

# MReadings: Upgrades

Contributions from our MAGNETOM users

Not for distribution in the US

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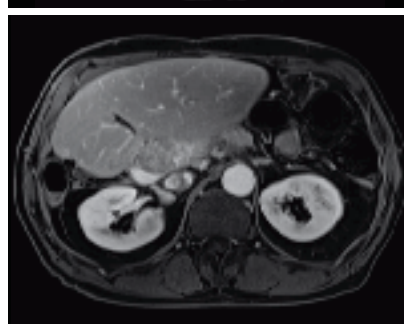
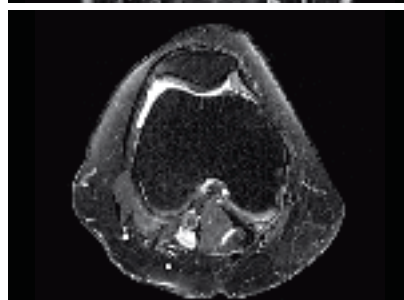
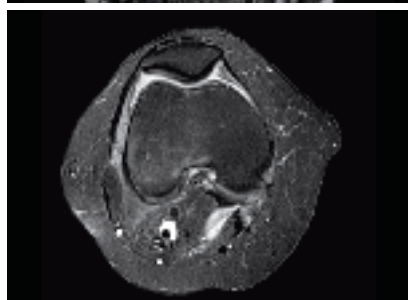
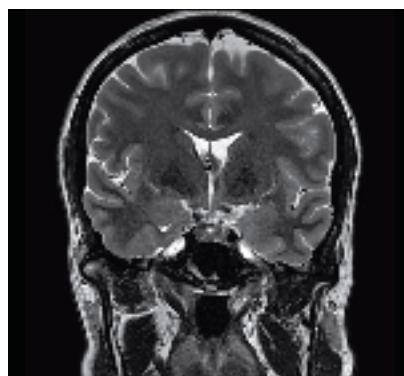
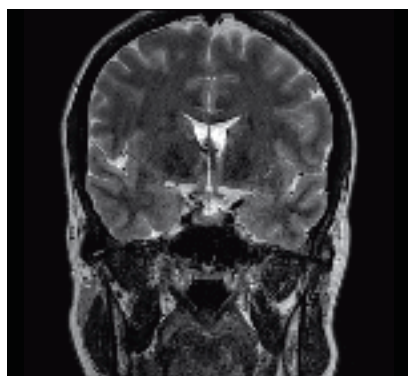
**MAGNETOM ESSENZA  
Dot Upgrade with  
syngo MR E11**

Izumi Togami

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Kevin Dirlam



Before the upgrade

After the upgrade

## Dear Reader,

Healthcare systems worldwide are under pressure. As declining fertility rates and longer life expectancy reshape the age structure of the population, unprecedented changes are underway [1]. The demand for health services is growing, but healthcare budgets are shrinking [2]. Politicians and healthcare officials try to solve this problem in various ways – often by reducing reimbursement rates or introducing new mechanisms such as value-based healthcare [3] – all of which require healthcare providers to do more with less.

We are aware of the challenges you face, and we understand them. This is why we continue to innovate on our current MAGNETOM scanners as well. All of our upgrades and options are specifically designed to help you stay up-to-date.

This forward-looking approach is nothing new: We first adopted it back in 1983, with our very first MRI system. From that day on, we have been offering MAGNETOM users several ways to keep their systems at the cutting edge – so that they can serve more patients, tackle challenging diagnoses, and make the most of their investments and infrastructure.

This issue of *MReadings: Upgrades* looks at the advantages of upgrading our existing MRI systems. First, we have a variety of articles on the Tim upgrades, which was available between 2004 and 2017 for all MAGNETOM Symphony, MAGNETOM Sonata, and MAGNETOM Trio systems. This new technology has an enormously positive effect on image quality, and accelerates scan speeds so much that users can increase their productivity by up to 40% [6]. With more than 800 Tim upgrades completed and hundreds of systems still in use, the technology has proven to be a resounding success.

In 2012, we began offering users of MAGNETOM Avanto, MAGNETOM Trio, A Tim System, and MAGNETOM Verio the option of a fit Upgrade to equip their systems with Tim 4G and Dot. In addition to allowing users to achieve even better image quality, the upgrade also makes it easy to expand into new clinical areas. The Cardiac Dot Engine, for instance, paves the way for routine cardiac MRI scans [4], while Tim 4G technology supports regular MRI prostate examinations without an endorectal coil in patients undergoing active surveillance [8].

### Our MRI scanners: Upgradable from the start.



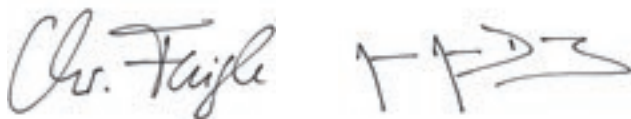
Our innovative software version *syngo* MR E11 is now available as an upgrade for MAGNETOM Verio<sup>1</sup>, MAGNETOM Avanto<sup>1</sup>, and MAGNETOM ESSENZA. The platform allows you to increase your efficiency with DotGO, which will reduce overall examination time and make time slots more predictable (with variations of less than one minute [9]). It also dramatically reduces the amount of time you have to spend interacting with the software (by up to 46% [10]), and helps you expand your MRI services with the latest Body MRI applications.

Each upgrade and option can move your institution forward in multiple ways. To help users identify the specific needs of their individual setting, we offer Asset Planning Sessions in a number of countries. The structured sessions involve an individual market analysis, a system utilization analysis, and a discussion about your strategic direction. The outcomes are then used to develop an individual asset management plan that will show you how to expand your services, be more efficient, and keep your equipment future-ready.

Looking back, we are proud of our long history of upgradability. Looking forward, we know we are on the verge of innovations that will once again change the face of MRI. As our existing MAGNETOM users, you have as much a stake in our future as you do in our past. So rest assured that we will be taking you with us as we take bold steps into the future, together.

Get the most from your investment!

Your MR Installed Base Management Team




Christine Faigle



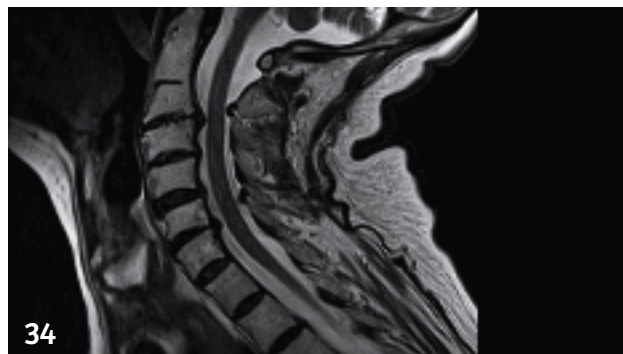
Juanjo Díaz Esmoris

## References and further reading

- 1 World Health Organization, National Institute on Aging. Global Health and Aging [Internet]. NIH Publication no. 11-7737; October 2011:18 [accessed Dec 14, 2017]. Available from: [https://www.nia.nih.gov/sites/default/files/2017-06/global\\_health\\_aging.pdf](https://www.nia.nih.gov/sites/default/files/2017-06/global_health_aging.pdf)
- 2 Porter ME, Kaplan RS. How to Pay for Health Care. Harvard Business Review. [Internet]. July–August 2016 [accessed Dec 14, 2017]. Available from: <https://hbr.org/2016/07/how-to-pay-for-health-care>
- 3 Marmor T, Oberlander J, White J. The Obama administration's options for health care cost control: hope versus reality. Ann Intern Med. 2009; 150(7):485-9. doi: 10.7326/0003-4819-150-7-200904070-00114. Epub 2009 Mar 2.
- 4 Armando E, Capitulo LM, Cesarani F. Cardiac MRI: Image Quality Improvement and Examination Time Shortening After MAGNETOM Avanto<sup>fit</sup> Upgrade. MAGNETOM Flash 2017; 67(1):8. Page 68 of this issue.
- 5 Marra MJ. MAGNETOM Symphony Maestro Class Upgraded to MAGNETOM Symphony, A Tim System [76 x 18]. MAGNETOM Flash 2006; 33(2):28. Page 30 of this issue.
- 6 Siemens Healthcare GmbH. Tim Technology (quote by Heraldo Mello, MD, Neto X-Leme Clinic, Brazil) [Internet]. Germany: Siemens Healthcare GmbH; 2017 [accessed Dec 14, 2017]. Available from: <https://www.healthcare.siemens.com/magnetic-resonance-imaging/mri-technologies-and-innovations/tim-technology/use>
- 7 Dirlam K. Dot for productivity. MAGNETOM Flash 2018; 70(1). Page 86 of this issue.
- 8 Egelhof T, Katz G, Mais C. The Skyra<sup>fit</sup> Experience in Basel. MAGNETOM Flash 2016; 65(2):37. Page XX of this issue.
- 9 Zhongshan Hospital Fudan University, Fudan, CN, Abdomen Dot Engine Workflow Study.
- 10 University Hospital Essen, GER, Brain Dot Engine Workflow Study.

<sup>1</sup> *syngo* MR E11 is currently under development for MAGNETOM Verio and MAGNETOM Avanto and not commercially available. It is not for sale in the US. Its future availability cannot be guaranteed.

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MAGNETOM Symphony Tim Upgrade<sup>1</sup>



## Learn from the experience of other MAGNETOM users

The MAGNETOM World is the community of Siemens Healthineers MR users worldwide, providing you with relevant clinical information. Here you will find application tips and protocols to optimize your daily work. Lectures and presentations from experts in the field will allow you to be exposed to new ideas and alternative clinical approaches.

Put the advantages of the MAGNETOM World to work for you!

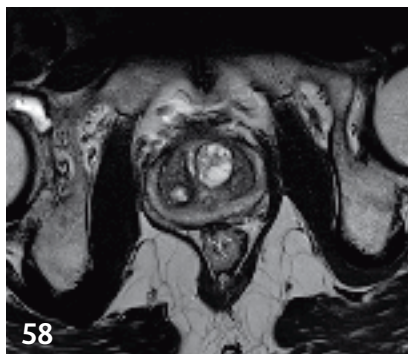
[siemens.com/magnetom-world](https://www.siemens.com/magnetom-world)

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<sup>1</sup> Tim Upgrade is not commercially available anymore.

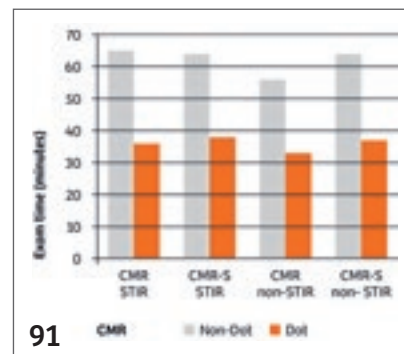




fit Upgrade



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## fit Upgrades

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# Tim proves to be a total improvement

J. Dehem, M.D.

Jan Yperman Ziekenhuis, Ieper, Belgium

The first impressions of my Tim (Total imaging matrix) upgrade: What is most significant to me is the overall improvement in image quality, especially the dramatic gain in signal intensity and homogeneity. The following side-by-side comparisons of routine cases – scanned before and after the Tim upgrade – demonstrate this striking enhancement in image quality.

The MAGNETOM Symphony, A Tim System comes with new coils. The CP Head, CP Neck Array, CP Spine Array and CP Body Array coils are exchanged for Matrix coils, each one containing multiple “clusters” of 3 coil elements which yield more signal.

The advantages of the new coils are shown in a side-by-side comparison of the same volunteer with the CP Head coil on the MAGNETOM Symphony and the Head Matrix coil on the MAGNETOM Symphony, A Tim System.



MAGNETOM Symphony, A Tim System

Additionally, if you combine the signal and quality gain from the RF system with the signal and quality gain of the new coils, you get even more improvement.

Several coil plugs on the patient table with the Tim system allow the combination of multiple coils. These coil combinations are indeed ‘seamless’ and offer major advantages in orthopedic, breast and angiographic imaging. Especially the light weight and flexibility of the Body Matrix coil is highly appreciated by both the patients and technologists.

Multiple coil combinations allow for extensive use of parallel imaging. Since the patient is covered by multiple coil elements, iPAT (integrated Parallel Acquisition Technique) is used in all 3 directions. And in 3D imaging the combination of iPAT in both the phase and slice directions is possible (iPAT<sup>2</sup>). The extensive use of higher PAT factors (PAT 3), combined with iPAT<sup>2</sup> imaging (PAT 2 x PAT 2 = PAT 4), takes advantage of the increased signal to scan faster with equal or even better image quality, but at shorter scan times. Prior to the installation of the Tim upgrade we used a (rare) spare moment on the last day of our MAGNETOM Symphony to scan volunteers. After the installation of our new MAGNETOM Symphony, A Tim System (same magnet, same gradients, same volunteer, but new RF system, new Body coil, new computers and software), we repeated for the sake of comparison the same sequences with exactly the same scan parameters (using Phoenix technology).

Again, most striking is the signal gain and the homogeneity of the image, especially when looking at the edges of the images on all sequences.

Below are some of the cases from this before and after comparison. Do I even need to mention that the upper rows of images are from the MAGNETOM Symphony, A Tim System?

Tim Upgrade is not commercially available anymore.

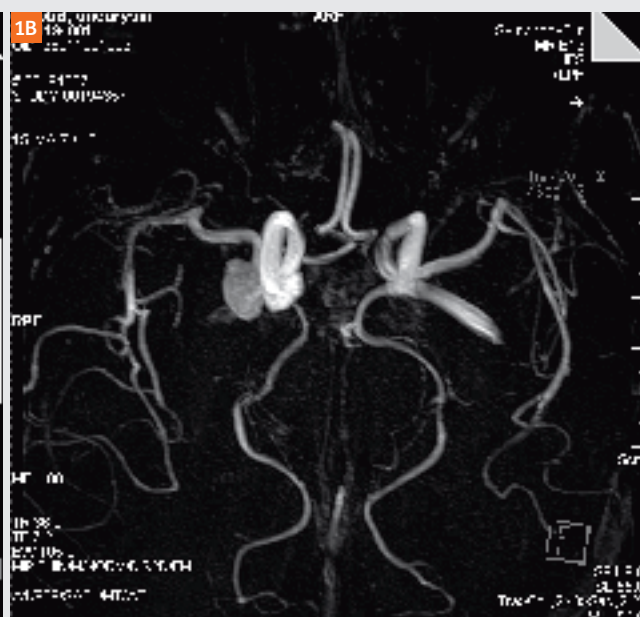
## Adding light and resolution

### Case 1

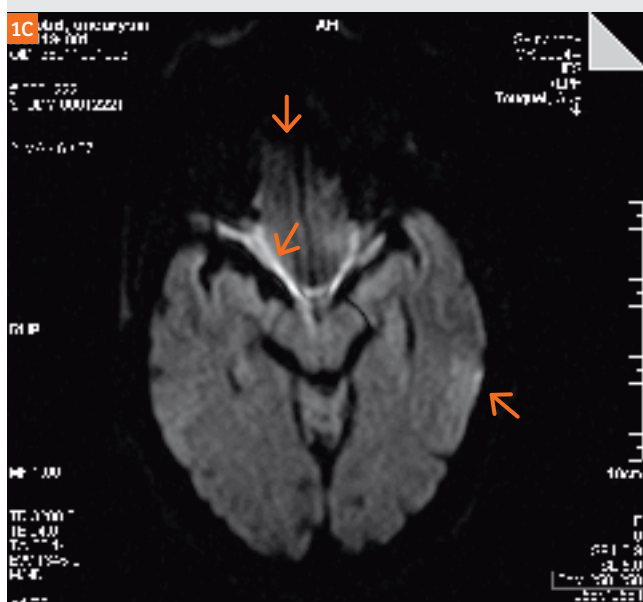
The Head Matrix coil allows for iPAT, which further reduces the image distortion artifact due to the long EPI-readout. This is demonstrated in the follow-up examination (follow-up carotid aneurysm) of this patient. 3D TOF (Time of Flight) has also markedly improved leading to depiction of smaller branches.



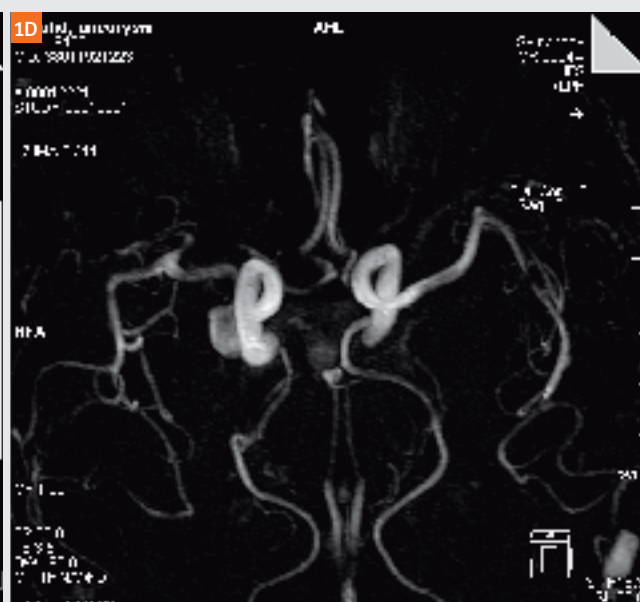
MAGNETOM Symphony, A Tim System



MAGNETOM Symphony, A Tim System



MAGNETOM Symphony



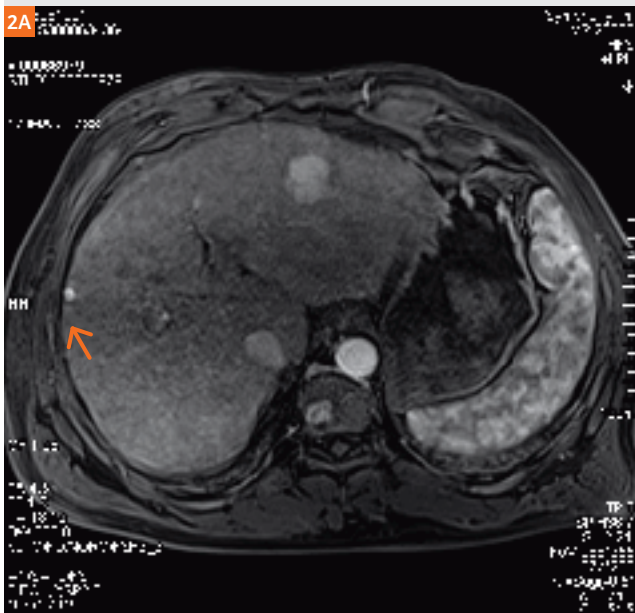
MAGNETOM Symphony

Tim Upgrade is not commercially available anymore.

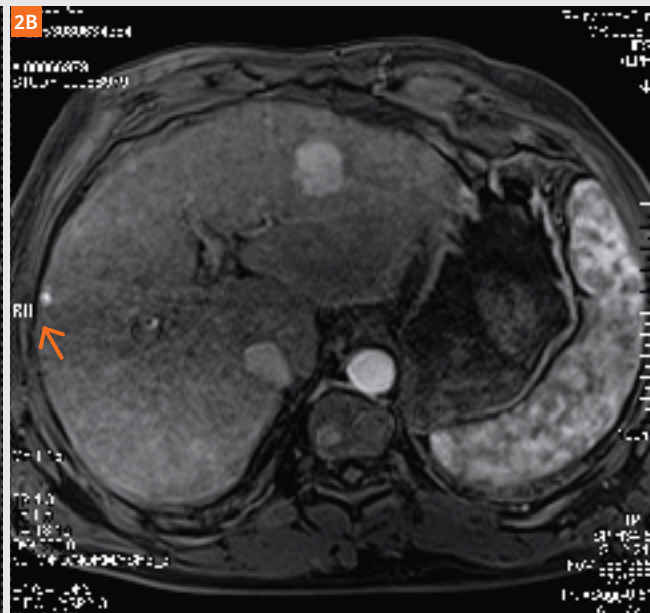


**Case 2**

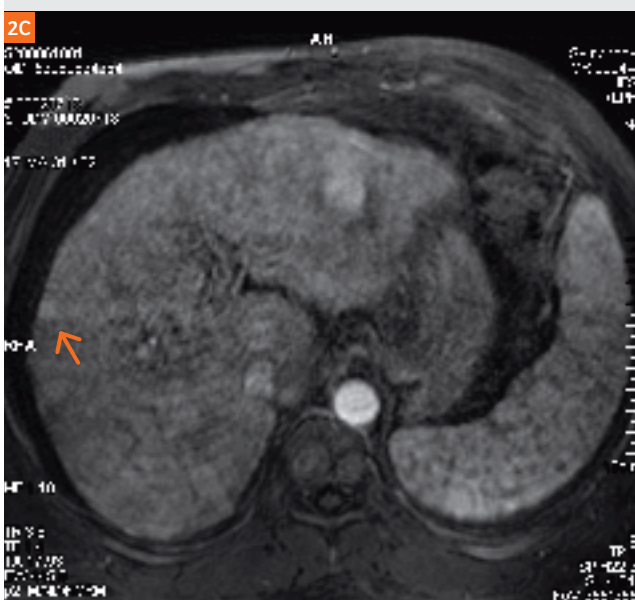
In this cirrhotic liver patient we see a boost in image quality in the follow-up examination on the Tim system. In a slightly shorter breathhold time we have thinner slices (4 mm  $\rightarrow$  2.4 mm) and a nice delineation of e.g. the right adrenal. The shorter breathhold allows the patient to cooperate more. Now we can easily identify 2 HCC lesions on the VIBE arterial phase acquired on the Tim system (upper row of images). In the previous examination, we cannot see the large one as well and, in retrospect, may only suspect the small one.



MAGNETOM Symphony, A Tim System



MAGNETOM Symphony, A Tim System



MAGNETOM Symphony

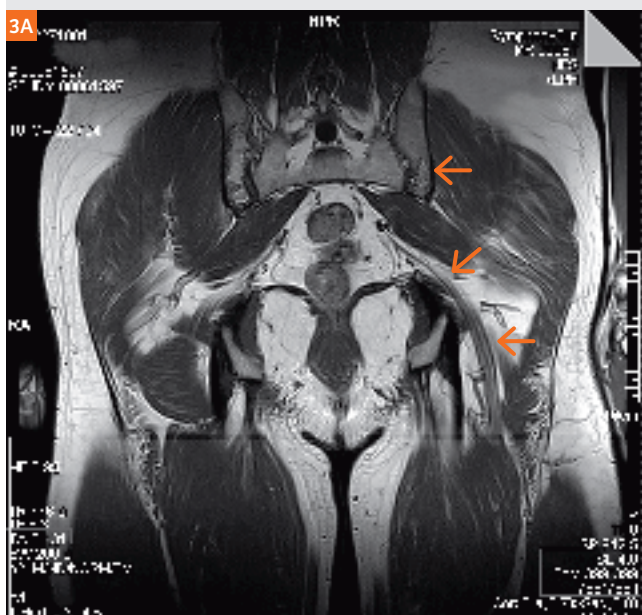


MAGNETOM Symphony

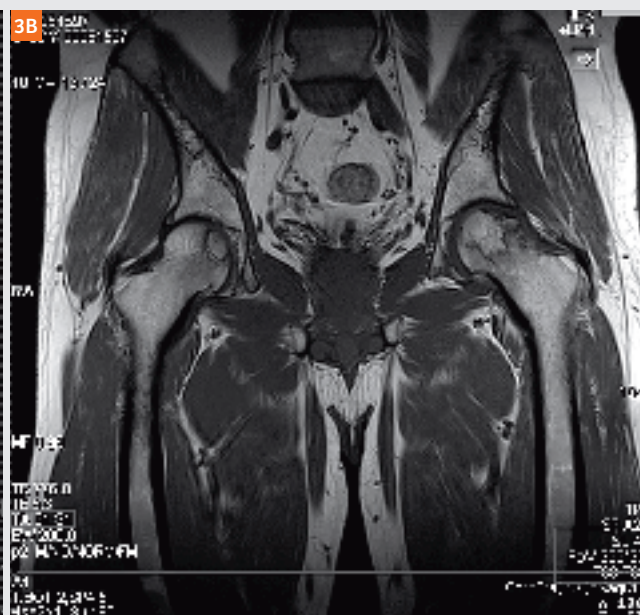
Tim Upgrade is not commercially available anymore.

**Case 3**

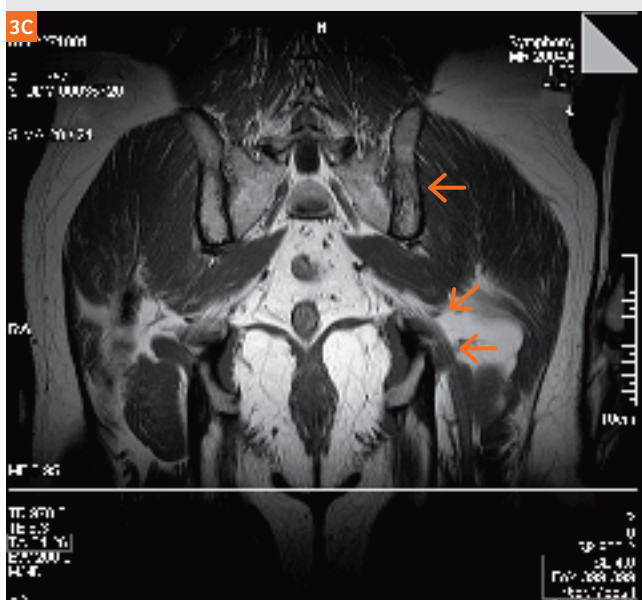
The signal gain can be used to significantly (3-fold) speed up acquisition and still enhance image quality. This case is a follow-up examination for avascular necrosis as a complication of chemotherapy treatment (lymphoma). The AVN and the sciatic nerve are better delineated. There is signal in the lower part of the image. And the scan time dropped dramatically from 4.26 → 1.30 min for the same resolution at better signal-to-noise ratio (SNR)!



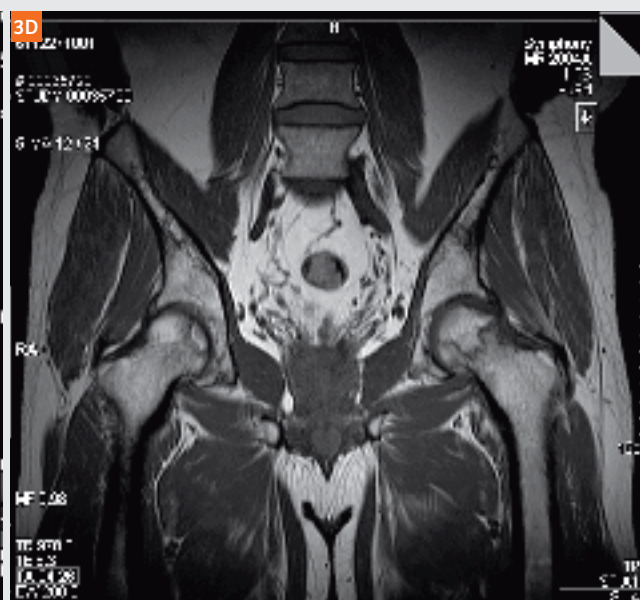
MAGNETOM Symphony, A Tim System



MAGNETOM Symphony, A Tim System



MAGNETOM Symphony



MAGNETOM Symphony

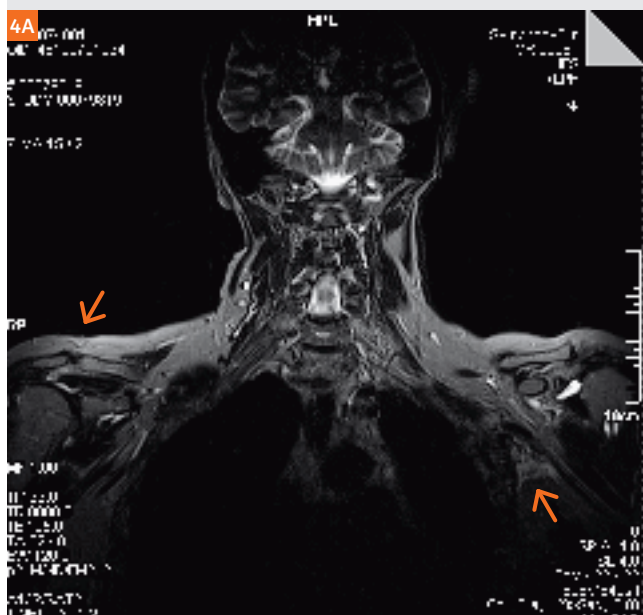
Tim Upgrade is not commercially available anymore.



**Case 4**

A follow-up study of plexus invasion demonstrates the seamless integration of Matrix coils on the MAGNETOM Symphony, A Tim System. Combining posterior elements of the Head Matrix, the upper row of the Spine Matrix and the Neck Matrix coils results in better image quality compared to the MAGNETOM Symphony images. Recurrent breast cancer invades the left brachial plexus. The same scan settings using a combination of the CP Spine Array

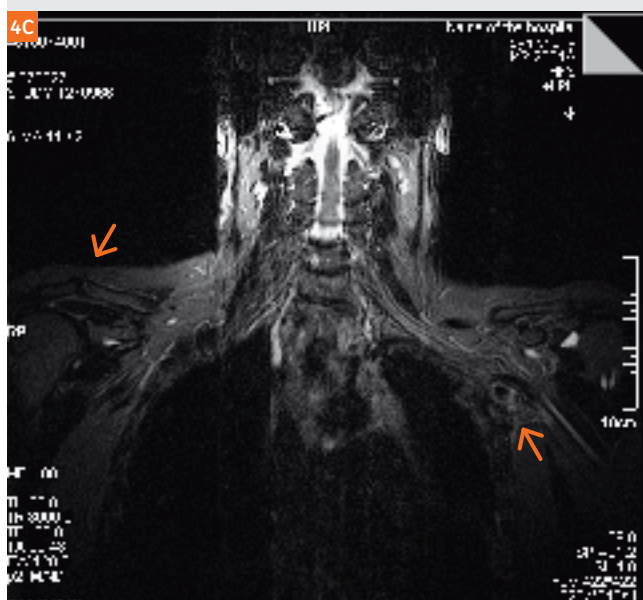
and CP Neck Array coils on the MAGNETOM Symphony, and the Head Matrix, Spine Matrix and Neck Matrix coils in the follow-up exam on the MAGNETOM Symphony, A Tim System. Overall there is better SNR and a more homogeneous image. Pay particular attention to the edges of the image: e.g. note much better depiction of AC joints and brain.



MAGNETOM Symphony, A Tim System



MAGNETOM Symphony, A Tim System



MAGNETOM Symphony

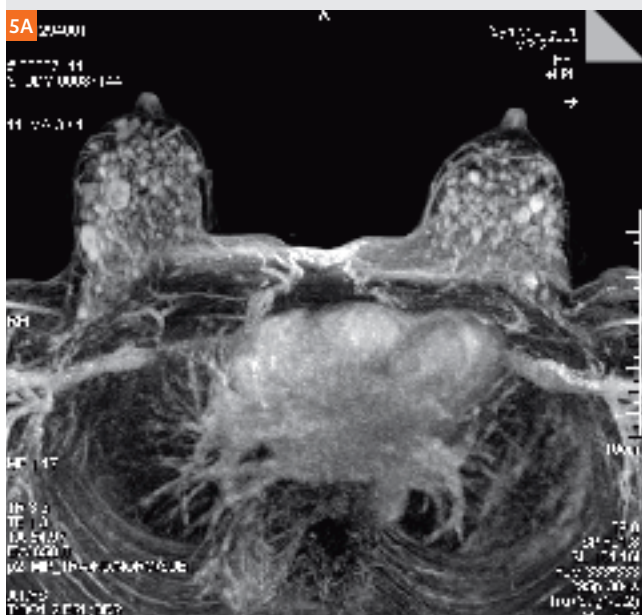


MAGNETOM Symphony

Tim Upgrade is not commercially available anymore.

**Case 5**

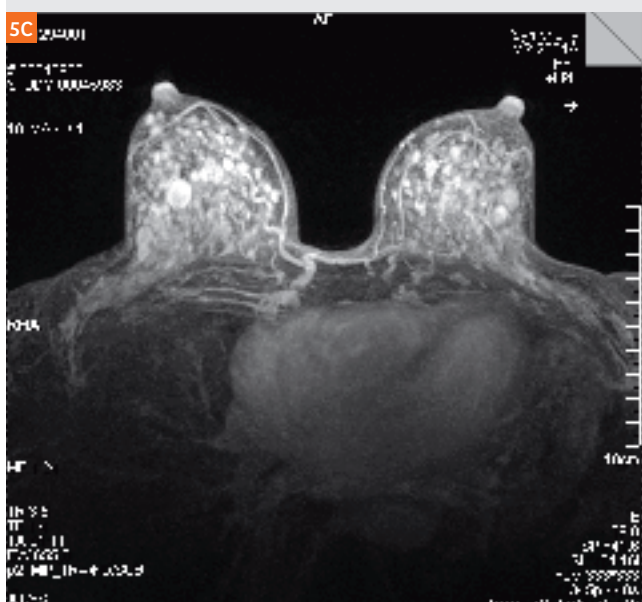
Of course it is also possible to set-up alternative and inventive coil combinations. For example, combining the Body Matrix coil with the Breast Matrix coil opens up the axillae. Shown here is a follow-up examination in a patient with multiple benign lesions: The field of view (FoV) has almost doubled and overall homogeneity has improved. There is a better depiction of the focal lesions.



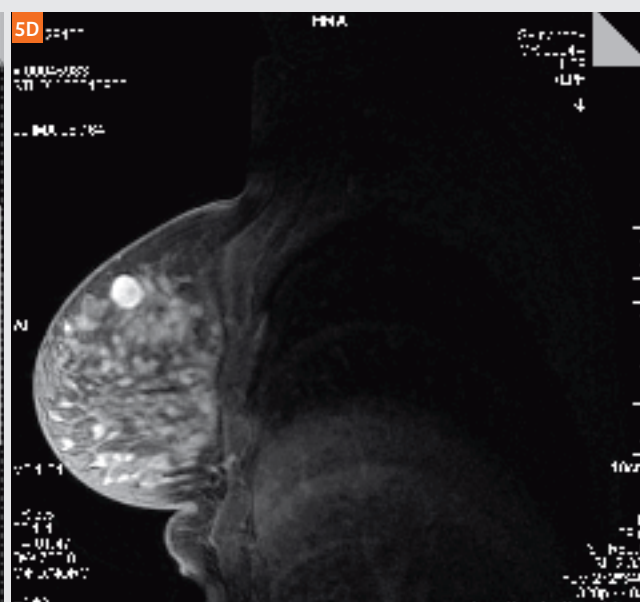
MAGNETOM Symphony, A Tim System



MAGNETOM Symphony, A Tim System



MAGNETOM Symphony



MAGNETOM Symphony

Tim Upgrade is not commercially available anymore.



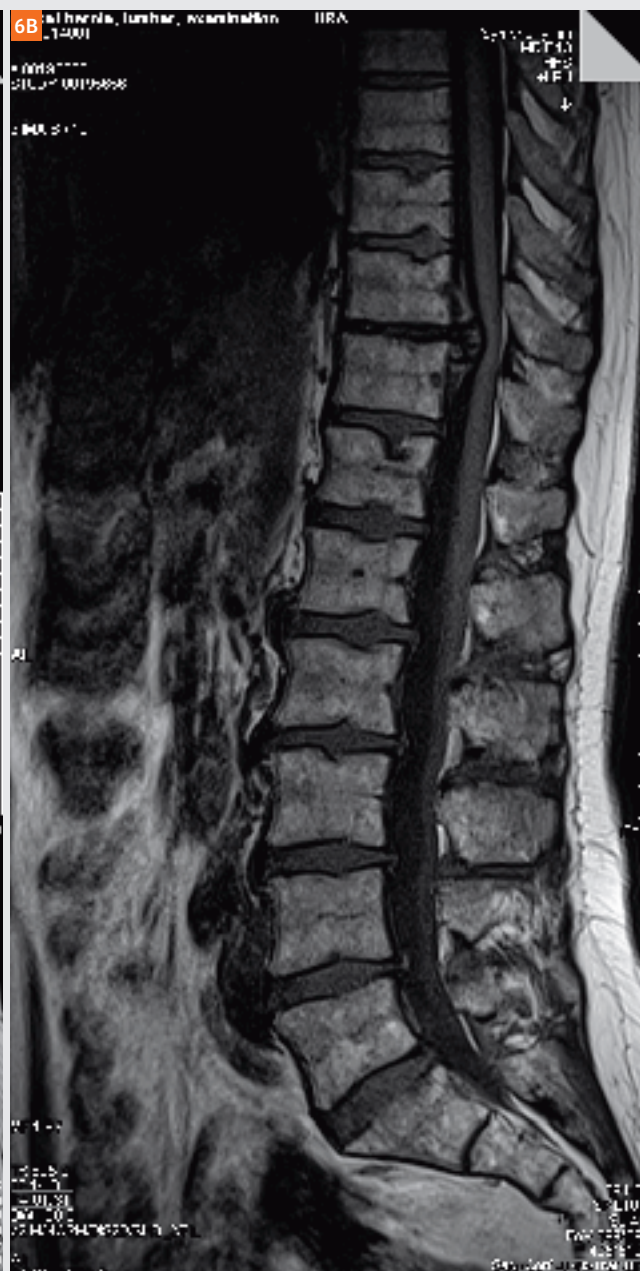
## Higher speed and larger FOV with MAGNETOM Symphony, A Tim System

### Case 6

The more conventional and frequent combination of the Body Matrix coil and the spine coil is shown here in an examination of the thoracic and abdominal region, e.g. dorsal and lumbar spine, where a large FoV is important. This patient was actually sent to us for an examination of the lumbar spine with clinically obvious S1 pathology. The dorsal hernia was rather unexpected. Note the fast scan time of the T2-weighted scan (1:36 s) with high resolution (512 matrix) and a PAT factor of 3.



MAGNETOM Symphony, A Tim System



MAGNETOM Symphony, A Tim System

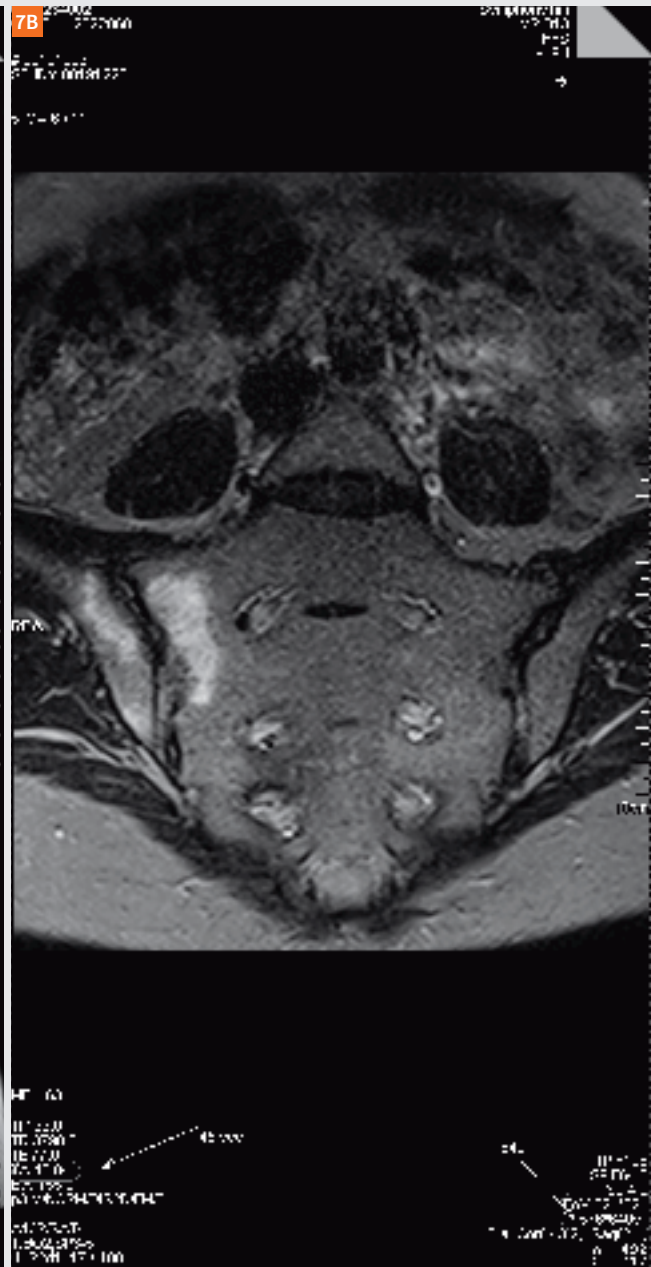
Tim Upgrade is not commercially available anymore.

**Case 7**

Combining the coils enables iPAT resulting in excellent image quality and fast acquisition times. For example if you want to do an additional coronal series of the sacroiliac joints, it takes only 46 seconds for high resolution thin slices! This middle-aged female repeatedly complained of right-sided lower back pain. MRI of the lumbar spine was uneventful. One coronal series of the sacro-iliac joints and 46 seconds later we have the diagnosis. These are 46 seconds that will change her life!



MAGNETOM Symphony, A Tim System



MAGNETOM Symphony, A Tim System

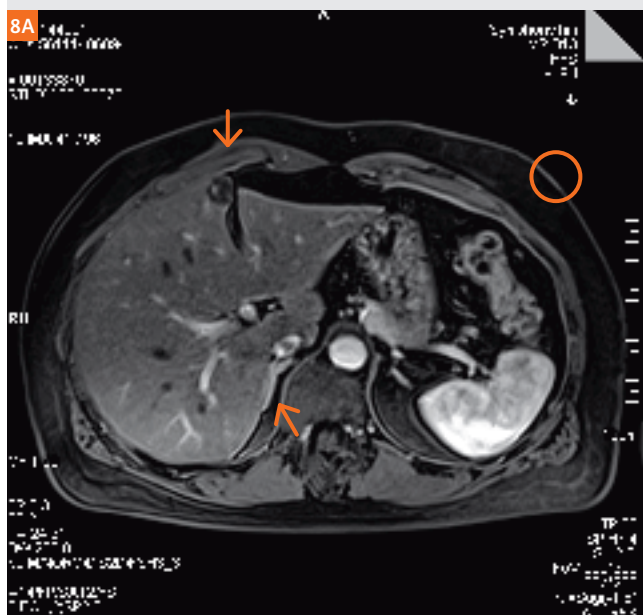
Tim Upgrade is not commercially available anymore.



**Case 8**

The same holds true for this patient in a follow-up for a benign liver lesion: Axial VIBE and coronal HASTE. Better Fat Saturation results in pencil lined delineation of e.g. the skin, the adrenal gland and the focal fatty liver in segment IV. We used the same in-plane resolution, but reduced slice thickness from 3.3 → 2 mm.

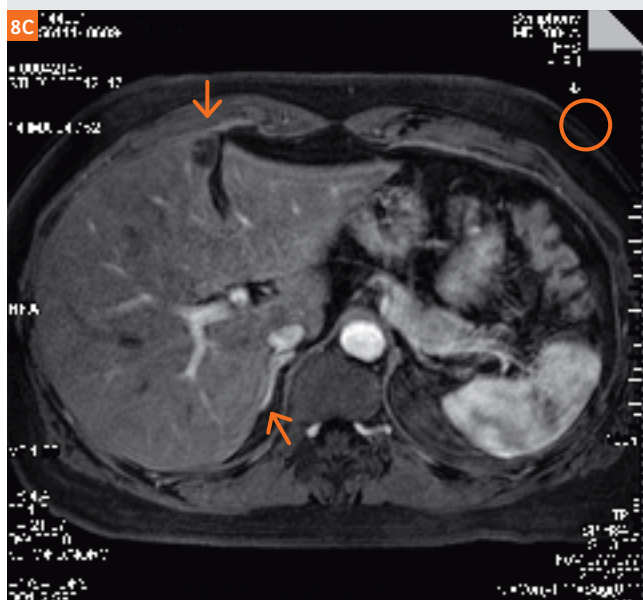
Also note excellent homogeneous Fat Sat and sharp delineation of e.g. skin or adrenal gland. Reducing the echo train length (iPAT) reduces the blur in the HASTE images. And slice thickness went down from 7mm → 5 mm.



MAGNETOM Symphony, A Tim System



MAGNETOM Symphony, A Tim System



MAGNETOM Symphony



MAGNETOM Symphony

Tim Upgrade is not commercially available anymore.



