to generate synthetic MR images with different contrasts, like PD, FLAIR and DIR. And lastly, quantitative MRI can be combined with AiCE, which removes the noise from the acquired images prior to calculation.



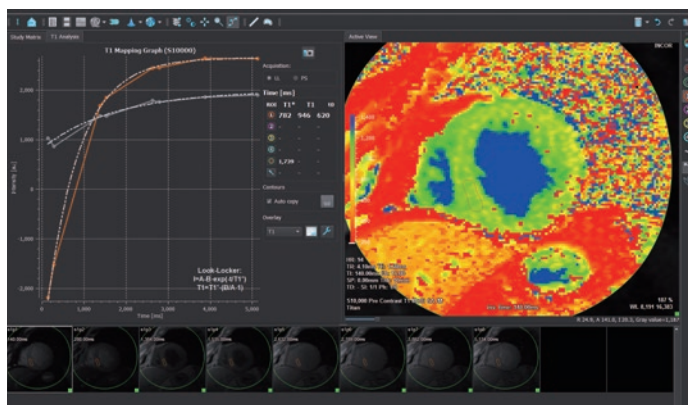
T2 map of the knee
0.5 x 0.5 x 1.6 mm resolution.



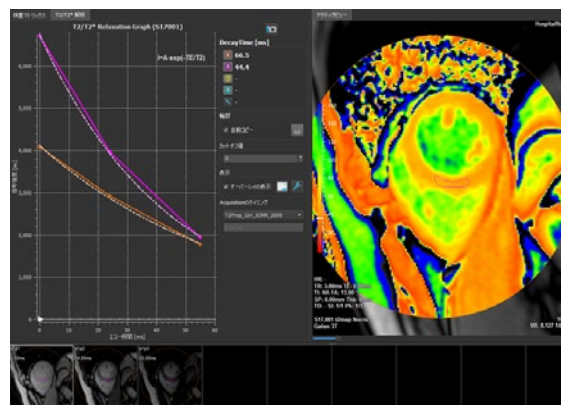
T2 map with AiCE
0.5 x 0.5 x 1.6 mm resolution.

Quantitative Cardiac MRI

Canon Medical offers a dedicated set of tools for quantitative MRI of the heart. For T1 mapping, an ECG-gated scan is utilized with a Modified Look-Locker Inversion-recovery (MOLLI). This enables the acquisition of a full T1 map within a single breath hold. For T2 mapping, pre-contrast pulses are used in an ECG gated scan. Next, the relaxation times can be calculated in the M-Power software or analyzed in further detail in dedicated software, like Medis QMass.



Cardiac T1 map processed with Medis. Courtesy of Instituto do Coração.



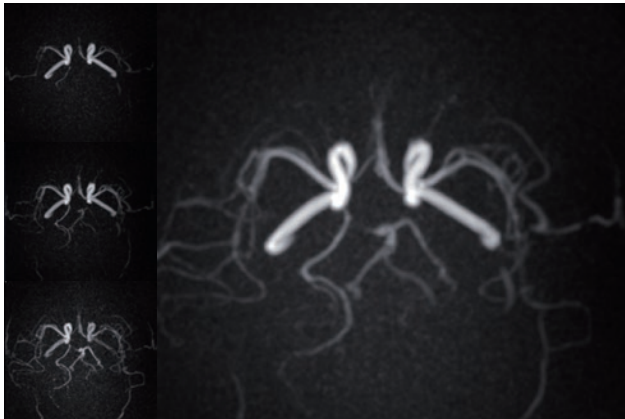
Cardiac T2 map processed with Medis.

M-Power - Features to improve Patient Comfort

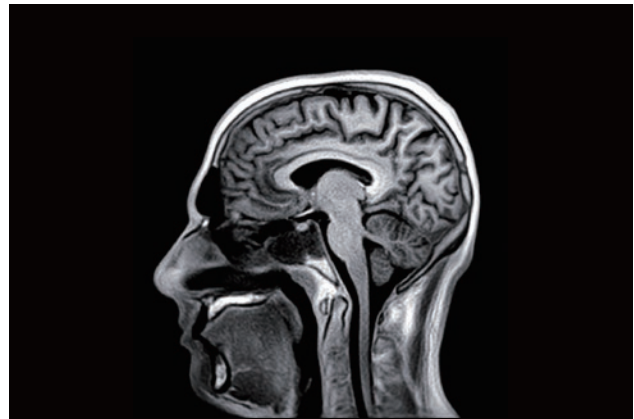
Pianissimo Zen

MR acoustic noise is one of the major complaints of patients and medical staff. Canon Medical's patented Pianissimo acoustic shielding technology significantly reduces the noise in and around the MRI environment for every sequence, every scan and every patient.

