visions

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*Image from our **Made possible** campaign. The campaign is a natural extension of our corporate **Made for Life** campaign that has been running over the last years. This new phase reinforces our clinical solutions approach, covering Oncology, Cardiology, Neurology, MSK | Sports Med., Women's Health and also supports HIT, AI and Service solutions like Cyber security.*

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Folow us:

// EDITORIAL

In 2012, some prehistoric remains were discovered at a ranch in Argentina. Not revolutionary in itself if you consider that there are often finds from prehistoric or medieval times. But in this case, it turned out to be something very special. It concerned more than 150 fossil remains of no less than six gigantic dinosaurs. A very rare kind of which, for example, the femur alone was more than two meters long. The type specimen, a young adult, was estimated 37 meters long with an approximate weight of 69 tonnes. As far as we know now, the biggest dinosaur that ever walked on earth - Patagotitan mayorum[1]: nice to meet you!

But history has shown that survival is not just a matter of size or strength. Both in the animal kingdom as in business life, adaptation, continuous development and transformation are of vital importance to survive and prosper.

At Canon Medical, we finalized one of the most important transformations in the history of our company. We carefully executed and confidently implemented our change plan under the name "Chouchou" project, which is Japanese for butterfly; symbolic for the transformation of the caterpillar into a beautiful butterfly.

Being a leading innovator in the medical imaging business for over 100 years, we naturally secured our knowledge, experience and kept our ever customer and patient-oriented attitude. Especially the latter is of paramount importance to us. Customer satisfaction is therefore continuously measured by an independent third party and shows time and time again that we score very high ratings, usually between 8.5 and 10, in the field of training, delivery & installation and services.

Despite these high ratings, we do not just sit back comfortably. “Everything changes and nothing stands still” as Heraclitus already concluded very long ago[2]. And that is exactly what we do. We continue to adapt, evolve and transform. Finding new ways to develop intelligent solutions that meet growing needs for fast and improved clinical confidence. We accomplish this with our unchanged, strong focus on putting our customers and patients at the centre of everything we do, as you can read in this edition.

And when you read more on transformation or see a butterfly next time, think of us. Because with Canon Medical, transformation and true innovation are made possible.

Kind regards,

JACK HOOGENDOORN
Senior Marketing & Brand Manager
Canon Medical Systems Europe BV

Reference
[1] *https://en.wikipedia.org/wiki/Patagotitan*
[2] *https://en.wikiquote.org/wiki/Heraclitus*

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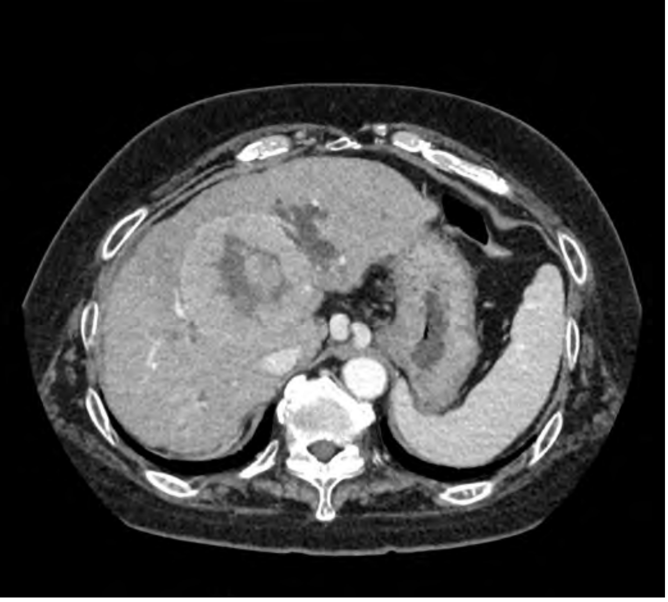

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Grand reopening Austrian office

"Ready for the Future" was the theme used for the opening of the redesigned Canon Medical Office in Wiener Neudorf on Friday, January 18, 2019.

The event was an lively mix of exciting lectures, inspiring discussions and an interesting evening with many surprises. Curious? Have a look at the M4TV video impression **https://youtu.be/MH7u0ed30vw** //

Official Opening Secondlife Refurbishment Centre

The Secondlife Refurbishment Centre moved from Denmark to the Canon Medical Head Quarters office in Zoetermeer, the Netherlands.

Building the new facility from scratch provided the opportunity to immediately accommodate all rooms with the latest and state-of-the-art equipment and also to arrange the workflow in the most efficient way.

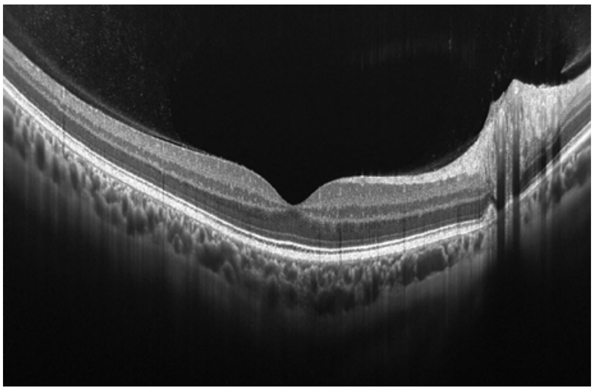
As the original equipment manufacturer, Canon Secondlife is the ideal source for reliable refurbished imaging systems. The refurbishment program is meticulous and demanding to meet the high standards of quality and reliability you can expect from Canon. All imaging systems considered for the Secondlife refurbishment program undergo the same process from careful selection, professional de-installation and refurbishment, installation and after-sales support.
The official opening was held in January. //

Welcome Eye Care

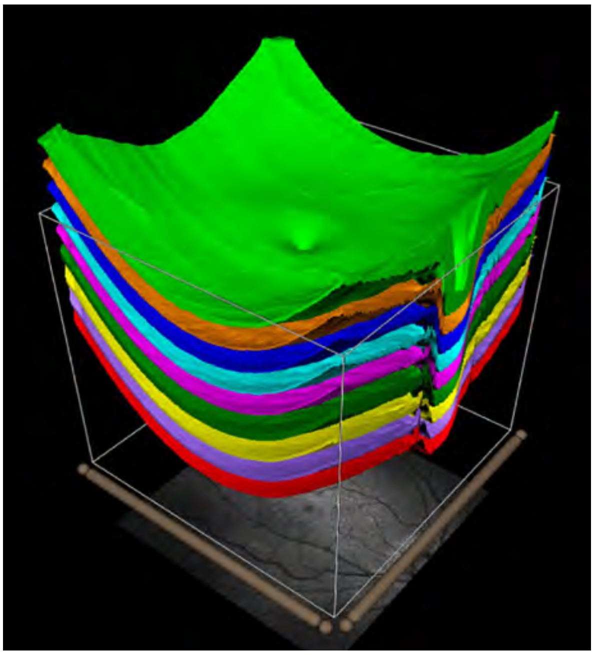
The global market for ophthalmic diagnostic devices is growing steadily due to the increasing aging population. But also young people are suffering from various eye related problems, due to the increased use of smartphones and long hours of working on computers. There is certainly an increased awareness among people regarding the need to get eye check-ups on a regular basis to avoid major eye problems.

As a result of the integration project, Canon Medical Systems Europe, now welcomes an additional business unit: Eye Care.

Canon has been active in the ophthalmic field with diagnostic devices since 1976, when the world's first Non Mydriatic retinal camera was introduced- a camera that could take images of the retina without requiring the use of any drugs to dilate the pupil. The current Eye Care product line up consists of measurement - and imaging devices and is available at: **https://eu.medical.canon/product-solutions/eye-care** //



Healthy Retina.



3D Visualisation.

Our vision for the year ahead

At Canon Medical we like to think of our main areas of focus as saving lives every day by working to stop the world's worst diseases. We do that by providing insights through information. We generate high quality clinical data with our CT, MR, PET, X-ray, ultrasound, and clinical lab systems, and we deliver the right information to our clinicians to provide their patients with the care they need.

Together, we are leveraging Canon's expertise in imaging processing to enhance our solutions in areas such as oncology. Through the use of techniques like deep learning, we will make new tools available to help clinicians detect the presence of cancer earlier than ever before and be able to predict and monitor disease progression with tremendous accuracy. I believe that's what customers can expect from Canon Medical in the next 12 months.

Cancer, stroke and Cardiac disease are on the rise and these are terrible conditions responsible for more than 23 million deaths per year. These are the diseases we have to stop. For all of these diseases, both early detection and accurate assessment are critical to effective treatment, and this means we need to see the tiniest details with even greater clarity. This is why we at Canon Medical have made high resolution one of our key focuses. With these technologies, the tiniest details are revealed with unparalleled clarity allowing our clinician partners to act early and make a difference to patients' lives.

We understand that the financial burden on healthcare, and hospitals in particular, continues to escalate. In order to support our partners, we focus on three key values: clinical value, operational value, and financial value.

In addition to our constant effort to minimise the acquisition and reconstruction time, we also strive to perfect the ergonomics of our systems so that total exam time can be reduced and the patient experience can be maximized. Furthermore, workflow improvements mean faster results a lower burden on hospital staff creating an efficient and effective environment for imaging physicians, radiographers, and the patients they care for.

We have developed technologies to manage human and equipment capital in order to maximize a hospital's investment. We aid radiologists with intelligent clinical decision support, which helps derive insights from data and automates findings management.

We augment our already world-class imaging systems with deep learning reconstruction to recover resolution within our images with the lowest possible time and dose. AI is changing the way we look at imaging.

Our "Made for Life" philosophy is a long-standing commitment to our partners, our patients and to you. We truly care about the lives of every patient, and we work tirelessly to create the solutions that will deliver better outcomes for our patients and our partners. We believe that this guiding principle sets us apart because of our dedication to and key focus on life.

TOSHIO TAKIGUCHI
President and Chief Executive Officer
Canon Medical Systems Corporation


i18LX5
i8CX1
i24LX8

Interview with Dr. Eichenberger and Prof. Kellenberger at the Zurich Children's Hospital (Kinderspital), Switzerland.

Aplio i800 Enhances Ultrasound Capabilities for Specialist Pediatric Applications

The Zurich Children's Hospital (Kinderspital) is the largest center of excellence in pediatrics and pediatric surgery in Switzerland. It is considered to offer the country's leading medical facilities for children and adolescents, as well as one of the best in Europe. With a total of 2,300 staff, the Radiology Department comprises of 20 radiologists with wide-ranging expertise. The acquisition of two Aplio i800 ultrasound scanners from Canon Medical enables the hospital to meet its growing needs. Prof. Christian J. Kellenberger, Head of Diagnostic Imaging and his colleague, Dr. Andre Eichenberger, Head of Sonography, explain how the new systems have already surpassed the performance of any others.

The Zurich Children's' Hospital provides sophisticated services in acute care, emergency medicine and rehabilitation, as well as outpatient care. It is also active in many cutting-edge research projects, including Elastography.

"We strive daily for the well-being and swift recovery of sick children. Our hospital provides the first, and as yet, only, research center in Switzerland that is solely dedicated to pediatric research," said Prof. Kellenberger. "Patients are referred to us from all areas of Switzerland and abroad. Alongside carrying out the normal tasks of a university hospital, we also train doctors to become specialists in their field."

Future modality in pediatrics

"Ultrasound is, and will remain for the foreseeable future, the primary advanced diagnostic modality in children," said Prof. Kellenberger. "We needed additional ultrasound capacity and particularly wanted portable, high-end systems."

"We bought two systems, because we needed considerable additional capacity. and we selected the Aplio i800 systems because they provided the best image quality of all the systems that we tested."

"The Aplio i800 has exceeded my expectations. The image quality possible with the Aplio i800 is so exceptional that we

from left to right: Roman Rechsteiner (Canon Medical Systems AG/SA), Dr. Eichenberger, Prof. Kellenberger.

simply do not need to use several of the other techniques, such as fluoroscopy, or other systems for clinical diagnosis," added Dr. Eichenberger. "Sonography has made great strides in recent years. It is already the gold standard in diagnostics. It is already an adequate alternative for many MRI and CT examinations, especially in pediatrics."

"The new Aplio i800 systems are capable of achieving a higher rate of successful studies than our older generation machines," continued Prof. Kellenberger. "The advanced Matrix technology means that the systems can provide beautiful images and offer consistently better image quality than any other machines. The images are like painted masterpieces!"

Dr. Eichenberger, Head of Sonography at Kinderspital.

The high image quality of the systems supports higher diagnostic accuracy, shorter imaging times, and allows for a greater work load.

"One example that we have noticed is in suboptimal visualization of structures in the rectovesical pouch are no longer as problematic, as with the older machines." noted Prof. Kellenberger.

"While we currently do not use the Aplio i800 systems for Interventional Radiology (IR) procedures, because we have other systems that are habitually utilized for interventions, as we expand our experience with the Aplio i800, it will be routinely applied to IR," said Prof. Kellenberger.

User-friendly

Ease of use of all appliances and applications is very important at the Children's Hospital.

"We instruct new doctors on ultrasound applications on a monthly basis. The Aplio i800 is easy to learn and it's very simple to get diagnostic quality images within a very short training period," he added.

New techniques for soft tissue diagnoses

Canon Medical has established a clinical cooperation with the hospital to develop software and hardware in Shear Wave Elastography (SWE) for use in pediatric imaging, as well as the use of Superb Micro-vascular Imaging (SMI).

Elastography methods work through variations in the elasticity of soft tissues that result from specific pathological or physiological processes. SWE relies on acoustic radiation force pulse sequence to generate shear waves that are perpendicular to an ultrasound beam, causing transient displacement. SWE is a promising technique in determining the severity of disease and identifying the most appropriate treatment and follow-up options of a variety of soft tissue conditions including musculoskeletal issues including problems with tendons, muscles, nerves and ligaments.

"The Aplio i800 has exceeded my expectations. The image quality possible with the Aplio i800 is exceptional."

> *"We selected the Aplio i800 systems because they provided the best image quality of all the systems that we tested. The images are like painted masterpieces."*

Prof. Kellenberger, Head of Diagnostic Imaging at Kinderspital.

It has already been used in several clinical studies to evaluate all kinds of other soft tissue conditions including tumors.

SMI is another complementary imaging technique for qualitatively confirming suspected lesions. However, additional research is still required to evaluate the added diagnostic value of elastography and SMI in children. SMI actually competes with Contrast Enhanced Ultrasound (CEUS) in many applications.

A big step forward

"The research is fascinating and is progressing fast. There are already many research papers exploring these techniques published," said Dr. Eichenberger. "Many of these papers explore the techniques in conditions that are found in older people and not in children."

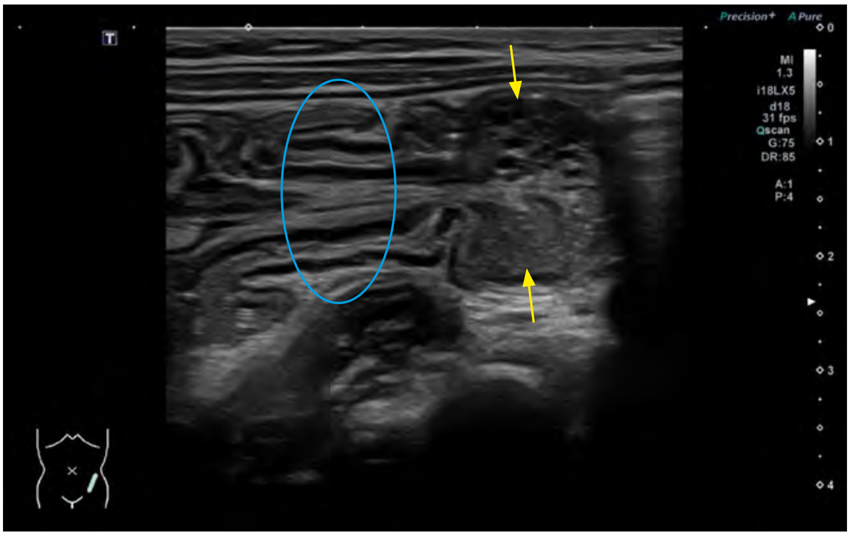
"With such quality, the staff at the Radiology Department consider the Aplio i800 a great advantage."

"Our experience with the Aplio i800 has been very good so far," remarked Prof. Kellenberger. "For routine clinical work, I would never return to our old systems."

Case study:

The advanced technology of the Aplio i800 was used at the Hospital to diagnose a rare condition in a young boy, which had not been successfully diagnosed with other clinical examination techniques.
A three year-old boy with recurrent abdominal pain and diarrhea without bleeding. He had no fever, nausea or vomiting. The clinical examination was unremarkable. An ultrasound examination with Canon Aplio i-series Matrix i18LX5 transducer showed an extremely rare presentation of descending colonic–colonic intussusception with a 2 cm large polyp as a pathological leading point.