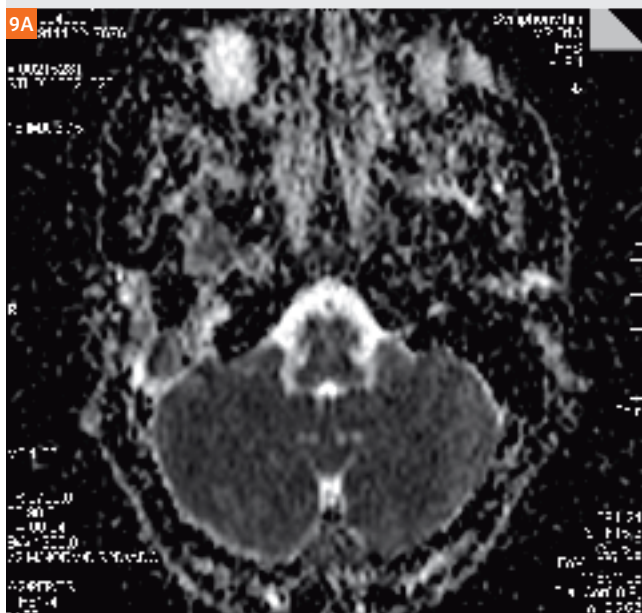
## New applications show the power of the new MAGNETOM system

Routine applications improved with our Tim upgrade, and many new ones became possible.

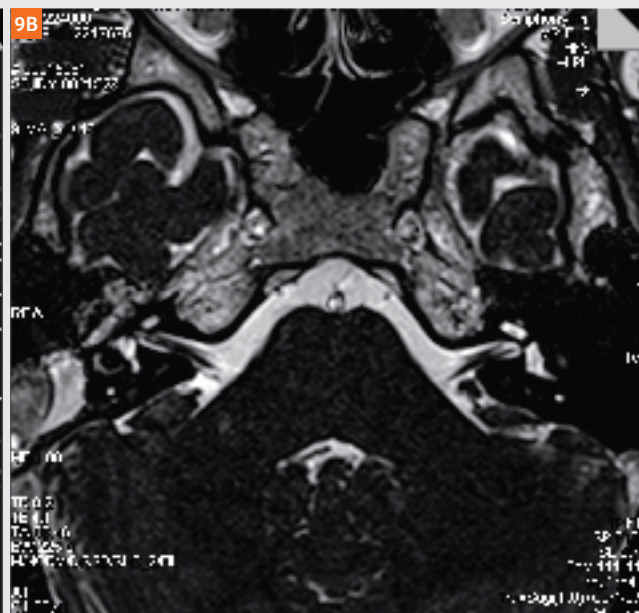
### Diffusion-Weighted Imaging (DWI)

DWI proves to be a decisive tool for detection of (recurrent) cholesteatoma with the Single Shot SE DWI revealing the diffusion restriction in a cholesteatoma in contrast to the surrounding

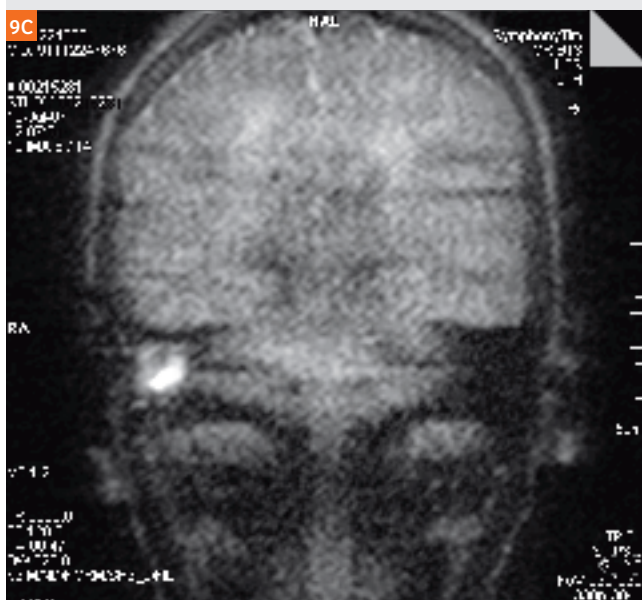
inflammation-fibrosis as depicted in this young girl. SE DWI allows a reduction in slice thickness down to 2.5 mm as compared to the 5 mm slice thickness of the EPI DWI. Moreover, SE DWI effectively removes all the susceptibility artifacts that obscure the EPI DWI images in the temporal bone.



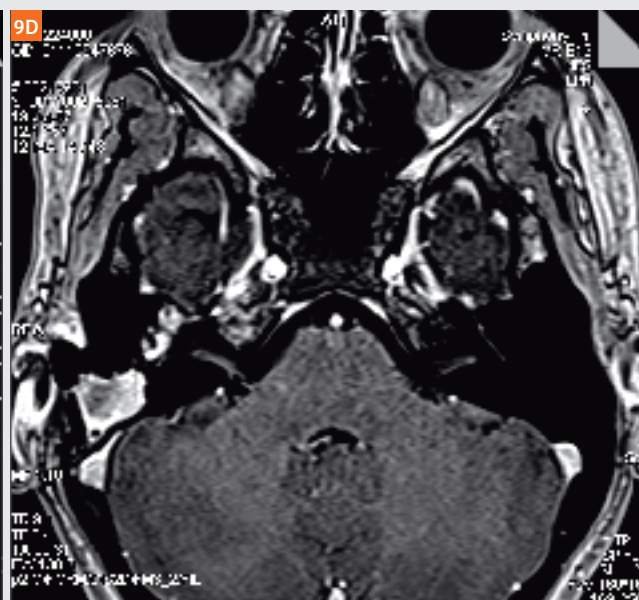
MAGNETOM Symphony, A Tim System



MAGNETOM Symphony, A Tim System



MAGNETOM Symphony, A Tim System

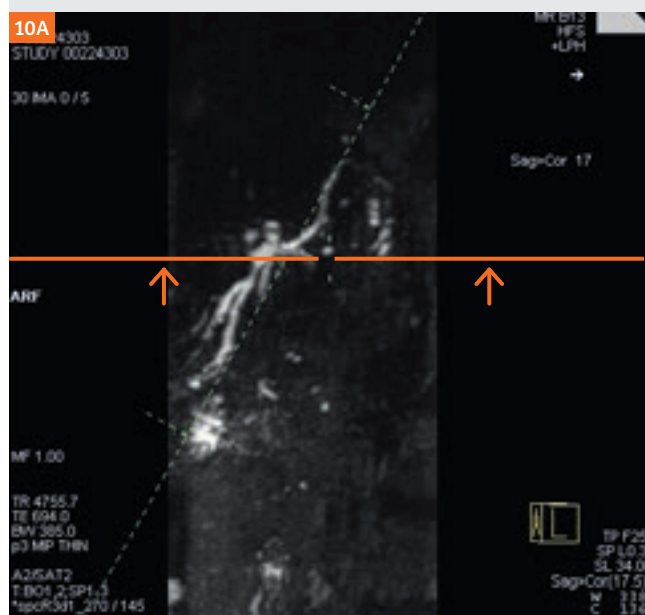


MAGNETOM Symphony, A Tim System

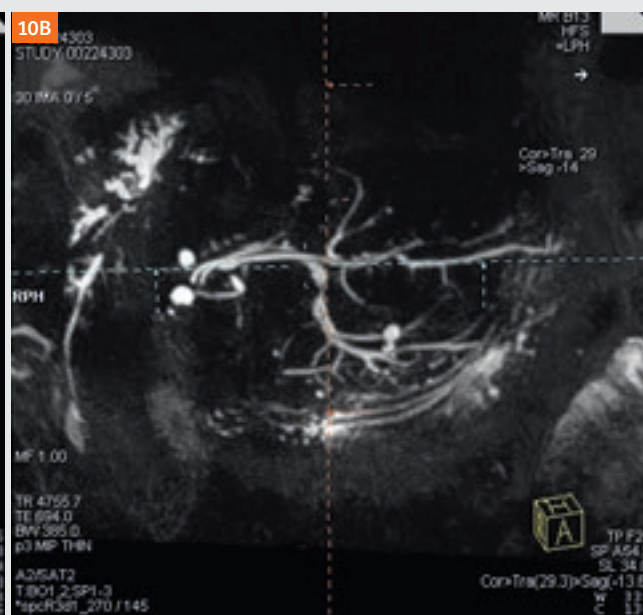
Tim Upgrade is not commercially available anymore.

**syngo SPACE**

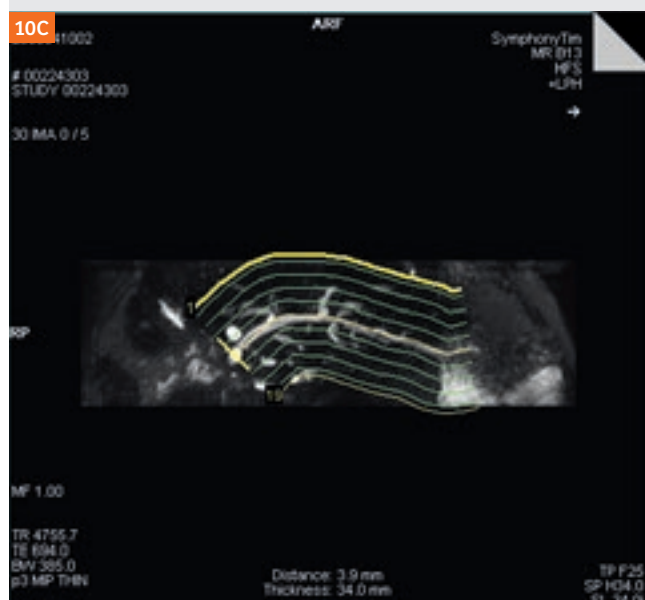
This patient has a tumor relapse after a partial liver resection for cholangiocarcinoma. Single shot MRCP (MR Colangiopancreatography) images are not satisfactory due to superposition of ascites. Triggered 3D SPACE acquisition helps to demonstrate and understand the altered biliary anatomy. Reconstructions on the isotropic dataset eliminate the need for invasive imaging.



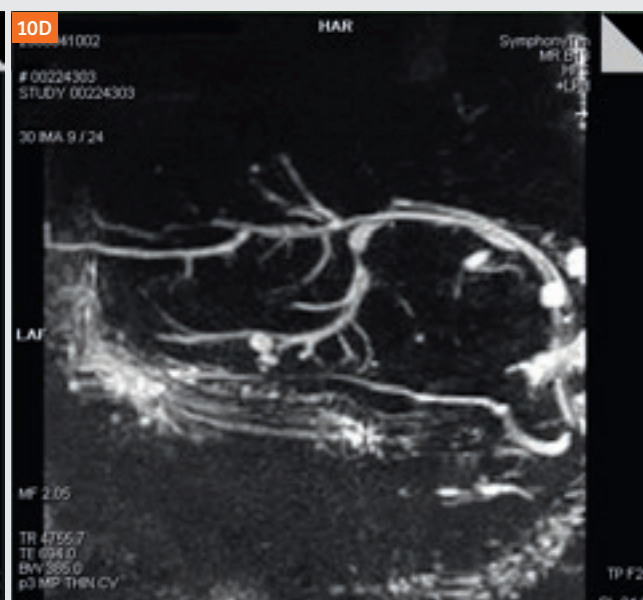
MAGNETOM Symphony, A Tim System



MAGNETOM Symphony, A Tim System



MAGNETOM Symphony, A Tim System



MAGNETOM Symphony, A Tim System

Tim Upgrade is not commercially available anymore.



**syngo Composing**

Separate regions can be composed in a single series of images, e.g. a vascular roadmap for the surgeon or an overview of the total spine for the oncologist.

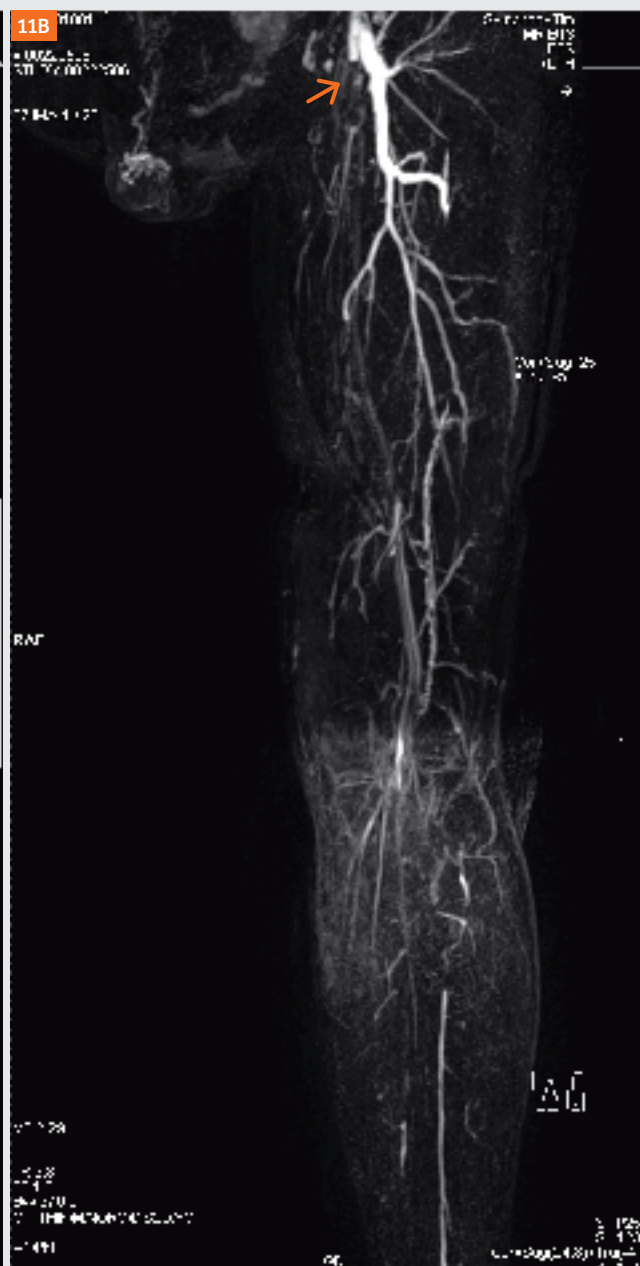
Vascularly-compromised patient with a history of more than 30 years of vascular interventions (but still smoking) presents with cold leg. History of high amputation on the right side, aorto-femoral graft (> 15 years) and femoro-tibial graft (6 months ago). Cold leg

since previous night. Occluded femoro-tibial bypass directly visible on the MiniIP (minimum Intensity Projection) of composed native pre-contrast images.

Occluded left superficial femoral artery on the left side with distal filling in fibular artery is easily depicted on the composed post contrast MIP (Maximum Intensity Projection) image. Occluded proximal anastomosis is also directly visible (stump).



MAGNETOM Symphony, A Tim System



MAGNETOM Symphony, A Tim System

Tim Upgrade is not commercially available anymore.

Diagnosis at a glance – and a surgical roadmap for free



MAGNETOM Symphony, A Tim System



MAGNETOM Symphony, A Tim System

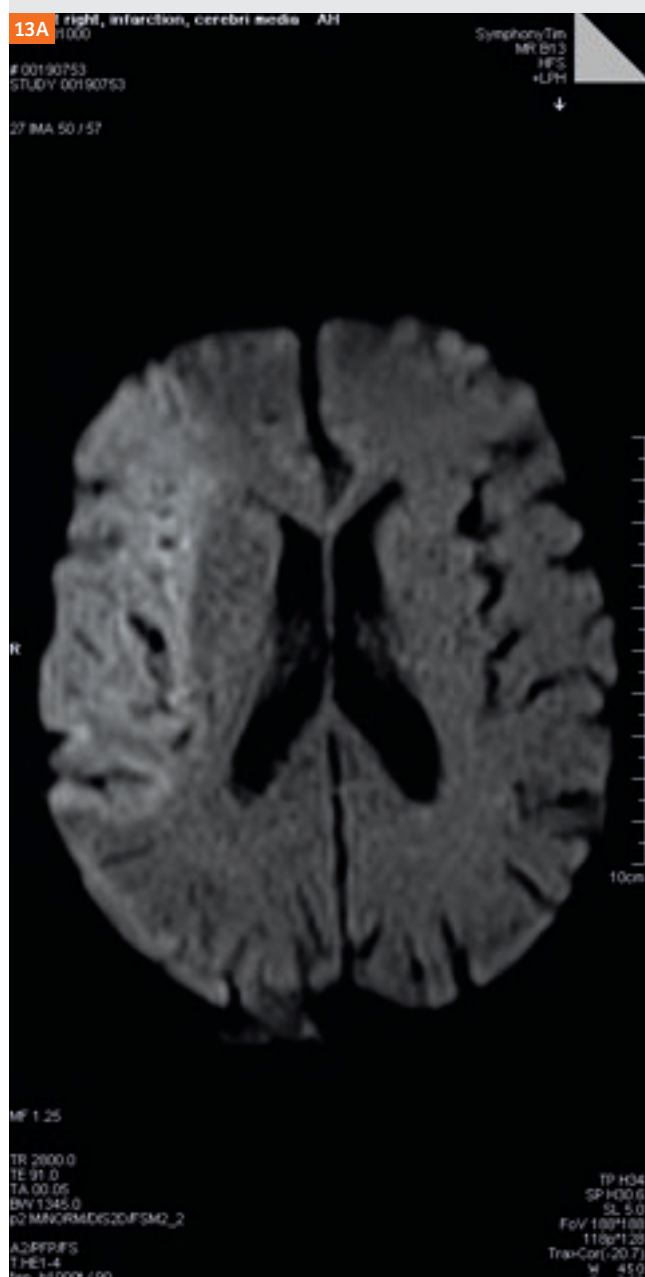
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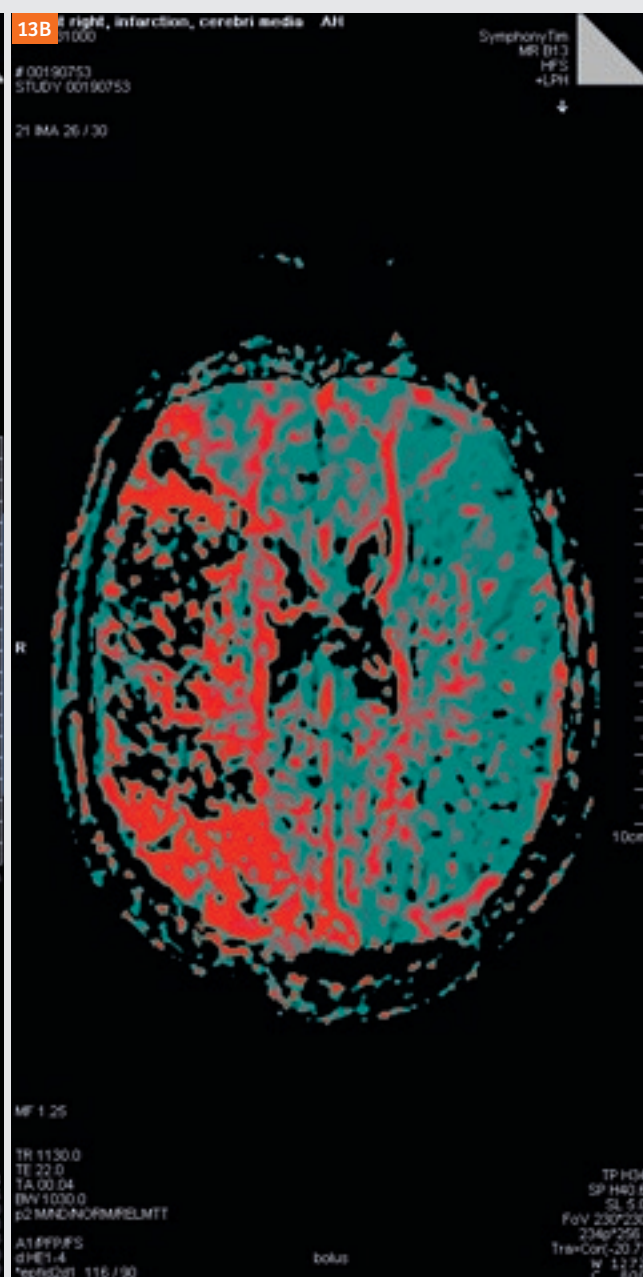
### syngo Perfusion

The Neuro Suite and the *syngo* Perfusion software<sup>1</sup> enables intuitive post processing of perfusion datasets as in this case depicting a perfusion/diffusion mismatch.

<sup>1</sup> Please note that the Neuro Perfusion software is only for tumor evaluation and not for stroke evaluation.



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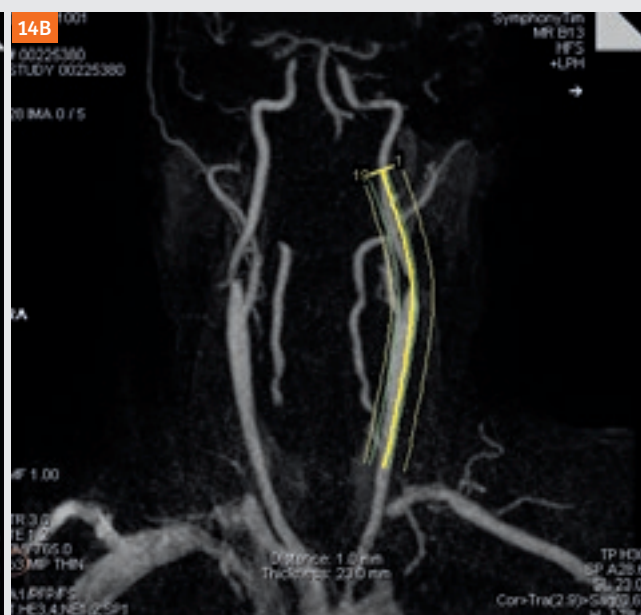


**syngo TWIST**

Increased speed, up to real time, during angiographic acquisition is possible with *syngo* TWIST. This can be used when you need dynamic information, for example in the evaluation of collateral circulation. Or you can use it to speed up the examination, for example in critical care stroke patients. For carotid arteries we scan 4 sub-millimeter datasets in 50 seconds. The resulting images have a good resolution and signal as demonstrated in this patient with a critical high grade stenosis on the left internal carotid and a high grade stenosis on the right internal carotid. The patient is less than 5 minutes on table including localisers and planning!



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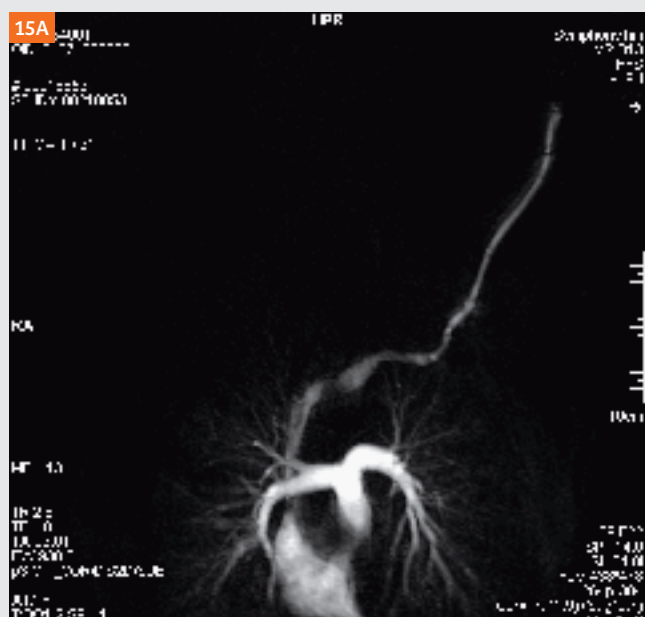
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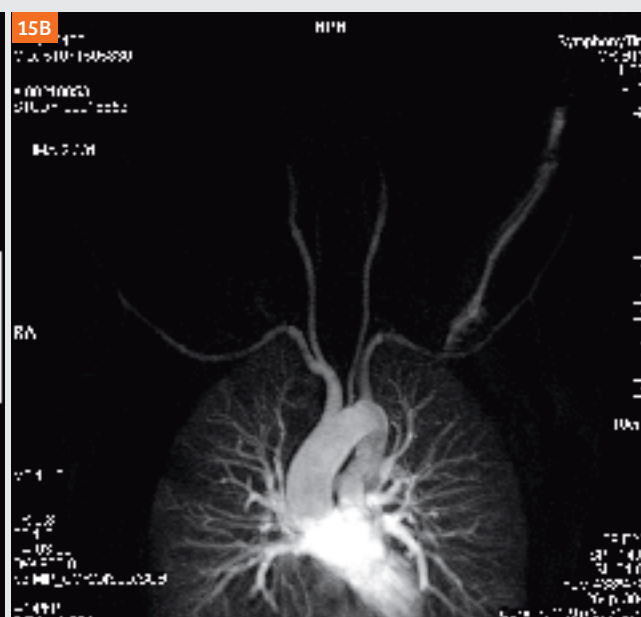
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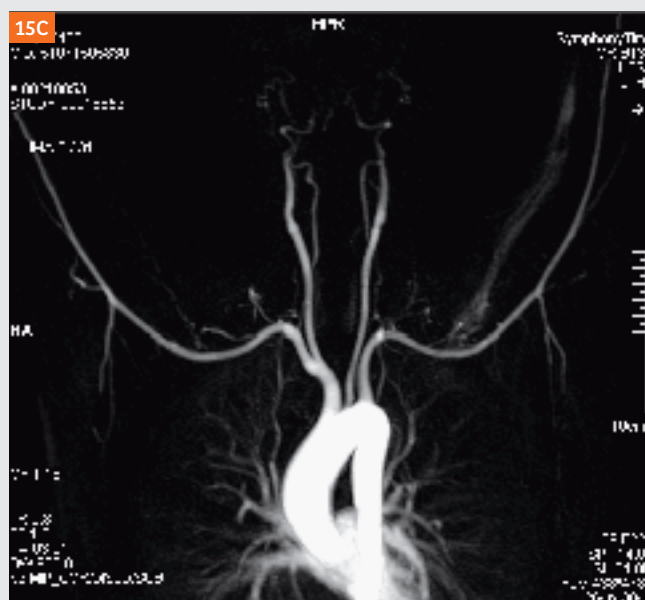
TWIST is also convenient for providing functional anatomy as in this patient, examined for thoracic outlet syndrome in the supine position while performing Addson manoeuvre. In high-resolution (1.1 x 1.3 mm) a slice thickness of 8 mm was achieved. You see the contrast arrival, pulmonary phase and early and late arterial phase at a temporal resolution of 3 seconds!



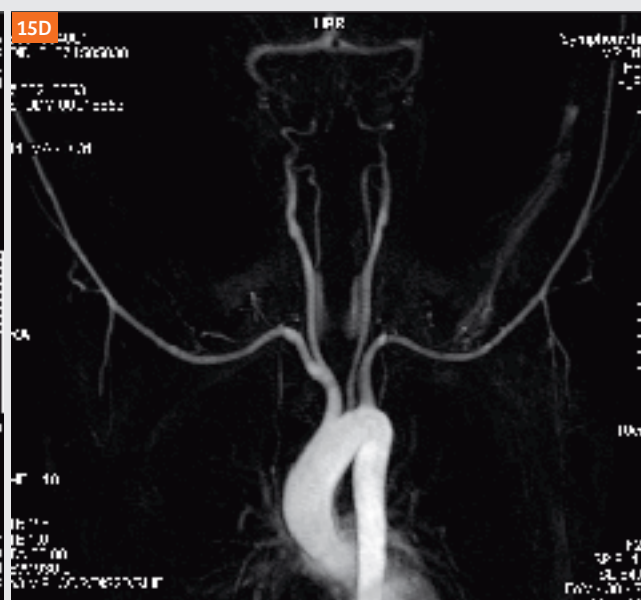
MAGNETOM Symphony, A Tim System



MAGNETOM Symphony, A Tim System



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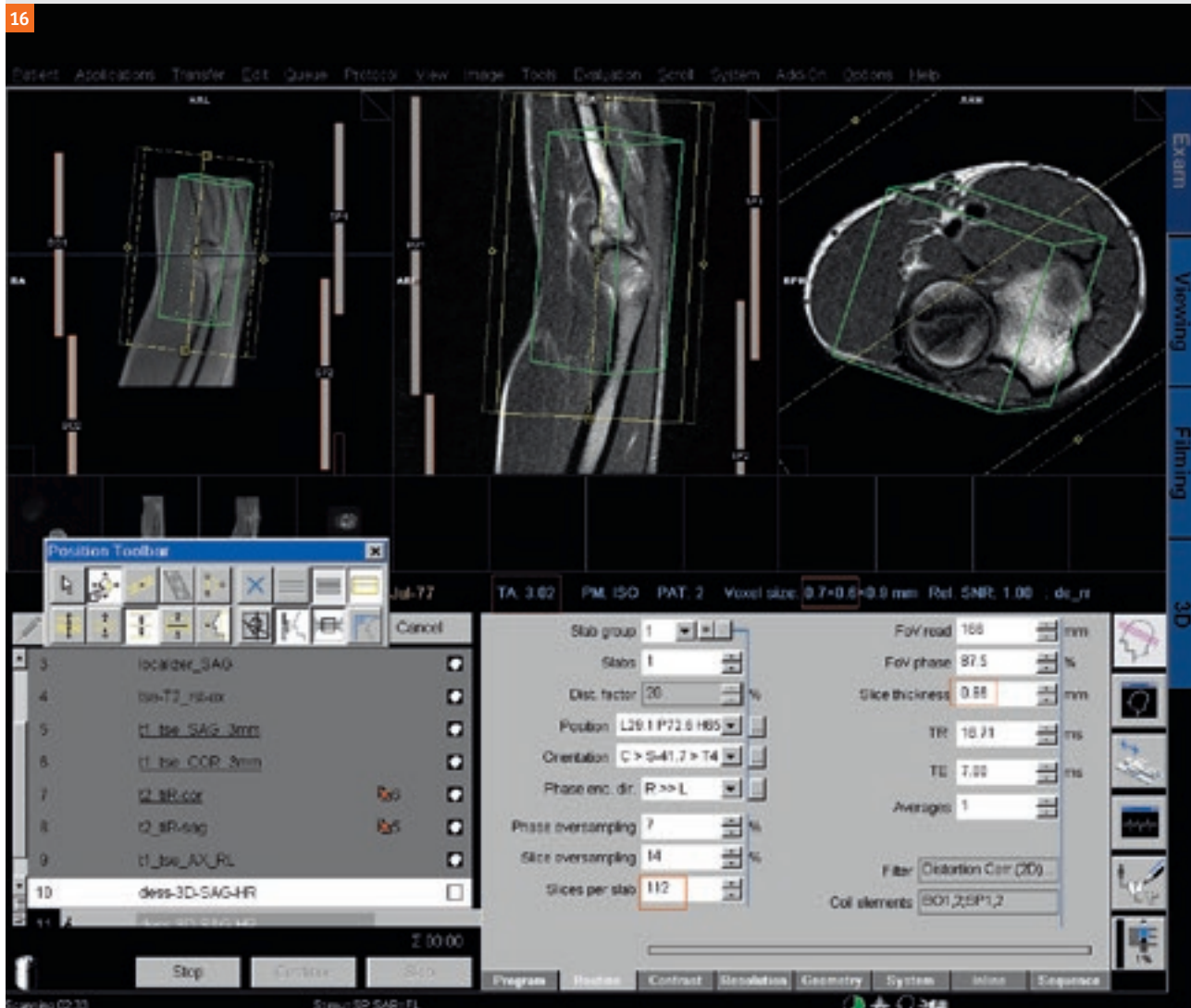
MAGNETOM Symphony, A Tim System

Tim Upgrade is not commercially available anymore.

syngo MR B13 brings improved planning software Iso-positioning and automatic coil selection: The operator simply selects the region of interest and the AutoCoil Select feature guarantees the activation of the appropriate coils. The table automatically moves the center of the region of interest (ROI) to the center of the magnet, thus ensuring the best magnetic field homogeneity.

This becomes even more important since we routinely use large fields of view. In this example you see how we scan an elbow by combining the Spine Matrix and Body Matrix coils. High resolution and high speed, scanned at the isocenter of the magnet!

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*“Although Tim stands for Total imaging matrix, after experiencing the MAGNETOM Symphony with Tim myself I have decided that Tim stands for Total improvement.”*

Dr. Johan Dehem  
VZW Jan Yperman, Belgium

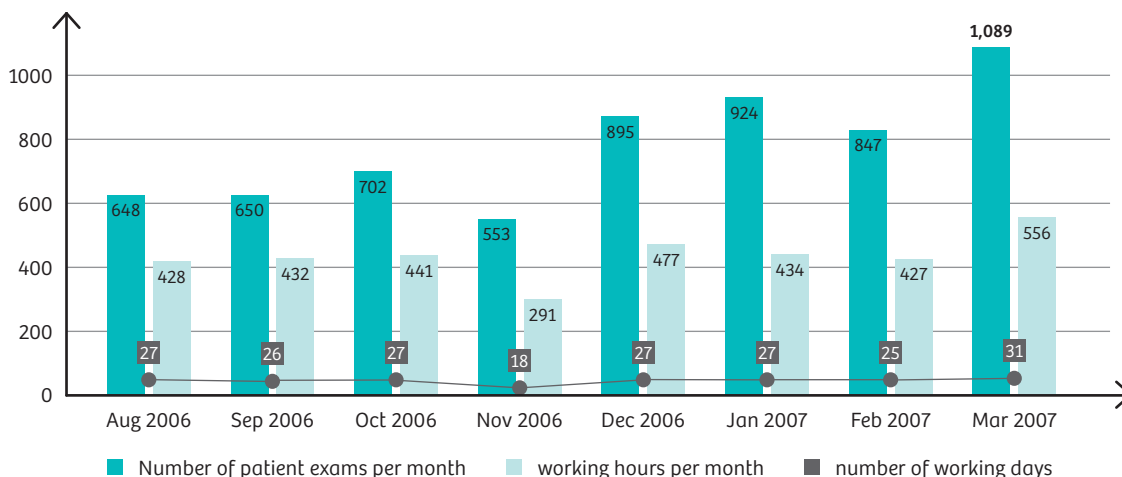
Tim Upgrade is not commercially available anymore.

## Tim Productivity Study at X-leme Clinic, Brazil

### More throughput in the same time

Data acquired with Siemens' Utilization Management tool was used to determine the change in productivity after a Tim upgrade. The upgrade was done at X-Leme Clinic in Brazil (Dr. Heraldo Mello Neto) in November 2006, where a MAGNETOM Symphony with Quantum gradient system had been used since 2001 to offer a complete range of MR examinations. With the MAGNETOM

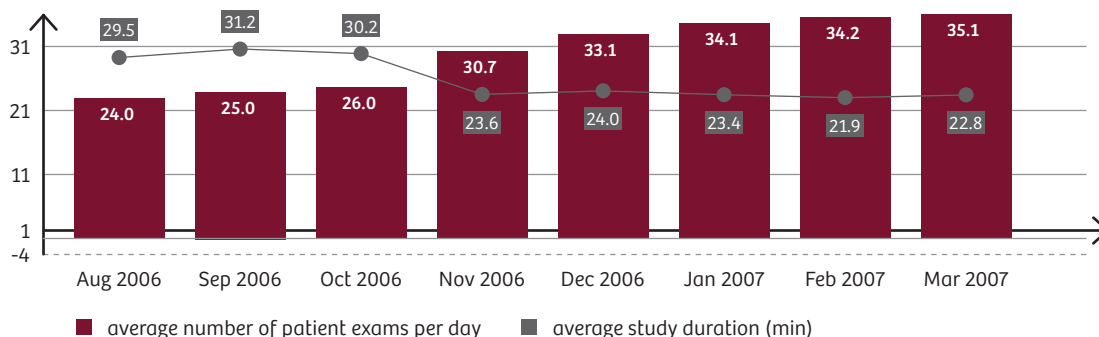
Symphony, A Tim System, productivity increased on average by nearly 40% (comparing the two months prior to the upgrade with the four months following it). Less scan time, more patients, and a fast return on investment. More patients per month in the same number of working hours.



### Faster scan times mean more patients per day

The productivity improvement can also be seen in the figure below. Due to faster scan times, study durations are significantly shorter and the number of patients per day increased in practically the same number of working hours: For example, between September 2006 and January 2007, the average study duration decreased by

nearly 8 minutes (-25%) with the same or even better image quality, thus the average number of patients per day increased significantly (from 25 in September to 34.1 in January 2007). The majority of this improvement was due to faster average scan time per patient.



*"... after the Tim Upgrade we reduced scan times from 30 minutes to 20 minutes ..."*

**Dr. Heraldo Mello Neto**  
X-Leme Clinic, Brazil

The statements by Siemens' customers described herein are based on results that were achieved in the customer's unique setting. Since there is no 'typical' setting and many variables exist there can be no guarantee that other customers will achieve the same results.

Tim Upgrade is not commercially available anymore.



# MAGNETOM Symphony Maestro Class upgraded to MAGNETOM Symphony, A Tim System [76 x 18]

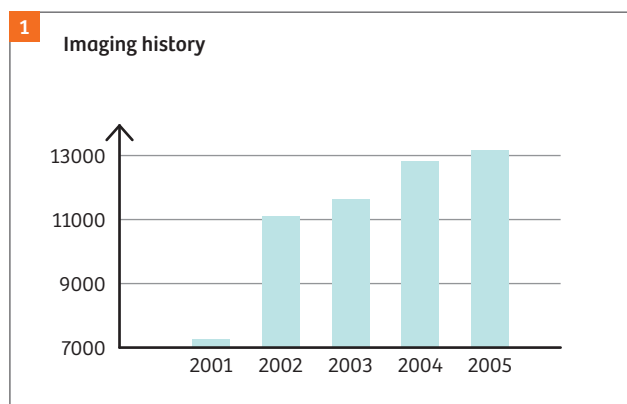
Michael J. Marra RT, Methodist Hospital, San Antonio, Texas, USA  
Contributors: Martin Krebs RT, Fernando Nino RT, and Richard Finch

## The MR story at Methodist Hospital

In 2001 we performed 7,270 MR procedures on an antiquated Siemens MAGNETOM SP 63 and a GE 5X. It was the consensus of the Radiologists and Administration that both systems be replaced with new technology to provide superior MR imaging. The MAGNETOM Symphony and MAGNETOM Sonata systems were chosen due to superior body, vascular, neuro and new cardiac capabilities.

The growth we experienced was unprecedented in our imaging history. In 2002 we performed 11,307 procedures, a 55.5% increase, 51.9% over projected growth. The majority of the growth was seen in body, vascular, neuro and cardiac. In 2003 we performed 11,745 procedures and began functional pre/post surgical planning. In 2004 we performed 12,811 procedures upgrading both MR systems to Maestro Class. In 2005 we performed 13,167 procedures (Fig. 1).

A system utilization report was generated and showed that a 99% and 94% capacity level had been achieved. It was felt that we had reached saturation, and that we could not provide the level of service that was expected by the clinicians and community. Siemens MR technology had advanced, and for Methodist Hospital to continue providing cutting edge imaging, the MAGNETOM Symphony Tim Upgrade was chosen.



Tim Upgrade is not commercially available anymore.

## Why was the MAGNETOM Symphony upgrade chosen?

The MRI department is two floors below ground level. It is very expensive to install or move a large piece of equipment. We did not want a long interruption in services. Therefore we felt that the upgrade would bring us to the next level of imaging without replacing an existing piece of equipment. The Tim platform provided the advanced template that could be upgraded in the future as technology advances.

Additional efficiency is what the MAGNETOM Symphony Tim upgrade added to our daily operations. The ease of moving from one body location to the next without repositioning patients or coils increased our patient throughput. We met our projected goal of 2 additional procedures a day in April 2006. In June 2006 we increased it to 3 procedures a day. We are on track to meet our projected goal of 4 procedures a day by August 2006. The projected 2006 procedure increase due to Tim is 618–738 exams.

## Benefits of the MAGNETOM Symphony Tim upgrade

The new Tim Spine Matrix coil is larger and provides additional coverage, this gives technicians flexibility in positioning patients. The Tim Spine Matrix coil (Fig. 2A) also has 24 coil elements compared to the 6 coil elements on the MAGNETOM Symphony Maestro Class systems. This allows for easier positioning of the patients head or feet first.

The Tim Body Matrix coil is one of the advances the technicians commented about right away. The coil covers a larger area, has greater flexibility, built-in straps and a longer cable for easier positioning (Fig. 2B).

The 12-channel Head Matrix coil can reduce imaging time by 20–30% with minimal decrease in quality. A 10% increase in signal to noise across the board when switching from CP mode to 12 channels with no noticeable shading.



## Coil set up

The coil locations are displayed anatomically on the display monitor, including the anterior coil location; this is not available on Maestro Class systems. This automatic coil selection indicates visually which coils are turned on. This reduces repeated scans by technicians who forgot to turn the anterior coils on. This also allows the technicians to see anterior coil placement and make adjustments if needed (Fig. 3A, 3B).

### Maestro Class vs. Tim

Wireless Gating (Fig. 2C) reduces the patient positioning time on the table. Less set up time equals greater efficiency. Specific electrodes are needed to get proper contact. We found that the package that came with the upgrade worked the best. We purchased both types of electrodes from Siemens accessories.

## Imaging benefits

### Runoffs

Pre-upgrade Runoffs with coil setup and patient positioning were 60 minutes +/- . With MAGNETOM Symphony, A Tim System imaging time dropped to 35 minutes +/- with higher resolution on VIBE (Volume Interpolated Breathhold Examination) sequences and angiographies. We were able to increase the matrix on the VIBEs to 320 and to 384 on the angiographies.

### Body

All Body work, including MRCP (MR cholangiopancreatography), renals and livers have a new HASTE (Half-Fourier Acquisition Single-Shot Turbo Spin Echo) sequence that is much sharper, with no time increase.

### Spine, C, T & L

We were able to decrease our imaging time by 20% on sagittal spine sequences and increase the resolution. We saw no change with axial spine imaging.

### Neck

By utilizing iPAT (integrated Parallel Acquisition Technique) we were able to increase the number of slices by 30% while maintaining the same time.

### Heart

The Dark Blood HASTE sequence provides sharper images.

### MPRAGE

We were able to reduce the time by 50% when using iPAT. We choose to do this on difficult patients.

### Gadolinium-Bolus Carotids, Renals and Aorta

We had increased signal with coronal images while still maintaining the time using iPAT. We increased the aorta resolution from a 256 matrix to 384.



Figure 2A: The Tim Spine Matrix coil is longer.  
Figure 2B: The Tim Body Matrix coil on the left.  
Figure 2C: Electrodes for wireless gating.

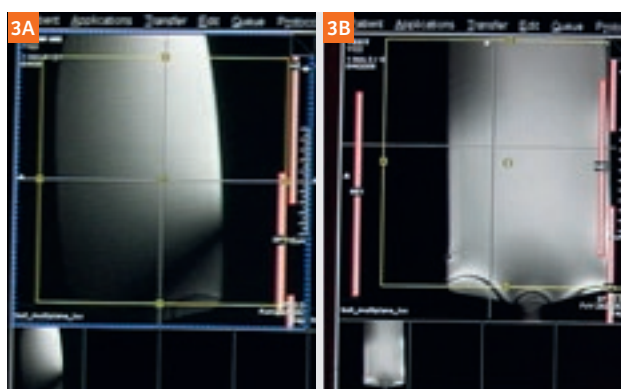


Figure 3A: Maestro Class.  
Figure 3B: Tim (Total imaging matrix).

Tim Upgrade is not commercially available anymore.



Figure 4: Methodist Hospital.



Figure 5: MAGNETOM Symphony, A Tim System in July 2006.

## Radiologists' Comments

### Neuro

Increased S/N utilizing the 12-channel Head Matrix coil in the 12-channel mode versus the CPU mode.

Image quality or MR Angiography (MRA) have increased with the 12-channel Head Matrix coil and the 8-channel Neck Matrix coil.

### Body & Cardiac

MRCs are much sharper, greater coverage with the Tim Body Matrix coil.

Cardiac quality of the images on the MAGNETOM Symphony, A Tim System is equal to the 8-channel MAGNETOM Sonata Maestro Class scanner.

## Upgrade time frame & Applications

The upgrade started on November 28<sup>th</sup> and was available for applications on December 15<sup>th</sup>, i.e. within 17 days.

We were able to continue with only one scanner by reducing some of our outpatient scheduling slots during the week and increasing weekend availability.

Applications training began on Thursday, December 15<sup>th</sup> and ended on Tuesday, December 20<sup>th</sup>.

The time it took for staff, 6 technicians, to feel comfortable and take advantage of the new capabilities consistently was on January 9, i.e. within 19 calendar days.

## MAGNETOM Symphony, A Tim System, July, 2006

To date we are very happy with the decision to upgrade the MAGNETOM Symphony to Tim. We are still able to utilize the MRI Devices coils that we have invested in over the years. The technicians favor the MAGNETOM Symphony, A Tim System over the MAGNETOM Sonata, especially when multiple areas need to be imaged. This upgrade has extended the life of the MAGNETOM Symphony system (Fig. 4, 5).

Purchasing and installing the upgrade prior to the installation of our third scanner in June 2006 allowed for accelerated training on the new 3T MAGNETOM Trio, A Tim System.

## Looking to the future

We would consider a similar upgrade for the MAGNETOM Sonata if Siemens moves in that direction.