Next, the Pianissimo Zen quiet sequences further reduce noise to just above ambient noise level, making exams even more comfortable and easier to complete.



mUTE¹ 4D-MRA.



mUTE¹ 3D T1.

1 mUTE : minimized acoustic noise utilizing UTE

Non-contrast Solutions

In M-Power, there is a full set of free breathing and contrast-free applications available to deliver the most comfortable patient experience. For non-contrast MR Angiography, there are TOF¹ options, but also other techniques like FBI² – to visualize the fresh blood ejected from the heart, Time-SLIP³ – to observe regional blood flow, or FSBB⁴ – to depict small vessels with slow blood flow that are difficult to visualize with TOF.

Next to these and other MRA options, there is ASL⁵ to obtain vascular or perfusion-weighted imaging without contrast.

The use of non-contrast imaging sequences does not only improve the patient experience, but could also affect patient safety. Recently, accumulation of gadolinium in the brain has been observed in patients without renal dysfunction, but the long-term effects of this accumulations are unknown. //



Time-SLIP - Kidneys

- ¹ TOF - Time of Flight
- ² FBI - Fresh Blood Imaging
- ³ Time-SLIP - Time-Spatial Labeling Inversion Pulse
- ⁴ FSBB - Flow Sensitive Black Blood
- ⁵ ASL - Arterial Spin Labeling

k-space: (in) Finite Widths of the Matrix

Jan Pieter Döling, MD

What do Lord Voldemort (for all Muggles among the readers: the villain in the Harry Potter series) and magnetic resonance imaging have in common? At first glance not much, but when looked into details, in both someone is interwoven into everything in many ways. Sounds like heavy stuff, at least it is according to an insider from both areas.

But first things first: In my last article, 'Music and MRI', I dealt with the frequency mixtures based on a comparison of the (partly fictitious) alternating sequence between conductor and orchestra vs frequency excitation and selection of spins in the MRI. What is measured at frequency mixtures in the MRI, must now be logged somewhere first.

Here comes He-Who-Must-Not-Be-Named into play (no, not Voldemort, but the k-space), the place where these frequency mixtures generated during an MR sequence are "dumped" as digitised data, and are then decoded to create an anatomical image through a Fourier frequency analysis.

Assuming some basic knowledge of an SE sequence, I would like to continue with the parallels drawn in the last article (see last article in the Visions!), and create the following thought experiment: An MR layer is an orchestra. Contrary to the usual arrangement, the musicians sit in a chessboard formation in front of the conductor, in a similar way to a shift on MRI. A pixel corresponds to a musician who produces a sound at a certain volume during the "sequence". The type of instrument does not matter for further consideration, all are playing a "Larmor violin" (corresponding to the spin precession of an atom with the Larmor frequency).

There is no classical work like Beethoven's Ninth on the programme, but rather a ultra-modern work, in which the quality of the music doesn't really matter... A piece called "Variations on a Sound" is played with the following structure or sequence: The orchestra consists (in further gradations) of white-clad musicians, that are always playing loudly, some musicians dressed in light grey, that are always playing at an intermediate level and some dressed in medium-dark, dark grey and black, that always play quietly. The volume of the sounds thus represent the tissue features, so to speak, whether this be the sound of CSF, muscle or brain tissue, etc. Just like the SE sequence, after the 90° stimulus and subsequent 180° refocussing, with appropriately selected TE time, the amplitude of the spin echo depends on the TE time of the tissue.

The pitch of the "one tone" corresponds to the Larmor frequency of all atoms in a slice during the first slice selection gradient (see GS in Figure 1). This one tone is then repeated and modified across as many rows as there are in the picture in the MR, just like in an orchestra. So, with a picture matrix of 256 x 256 this would be a giant orchestra. For illustration purposes, the graphics picture matrix 16 x 16 is represented by the 16 transverse lines in GP! (See GP in Figure 1).