The patient underwent colonoscopy, which confirms the ultrasonic diagnosis. This polyp was removed endoscopically. //



Colonic Polyp as Lead Point for Intussusception
A 3-year-old boy with recurrent abdominal pain and diarrhea without bleeding. He had no fever, nausea or vomiting. The clinical examination was unremarkable. A ultrasound examination with Canon Aplio i-series Matrix i18LX5 transducer showed an extremely rare presentation of descending colonic–colonic intussusception (encircled) with a 2 cm large polyp (yellow arrows) as a pathological leading point. The patient underwent colonoscopy confirming the ultrasonic diagnosis. This polyp was removed endoscopically.

Five reasons why the Aplio i800 is so well suited to pediatric applications:

1. Ultrasound is the future modality for pediatric medicine.
2. Image quality is exceptional.
3. Diagnoses can be carried out safely with minimal or no contrast required.
4. Training is easy with the system. The Zurich Children's Hospital has found that the new users of the system can get up to speed with it extremely quickly.
5. The 24 MHz transducer enables every detail to be easily detected by the system.


MAVIG
infinix

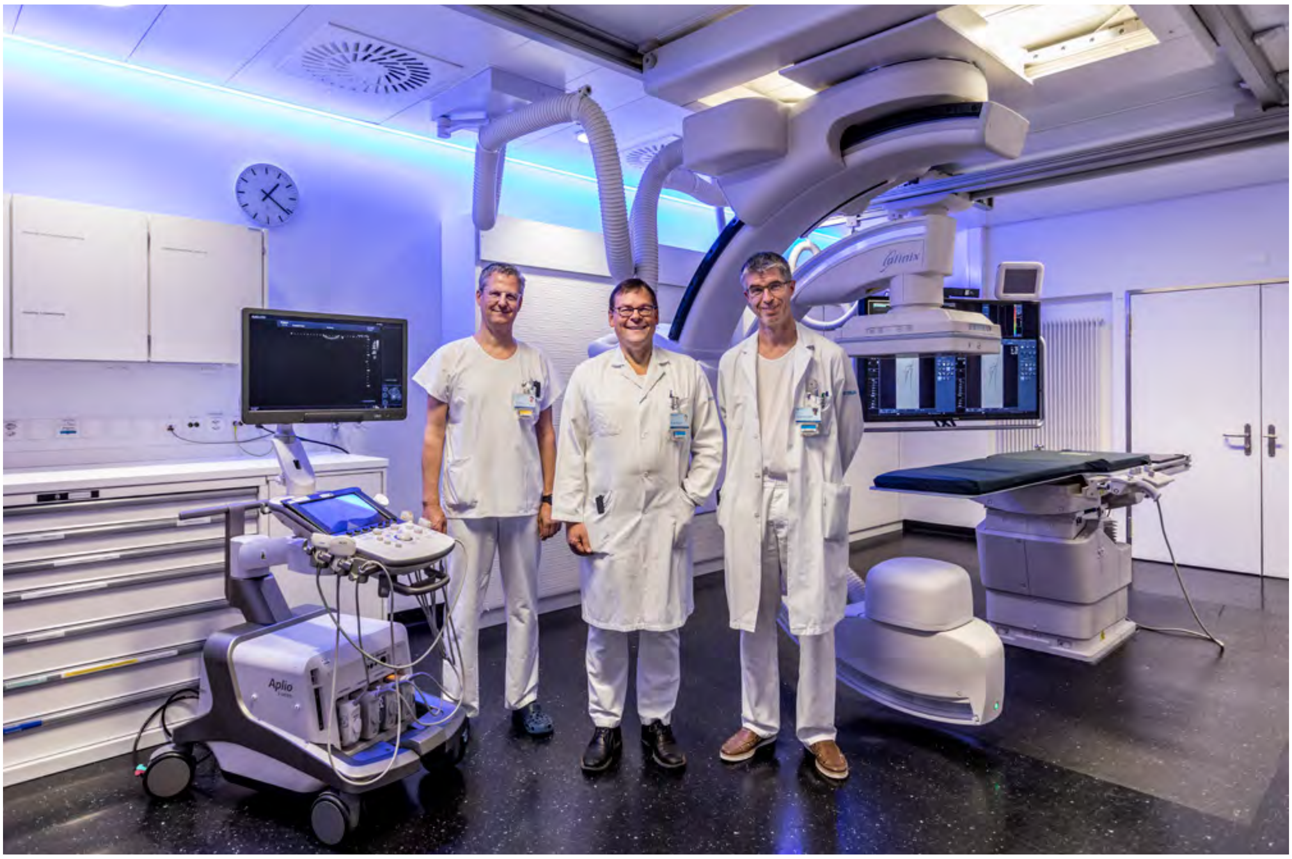
Interview with Dr. Jung and Dr. Pfiffner at Stadtspital Waid, Zurich, Switzerland.

The Infinix-i Sky + Expands the Range of Interventions in Acute Care

Stadtspital Waid (Waid City Hospital) is a public health facility that provides acute care to 180,000 patients in North Zurich, Switzerland, with a focus on peripheral arterial occlusive diseases and the revision of dialysis shunts. Interventional radiology increasingly helps to treat acute conditions and the hospital recently acquired the new Infinix-i Sky + from Canon Medical to carry out both simple and complex procedures in clinical practice. Dr. Roger Pfiffner, Head of Interventional Radiology, and Dr. Tarzis Jung, Chief Physician of the Institute of Radiology and Nuclear Medicine, explained why they again trusted Canon Medical to stay at the edge of patient care.

Stadtspital Waid has one of Switzerland's largest dialysis centers, which it runs together with Stadtspital Triemli. Patients receive state-of-the-art dialysis treatment, from dialysis catheter inserts, dilatations and recanalizations, to dialysis shunts. "Interventions on dialysis shunts are part of our daily life and we now also offer the endovascular insertion of dialysis shunts, which is much less invasive than surgery," said Dr. Jung, who worked as an interventional radiologist during 20 years before handing over that task to Dr. Pfiffner.

In daily routine, Dr. Pfiffner and six radiographers also perform peripheral vascular procedures such as PTA and stenting on leg and pelvic arteries, and a wide range of non-vascular interventions such as biopsies, drainages and biliary, urological and gastrointestinal interventions, including cholangiographies, drainages, nephrostomies and gastrostomies.



Mr. Ulrich Anker (chief technician), Dr Jung and Dr. Pfiffner with the Infinix-i Sky + and Aplio i800.

In addition, the hospital operates the University Clinic for Acute Geriatrics and offers central venous catheters for patients with venous disorders, as well as various oncological treatments. “Our patients tend to be at an advanced age and sometimes require long-term antibiosis or chemotherapy,” Dr. Pfiffner said.

The benefits of rotational angiography

The Infinix-i Sky + rotational angiography system enables Dr. Pfiffner to perform not only percutaneous interventions on the biliary and urinary tracts, but also chemical and physical tumor ablations, for example chemoembolization for hepatobiliary cancer and radiofrequency ablation of liver and kidney tumors.

Although these interventions have been performed less frequently to date, they will become more and more common in daily clinical practice, both experts believe.

Dr. Tarzis Jung.

“We have a clear improvement of image quality. The system is also gentler in terms of radiation, which is very important for both the patients and us. With the new Dose Tracking System, we can monitor dose better.”

"The angio navigation makes us very happy, as well as the large 58" monitor. We have all the important data in the overview."

Dr. Roger Pfiffner.

"Interventional angiography is becoming increasingly important as minimally invasive technology continues to evolve. For example, it is now possible to perform vascular recanalization to any length. Even oncological interventions can be increasingly treated without surgical intervention," Dr. Pfiffner said.

"Interventional angiography, percutaneous tumor therapy, percutaneous interventions on the biliary tract, gastrointestinal tract, urinary tract and the locomotor system will increase in the future. New endovascular and percutaneous procedures will replace various surgical procedures and allow gentle, less invasive patient therapy," Dr. Jung echoed.

The Infinix-i Sky + is proving to be a great ally for all kinds of applications, since the rotational system offers more flexibility, and therefore, more precision and safety. "Thanks to rotational angiography, ablation therapies can be more targeted and safer. The lateral displacement of the examination table also makes the treatment of dialysis shunts significantly easier," Dr. Jung said.

New interventions made possible

Dr. Pfiffner can now carry out examinations that used to be impossible to perform, for instance fluoroscopic control in biopsies. This is a tremendous advance for clinical practice, and it is not the only one that is now within reach, he believes.

"As an advanced option, we would like to offer percutaneous vertebroplasty, which we haven't been able to offer so far due to the lack of image quality of the old system. We have already performed such an intervention with the new platform, and we were very impressed with the excellent image quality," he said.

Another area worth exploring with the Infinix-i Sky + system for Stadtspital Waid and partner Stadtspital Triemli would be cardiac intervention, such as pacemakers insertion and coronary angiography.

Unequalled operating, improved image quality, robustness

An endless list of benefits comes to mind when describing work with the Infinix-i Sky +. Dr. Pfiffner particularly enjoys the simple, intuitive operating of the system. "The operating is very good. We have all the benefits of a ceiling-mounted system, which moves in all planes. The C-arm that can be approached in any position is a big plus," he said.

Pfiffner also values the flat detector cone beam CT and the speed at which he and his team can now work. "The angio navigation makes us very happy, as well as the large 58" monitor, which we like a lot. We have all the important data such as patient monitoring, etc. in the overview. Even the rapid scaling of the data on the monitor is very helpful and helps to relieve tired eyes," he said.

The ceiling displacement is another clear advantage for handling. "The table does not have to be turned out, e.g. for a shunt intervention. This is very important for us," he said.

As a result, "operating the Infinix-i Sky + is a lot more pleasant than competitors", according to Dr. Pfiffner, who has also worked with other manufacturers in his 20-year long career.

The radiologist and his team are also very fond of the Dose Tracking System (DTS), which enables to monitor patient skin dose in an unprecedented way. "The exposed areas on the patient skin are displayed in color and in real time. The possibility to perform lesion focused asymmetric collimation, so called spot fluoroscopy, where dose can be significantly reduced without loss of image quality, is also a huge plus," he said.

The ability to reduce dose without impairing image quality is paramount for this kind of equipment. The Infinix-i Sky + system has also managed to improve image quality tremendously. "Compared to the previous system, we have a clear improvement of image quality. The system is also gentler in terms of radiation, which is very important for both the patients and us.

Robustness of the system and a very satisfying, ten-year long experience working with the Infinix-i Sky + predecessor also convinced Stadtspital Waid to continue its successful partnership with Canon Medical.

"Price, service and support from Canon Medical, formerly Toshiba Medical, have always been to our highest satisfaction. We were always satisfied with the performance of the system. For us, there was never any doubt that the state-of-the-art successor device would also be included when considering a new procurement. With the new generation of devices, the Infinix-i Sky + from Canon Medical has once again proven to be clearly the best system. The price-performance ratio convinced us and we unanimously decided to purchase the Infinix-i Sky +," Dr. Jung concluded. //

Global Illumination Applied to Forensic Radiology

Nicolas Douis, MD, Alain Blum, MD, PhD, Pedro Augusto Gondim Teixeira, MD, PhD, Laurent Martrille, MD, Martin Kolopp, MD

The first case is from a 31-year-old man who deceased in a car accident and the second from a child deceased following a head trauma. A post-mortem computed tomography was performed in cases in order to provide forensic evidence of the circumstances of the death. CT data from these cases were post-processed using conventional volume rendering and Global illumination reformats, which were then compared.

In contrast to conventional volume rendering, Global illumination algorithms include light propagation, absorption, reflexion into image reconstruction models and thus a large number of iteration. This technique is commonly applied in the film and gaming industries as well as in flight simulators. Also known as Cinematic rendering, Global illumination provides photorealistic 3D reconstructions from conventional CT images.

Fig. 1a, three dimensions reconstruction with global illumination.

Fig. 1b, rendering reconstruction technique.

Fig. 2a, three dimensions reconstruction with global illumination.

Fig. 2b, rendering reconstruction technique.

Fig. 2c, autopsy photograph, which presents two fractures of the outer cortical layer of skull.

In the first case Global illumination (Fig. 1a) provides improved accuracy compared to conventional volume rendering (Fig. 1b) for the characterization of a non-displaced occipital fracture and a split fracture extending to the left and right lambdoid sutures.

In the second case Global illumination allows to highlight two fractures (Fig. 2a) of a left frontal bone external surface, confirm by autopsy (Fig. 2c)

This element was crucial because suggest the existence of two skull blunt traumas. Analysis of the inner frontal bone surface indicated that it was actually only one fracture.

Conclusion

These two forensic medicine cases demonstrate that Global illumination can improve the perception of skull fractures with respect to conventional volume rendering. The interpretation of skull fractures is essential in forensic medicine as it helps to ascertain the mechanism of injury and the cause of death. Applied to bone trauma in general, Global illumination can also be helpful in forensic radiology and anthropology.

- Acquisition parameters for this two cases :
- Model: Aquilion ONE
- Scan Mode: helical scan
- Collimation: 0.5mm x 64
- kV: 135
- Rotation Time: 0.5 second
- Dose Reduction: AIDR 3D enhanced
- CTDI: 77.80 mgy (first case) and 76.20 mgy (second case)
- DLP: 1809.90 mgy.cm (first case) and 1735.10 mgy.cm (second case). //

Nicolas Douis, MD
CHU Nancy, France

Alain Blum, MD, PhD
CHU Nancy, France

New Vitrea Post-Processing Transforms the Efficiency of Imaging

The Charité University Hospital in Berlin, Germany, is one of the largest university clinics in Europe. It has 70,000 employees and more than 7,200 students, and currently deals with more than 140,000 patients per year. Before the Hospital started to work with Canon Medical, its IT environment included large PACS with local post-processing facilities, which required the use of a specific room for examining images. This was quite inconvenient for the staff and made increasing the efficiency and capacity of the department difficult. The Vitrea Advanced Visualization software from Canon Medical enables a huge step forward for the Radiology Department.

"We can now meet the medical imaging challenges, and the demands of our many different clinics," explained Dr. Stefan M. Niehues. "When we started with Vitrea, the era of targeted examinations in clinical practice was on the rise. Using the software really enhanced our workflow and made it pretty easy to examine all the different parameters that we need to check. We are also able to perform high-quality CT of the heart, calcium scoring and other cardiovascular examinations. Evaluation has become much quicker, easier and routine to us."

Direct contact to experts in achieving optimal arrangement

Together with Canon Medical, the Charité focused on establishing the optimal arrangement of the system, not only for diagnostic scans, but also for interventional CT.

"One of the major strengths of working with Canon Medical that I see, is the direct contact to the service engineers and application specialists," said Dr. Niehues. "They have been assisting me from day one. I have been in several situations, in which I have required advice. Whenever I have tried to call them directly, they have answered or they called back from somewhere in the world, sometimes even during their vacation to help me. We continually improve our examination- and scanning protocols to enhance patient care."

One-click system

"Many post-processing items have become a one-click solution for us," he continued. "There are several things within our clinical routine that would not have been possible

Dr. Stefan M. Niehues and Dr. Chie-Hee Cho-Nöth.

“Because of the Vitrea software, many post-processing items have become a one-click solution.”

Dr. Stefan M. Niehues.

without the use of the new Vitrea software. We can access the images we obtain locally, as well as images from the different campuses from different systems, different vendors and different modalities. We can also post-process the images in a more sophisticated way and compare them, enabling us to make better diagnoses."

Advanced protocols

Alongside this, the Charité has been working on perfusion imaging, as well as subtraction imaging. Not only on the regular aspects, such as liver or kidney disease, but also on head- and neck cancer and interventional CT imaging. From this, the Charité has been able to publish protocols offering the lowest radiation dose for CT interventions worldwide.

Reliability

“The major changes we have achieved by using Canon Medical hardware and software are better images with lesser dose and compressed information,” concluded Dr. Niehues. “To describe Canon Medical in a few words: reliable, responsible and dedicated to medical imaging.”

The Charité opted for Vitrea’s Advanced Visualization software, and initially purchased one single CT system from Canon Medical. It later bought three CT systems that were installed locally, and use altogether eight CT systems located on different campuses. Additionally, eight Canon ultrasound systems are used on a daily basis. //

Dr. Stefan M. Niehues, working with Vitrea on the PACS-workstation.

Artificial Intelligence in Image Reconstruction

Brand new image reconstruction that is based on highly innovative Artificial Intelligence (AI) based Deep Learning technology.

Development of the best image reconstruction algorithms has been an important focus for Canon Medical. By working together with expert partners , like Prof. Prokop and his team at Radboud University Medical Center in The Netherlands, Deep Learning Reconstruction (DLR) based on AI, has become a reality.