# Tim Trio Upgrade benefits

Jeff Zimmers RT, (R, MR) ARRT<sup>1</sup>; Karen Ziadie, RT (R) ARRT<sup>2</sup>

<sup>1</sup> Advanced Education Specialist, Siemens Medical Solutions, Inc., USA

<sup>2</sup> MR Clinical Specialist, Baptist Hospital MRI Department, Baptist Health South Florida, USA

In the recent months there has truly been a revolution for Siemens 3T users. 3T has moved from a “research only” environment to mainstream clinical MR imaging. This is possible due to the improvements and developments with the Siemens unique Tim technology, now available on MAGNETOM Trio, A Tim System and available for existing MAGNETOM Trio systems. Many Siemens customers have already upgraded to the Tim technology and their testimonies offer proof to the benefits of Tim.

Karen Ziadie is an MR Clinical Specialist from Baptist Hospital in South Florida and she offers the following insight:

## Our upgrade experience

“In February 2006, we received the Tim upgrade on our MAGNETOM Trio” Karen states. “We were one of the first Trio systems to receive the Tim upgrade so a team of engineers (some from Germany along with our local service personnel) descended on our site and set to work. We had been informed that the upgrade would take three full weeks. We wondered why an upgrade would take that amount of time, we soon found out why. The engineers literally stripped the system of everything except the magnet. Every component was replaced, including the gradients, the rf transmitter, table, surface coils, even the computer.”

## With Tim capabilities are expanded

The gradients and rf systems bring dramatic changes to the performance available at 3T. The TQ Engine gradients have similar peak and slewrate, however the gradient linearity improves to the best in the industry at 1.7% across 50 cm, and the audio comfort of the Tim system reduces noise by up to 90%.

Previously the body coil limited the field of view to 40 cm, now with a full 50 cm field of view many users are able to scan the same protocols between their 1.5T Siemens scanners and the MAGNETOM Trio, A Tim System.

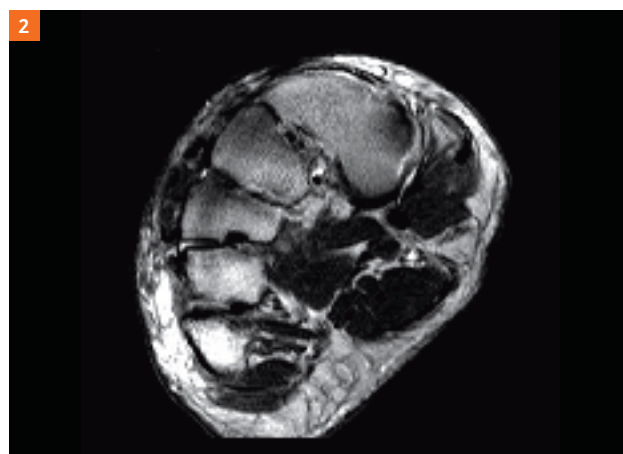
Tim brings Matrix coils, as the MAGNETOM Trio before Tim relied solely on third party coils, and as a result was not able to be integrated to a level that allowed syngo GRAPPA to be implemented outside of the brain and 8-channel body coil.

## New Look

Oh what a difference! Our “new” 3.0T Trio looks awesome! Now it looks like the high tech imaging machine that it is. In addition to the new high tech look, the magnet bore is also much shorter and therefore much more patient friendly.



**Figure 1:**  
T2-weighted Turbo Spin Echo (TSE) using the Body Matrix coil.



**Figure 2:**  
T1-weighted Spin Echo using the Body Matrix coil.

Tim Upgrade is not commercially available anymore.



## Coils

With the Tim Matrix coils we can quickly and efficiently do multiple studies without taking the patient off the table and without changing the coil configuration. Many of our patients have orders for brain, cervical, thoracic and lumbar spines, and sometimes hips. With the Matrix coils we can do all five studies without moving the patient and changing the coils. In addition, we can now use iPAT (integrated Parallel Acquisition Technique) with every coil.

The coils are also flexible. These high resolution foot images were acquired using the Body Matrix coil. Imaging times are very short and iPAT is used exclusively.

## The images

We immediately noticed how much nicer the images looked. The images now have more signal to noise than before Tim. We are able to take advantage of this increased signal by utilizing iPAT, thinner slices, and higher resolution factors.

We now routinely use 2 mm and 3 mm slice thicknesses for our brain and orthopedic studies. Many abdomen studies now employ a 3 mm or 4 mm slice thickness. This knee scan was acquired using DESS (Dual Echo Steady State) and an isotropic voxel size of 0.6 mm. iPAT and high signal to noise allowed this scan to be acquired in just over four minutes. High resolution allows multiplanar reconstruction with no loss of resolution.

## Special Absorption Rate (SAR)

One of the big challenges with 3.0T imaging was SAR. Almost every protocol required the technologist to adjust the parameters as not to exceed the SAR limitations.

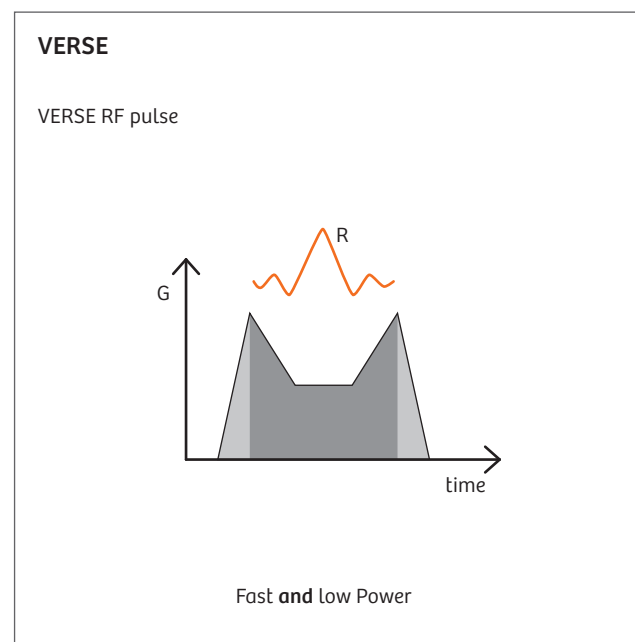
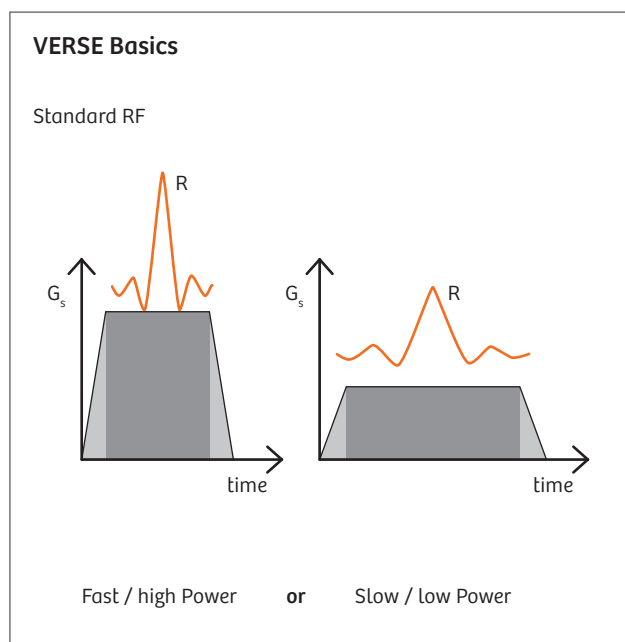
The Tim upgrade has reduced the challenge of SAR at 3T. We are able to achieve lower TR values without exceeding the SAR limitations, resulting in reduced scan times and protocols that run smoothly without technologist adjustments required. With the new operating system also comes an increase to the number of SAR reduction methods. In addition to Hyper Echo, GRAPPA, and SPACE there are now low SAR pulses for ceMRA, VERSE is available, which through a different gradient pulse shape dramatically lowers rf power.

## T1 contrast

The upgrade has provided greatly improved T1 contrast abilities. As a result of reduced SAR we are able to utilize TSE-T1 pulse sequences for spine imaging and we consistently obtain good T1 contrast in the spine.

The Spine Matrix coil provides a major improvement in signal to noise and iPAT imaging. The previous coil did not offer iPAT capabilities.

T1 DarkFluid imaging as well as VIBE sequences (Volume Interpolated Breathhold Examination) demonstrate excellent T1 contrast and very high signal to noise. High resolution spine imaging has now become reliable and very fast for clinical imaging.



Tim Upgrade is not commercially available anymore.

## Abdomen examinations

„Abdominal studies have been difficult on the 3.0T. We were very pleasantly surprised by the quality of the abdominal images after the upgrade, they were excellent. Breathholds are shorter and we are now able to take

advantage of the extra signal 3T provides by using higher resolution factors. Additionally, the T1 contrast improved, and we have seen dielectric shading substantially reduced.

Our radiologists liked the images so much we now routinely do abdomen studies on our 3.0T. In fact, there are some body studies that our radiologists definitely prefer to be done on the 3.0T such as adrenal, urography and prostate studies.” says Karen Ziadie.

„Sequence development and Tim have improved signal to noise, and reduced artifacts since the upgrade was completed.”

This upgrade is, all in all, the best upgrade that we have ever received. Image quality, scan times and throughput on the MAGNETOM Trio, A Tim System are greatly improved and we routinely obtain spectacular images. The 3.0T is now a fully functional clinical system.”

Karen and I had a great experience with the Tim Trio upgrade. Many other sites have as well. Similar results have been experienced on the Symphony Tim upgrades, too. The very reliable MAGNETOM Symphony is now a cutting edge system with the Tim upgrade.



Figure 3: T1 3D VIBE .3 x .3 x 1 mm resolution.

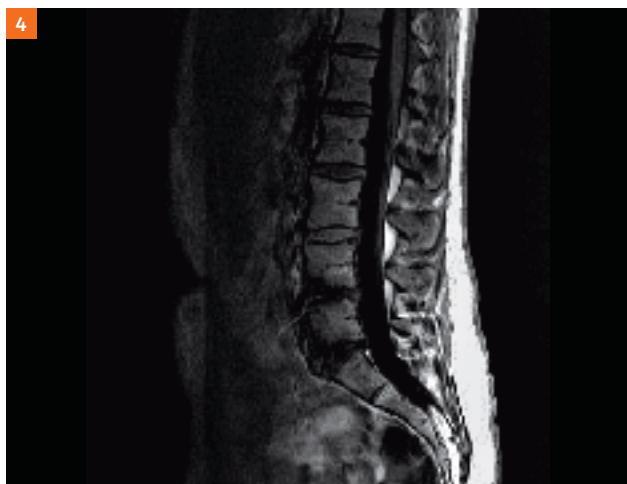


Figure 4: T1 TIRM DarkFluid.



Figure 5: T2 TSE RESTORE with PACE (Prospective Acquisition CorrEction).

# MAGNETOM Symphony Maestro Class upgraded to MAGNETOM Symphony, A Tim System [76 x 18]

David Forrest

Siemens Healthineers, Macquarie Park, NSW, Australia

In May 2006, Westmead private Hospital became the first radiology facility in Australia to undertake a MAGNETOM Symphony Tim Upgrade. We asked Dr. David Ho, lead radiologist, Mrs. Francis Gray, lead MR technologist, and Ms. Kumaransi Silva, MR technologist, to comment on the difference this technology has made.

## Ergonomics

The technologists are very excited about the coil concept provided with Tim. The ability to have multiple coil elements plugged in at once and to be able to use various flexible combinations of these coils simultaneously has had a major impact on both workflow and patient comfort. No longer is it necessary to re-enter the scan room and reposition the patient or coils when scanning multiple body regions. The coil set up is easy and quickly adaptable for patients with various different body habitus. The patients love the light weight nature of the matrix coils and the unique modular nature means that anatomical and pathological coverage is no longer limited by individual coil design. The "Intelligent Coil Control" provides a quick and easy way to visualize the "active coil elements" on the monitor, thereby helping to optimize image quality and saving sequence planning time. As the practice gets busy these factors become more important and assist in reducing the pressure on staff.

## Image quality

Having used a MAGNETOM Avanto previously, Dr. Ho has been very impressed with the image quality on his MAGNETOM Symphony, A Tim System. He has found the fat suppression to be very uniform, even in hard to fat suppress areas such as the neck. The referrers have also been impressed by the carotid angiographies, the higher

resolution now possible with the Tim Matrix coils playing a major part in this.

The Tim open architecture has created the opportunity to use a wide range of third party coils: e.g. specific musculoskeletal coils, resulting in beautiful orthopedic images.

Signal to noise has noticeably increased with the Tim Matrix coils, with examinations such as the head and angiographies being noticeably better. Larger matrixes and more slices are now able to be used without extending the examination time, by using iPAT (Integrated Parallel Acquisition Technique).

The Body Matrix coils give greater clarity and coverage. If we see something peripherally it is easier to zoom in and examine the pathology in more detail.



(Right to left) Ms. Kumaransi Silva, Dr. David Ho, Angela Tedesco, Key account manager, David Forrest, MR Business Manager.

Tim Upgrade is not commercially available anymore.



## Referring physicians and patients

As a private provider this site is in competition with other practices. The referring doctors may not understand technology, but they want their patients to have the best leading edge technology.

Of course our competitors used the fact that we had a 5-year-old MR system against us. With the Tim Upgrade, referring doctors now know that we do have leading edge technology. Not only have they noticed an improvement in image quality, but have fallen in love with other aspects of the new technology, such as the composed spine images, which provide an additional visualization tool to standard image assessment. The surgeons also love these composite image representations, and use them in conjunction with the individual source images.

Trigeminal studies are also improved; 3D volumes have better flow compensation. The referrers know that for their patients there is greater comfort and faster examinations thanks to the better workflow attributable to Tim. Not having to change coils greatly affects patient comfort and some referrers have told us, that they were waiting until we had the Tim Upgrade before they would refer some cases.

We have found the Tim technology to be very useful in other ways, for example when there is a lesion at the Cervico-thoracic junction, I do not have to ask for the patient to be repositioned, I can just zoom in to get the detail. It is also a fact that the speed of the examination as a whole makes patient movement less likely and consequently we see less movement in the images.

## Financial outcomes and productivity

After the Tim Upgrade, we have seen a 30% increase in the number of examinations performed compared to before. It should also be noted that the upgrade has reduced waiting times. The financial impact is easy for us to see, this is due to an increase in patient volume which also translates to an improvement in cash flow.

## Staff retention and development

There is a significant cost (both financial and clinical) associated with the loss and re-training of professional staff. It has been easy to attract staff and train them with this technology. There are fewer mistakes made and if there are any, they are much easier to recover from. In this environment, high levels of staff retention within radiology is very important.

## Future developments

We believe that we will see other MR applications increasing in our practice now, for example an increase in the use of MR Angiography.

## Conclusion

The initial business case developed in support of the Tim Upgrade for MAGNETOM Symphony has been proved so far, looking at the patient activity and financial results. Over the next year, we plan to introduce new techniques and expand the potential use of this technology. The Tim Upgrade has met and in many cases exceeded our high clinical and financial expectations.



Ms. Kumaransi Silva, with a light weight Tim Body Matrix coil.

Tim Upgrade is not commercially available anymore.

# MAGNETOM Symphony Tim Upgrade: the Mater Misericordiae University Hospital experience

Bolster F; Moynagh M; Dolan A; Cradock A; Murray J G

Dept of Radiology, The Mater Misericordiae University Hospital, Dublin, Ireland

The Mater Misericordiae University Hospital (MMUH) is a public, acute voluntary teaching hospital and a tertiary referral center which was established in 1861. Located in Dublin's north inner city it provides a 24 hour on call service to the local and county area and contains approximately 600 beds. The MMUH not only treats patients from its local catchment area but due to its regional and national status, sees patients from all over Ireland. The MMUH houses the national center for cardiothoracic surgery, the national spinal injuries unit and is a designated national cancer centre. The Radiology Department at the MMUH performed 160,000 radiology studies including over 5000 MRIs in 2008.

## Problems

- 1. Old scanner:** The MMUH had a single 1.5T Siemens MAGNETOM Symphony scanner in operation since its installation in October 2000.
- 2. New applications, teaching and research:** As a university teaching hospital and national referral center there was a need to maintain state of the art MR imaging facilities not only for patient care, but also to train radiology and radiography staff as part of national programs, and to facilitate meaningful research programs.



Figure 1: The Mater Misericordiae University Hospital (MMUH) in Dublin, Ireland.

Tim Upgrade is not commercially available anymore.

3. **Demand for services:** In the first full year of operation 3,200 MR scans were performed. This had risen by 38% to 5,208 MR scans in 2008. However the number of requests for MR had been steadily rising by 5–10% per annum since scanner installation. The waiting list for MR had become unacceptably long necessitating outsourcing of low risk MR studies.
4. **Funding:** Any proposal to address the above issues had to be budget neutral. In addition new staff could not be hired due to a government imposed hiring embargo. This precluded purchase of a second scanner.
5. **MR in 'Listed Building':** The MR was located in an architecturally preserved 'listed building'. When the scanner was initially installed in 2000, access was gained through an inner back wall via a central courtyard. Since that time further structural building work had taken place in this courtyard which made this route inaccessible. Thus a full upgrade with removal of the magnet bore would have produced serious logistical and secondary cost issues.
6. **Downtime:** The MMUH has only a single MR scanner. A short installation time was thus important to ensure continuity of service.

### Why the Tim upgrade in the MMUH?

1. **Software applications:** Gave access to the same full range of sequences available as if a new magnet purchased. This addressed the clinical, teaching and research issues.
2. **Productivity:** We estimated that with the new technology we could increase the throughput in our MR department by about 15% or 3 extra scans per day. With the increase in throughput, we believed that the upgrade would be "cost neutral" over a three-year period of time.

3. **Staffing:** No new staff would be required.
4. **Architecturally preserved building:** Because the Tim upgrade involved keeping the original magnet bore, the upgrade did not involve building works.
5. **Short installation time:** The Tim upgrade process was estimated to take 10 days to complete. This involved two weekends and as such a loss of just six working days.

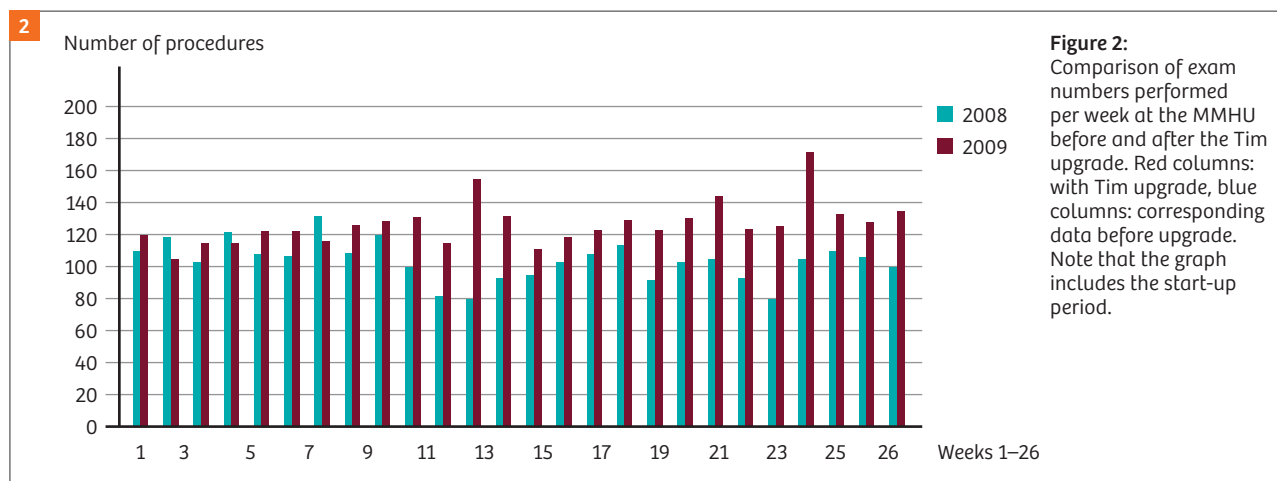
### Our experience

#### Installation:

1. The old scanner was stripped to its bare magnet and new hardware in the form of new external casing and table top, a new RF system, new standard (and optional coils), a new computer system with new software were installed. A mobile MR provided coverage during installation.
2. The entire upgrade process took 5 days longer than anticipated. We continued an inpatient and urgent out-patient service from the mobile unit. Engineers worked around the clock to sort out teething difficulties but it was worth the wait!

#### Technology:

Several tailored upgrade packages were also purchased to the specific services of the adult population with congenital heart defects. We have now applied it to venous and tumor imaging. The *syngo* BLADE sequence has become invaluable to us and is generally used in patients with movement disorders or patients who are slightly confused. It has greatly reduced the need to sedate these patient groups. The cardiac package included the PMU wireless physio control and vector ECG tracing which has greatly increased the efficiency of our cardiac clinic. The old ECG device was cumbersome and frequently needed replacing and a good trace proved difficult to attain in



Tim Upgrade is not commercially available anymore.

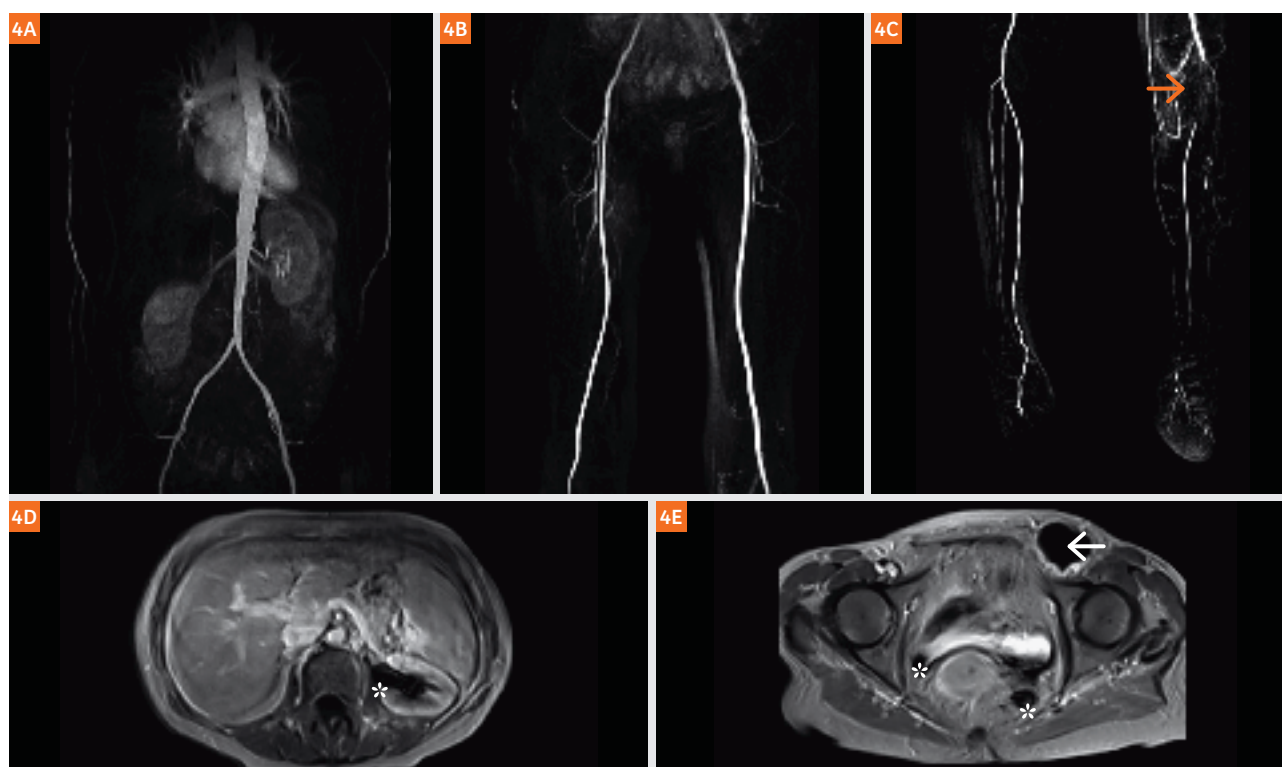




**Figure 3:**

Example of a whole-spine exam. **3A–C** composed sagittal T2w TSE images, consisting of three stages (TR / TE = 4000 / 100 ms; slice thickness 3 mm). Note the slight scoliosis (best shown in **3C**). Magnified images do demonstrate multiple degenerative changes of the cervical spine with narrowing of the spinal canal (**3D**) and the compression fracture of the first lumbar spine without relevant stenoses of the canal (**3E**).

Tim Upgrade is not commercially available anymore.



**Figure 4:**

Multi-step MR angiography of a 55-year-old female patient with limited breath-hold capabilities. **4A–C** MIP based on the large-FOV MR angiography (TR / TE = 3.10 / 1.08 ms, FOV 328 x 500 mm, matrix 214 x 383, slice thickness 1.4 mm). Complete occlusion of the left popliteal artery is found (orange arrow). Note also a seroma on the left inguinal side (white arrow) and susceptibility artifacts at the area of the ureters on both sides (marked by stars). **4D, E:** ce 2D FLASH.

certain patients. We invested in the 8-channel knee coil and are impressed with the image quality attainable for MR arthrography, foot, ankle and wrist imaging with this device. Parallel imaging technology has greatly reduced scan times for many of our sequences. A new, sturdier head and neck coil replaced the old. Compared to the former flexible neck coil, a clear gain in signal-to-noise ratio (SNR) is obvious and also clinical advantages by application of parallel imaging e.g. for MR angiography of the supraaortic vessel are obvious. However, the old flexible neck coil is sometimes greatly missed, especially for our spinal trauma patients. Our image quality is compromised in these patients as the new neck coil will not fit over spinal immobilization devices and tracheostomy tubes.

#### **Productivity:**

Since the upgrade there has been a notable increase in throughput and productivity due to faster scanning and examination times. Over the same 6 month period one year prior to and after installation of the Tim upgrade

there has been a 20%<sup>1</sup> increase in the number of procedures performed. Faster scan times amount to a significant increase of at least 4 procedures per day or an average of at least 20 MR studies per working week.

#### **Cost:**

The approximate cost for our institution of outsourcing an MR scan in 2008 was € 220.00. Based on achieved additional throughput of 20 scans per week (Fig. 2) for an operational 50 weeks of the year the total savings will pay for the upgrade including VAT (value added tax) at 21% and our interest costs in 3 years.

In summary the Tim upgrade has allowed us to achieve state of the art imaging on site on a cost neutral basis. This was achieved by a commitment on the part of all staff to increase patient numbers without additional staff.

Tim Upgrade is not commercially available anymore.

<sup>1</sup> Results may vary. Data on file

# MAGNETOM Trio Upgrade to Prisma<sup>fit</sup> better imaging technique combined with higher throughput in clinical practice

Stephan Zangos; Thomas J. Vogl

Institute for Diagnostic and Interventional Radiology, University Hospital Frankfurt, Frankfurt/Main, Germany

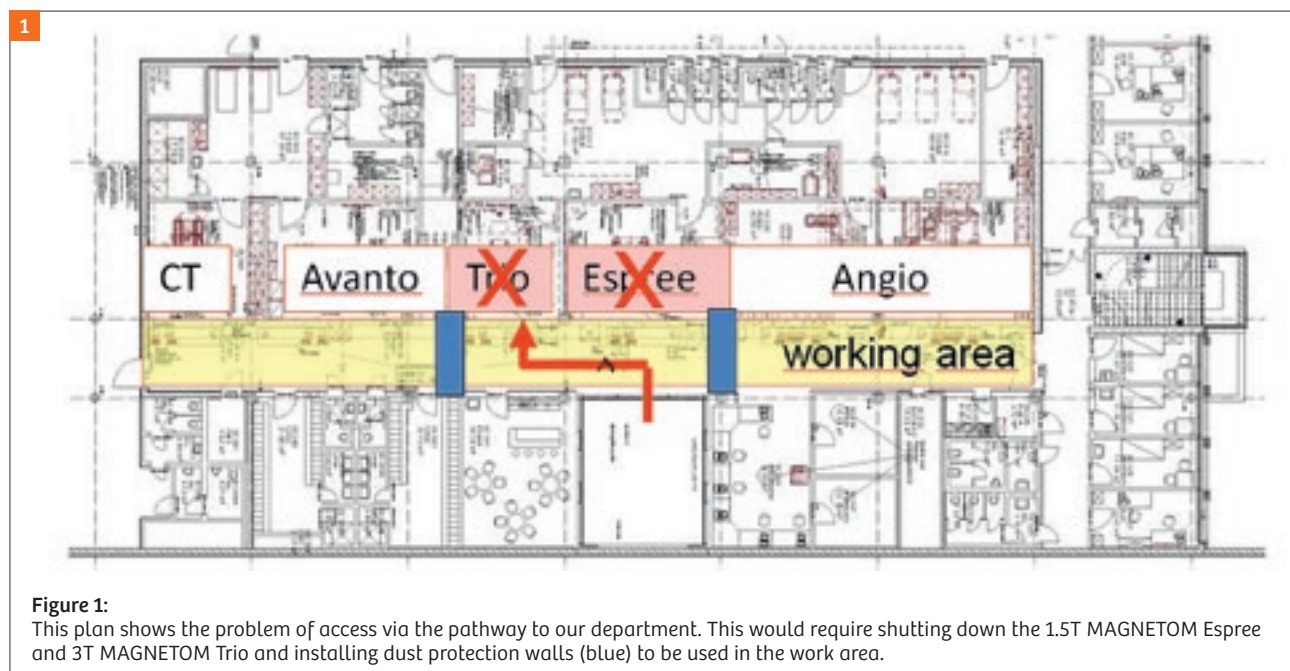
The decision to purchase a new MRI system is based on several factors. The cost of the purchase and installation are a particularly important factor in such a decision. However, a new MRI system with innovative technology offers unique features and the opportunity to develop into new markets. The use of new technology can lead to improved patient comfort, better image quality and an increase in the number of examinations.

The installation of a new MRI system in an ongoing clinical routine always poses a logistical challenge. In a worst-case scenario this may involve the decommissioning of neighboring devices. However, replacing the devices after several years cannot be avoided for ever.

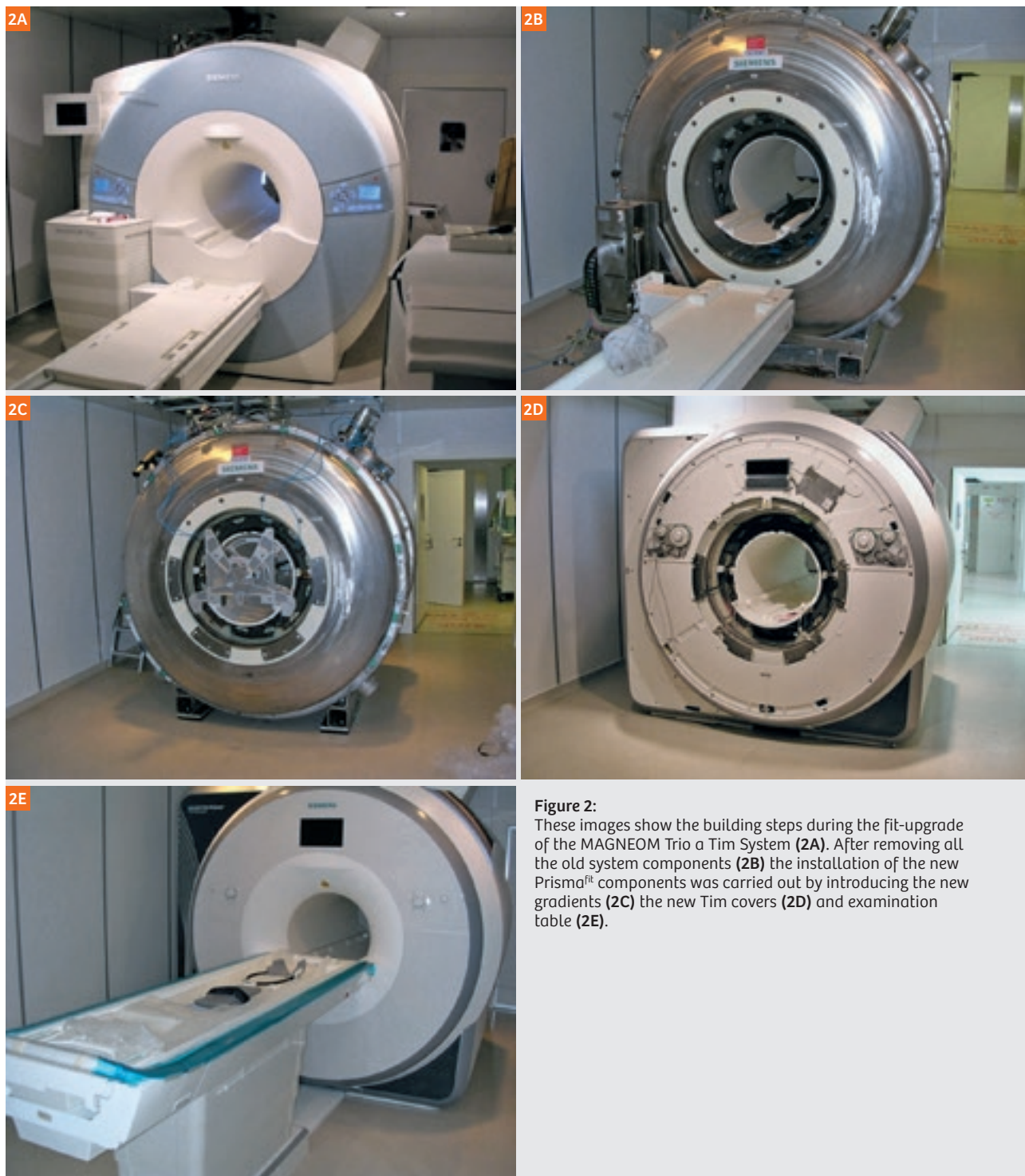
The MAGNETOM Trio a Tim System was used in the clinical routine in our institution for 6 years to obtain images across the entire diagnostic spectrum, including angiograms, as well as musculoskeletal, thoracic and abdominal imaging.

In order to regain access to the latest MR technology in our clinic and to pursue new research areas, the possibility of a new acquisition was evaluated.

Due to the physical layout of our Institute, our working area would have had to be used for the installation of this new device. This would have led to additional decommissioning of the neighboring 1.5T MAGNETOM Espree for at least 10 days (Fig. 1).







In addition to the initial cost of the new unit, considerable additional costs for the use of a crane, the cabin construction, the clearance of the transport paths and the restoration of the premises would have been incurred (Table 1). Examining alternatives, an upgrade to the Trio a Tim System was offered by a Prisma<sup>fit</sup>. The upgrade included the latest MRI technology including an XR 80/200 gradient system, Tim 4G architecture and Dot (Day optimizing throughput) workflow engines. The new Tim table can combine up to 204 coil elements.

After analysis of the additional costs, an upgrade seemed to be the only economically meaningful option. After successfully upgrading our 1.5T MAGNETOM Avanto to Avanto<sup>fit</sup> in the spring, the decision was easily made for a MAGNETOM Prisma<sup>fit</sup> upgrade.

During the upgrade of the scanner, the original 3 Tesla magnet was left in the magnet room (Fig. 2). All covers, the body coil, and the gradients were replaced with new ones. All analog cables were eliminated and the new all digital-in/digital-out DirectRF design was installed directly at the scanner. In the technical room, all cabinets were removed and a new cooling control unit and gradient power amplifier were installed. Additionally, all workstations, monitors, and keyboards were removed and replaced with new ones. Finally, all installed licenses were migrated into the new software version syngo MR D13.

After installation and quality tests, the upgrade to the MAGNETOM Prisma<sup>fit</sup> was completed in only 15 working

days. A great advantage of this upgrade during the installation was that there were no restrictions to the operational capability of the surrounding MRI in the working area. For this reason, the upgrade could be made without limitations to patient care and the workflow. After a short training phase, the system was smoothly integrated into the clinical routine. Since the focus of our department is on abdominal and hepatobiliary imaging, the use of the Abdomen Dot Engine in particular has led to an improvement of the workflow.

The resulting reproducibility of the investigations has led to a better comparability of the images during follow-up. In particular, the timing of the arterial phase is made much more efficient by using Dot. In general, the new technology has led to improvement in image quality. In liver imaging, the use of CAIPIRINHA Dixon VIBE technology has led to a significant improvement in image quality compared to the standard VIBE sequence.

For the technical staff, the Dot software provides a significant reduction in study planning and implementation through the automatic positioning of the examination area, as well as automatic breathing commands. In addition, the Dot engines are routinely used for neurological, cardiac, and spinal diagnostics. Whenever the workflow allows, we try to investigate the joints in the new 3 Tesla system due to the significantly better image quality compared to the other MRI systems in the department.

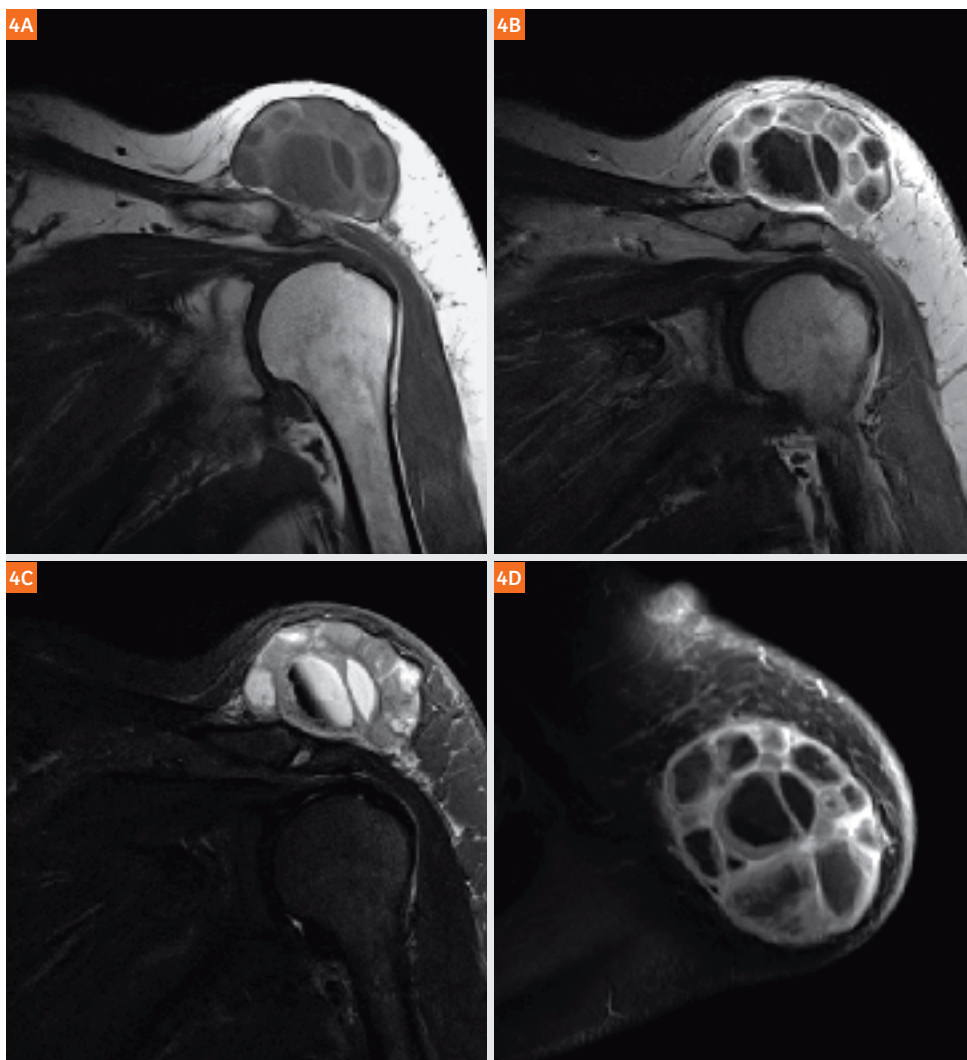
Costs		Upgrade (fit)	Ex-Factory
Invest costs		<<<	>>>
Local costs			
Architectural			
	Structural	not necessary	new infrastructure
	Power	not necessary	new infrastructure
	Cooling	not necessary	new infrastructure
	RF-Cabin	not necessary	high cost (customer choice)
Other			
	Crane	not necessary	depends on site, high cost
	Local permits	not necessary	see above
	System downtime	15 working days	n.a.
	Taxes	Local (Germany: 19%)	Local (Germany: 19%)
Applications Training Standard 1–2 (weeks)		equal for either option	
Service		equal for either option	

**Table 1:** A comparison of the construction costs between an upgrade and a new installation.



**Figure 3:**

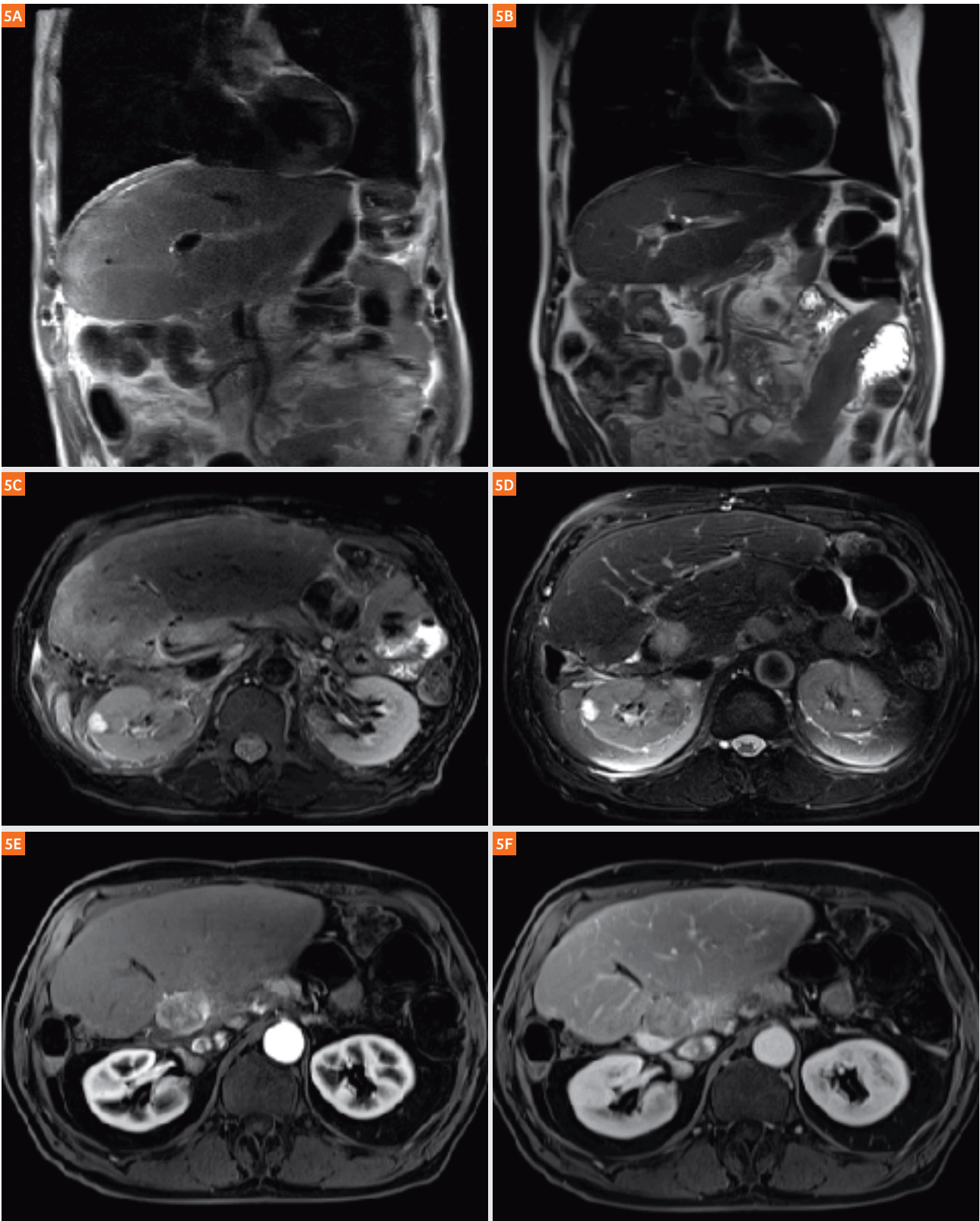
Figure 3 shows a patient with bony avulsion of the posterior cruciate ligament: T1-weighted (3A) and T2w PD FS sequences (3B, C) in sagittal and transverse orientation. For imaging, a 15-channel knee coil was used.

