The fit Experience in Canada
Nancy Talbot, MAppSc, M.R.T.(R.)(M.R.)
Page 9

Long-term Experience with MRI Upgrades
Christos Loupatatzis, M.D.
Page 16

MR Options and Upgrades Edition

MAGNETOM Flash

The Magazine of MRI

usa.siemens.com/magnetom-world

SIEMENS Healthineers

With increasing pressure on healthcare providers to treat more patients, often with more complex treatment paths, and limited budgets for new capital investments, many providers are opting to extend the lifespan of their MRI scanners—on average, from 6.7 years in 1996 to 12.1 years in 2016[1]. Our Customer Development (CDV) team works closely with providers to maximize their MRI equipment with upgrades that best support their business objectives. This special edition of the MAGNETOM Flash magazine highlights how some of these cost-effective upgrades can help providers optimize scanner performance and utilization, as well as expand their clinical capabilities to help attract more referrals and increase competitiveness.

[1]IMV's 2016 MR Market Outlook Report (December 2016).

A free Asset Planning Session can help you make the most informed decisions about your imaging systems. We work with you and your stakeholders to identify your organization's needs, review your challenges and competitive landscape, and determine how to best maximize the potential of your installed MRI systems from Siemens Healthineers.

usa.siemens.com/asset-planning

Additional Resources

Webinars: Industry experts discuss the latest trends and innovations in MRI.
usa.siemens.com/mr-webinars

Case Studies: Customers share how our MRI solutions support their success.
usa.siemens.com/mr-casestudies

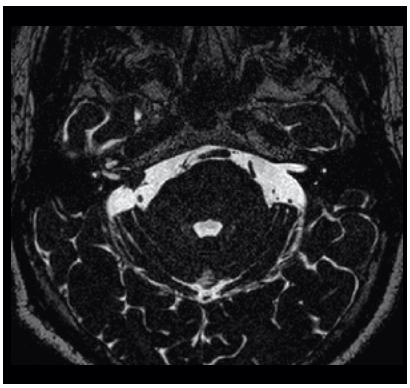
Editorial Board

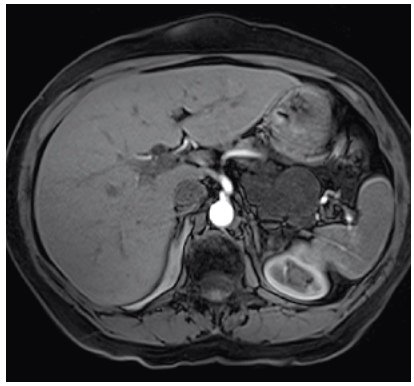
We appreciate your comments.
Please contact us at magnetomworld.med@siemens-healthineers.com

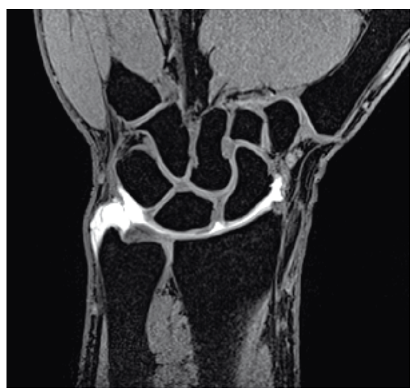
Review Board

Contents

Customer Development







fit-Upgrade: A Success Story

Stephan Zangos; Thomas J. Vogl
Institute for Diagnostic and Interventional Radiology, University Hospital Frankfurt, Frankfurt/Main, Germany

We reported on our first experiences with fit-upgrades on the MAGNETOM Avantofit and MAGNETOM Prismafit in MAGNETOM Flash[1] a year ago. 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.

Table 1.
A retrospective analysis1 shows that the fit-upgrades increased exam frequency in our department. 697 more cases with Avantofit and 469 more cases with Prismafit.

	01.01.-31.12.2012	01.01.-31.12.2014
Workdays	252	252
	MAGNETOM Avanto	**MAGNETOM Avanto^{fit}**
Cases total	3377	4074
Cases/day	13,4	16,2
	MAGNETOM Trio Tim	**MAGNETOM Prisma^{fit}**
Cases total	3543	4012
Cases/day	14,1	15,9

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 analysis1 (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 Avantofit, and by 13.2% to 469 examinations/year using the Prismafit. 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.