DLR, introduced as AiCE (Advanced Intelligent Clear IQ Engine) during the 2018 RSNA, is a world first and the latest advanced image reconstruction from Canon Medical. This sophisticated reconstruction algorithm produces almost noise free images with spatial resolution improvement. Reconstruction is extremely fast and the images appear very natural. Very thin slices can be examined, revealing more detail, without being hampered by noise. Prof. Prokop explains what a revelation AiCE is.

"Even the best Model-Based iterative reconstruction (MBIR) algorithms can suffer from poor noise and texture at low dose levels. Moreover reconstruction times are sometimes workflow-prohibitive in a busy clinical environment," remarked Prof. Prokop. "Deep Learning has opened the door to a host of applications. The Deep Convolutional Neural Network embedded into AiCE differentiates and removes noise from signal, creating extraordinarily high-quality images."

Artificial Intelligence (AI) and Medical imaging

AiCE is a breakthrough development that has been brought to life in response to a number of major trends. Most notably, the forward momentum of Big Data projects, particularly in the US. It is anticipated that Big Data will have a significant impact on diagnostic imaging.

Canon has collaborated with multiple institutes like Johns Hopkins University (in Baltimore, Maryland, in the US) on their own Big Data healthcare research for some time. Next to this, Canon Medical has also partnered with NVIDIA Corporation (a leading US Technology company) on deep learning for imaging.

What is AiCE?

AiCE is a deep learning reconstruction algorithm trained to differentiate noise from true signal[1]. The algorithm learns to preserve edge and maintain details. AiCE has been developed to produce noise free images of the best quality. Based on advanced true MBIR[2], AiCE differs from deep learning reconstruction techniques which are based on Filtered Back Projection (FBP). By applying true MBIR in the training process, spatial resolution improvement can be achieved.

Prof. Prokop.

"AiCE impressed me from the first day that I have seen it used in practice."

Radboud University Medical Center, Nijmegen, The Netherlands.

”We can now base our reports on very thin slices without disturbing noise. The reconstruction speed is extremely fast. AiCE provides quick and reliable high quality, high resolution images that look natural.” confirmed Prof. Prokop.

Already in daily practice

“AiCE impressed me from the first day that I have seen it used in practice,” added Prof. Prokop. “On the Aquilion Precision, our Ultra High Resolution CT, AiCE is in use since early 2018 and for the Aquilion GENESIS, AiCE was installed in September. On both CT systems AiCE is used daily and the referring physicians love it. Even at the low radiation expose levels used by us in routine practice we see a substantial improvement in image quality.

“We are working towards optimizing the use of AiCE. Deciding under which clinical conditions we can further reduce exposure dose and under which conditions we aim for optimum image quality.” said Prof. Prokop. //

Aquilion Precision at Radboud University Medical Center, Nijmegen, The Netherlands.

Benefits of AiCE (Artificial Intelligent Clear IQ Engine):

- Used to differentiate noise from signal
- Removes noise or reduces it significantly
- Preserves image texture
- Overcomes plastic images
- Keeps doses in UHR-CT at routine CT dose levels
- Almost as fast as AIDR 3D Enhanced[3]

References:

1 *K. Boedeker, “AiCE Deep Learning Reconstruction: Bringing the power of Ultra-High resolution CT to routine imaging”, Canon Medical Systems white paper, 2018.*

2 *K. Yasaka, M. Katsura, M. Akahane, J. Sato, I. Matsuda, K. Ohtomo, “Model-based iterative reconstruction for reduction of radiation dose in abdominopelvic CT: comparison to adaptive statistical iterative reconstruction”, SpringerPlus 2:209 (2013).*

3 *I. Hernandez-Giron, W. Veldkamp, J. Geleijns, “AIDR 3D Enhanced — The latest hybrid model-based iterative dose reduction technology from Canon”, Canon Medical Systems (2018).*

Subtraction CT with Iodine Mapping in Follow-Up of Renal Cell Carcinoma

Ewoud Smit, MD, MSc

SURESubtraction Iodine Mapping increases the diagnostic information available for any routine multiphase body protocol by extracting the iodine enhancement on each phase. The iodine signal is displayed in color blood flow maps to help assess local vascularization.

These iodine maps can be widely applied and aid, for example, in differentiating solid from cystic lesions, evaluating treatment effects, distinguishing hypo- from hypervascular lesions, and establishing organ ischemia, explains Dr. Ewoud Smit, Radiologist at the Radboud University Medical Center Nijmegen in the Netherlands.

Patient history

A 54-year-old male presented with a history of renal cell carcinoma of the left kidney for which a radical nephrectomy was performed, and a few years later renal cell carcinoma of the right kidney for which a partial nephrectomy was performed. A multiphase CT scan of the kidneys was requested to assess local recurrence and potential metastasis.

Results

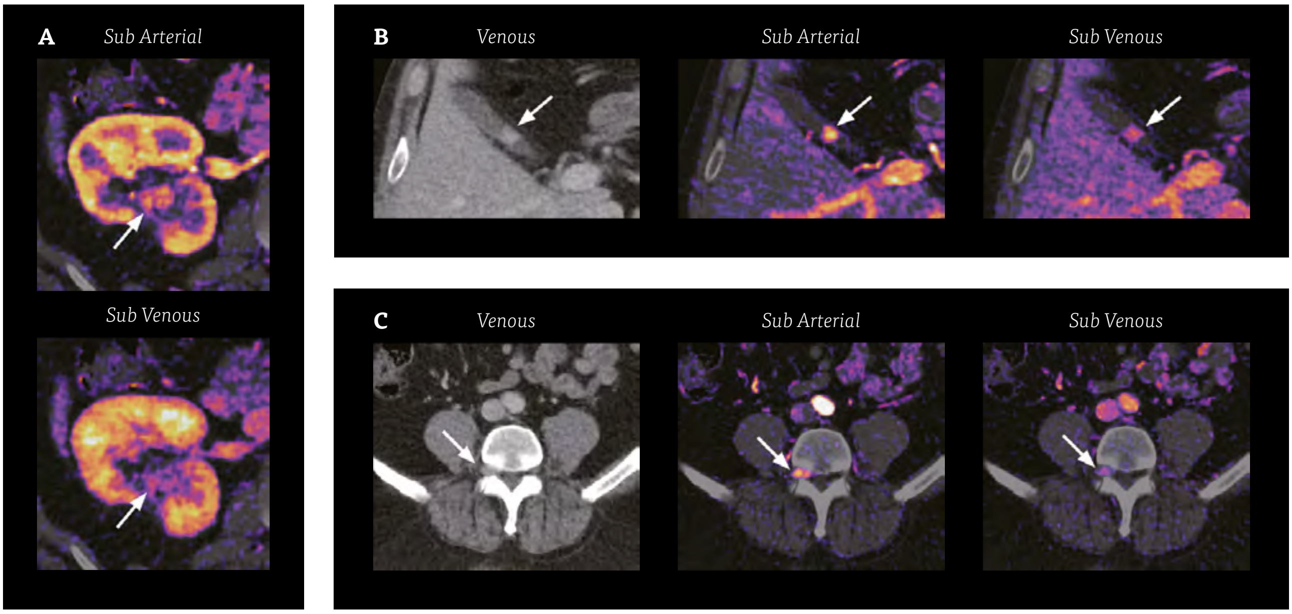
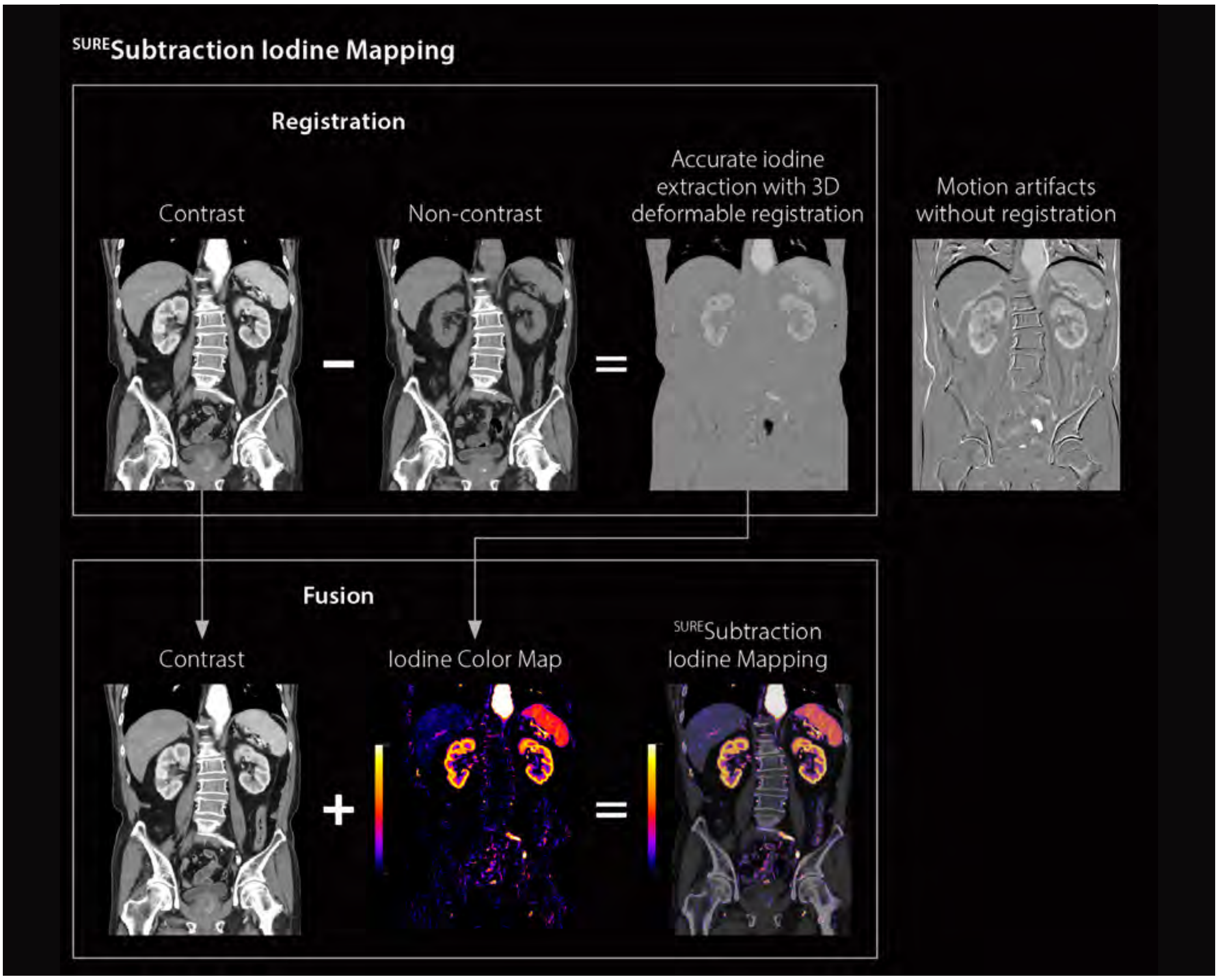


Figure A:
The arterial subtraction images show an enhancing lesion within the surgical defect of the right kidney with washout on the venous subtraction images, consistent with recurrent renal cell carcinoma (RCC).

Figure B:
In the gallbladder, a lesion is visible with a similar enhancement pattern of arterial enhancement and washout, consistent with a RCC metastasis. The gallbladder lesion may easily be mistaken for a gallbladder stone on the venous phase CT images alone.

Figure C:
Furthermore, a lesion is visible in the right intervertebral foramen at the L4 level with a similar enhancement pattern of arterial enhancement and washout, consistent with a RCC metastasis. Please note the accuracy of image registration in the spine, arteries and bowel. All three lesions were confirmed with FDG-PET-CT and Zirconium-89-girentuximab PET-CT Imaging (a clear cell renal cell carcinoma specific tracer).



Technology

Enhanced Iodine Mapping for "free" in any routine multi-phase CT protocol with SURESubtraction Iodine Mapping.

SURESubtraction Iodine Mapping utilizes pre- and post-contrast scans to isolate iodine signal. This enables the assessment of the distribution of contrast media within the body to visualize local perfusion differences.

Acquisition	
Scanner Model:	Aquilion Precision
Scan Mode:	Ultra Helical
Collimation:	0.5 mm × 80 row [NR mode]
Matrix:	512x512
Exposure:	100 kV SUREExposure
Rotation Time:	0.5 second
Dose Reduction:	AIDR[1] 3D Enhanced
CTDI:	9.0 mGy per phase
DLP:	300.8 mGy·cm per phase 904.3 mGy·cm (3 phases total)
Effective dose:	4.5 mSv per phase 13.5 mSv (3 phases total)
k-factor:	0.015[2]

SURESubtraction has protocol integrated automation at every step to empower even a novice operator with the skills to perform brilliantly the first time — every time.

The key to obtaining accurate results lies with an anatomically aware 3D deformable registration algorithm that compensates for patient motion which may occur between the two scans. This ensures highly accurate iodine signal extraction, with the result superimposed on the post-contrast CTA image as a color overlay to clearly demonstrate even subtle differences in iodine HU attenuation.

Conclusion

SURESubtraction Iodine Maps can be generated for free from any routine multiphase scan protocol, which may help to improve the conspicuity of vascular lesions with color enhanced visualization. //

Dr. Ewoud Smit
Radiologist

References:
1 *Adaptive Iterative Dose Reduction.*
2 *American Association of Physicists in Medicine (AAPM) Report 96, 2008.*


Aplio i900
i8C1

Dr. Daniel Merkel, Chief physician of the Department of Internal Medicine of Immanuel Klinik Rüdersdorf.

“The Fine Resolution in Greyscale is Special!”

Dr. Daniel Merkel is an expert on fine anatomical structures. The Berlin gastroenterologist scans on average about 15 patients a day with complex findings in the abdomen. He specializes in sonography of pancreas, biliary tract, and hepatological diseases. Since September 2017, the Aplio i800 has been running in Dr. Merkel's examination room. "I'm not a fan of praise, but the special thing about Canon is really the fine greyscale resolution in B-mode," Dr. Merkel. Since 2015 he has been chief physician of the Department of Internal Medicine of Immanuel Klinik Rüdersdorf. The hospital on the outskirts of the German capital also offers, beside acute and standard care, various specializations, for example, Dr. Merkel's sonography laboratory.

After fifteen years of daily experience, he has operated many ultrasound systems and has worked with three different Canon scanners himself. "I can compare over a year now," says Dr. Merkel. "The Aplio i800 definitely performs in Contrast Enhanced Ultrasound (CEUS) a lot better than other manufacturers'models," says Dr. Merkel. "For example, if I am looking for metastases or benign liver lesions that sometimes like to hide sonographically, the Aplio i800 is clearly superior to all other scanners in my opinion."

For more "common" issues such as pleural effusions, swollen joints, or urinary retention, similar results can be achieved with conventional instruments. In investigations of the liver parenchyma or general investigations in the area, the Aplio i800 offers a clear advantage.

"It's really fun to find things that have gone unnoticed on CT, for example, because of the good resolution," says Dr. Merkel. Especially for indications in the liver, pancreas, kidney or spleen, he would not want to miss his Aplio i800.

Dr. Daniel Merkel.

SMI much more than a gimmick

Dr. Merkel also has been nicely surprised by Superb Microvascular Imaging (SMI), an advanced Doppler imaging algorithm, optimized for sensitivity, resolution, and frame rate. SMI aims to expand the area of visible blood flow to microvessels with very low flow velocities. For Dr. Merkel it has fulfilled this promise. "With the SMI technology, I enjoy my work a lot, this imaging mode allows the capillary vessels to be displayed excellently, almost as well as contrast-enhanced sonography." SMI is - contrary to what he first thought - much more than a gimmick.

Dr. Merkel mainly uses CEUS for two indications. "The first is the characterization of liver lesions," reports the chief physician. "CEUS very convincingly enables the differentiation of benign and malignant lesions," says Dr. Merkel. "If I diagnose a hemangioma, with my Aplio i800, it is in 98% of the cases consistent with histology. This is more than convincing," says the gastrointestinal specialist. For sure not every finding is always clear, in this case Dr. Merkel conducts a follow-up. "The scanner makes biopsy redundant in most cases," says the chief physician.

Bleeding sure to be detected

The second indication for CEUS is to check whether there is hemorrhage, a typical gastroenterological situation and one that Dr. Merkel sees several times a day. "Whether it is an abscesses, hematomas, blood oozing, seromas, complications after surgery, or acute bleeding," the ultrasound expert points out. "The contrast-enhanced sonography with the Aplio i800 can reliably detect bleeding and fluid retention."

Does he have anything to complain about with the Aplio i800? Dr. Merkel thinks about it. "The only thing that might irritate the Canon-inexperienced eye in the beginning is the richly detailed image," says Dr. Merkel. Once you get used to the Canon-typical image presentation very quickly however, you can't speak of a real disadvantage anymore.