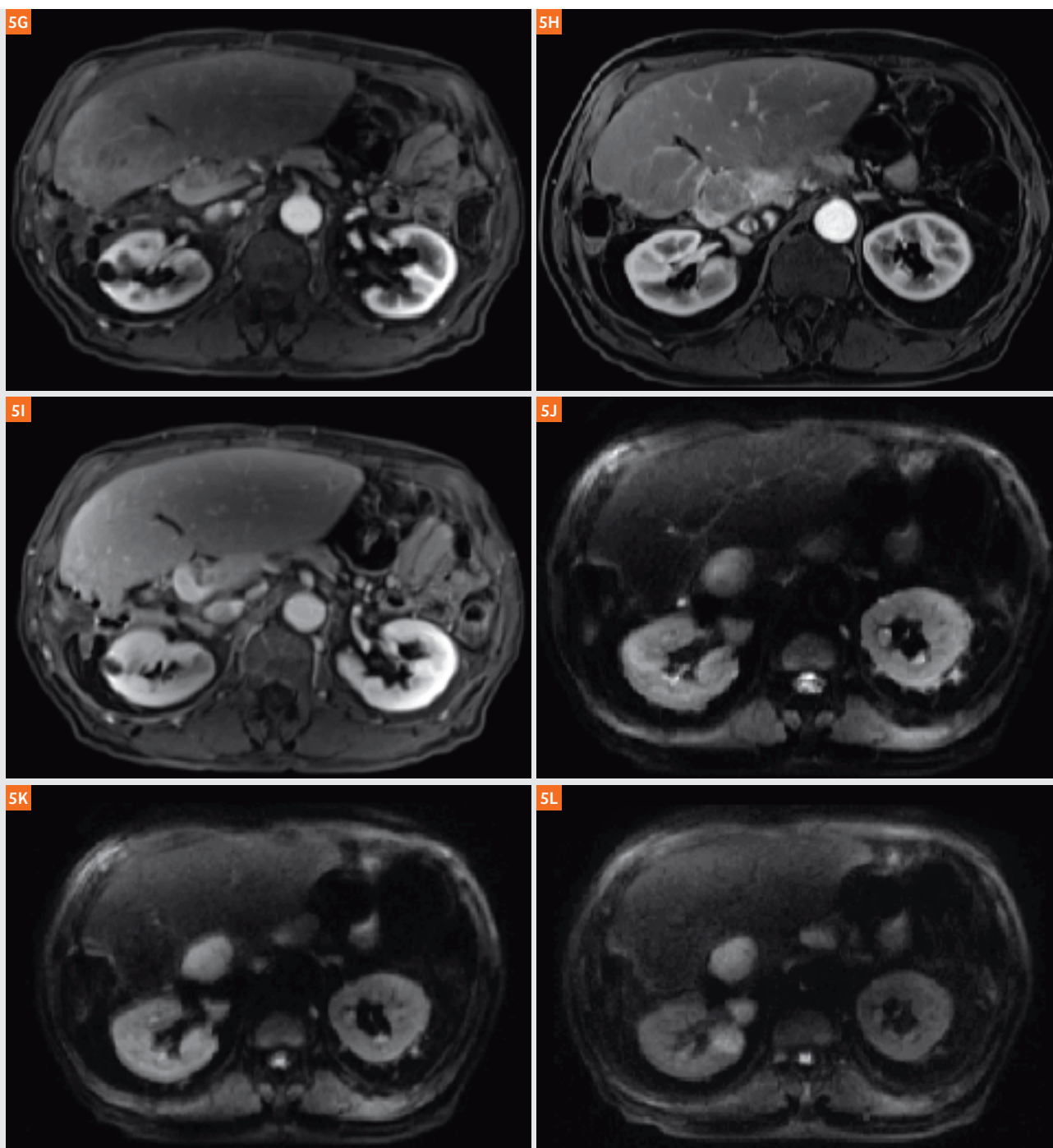


**Figure 4:**

Metastasis of a malignant melanoma investigated in a shoulder coil. Native and contrast-enhanced T1w sequences (4A, B) and T2w PD FS (4C) in paracoronal orientation. Contrast-enhanced T1w FS sequence in transverse orientation (4D).

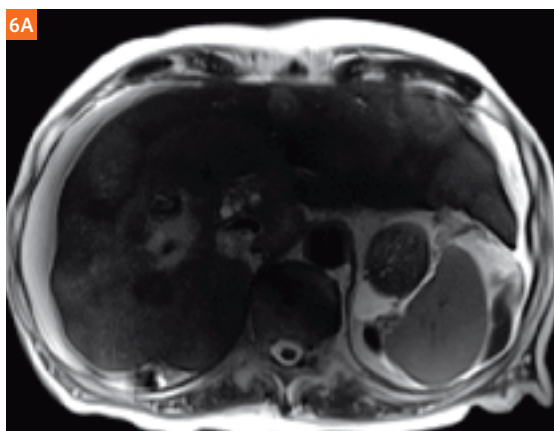






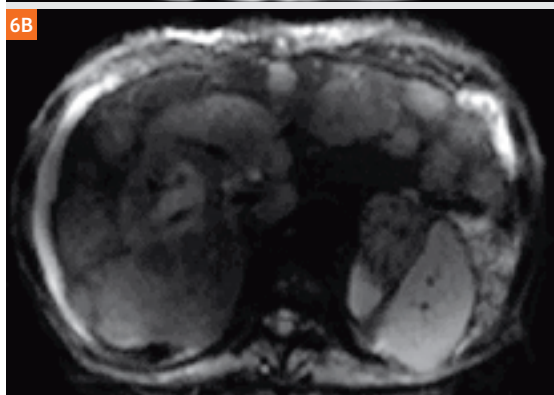
**Figure 5:**

Staging in a patient with a neuroendocrine tumor of the pancreas. In the follow-up, one examination was performed with the MAGNETOM Trio a Tim System and one with the Prisma<sup>fit</sup>. In direct comparison, an improvement in image quality could be observed in all sequences after the upgrade: Coronal HASTE sequence (Trio vs. Prisma<sup>fit</sup>) (**5A, B**) / T2-weighted TSE FS (Trio vs. Prisma<sup>fit</sup>) (**5C, D**) / T1-weighted VIBE FS (Trio) (**5E, F**) vs. CAIPIRINHA Dixon VIBE (Prisma<sup>fit</sup> early and late arterial, venous phase) (**5G–L**). But even in the diffusion-weighted scans (b 50/400/800) the anatomical structures and pathologies can be better distinguished after the upgrade.

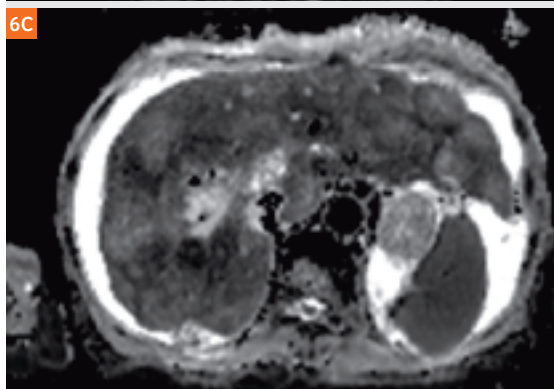


**Figure 6:**  
Even in patients with ascites, examinations on a 3 Tesla system are possible due to the new technology by the Prisma<sup>fit</sup> upgrade.

**(6A)** HASTE sequence



**(6B)** diffusion-weighted imaging



**(6C)** ADC map

Over the last half year, the Prisma<sup>fit</sup> could be used after the upgrade without any problems in routine clinical practice and research, and more than 1,700 patients have been examined to date. In particular, there has been improvement of image quality resulting in clinical partners stimulating demand for Prisma<sup>fit</sup> examinations.

In our department, work is ongoing to optimize MRI scanning techniques in various parts of the body and for various diseases.

## Summary

We have implemented the first upgrade of a MAGNETOM Trio a Tim System to a MAGNETOM Prisma<sup>fit</sup> without any problems either during or after the upgrade. This upgrade has allowed us to access the latest technology on a 3T system for research and in daily routine, which has led to a significant improvement in image quality as well as the facilitation of the workflow through the use of Dot technology.

Prisma<sup>fit</sup> is not commercially available in all countries. Due to regulatory reasons its future availability cannot be guaranteed.

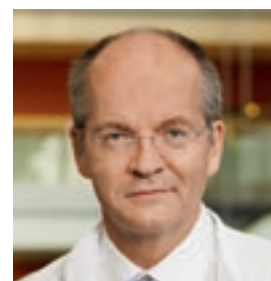
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Stephan Zangos



Thomas J. Vogl



# fit-Upgrade: a success story

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We reported on our first experiences with fit-upgrades on the MAGNETOM Avanto<sup>fit</sup> and MAGNETOM Prisma<sup>fit</sup> in MAGNETOM Flash [1] a year ago (page 36 of this issue). This article is an update of this experience. fit-upgrades to both MR systems were carried out, problem-free, in only 15 days, without additional rebuilding measures. The magnet remained in the scanner room while all other components were replaced. The fit-upgrades gave us access to the latest MRI technology, including a new gradient system, Tim 4G architecture, and day optimizing throughput (Dot) workflow engines on both systems. Both systems are currently operating without problems and without unscheduled downtime.

These upgrades should help improve workflow and image quality, and ultimately lead to an increase in the number of examinations.

In addition, the new Dot engines provide improved examinations through fast and reproducible imaging. These are now routinely used for all liver, spine, cranial, and heart examinations in our clinic, where examinations can be adapted easily to answer specific questions at decision points.

When financing new devices today, we see a widening gap between the high costs of the system and lower revenue per exam. Today, radiologists aim to develop their own departments, with high quality services at acceptable prices.

Various strategies could be utilized to increase the number of examinations within the same number of working hours. The new systems enable a significant reduction

in examination times as a result of better system performance, giving the same image quality. Indeed, the new systems can often provide improved image quality in shorter examination times.

Inexperienced staff can be led through examinations using the guidance features of the new Dot engines, reducing unnecessary or repetitive images. As a result, training time can be significantly reduced and consistent imaging quality achieved. This is an important factor, particularly in teaching hospitals, where inexperienced staff must often be deployed. The additional use of the Dot engines with their built-in automation assists the technologist during the examinations.

In a retrospective analysis<sup>1</sup> (Table 1), we showed that with the fit-upgrades, exam frequency could be increased in our department by 20.6% to 697 examinations/year using the Avanto<sup>fit</sup>, and by 13.2% to 469 examinations/year using the Prisma<sup>fit</sup>. After upgrades, changes in the number of examinations are often multifactorial and cannot be accurately broken down to individual causes. The increased system performance allows us to provide improved image quality to our referring physicians.

After the upgrade we could increase the number of examinations without any conscious change to our examination strategies, or by extending our working hours. In particular, we found that better performance of the new systems and use of the Dot engines were the primary contributors to the increase in number of investigations. Improvement in image quality has also been recognized by our clinical partners, which has led to good acceptance of our MRI examinations in the hospital.

## Conclusion

The fit-upgrade remains an economically attractive approach for an aged MR system. By improving system performance and workflow using the system software, the number of examinations can be increased, together with improved image quality, with little effort.

	01.01.-31.12.2012	01.01.-31.12.2014
Workdays	252	252
	<b>MAGNETOM Avanto</b>	<b>MAGNETOM Avanto<sup>fit</sup></b>
Cases total	3377	4074
Cases/day	13,4	16,2
	<b>MAGNETOM Trio Tim</b>	<b>MAGNETOM Prisma<sup>fit</sup></b>
Cases total	3543	4012
Cases/day	14,1	15,9

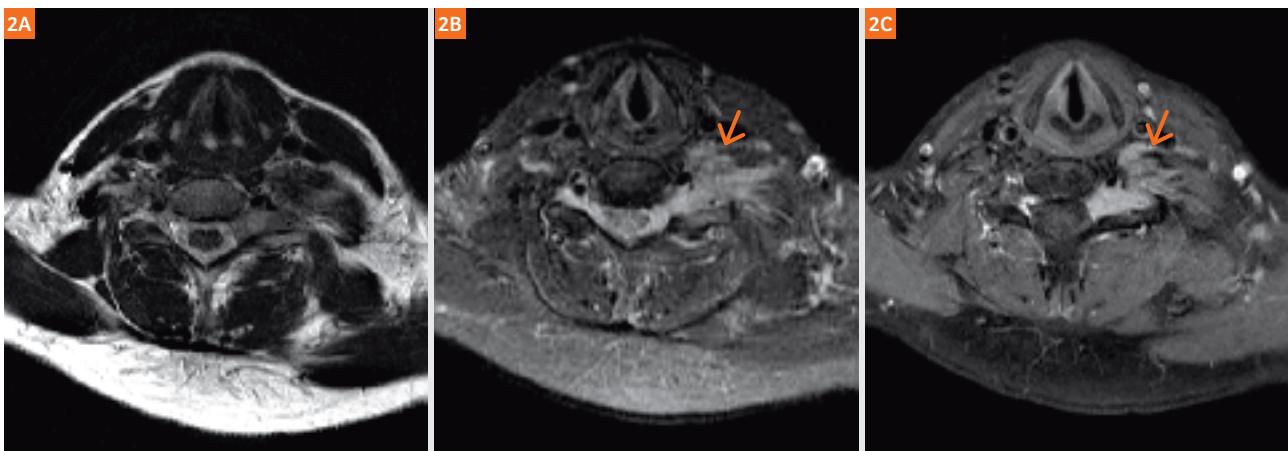
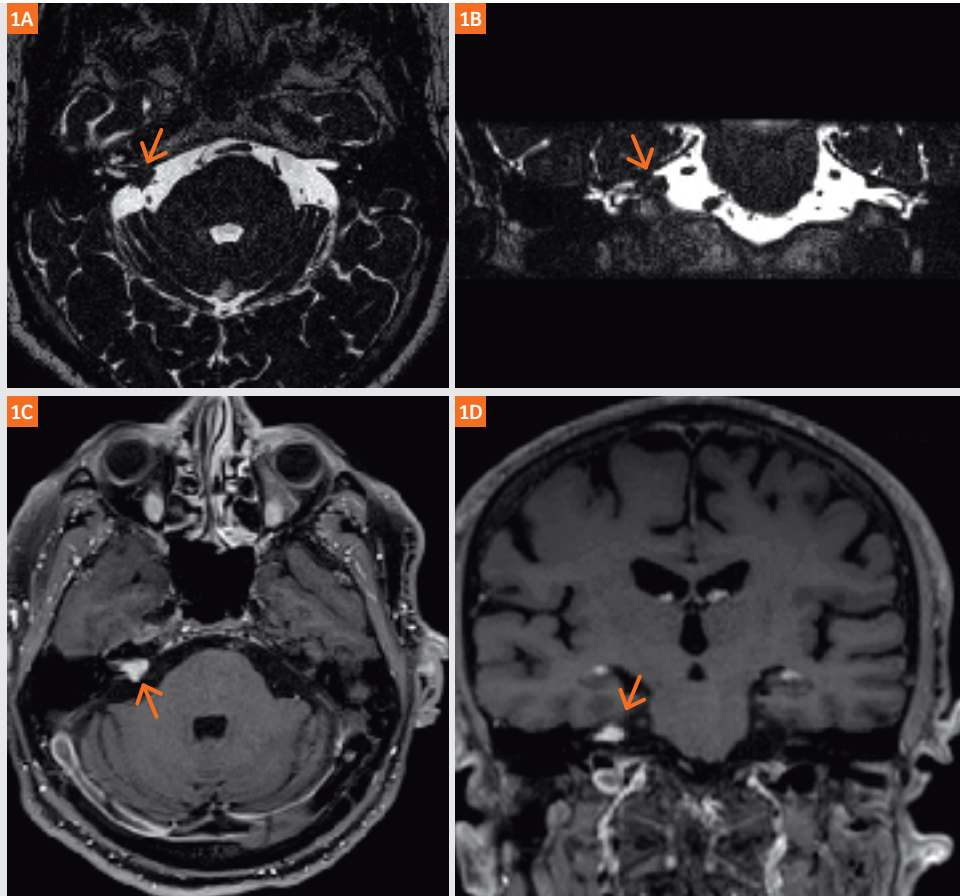
**Table 1:** A retrospective analysis<sup>1</sup> shows that the fit-upgrades increased exam frequency in our department. 697 more cases with Avanto<sup>fit</sup> and 469 more cases with Prisma<sup>fit</sup>.

<sup>1</sup> The statements by Siemens' customers described herein are based on results that were achieved in the customer's unique setting. Since there is no 'typical' setting and many variables exist there can be no guarantee that other customers will achieve the same results.

**Figure 1:**

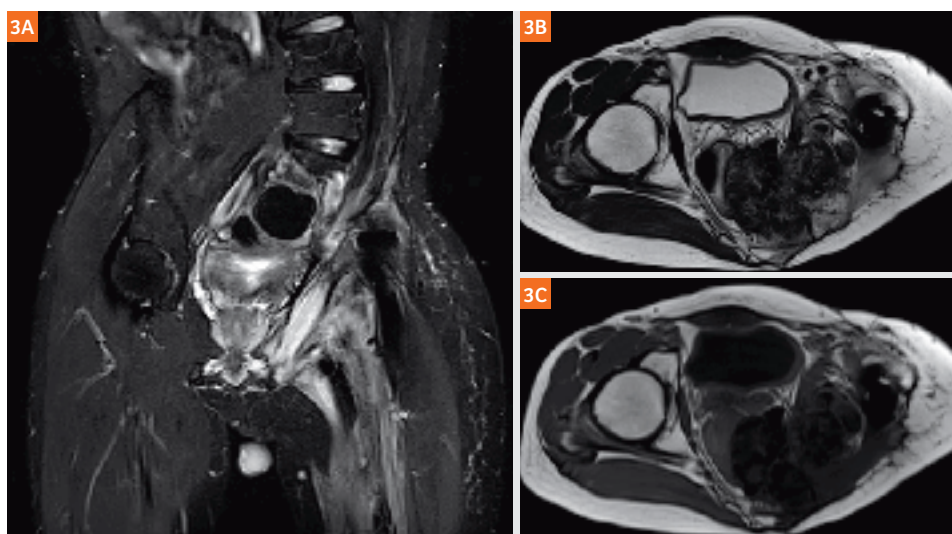
(1A, B) Representation of an acoustic neurinoma (arrow) on the MAGNETOM Avanto<sup>fit</sup>. T2-weighted SPACE transversal (TR 1200 ms, TE 264 ms, slice thickness 0.6 mm) and reconstructed coronal slice orientations.

(1C, D) Contrast-enhanced T1-weighted MPRAGE (TR 1800 ms, TE 2.6 ms, slice thickness 1 mm) with automatically calculated coronal MPR.

**Figure 2:**

Relapse of B-NHL (arrow) on the Avanto<sup>fit</sup>.

Comparison of the T2w TSE (TR 4000 ms, TE 79 ms; slice thickness 5 mm), T2w TIRM (TR 4140 ms, TE 32 ms; slice thickness 6 mm) and contrast-enhanced T1w TSE FS-Dixon sequences (TR 520 ms, TE 14 ms; slice thickness 5 mm). The images show homogeneous fat saturation in this problem area, facilitating diagnosis.



**Figure 3:**  
Recurrence after resection of  
osteosarcoma of the ilium on  
the MAGNETOM Avanto<sup>fit</sup>.

T2w TIRM WARP (TR 4670 ms,  
TE 39 ms; slice thickness 5 mm),  
T2w TSE WARP (TR 5530 ms,  
TE 77 ms; slice thickness 6 mm),  
T1w TSE WARP (TR 500 ms,  
TE 7 ms; slice thickness, 6 mm),  
and T1w TSE WARP sequences  
show the reduction of metal  
artifacts of tumor prosthesis.



**Figure 4:**  
MIP (maximum intensity  
projection) of a TWIST  
angiography in neutral  
and provocation positions  
on the MAGNETOM Avanto<sup>fit</sup>.  
The images show an  
entrapment on the left side.

## References

- 1 Zangos S, Vogl TJ. MAGNETOM Trio upgrade to Prisma<sup>fit</sup> better imaging technique combined with higher throughput in clinical practice. MAGNETOM Flash no. 58, 3(2014): 32-38. Page 36 of this issue.

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# The Skyra<sup>fit</sup> experience in Basel

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Merian Iselin Spital, Radiology Department, Basel Switzerland

## Introduction

Merian Iselin is one of the leading clinics for orthopedic and surgical procedures in Switzerland and it has 120 acute care beds. In 2014 there were 4,893 orthopedic cases (71% of all new cases), 615 surgical cases, and specifically 514 urological cases registered. By 2014 we observed that other institutions were catching up with our clinical service and we therefore evaluated how we could take advantage of new opportunities in MR imaging to differentiate and to improve existing services. The option we considered was a fit-Upgrade of our installed MAGNETOM Verio MRI scanner.

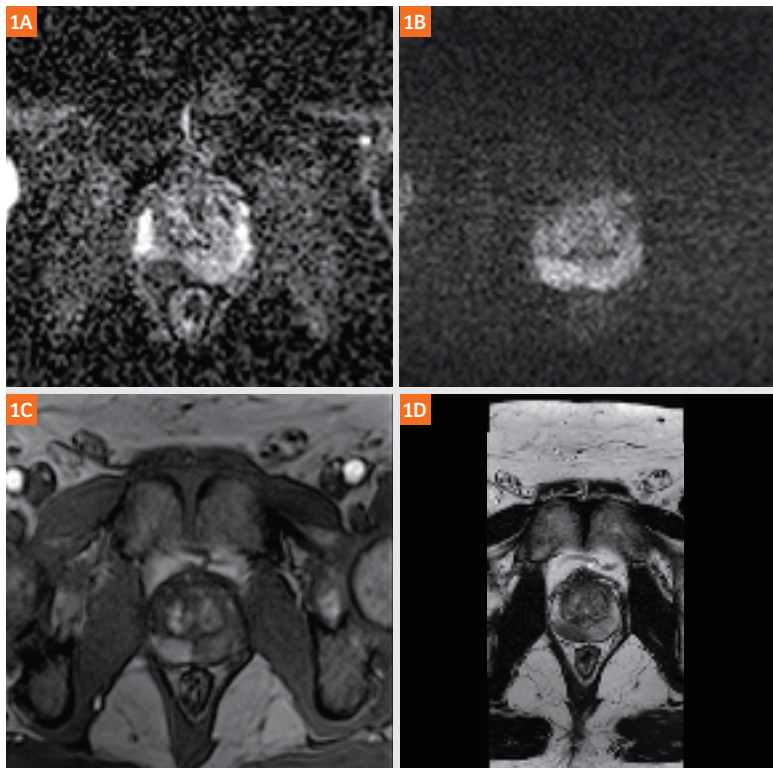
A fit-Upgrade is an upgrade of the installed 3T MRI system with the new Tim 4G coil technology, the new DotGO workflow and most recent applications available, including Quiet Suite. It also includes the installation of the new digital-in/digital-out RF system and new covers with Dot Display and Dot Control Centers, as well as the replacement of the control unit cabinet, body coil and surface coils, examination table and workstations.

## Challenges

As a surgery reference hospital, prostate evaluation and therapy have become important topics for Merian Iselin, and consequently for the Radiology Department as well. One frequent request by our urology department and external referrers is pre-biopsy imaging of the prostate in order to guide targeted biopsies. However, before the upgrade the imaging department lacked the means to offer additional guidance for a targeted biopsy.

With our equipment prior to the fit-Upgrade, a prostate MR examination used to be rather uncomfortable for the patient because an endorectal coil was needed to achieve sufficient SNR. In many cases this device caused patient movement, affecting image quality and thus biopsy planning. Or, even worse, in some cases patients refused to undergo this kind of procedure at all.

Furthermore, scheduling of prostate patients required an extra time buffer to describe the procedure and to explain



**Figure 1:**

Prostate images.

**(1A)** ADC RESOLVE b50, 800, 1500 transversal, SL 3 mm, FOV 150 x 150, matrix 100 x 100. **(1B)** DWI b 800 transversal, SL 3 mm, FOV 150 x 150, matrix 100 x 100. **(1C)** T1-weighted VIBE transversal post-contrast, SL 3.5 mm, FOV 180 x 180, matrix 122 x 160. **(1D)** T2w TSE transversal, SL 3 mm, FOV 240 x 120, matrix 384 x 192.

the use of an endorectal coil. While routine MR examinations take around 20 to 30 minutes, patient preparation for prostate examinations required additional time in the MR scanner – especially for non-German speakers because language barriers made it slower to explain.

Another key reason for the fit-Upgrade was the offered advantage in musculoskeletal imaging: As a hospital focused on orthopedic procedures, we need to evaluate the whole hand, especially for finger ligament diagnosis and degenerative pathologies. Ideally, a hand coil should support an examination where the wrist and finger can be examined as a whole.

Our analysis further revealed that time pressure had also been a major issue in Merian Iselin before the fit-Upgrade. In order to acquire images in all required orientations and contrasts as requested by the radiologist for some clinical questions, the team of technologists had occasionally found themselves under pressure to finish an examination within the patient time-slot. This was particularly the case for finger and hip examinations. And, in general, the team has been under pressure to reduce patient time in the scanner to the minimum.

## Solutions

After upgrading the system to MAGNETOM Skyra<sup>fit</sup>, we changed our prostate protocol and decided to abandon the use of an endorectal coil. With the upgraded 3T system and using only the surface body 30 coil and the spine coil we now ensure patient comfort and compliance. We obtain images with high quality while eliminating the challenges associated with the endorectal coil.

We also replaced our standard diffusion-weighted imaging protocol, which is prone to susceptibility artifacts, with a high-resolution, diffusion-weighted imaging sequence (RESOLVE), and in general benefitted from a higher signal-

to-noise ratio (SNR) and improved FatSat imaging. All these changes have very positively influenced the quality of our prostate MR exams provided to the urologists and improved diagnostic confidence (Fig. 1). Consequently, we are now able and confident to recommend if a biopsy is required or not, based on a MRI scan.

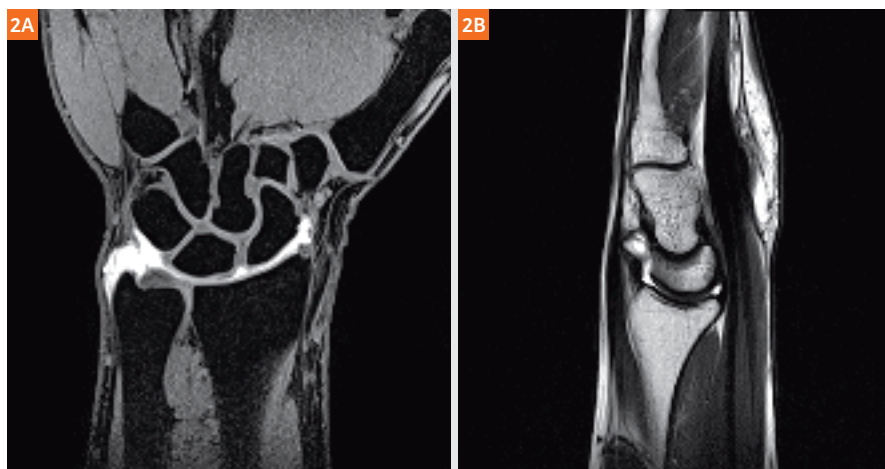
With the new hardware, providing higher coil density, we were able to improve the spatial and temporal resolution of our protocols in abdominal and pelvic imaging in general. One sequence of particular use is StarVIBE. Now it is possible to perform abdominal and pelvic examinations allowing patient's free breathing and reducing artifacts in the image.

The fit-Upgrade also included a new set of high element-density orthopedic coils. The 16-channel hand and wrist coil, in particular, enables a complete hand examination, without additional coils or specific coil or patient repositioning (Fig. 2).

We have also been able to accelerate orthopaedic examinations such as hip exams with the high element-density of the body coil and the additional workflow support provided by the Large Joint Dot Engine (Fig. 3). In the case of ankle examinations we have been able to reduce the scan time while even improving image quality by using the 16-channel foot and ankle high element-density coil. This coil also requires less time for shimming.

## Results

The improvements introduced with our Skyra<sup>fit</sup> upgrade have been crucial for us, our referring physicians and our patients. We are now able to offer a very convenient and comfortable examination to patients referred for prostate MRI and can consistently acquire all images required for diagnosis and (as far as needed) targeted biopsy. The avoidance of an endorectal probe is especially appreciated



**Figure 2:**  
Wrist images.  
(2A) T1w VIBE coronal, FOV 90 x 100, matrix 273 x 320. (2B) T2w TSE sagittal, SL 3 mm, FOV 100 x 100, matrix 307 x 384.

by patients undergoing active surveillance where regularly repeated exams are standard.

Dr. Georg Katz particularly points out: "Now urologists ask us to revise cases previously diagnosed in other sites or perform follow-up examinations."

Since the introduction of the new orthopedic coils, wrist and finger lesions referrals have increased in the region and we have also seen an increase in scanning rheumatic hands. For finger evaluations, Technologist Claudia Maise commented: "It is now easier and faster to perform an MRI scan than an ultrasound and we provide to the orthopedic physicians complete wrist and finger evaluation." In this way, orthopedic physicians offer patients a targeted treatment or physiotherapy.

Being able to scan faster has resulted in having more time available within the patient time-slot for techs to ensure

all possible sets of images are available. They are under less stress and this also guarantees a good result.

We provide the treating physician and the patient all the possible images needed for the diagnosis, therapy, surgery and follow-up questions which may later arise. Thus ensuring that no recall of patients is needed.

## Conclusion

Given challenges and the tremendous improvements achieved, the fit-Upgrade with software version syngo MR E11 has proved to be the best cost-benefit solution. The building costs were very low, installation was fast and the upgraded system is practically the same as a new scanner. Even though patients don't recognize the changes to the system, our referring physicians have specifically noticed the difference. And all this has been achieved with a reduced investment.



**Figure 3:**

Hip images.

**(3A)** T1w TSE coronal, SL 3 mm, slices 20, FOV 160 x 160, matrix 269 x 448, A 3:56 min. **(3B)** PDw TSE FatSat coronal, SL 3.5 mm, slices 20, FOV 150 x 150, matrix 272 x 320, TA 2:42 min. **(3C)** PDw TSE sagittal, SL 2 mm, FOV 130 x 130, matrix 230 x 256. **(3D)** T2w TSE FatSat transverse, SL 3 mm, FOV 192 x 200, matrix 279 x 384.

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Georg Katz



# A within-subject comparison of common neuroimaging protocols on MAGNETOM Prisma<sup>fit</sup> and MAGNETOM Trio scanners

Ross W. Mair<sup>1,2</sup>; Stephanie McMains<sup>1</sup>

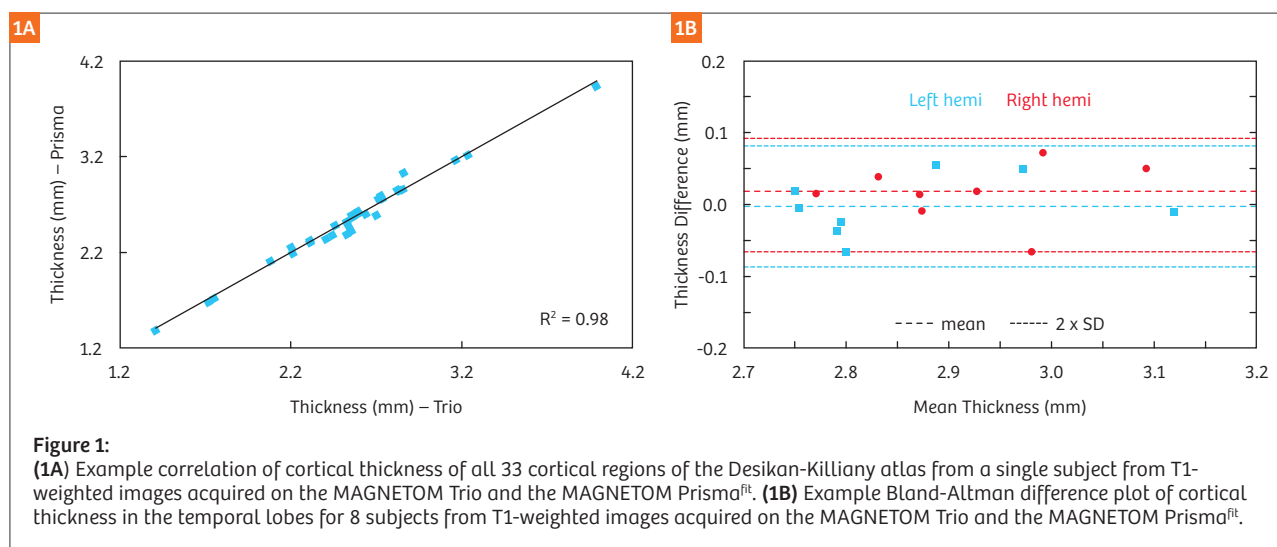
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<sup>2</sup> Athinoula A. Martinos Center for Biomedical Imaging, Massachusetts General Hospital, Charlestown, MA, USA

## Introduction

The Center for Brain Science – Neuroimaging Facility (CBS) at Harvard University is a key imaging resource for a wide array of university psychology department and medical school faculty in the Boston area. Started with the installation of a MAGNETOM Trio (Siemens Healthcare, Erlangen, Germany) in 2008, the center achieves a funded average usage by researchers of ~2000 hours per year with an approximately 1000 additional hours per year of use for maintenance, development, and educational purposes. As such, the scanner is used consistently and at near-capacity by an active and diverse group of scientists from Harvard and from other institutions, including Harvard teaching hospitals, in the Boston community.

The vast majority of this MRI data is task-based or resting-state functional MRI employing T2\*-weighted echo-planar imaging, or blood-oxygen level dependent (BOLD) techniques. Sessions also include a T1-weighted high-resolution structural or anatomical scan for co-registration to the BOLD images, and sometimes for brain morphometry. Many researchers also supplement their sessions with a short diffusion-weighted MRI scan. While most user-groups are eager to embrace new imaging technology and techniques when there is an appropriate benefit to the quality of their neuroimaging data, a key factor to ensuring quality data over studies that may run over periods stretching from 2 months to 2 years



is stability and consistency of scanner performance, and continuity in image acquisition protocols and the resultant MRI data itself. At CBS, we have placed a very high priority on maintaining a stable and consistent scanning environment. As a result, when major imaging advances and hardware or software upgrades arrive, there are equal parts anticipation and trepidation for many of our user groups.

We upgraded the MAGNETOM Trio to the MAGNETOM Prisma<sup>fit</sup> in the summer of 2015. The Prisma<sup>fit</sup> represented a significant upgrade in performance capability over the Trio. The MAGNETOM Prisma platform included a major advance in gradient strength (80 mT/m, up from 45 mT/m), new highly-parallel array receive coils for the head, a digital RF transmit/receive architecture, and a much faster reconstruction computer. While the new gradient coil was expected to offer significant improvements in diffusion experiments, any change to the gradient system has the potential to bias brain morphometry data if there were changes in gradient linearity and performance. We believed the digital RF chain had the potential to significantly improve BOLD imaging with improved RF fidelity and a reduction in spurious noise pick-up, however it was unclear whether such benefits would hold up in the human head with its attendant physiological noise effects. In addition, as Simultaneous Multi-Slice imaging techniques were beginning to be adopted, the improved reconstruction system was seen as a key component that would allow routine use of this technique for high-temporal resolution BOLD imaging with real-time image reconstruction, rather than suffering often intolerable reconstruction lags, as was the case on the Trio.

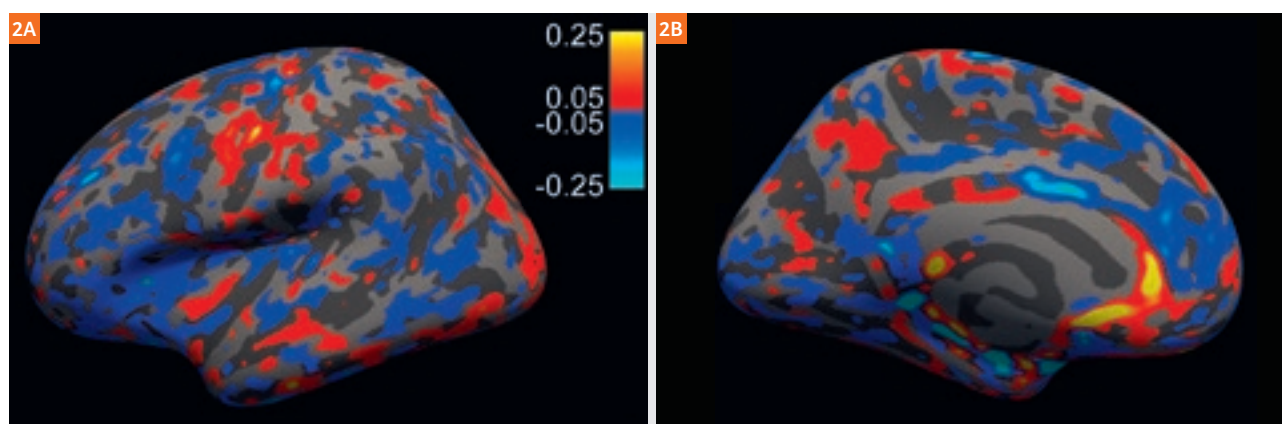
To quantify the impacts and improvements offered by such a significant system upgrade, we scanned 8 subjects using a variety of anatomical, functional and diffusion protocols commonly employed at the time on the Trio platform, and then repeated the same scans with the same protocols on the Prisma<sup>fit</sup> after the upgrade process. In addition, we devoted effort to assessing where the new hardware would permit improvements to temporal and spatial resolution in conventional BOLD imaging, both immediately after the hardware upgrade, and again following the software upgrade from syngo MR D13D to E11C in late 2016.

## Methods

8 subjects were scanned on the 3T MAGNETOM Trio in July 2015. The same 8 subjects were scanned a second time on the MAGNETOM Prisma<sup>fit</sup> in October 2015, after the scanner conversion. The relevant 32-channel head coil was used on each system. The scans included a 1.0 mm resolution multi-echo MPRAGE [1] anatomical

scan acquired with FreeSurfer-recommended parameters (6:03 min, TR/TI = 2530/1100 ms, matrix 256 x 256 x 176, resolution = 1 x 1 x 1 mm (no partial fourier), parallel imaging acceleration (GRAPPA) = 2, pre-scan normalize enabled). Two resting state BOLD scans of 8-min duration were acquired, one with 3 mm resolution and TR = 3 s, the other with 2 mm nominal resolution, slice-acceleration [2, 3] (SMS) of 8 and TR = 750 ms. Additionally, a third BOLD scan employing a protocol commonly used for task studies at the time was acquired: 2 mm nominal resolution, SMS 3 and TR = 2 s. Two diffusion MRI protocols were employed, both with nominal 2 mm resolution: no SMS, 30 *b* directions, *b* = 1000 mm<sup>2</sup>/s; and SMS 2, 64 *b* directions, *b* = 1000 mm<sup>2</sup>/s. On the Prisma<sup>fit</sup>, the diffusion protocols were reproduced exactly as implemented on the Trio, and then repeated utilizing the monopolar diffusion encoding scheme available in syngo MR D13 and E11, the performance gradient mode allowed by the Prisma<sup>fit</sup> gradient set, and then optimizing the echo spacing and minimizing TE and TR. No changes were made to spatial resolution, number of *b* directions or *b* values, although it is widely expected such advances will become commonly employed on Prisma<sup>fit</sup> system and similar scanners.

Anatomical images were analyzed using a FreeSurfer [4] processing stream. They were first corrected for gradient non-linearities according to the different scanner gradient coil parameters, after which the pairs of scans from each subject were aligned using the FreeSurfer robust registration tool [5]. FreeSurfer v.5.3 was used to perform an automated parcellation of the cortex, subcortical and white matter structures. The 33 cortical regions of the Desikan-Killiany atlas [6] were combined into five principal cortical lobes for simpler analysis [7]. Correlation and Bland-Altman difference plots were made for the thickness and volume of each principal cortical lobe determined from each scan, and for the volume of key sub-cortical structures. Surface-based plots were made to show regions of thickness difference and significance of difference. Diffusion scans were analyzed from raw DWI images and ADC and FA maps generated by the scanner software at the scanner console. In addition, diffusion scans were post-processed with a detailed stream that included gradient non-linearity correction, motion correction/realignment, eddy-current distortion correction, and registration to the anatomical space of the T1-weighted image. This alignment enabled the ADC and FA to be probed in the parcellated corpus callosum only, while the whole brain and white-matter-only masked images were analyzed for stability. BOLD scans were analyzed by assessing tSNR for each voxel, and averaged over the whole brain, after motion correction and detrending. Functional-connectivity



Thickness difference

**Figure 2:**

Surface plots of average cortical thickness difference for pairs of T1-weighted images acquired on the MAGNETOM Trio and the MAGNETOM Prisma<sup>fit</sup>. Thickness differences are threshold at  $\pm 50$ – $250 \mu\text{m}$ , color bars are in mm. The left hemisphere is shown – results are similar for the right hemisphere.

analysis was performed on the two resting-state BOLD scans with a seed-based correlation procedure using correlations between major network seeds [8].

## Results/discussion – anatomical scans

The anatomical scans from each subject, acquired on the MAGNETOM Trio and on the MAGNETOM Prisma<sup>fit</sup> appeared visually very similar. The offline gradient non-linearity correction modified the appearance of the neck/spine region on scans acquired on the Trio, but the brain and skull appeared unaffected. On the Prisma<sup>fit</sup>, in addition to modification of neck/spine region, a slight extension to the crown of the skull and the parietal cortex just below it could be observed for some subjects following gradient non-linearity correction. Therefore, for comparison of brain morphometric data, gradient non-linearity correction was performed on the anatomical scans from each scanner, prior to robust registration of the pairs of scans to an unbiased base-space, after which the standard FreeSurfer processing stream was performed.

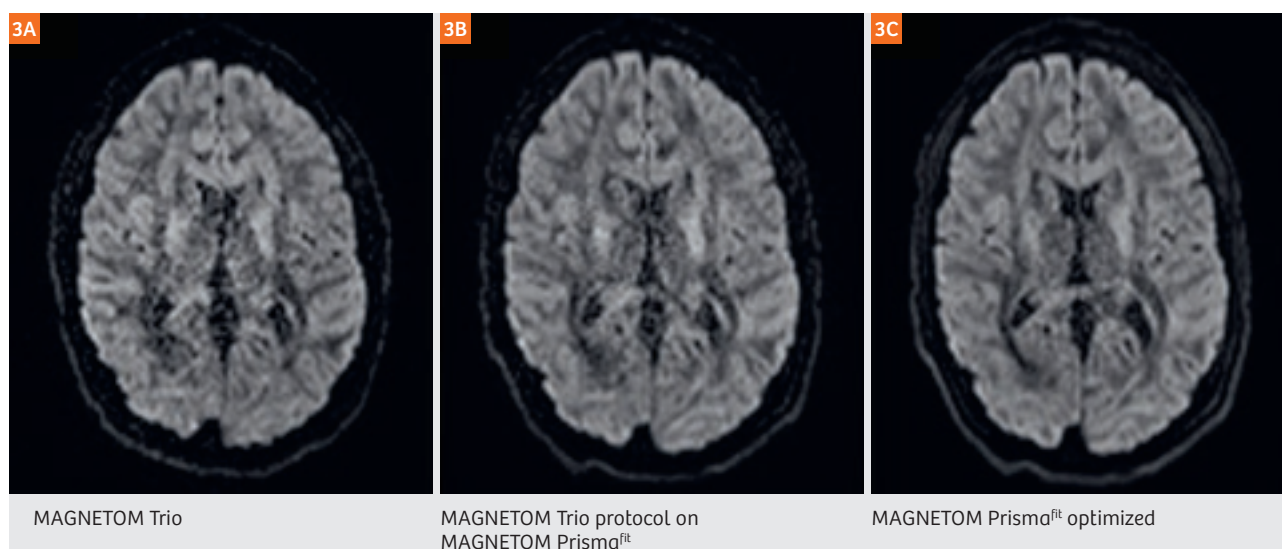
Figure 1A shows an example correlation plot for the thickness of all 33 cortical regions of the Desikan-Killiany atlas, from a single subject, as determined from images acquired on the Trio and on the Prisma<sup>fit</sup>. Similar correlation plots were obtained for gray matter volume for the 33 cortical regions, and for the volumes of sub-cortical/white matter structures. Correlation Coefficients ( $R^2$ ) were routinely  $\sim 0.95$ – $1.00$  for all subjects, and were especially high for the sub-cortical/white matter structure volumes. However, while intuitively simple, correlation plots can hide systematic biases, and so a Bland-Altman difference analysis was also performed. Figure 1B shows

an example Bland-Altman difference plot, plotting the difference of the measured average cortical thickness of the temporal lobes for all eight subjects, when scanned on the Trio and on the Prisma<sup>fit</sup>. The average thickness value was obtained from aggregating the relevant cortical regions from the Desikan-Killiany atlas for each subject [7]. The mean difference for both the left and right hemispheres was close to zero, with a standard-deviation inside  $\pm 0.1 \text{ mm}$ . Similar plots were obtained for the other principal cortical lobes, with differences always considerably less than  $\pm 50 \mu\text{m}$ . Such differences are on the order of those seen for test-re-test scans on the same scanner on the same day [9]. For the sub-cortical/white matter structures, a wider range of differences were observed – up to  $\pm 5\%$ , but again were respectable compared to prior studies of variation between head coils or repeated measures on different days [10].

Figure 2 shows inflated-surface plots of cortical thickness difference for groups of scans on the Trio and on the Prisma<sup>fit</sup>. Cortical thickness difference was determined using all 33 cortical regions of the Desikan-Killiany atlas for each scan, with each subject registered to FreeSurfer average-space, so differences can be analyzed on a single surface. Thickness differences are thresholded at  $\pm 50 \mu\text{m}$  – the vast majority of difference observed is either below  $50 \mu\text{m}$  (masked out), or between  $50$  and  $100 \mu\text{m}$ . Only the inner surface of the temporal lobe and a spot in the central gyrus shows values higher. However, a t-test determined that none of the thickness differences are statistically relevant ( $p > 0.01$ ).