The middle row always plays the same tone, the foremost row starts by playing a very high tone, the back row plays a very low tone and the intermediate rows gradually play the

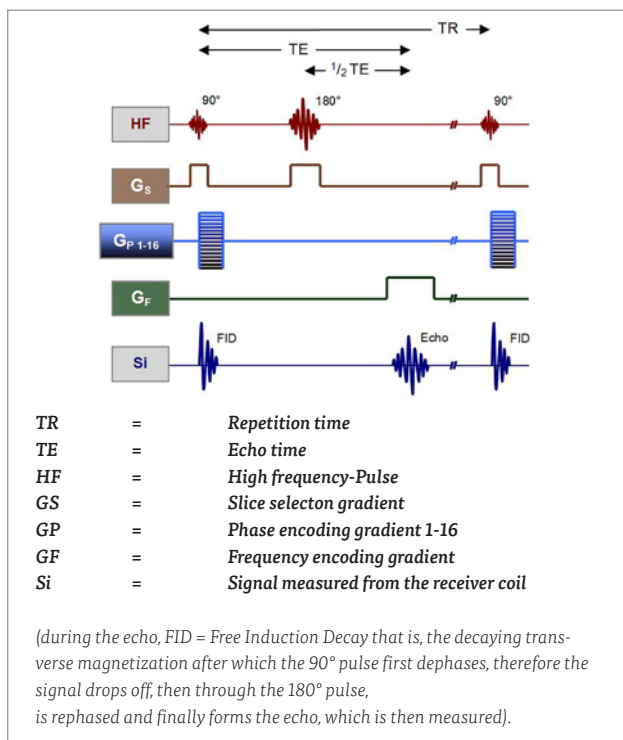


Figure 1, Spin Echo Sequence (SE Sequence) with an assumed image matrix size 16 x 16 (matching the k-space figure 3).

intervening tones from the front very highest notes to the very lowest (Just as with precession, the atoms in the MR layer vibrate at different speeds due to the changing phase-encoding gradient). This process repeats continuously, with the first row always playing one tone lower with each repetition. It will reach the same pitch as the middle row halfway through the process, before reaching the lowest note originally played by the rearmost row at the end. The last row does the same but in the opposite direction, ascending to the highest note at the end. The rows between them play either increasingly or decreasingly the intermediate pitches (= frequencies).

For those who now feel like this:



Breathe in, breathe out and keep breathing

So far, this music would be cruel, but it gets worse. In a similar way to MRI, this has so far been the phase encoding of a spin-echo sequence, in which these steps (k-space) series for (k-space) series are repeated with differently switched phase coding gradients (see GP in Figure 1).

Now just the frequency encoding is missing, which has come about by the fact that at the end of each of the steps described above, upon the conductor's mark (this assumes both the function of the transmitting and the receiving coil), the musicians playing in a line to the left of the conductor change their pitch into an even higher one, and those sitting on the conductor's right change their pitch to a lower one, with those in the middle corresponding to the intermediate values. This is done in always the same way and extent with the left ascending and the lower descending according to the constant frequency encoding gradients (see GF in Figure 1). Only the original tone levels are different - depending on the gradually decreasing strengths of the previous phase encoding gradient, as shown in our example 16.

At the end of this, depending on the image matrix, e.g. repeated 256 times, a mixture of different frequencies and volumes (in music, the appropriate name would be a cluster) can be heard and are measurable in the MR. This mixture has only slight differentiations, the human ear could hardly perceive any differences. However, Fourier frequency analysis makes it possible to calculate who played what and at what pitch and volume in the orchestra, since the type and extent of the manipulations are known - this is the case in the MRI!

It is crucial that at each end of each step described, the tones (clusters) of the whole orchestra (= MR layer) are recorded, so that the geometry of the k-space has nothing to do with the later geometry of the image, but that initially only data corresponding to the frequency mixtures (also: spatial frequencies) are stored in the k-space. The frequency mixes can be found in the first row of the k-space, where the first row played the highest notes, the last row the deepest notes (in a similar way to the first phase-encoding gradient!). Each point on that row corresponds to the changes, which are then replaced by the pitch changes from left to right that took place (similar to the frequency encoding gradient!) etc. etc ...

In every single point of the k-space there is information from the whole layer and only through a Fourier frequency analysis and recalculation of this data can an image be created. The pitch or the frequency is used by means of encoding processes described here solely to identify the location within the layer / orchestra, and finally also to assign to this point the volume with which this sound was played. Because the volume (loud = light, quiet = dark) ultimately represents what we want to know, namely, which tissue property is there or how intensely it is represented in the picture (did a light grey or black-dressed musician play ...?).