Dr. Merkel also received a lot of support from Canon Medical in a project that he runs with passion in his spare time. The ultrasound expert has been supporting the online portal Amboss for many years. The team behind it prepares knowledge in sonography of all disciplines for students and young doctors in a guideline-oriented and up-to-date manner. Amboss supports doctors in their daily work as well as in preparing for exams. Dr. Merkel has proof-read the content for theoretical ultrasound training for Amboss. In addition, he has created several video tutorials with an Aplio 500 with the support of Canon Medical and has written comments on more than 140 findings in classic diseases.

"All video sequences and images were cre- ated at my request on a Canon Medical scanner," says Dr. Merkel. "The results are really very high quality," he summarizes. "I am therefore not surprised that the learning content for sonography on Amboss is so popular and the video sequences have a high click-through rate."

Dr. Merkel makes no secret of it: he calls himself a Canon fan. However, he was not biased when choosing the new scanner for his department at Immanuel Klinik Rüdersdorf. On the contrary. He performed a comparative study, which will soon be published. To objectively select the best device, Dr. Merkel first of all put all the high-end ultrasound scanners available in the German market to a test: four subjects were examined with each scanner and video sequences were recorded.

"In order to find out the best scanner model objectively, we anonymized the video sequences so it was unknown which video was created on which machine" says Dr. Merkel. He played the video clips in front of several students and experienced colleagues for comparison. The result was unanimous: "My guess that the Canon Medical system would be best device has been confirmed by many and especially by our experienced colleagues," notes Dr. Merkel. "When that was clear, I ordered the new Aplio i800 with a clear conscience." //

Training portal "Amboss"

www.miamed.de/amboss/sonokurs

“My guess that the Aplio i800 would be the best system for our department has been objectively confirmed by many and especially by our experienced colleagues.”

Dr. Daniel Merkel

AiCE Deep Learning Reconstruction

Kirsten Boedeker, PhD, DABR

Canon Medical is proud to introduce the AiCE (Advanced Intelligent Clear-IQ Engine) Deep Learning Reconstruction (DLR) algorithm for Computed Tomography (CT), featuring a deep learning neural network that can differentiate signal from noise, resulting in extraordinary high quality CT images.

Deep learning, the state-of-the-art in Artificial Intelligence (AI), has been successfully applied to such tasks as image recognition, segmentation and classification. With deep learning, a Deep Convolutional Neural Network (DCNN) comprised of layers of neurons is trained in the performance of a complex task.

A neuron is a node where a mathematical operation takes places, the output of which is connected with other neurons, forming a network. The neural network derives its name from the neuron-synapse paradigm found in biology and mimics how humans draw conclusions, based on training. This ability to learn via a convolutional neural network gives the deep learning algorithm the freedom to find the optimum way to perform the desired task.

The goal of image reconstruction in CT is to facilitate the diagnosis of the patient by converting the raw projection data into an image of the highest possible quality. Prior to DLR, a reconstruction algorithm that produced exceptional low contrast detectability (LCD), preserved spatial resolution, and markedly reduced noise and artifact—without requiring an increase in radiation dose or hindering workflow—was a tool that remained elusive. Even the best Model-Based Iterative Reconstruction (MBIR) algorithms can suffer from poor noise texture at low dose levels and reconstruction times that are workflow-prohibitive in a busy clinical environment.

Workflow Efficiency: Achieving the speed you need in a busy clinical environment

During engineering development, the AiCE DLR algorithm is taught to produce high signal-to-noise ratio (SNR) images through an intense training process. AiCE DLR learns to differentiate signal from noise by in part by training on select, high quality patient data sets acquired with high tube current and reconstructed with all the benefits of state-of-the-art MBIR—including sophisticated system and noise models as well as a large number of iterations not possible clinically.

Because this time-consuming training process is completed before leaving the factory, the fully-trained AiCE DLR is able to work quickly in the clinic. This rapid reconstruction allows the clinician to take advantage of the benefits of deep learning, which by design incorporates all the sophisticated modelling utilized in MBIR, in a time-efficient manner: working at over five times the speed of MBIR reconstruction, AiCE DLR is making the benefits of low noise, ultra-high resolution an everyday reality.

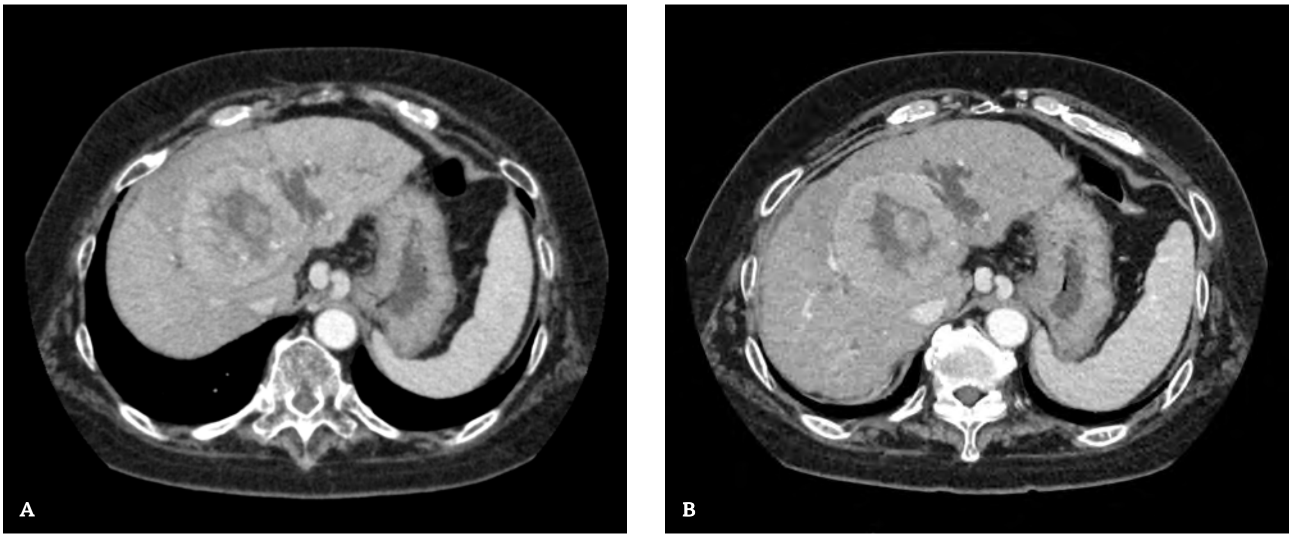


Figure 1, Improved liver lesion visibility on UHR CT images with similar radiation dose. AIDR 3D at 11.8mGy (A) compared to AiCE at 12.4 mGy (B).

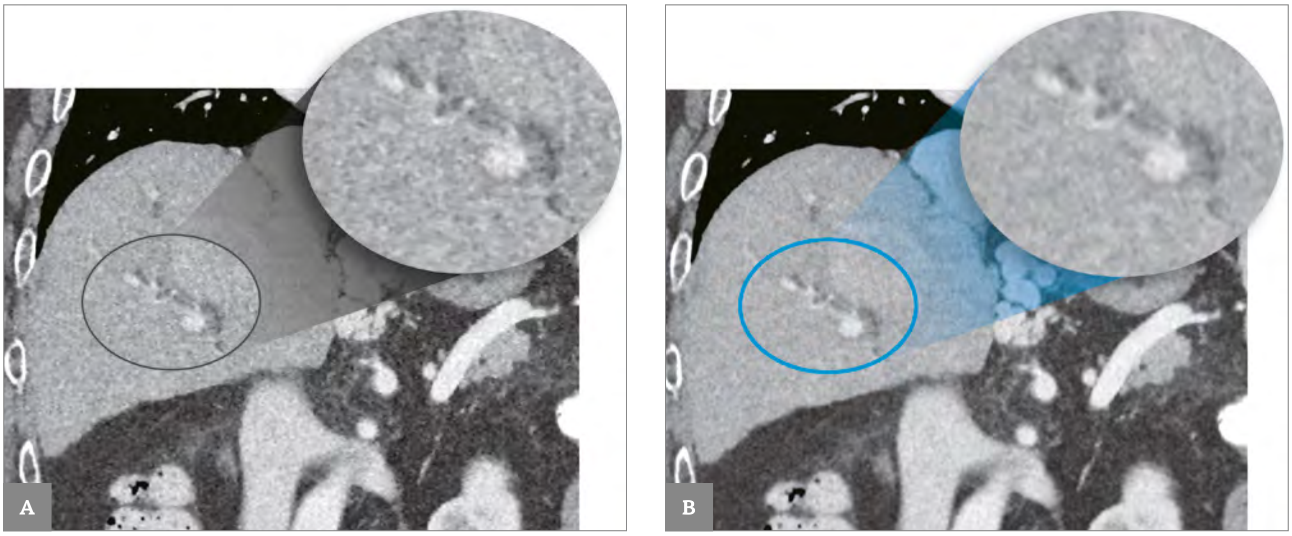


Figure 2, Improved noise properties on Ultra-High Resolution abdominal images with AiCE. A: MBIR, B: AiCE.

Like Canon's iterative reconstruction algorithms, AiCE DLR is also fully integrated into the SUREExposure mA modulation system. The system automatically adjusts each individual patient's mA profile based on the associated benefits and dose reduction abilities of AiCE reconstruction.

AiCE DLR is available in three straightforward settings like in AIDR 3D, i.e. Mild, Standard, and Strong, making the application of AiCE DLR simple and easy-to-use.

Improved LCD

AiCE DLR is able to dramatically decrease the magnitude of noise in an image, improving LCD. When used with, for example, the Aquilion Precision's ultra-high resolution mode, which acquires data with a 0.25mm nominal slice width and reconstructs to 1024x1024 matrix, AiCE DLR can achieve the same LCD as conventional resolution images reconstructed with AIDR 3D. This combination of technologies opens up the advantages of ultra-high resolution imaging to the clinician without concern of LCD loss or increased radiation dose to the patient.

Notice the visibility of the lesions on the ultra-high resolution image reconstructed with AiCE DLR at 12.4 mGy compared to the normal resolution image reconstructed with AIDR 3D at 11.8 mGy in Figure 1.

In addition, AiCE DLR reduces the magnitude of visually unappealing noise textures found at low dose with iterative reconstruction algorithms, resulting in an appearance more similar to low noise filtered back projection (FBP) as shown in Figure 2.

Improved spatial resolution

Because AiCE DLR is trained on images of the highest quality using MBIR reconstruction, AiCE DLR learns to preserve edge and maintain image detail.

Furthermore, as it incorporates the spatial resolution benefits of MBIR, AiCE DLR improves high contrast resolution compared to hybrid iterative reconstruction techniques such as AIDR 3D. This spatial resolution improvement is demonstrated in the Modulation Transfer Functions (MTF) in Figure 3, and in the line pair images in Figure 4.

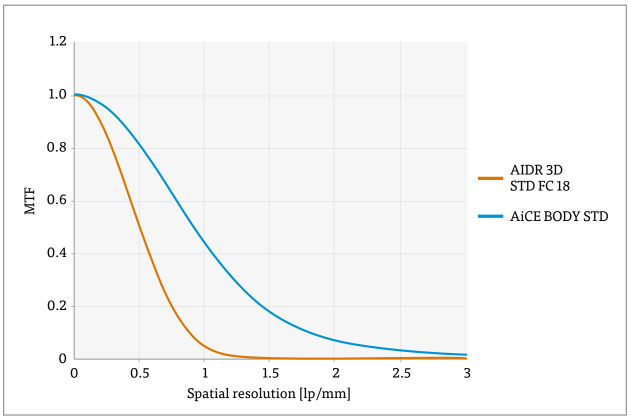


Figure 3, AiCE improves the MTF relative to AIDR 3D, indicating improved high contrast spatial resolution with AiCE.

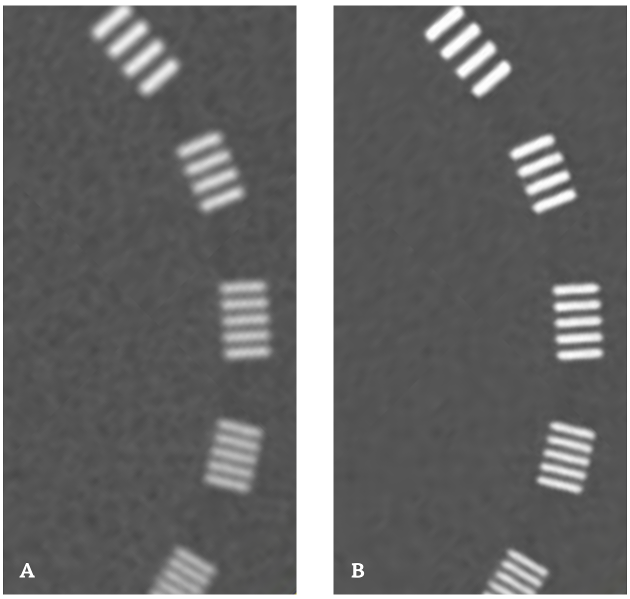


Figure 4, Line pair phantom demonstrating superior high contrast spatial resolution for AiCE. A: AIDR 3D, B: AiCE.

AiCE DLR: How Does it All Work?

AiCE DLR process consists of two major steps (Figure 5): A. training and optimization of the DRL which takes place at the factory, B. AiCE reconstruction which takes place at a hospital. We describe these two steps briefly below.

A. AICE DLR: Training at the factory

The key to a successful DCNN lies in its training, the process by which the DLR learns how to successfully perform its function. The network must compare its output image to a gold standard reference image in order to gauge its performance and learn, i.e. adjust the weights of its neurons.

In order to do this the DCNN uses a mathematical loss function to determine and minimize the amount of error between its output and the reference datasets. In the case of AiCE DLR, the gold standard clinical reference images are acquired with high tube current and reconstructed with true MBIR reconstruction, which takes into account modelling of the system optics, system physics, scanner statistical properties and human anatomy, and uses a greater number of iterations than could be otherwise used in a clinical setting due to time constraints.

Using the estimation of error between the output of the DCNN and the gold standard, the DCNN backpropagates the error estimate through the network and adjustments are made to the neuron's weights in order to reduce the discrepancy. This input-forward, error-backpropagation process is iteratively repeated until the network is optimized. In order to ensure optimal results, millions of image patches were used in the training of AiCE DLR. This complex training process is completed in development with no off-site unsupervised training, which could alter algorithm performance, taking place.

A vast number of phantom and patient images were examined by medical physicists and radiologists in the development of the AiCE DRL reconstruction algorithm.

B. AiCE DLR at a hospital

The AiCE reconstruction process begins in the raw data domain where AiCE analyzes the raw data and, armed with detailed scanner model information, makes modifications. These modifications in the projection domain improve output SNR and reduce artifacts, such as streaks. This raw data is then initially reconstructed to form a seed image, known as the "input layer", to the DCNN.

Once the input image is fed into the DCNN, it is analyzed by several network layers referred to as "hidden layers." The hidden layers of a DCNN contain convolutional layers, in which the component neurons act as feature selectors on small patches of data.
In a traditional heuristic algorithm explicit image features, such as a curved edge, would be pre-selected by the programmer and "convolved," i.e., filtered, with the image data. During the deep learning process, each neuron in a convolutional layer learns what features to look for based on the training data. AiCE's DCNN has thousands of neurons, thoroughly sampling feature space. The network "learns" image features and their level of importance by adjusting the parameters, known as weight and bias, utilized by each neuron in the convolutional layer.