In combination, the results from Figures 1 and 2 indicate that, with careful control for gradient non-linearity and





**Figure 3:**

Representative DWI images, as displayed at the scanner console, from the same subject acquired on the MAGNETOM Trio and the MAGNETOM Prisma<sup>fit</sup>. A 2 mm isotropic, SMS = 2, 64-direction,  $b = 1000 \text{ s/mm}^2$  DTI protocol was used. **(3A)** Image from the Trio. **(3B)** Image from the Prisma<sup>fit</sup> when the Trio protocol was implemented. **(3C)** Image from the Prisma<sup>fit</sup> after optimizing echo-spacing, bandwidth, and TE as permitted by the Prisma<sup>fit</sup> hardware.

robust registration, brain morphometric data should not be biased by scanner whether a Trio or Prisma<sup>fit</sup> is used, or when the former is upgraded to the latter.

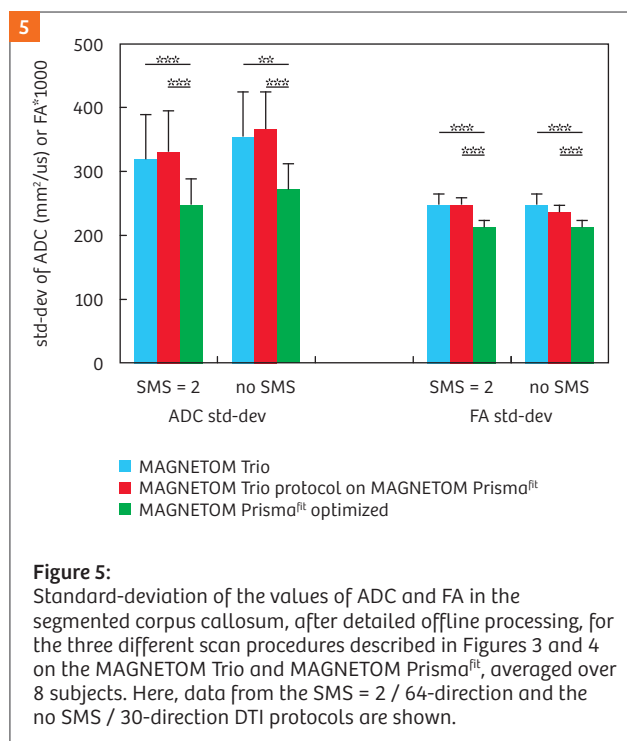
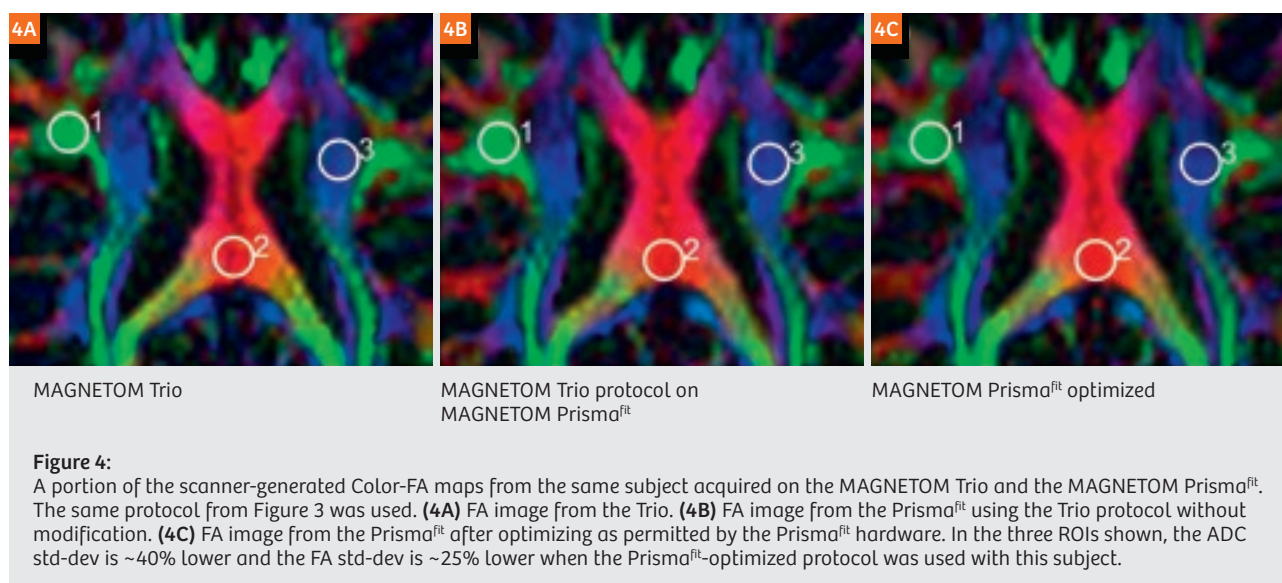
## Results/discussion – diffusion scans

For the diffusion scans, the protocols used on the Trio were implemented exactly on the Prisma<sup>fit</sup> without modification, to check for between-scanner variation, being cognizant of reducing bias for ongoing studies that straddled the upgrade period. Using “fast” gradient mode on the Sequence/Part 2 tab restricts the Prisma<sup>fit</sup> gradient to the maximum strength and slew-rates employed on the Trio. These scans are referred to as “Trio protocol on Prisma”, which we hoped would show insignificant variation from the scan on the Trio. The scans were then repeated employing the hardware and software advances of the Prisma<sup>fit</sup>, principally the use of the monopolar diffusion encoding scheme which significantly reduces TE; the performance gradient mode allowed by the Prisma<sup>fit</sup> gradient set allowing stronger gradient strengths with shorter gradient durations; and then optimizing the echo spacing and minimizing TE and TR as a result of the above changes. These scans are referred to as “Prisma optimized”, although no changes were made to the spatial resolution, number of  $b$  directions or  $b$  values, as is likely for diffusion protocols truly optimized for the Prisma<sup>fit</sup>.

Figure 3 shows a single slice from a diffusion-weighted image on the Trio, and the two corresponding scans on

the Prisma<sup>fit</sup>, all acquired with the 64-direction / SMS = 2 protocol. The reduction in TE, from 90 to 57 ms in the “Prisma optimized” protocol, results in a noticeable improvement in SNR in the DWI. The same impact is seen in the color-coded FA maps as generated by the scanner software without offline processing, which are shown in Figure 4. Again, the “Prisma optimized” protocol results in a noticeable improvement in SNR in the FA map. For the three marked ROI’s shown in the images, which were chosen to comprise regions of highly uniform fiber orientation and density, an average reduction in the standard-deviation of FA in the three ROIs in the “Prisma optimized” image was found to be ~25%. For the same three ROI’s, the average ADC standard-deviation fell by ~40% with the “Prisma optimized” protocol, but were otherwise similar for the Trio and the “Trio protocol on Prisma” scan.

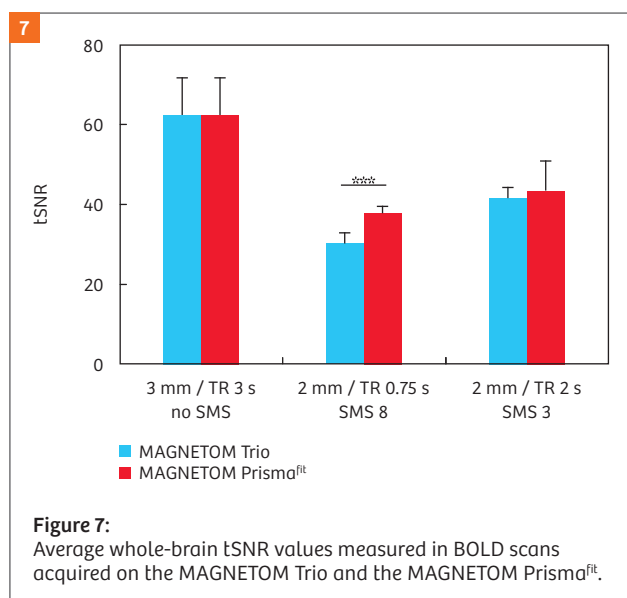
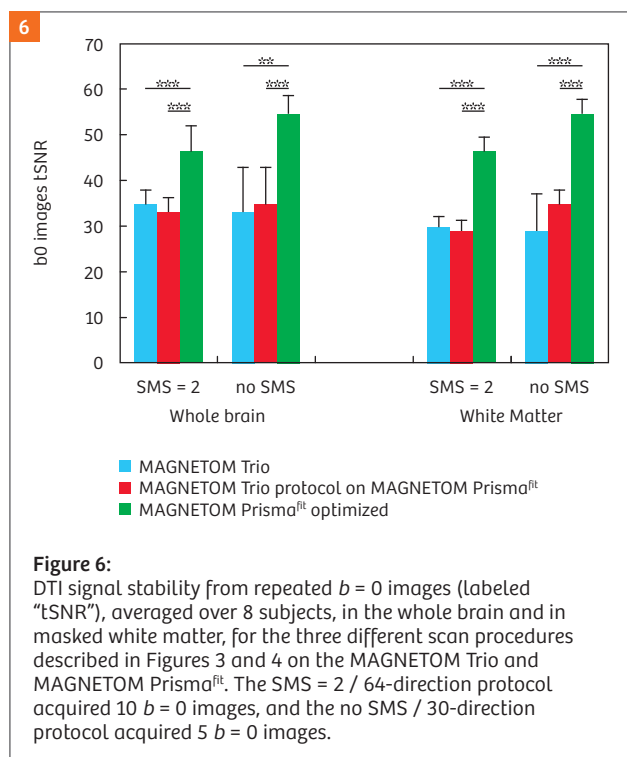
To more carefully quantify the effect of the SNR increase and improved signal stability with the “Prisma optimized” protocol, the diffusion scans were also processed offline using a conventional processing stream including alignment to the T1-weighted image native space before recalculation of the ADC and FA images. The resultant ADC and FA images were then masked by the corpus callosum as derived from the FreeSurfer-processed T1-weighted image for each subject. Figure 5 shows the average of the standard-deviation of ADC and FA within the corpus callosum for the 8 subjects, using the two



acquisition protocols (SMS 2 / 64 directions, and no SMS / 30 directions) on the Trio, and for the “Trio protocol on Prisma” and “Prisma optimized” scans on the Prisma<sup>fit</sup>. Noticeable reductions are seen in both the ADC and FA standard-deviations for the “Prisma optimized” scans for both protocols (all  $p < 0.001$ , except, “Trio protocol on Prisma” versus “Prisma optimized”,  $p < 0.01$ ); while the “Trio protocol on Prisma” and the original scan on the Trio essentially give indistinguishable results ( $p > 0.05$ ).

Signal stability was also assessed from the repeated  $b = 0$  images in each diffusion scan, in the same way it would be done for BOLD scans – dividing the mean image (after realignment) by the standard-deviation, to give a “time-series SNR” or tSNR image. This was done with 5  $b = 0$  images from each scan for the no SMS / 30 direction protocol, and 10  $b = 0$  images for the SMS 2 / 64 direction protocol. In each case, the metric was calculated on the whole brain after brain extraction, and on an image masked to show only the segmented white matter from the FreeSurfer-processed T1-weighted image for each subject. As shown in Figure 6, the “Prisma optimized” scans for both protocols exhibited improvements in tSNR of ~30–40% compared to the “Trio protocol on Prisma” and the original scan on the Trio (all  $p < 0.001$ ), while the “Trio protocol on Prisma” and the original scan on the Trio were similar ( $p > 0.05$ ).

These results show that the new, high-performance gradient coil that is the heart of the Prisma indeed delivers the expected boost of SNR to MRI diffusion scans, when the acquisition protocols are optimized to take full use of the new gradient strength and slew rate. The reduction in TE of ~30–40% for a commonly employed acquisition protocol can yield similar increases in diffusion-scan signal stability, and reduce the uncertainties in derived diffusion metrics by similar amounts. Of course, these new gradient capabilities are also being used to bring more advanced diffusion acquisition protocols into the mainstream, employing higher, and multiple,  $b$  values, and more diffusion directions; to improve fiber-tracking definition in areas where fibers cross. The multi-site Human Connectome Projects on Aging and Development, and the Adolescent Brain Cognitive Development (ABCD)



study, both in the US, are both employing  $b$  values up to 3000 s/mm<sup>2</sup> with 100–200  $b$ -vectors for routine use in studies that will scan thousands of subjects. Alternatively, for those wishing to replicate the diffusion protocol and data quality for studies ongoing from Trio scanners, the identical implementation of a protocol, with the gradient mode restricted to “Fast” mode, should give equivalent data on the Prisma.

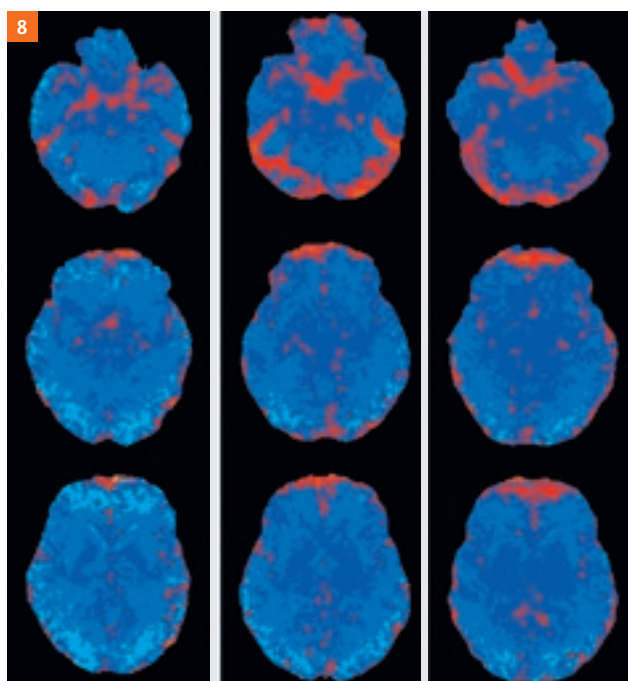
## Results/discussion – functional scans

Although Siemens Healthcare had not promised improvement to the quality and stability of EPI-BOLD scanning, we had initial hopes that some of the other hardware improvements, such as the all-optical transmit/receive chain between the magnet and the equipment room, the new solid-state RF amplifier system on the side of the magnet, and the fact that BOLD imaging would use a lower % of the maximum gradient strength (same gradient strength as used on the Trio, to avoid severe peripheral nerve and possibly cardiac stimulation) might serve to reduce instrumental noise and so increase the time-series SNR (tSNR) that determines the ability to detect BOLD activations.

Initial tests with the standard water phantom bore this expectation out. Using the 32-channel head coil, and the 3 mm / 500-timepoint EPI-stability protocol we run daily for scanner quality assurance, we observed a ~25% increase in tSNR when the protocol was first implemented on the Prismafit. However, the BOLD scans conducted on the 8 human subjects suggest that physiological noise in humans, at this frequency and field strength, is a great equalizer [11]. Figure 7 summarizes the tSNR results. The 3 mm / TR = 3 sec / no SMS resting state BOLD scans showed no change in average tSNR across the whole brain for the 8 subjects ( $p > 0.05$ ). At higher spatial resolution, there were small gains in tSNR observed with the Prismafit. The TR = 2 s / SMS 3 protocol showed a ~5% gain in tSNR – although not statistically significant given the number of subjects ( $p > 0.05$ ). The high temporal resolution resting-state BOLD scans (TR = 750 ms / SMS = 8) showed a modest gain of ~20% when averaged across all subjects ( $p < 0.001$ ). However, benefits for resting-state network analysis were minimal, with improved definition of the networks seen in some subjects, but no quantifiable improvement observed in other subjects, or when averaged over all eight subjects. It is possible that certain tasks that yield weak activations may provide better results on the Prismafit under conditions of high spatial and/or temporal resolution. But for routine BOLD scans as commonly carried out in neuroimaging studies, with a spatial resolution of ~2.5–3 mm and TR of 2–3 sec, the Prisma will provide similar quality BOLD data to the Trio.

However, the new hardware of the Prismafit led us to re-evaluate what should be baseline acquisition protocols for BOLD scanning for routine use, with respect to either spatial or temporal resolution. The full details of this BOLD optimization is beyond the scope of this article. However, one example warrants brief mention, for it relies on a combination of improvements in the gradient coil and the improved speed of the new reconstruction





**Figure 8:**

Maps of tSNR difference in resting-state BOLD scans from three axial slices in three subjects, acquired on the MAGNETOM Prisma<sup>fit</sup>. Red / orange indicates regions where tSNR is higher using a 1.7 mm resolution / GRAPPA = 2 / SMS = 3 protocol. Blue indicates regions where tSNR is higher with a 2.2 mm / no GRAPPA / SMS = 3 protocol.

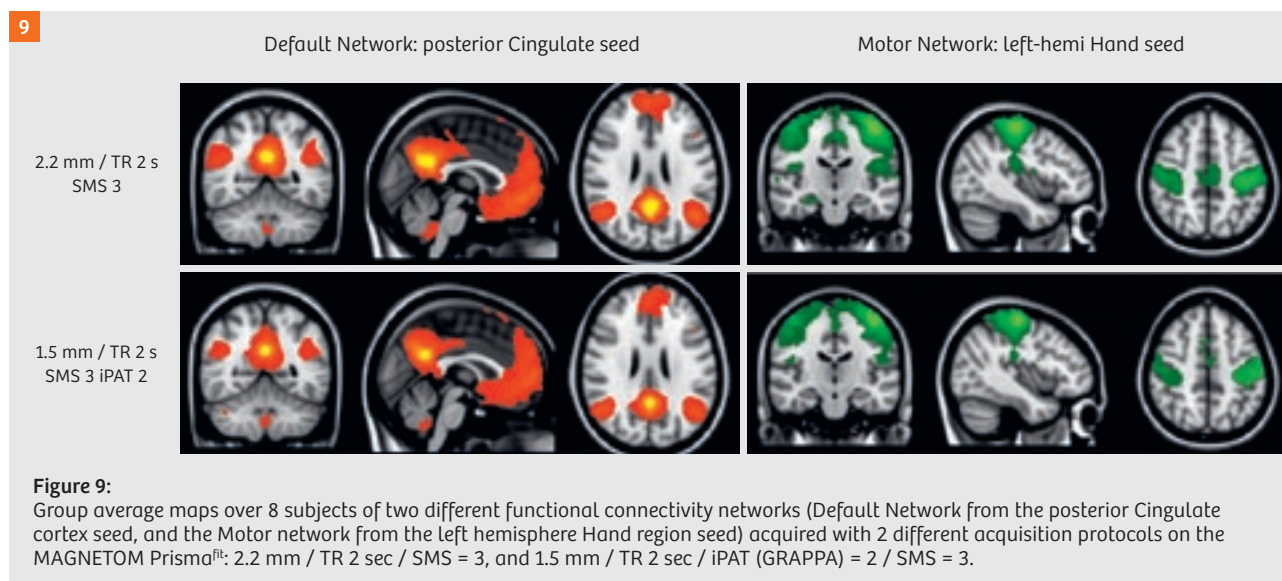
computer, combined with simultaneous multi-slice techniques, which allowed us to push the envelope of spatial resolution for whole-brain BOLD scanning beyond what was routinely possible on the Trio, and achieve 1.5 mm and 1.7 mm isotropic resolution that our psychology faculty are now using successfully in standard neuroimaging studies. While not technically impossible on the Trio, the improved slew rate of the Prisma gradient coil and the higher “forbidden echo spacing” range due to acoustic resonances (0.78–0.93 ms vs ~0.58–0.69 ms on the Trio), enable the very large matrix size required for this spatial resolution with only two-fold GRAPPA acceleration to keep the TE to around 30 ms. Along with the improved echo-spacing that makes each echo train slightly shorter, the use of SMS allows the ~80–90 slices required for full brain coverage to be acquired in a 2-second TR, while the improved reconstruction system enables the data to be reconstructed without lagging behind the acquisition, despite the large matrix size and number of slices. Acquiring such data would certainly tax the older reconstruction hardware of the Trio.

The main benefits of using such a high spatial-resolution is to reduce partial volume effects over the cortical surface

and to further ameliorate susceptibility-induced dropout and distortion in high-susceptibility areas of the human brain such as the orbital frontal cortex and the temporal poles. In these areas, EPI signal, and BOLD activations, may be seen from brain regions that are often not detected at 3T. (The benefits of higher spatial resolution, while maintaining high MR signal despite using smaller voxels, is one of the benefits of using an ultra-high field MRI system such as the 7T MAGNETOM Terra.) While the tSNR is lower in much of the brain than for acquisition protocols with ~2.0–2.5 mm spatial resolution, on the MAGNETOM Prisma<sup>fit</sup>, we found the tSNR remained high enough to detect robust BOLD activations such as those of the principal resting-state networks with similar BOLD sensitivity to what was achieved at coarser spatial resolutions. In addition, not only was tSNR improved in the frontal and temporal regions, but we have detected – in numerous subjects – increased tSNR around much of the cortical surface, specifically in visual and parietal regions, where we did not initially expect significant benefit. This improved tSNR at high resolution presumably results from decreased partial-volume effects around the cortical surface, where larger voxels are contaminated by significant amounts of CSF with inherent physiological fluctuations. Figure 8 shows, for 3 axial slices in 3 different subjects, areas in red where tSNR is higher when using a 1.7 mm / TR 2 sec protocol than when using a 2.2 mm / TR 2 sec protocol (2.2 mm being the highest spatial resolution we could achieve without using in-plane acceleration, while keeping TE below 35 ms). The blue regions indicate where the 2.2 mm protocol had higher tSNR, as a result of higher mean signal in the larger voxels. Figure 9 shows group-average functional connectivity maps for 2 different protocols trialed on the Prisma<sup>fit</sup>, namely the 2.2 mm spatial resolution protocol used in Figure 8 and the 1.5 mm protocol described above. The network maps, from two different seed regions, were remarkably similar despite the reduction in voxel size. Work from some of CBS’s psychology faculty users employing the 1.5 mm spatial resolution protocol at 3T is already appearing in the literature [12], while others have employed increased temporal resolution in new studies [13].

## Conclusions

The MAGNETOM Prisma<sup>fit</sup> has been an incredible resource and superb tool for high-quality neuroimaging studies at Harvard’s Center for Brain Science Neuroimaging facility. The hardware advances in the MAGNETOM Prisma<sup>fit</sup>, as compared to the MAGNETOM Trio, provide the potential for significant improvements in diffusion imaging acquisition protocols, while functional (BOLD) imaging can benefit in a narrower range of optimized high-resolution protocols making higher spatial or temporal



resolution routinely attainable. However, of importance to those running long-term studies that require system stability, we have shown that coarser-resolution BOLD protocols and older, simpler diffusion protocols can be translated from the Trio to the Prisma<sup>fit</sup> and provide data of a similar quality in terms of signal stability (tSNR), resting state BOLD activation, and standard-deviation of ADC and FA for fixed ROIs of ordered white matter. Additionally, minimal variation is observed in brain morphometric data derived from T1-weighted images from the same subjects, acquired over a 4-month interval, on the Trio and the Prisma<sup>fit</sup>, indicating that scanner upgrade, in this case, should not bias long-running morphometric studies, provided gradient non-linearity is accounted for.

## Acknowledgements

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# The fit experience in Canada

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## Introduction

Canada has a large number of MAGNETOM Avanto 1.5T scanners, and a growing number of MAGNETOM Avanto<sup>fit</sup> 1.5T scanners.

Due to the funding models in Canada, currently and in the foreseeable future, there is the mentality of having to do more with less. Canada has a low number of MRI systems per capita compared to many other countries, and a scanner runs on average 18 to 24 hours per day.

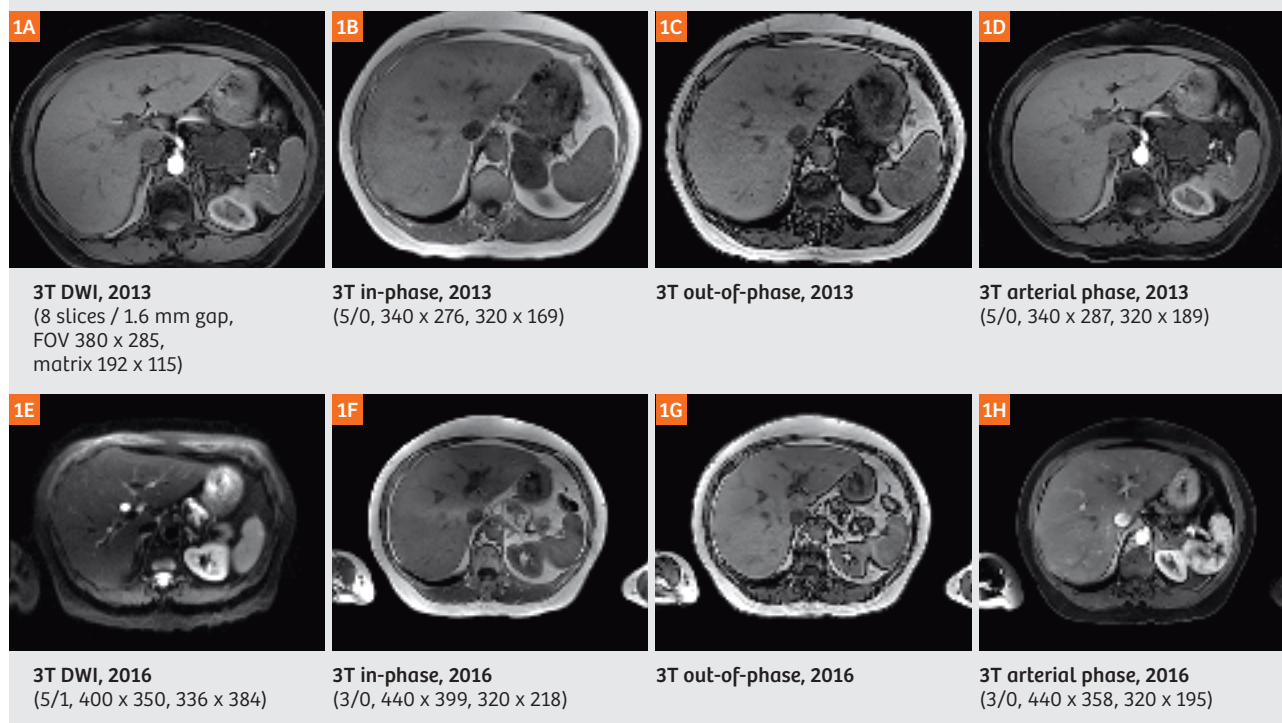
The Siemens Avanto<sup>fit</sup> upgrade program allows radiologists and technologists to bring their existing systems up to the cutting edge of MRI technology, at a significantly

lower cost than a new high end clinical system, all within a very short three weeks of downtime. A new system installation is normally ten to fourteen weeks of downtime due to construction, possible damage/replacement of the radio frequency cage etc.

## The upgrades

The Toronto General Hospital (TGH) and the Princess Margaret Cancer Center (PM) MRI departments, both part of the University Health Network (UHN) and the Joint Department of Medical Imaging (JDMI), upgraded to the MAGNETOM Avanto<sup>fit</sup> and MAGNETOM Skyra<sup>fit</sup> systems in late 2013.

Figure 1: Liver imaging.





These included two MAGNETOM Avanto 1.5T scanners to Avanto<sup>fit</sup>, and two MAGNETOM Verio 3T scanners to the Skrya<sup>fit</sup> system. As the first fit upgrades in North America for Siemens, each scanner had a planned downtime of 4 weeks to anticipate a learning curve on the install process. The upgrade process, which included mechanics, Siemens commissioning and applications training spanned approximately four months for the two hospital sites. Back to back upgrades took place at Toronto General followed by Princess Margaret.

The upgrade itself included all components except the gradient coil and the magnet for all four of the systems. Each scanner was already equipped with the SQ gradients 45/200. Systems that were equipped with the Q gradient 33/125 would be upgraded to the SQ gradient. Coil and software upgrades were dependant on the configurations of the existing systems and discussions with Siemens during the purchase. The upgraded 1.5T systems are essentially now a MAGNETOM Aera scanner with a 60 cm bore, and the 3T upgraded system is now a MAGNETOM Skrya scanner, bringing them up to the current standards of the top systems in the fleet. The fit systems also offer the option of upgrading to the Tim Dockable Table.

## First experience

Once the upgraded systems were in operation, from an imaging perspective, users immediately saw an improvement in signal-to-noise ratio (SNR) for neuro exams. For exams requiring greater resolution, users were able to drop the field-of-view (FOV) and still see better SNR than on the previous system. This was also evident with the 3T system where pelvic and abdominal imaging was greatly improved both by the 18-channel body matrix coil, but also with the use of the FREEZEit CAIPIRINHA-Dixon-TWIST-VIBE sequence. In our cardiac imaging at the Toronto General site, scan times were shortened on many exams by the implementation of the Cardiac Dot Engine.

If the technologists were to list their favorite features of the upgrade, they would name: the Tim Dockable Table, the ability to reset the patient alarm in the room, faster table movement when the align light is on, and the ability to start the scan from inside the room.

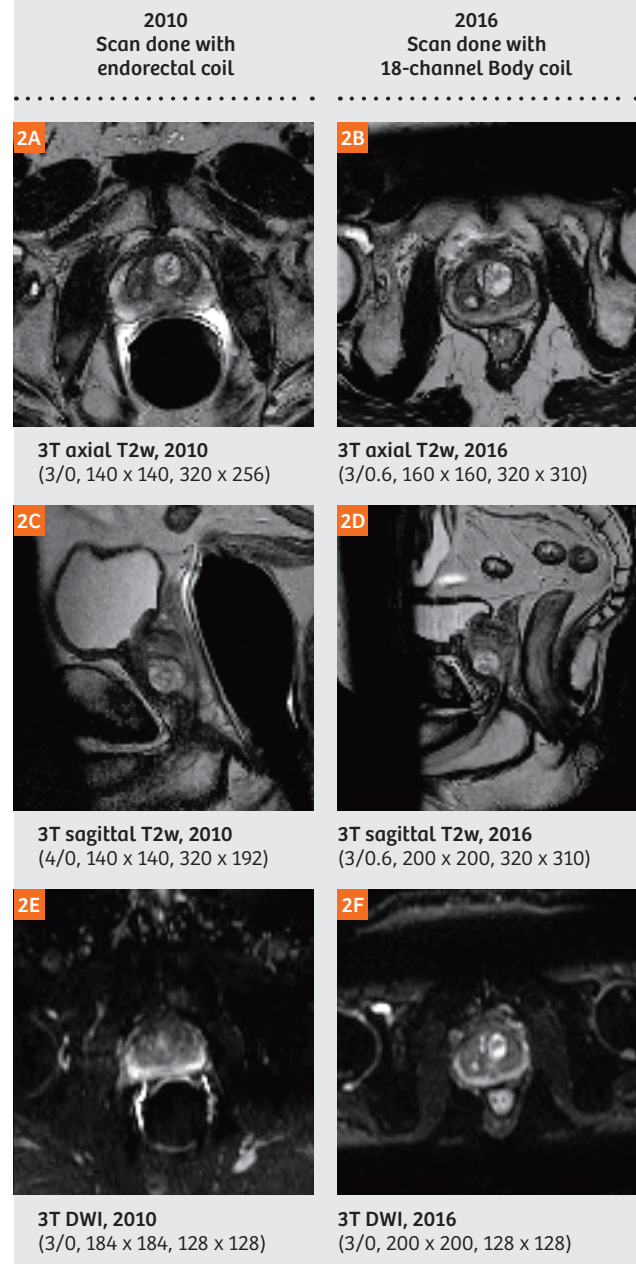
From an exam quality perspective, there were improvements in imaging across the entire body. Time is needed to work through site protocols to optimize to radiologists preferences, however, there is no doubt that the upgrade has been well worth it. Some examples following will show improvements to the imaging. In drastic cases, we were able to eliminate the use of the endorectal coil for 3T prostate imaging for most indications, while in subtle cases, there is simply improved SNR while utilizing the same parameters.

## Imaging examples

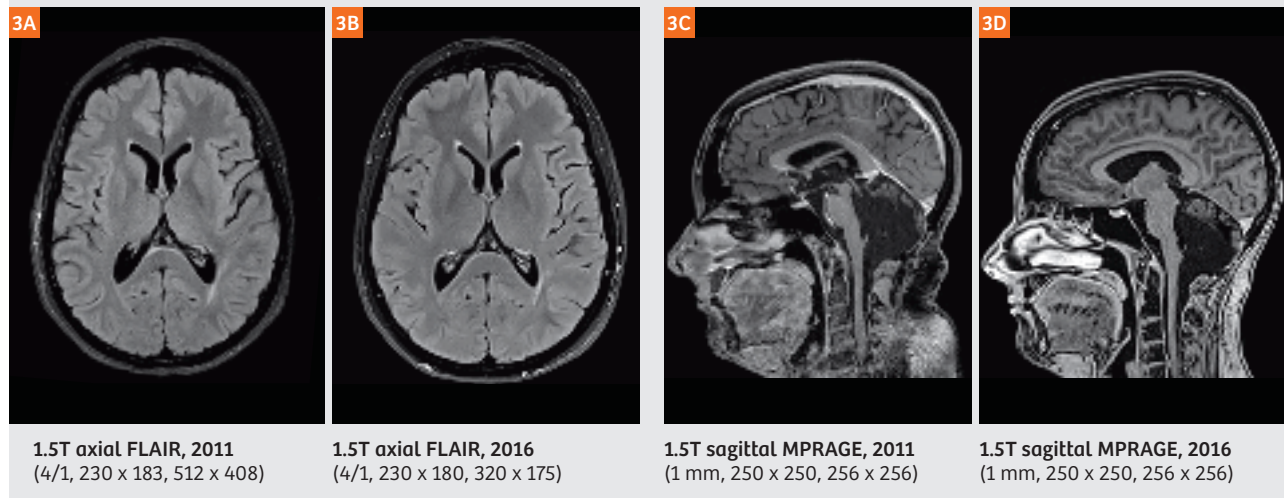
All images shown are of the same patient and on the same scanner before and after the upgrade. The sequence details provided are (slice/gap, FOV, matrix).

**Figure 2:**

Prostate imaging. After the 3T system upgrade (2016) we gained equivalent image quality as previous exams done with the endorectal (ER) coil (2010).

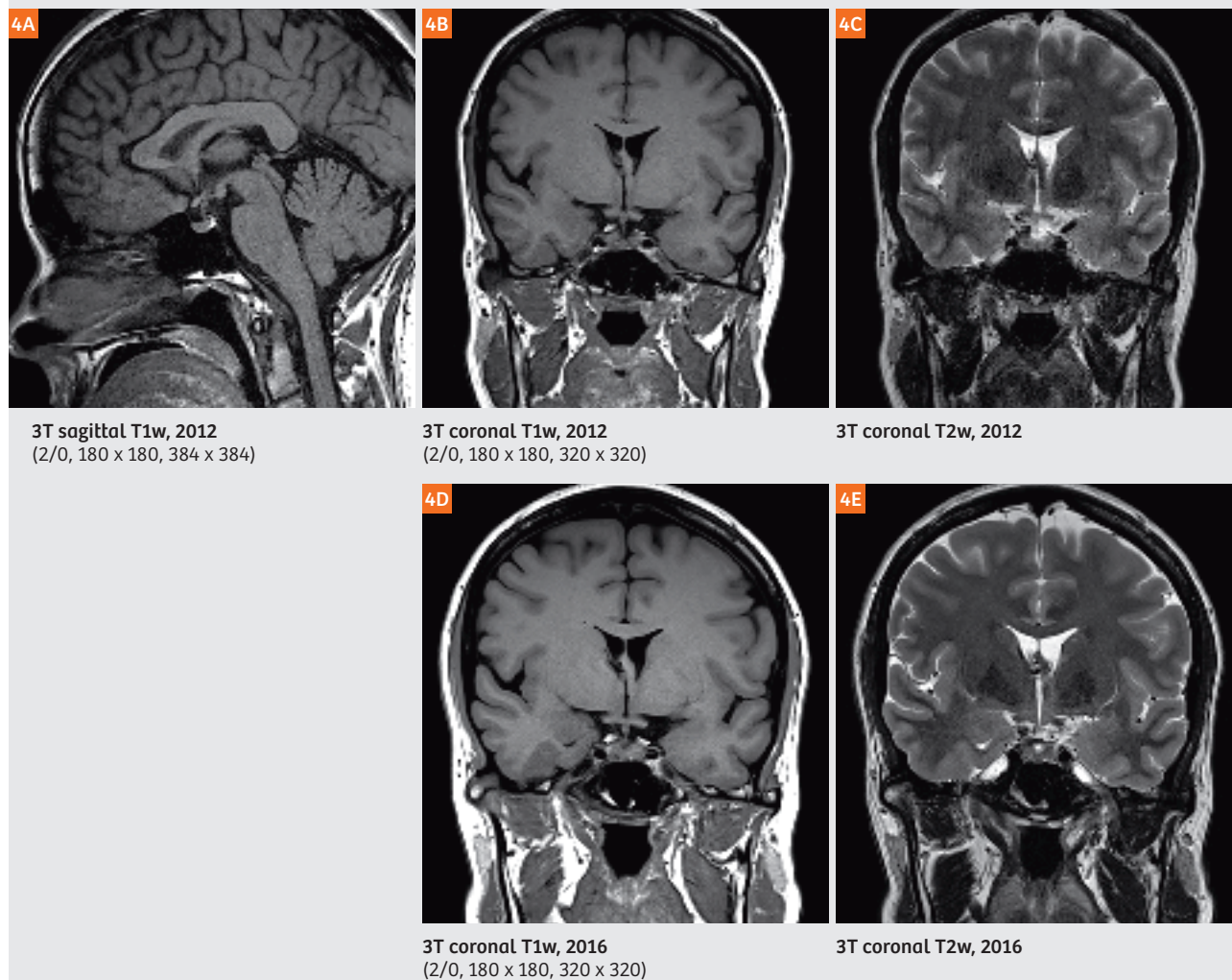


**Figure 3:** Brain imaging at 1.5T shows improved SNR (note: the resolution for FLAIR is decreased).



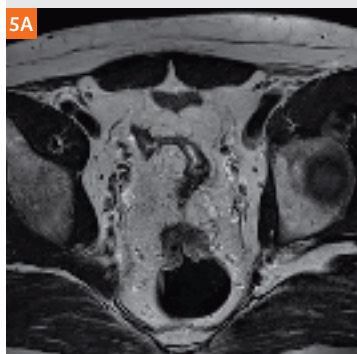
**Figure 4:**

Sella imaging at 3T. The parameters are the same but note the significant increase in SNR throughout the images with the Skyra<sup>fit</sup> upgrade.





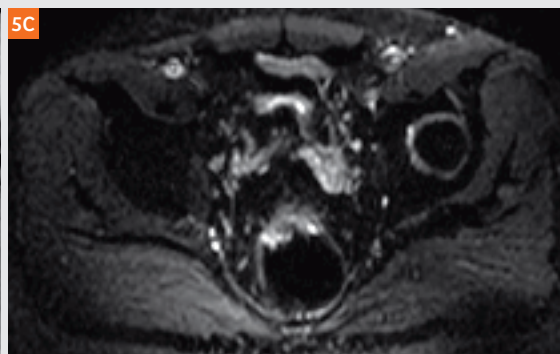
**Figure 5:** After the 3T system upgrade (2016) we increased resolution on T2 imaging in pelvic exams.



**3T axial T2w, 2012**  
(4/1, 220 x 220, 320 x 320)



**3T sagittal T2w, 2012**  
(4/1, 220 x 220, 320 x 320)



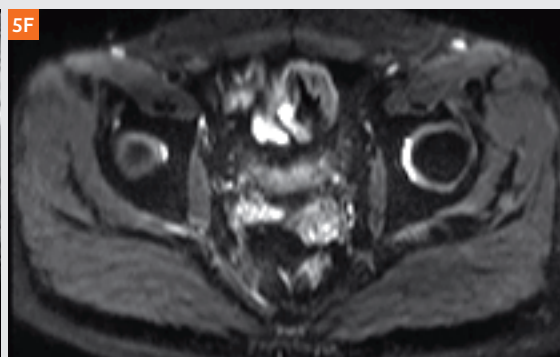
**3T axial DWI, 2012**  
(4/0.8, 278 x 370, 384 x 230)



**3T axial T2w, 2016**  
(4/1, 200 x 200, 320 x 320)



**3T sagittal, T2w, 2016**  
(3/0.5, 220 x 220, 320 x 320)



**3T axial DWI, 2016**  
(4/1, 144 x 192, 340 x 340)

*“The fit upgrade option is of an amazing value. If you have a system with a stable magnet, you will end up with the equivalent to a new system at approximately a third of the cost, as well as decreased downtime.”*

*We are happy to keep our Avanto magnet, with the 50 cm z-axis FOV and excellent homogeneity, and yet have all the features and software of the Aera system.”*

**Nancy Talbot, MRI Supervisor**  
Princess Margaret Cancer Centre

The statements by Siemens' customers described herein are based on results that were achieved in the customer's unique setting. Since there is no 'typical' setting and many variables exist there can be no guarantee that other customers will achieve the same results.

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# Long-term experience with MR Upgrades

Christos Loupatatzis, M.D.

MRI AG Spital Maennedorf, Switzerland

In this article we share some of our experiences over the last few years with MR upgrades.

The MRI AG Spital Maennedorf is located beside Lake Zurich in Switzerland and is one of the leading MR-centers in the region. With its close relationship to the academic hospital Maennedorf and to specialized practitioners with a variety of subspecialties including Orthopedics, Trauma-/General-/Hand- and Neuro-Surgery, Neurology, Psychiatry, Gastroenterology, Urology, Gynecology and Angiology we receive requests for MR examinations all over the body ("from head to toe"). We therefore need an MRI scanner able to perform all kinds of examinations at a

very high level. Our referring physicians recognize the high quality of our work and our participation in radiology boards and meetings (e.g. European School of Radiology). Without the proper technical equipment it would not be possible to sustain this high level.

In 2007 the decision was made to acquire a MAGNETOM Avanto 1.5T MRI system (Siemens Healthcare, Erlangen, Germany). This scanner worked consistently over the years to provide very good image quality. Nevertheless, always aiming to optimize our image quality and performance, in 2013 we became one of the first MRI centers in Switzerland to perform a fit upgrade, accompanied by a Dot upgrade.

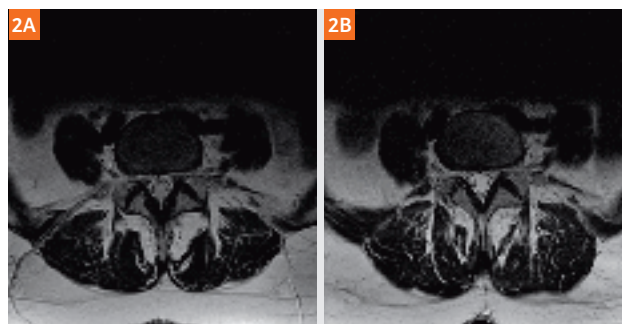


TR 4000 ms, TE 122 ms,  
TA 3 min, 12 slices,  
FOV 317 x 320,  
matrix 754 x 896, SL 4.0 mm

TR 3250 ms, TE 91 ms,  
TA 3:31 min, 15 slices,  
FOV 300 x 300,  
matrix 307 x 512, SL 4.0 mm

**Figure 1:**

46-year-old female patient. T2w sagittal images of the lumbar spine, before (1A) and after (1B) MAGNETOM Avanto<sup>fit</sup> upgrade. Note the improved image quality in 1B (i.e. better delineation of the nerve roots).



TR 3100 ms, TE 108 ms,  
TA 3:03 min, 15 slices,  
FOV 248 x 250,  
matrix 311 x 448, SL 4.0 mm

TR 3800 ms, TE 108 ms,  
TA 2:58 min, 16 slices,  
FOV 200 x 200,  
matrix 269 x 448, SL 4.0 mm

**Figure 2:**

Same patient as in Figure 1. T2w axial images of the lumbar spine, before (2A) and after (2B) MAGNETOM Avanto<sup>fit</sup> upgrade. In 2B note the possibility to reduce the FOV and therefore improved image resolution, in shorter acquisition time (i.e. the nerve roots).

Notwithstanding the acquisition of additional diagnostic tools during the first years (such as spectroscopy, perfusion imaging and susceptibility-weighted imaging), this fit upgrade was our first major MR upgrade. A second major step has been our update to software version *syngo* MR E11C. A milestone in this context was our participation as a CPF ("Customer Preference Feedback") reference center for the *syngo* MR E11C software version in 2015/2016.