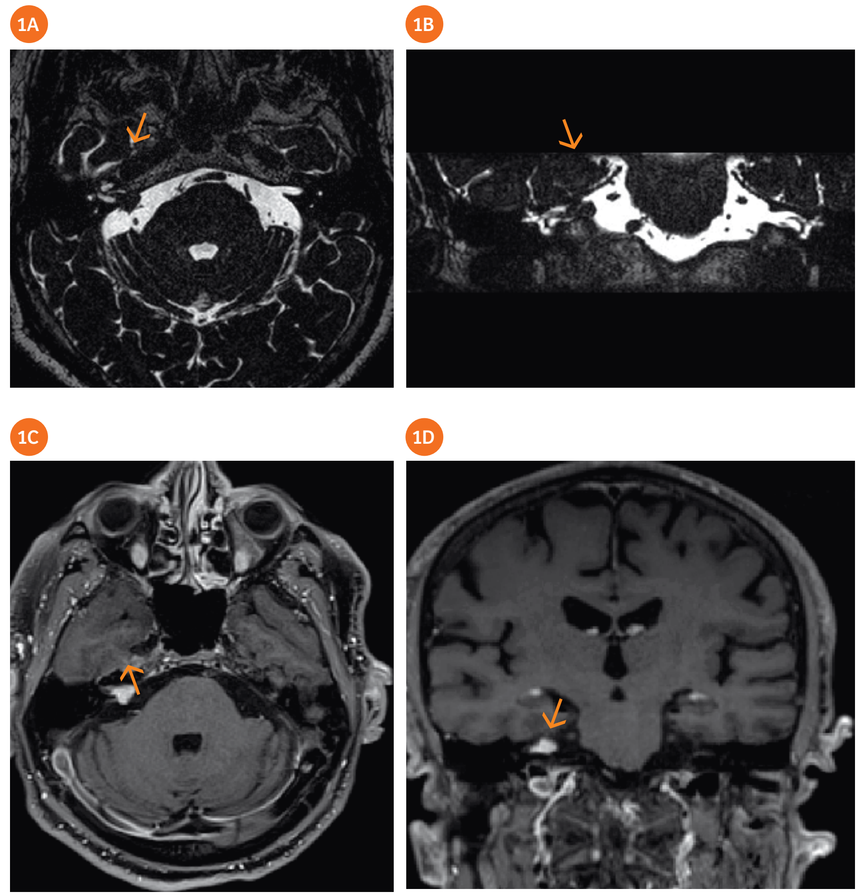


Figure 1. (1A, B) Representation of an acoustic neurinoma (arrow) on the MAGNETOM Avanto$^{\text{fit}}$. T2-weighted SPACE transversal (TR 1200 ms, TE 264 ms, slice thickness 0.6 mm) and reconstructed coronal slice orientations. (1C, D) Contrast-enhanced T1-weighted MPRAGE (TR 1800 ms, TE 2.6 ms, slice thickness 1 mm) with automatically calculated coronal MPR.