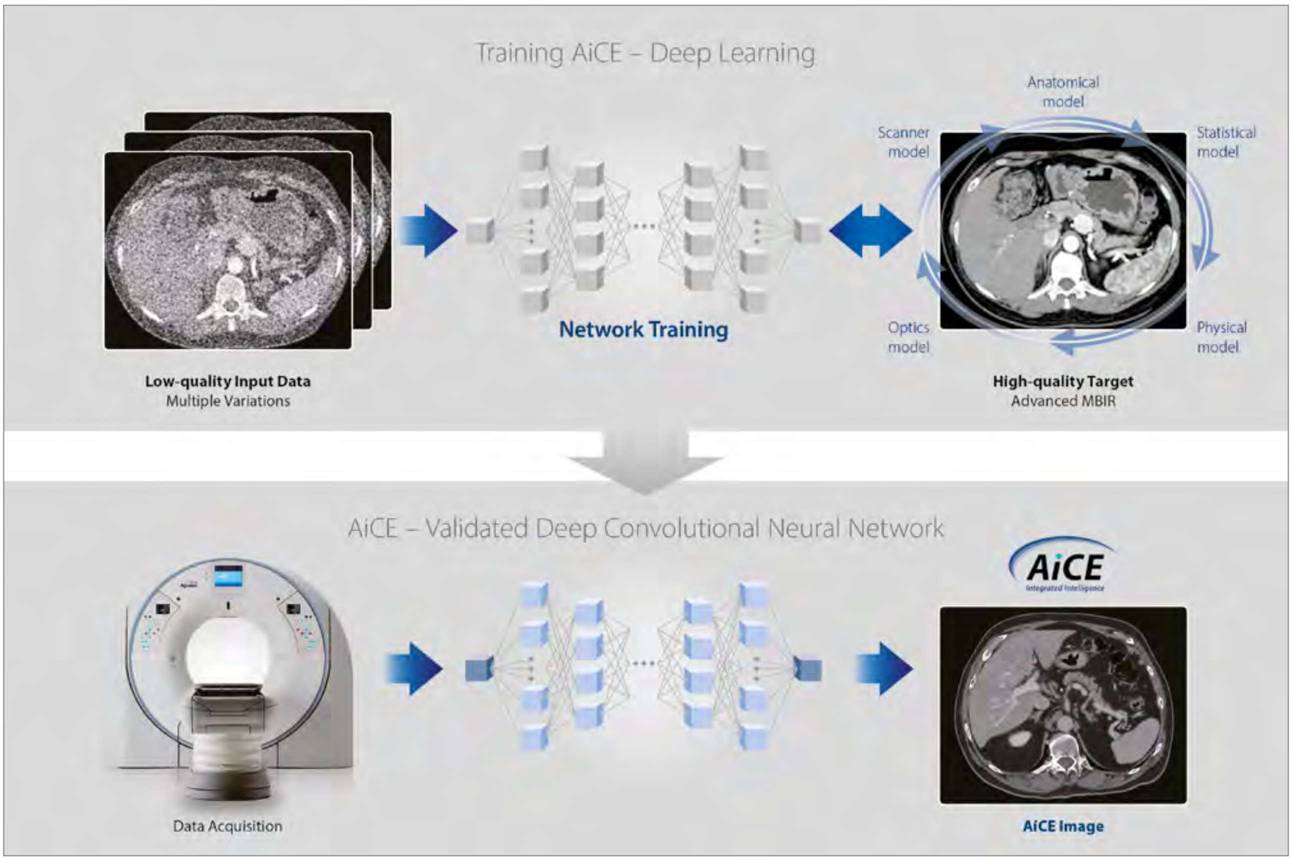


Figure 5, Overview of AiCE Deep Learning Reconstruction: The AiCE DLR is trained with high quality, advanced MBIR Target Images and learns to turn low quality input data into low noise images that are sharp and clear. In the clinic, AiCE DLR operates in the raw and image domain to efficiently reconstruct images.

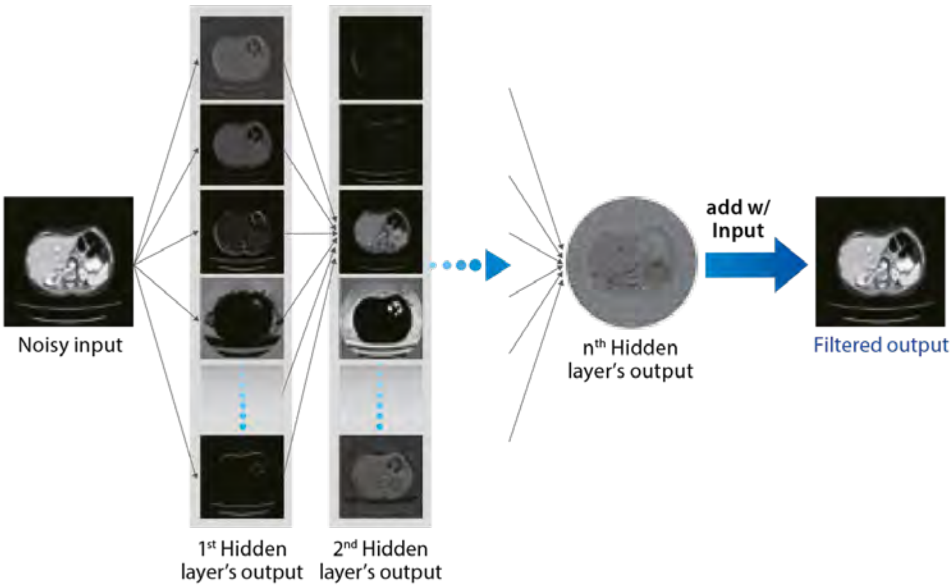


Figure 6, An illustration of a simple neural network consisting of layers of neurons working together to perform a task.

The output of the convolutional layer is the fed into an "activation layer." In biology, a neuron only fires when the input to it surpasses a threshold. Similarly, the activation layer in a DCNN serves an analogous purpose in that, based on the strength of a neuronal response to the input data, the activation layer determines which neuron responses will pass to the next layer in the DCNN.

After passing through all the hidden layers of the AICE DLR neural network, the signal and noise are separated and a signal image, known as the output layer, is generated for the user.

One key to a successful DCNN lies in its network structure design, which impacts both image quality and reconstruction speed. To achieve the best computational efficiency and improve output image quality, network structure factors such as number of network layers, number of neurons in each layer, convolution kernel sizes, etc, were fully optimized in the AiCE DLR algorithm. Elegant acceleration strategies and memory management technologies were carefully designed and integrated in the system to fully utilize hardware capabilities and maximize reconstruction speed.

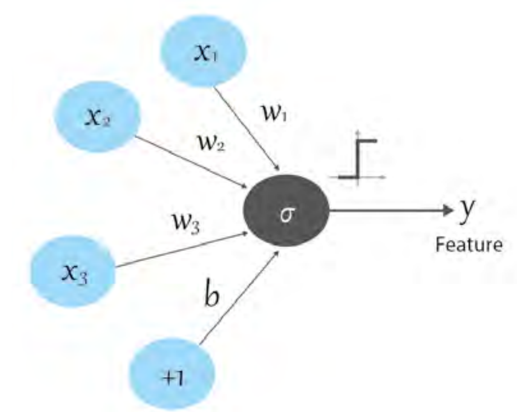


Figure 7, The structure of a basic neuron. A neuron will adjust the weighting factors (w) of its associated feature as it learns. The activation function (sigma) gauges the strength of the neuron response.

Conclusion

Integrated, effective, and easy-to-use, AiCE DLR brings the power of deep learning to the world of CT image reconstruction. The raw data domain aspects of AiCE DLR combined with the ability of the deep convolutional neural network to differentiate signal and noise leads to a wealth of advantages compared to other forms of reconstruction, including improvements in noise, LCD, and spatial resolution — making extraordinary high quality CT images at standard doses available to the clinician in daily clinical routine. //

Kirsten Boedeker, PhD, DABR
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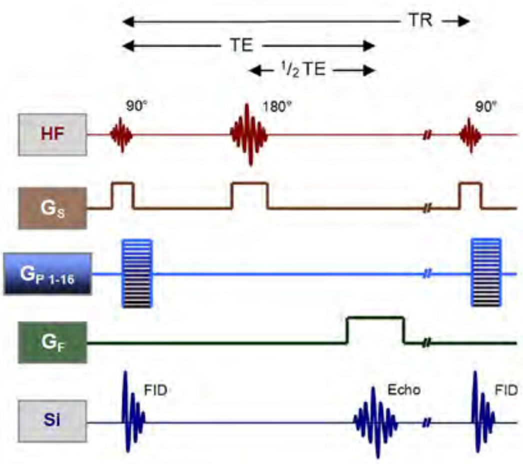
k-space: (in) Finite Widths of the Matrix

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.



TR = Repetition time
TE = Echo time
HF = High frequency-Pulse
GS = Slice selecton gradient
GP = Phase encoding gradient 1-16
GF = Frequency encoding gradient
Si = Signal measured from the receiver coil

(during the echo, FID = Free Induction Decay that is, the decaying transverse magnetization after which the 90° pulse first dephases, therefore the signal drops off, then through the 180° pulse, is rephased and finally forms the echo, which is then measured).

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

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 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!

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!

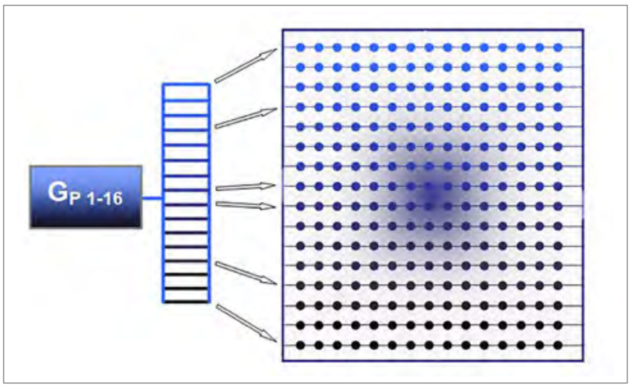


Figure 3, A sweep of a frequency coefficient in a spin-echo sequence (see Figure 1) represents one row in the data matrix of the k-space.

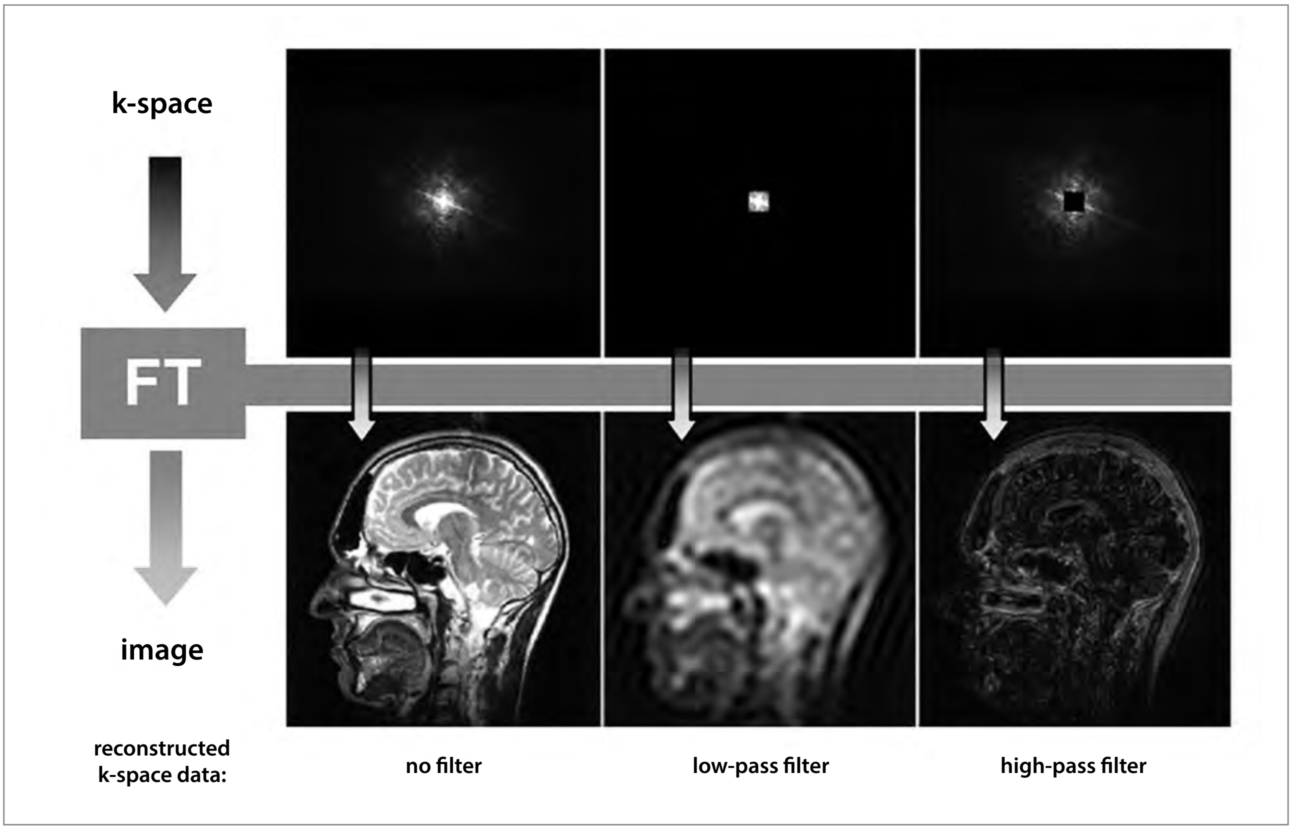


Figure 4, Different localization of image information in k-space, results of image reconstruction after filtering; FT = Fourier transformation according to Dr. F. Wetterling, Imaging Systems in Medicine, Magnetic Resonance Tomography III: The k-space Ruprecht-Karls-University Heidelberg.

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! //

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New Concept of Wide Area Detector CT in the Exploration of Peripheral Arterial Disease:

The combination of zero click subtraction and Virtual Iodine Boost

Prof. Catherine Roy, MD, Mickael Ohana, MD PhD, Pierre Leyendecker, MD

Peripheral arterial occlusive disease is mainly caused by arteriosclerosis which is widespread in the general population. It can lead to severe tissue damage or even tissue loss. The success of any interventional procedure, whatever the type, is strongly supported by the efficiency and precision of the pre-operative mapping of the arterial anatomy and lesions. Currently, CT angiography (CTA) can be considered as the best suited imaging modality for that purpose[1].

The challenge for the radiologist is to provide an accurate visualization of the vessel lumen, a precise localization of the calcifications, a quantification of the severity of the lesions and an appreciation of the patency of the small distal vessels, all within a timeframe compatible with the usual overbooked clinical routine. Having an entirely automatic reliable post- processing with a minimal manual or ideally no need for any kind of human intervention would be extremely helpful in achieving these tasks.

In the past, the technique of subtraction had been widely used in Conventional Angiography to improve the visualization of vessels and is nowadays universally used in Digital Subtraction Angiography (DSA). The routine CT Angiography must be post-processed with an algorithm designed to remove the bones and leave the contrasted-enhanced segments (i.e. the vessel lumen): it is known as manual bone removal directly applied on the contrast enhanced acquisition. However, manual bone removal algorithms are not perfect and require some manual editing. The complexity of the case will determine the amount of editing time required.

A technique of CT Angiography called subtraction CTA (SCTA) similar to the concept of DSA, has been recently introduced. It requires an additional non-enhanced acquisition. The subtraction dataset is obtained by subtracting non-contrast images from contrast-enhanced images.

As a result, high-density structures such as calcifications and metal are removed while the contrast enhanced areas are retained and correspond to the vessel lumen. In theory some artifacts such as blooming and streak artifacts caused by these structures are also effectively removed.

Department of Radiology B, University Hospital of Strasbourg, France.

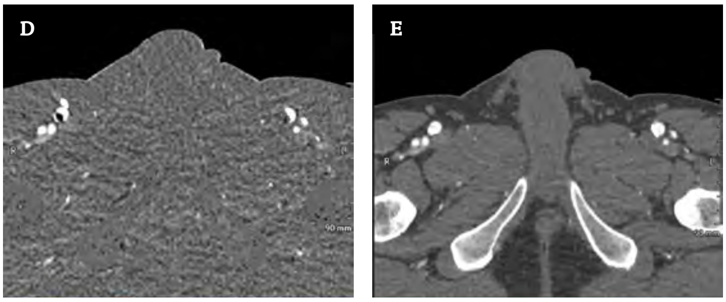

Figure 1: Example of procedure - level of femoral arteries – male patient: 90kg – height: 180cm.
A) *axial view – precontrast acquisition- some calcifications are present bilaterally -- Radiation dose: $CTDI_{vol}$: 1.2mGy / DLP: 151.6mGy • cm.* ***B)*** *axial view - same level - post contrast conventional acquisition – Ultravist 370mgI/ml Bayer– 1,5 cc/kg. Radiation dose $CTDI_{vol}$: 4.3mGy / DLP: 534.6mGy • cm. Density: 249 ± 26 HU in left iliac artery.* ***C)*** *axial view – subtracted dataset.* ***D)*** *axial view – filtered subtracted dataset.* ***E)*** *axial view – Virtual Iodine Boost post contrast dataset. Density: 348 HU ± 49 HU in left iliac artery. With this technique there is always a virtual increased density of the lumen of the opacified vessel, so that the contrast with the parietal calcifications is decreasing. There is also a slight overestimation of the stenosis in case of calcifications (or stent); but it does not affect the medical decision for the treatment.*

Figure 2: A 75 year-old man with a clinical suspicion of bilateral subacute lower limbs ischemia.
A) *automatic MIP projection- oblique view – subtracted dataset 1.* ***B)*** *Manual bone removal - 3D MIP view – Virtual Iodine Boost 1 post contrast dataset. Time for physician manual post processing on the workstation: 12 minutes. Multiple segmental occlusions are better evaluated on (a) with the development of the collateral circulation and the patency of the distal arteries. This result is obtained completely automatically (zero click workflow).*

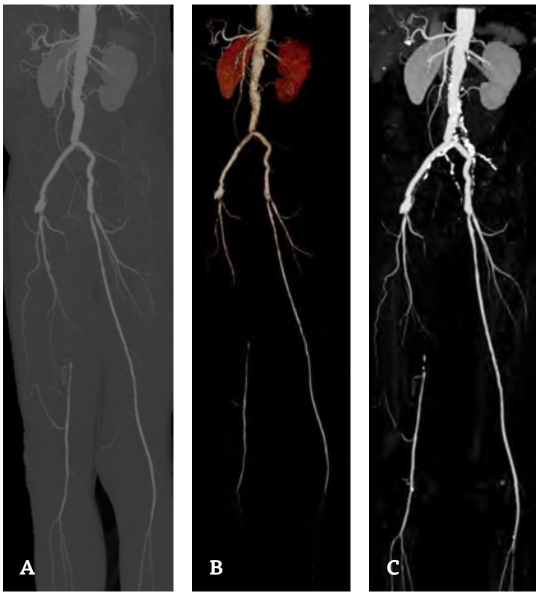

Figure 3: A 45 year-old man with previous aorta iliac surgery – follow up – clinical suspicion of chronic lower limb ischemia.
A) *Subtracted CT Angio - 3D MIP - automatically created. The severe stenosis of the proximal left superficial femoral artery distal to the common femoral anastomosis is well seen as well as the occlusion of the right superficial femoral artery and the severe stenosis of the right deep femoral artery. The collateral circulation secondary to right occlusion of the superficial femoral artery is also well appreciated. The stenosis of the proximal left ilac artery of the prosthesis is clearly demonstrated. There is also a moderate stenosis of the proximal left superficial femoral artery.*
B) *Subtracted CT Angio - 3D VRT - automatically created. This is an attractive presentation; however the medical information is more pertinent on (a).* ***C)*** *Manual bone removal - 3D MIP - oblique view – Virtual Iodine Boost 1 post contrast dataset– time for physician manual intervention on the workstation: 5 minutes. The calcifications around the prosthesis are seen as well as the multiple stenosis however the collateral circulation is better seen on (a).*

Patient motion between the two acquisitions is an important issue that must be corrected for an optimal result. This means that motion correction is the biggest challenge in SCTA. The key to obtaining accurate results lies in an anatomically 3D deformable (or non –rigid) registration algorithm that corrects motion between the two scans.