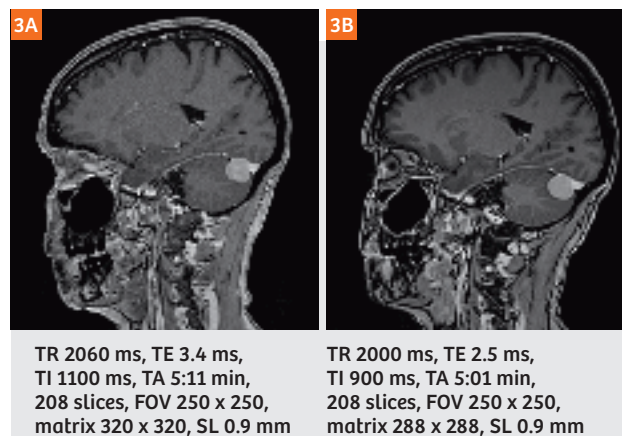
### Avanto<sup>fit</sup> and first Dot engine experiences

Despite the high image quality of the MAGNETOM Avanto system, we needed firstly to respond to our referring physicians' demands for the best image quality, and secondly to stay competitive as a leading MRI center amongst the increasing number of 3T systems available in the Zurich area. We decided on the Avanto<sup>fit</sup> upgrade instead of buying a new scanner, a solution we thought would be more cost efficient and less time consuming. Since we have only one MRI scanner, we could not afford the time required for the de-installation and a new installation, whereas an upgrade would reduce the downtime of the system to a couple of days. We decided to carry out this fit upgrade during the summer holiday season, when most of our referring physicians were on holiday. Following the fit upgrade installation we received one week's intensive support from our Siemens MR Application Specialist, since obviously an adjustment of all our sequence protocols was necessary. This intensive and time-consuming period after installation was followed by a two-month period of further protocol optimization, with the help of the application specialist, adapting the initial protocols after gaining some experience with the new system. In retrospect, all of our efforts were worthwhile.

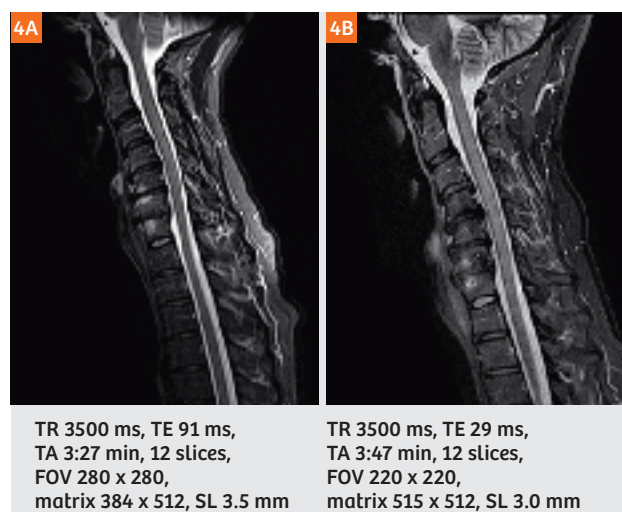
The improvement of the image quality was obvious in all examinations over the whole body. External neurologists and orthopedic surgeons mentioned that our image quality was so good that they thought we bought a 3T-system (Figs. 1, 2). This fit upgrade had two benefits of a 1.5T over a 3T system: Less susceptibility artifacts, specifically in abdominal imaging, as well as patient security and fewer limitations in case of intracorporeal medical devices such as prosthetic cardiac valves etc. This was definitively the right choice for our institution.

In brain-imaging specifically the 3D-MPRAGE-sequence became much crispier and clearer (Fig. 3) and the RESOLVE-diffusion showed significantly less artifacts in comparison to the standard EPI diffusion. In spine-imaging we were able to reduce the field-of-view (FOV) and therefore increase the resolution with even higher signal-to-noise ratio (SNR) (Fig. 4). In shoulder-imaging, the new Shoulder 16-channel coil not only gave better image quality, but also increased patient comfort when

positioned. In knee-imaging, the new 15-channel Tx/Rx Knee coil produced images of a quality superior to the previous system (Fig. 5). The only disadvantage is that obese patients and patients after trauma unable to stretch-out their knee do not fit into this coil: For those cases we still use the previous Extremity coil with an additional adapter in order to enable the link with the new system. Special mention should go to the Hand/Wrist



**Figure 3:** 54-year-old female patient. 3D-MPRAGE-sequence of the brain after contrast administration before (3A) and after (3B) MAGNETOM Avanto<sup>fit</sup> upgrade showing a meningeoma of the cerebellar tentorium. Note the much better image quality in less acquisition time in 3B (i.e. the delineation of the cortical matter).



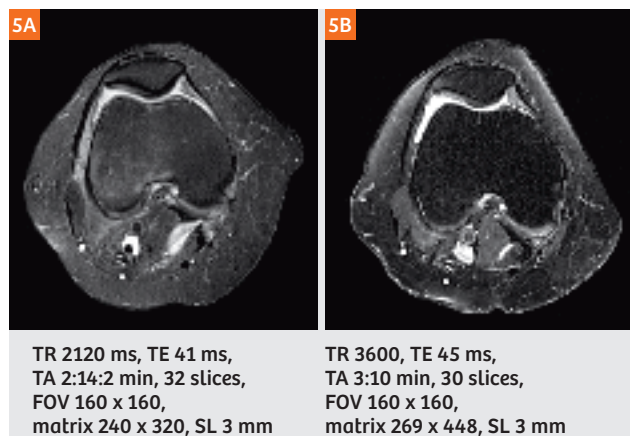
**Figure 4:** 45-year-old male patient. STIR sagittal images of the cervical spine, before (4A) and after (4B) MAGNETOM Avanto<sup>fit</sup> upgrade. Note the possibility to reduce both the FOV and the slice-thickness with minimal increase in acquisition time, and with a superior image quality in 4B (i.e. the subtle signal intensity changes of the spinal cord).

16 coil and Foot/Ankle 16 coil for their convenience for the patient and for enabling the scan of very small structures (such as a finger joint) or the whole hand, and the foot without moving the target area within the coil (for example imaging a distal joint or a proximal joint; Fig. 6).

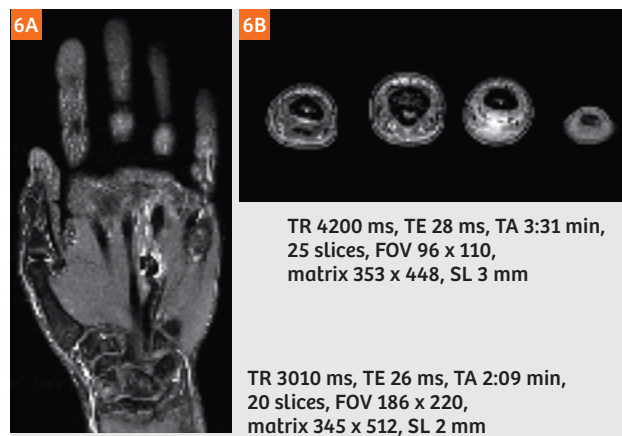
Feedback from our technologists tells us that one of the advantages of the fit upgrade is the much easier handling

of the coils with the new innovative SlideConnect system and the new in-room display at the scanner, which enables the technologist to get information about the coils before leaving the scanner room. Additionally the display provides patient-data-information, ECG-waves, etc.

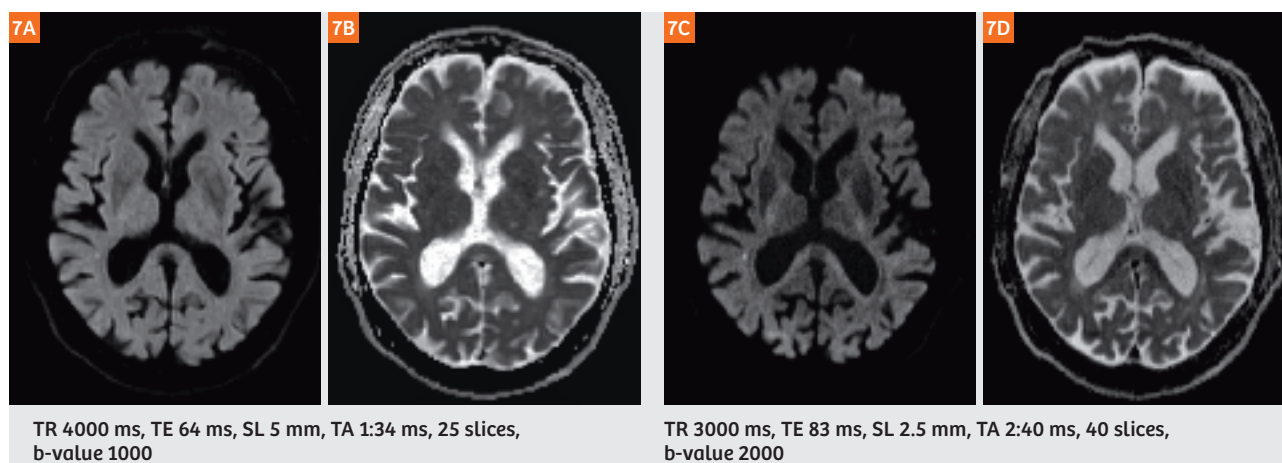
Definitely one of the biggest steps of evolution and advantage of the new system is the standardization of the exam



**Figure 5:** 75-year-old female patient. Proton Density-weighted fat sat (PDFs) axial images of the knee before (5A) and after (5B) MAGNETOM Avanto<sup>fit</sup> upgrade, using the new 15 channel knee coil. Note the much better image quality in 5B (i.e. in the retropatellar cartilage).

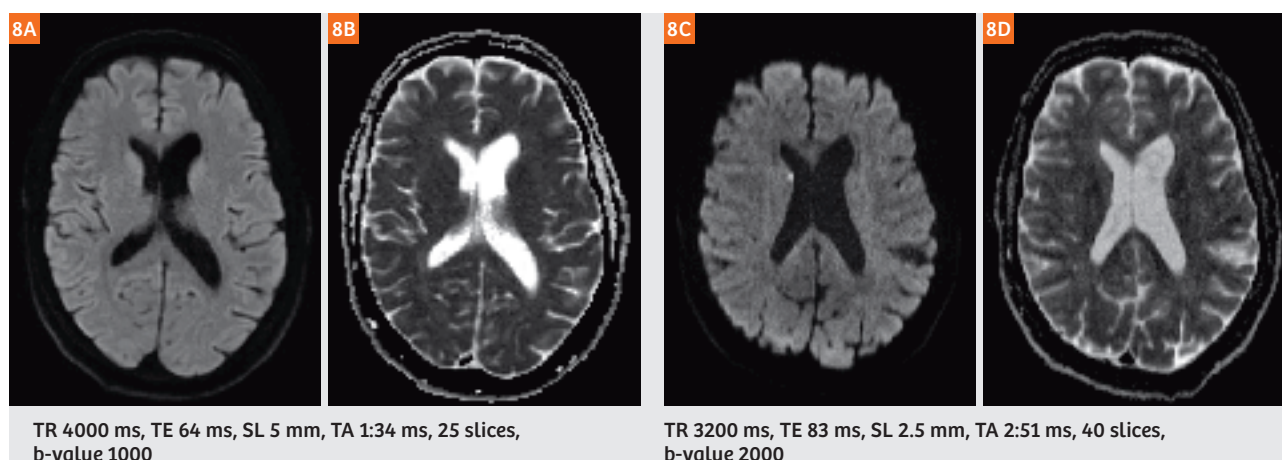


**Figure 6:** 15-year-old male patient with rupture of the flexor digitorum profundus tendon (4th finger). Note the high quality images: (6A) Coronal PDFs image showing the retracted tendon and (6B) axial PDFs image showing the empty space, where the tendon should be.



**Figure 7:** 71-year-old male patient with focal acute embolic ischemia within the Meyer's loop on the right hemisphere (standard RESOLVE Diffusion (7A) b1000 image, (7B) ADC map). Note the much better visibility of the pathology using thinner slices and higher b-value (modified SMS-Diffusion (7C) b2000 image, (7D) ADC map). Because of the Simultaneous Multi-Slice acquisition, the image quality is very good (7C, D), even with a b-value of 2000. (Also see Table 1.)





**Figure 8:**

56-year-old male patient with focal acute lacunar infarct in the head of the right caudate nucleus, only visible in the modified SMS-Diffusion sequence (8C, D). No visibility of the pathology at all in the standard 5 mm RESOLVE diffusion (8A, B). Standard RESOLVE Diffusion (8A) b1000 image, (8B) ADC map; modified SMS-Diffusion (8C) b2000 image, (8D) ADC map. (Also see Table 1.)

protocols using the Dot engines in routine examinations. The first Dot engines we used were the Brain and the Spine Dot Engines. The Brain Dot Engine, with AutoAlign, its automatic anatomic orientation, not only helps less experienced technologists to reliably find the anatomic landmarks for an optimal examination, but also guides the radiologist in the comparison of the image-planes in follow-up brain studies such as in multiple sclerosis patients, because of the identical slice orientation and slice-positioning. The Spine Dot Engine was very useful in ensuring a complete coverage of the spine, even for patients with scoliosis. The automatic labelling of the axial slices is very much appreciated by our referring spine-surgeons, helping them to look quickly through the images even as hard-copy films, which many of them still share and discuss with their patients, rather than the primary images taken from CD.

### Update to syngo MR E11C

The update to the new software version syngo MR E11C has had profound benefits for our team. Whilst we faced major software layout changes, we also benefited from new possibilities and opportunities by using the new workflow and a number of new Dot engines.

Perhaps the most important improvement in image quality due to syngo MR E11C is simultaneous multi-slice (SMS) diffusion-imaging. Realizing the possibilities of high SNR and time-efficiency of this sequence, one of our first modifications for brain imaging was to create a 2.5 mm thin sliced sequence with a b-value of 2000 s/mm<sup>2</sup>. This modification was initially scrutinized by the Siemens-

developers, who were quickly convinced of the advantages of this modification. With such a high b-value the conspicuity of acute ischemic lesions increased dramatically. Using the very robust RESOLVE diffusion (b-value 1000 s/mm<sup>2</sup>, 5 mm slice thickness) as a standard sequence, we sometimes doubted the interpretation of our findings as to whether or not there was an ischemic lesion. However, using the modified SMS-diffusion, we were able to eliminate these doubts in all cases. Therefore this sequence found its way into our standard stroke protocol (Figs. 7, 8, Tab. 1).

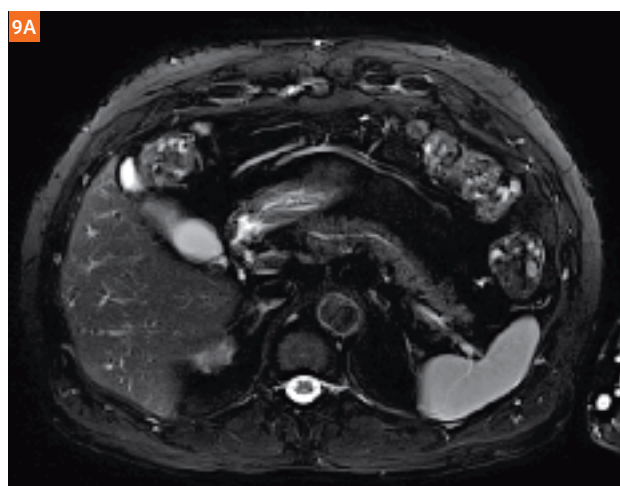
A substantial improvement of the new syngo MR E11 software has been the new ability with the Dot Cockpit to create and combine Dot protocols in a definitively easier way than in prior software versions. With a basic instruction we were able to create our own new Dot-protocols, according to our local needs, without reliance on an application specialist.

Initially, the acceptance of the Abdomen Dot Engine was suboptimal: being used to manually adapting the positioning of various parameters (e.g. slice, slab, FOV etc.) to the patients' anatomy and cooperation, we had to learn a more passive role during the acquisition of the examination. Nevertheless, the vast advantages of a guided workflow and automatic adaption of field-of-view and number of slices to the individual anatomy with AutoCoverage soon convinced us – especially for the liver. Less experienced technologists in particular appreciated the automatism for the more challenging abdominal studies. The automatic breathing commands in the Dot Engine allowed us to standardize the timing of our

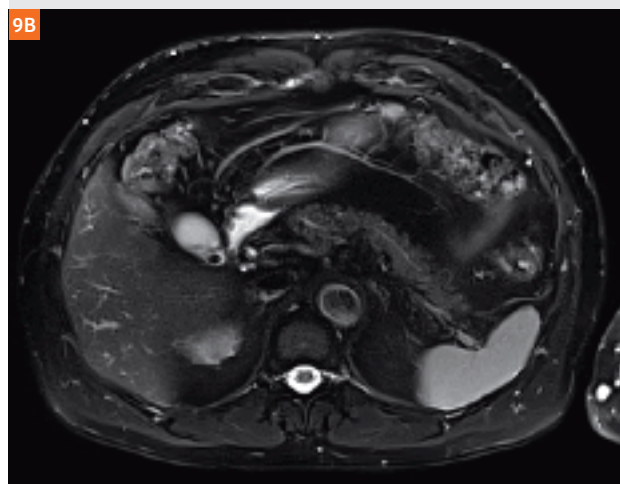
	Original parameters	Parameters for SMS Diffusion in stroke protocol
Voxel size (mm)	0.6 x 0.6 x 4.0	0.6 x 0.6 x 2.5
PAT	4	4
Accelerator factor slice	2	2
Slices	28	40
Position	Isocenter	L2.8 A26.4 H21.7 mm
Orientation	Transversal	T > C-4.1 > S-2.1
FOV (mm)	220	230
Slices (mm)	4	2.5
TR (ms)	4000	3200
TE (ms)	97	83
Coil elements	HE 1-4	HE 1-4; NE1,2
AutoAlign	—	Head > Brain
Initial position (L x P x H) (mm)	Isocenter	0 x 17 x 2.8
<b>System adjustments</b>		
B1 Shim mode	TrueForm	None
Diffusion mode	4-scan trace	4-scan trace
Diffusion scheme	bipolar	monopolar
<b>Diffusion-weightings</b>		
b-value 1	0 s/mm <sup>2</sup>	0 s/mm <sup>2</sup>
b-value 2	1000 s/mm <sup>2</sup>	2000 s/mm <sup>2</sup>
<b>Sequence part 1</b>		
Echo spacing (ms)	1.04	0.91
Bandwidth (Hz/Px)	1042	1240
TA (min)	1:17	2:51

**Table 1:** Modified parameters of Simultaneous Multi-Slice (SMS) Diffusion for standard stroke protocol.

arterial phase in liver imaging by using the bolus-tracking technique with automatic bolus detection, thereby enabling us to acquire a consistent arterial phase, independent of patients' cardiac output. This contrast phase stability has been particularly useful in the follow-up of patients with liver cirrhosis and screening for hepatocellular carcinoma. As to time-efficiency, the new fast BLADE technique allowed a much quicker T2 acquisition of the liver, especially when using a gated



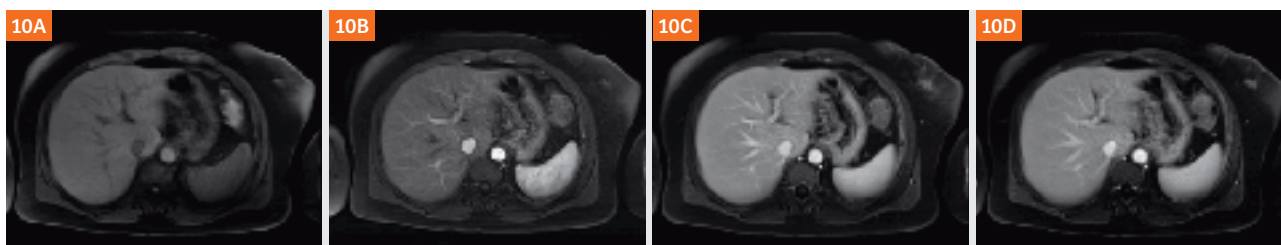
TR 5325.3 ms, TE 96 ms,  
TA 46.06 x 5, FOV 380 x 380,  
matrix 320 x 320, SL 6 mm



TR 5274.1, TE 83 ms,  
TA 22.77 x 5, FOV 380 x 380,  
matrix 320 x 320, SL 6 mm

**Figure 9:** Abdominal imaging of a 64-year-old male patient. Comparison between T2w fs-acquisition of the liver with gated T2 BLADE (9A) and T2w fast BLADE technique (9B). Note the sharper image contrast and better visibility of the gallbladder stone in less than half of the time in T2w fast BLADE in 9B.

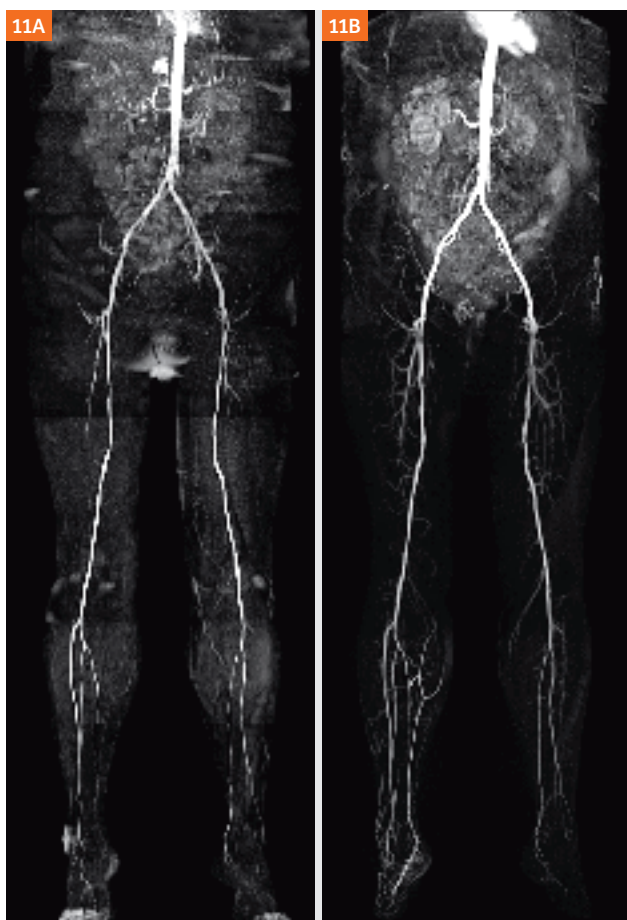
technique (Fig. 9), and the coronal T1 3D acquisition became much faster by using FREEZEit and the StarVIBE (T1 VIBE CAIPIRINHA) technique. The DynaVIBE offers the possibility of multi-arterial phase acquisition, although some institutions prefer only one well-timed arterial phase with bolus-tracking. The StarVIBE technique minimizes breathing artefacts, and is especially useful with patients who are not able to hold their breath, or deaf patients. This was also one of the sequences we modified with



TR 3.3 ms, TE 1.4 ms, TA 21.35 sec, SL 4 mm, FOV 380 x 380

**Figure 10:**

46-year-old female patient, immigrant, unable to understand the language in which the breathing commands were spoken. Modified StarVIBE sequence was used to acquire dynamic imaging before and after contrast-enhancement: (10A) without contrast medium, (10B) late arterial phase, (10C) first hepatovenous phase, (10D) second hepatovenous phase. Note the sharp organ contours and the well delineated anatomic structures without breath-hold imaging in different phases (each phase less than 22 seconds). (Also see Table 2)



TR 544.4, TE 1.7, TT 475.0,  
TI 345.0

TR 3.0, TE 1.0

**Figure 11:**

71-year-old female patient. Comparison between MR Angiography (MRA) with QISS technique without intravenous contrast administration (11A) and MRA with intravenous contrast administration (gadobenate dimeglumine) (11B). Note the comparable image quality in (11A) without intravenous contrast. One of the additional benefits of the QISS technique is the lack of overlapping venous artifacts as seen sometimes in contrast-enhanced MRA.

	Original parameters	Parameters for T1 StarVIBE dynamic liver imaging
Voxel size (mm)	1.2 x 1.2 x 3.0	1.7 x 1.7 x 4.0
<b>Slab group</b>		
Position	Isocenter	Isocenter
Orientation	Transversal	Transversal
Rotation	0.00 deg	90 deg
Phase directions	A - P	R - L
Slice oversampling	44.5%	0.0%
Slices per slab	72	52
FOV (mm)	380	380
Slice thickness (mm)	3	4
TR (ms)	2.83	3.26
TE (ms)	1.48	1.44
Flip angle	9 deg	10 deg
Lines per shot	56	18
Coil elements	BO1-3;SP2,3	BO1-3;SP2-4
<b>Contrast – Dynamic</b>		
Multiple series	Each measurement	Off
<b>Resolution</b>		
Base resolution	320	224
Radial views	680	220
<b>System adjustments</b>		
B1 Shim mode	TrueForm	Off
<b>Sequence part 1</b>		
Bandwidth (Hz/Px)	820	600
<b>Sequence Assistant</b>		
Allowed delay	60 s	–
TA (min)	2:53	0:21

**Table 2:** Modified parameters for dynamic liver imaging for totally uncooperative patients.



the assistance of Siemens creating a test-version<sup>1</sup> of a dynamic StarVIBE sequence, which enabled dynamic liver imaging with decent image quality even with totally uncooperative patients (Fig. 10, Tab. 2). Liver-evaluation techniques with quantification of fat and iron-deposition within the liver are completing an advanced evaluation of liver pathologies.

A new innovative technique with the potential to revolutionize MR-Angiography is the Quiescent-Interval Single-Shot (QISS) sequence. This is the first reasonable alternative to contrast-enhanced angiography, in particular peripheral angiography of lower extremity arteries (Fig. 11). Furthermore the QISS sequence can visualize arterial vessels in the lower leg each time without any overlay of venous vessels, which may happen in contrast-enhanced angiography. Knowing the adverse effects of contrast-media discussed in recent years, such as nephrogenic systemic fibrosis (NSF) and gadolinium accumulation in the brain, and having recently had the personal experience of a very rare life-threatening anaphylactic shock due to gadolinium administration, we do appreciate any development in this direction.

<sup>1</sup> WIP, the product is currently under development and is not for sale in the US and in other countries. Its future availability cannot be ensured.

## Summary

Our long-term experience with MR upgrades is a real success story. Technical innovations lead to better image quality and faster examination protocols, help improve the comfort and safety of the patients through the MR-examination, and especially help increase the radiologists' confidence in the final diagnosis. Therefore, an increased image quality that convinces the referring physician is an improvement in the quality of our product that we hope will lead to a better patient outcome.



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## How many patients do you have to send away or keep waiting due to unpredictable scheduling of MRI exams?

**The Dot Upgrade with syngo MR E11 keeps most common patient time-slot with "10-min exam".**

With an upgrade of your current MAGNETOM Avanto<sup>1</sup>, MAGNETOM Verio<sup>1</sup> or MAGNETOM ESSENZA you can get:

- More predictable scheduling with exam-time variations of less than one minute<sup>2</sup>
- Increased patient throughput up to 20%, e.g. with Brain Dot Engine<sup>3</sup>
- Reduction of patient waiting list

More information under  
[www.siemens.com/dot-upgrade](http://www.siemens.com/dot-upgrade)



<sup>1</sup> syngo MR E11 is currently under development for MAGNETOM Verio and MAGNETOM Avanto and not commercially available. It is not for sale in the US. Its future availability cannot be guaranteed.

<sup>2</sup> Zhongshang Hospital Fudan University, Fudan, CN.

<sup>3</sup> University Hospital Essen, GER, Brain Dot Engine Workflow Study.

The statements by Siemens' customers presented here are based on results that were achieved in the customer's unique setting. Since there is no 'typical' hospital and many variables exist (e.g., hospital size, case mix, level of IT adoption), there can be no guarantee that other customers will achieve the same results.

# Cardiac MRI: image quality improvement and examination time shortening after MAGNETOM Avanto<sup>fit</sup> Upgrade

Enrico Armando; Leonardo Maria Capitolo; Federico Cesarani

Radiology Department, Ospedale Cardinal Massaia, Asti, Italy

## Introduction

Cardiac MRI examinations have long been considered too difficult for general radiologists and radiographers and have therefore often been restricted to academic or dedicated heart centers.

The main technical difficulty of a standard cardiac MRI protocol for the assessment of cardiac function and tissue characterization is the high number of breath-hold and cardiac triggered sequences (about fifty) along cardiac planes, which differ from the anatomical sagittal, coronal and axial planes used in almost every other body application.

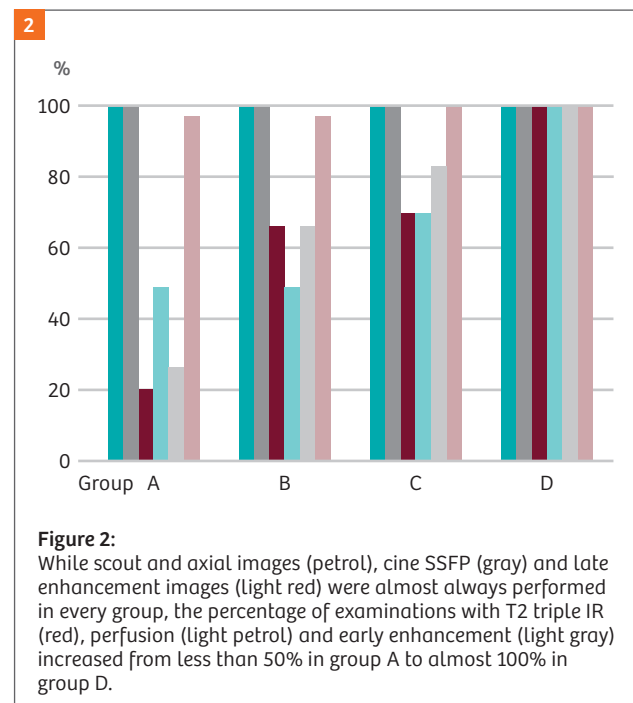
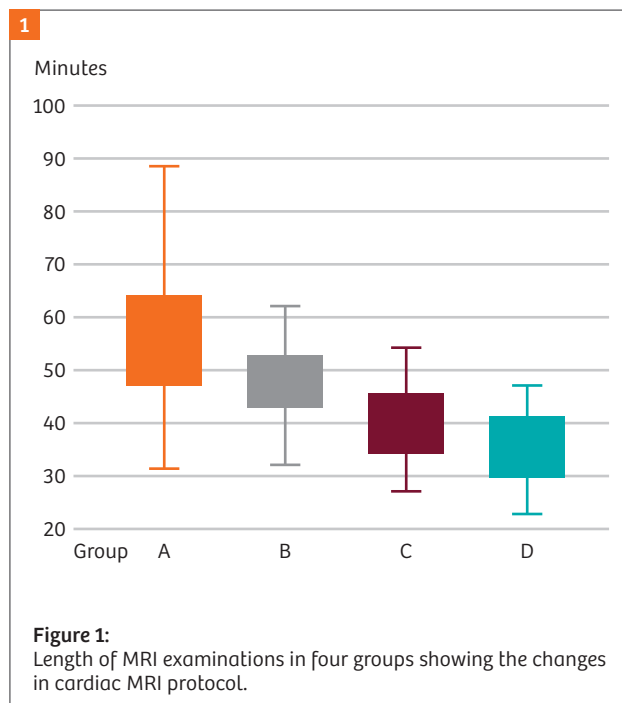
## Gaining time

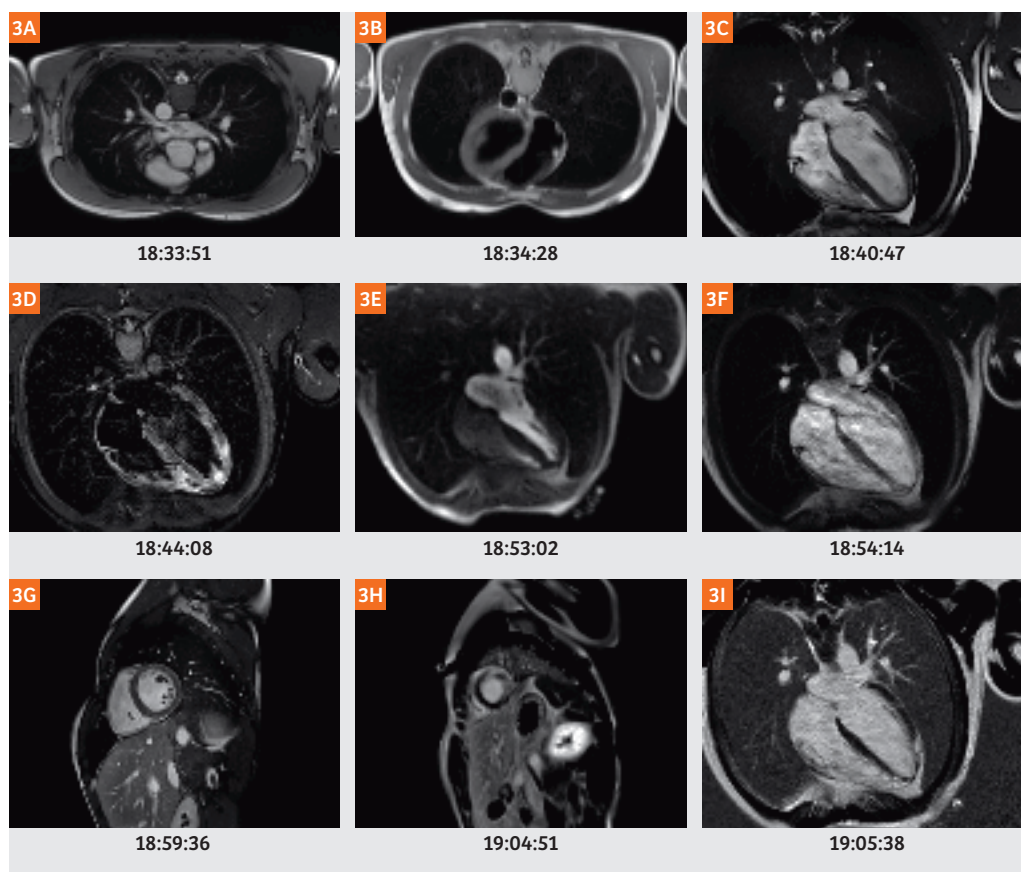
However, at the Radiology Department of Cardinal Massaia Hospital in Asti, Italy, thanks to the 2014 upgrade of our MAGNETOM Avanto scanner to MAGNETOM Avanto<sup>fit</sup>,

cardiac MRI has progressed steadily from being the nightmare of every radiographer – due to its length and difficulty – to become a routine examination of about the same duration as a conventional brain protocol for multiple sclerosis.

Before the upgrade, a conventional cardiac MRI protocol including cine SSFP on cardiac long and short axis, evaluation of myocardial edema with triple inversion recovery sequences, perfusion FLASH sequences, early and late enhancement IR or PSIR T1w images, lasted about one hour from the first scout sequence to the last one (Figure 1, Group A).

The first innovation – the introduction of the automatic commands for breath-hold – has shortened the examination time. Since the radiographers are no longer focused on speaking to the patient, they can instead plan the next sequence (Figure 1, Group B), a saving of about 10 minutes.



**Figure 3:**

A 32-minute complete protocol for myocarditis using axial TrueFISP and T2w HASTE sequences (3A, B), TrueFISP cine long axis (3C), T2w triple IR images (3D), GRE perfusion images (3G), PSIR late enhancement sequences along short and long cardiac axis (3H, I), showing patchy edema, early and late enhancement in the apical anterior, lateral and inferior walls of the left ventricle and in the apical free wall of the right ventricle.

The second improvement has resulted in a better image quality due to the higher number of coil channels and the possibility to use GRAPPA in cine SSFP sequences: Image resolution is higher, SAR (specific absorption rate) is lower, and it is possible to increase the flip angle of cine SSFP from 55° to 80°, performing short axis cine SSFP sequences after the administration of paramagnetic contrast medium. This protocol change has also allowed a mean reduction in scan time of an additional 8 minutes (Figure 1, Group C).

Finally, by changing the protocol design, we were able to further exploit the features of the syngo MR D13 software. Once the radiographer has set the cardiac long axis and short axis planes, the following sequences automatically copy the measurement parameters, including field-of-view, phase oversampling and matrix. All the radiographer needs to do is adapt the sequence to the cardiac cycle, shortening the examination time even further to 35.8 minutes (Figure 1, Group D).

## Conclusion

An analysis of our cardiac examinations reveals a reduction in acquisition times of about 40%, alongside an actual increase in the number of sequences (Figure 2). Prior to the scanner upgrade, the length of the examination meant that rest perfusion imaging, T2 triple inversion recovery

imaging and early enhancement were performed in less than 50% of our patients. With the upgrade, almost all our patients undergo a complete examination. Moreover in the definition of acute myocarditis it is now possible to perform every long axis early enhancement IR sequence twice, increasing the number of positive findings because of fewer movement artifacts.

As an example, we share images of a patient who underwent a cardiac MRI examination before the upgrade in the follow-up exam of myocarditis, and after the upgrade during a myocarditis relapse. The first examination lasted one hour and included cine long and short axis and late enhancement PSIR images. The second examination lasted 32 minutes, including cine SSFP short and long axis, T2 IR, rest perfusion imaging, early and late enhancement (Figure 3).



## Contact

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14100 Asti  
Italy  
enrico.armando@gmail.com



# Upgrade and save for future 3T purchase

Shinichi Miyamoto M.D., Ph.D.<sup>1</sup>; Fumio Ohtani<sup>2</sup>

<sup>1</sup> Hospital director, Radiology Clinic Ohgimachi, Japan

<sup>2</sup> Chief technologist, Radiology Clinic Ohgimachi, Japan

Our clinic was established as radiology specialized clinic 11 years ago. We chose to upgrade to MAGNETOM Avanto<sup>fit</sup> as the costs are quite reasonable compared to a system replacement and the time and effort needed for construction is much less. For a system renewal it would have been necessary to remove walls as our building has construction limitations. For the upgrade to Avanto<sup>fit</sup> all the equipment fit into the elevator and through the corridor instead of using a crane. In addition, the long interruption of MRI scanning for one and a half months with a system replacement might have led to patients leaving our clinic resulting in severe losses. Without the possibility to fit upgrade, we considered relocating to a new place for our MRI service or even the clinic itself without any interruption of MRI examinations, by introducing a new 1.5T. Now, we can save for a new 3T in the first place.

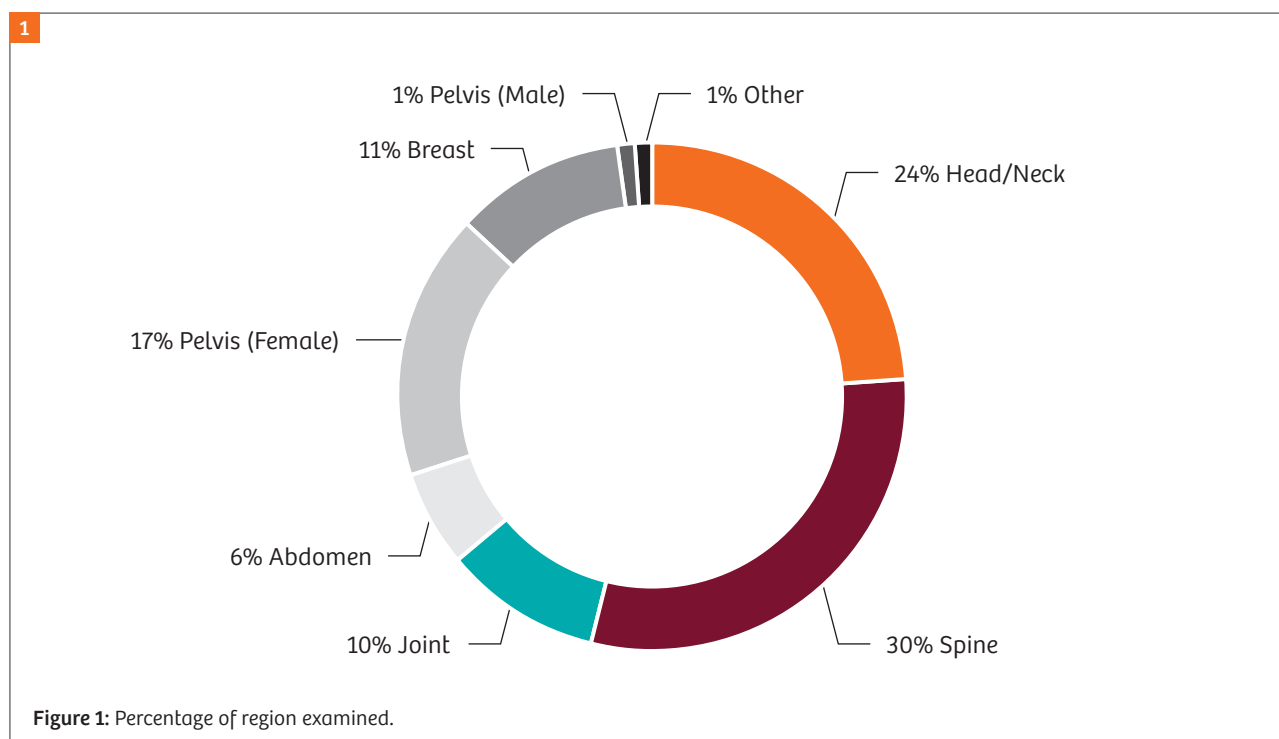
After upgrading the system, the number of patients examined per day increased significantly, allowing 5 additional patients to be examined per day. The average examination time was shortened by 5 minutes to 25 minutes per examination using the same or even higher number of sequences as well as improvement in image quality.



## Contact

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Radiology Clinic Ohgimachi,  
Japan

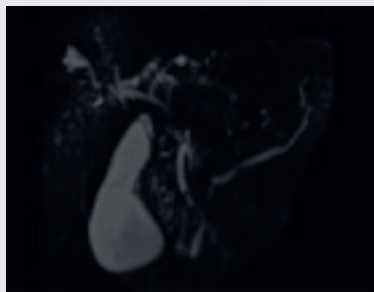


**MRCP****Case: Main pancreatic duct dilatation (Intra-patient comparison)**

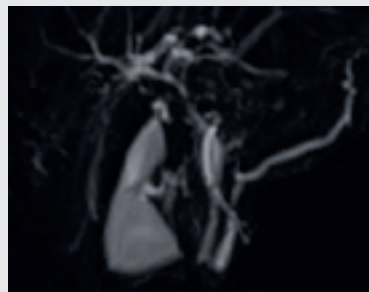
For PACE-triggered free-breathing acquisition image blurring and artifacts are less likely to occur. Imaging time is also shortened due to highly accurate detection of trigger signal.

**MAGNETOM Avanto**

**T2 TSE 3D**  
Matrix 256,  
SL 1.2 mm,  
TR 5833 ms,  
TE 609 ms,  
TA 9:38 min

**MAGNETOM Avanto<sup>fit</sup>**

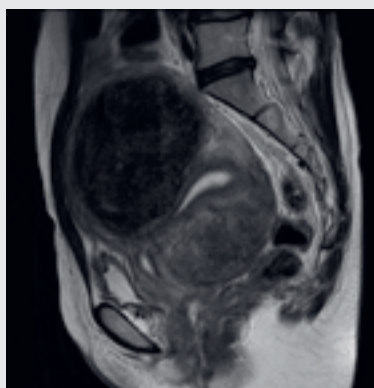
**T2 SPACE**  
Matrix 320,  
SL 1.3 mm,  
TR 4912 ms,  
TE 600 ms,  
**TA 4:20 min**

**Female Pelvis****Case: Adenomyosis/Myoma in the retroflexion of uterine body (Intra-patient comparison)**

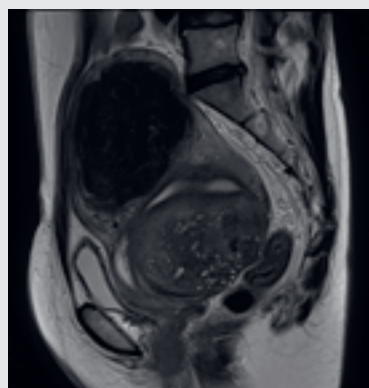
Motion artifact in abdominal wall or intestinal tract was reduced by using BLADE for sag and parallel imaging (GRAPPA3) for tra.

**MAGNETOM Avanto**

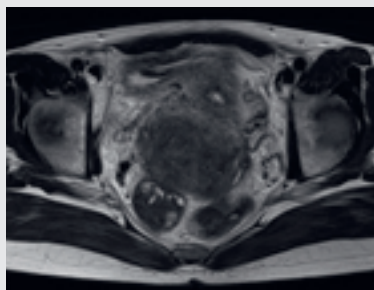
**T2 TSE sag**  
Matrix 256 x 512,  
SL 6.5 mm,  
TR 4020 ms,  
TE 78 ms,  
TA 2:17 min

**MAGNETOM Avanto<sup>fit</sup>**

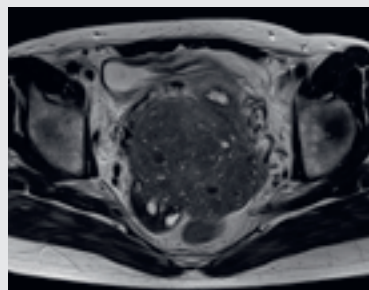
**T2 TSE sag BLADE**  
Matrix 384 x 384,  
SL 6 mm,  
TR 4180 ms,  
TE 102 ms,  
TA 2:34 min



**T2 TSE tra**  
Matrix 256 x 512,  
SL 6.5 mm,  
TR 4020 ms,  
TE 92 ms,  
TA 2:17 min



**T2 TSE tra GRAPPA3**  
Matrix 336 x 448,  
SL 6 mm,  
TR 4460 ms,  
TE 88 ms,  
TA 2:00 min



# Operation at full capacity in less than one month

Hiroyuki Horikoshi M.D., Ph.D.