When measuring the next layer - next k-space - a new slice selection gradient is switched; similarly, all musicians in the orchestra tune their instrument (the "Larmor violin") a little higher and the whole procedure starts from the beginning again - now onto variations on the next-higher tone!

If you look more closely at the sequence of the "variations on a tone" described above - or if you listen carefully - you will notice that the first and last step result in an identical mixture of tones / frequencies. First, the front row plays the highest and the rear the lowest tone, and in the end it is exactly the opposite, i.e. the roles of the musicians in front and behind have been reversed, so that the resulting frequency mixes are the same. This means that the k-space filled in this way has corresponding symmetries, which make it possible to "knit" MR sequences, which make up only (slightly more than) half of the k-space, since the other half is already known in principle is, this is called e.g. half Fourier acquisition and saves time!

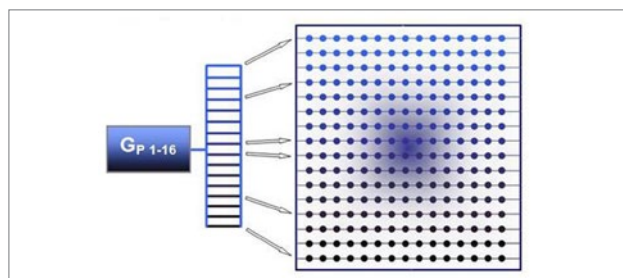


Figure 3, A sweep of a frequency coefficient in a spin-echo sequence (see Figure 1) represents one row in the data matrix of the k-space.