Finally, a SCTA will have a non-enhanced low-dose acquisition, an enhanced CTA acquisition and a subtracted acquisition.We have the possibility to add to the initial CTA acquisition the registered subtracted volume obtained to automatically create a virtual iodine boost dataset with a virtual increased contrast enhancement of the lumen.

The ^{SURE}Subtraction Angio algorithm developed by Canon Medical is a zero click procedure which is effective if the patient remains still or even if there are small involuntary movements.

Principle of zero-click automation

^{SURE}Subtraction Angio has protocol integrated automation at every step to empower even a novice operator with the skills to perform flawlessly the first time, every time. After scanning is performed, the two volumes are automatically registered and subtracted in the background by the CT system.

When subtraction is completed the application transfers automatically the subtracted volume and 3D MIP/VR to the PACS or workstation. With zero-click and within minutes the images are available for diagnosis.

Automatic details with the two steps

1. Post –contrast **minus** Pre-contrast = Subtracted dataset 1.
   As a result, spontaneously high density structures such as calcifications and stents are removed in the Subtracted dataset. The true lumen with iodine contrast agent remains.

2. Subtracted dataset 1 **plus** Post contrast = Virtual Iodine Boost.

At the end of this automatic procedure, three series are automatically transferred to the Vitrea workstation for review (Figs 1-4):

- The subtracted dataset 1.
- The software automatically generates a MIP and a VRT of the subtracted dataset lumen projection with a 360° rotation.
- The Virtual Iodine Boost post contrast dataset for routine post processing (as a complementary dataset if needed) with any type of reconstructions including MIP, VR, curved reformations and stenosis evaluation.

The total automatic processing time for a lower-limb CTA is less than 10 minutes.

Option: additional post procedure (Fig 5)

1. Virtual Iodine Boost 1 post –contrast dataset **minus** Pre-contrast = Subtracted dataset 2
2. Virtual Iodine Boost 1 post –contrast dataset **plus** Subtracted dataset 2 = Virtual Iodine Boost 2 post –contrast dataset

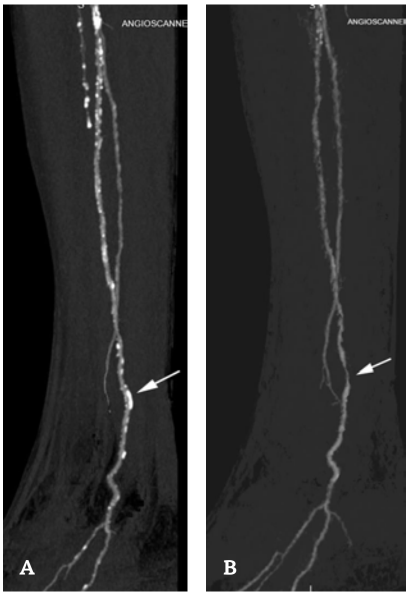

Figure 4: A 72 -year- old man (smoker with diabetes) who presents with bilateral chronic lower limb ischemia. On clinical examination he has bilateral cyanosis of the toes.
*Oblique MIP focus on the distal part of the posterior tibial artery with calcifications, the automatic bone removal dataset **(A)** and with subtraction dataset 1 **(B)** (arrow). MIP Subtracted images clearly demonstrate the severity of the disease with extensive stenoses in all distal arteries.*

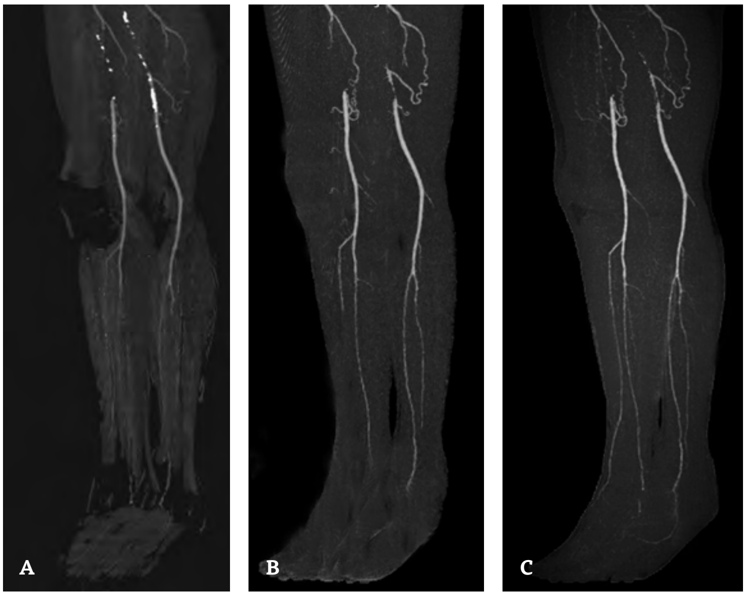

Figure 5: A 62 -year- old man, weight 130kg with moderate renal deficiency (eGFR: 45ml/min/1.73m2) presented with bilateral subacute chronic lower limb ischemia. A subtraction scan was performed of the lower limbs with 90cc of Visipaque R 320mgI/ml.
Radiation dose: pre contrast: $CTDI_{vol}$: 1.4mGy / DLP: 200mGy • cm
post contrast CT $CTDI_{vol}$: 4.7mGy / DLP: 649mGy • cm

***A)** post contrast – manual bone removal post processing. Note the poor assessment of the distal arteries. **B)** Subtracted dataset 1. Automatic MIP reconstruction - oblique projection. There is an improvement of the identification of the arteries. **C)** Additional subtracted dataset 2. Automatic MIP reconstruction- oblique projection. Distal portion of patent arteries are clearly seen.*

	Collimation	Pitch	kV	Rotation	mAs	Iterative Reconstruction Dose reduction	Slice thickness - interval reconstruction	Scan time
Pre contrast	0.5 mm x40	Standard	100	0.4s	SUREExposure 3D (8~50mAs) (SD = 23.5)	AIDR 3D Enhanced[4]	1mm/0.8	30–40s
Post contrast	0.5 mm x40	Standard	100	0.4s	SUREExposure 3D (32~148mAs) (SD = 10)	AIDR 3D Enhanced[4]	1mm/0.8	30–40s

Table 1: Acquisition and reconstruction parameters for lower limbs.

	Time for manual reconstruction
Manual Bone Removal	5-30 minutes (depending of the severity of the disease)
Subtracted CT Angio	None (time to compute ~8 minutes)

Table 2: Time for radiologist or technician for post processing.

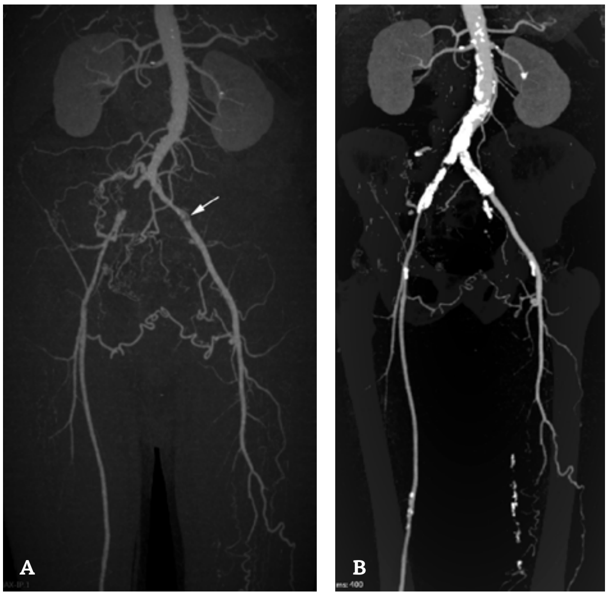

Figure 6: A 75 year-old man – follow up after the treatment of a stenosis of the proximal left iliac artery by stenting.
A) *automatic MIP projection- oblique view –subtracted dataset.* ***B)*** *Manual MIP manual bone removal projection - oblique view – Virtual Iodine Boost 1 post contrast dataset. The left iliac stent is patent, but there is some artefact at its distal part (↘). There is an occlusion of the right iliac artery with the collateral circulation well demonstrated on (a). This result is obtained without any human intervention.*

Details of the procedure:
To perform subtraction, a low dose precontrast scan ($CTDI_{vol}$ 1.1-1.2 mGy, and DLP range 150 - 200 mGy.cm) is performed as the subtraction mask, followed immediately by a low-dose CTA scan with similar parameters. SURESubtraction Angio can be performed with up to 50 cm of FOV (range from 35-45 cm) and a sufficient length of coverage (from 110 to 145cm). (Tables 1, 2)

Initial experience:

Advantages: (Figs 2-4)

- Visualization with an excellent contrast to noise ratio of the distal small vessels and the tiny collaterals. SCTA can provide fine luminal imaging even in patients with severe arterial calcifications, with reduced blooming artifacts.

- Virtual Iodine Boost allows a reduction in the total iodine load needed for lower limb CTA, which is particularly useful in patients with renal insufficiency.

An additional post procedure option is necessary in certain circumstances (renal deficiency and obese patient) (Fig 5).

- The SURESubtraction Angio processing is fully automated as part of the scan protocol. There is no need for additional technologist interaction after the initialization of the dedicated post processing: it is therefore a real zero click procedure without any interruption or slowing down of the workflow. In the daily practice, high-quality MIP and VR reconstructions are immediately obtained, without painful and time consuming human post processing. This is also very convenient in our emergency unit, where the users do not have the time-or the experience- to deliver high quality 3D and MIP CTA rendering.

- Since any CT scanner is capable of performing an unenhanced and enhanced CT scan at the same tube voltage, this technique would be more widely applicable than the Dual Energy CT (DECT). No dedicated sophisticated hardware is necessary compared to DECT. Both techniques are quantitative in that the signal intensity of the iodine maps is proportional to the iodine uptake[2], but an advantage of SCTA over DECT is that the signal difference between pre- and post-contrast acquisitions is obtained at a single tube voltage by opposition to the iodine attenuation difference at two tube voltages, as used in DECT. It has been recently demonstrated that SURESubtraction Angio CT provides the highest CNR in iodine maps , a better discrimination of details smaller than 10 mm and a reduced radiation exposure to the patient without compromising contrast-detail discrimination compared to both second and third generation DECT[3].

Remarks

- In theory, blooming artifacts are significantly reduced, thus increasing reader confidence when assessing the lumen and the degree of stenosis. Potential streak artifacts induced by stents or surgical clips are also removed, making in-stent restenosis more clearly visible. However, in practice a certain number of residual artifacts are sometimes remaining for stents or heavily calcified vessels, and could result in an overestimation of the lesion. For calcifications, the subtracted images are significantly improved compared to non-subtracted images (Fig 6).

- In case of severe motion between the acquisitions, black lines parallel to the vasculature will appear. The thicker the lines, the worse the artefacts are.

Conclusion

SURESubtraction Angio is a robust and accurate technique to remove calcification, stents and bone from CTA examinations, with identification of the true lumen even in cases of highly calcified distal arteries. The automation of the subtraction process with a zero click experience generating good quality MIP and VR reconstructions has been a great advance in terms of time saving in our routine workflow.

Finally, the possibility of Virtual Iodine Boost with the subtraction technique is an advantage for patients with impaired renal function or in case of suboptimal examinations. //

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More Precise Information with Dual-Energy CT in Neuroradiology

Dr. Sascha Pietruschka

With the 320-row Volume CT Aquilion ONE, the Dietrich-Bonhoeffer-Klinikum in Neubrandenburg in Germany is carrying out Dual-Energy CT examinations, amongst others. In this interview, Dr. Sascha Pietruschka, Senior Consultant in the Clinic for Radiology and Neuroradiology, speaks about the deployment options in Radiology. His conclusion: Less open questions with Dual-Energy CT.

Why and how were Dual-Energy scans first introduced into your clinic?
The focus within the Department of Radiology and Neuroradiology is the diagnosis and treatment of neurological disorders. Within this framework, we also carry out radiological interventional procedures. Two aspects have allowed us to incorporate the procedure here: Firstly, our department has been able to purchase a modern Volume Computed Tomography. The technical requirement was met as a result of this.

Secondly, I have been extremely curious about the uses of Dual-Energy since I heard about the use of Dual-Energy scans in the diagnosis of gout for the first time a few years ago. I have heard many presentations on this topic since then, including on the subject of post-interventional CT. I wanted our patients and doctors to be able to enjoy the benefits of a Dual-Energy CT.

What clinical questions can you answer with the help of Dual-Energy scans?
Dual-Energy is extremely helpful within the field of Neuroradiology. The procedure can be used to reliably detect or rule out early internal bleeding. Data from Dual-Energy scans is used to generate a "water image", a "calcium image" and an "iodine image".

These raw data images are weighted against one another or subtracted from one another. The findings from the information obtained in these images make it possible to reliably differentiate between bleeding and contrast medium stasis. In our department, this procedure is normally used following revascularization procedures during the first CT follow-up check.

In your opinion, what is the specific added value of Dual-Energy?
In Neuroradiology, we can reliably differentiate between internal bleeding or effects of contrast medium stasis following intervention via Dual-Energy CT. This is information that is crucial to the continuation or introduction of post-interventional anticoagulant therapy. Dual-Energy scans simply offer more information in these patient.

How would you work if you were unable to use Dual-Energy imaging? Would patients have to accept drawbacks?
Without Dual-Energy scans, we would use traditional imaging. However, in the past our diagnisis was not as confident.

Dr. Sascha Pietruschka with the 320 detector volume-CT Aquilion ONE at the Clinic for Radiology and Neuroradiology.

Dual-Energy imaging offers a greater level of reliability and confidence in the diagnosis. As we are a full-service provider and we are not a hospital with a research focus, the method is so far being used for a smaller patient group here at Dietrich-Bonhoeffer-Klinikum. However, the method works very well and brings crucial added value to the routine - we simply have less open questions when we have the Dual-Energy results.

Does the method have disadvantages?
No. The method can lead to a significant head start in stroke treatment compared with routine examinations.

How do Dual-Energy CTs fit into your workflow?
These are routine applications and there is no additional expense. Partners from the respective departments know what they need to note down. They must complete a normal request for a CT examination.

How do you assess the dose in the case of Dual-Energy CTs?
There have been considerable developments in dose reduction with the introduction of interative reconstruction techniques. With the average age of the patients eligible for the examination and the severity of the diseases to be diagnosed, the slightly higher dose is more than compensated by the added diagnostic value.

What future applications do you envisage for your hospital and in general for Dual-Energy scans?
We are considering using Dual-Energy scans after all neurological interventions. I could also easily imagine the Dual-Energy CT being used in tumor imaging. I am also keeping an eye out for other areas of use.