Director of Diagnostic Radiology, Gunma Prefectural Cancer Center, Japan

We have two MRI systems, a 3T MAGNETOM Trio and a 1.5T MAGNETOM Avanto, which was now upgraded to MAGNETOM Avanto<sup>fit</sup>. The reason why we chose to upgrade it is that we were not willing to accept a longer suspension of our MRI operation and large-scale construction in our hospital, such as removal of raised floors. A replacement of an MRI device requires a period of time to learn how to operate the new MRI in which the system can only be used with reduced frequency of examination. With an upgrade, however, we already know the basic sequences which allowed us to operate the system at full capacity in less than one month after the start of the construction for upgrading.

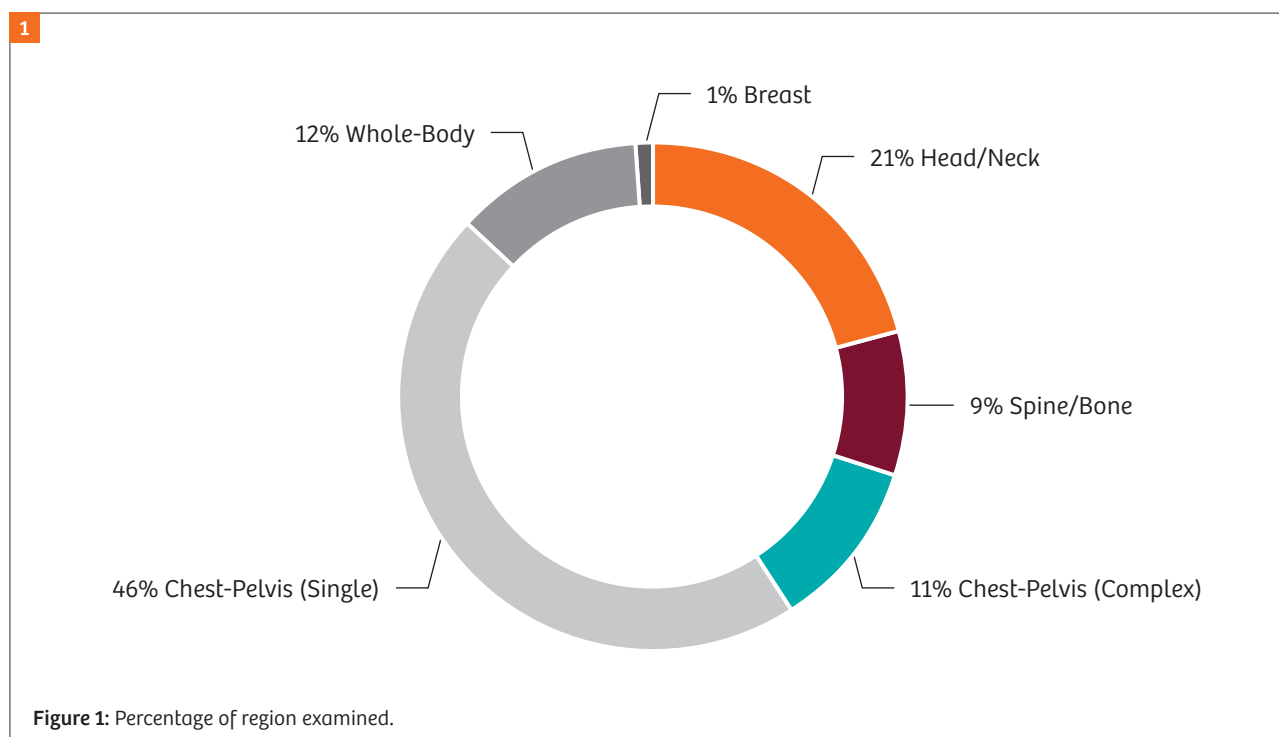
As we do a lot of whole body imaging it is essential for our center to have a large FOV in z-direction to cover the imaging range in as few steps as possible. The Avanto has

the advantage of a large FOV with high magnetic field homogeneity. This was also a major factor why we were not willing to replace the existing magnet. Since upgrading to Avanto<sup>fit</sup> our contrast improved more than expected and images close to 3T can be obtained. We are now also considering upgrading our 3T MAGNETOM Trio to Prisma<sup>fit</sup>.



#### Contact

Hiroyuki Horikoshi  
Gunma Prefectural Cancer Center,  
Japan



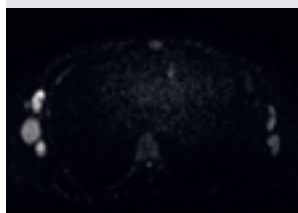


## Whole-Body

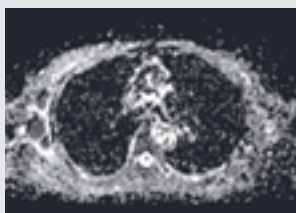
### Case: Malignant lymphoma

Enlarged lymph nodes with high intensity is noted in the area of axilla and iliac artery on Fusion images. It can be confirmed on whole body images.

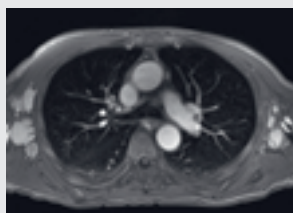
b1000



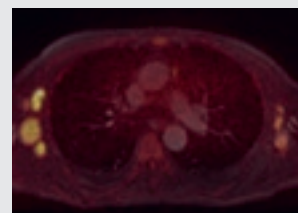
ADC



T1w



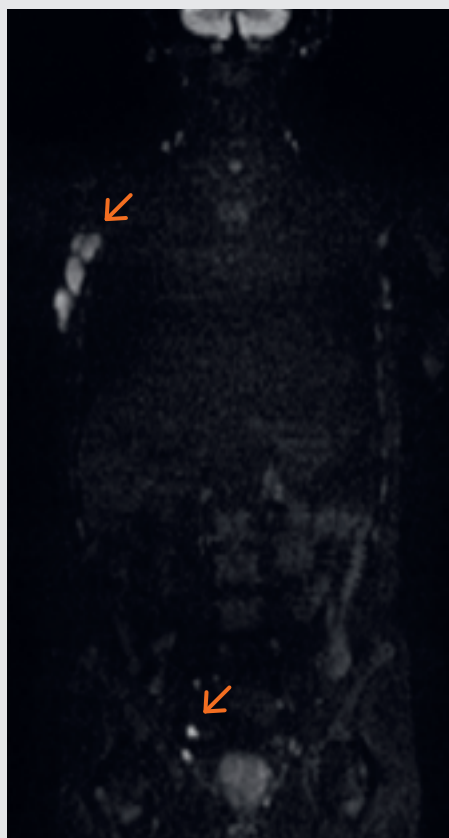
Fusion Diffusion &amp; T1 VIBE



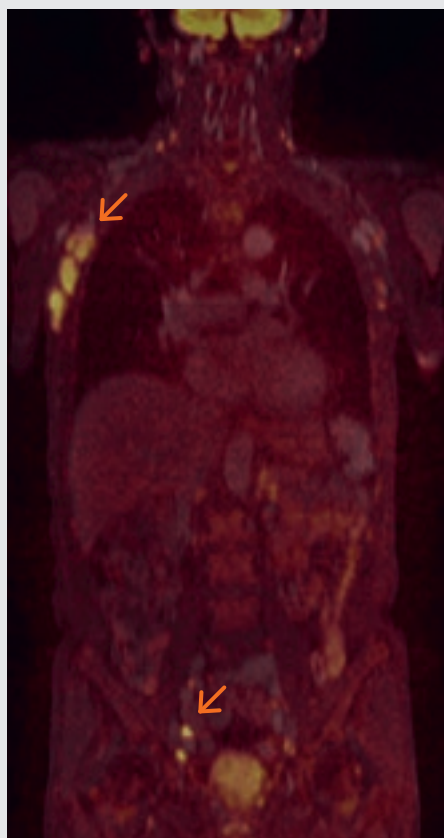
**Diffusion**  
Matrix 160, SL 4 mm,  
TR 10500 ms, TE 68 ms,  
TI 180 ms

**T1 VIBE**  
Matrix 256, SL 4 mm,  
TR/TE 3.77/1.68 m

b1000



Fusion Diffusion &amp; T1 VIBE



# Realizing the latest performance of two MRI systems simultaneously

Dr. Fumitaka Arakawa<sup>1</sup>; Dr. Yusuke Hino<sup>2</sup>; Takamitsu Yasukawa<sup>3</sup>; Tomoyuki Kurohata<sup>4</sup>

<sup>1</sup> Director of 1<sup>st</sup> Department of Radiology, Toyama Red Cross Hospital, Japan

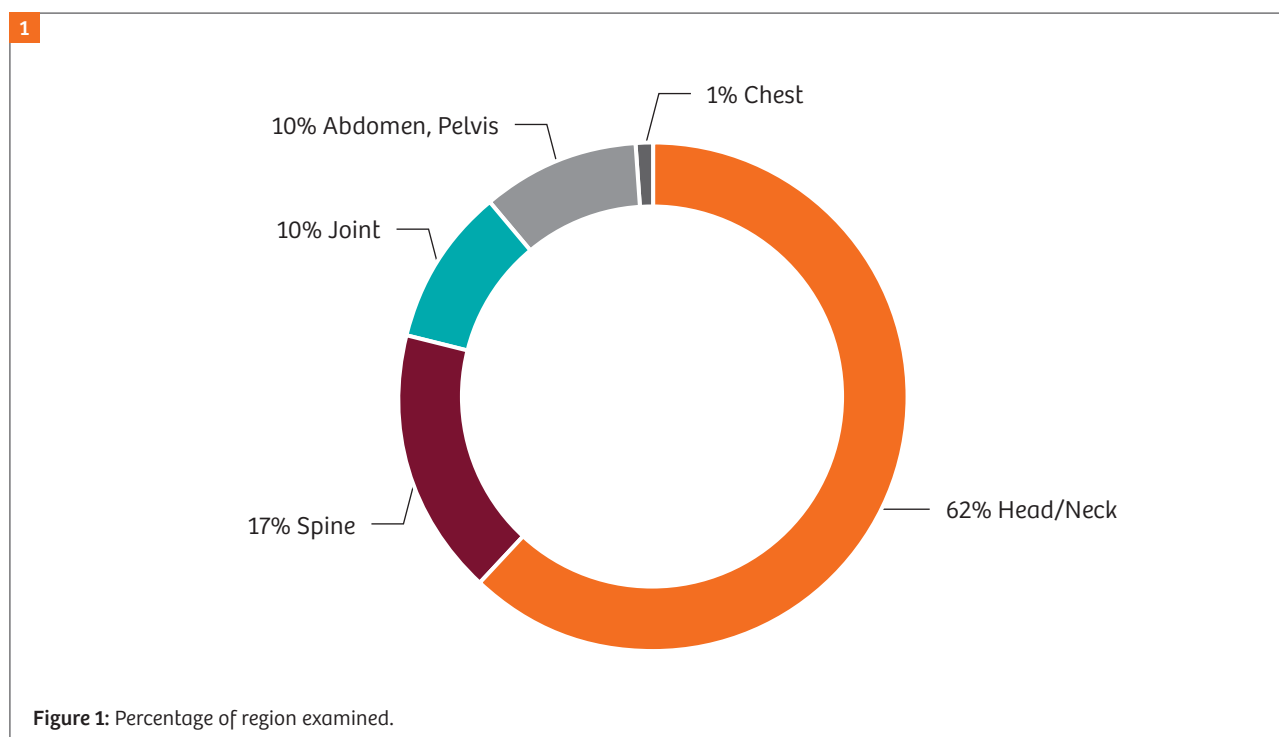
<sup>2</sup> Director of 2<sup>nd</sup> Department of Radiology, Toyama Red Cross Hospital, Japan

<sup>3</sup> Chief technologist of Department of Radiology, Toyama Red Cross Hospital, Japan

<sup>4</sup> Senior technologist of Department of Radiology, Toyama Red Cross Hospital, Japan

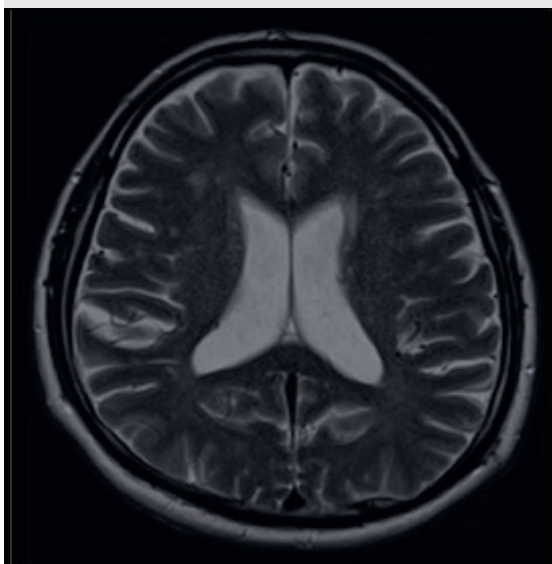
We decided to exchange one of the two 1.5T MRIs from another vendor with a MAGNETOM Aera and to upgrade the MAGNETOM Avanto to AvantoFit at the same time. In the past we suffered from an inconvenient concentration of certain type of examinations onto one system. We were concerned that after the system replacement with a new MAGNETOM Aera this concentration would fall onto the Aera. Although it was too early to replace the Avanto, we took the decision to upgrade it. A performance

equivalent to the Aera can be achieved with substantially lower cost than purchasing two new systems. Limitation to Avanto for certain examinations have resulted in prolongation of waiting time for examination before upgrading. The waiting times considerably improved with the two systems Avanto and Aera. While a new machine may fall short of expectations, we already know the benefit of the Avanto and can be further improved after upgrading.

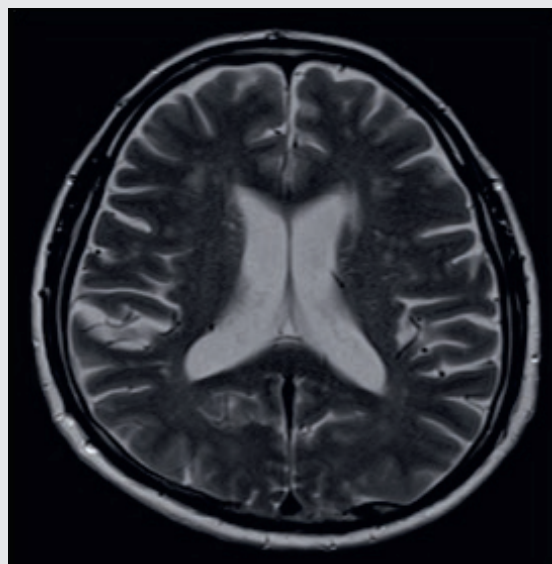


**Head****Case: Lacunar infarction (Intra-patient comparison)**

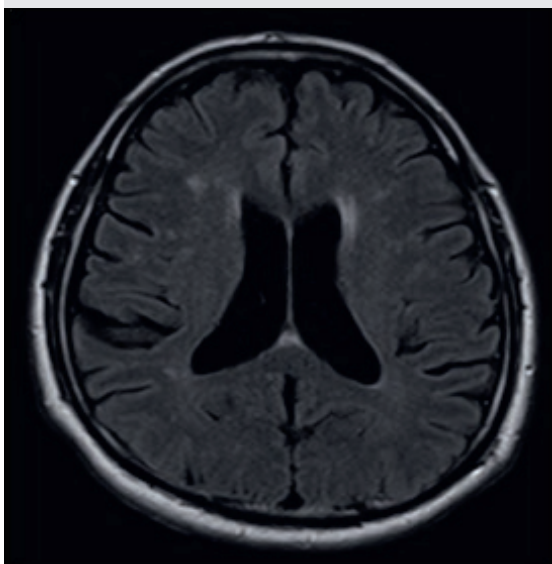
Increase in resolution and improved SNR has led to improved image quality.  
The high signal intensity on T2 and FLAIR in white matter became clear.

**MAGNETOM Avanto**

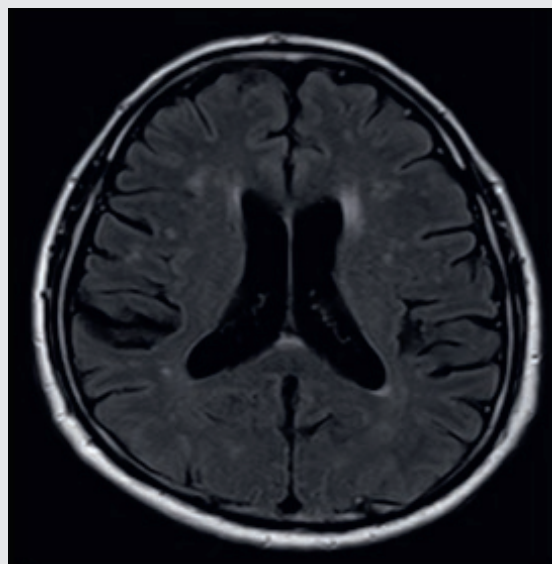
**T2 TSE**  
Matrix 320, SL 5 mm, TR 4500 ms, TE 89 ms

**MAGNETOM Avanto<sup>fit</sup>**

**T2 TSE**  
Matrix 384, SL 5 mm, TR 4000 ms, TE 86 ms



**T2 FLAIR**  
Matrix 256, SL 5 mm, TR 9000 ms, TE 105 ms, TI 2500 ms



**T2 FLAIR**  
Matrix 256, SL 5 mm, TR 9000 ms, TE 110 ms, TI 2500 ms



# System capable of coping with any examination with great contribution to improvement in throughput

Dr. Susumu Kubota<sup>1</sup>; Toyoshi Matsuura<sup>2</sup>; Naoya Tomura<sup>3</sup>

<sup>1</sup> Director of Department of Radiology, Kansai Electric Power Hospital, Japan

<sup>2</sup> Technologist of Department of Radiology, Kansai Electric Power Hospital, Japan

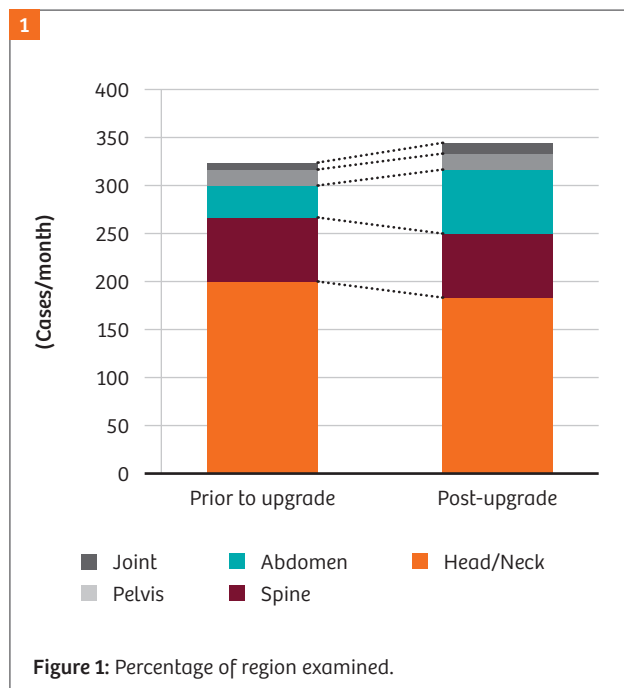
<sup>3</sup> Technologist of Department of Radiology, Kansai Electric Power Hospital, Japan

Before upgrading we sometimes had our patients wait for examination on the 3T MAGNETOM Skyra even if the Avanto was available. With the system upgrade, we expected from the beginning that the Avanto would be capable of dealing with any examination similar to Skyra. Although there were some opinions on buying a system by another company, the following reasons lead to the decision of upgrading: familiar images are preferable for diagnostic reading; same operational environment may give technologists who are not regularly scanning a strong sense of security, and reduced downtime due to short construction period.

Before the upgrade we used to secure 6–10 timeslots for urgencies in addition to 24 regular examinations per day unequally split to the two systems. Considering the

imbalanced performance of those systems we have not been able to take additional requests for examination within one week. After the upgrade the two systems were performing at the same level. As a result examinations could be equally allocated to the two systems. Thus, throughput improved so the capacity for normal examinations could be expanded to 30. The total number of acceptable urgency cases also increased to 34–38, leading to great benefit in terms of revenue as well. Moreover, the issue of handling additional requests within one week not existed anymore, because the capacity for normal examination allows for reservations.

Since 1.5T may be restricted in some cases, it greatly benefits of an upgrade from image quality getting close to 3T. For example diagnostic performance for abdomen and pelvis improved as higher SNR allows us to adjust slice thickness, resolution, and types of fat suppression as well as to shorten imaging time. Regarding liver and pancreas dynamic imaging with Abdomen Dot Engine, robust images became available without difference among technologists for timing of arterial phase imaging.



## Contact

Susumu Kubota  
Toyoshi Matsuura  
Naoya Tomura

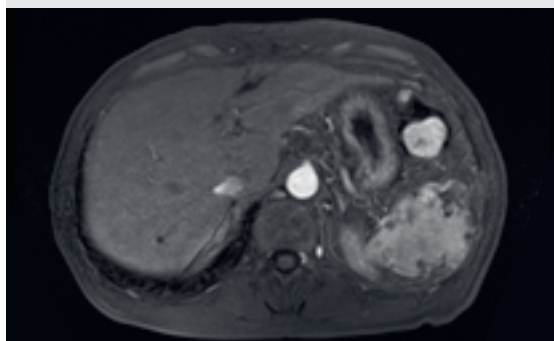
Kansai Electric Power  
Hospital, Japan

## Abdomen

### Case: Polycysts

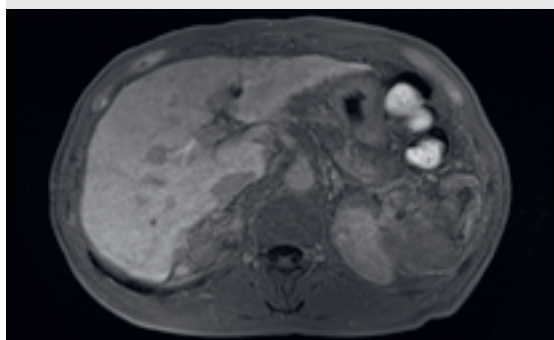
Nodes with dense staining in the early phase of liver S4 and poor EOB uptake increased. r/o HCC.  
Other than that, it is unclear whether nodes with dense staining in the early phase has poor EOB uptake.

#### MAGNETOM Avanto T1 VIBE dynamic



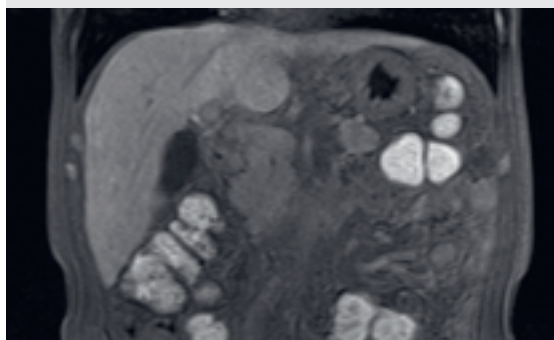
##### Early phase

Matrix 256, SL 3.75 mm, TR 3.7 ms, TE 1.4 ms,  
GRAPPA 2, TA 19.8 s



##### Delayed phase

Matrix 256, SL 3.75 mm, TR 3.7 ms, TE 1.4 ms,  
GRAPPA 2, TA 19.8 s



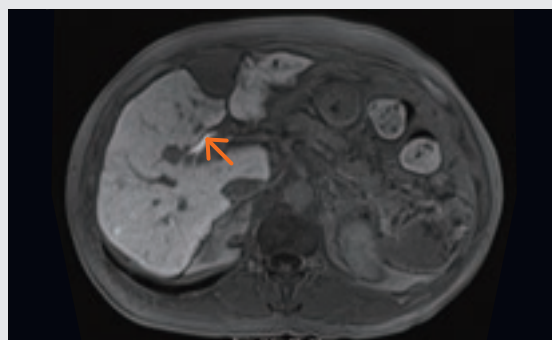
##### Delayed phase

Matrix 256, SL 3.5 mm, TR 3.6 ms, TE 1.3 ms,  
GRAPPA 2, TA 22.7 s

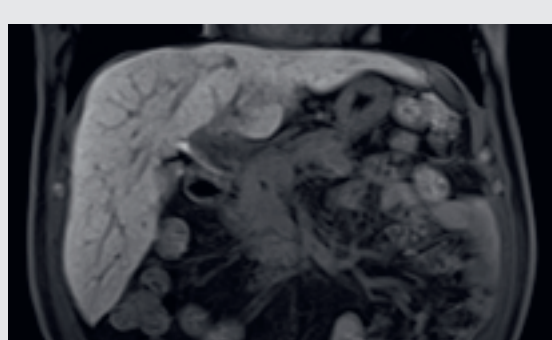
#### MAGNETOM Avanto<sup>fit</sup>



Matrix 320, SL 3.5 mm, TR/TE 2.0/4.6 ms,  
CAIPIRINHA 1 x 3, TA 8.7 s



Matrix 320, SL 1.5 mm, TR/TE 4.1/1.5 ms,  
CAIPIRINHA 1 x 3, TA 21.3 s



Matrix 320, SL 3.5 mm, TR/TE 3.4/1.4 ms,  
CAIPIRINHA 2 x 2, TA 13.2 s

# Asset planning at Women & Infants Hospital

Charles Deschamps, Women & Infants Hospital of Rhode Island, Providence, RI, USA

## Opportunity: Optimizing service lines within an ACO

In 2015, the Care New England Health System established the Integra Community Care Network ACO with the mission of “pursuing the IHI Triple Aim – improve the care experience, improve the health of the population, and reduce overall cost – for attributed populations.” In support of achieving these goals across the newly formed ACO, the health system needed to evaluate how it could best coordinate the service lines of its numerous member organizations. And, at the same time, maintain the high quality of patient care for which each of these members are known, while maximizing efficiencies and patient satisfaction and minimizing costs.

For Women & Infants, creation of the Integra ACO provided the hospital with a unique opportunity to assess its service offerings within a defined geographic area, as well as compare its services with those offered by other Integra members. Doing so would enable Women & Infants to differentiate itself by clinical specialty, particularly breast imaging, and help identify which of its other service lines could be improved to achieve greater efficiencies and cost savings. In addition, it would also enable the health system to determine if any of the hospital’s low performing services could potentially be shifted to another ACO member with better system capabilities and staff experience.

### About Women & Infants Hospital

Women & Infants Hospital of Rhode Island, part of the Care New England Health System and its Integra Community Care Network ACO, is one of the nation’s leading specialty hospitals for women and newborns.

The hospital is the major teaching affiliate of The Warren Alpert Medical School of Brown University for obstetrics, gynecology, and newborn pediatrics, as well as a number of specialized programs in women’s medicine. It is also a Designated Baby-Friendly® USA hospital, *U.S. News & World Report* 2014–15 Best Children’s Hospital in Neonatology, and a 2014 Leapfrog Top Hospital.

Women & Infants is the 11<sup>th</sup> largest standalone obstetrical service in the country with about 8,400 deliveries annually. In 2009, it opened, what was at the time, the country’s largest, single-family room neonatal intensive care unit.

Source: [womenandinfants.org](http://womenandinfants.org)

## Solution: Asset planning with Siemens Healthineers

Women & Infants engaged Siemens Healthineers to conduct an Asset Planning Session. The session combined the hospital’s understanding of its business and market with Siemens’ expertise in system capabilities and optimization to develop a multi-year plan for enhancing the performance and extending the life of the hospital’s imaging equipment in support of its clinical and business goals.

The Asset Planning Session provided greater insight into the demographics of Women & Infants’ target market and the projected demand for services, as well as details on how the hospital is utilizing its imaging systems and opportunities for improvement. The end result was a comprehensive asset plan detailing how the hospital could best optimize its systems and services in support of efficient, high-quality patient care, as well as establish its service line specialties within the Integra ACO.

### Workflow enhancements

During the Asset Planning Session, Siemens Healthineers and Women & Infants identified extended amounts of downtime between MR exams. By addressing workflow issues and standardizing protocols to help minimize technologist errors and uncertainties, the hospital was able to improve patient volume while eliminating its underutilized third shift (from 11:00 p.m. to 7:00 a.m.).

### Addressing future population needs

Since market assessment data showed demographic and population changes coupled with system utilization, Integra was better able to determine which ACO member was best equipped to deliver which services, specifically those related to diagnostic imaging, based on the system capabilities. Each ACO member offers multiple services within a 30-mile radius.

## Outlook: A plan for continued success

Following the Asset Planning Session, Women & Infants was better able to develop an internal plan for maximizing the productivity of its MR systems to service a larger volume of patients, while still providing an exceptional level of care. The hospital was also able to gauge projected demographic changes in the surrounding regions to better plan its scope of services for the future.

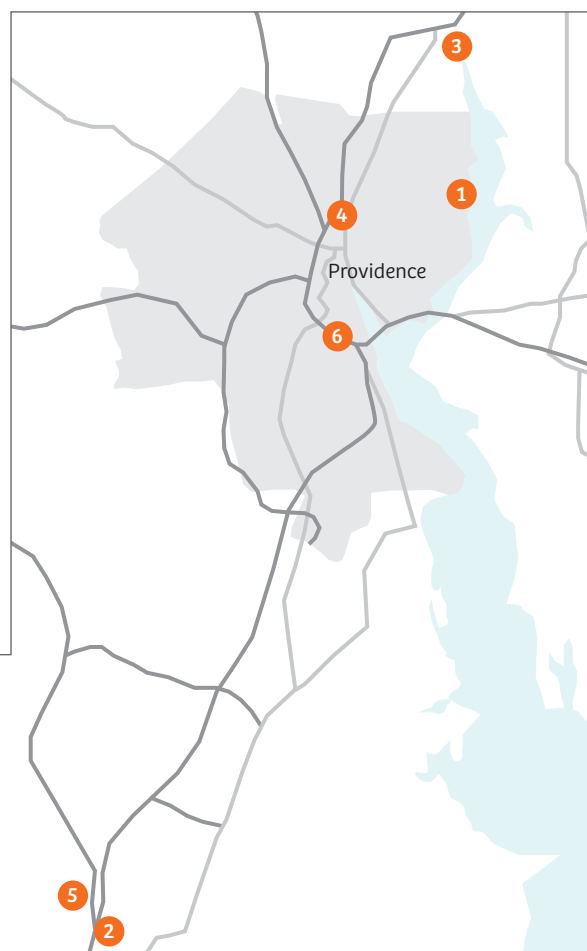
Collectively, using system utilization data and considering each facility’s clinical specialties, Integra is evaluating



MR options and upgrades, such as Dot™ engines, to help achieve improved workflow efficiencies and cost savings by standardizing its fleet and exam protocols across the ACO.

When asked about the overall value of the planning session, Charles Deschamps, diagnostic imaging site manager at Women & Infants, stated: “Asset Planning Sessions validate that the old, silo-focused planning process for capital assets and volume growth is inefficient for both short- and long-term forecasting. As we move toward an ACO environment, data collection and sharing at all levels of our operation will be key for success. We cannot function as one entity but, rather, as part of a health system that extends beyond our walls and borders.”

Moving forward, Siemens and Women & Infants plan to conduct more Asset Planning Sessions to continue providing the hospital with the information needed to support its success within the Integra ACO.



- 1 **Butler Hospital** – neurology and substance abuse
- 2 **Kent Hospital** – emergency services, cardiology, and physical therapy
- 3 **Memorial Hospital** – emergency services, surgical services, and primary care
- 4 **The Providence Center** – mental health and addiction treatment
- 5 **VNA of Care New England** – home care and hospice
- 6 **Women & Infants Hospital** – oncology, gynecology, gastroenterology, infertility, and neonatology



*“Asset Planning Sessions validate that the old, silo-focused planning process for capital assets and volume growth is inefficient for both short- and long-term forecasting.”*

**Charles Deschamps**

Diagnostic Imaging Site Manager Women & Infants Hospital

The statements by Siemens' customers described herein are based on results that were achieved in the customer's unique setting. Since there is no 'typical' setting and many variables exist there can be no guarantee that other customers will achieve the same results.

#### **Asset Planning Session – Data and dialogue to drive your imaging decisions.**

An Asset Planning Session helps you establish a multi-year plan and budget for maximizing the potential of your Siemens Healthineers systems. The collaborative session combines your understanding of your business and market with our expertise in system capabilities and optimization. The result is an impartial, evidence-based asset plan that identifies opportunities to improve the performance and extend the life of your systems in support of your clinical and business goals.

# Value added

An interview with Jörn Sandstede, Radiologische Allianz, Hamburg, Germany

Stakeholders who operate in the market for medical care services are concerned about many different issues. They wonder, for instance, what challenges their medical facility will face in the future, how the market is developing, and how they can get the best use out of their systems' resources. Professor Jörn Sandstede, head of the Radiologische Allianz in Hamburg, takes stock: „We were trying to answer those questions when a new service from Siemens Healthineers came along. It was perfect timing.“ The Radiologische Allianz (an alliance of 11 radiological practices in Hamburg) is currently implementing this new approach, known as an Asset Planning Session. The session identifies potential for optimizing system usage and pinpoints future challenges in the medical market. Its aim is to produce a plan that is optimally aligned with a facility's specific needs and requirements.

An Asset Planning Session moves through three phases: Phase one is a market analysis, which uses relevant statistics, evaluations, and studies to establish the status quo. It includes data on regional infrastructure, population, risk factors, disease prevalence, as well as future developments and trends in the clinical field. Phase two is a utilization analysis, which provides a detailed picture of patient throughput, exam duration, and exam volumes per system. Customers benefit from this analysis because it establishes benchmarks via comparisons with other facilities. It also identifies areas in which workflow or clinical improvements could make sense. Phase three evaluates the collected data and uses it to produce a suitable customer strategy. An Asset Planning Session is interdisciplinary, which means it can accelerate essential standardization processes across all departments at a facility – with the aim of minimizing costs while maximizing system potential.

**You were introduced to the Asset Planning Session in August 2014. What were your subsequent expectations?**

Sandstede: Given our need to balance clinical demands with economic feasibility, our expectations initially focused on the market analysis. We were particularly interested in the statistical data and its meaningfulness in a regional context. Then we were curious about the utilization analysis of the individual systems, and about the results that it would produce.

**What insights did you gain from the market analysis?**

An Asset Planning Session is based on a collaborative exchange of information from the outset. This meant we became involved in a lively debate in the very first phase,

the market analysis. The data sources and their presentation were convincing, and we produced new insights even at this early stage. For instance, we identified a regional decline in two oncological and cardiovascular risk factors. We hadn't had that kind of information before, and it was very helpful.

**Which systems did the utilization analysis focus on?**

We analyzed our MRI and CT systems. In the end, we focused on the MRI systems because they offered the greatest scope for testing the Asset Planning Session across all our locations. It turned out that the data collected by Siemens Healthineers were considerably more informative than the data we gather internally. This is due to – along with the quality – the number of parameters that were investigated as well as the potential to correlate these findings with other reference values via benchmarks.

**The Asset Planning Session is made up of three stages.**

**Do you think this approach makes sense from a clinical and economic perspective?**

Yes. The market analysis, for a start, makes a great deal of sense. It provides clinical information about issues such as the diseases we will have to deal with in the future. It also provides economic information, such as the segments that are likely to experience the largest demand and require the most work. The second phase, the utilization analysis, provides valid indicators for conducting internal comparisons to establish best practices. The third phase, the evaluation and strategic orientation, again demands a precise focus because it involves turning the findings from the first two phases into concrete measures. So, the way I understand it, this is primarily about optimizing the existing situation.

**What specific results were you able to deduce from the utilization analysis?**

One example is that the data led us to change the way we schedule appointments so that we can better manage peak and idle times. As for our system workflow, we are currently using the findings to optimize our throughput. And finally, we are naturally also particularly interested in finding out how we can reduce the number of sequences while retaining a consistently high examination quality. The parameters that were investigated therefore cover a very broad field – which is to our advantage. The Asset Planning Session allows us to identify and respond to all these different aspects.

**The Asset Planning Session starts at the executive level.**

**How did you get the team involved?**

With this kind of thing, you obviously need more than just sensitive communication – you have to work well together, too. It was also important that we had support from our partners at Siemens Healthineers at that point in time. As a result, everyone quickly understood that this was a learning tool, not a monitoring tool. Also, once we had studied the systems and completed the evaluation at the practice where I work, the other practices soon followed suit.

#### **Is the Asset Planning Session better suited to individual or integrated systems?**

We used the Asset Planning Session at each of our locations, purely because it gave us the best scope for using the data to learn something for the network as a whole – by comparing the systems with one another. That was one of the questions we were most interested in. However, I think the Asset Planning Session would be equally well suited for studying an individual system. Basically, the decision depends on the data and what you want to achieve.

#### **Will the Asset Planning Session play any part in future budget planning?**

Salaries are the main driver of our budget planning. We then consider, depending on the situation, which system investments make sense and which do not. The Asset Planning Session helps us maintain this detailed focus. It gives us outstanding clarity on whether we need to purchase a new system or arrange an upgrade, or whether some other kind of added option will suffice.

#### **What was it like working with Siemens Healthineers?**

This is a totally new approach, and I was curious about the session after just a few initial discussions. We've been collaborating with Siemens for more than 20 years. In that time, I've mainly known them as a leader in the technology field. The Asset Planning Session has allowed me to experience a new level of our partnership. You have to be able to work together openly from the outset so that you can collaborate constructively on finding solutions. You need a foundation of solid, well-developed trust, as the sessions involve highly sensitive data. I was won over by the idea that we would begin by working with what we already have – via the market analysis and utilization analysis. The approach also allows me to work with “real” data from the system, rather than with unknown “black-box” data that is difficult to map onto individual needs. Siemens Healthineers will therefore continue to play a key role in our strategy discussions in the years ahead.

#### **Would you recommend the Asset Planning Session to others?**

Absolutely. The Asset Planning Session offers a broad scope for improving internal workflows. It is obviously vital that the data are handled sensitively.

#### **Is there any room for improvement?**

To make the information even more accurate, it would be good to have slightly more in depth, broader data on the groups being compared, for instance. For us, statements limited to the national context as part of the market analysis are sufficient. Other than that, we are very happy with the session as it is.



*“The Asset Planning Session provided us with key answers to clinical and economic questions. It will remain a permanent feature of our strategy discussions in the years ahead.”*

**Professor Jörn Sandstede**  
Head of the Radiologische Allianz, Hamburg

The statements by Siemens' customers described herein are based on results that were achieved in the customer's unique setting. Since there is no 'typical' setting and many variables exist there can be no guarantee that other customers will achieve the same results.

#### **Summary**

The Radiologische Allianz in Hamburg is one of the first Siemens Healthineers customers to complete an Asset Planning Session. The three-stage process – which comprises a market analysis, a utilization analysis and an evaluation – provided Professor Jörn Sandstede and his team with a comprehensive overview of how their systems were being used and where they could make improvements. The new approach, which is based on a collaborative exchange of information, won over the Hamburg radiologists and will play a key role in defining the alliance's clinical and economic direction in the future.



# MAGNETOM ESSENZA Dot

An interview with Izumi Togami and Daisuke Suzuki, Okayama Saiseikai General Hospital, Japan

## The world pioneering E11Q version introduced

Okayama Saiseikai General Hospital is a core hospital in Okayama Prefecture, contributing to community medicine with the aim of enriching and developing medical treatment, health, and welfare. The hospital was relocated to a new site to become a hospital specialized in in-patient and emergency medicine in January 2016. With this, the hospital was separated from the Okayama Saiseikai General Hospital Out-Patient Center.

Presently, MAGNETOM Skyra (hereinafter, "Skyra") is in operation at the general hospital and MAGNETOM ESSENZA (hereinafter, "ESSENZA") and Skyra are in operation at the out-patient center. In 2008, the hospital introduced the first ESSENZA to be implemented in Japan and in 2013 executed the world's first Dot upgrade. Then, in 2016, the hospital updated to the world pioneering E11Q software version. Also, the hospital already uses the E11 Skyra. We spoke with Okayama Saiseikai General Hospital's Vice President, Izumi Togami, and technician, Daisuke Suzuki, about their use of the E11Q upgrade in light of their many years of experience.

## The general hospital and out-patient center adopted a new organization. Please tell us about the roles of each system in both hospitals.

Togami: The general hospital Skyra is mainly used for the in-patients, urgent-care patients, and those referred from local hospitals and doctors, while the out-patient center Skyra and ESSENZA are mainly used for out-patients and examination patients. At the out-patient

center, the ESSENZA is used to take care of examinations, screenings, and while the out-patient center Skyra is used to take care of examinations of the liver, MRCP, prostate and detail of other organs. A future initiative will involve the introduction of whole-body MRI with the Skyra and conducting examinations and close examinations using fusion images of T1 and T2-weighted images, mainly for whole-body diffusion.

## Tell us about your impressions of the E11Q version in terms of operation.

Suzuki: As technicians, we are always on rotation, so having multiple systems with the same version is incredibly helpful. With the E11Q version, the Dot engines that compile the sequence has become easier to use, especially the Dot Cockpit. In the previous version, it was impossible to do anything without an application specialist the Dot engine application, but the Dot Cockpit is very easy to understand and we can make Dot engines by ourselves. It's a great thing.

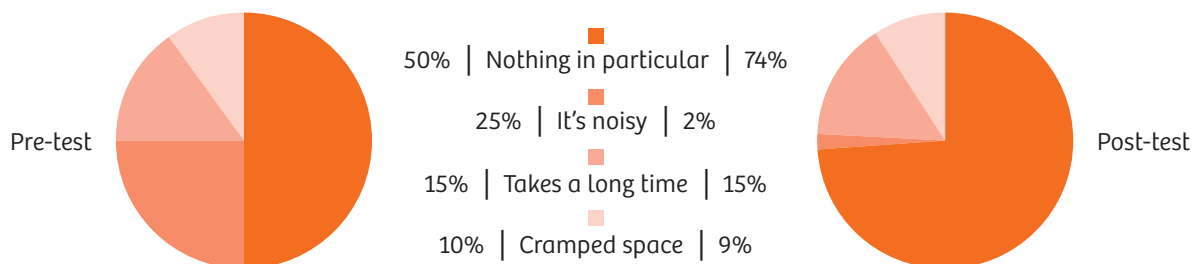
## Tell us about the clinical usefulness of the new sequences in the E11Q version.

Togami: In imaging prostatic carcinomas, we use the no-breath-holding StarVIBE, and in dynamic imaging of uterine and ovarian tumors, we use the TWIST VIBE. In the past dynamic, it took 30 seconds per phase in VIBE, but TWIST VIBE improves temporal resolution to 15 seconds, while retaining high image quality with the same spatial resolution. Because it is possible to measure in a short time phase, the level of tumor stain is very easy to read. Also, the TWIST can be used to evaluate blood flow, so we would like to expand its use to other regions. Then, we can

### Results of the survey of patients and radiologists regarding Quiet Suite

N = 459 (200 patients + radiologists)

Question: "What distresses you about MRI?"