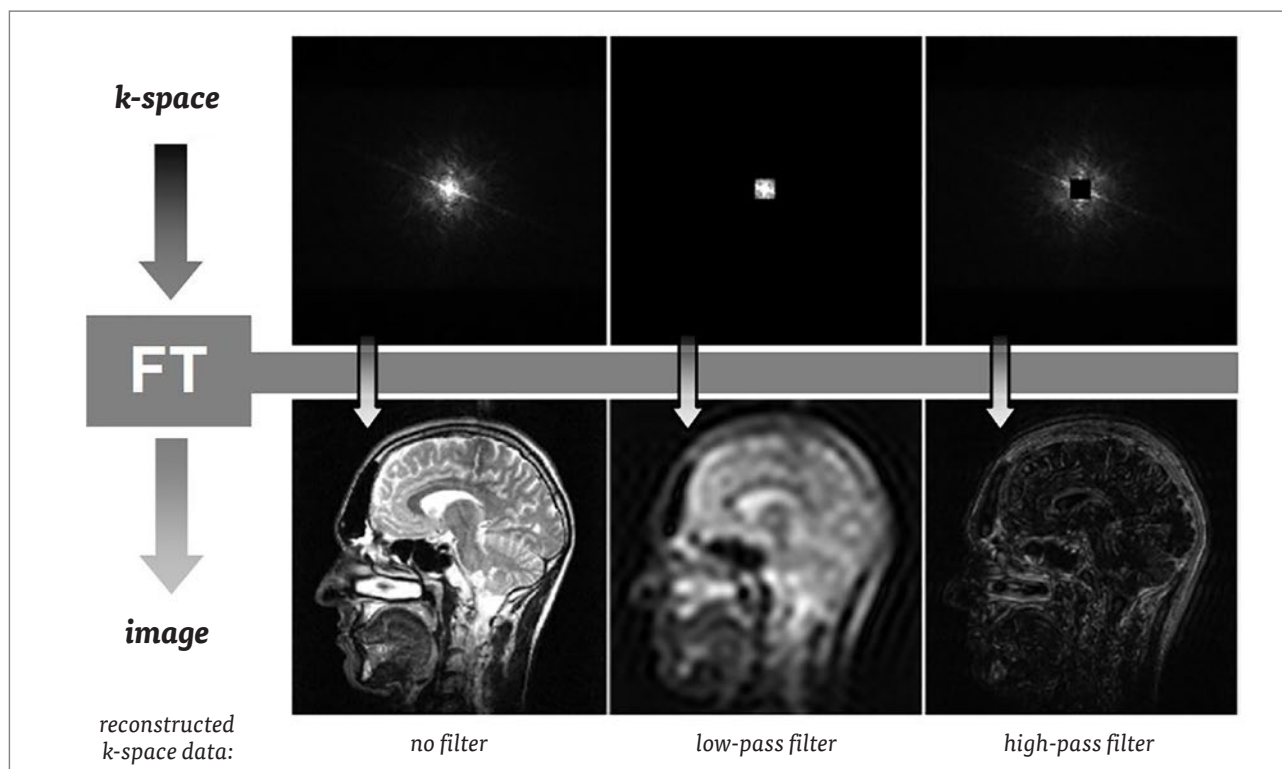


Figure 4, Different localization of image information in k-space, results of image reconstruction after filtering; FT = Fourier transformation according to Dr. F. Wetterling, *Imaging Systems in Medicine, Magnetic Resonance Tomography III: The k-space* Ruprecht-Karls-University Heidelberg.

Another characteristic of k-space is that it is predominantly contrast information that is stored in the central sections (see Figure 3 dark blue), whereas in the outer areas, it is predominantly detail or contour information that is coded. Mathematics and physics are behind this.

Once again it is arbitrarily complicated but let's just accept it!

Imagine this as follows: around the middle of k-space, the frequencies deviate only slightly from those of the entire layer, and vice versa, the different higher and lower frequencies are to be found in the outermost sections, for in the first variation of the “one tone” (in a similar way to the first frequency encoding gradient with a high amount), the first and last row of the orchestra (= the layer) played both the highest and lowest tones (= frequency). The subsequent constant manipulation of the frequency encoding gradient always requires the highest tones to be on the left and the lowest tones to be on the right (= frequencies).

In fact, it is not the absolute height of the tones (= frequencies) that is important but their deviation from the frequency before manipulation by phase and frequency gradients for the division into high and low frequencies. By interpolating frequency filters in the Fourier analysis, i.e. a high or low pass, the results would be as follows: This k-space architecture is also important in situations in which important information about the contrast does not persist, as in the prime example of contrast agent angiography where the intravenously administered contrast agent remains in the body for only a limited amount of time, e.g. in leg arteries. Thus, the central k-space sections are first read out, which above all

represent the contrast (generated by the gadolinium) and only a little later, the exact contours of the tissue are added by the peripheral k-space sections and are read out.

If this would be read in “normal” order, line by line, the contrast information in a pelvic-leg MR angiography in 3 levels would no longer be available by the time you reached the lower legs and the investigation would thus be unusable.

And there are of course other readout possibilities for k-space in the manifold- developed sequence types, and perhaps other areas too!

Breathe in, breathe out and keep breathing

Admittedly heavy stuff, but you must try to visualise these processes again and again, because only constant repetition leads to the goal here - I hope my imaginary orchestra was helpful!

Until next time! //



Jan Pieter Döling, MD
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Municipal Hospital Kiel.

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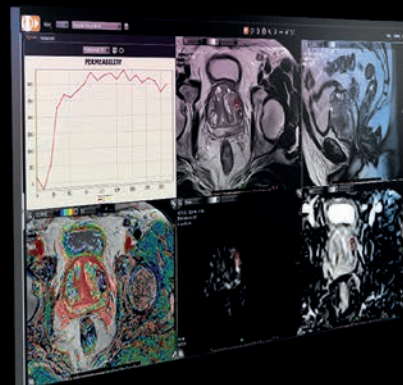
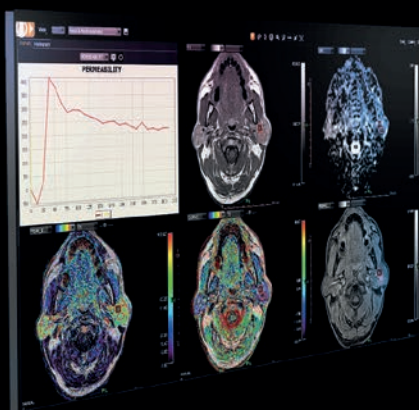
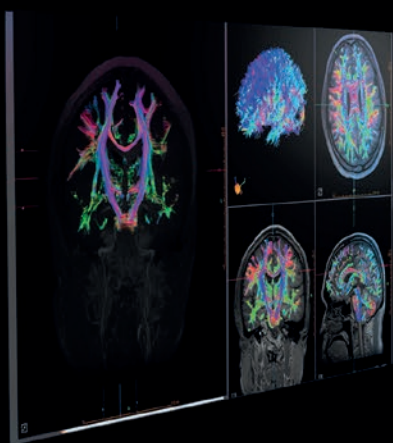


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