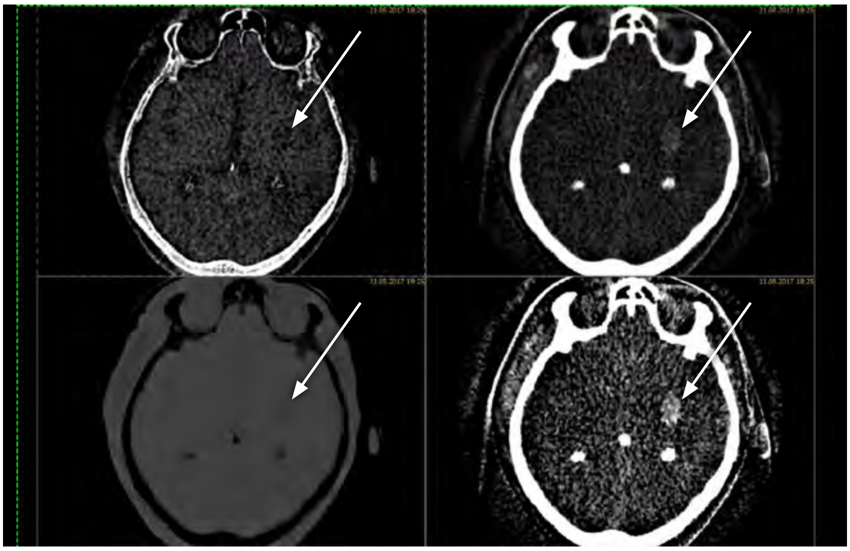

Figure 1.1: Right side images: Iodine basis material (top) and Calcium basis material (bottom images). There is a hyperdense area in the region of the N.Lentiforms. Left side images: the water basis material images show hyperdense areas in the corresponding N.Lentiform region.

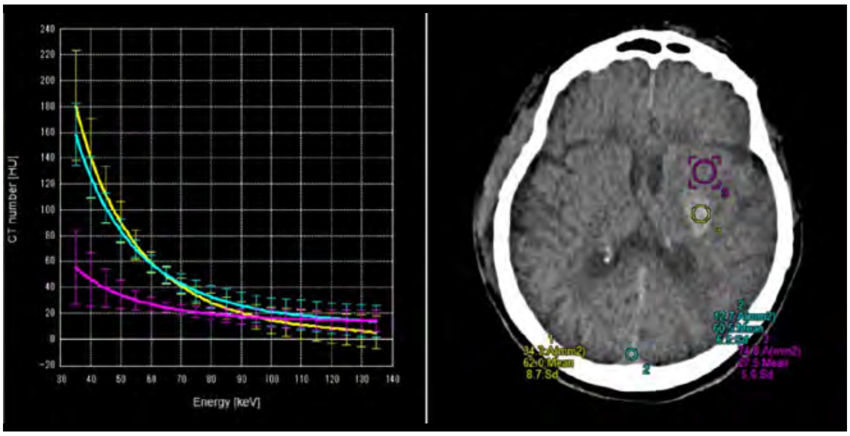

Figure 1.2: The 59 keV monochromatic image shows the hyperdense area in the N.Lentiform region. The spectral curves of this region and the venous sinus show similar upslope typical of iodinated contrast (yellow and blue) as compared to normal brain parenchyma (purple).This confirms the collection is contrast media stasis.

Case 1: Dual-Energy CT following thrombectomy - bleeding or contrast medium stasis?

The 89-year-old patient was found unconscious. There was a monocular hematoma of the right eye and atrial fibrillation. The initial CT showed marked early signs of infarction in the region of the basal ganglia and the insular lobe on the left. An M1 occlusion was diagnosed in the CT angiography.

Due to the unclear time window, an MRI was subsequently performed with the detection of diffusion disturbances in the entire middle cerebral artery area on the left without correlation in the T2 FLAIR image. Together with the Neurologist, the decision was made for an invasive recanalization attempt. Recanalization of the M1 segment was successful.

Subsequent Dual-Energy CT. In this CT contrast medium stasis was found in the N. Lentiform. The Dual-Energy CT made it possible to reliably differentiate between bleeding, which was equally conceivable, and contrast medium stasis.

Case 2: Post-interventional control after coiling by means of Dual-Energy CT: bleeding or contrast agent stasis?

The 59-year-old patient was diagnosed with an 8mm diameter basilar aneurysm. The elective use of the "pCONus Device" was used in an attempt to optimally place one coil, which made it necessary to recover the stent initially inserted with the coil. Subsequently the stent placement and endovascular occlusion with a coil was achieved. No contrast medium appeared to escape throughout the entire procedure.

We decided to carry out an immediate post-interventional follow-up check with Dual-Energy imaging. Here we saw a unilateral cortical band-like to patchy left occipital hyperdensity.
Thanks to the Dual-Energy CT, we were able to unequivocally define this change as CM stasis. There was no diagnostic uncertainty. The follow-up CT the next day showed complete resorption of the contrast medium.

Figure 2.1: Angiographic representation before and after care.

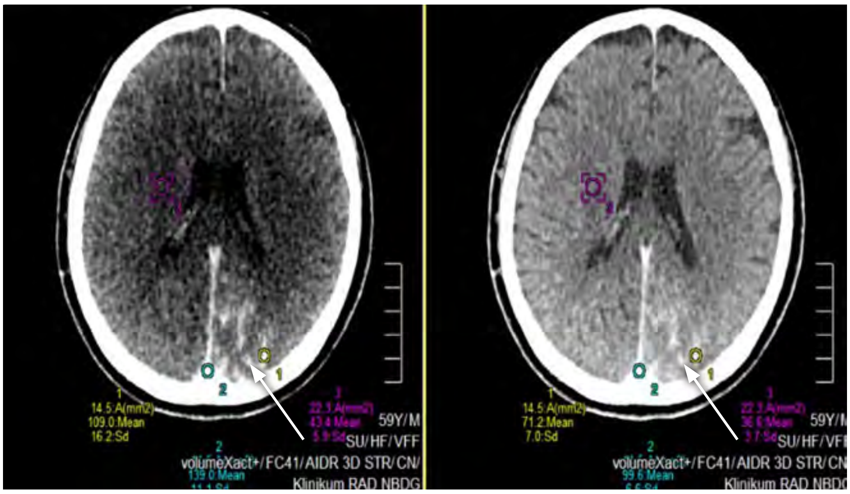

Figure 2.2: 80KV and 135KV image with hyperdense representation of the left occipal cortex band.

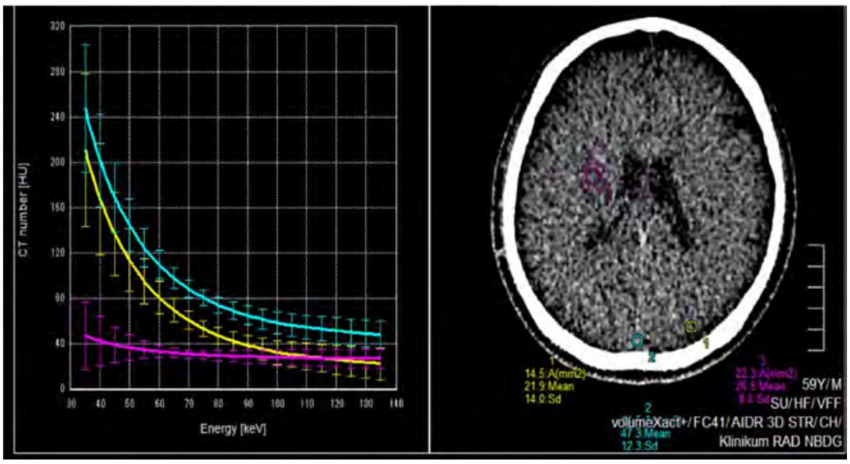

Figure 2.3: the spectral curves demonstrate the typical upslope of iodinated contrast from the ROI in the left occipital cortex (yellow) and sagittal sinus (blue).The normal brain parenchyma curve is shown in purple.

Case 3:
Raw data subtraction image to distinguish between bleeding or a calculus

At the beginning of May 2017, the patient suffered a watershed infarct as a result of carotid dissection on the right. After stabilizing the patient on a new oral anticoagulant, rehabilitation measures ensued. Two seizure events accompanied by falls occurred eight weeks after the first incident. These led to inpatient admission. In the CT on admission, we saw band-like, but not continuous hyperdensities in the peripheral region.
Thanks to a Dual-Energy scan using specific parameters bleeding was rapidly ruled out by means of an assessment of the raw data subtraction images. There was a calcification in the peripheral region of the infarcted tissue. //

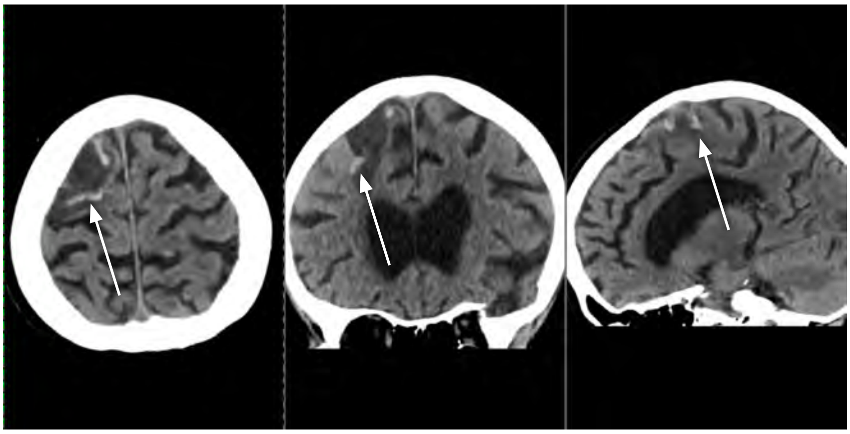

Figure 3.1: Native CCT 120 KV with post ischemic parenchymal lesion on the right in the border area.

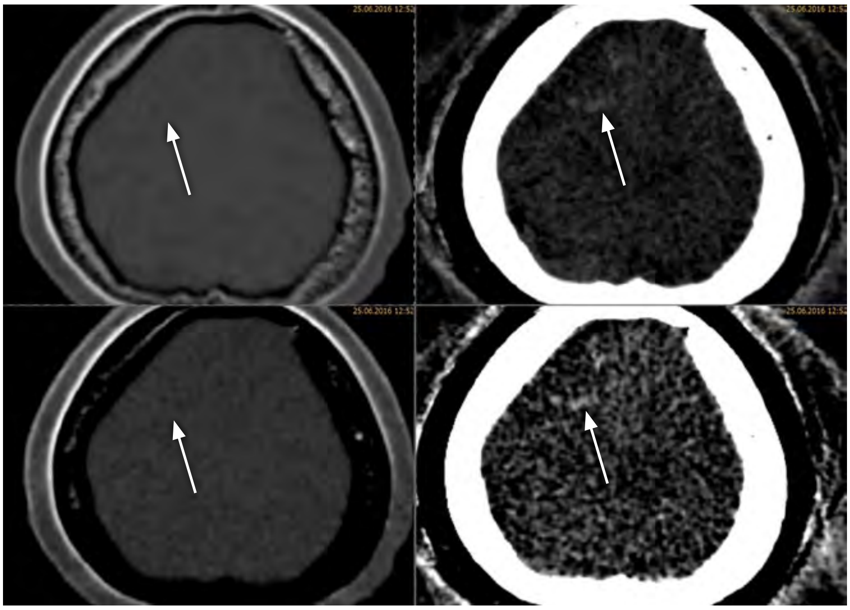

Figure 3.2: Right side images show the iodine basis material (top) and the calcium basis material (bottom) with hyperdensities in the edge area of the old infarct. The water images (left hand side) show these area as iso-dense suggesting calcifications.

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Dr. Wolfgang Möller (l.)Neurologist Berlin, Nerve sonography.

Rober Meyer (r.) Specialist in Neurology Berlin.

Nerve Ultrasound Opens Up Completely New Perspectives

Dr. Möller, why are you offering nerve sonography?
Nerve sonography can be useful, for example, to determine the exact location in case of suspected nerve damage - and to make a faster diagnosis. With the classical examination, the electrophysiological measurement of the nerve conduction velocity, I obtain indications of a changed or disturbed function.

In addition, I may obtain rough indications of where the nerve is damaged, inflamed or pinched. However, I can not clarify the cause of the damage with the electrophysiological measurement. High-resolution ultrasound imaging with one of the most advanced devices, such as the Aplio i800, in the hands of an experienced and well-trained examiner is, in my opinion, the ideal form of investigation to visualize the cause of a nerve disorder.

To what extent has the ultrasound changed your practical work?
Nerve sonography is a relatively new method, which offers far-reaching additional possibilities for neurological diagnostics. Until the 1990s, we had no other method than the electrophysiological measurement. So, above all, we worked with the patient's clinic and the curves of nerve conduction velocity. But we had no idea what a damaged nerve looks like, we did not have a picture. Thanks to high-frequency probes, I can now see and assess even the smallest peripheral nerves noninvasively, three-dimensionally and in real time. That's a great advantage.

What additional information does the three-dimensional image provide?
The three-dimensional insight into the body using the Aplio i800 takes on a whole new dimension, giving us a new perspective on the nerves. You can imagine it like a theater

in which a great curtain stands closed before us. Although we can look at the wonderful fabric, its colors and how nice it is - it is only when the curtain opens that the images, actors and scenes that make up the play open up to us.

What does the theater have to do with sonography?

With nerve ultrasound, the curtain opens into the three-dimensional reality of the nerve plexus and its surroundings. On the one hand, I get a look at the individual structures. But the ultrasound has changed even more: I can see in real-time a three-dimensional network where one nerve is there, the next one somewhere else. There are also individual variants, each person has a different anatomy.

Through the imaging of, for example, an irritated nerve, one can generally better understand how, for example, irritation develops and which processes take place. So it's not just about the picture we see when we're sitting in front of the device. It's about the entire pathological process, which we understand better through ultrasound. For us, today nerve ultrasound is a significant modern building block in neurological diagnostics.

How do patients react?

From our practical experience, visual nerve sonography, in addition to traditional examination methods such as nerve conduction velocity measurement, is also immensely important for patients. Because they get additional information by looking at the screen, they can better imagine where their pain comes from and how to best treat it. The patient sees his illness and gets a clear idea of it. And the ultrasound offers him or her more security in the treatment due to the clear instructions for the diagnosis.

> *“With nerve ultrasound, the curtain opens into the 3D reality of the nerve plexus and its surroundings.”*

Can you name typical indications?

The ultrasound can even make small peripheral nerve structures and muscles visible. The investigation can clarify whether a nerve is only pinched as in a nerve constrictor syndrome, whether it is irritated or inflamed. A typical indication is discomfort and tingling in the hands. The ultrasound provides indications as to whether the problem is peripheral or, for example, in the area of the cervical spine. In addition, the nerve ultrasound helps us to weigh up for or against surgery. Preoperatively, however, it can also be revealing, for example, about where to incise - or prepare for anatomical variants.

Nerve sonography fell behind normal ultrasound for a long time.

The technology and development of the sound probes took a long time. But now that the devices are on the market, new improvements are constantly being added. The structures that we can detect with the nerve ultrasound become smaller and more detailed. Nature opens up to us completely differently again. Here with the Aplio i800 Canon offers the best device on the market. We've been working with Canon for years.

Why are you and Canon so close?

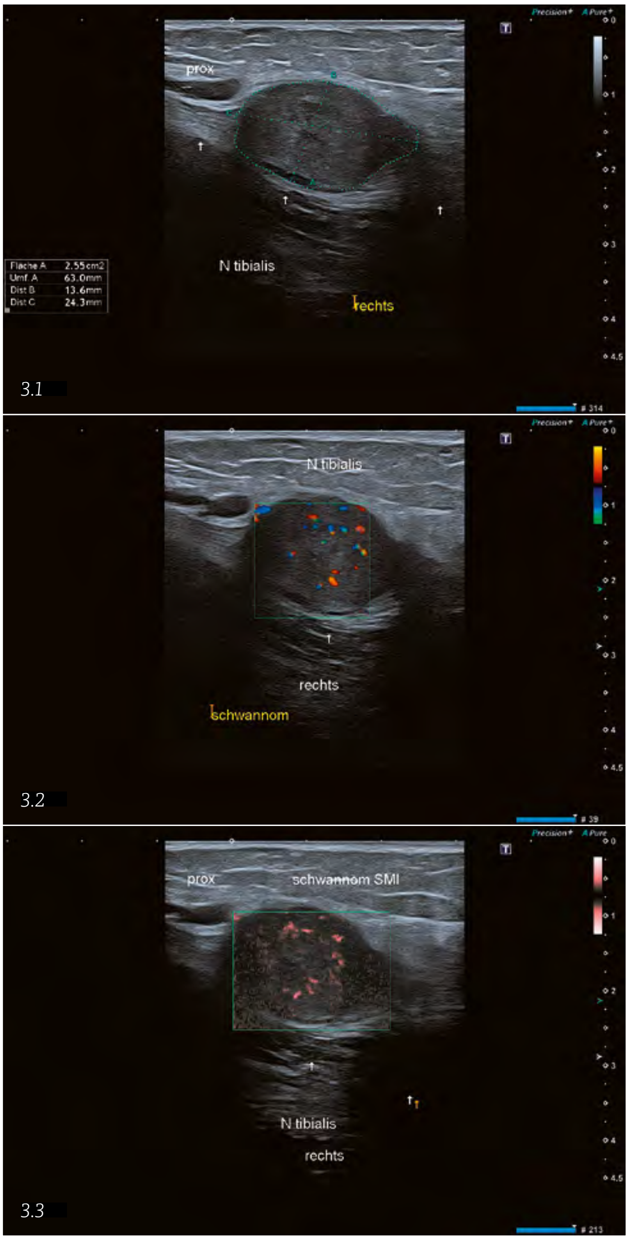
We are extremely satisfied with the company in many ways. As Canon offers a service that we rarely find today. For sales, we have such a good contact, I've never experienced that with any other manufacturer. In case of problems, the technicians are immediately accessible, the customer care is excellent. I've experienced that with Canon over the years. The company even provided us with a loaner device very quickly when we had problems with the equipment of another company. We chose the Aplio i800 because it's the first choice in terms of imaging, quality and resolution.