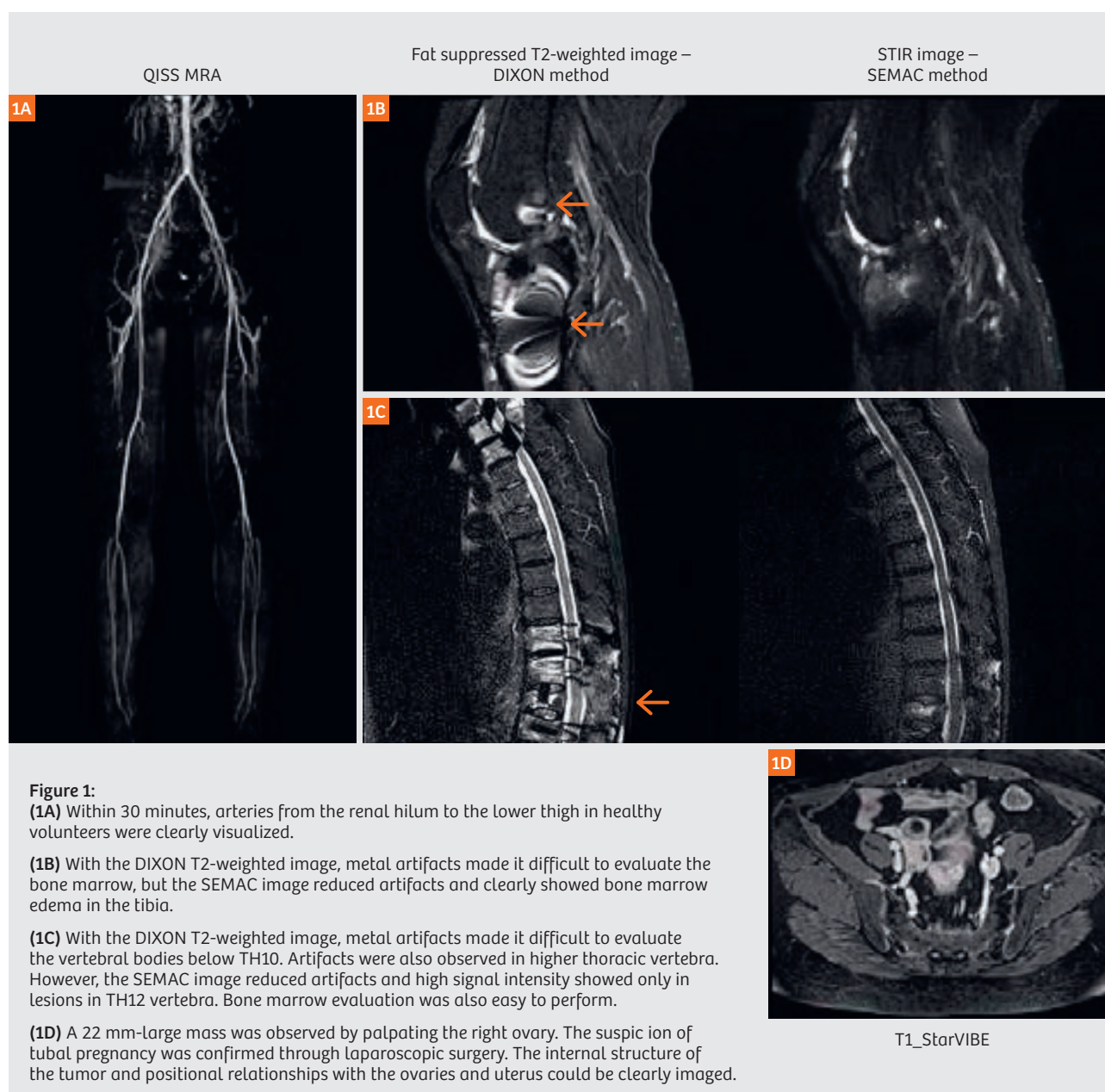
use StarVIBE images with thin slice and broad to evaluate lymph nodes and metastases in the equilibrium phase. In the pelvic cavity, respiratory and bowel movements create artifacts, but StarVIBE allows the lymph nodes to be clearly evaluated. The previous syngoBLADE showed specific artifacts with bowel movements, but the StarVIBE shows none. Also, even when lymph node metastases are widespread, there is good contrast between thin slices, while maintaining high spatial resolution. I was very surprised and impressed with the level of image quality.

Advanced WARP (SEMACE) is used for STIR as a way to evaluate inflammation around sites where metals have

been implanted as well as inflammation around prostheses, and in addition to low distortion, SEMACE makes up for the low additive efficacy of the SNR of the old STIR.

#### What can you say about the usefulness of QISS?

Suzuki: For peripheral angiography of blood vessels, the past TOF took 30–40 minutes and the syngo NATIVE (hereinafter, "NATIVE") also would take a little under one hour to come to that point. However, with QISS, usually a 30-minute time frame is enough to get a thorough imaging from the renal artery to the lower thigh.



Togami: It has become possible to do MRA imaging without using a contrast agent to screen patients with poor kidney function, so it is highly regarded by clinical physicians, especially since the population is aging and the number of diabetic patients is increasing. Imaging is better than TOF and NATIVE and it is possible to thoroughly evaluate the infrapopliteal trifurcation as well as the periphery. Though imperfect, it is also possible to evaluate the course of the renal artery. Applicable for sites other than the lower leg blood vessels, imaging from the shoulders to the arms has also been highly regarded by clinical physicians.

#### What do you think about Quiet Suite?

Togami: When Quiet Suite was introduced for Skyra a few years ago, we measured scan noise and evaluated the image quality, and conducted a survey of 459 patients and radiologists. The most important thing, image quality, was rated equivalent to the normal sequence, and noise reduction during scan was also confirmed.

Suzuki: The patient survey was done before and after an exam with Quiet Suite. When patients were asked what distressed them about MRI exams, 25% of patients responded, "It's noisy," before the exam, while a mere 2% responded this way after the exam. Also, when asked whether the noise was improved and whether they would like the hospital to switch to Quiet Suite from now on, 98% of respondents said, "Quiet Suite is better." Image quality evaluation and confirmation of noise reduction, combined with the results of the patient survey, led us to switch to routine exams with Quiet Suite.

Togami: The other day, I introduced Quiet Suite in a meeting with practitioners and cooperating hospitals and clinics, they were all surprised by how much quieter the system was than they expected it to be. We hope that a variety of sequences will be supported in the future.

#### What is your overall evaluation of the upgrade?

Togami: ESSENZA has been upgraded twice since being introduced in 2008. Currently, it is used for about 15 exams a day. Considering that we conduct 5,000 exams a year, it has been used for approximately 40,000 exams. When we introduced the 1.5T system, selecting the first ESSENZA in the country over MAGNETOM Avanto, it made some people apprehensive. After that, application representatives worked hard to adjust image quality with the Dot upgrade and E11Q upgrade. We are very satisfied with the results coming out as expected.

Actually, not all exams are done using Skyra. As for ESSENZA, we want to keep using it to obtain approximate information without resorting to the use of Skyra when urgent exams are needed or as a backup for Skyra. This is something that we considered with the previous Dot

update as well, but it is important to always keep the system in an optimal state in order to maintain high image quality that does not require rescans.

And in a hospital running multiple systems, ordering physicians can get confused about which exams different systems are able and not able to do. Having all systems in the same software version and at the same level is very important.

Suzuki: Many people all over the country visit our hospital to learn about the introduced systems. Because we are working hard to produce good images every day, our skills have been improved. Also, when the system was upgraded, we held study groups about the new technology, which provided a great opportunity to improve everyone's skill.

#### syngo MR E11Q Version – Main Optional Software

##### Option



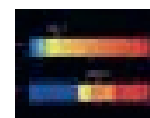
Quiet Suite



syngo RESOLVE



FREEZEit



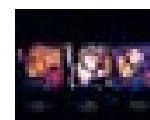
LiverLab



Advanced WARP



QISS



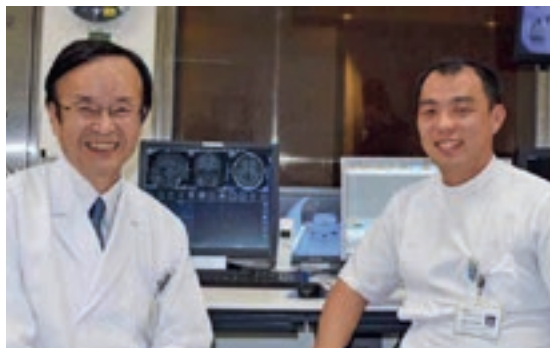
MyoMaps



For example, the upgrade allowed 2x speed in iPAT and after that, 3x speed and 4x speed in CAIPIRINHA, gradually reducing the scan time, which reduced the effects of poor breath holding and improved success rates. In particular, our abdominal exams have become highly regarded by other hospitals.

#### What do you expect to see from Siemens in the future?

Togami: Eight years ago, when we introduced ESSENZA, in an article in this publication, I said, "I have no apprehensions about introducing the first system. I would like to send our wonderful images throughout the country and the world." I am glad that that is exactly how it turned out. It's time to start thinking about what will come next after ESSENZA. I expect to see support for the latest technology in the future.



Izumi Togami and Daisuke Suzuki

#### Main Function

##### Quiet imaging

SE, TSE, GRE, PETRA sequences supported.

##### Multi-shot EPI Diffusion imaging

Allows for low-distortion high-resolution diffusion imaging and tensor imaging.

##### Contrast 3D image including TWIST VIBE and StarVIBE

- TWIST VIBE: Using the TWIST method and echo-sharing k-space loading method together for the VIBE sequence makes it possible to get dynamic 3D images with high temporal resolution.
- StarVIBE: This is a motion-correction 3D contrast image using radial sampling method in VIBE sequence.

##### Qualitative and quantitative evaluation application of iron and fat content for early detection of liver disease

- Multi-point DIXON sequence: Allows automatic extraction of liver contours and quantitative evaluation of fat and iron content. Fat Fraction Map, R2\* Map can be obtained.
- HISTO sequence: Single Voxel Spectroscopy(SVS) sequence allows quantitative evaluation of fat content.

##### Imaging aimed to reduce artifacts caused by implants in the body

With the SEMAC method, not only are distortions corrected in the slice surface, but also in the direction of the slice.

\* This software aims to suppress metal artifacts and does not guarantee safety in terms of heat generation, etc. In-hospital exams should be conducted in accordance with the hospital's operating procedures.

##### Non-contrast lower-limb MRA imaging

This is a 2D imaging sequence aimed to enable non-contrast MRA exams to be conducted in a short time period by adjusting the imaging timing through QI (Quiescent Interval) time settings in the steady-state gradient echo method.

##### Myocardial quantitative evaluation function

This allows for quantitative evaluation of individual pixels by creating a T1 map, T2 map, and T2\* map of the myocardium. In order to reduce the effects of respiratory movements on the quantitative values, the Heart Freeze (Inline Motion Correction technology that corrects pixels in each phase automatically after scan) is included.

# Dot for productivity

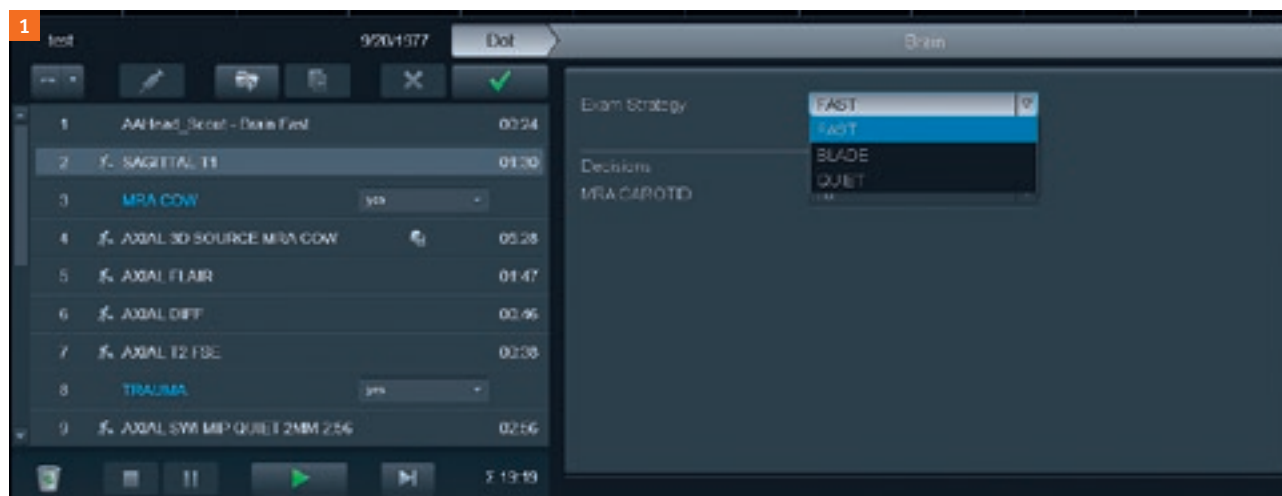
Kevin Dirlam

Halifax Health, New Smyrna Beach, Florida, USA

Breaking the status quo is not an optimal strategy for any viable, fast paced institution. However, developing and implementing a robust Dot platform can overcome any of the anxiety and disruption that typically characterize change. The Dot platform has not always been the highlight of protocol building, but with the advances introduced by the *syngo* MR E platform, creating and using protocols far surpasses the expectations that came with the earlier *syngo* MR D platform. We began our Dot journey by stumbling through the early iterations of Dot development, and now find ourselves equipped with an efficient and user-friendly software that streamlines processes and increases functionality, but only as far as we allow the platform to go.

The *syngo* MR D line was the jumping off point for our Dot journey – and it really was a matter of jumping off. This new software was meant to ease the workload for the user, but adopting the design elements took some acclimatization. The D line allowed the user, or rather the application specialist, to build site protocols into a multilevel user platform that organized the workflow into strategies that achieved efficiency by making it possible to

quickly switch scanning patterns for different patients. To better explain this, I will use an everyday example of a typical MRI patient: The exam begins with the patient asking what MRI is and how MRI differs from CT scans. After listening to a brief explanation of how MRI uses a large magnet to make detailed pictures from the protons inside the body, the technologist makes the patient as comfortable as possible and begins the exam. Some of the streamlined efficiencies start at this point. In the case of basic brain or abdomen scans, the MRI system knows the common centering points for certain body regions and automatically positions the patient at the center of the magnet. Technologists do not have to turn on the laser light to initiate location of isocenter. Instead, they simply press and hold the toggle wheel on the front of the scanner to center the patient directly at isocenter. By handling simple tasks like this, the scanner allows technicians to concentrate on the patient and the exam. Dot was created to relieve users of some monotonous tasks by having the system perform them without demanding too much expertise. At the console equipped with the D level software, technologists can choose the



**Figure 1:**

The window on the right shows the Dot exam strategy chosen from a simple dropdown menu. The three strategies that we built are FAST, BLADE, and QUIET.

exam strategy that best fits their assessment of what the patient can tolerate. Dot allows users to determine if the patient is compliant enough for the routine exam or if a fast strategy is needed to accommodate the patient's needs. With Dot, users can simply choose a strategy from the Dot menu and start the exam. It is also possible to change the exam strategy along the way.

Back in our example patient scenario, the patient in the scanner begins to wonder where the loud noise is coming from and starts to look around. The diligent technologist asks the patient to stop moving and to remain still for the exam. After a few more minutes, the patient starts to move again, but this time the technologist decides to employ a different strategy. By simply clicking on the Dot menu again, the technologist can switch the pulse sequence strategy to BLADE sequences. The Dot menu makes it possible to change the manner in which the exam is delivered with four mouse clicks. For busy technologists managing patients who need extra attention, this ease of altering the exam strategy is key. The D platform changes the routine series into a BLADE series without the technologist having to enter the user tree and locate the sequences manually – as demonstrated in this Dot Cockpit screenshot.

For a fast-paced, patient-centered facility, the efficiency gains here are monumental. The speed at which technologists can alter the scan to accommodate the patient reduces scan times and improves exam quality.

The Dot platform added another ingenious option that streamlines throughput: AutoAlign is a user-preference feature that allows the scanner to attempt to align the slices as set out in the protocol. To illustrate this, think of the basic axial brain. The scanner has built-in options that tell the software to align the slices in an axial fashion with the base of the brain, orbits, temporal lobe, etc.

With the slice set-up fixed in the protocol, the scanner will attempt to align the slices as programmed, which means users can simply accept the scanner's decision or adjust the slices as they see fit. This may seem like the scanner is taking over the job of the technologist, but it is simply a tool that helps technologists achieve the efficient throughput that today's busy MRI departments require. As mentioned above, this option is entirely user-induced, and the creator of the protocol can choose the extent to which the scanner operates on behalf of the technologist. This feature also allows for reproducibility across different users in a single facility, which benefits the patient and the radiologist.



Figure 2: The Dot Cockpit with all the brain strategies tailored for our facility.



Advances to the D platform came with some limitations. The software would occasionally freeze when attempting to mix pulse sequences that were not in Dot protocols with

Dot scans. This sometimes left users with only one option: Restarting the software. In addition to this shortcoming, my earlier comment about an application specialist

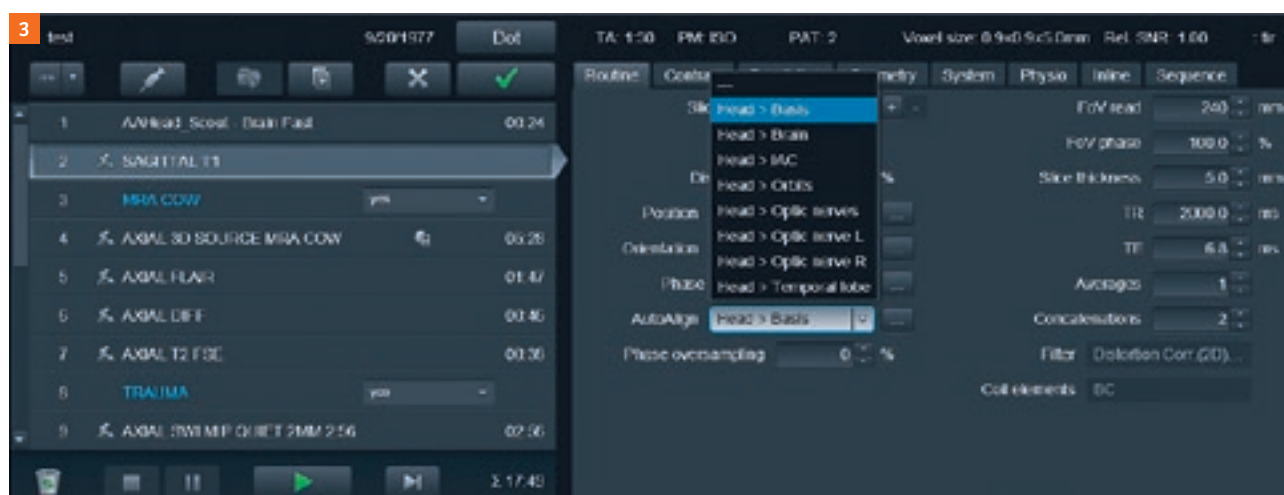


Figure 3: Screenshot illustrating the different AutoAlign features that are preprogrammed for brain imaging.

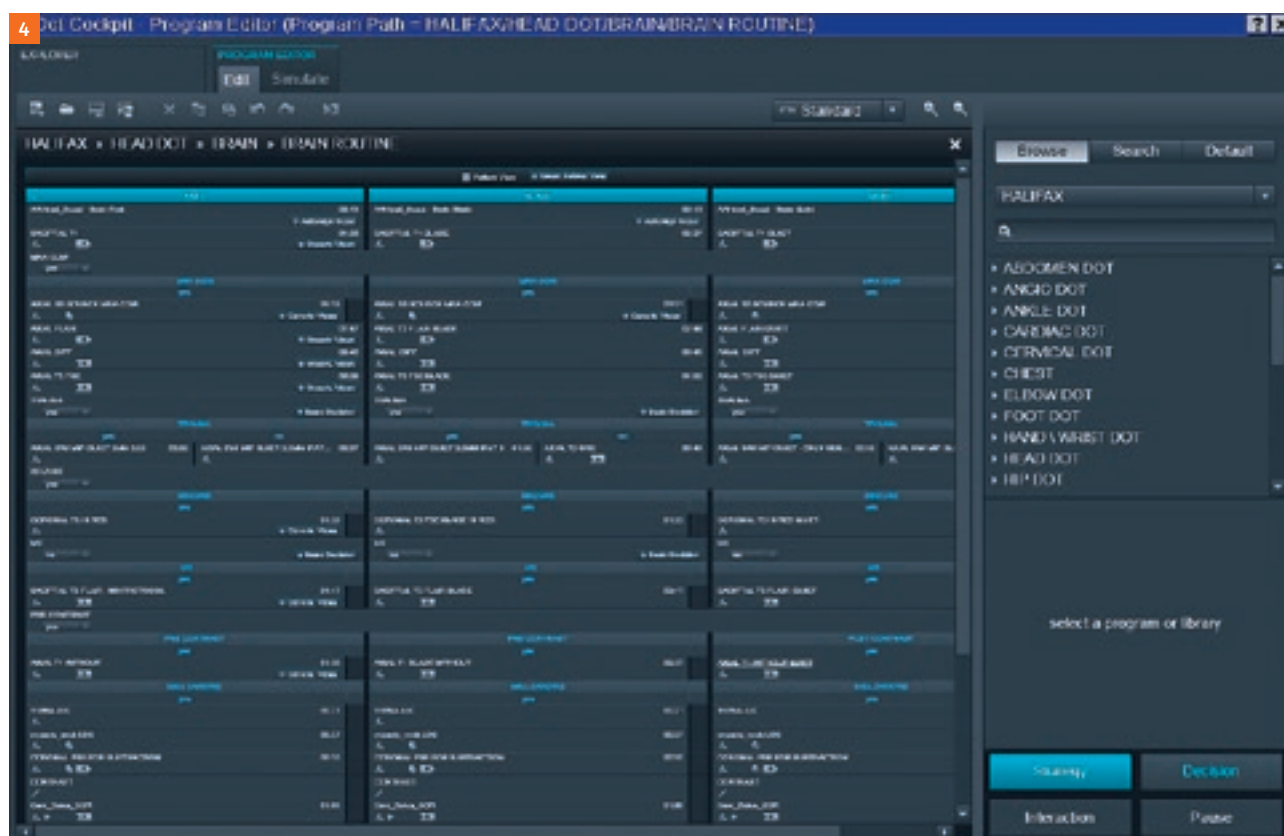


Figure 4: The bottom-right corner of this screenshot shows the Strategy option, which can be dragged directly into the exam series list for ease of protocol building.

building the Dot tree for users was not lightly made. The Dot building in the D platform did not make it easy for authors to navigate the string of pulse strategies. This statement is not characterizing the platform as a useless toy, but as a sophisticated tool that can enhance a department's productivity once the software has been implemented in a logical and user-friendly fashion.

After working with the D line for two years, we acquired the E line with Evolve. The benefits of this version exceptionally enhanced our workflows both in terms of daily throughput and protocol management. The E line is what the D line needed. To start with, the protocol-building portion of this upgrade is fast and user-friendly. After a day of application training, users can build a Dot protocol with multiple strategies from scratch. Some of the best

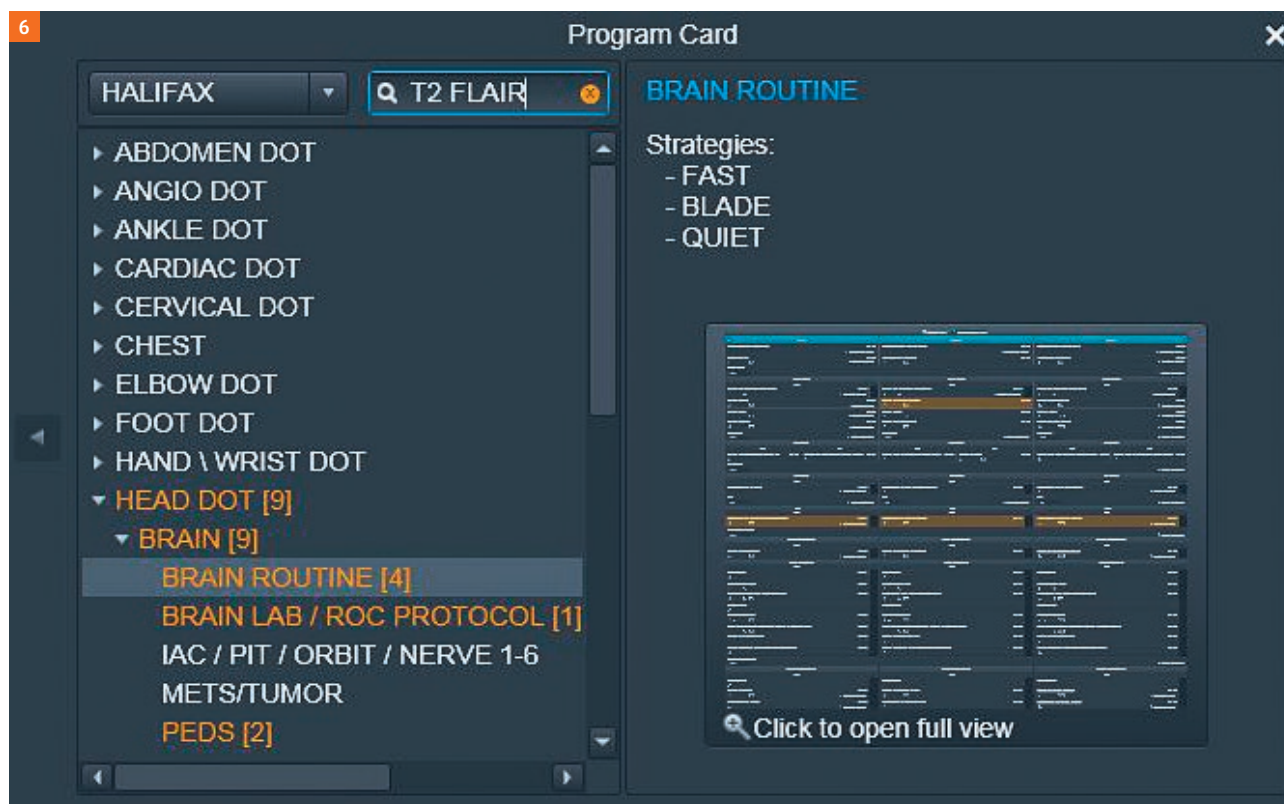


Figure 6: Screenshot showing the ease of finding a sequence using the search function.



Figure 7: Copy series options

additions are the drag-and-drop AddIns that appear directly on the protocol screen.

Users can decide whether a decision such as giving contrast should be built into the protocol or added to the options in the Dot screen so that technologists can choose it at the same time as the strategy. Adding images and text for guidance is simple. It can be done for any sequence so that all technologists can reproduce difficult or rare exams accurately and easily.

This is also a good feature for new technologists who might need assistance in achieving proper characterization of an exam. Another excellent workflow improvement is the ability to intertwine Dot and non-Dot sequences without overwhelming the scanner. Sequences can be easily added to an exam by simply opening the Dot Cockpit to the desired protocol and using the drag-and-drop function. In addition to locating sequences by protocol, Dot also offers an ingenious search feature. If a sagittal T2w FLAIR is needed for an MS patient but is not already built into the protocol, users can simply open the Dot Cockpit and type 'T2 FLAIR' (or the name of any

other pulse sequence). The scanner will search all the sequences in the active user tree and highlight relevant protocols in yellow.

This allows the user to see all the protocols containing T2 FLAIR, and to choose one that will fit the needs of the patient. Although this might not sound like much, the feature can help alleviate the anxiety that a technologist might feel when a radiologist stops by and asks to have a special pulse added to an exam.

Another excellent Dot feature is the speed at which it can preset copy references. Again, this sounds basic, but the ability to build the exact slice copy into a sequence allows the technologist to set the orthogonal slices as desired and have the scanner copy options such as slices and saturation bands, or indeed everything about the sequence.

This function makes it possible to set the basic axial brain and have the following axials copy the slice locations. Technologists might therefore only have to set up one sagittal, one axial, and one coronal for the entire exam. For the remainder of the time, they are free to complete other tasks involved in the exam or workflow. In a high-volume facility, every minute counts, and relieving staff of some monotonous tasks improves patient care and increases efficiency.

MRI scans can still be performed without Dot. However, to effectively accommodate the needs of today's patients and fulfil clerical expectations, using Dot to streamline repetitive or mundane tasks is the far superior option. By allowing the scanner to handle basic user tasks without removing the autonomy of the technologist, a well-developed Dot system can simplify workflows and enhance efficiency. Entrusting the scanner with these tasks does take a leap of faith, but once users see the consistency and reliability that is available through the Dot system, the benefits will greatly outweigh the concerns. The one thing to remember is that Dot is a tool and not a replacement. Working with the system to improve patient outcomes and efficiency is paramount in modern healthcare, so embrace the technology, but rest assured that you are always in control.

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# Cardiac Dot Engine: significant time reduction at cardiac magnetic resonance imaging

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## Introduction

Cardiac Magnetic Resonance (CMR) has rapidly developed and is now the technique of choice in the study of multiple heart diseases and an important tool for planning revascularization strategies in patients with coronary artery disease [1]. It allows the assessment of cardiac morphology and function. Therefore, it provides important information about tissue characterization by detecting the first steps of the ischemic cascade through perfusion sequences. An appropriate assessment of myocardial viability can be performed with delayed enhancement sequences [2].

However, CMR is not without certain limitations. Firstly, it requires skilled personnel with a good knowledge of cardiac anatomy and cardiac planes. Secondly, the scan times for CMR studies are substantially longer than for other types of study (with up to more than an hour on

stress heart exams) and remain a limiting factor in the recruitment of patients suffering from claustrophobia.

In order to reduce CMR scan times, the Cardiac Dot Engine has been developed. It is a new software technology from Siemens Healthineers, which offers a review of CMR fully guided and suited to the needs of the patient.

The system guides you through a series of graphical illustrations selecting some anatomical reference points on the heart. The software then performs an automatic planning of the different cardiac planes with-out the need for user intervention. It also allows you to obtain super-imposable slices in all sequences of the study, increasing confidence in our diagnoses [3].

## Clinical experience

Our experience with the Dot software began in June 2013. To date, we have performed in our center over 272 CMR

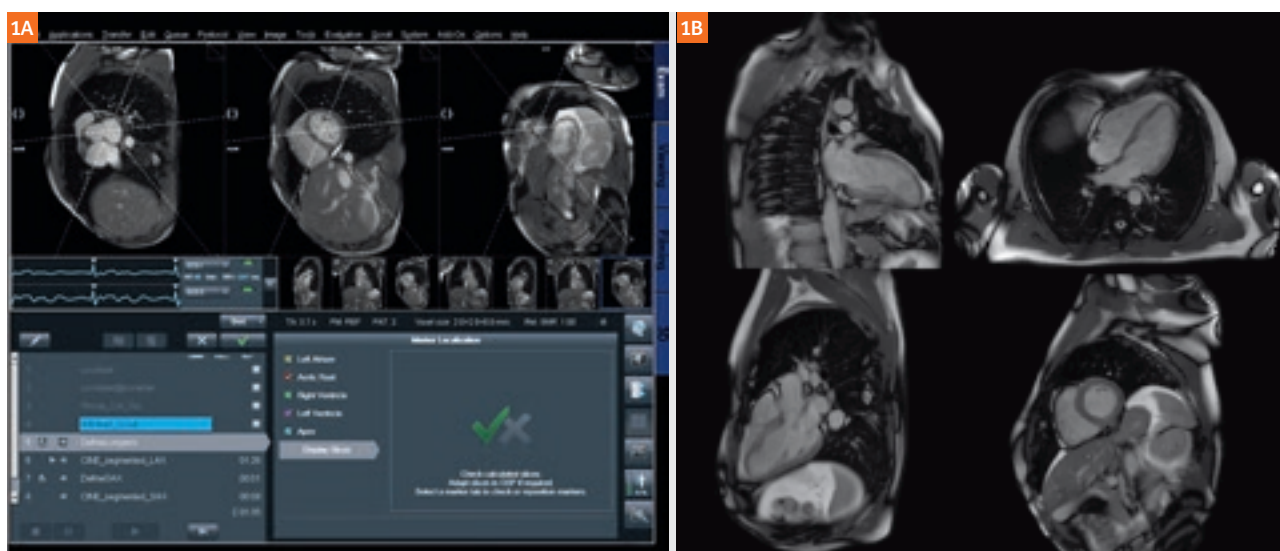


Figure 1: Automatic planning of the different cardiac axis with Cardiac Dot Engine.

studies of which 60% are stress studies after administration of adenosine. All studies have been performed under medical supervision and have been reproducible and high-quality diagnostic scans. During this time, we have observed a significant reduction of the average scan time.

We therefore proposed the following study to assess the time saved by using the Cardiac Dot Engine in both conventional and stress studies, compared to standard cardiac scans.

## Materials and methods

### Study design and patients

We have retrospectively reviewed a total of 194 patients consecutively between October 2012 and March 2014 with CMR studies performed at our Siemens 1.5T system (MAGNETOM Aera XQ) with an 18-channel body matrix coil.

For the correct categorization of the study we took into account some variables:

- First, the type of study of stress or conventional CMR. The technical specifications of both protocol studies are summarized in Table 1.
- Second, the use of Short Tau Inversion Recovery (STIR) sequences. We usually use this sequence for patients with suspected acute disease or suspicion of infiltrative heart disease.
- Third, the use of the Cardiac Dot Engine or conventional software.

Depending on the different variables, we obtained eight groups comparing the average scan time with the Cardiac Dot Engine and without it (conventional software).

The total examination time comprises the time from the beginning until the end of each scan.

The image quality of the studies has been assessed by a radiologist with over 20 years of experience on a 10-point scale (1 = poor to 10 = excellent).

The statistical analysis has been performed using a Student's T-test for independent samples to compare means. SPSS Statistics software 20.0 (IBM corporation, Armonk, NY, USA) has been used.

## Results

The image quality of all studies obtained a result between 9 and 10.

For conventional CMR studies with STIR sequences (58 patients) statistically significant differences in the average examination time using the Cardiac Dot Engine

( $t = 39.1 \text{ min} \pm 12.1$ ) have been observed, reducing the average examination time by 26.5 minutes compared to examination times using conventional software ( $t = 65.6 \text{ min} \pm 14.1$ ) ( $P = .003$ ).

For stress CMR studies with STIR sequences (27 patients) a statistically significant decrease of the examination time has been observed with a reduction of 19.7 minutes ( $t = 45.11 \text{ min} \pm 14.7$ ) using the Cardiac Dot Engine compared to ( $t = 64.9 \text{ min} \pm 7.8$ ) examination times using conventional software ( $P = .001$ ).

Furthermore, for CMR studies without STIR sequences (31 patients) a significant mean reduction of the examination time of 15.5 minutes has been found, which has been also statistically significant ( $t = 57.7 \text{ min} \pm 14.7$ ) compared to ( $t = 42.2 \text{ min} \pm 16.1$ ) ( $P = .001$ ).

Stress CMR studies without STIR sequences (78 patients) have also shown mean examination times of ( $t = 44.6 \text{ min} \pm 16.8$ ) using the Cardiac Dot Engine compared to ( $t = 65.1 \text{ min} \pm 22.3$ ) using the conventional software, which means a time reduction of 20.4 min ( $P = .002$ ) (Table 2).

## Discussion and limitations

Our study is not without limitations.

First of all, it is a retrospective study, which has inherent disadvantages.

There are also independent variables that may alter the average examination time. For example, at the time of infusion of adenosine, as a rule, there is a cardiologist present. The mean arrival time of the cardiologist is ( $t = 4.8 \text{ min} \pm 7.1$ ), which introduces a considerable delay.

There may also be glitches that force the study to be repeated, although this is very rare. This process, however, rarely extends beyond 5 minutes.

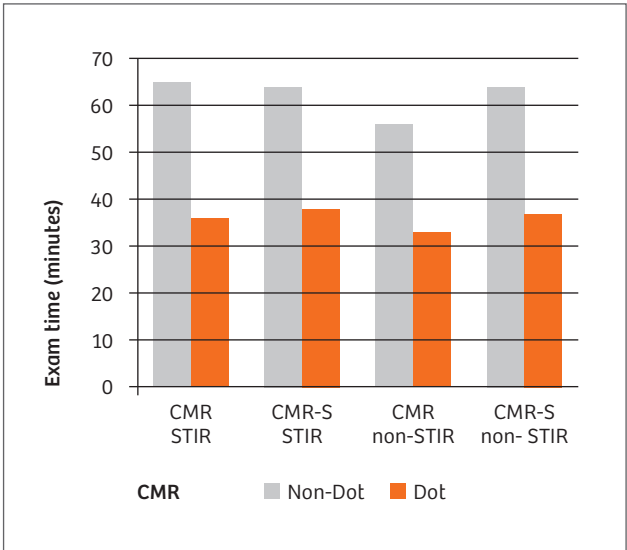
Another factor that may have extended the examination times at the beginning of this study is the universal training of all MRI personnel. It has been observed that during the initial learning phase, after the introduction of the Cardiac Dot Engine, the average examination times have been longer than afterwards. However, once the basic handling of the Dot Engine has been learned, the Cardiac Dot Engine has a fast learning curve without requirement of highly specialized technologists.

## Conclusion

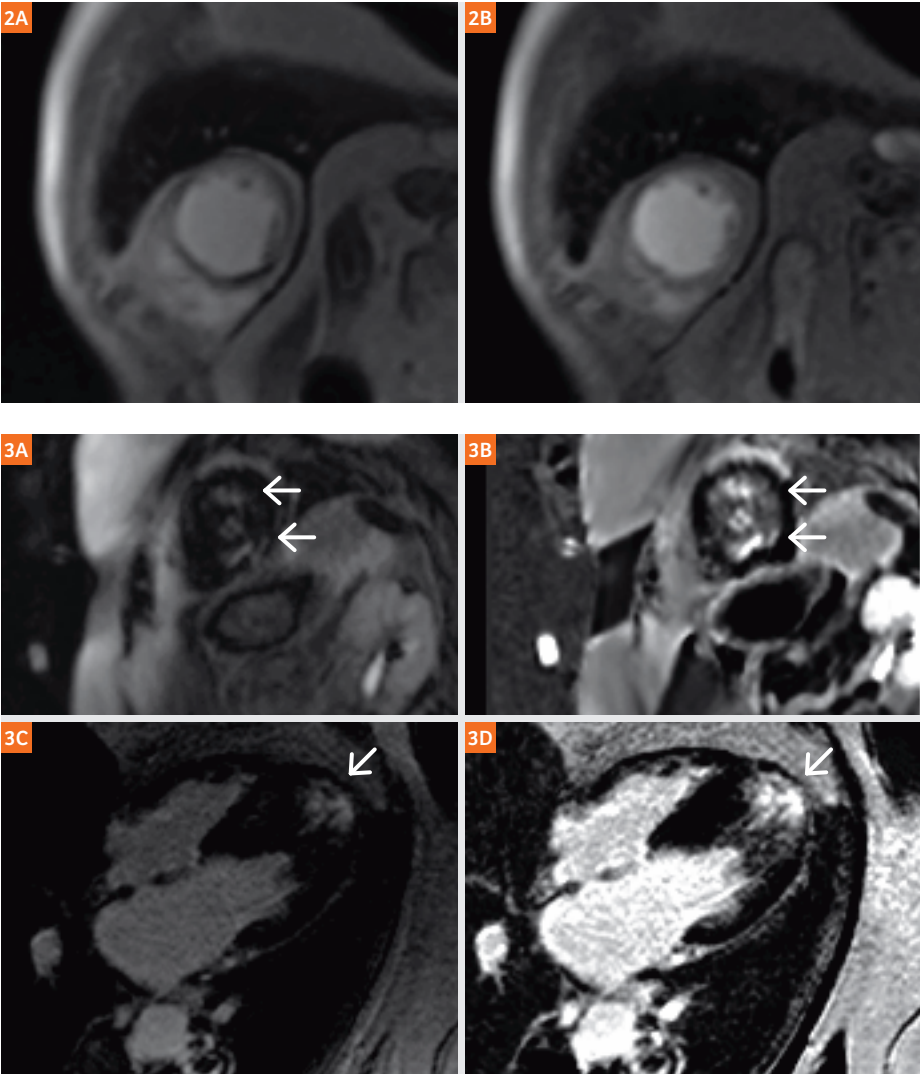
The Cardiac Dot Engine introduces patient benefit by providing systematically reproducible and efficient studies that consistently reduce examination time, resulting in increased efficiency, reduced costs and improved patient satisfaction without ever sacrificing high-quality diagnostic images.

Conventional CMR	Stress CMR
Localizer	Localizer
HASTE	HASTE
AAHeart-Scout	AAHeart-Scout
Function 4-chamber	Function 4-chamber
Dynamic rest (Gadovist® 0.1 mmol/kg, 4 mL/s)	Dynamic stress adenosine (Gadovist® 0.1 mmol/kg, 4 mL/s)
Function 2 + 3-chamber	Function 2 + 3-chamber
Function short-axis	Function short-axis
Delayed enhancement	Delayed enhancement
	Dynamic rest (Gadovist® 0.1 mmol/kg, 4 mL/s)

**Table 1:** Specifications of both study protocols (stress and conventional CMR) performed at our Siemens 1.5T MAGNETOM Aera XQ.



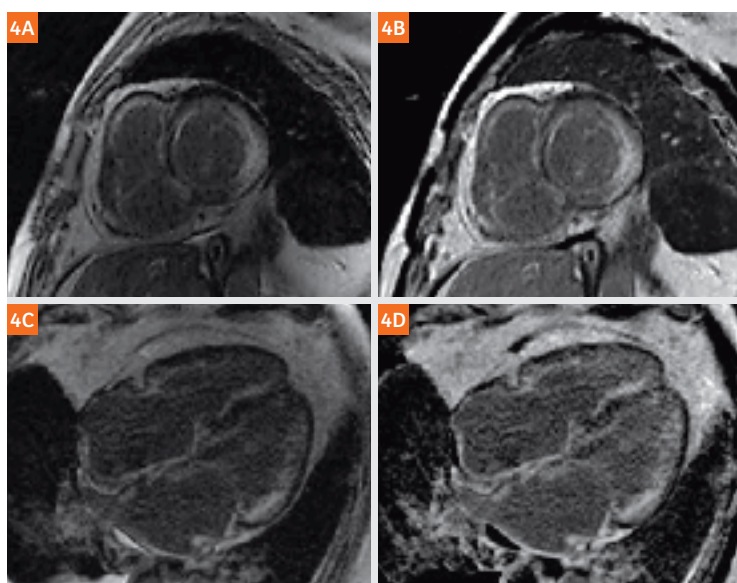
**Table 2:** Time reduction in cardiac magnetic resonance.



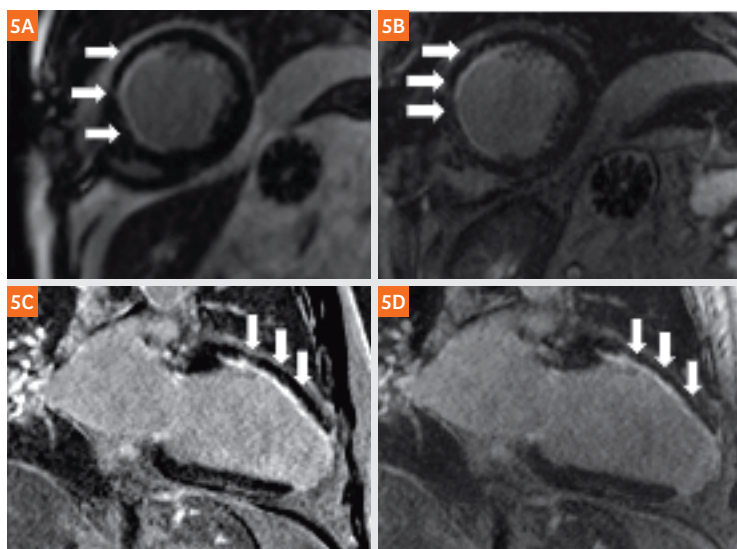
**Figure 2:** MR images show positive findings on stress study in a 53-year-old man with chest pain. The inferolateral wall stress-induced perfusion shows a defect (2A) that corresponds with a stenosis involving the left circumflex artery (LCX), disappearing in the dynamic perfusion study (2B). These findings were confirmed on subsequent invasive angiography with successful coronary stenting of the stenosis.

**Figure 3:** Short axis (3A, B) and four-chamber-view (3C, D) demonstrates hypertrophic changes as well as delayed contrast enhancement in the apex in a 43-year-old man with hypertrophic cardiomyopathy.





**Figure 4:** Delayed enhancement in the short axis (4A, B) and four-chamber-view (4C, D) reveals the presence of a diffuse patchy enhancement pattern, very suggestive of cardiac amyloidosis in a patient with congestive heart failure. A cardiac biopsy confirmed the diagnosis.



**Figure 5:** (5A, B) Short axis and (5C, D) two-chamber-view of delayed enhancement sequences. Arrows point to the septal wall of this patient, showing a severe subendocardial hyperenhancement that represents the region of myocardial infarction in the territory of left anterior descending (LAD) and the left circumflex artery (LCX).

## Acknowledgements

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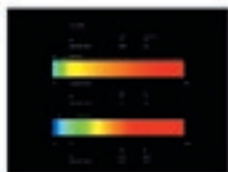
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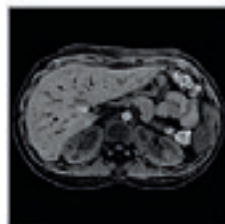
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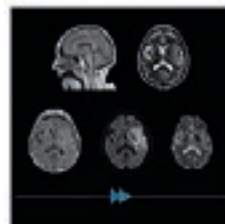
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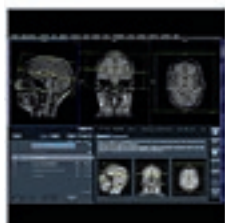
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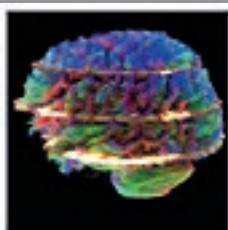
Spine Dot Engine



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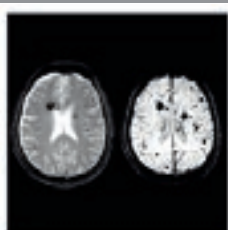
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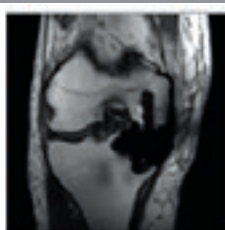
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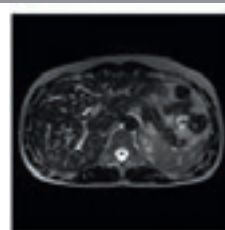
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