Will the importance of nerve sonography change in the future?

Like me, my colleagues are convinced that nerve sonography will continue to grow in importance in the future. Because most people work on the computer, fine motor, detailed work is becoming increasingly important. We need to be able to help patients quickly and effectively with disorders even of the smallest peripheral nerves. So, diagnostics, for example with the Aplio i800, will make a major contribution in the future. //

Fig. 1: Here a neuroma after injury in the area of the distal R. superficialis of the N. radialis is shown.

Fig. 2 shows an elongated neuroma / neurinoma in the area of the left ulnar nerve in the upper arm after a long-standing trauma.



[I] Figs. 3.1 to 3.3 show a schwannoma in the area of the right tibial nerve in the area of the distal lower leg.

[I] Fig. 4 shows a neuroma formation after injury of the left sural nerve.

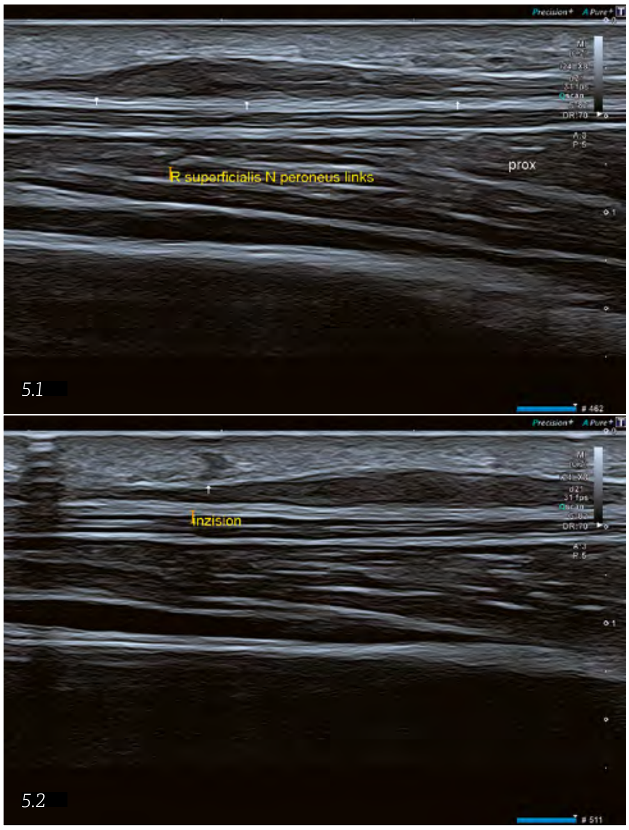


Fig. 5: Incision of the R. superficialis of the N.peroneus.

Fig. 6: Ulnariskompression in the area of the sulcus ulnaris right.

Added Value of Dual-Energy in MSK Imaging

Dr. Torsten Diekhoff

Dual-Energy CT (DECT) has different application in Musculoskeletal Radiology. In this article, we present four clinical cases.

DECT allows measurement of the composition of bone marrow, which is not possible with conventional computed tomography. The detection of bone marrow edema in acute vertebral fractures with DECT allows for faster and more effective patient management. For example, the reconstruction of non-calcium virtual images (VNCa) allows the bone marrow to be scanned for edematous or infiltrating processes, providing crucial additional information on conventional CT, see Case 1. Bone marrow edema of the peripheral skeleton can also be detected by DECT, see Case 2.

By searching for uric acid deposits and their color-coded representation, DECT provides a quick overview of the tophus load and, thus, crucial additional information to the conventional CT.

The three-dimensional representation makes it easier to explain the findings to the patient and can increase his or her readiness for therapy. Tophus volumetry quantifies uric acid deposits for follow-up with drug therapy or diet. DECT allows reliable monitoring of patients under therapy. This makes it a valuable tool in the diagnosis of atypical gout cases, see Cases 3 and 4.

Dual-Energy CT can be acquired on Canon volume CTs with two fast sequential volumes, including wide-volume technology. The Canon Aquilion PRIME CT systems allow acquisition with two separate helical CTs, or the Dual-Energy helical scanmode. Radiation exposure is low and is dose neutral, when using iterative reconstructions.

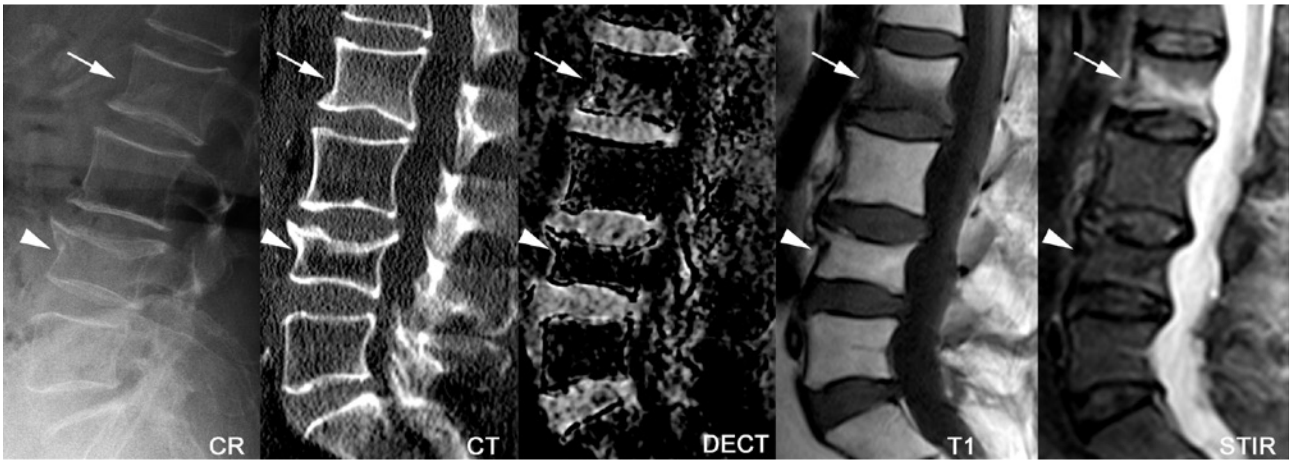
Case 1:
Representation of bone marrow edema in acute vertebral body fracture using 'Virtual Non-Calcium images' (VNCa).

A 76-year-old female patient presented with acute back pain in the central emergency room during the evening. There was no sign of trauma. Neurological status was normal. The radiograph showed a reduction in the height of the L4 vertebra, more in-keeping with an older fracture. Magnetic resonance imaging was not immediately available. Therefore, a Dual-Energy CT (DECT) was performed.

The reconstructed Virtual Non-Calcium images (VNCa) from the DECT datasets show normal, fatty bone marrow in the L4 vertebra, but increased density in the L2 vertebra. This corresponds to an acute basal plate compression fracture with bone marrow edema. The patient was hospitalized and the diagnosis was confirmed the following day with MRI. With a negative DECT, she could have been discharged with pain therapy at home.

Key messages: Case 1

The DECT with the reconstruction of VNCa images allows the assessment of bone marrow edema in vertebral body fractures. This may in some cases avoid additional MRI and improve patient guidance and care in the hospital or on an outpatient basis.



Case 2:
Detection of bone marrow edema in inflammatory joint diseases using 'Virtual Non-Calcium technique' (VNCa).

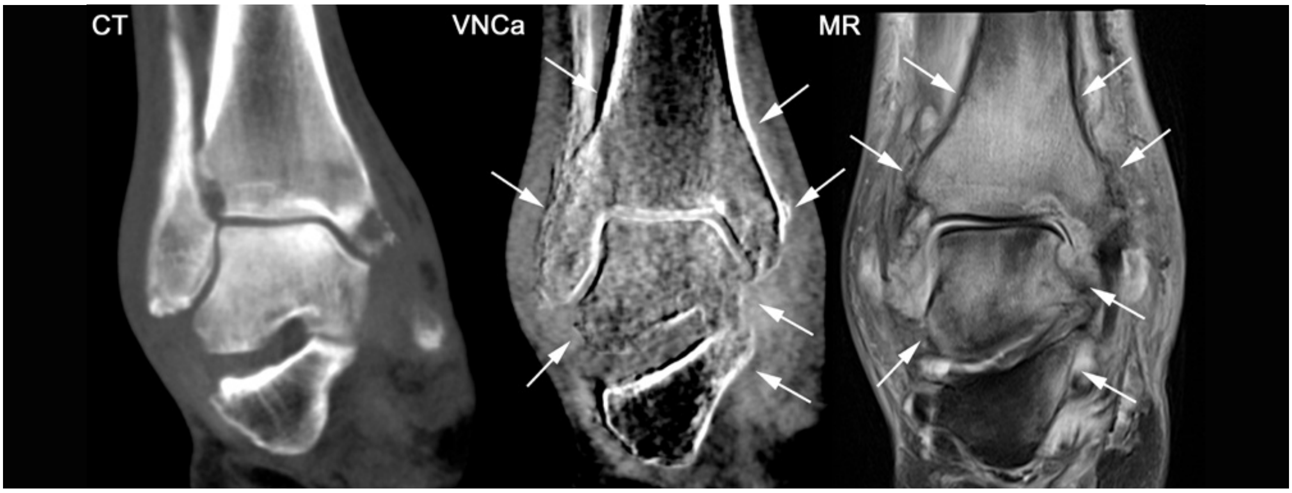
A 53-year-old patient presented with pronounced swelling and mild rheumatological ankle pain. The initial radiography was normal. Due to borderline high uric acid, a Dual-Energy CT (DECT) was performed to evaluate possible gouty arthritis.

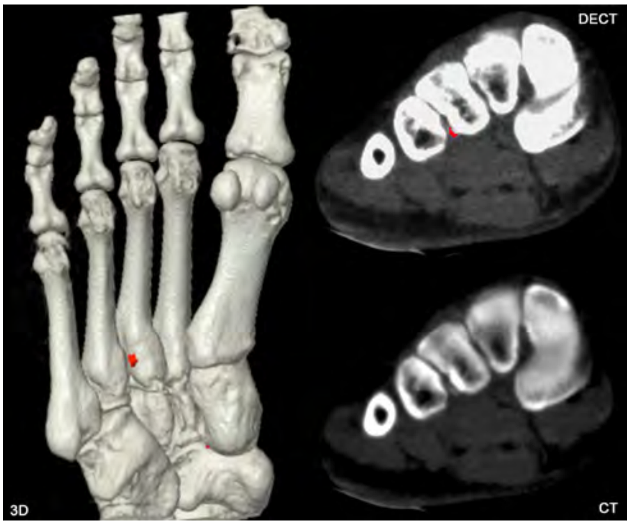
The DECT with 2 material decomposition showed no evidence of gouty arthritis. However, the conventional CT showed some erosion. Subsequently, the dataset was additionally reconstructed using three-material decomposition for the creation of non-calcium virtual images. The extensive bone marrow edema of the talus, tibia and fibula confirmed severe, acute arthritis in stark contrast to the patient's mild clinical condition. After the edema was confirmed on MRI, septic arthritis was confirmed as tuberculosis in the subsequent articular puncture. Joint destruction and bone marrow edema in this case, gave the decisive indication for the further diagnosis of the patient.

The use of DECT to diagnose gout is also worthwhile for the reconstruction of VNCa images. They are the only way for native CT to gain insight into acute inflammation and disease activity. In patients with arthritis, bone marrow edema is the strongest predictor of future bone marrow destruction. Evidence of it usually entails a forced initiation or conversion of therapy.

Key messages: Case 2

Bone marrow edema of the peripheral skeleton can be detected by DECT. It is valuable additional information for the further treatment of the patient and can be obtained from conventional DECT acquired for gout diagnosis.





Case 3:
Visualization of the smallest gout tophus by 'Dual-Energy Composition Analysis'

A 36-year-old man presented with acute foot pain first to the General Practitioner and later to the orthopedist, and finally to rheumatology. In a blood test, borderline uric acid levels were detected. The radiograph and sonograph were normal. Nevertheless, gout is suspected because of his lifestyle.

A Dual-Energy CT (DECT) was performed and reconstructed using DE Composition Analysis. A small gout tophus between the base of the 3rd and 4th metatarsal bone could be seen (marked red in the figure). With conventional CT it would certainly not have been detected. The unusually young patient was discharged with dietary measures and uric acid lowering medications and the symptoms soon improved.

Key messages: Case 3

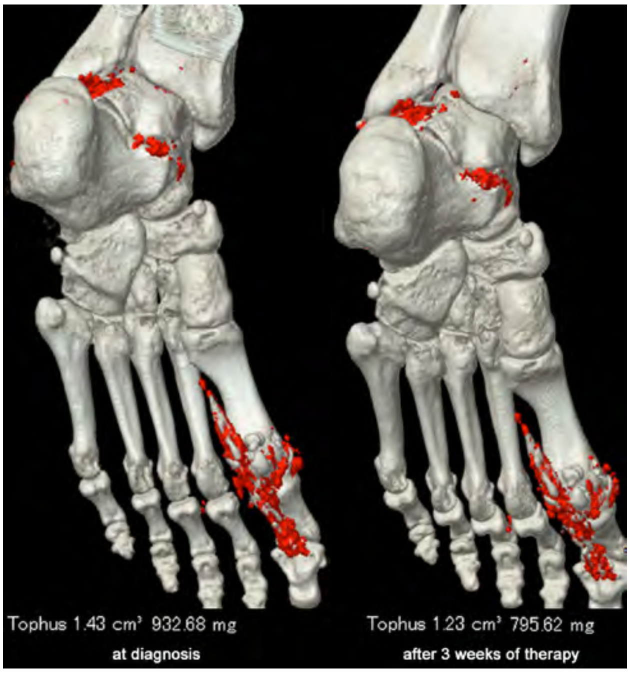
The DECT with appropriate post-processing is sensitive to small deposits of uric acid and thus allows accurate diagnosis of gout, even with an atypical clinical presentation. The color-coded representation makes it easy to explain the findings to colleagues and patients. This makes it a valuable tool in the diagnosis of atypical gout cases.

Case 4:
Demonstration of the reduction in uric acid load following treatment by means of Dual-Energy Composition Analysis.

A 56-year-old man presented to the GP with acute foot pain. Pain and swelling were rapidly increasing, so that hospitalization in Rheumatology was necessary. Here, a Dual-Energy CT (DECT) was initiated to confirm the suspected diagnosis. After initiation of therapy, the condition improved, at first. Three weeks later, however, the patient presented at the hospital with exacerbated pain.

A second DECT was performed and reconstructed by two material decomposition. The automatic tophus volumetry shows a significant decrease in the uric acid load, which alone does not appear to be so impressive in the morphological image. This proved the effectiveness of the therapy. The patient was able to be discharged back home with adapted pain therapy.

Radiation exposure is low when using iterative reconstructions. The data sets are analyzed with the software module "Dual-Energy Composition Analysis" by means of a preset optimized parameter. The software also allows the determination of the tophus volume in ml or the uric acid load in mg.



Key messages: Case 4

The DECT with corresponding post-processing is sensitive to changes in the uric acid load over the course of time. However, the quantification of the tophus load is also important information in the initial diagnosis of the severity of the disease for clinical colleagues. //

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Full length articles should generally include the following:
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- Text approx 4 to 5 pages or 12.000 to 14.000 characters (not including figures, tables and photographs)
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- Literature (no more than 10 references)
- Separate, continuous numbered image- and table captions

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- Text including headline, sub-title, introduction and full description of methods & materials/equipment used
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- Correspondence address
- Literature (no more than 10 references)
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