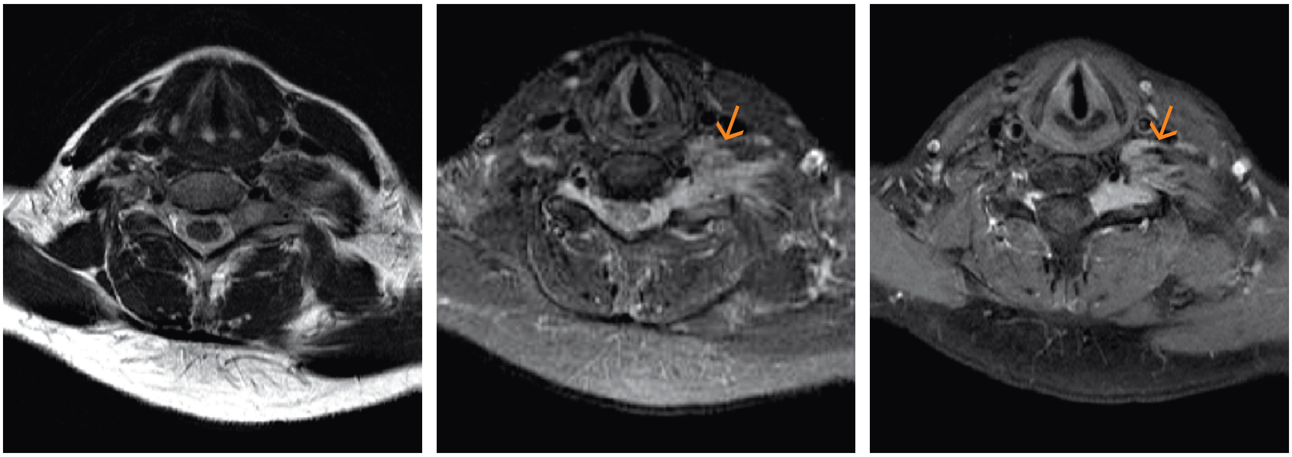


Figure 2. Relapse of B-NHL (arrow) on the Avanto^fit.
Comparison of the T2w TSE (TR 4000 ms, TE 79 ms; slice thickness 5 mm), T2w TIRM (TR 4140 ms, TE 32 ms; slice thickness 6 mm) and contrast-enhanced T1w TSE FS-Dixon sequences (TR 520 ms, TE 14 ms; slice thickness 5 mm). The images show homogeneous fat saturation in this problem area, facilitating diagnosis.

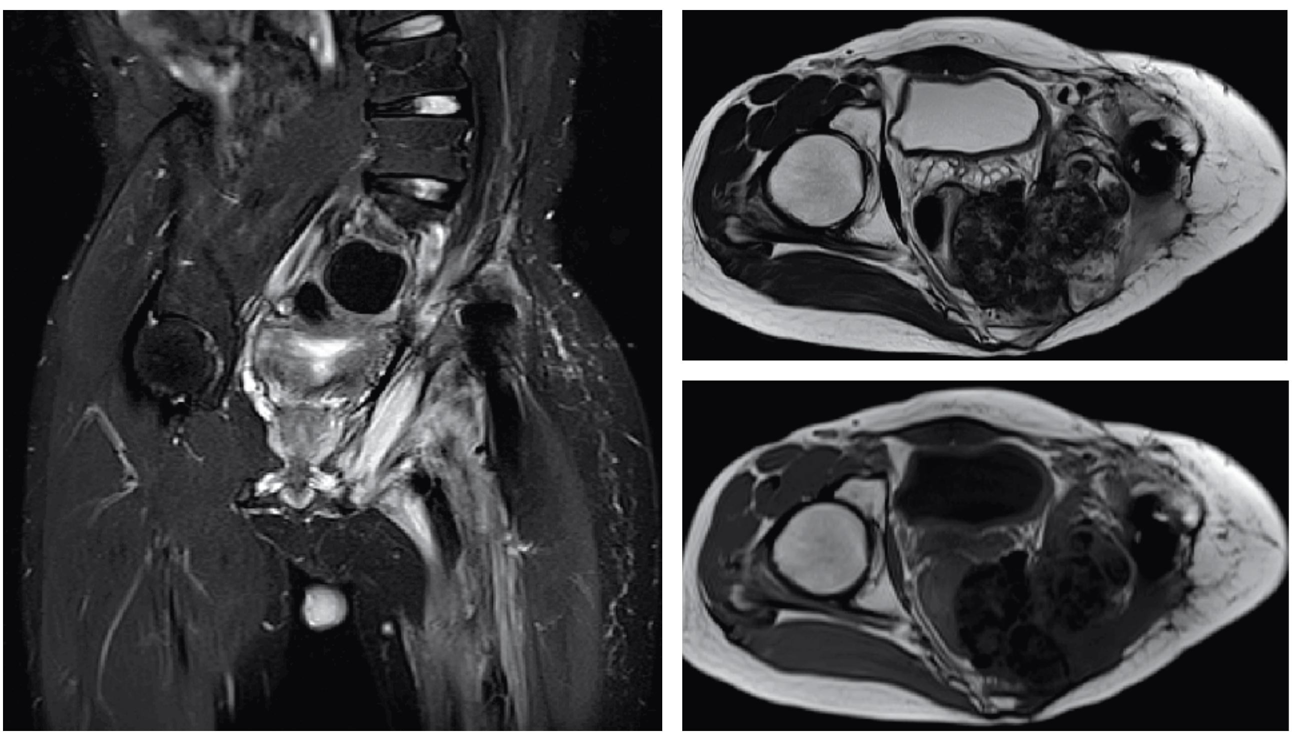


Figure 3. Recurrence after resection of osteosarcoma of the ilium on the MAGNETOM Avanto^fit.
T2w TIRM WARP (TR 4670 ms, TE 39 ms; slice thickness 5 mm), T2w TSE WARP (TR 5530 ms, TE 77 ms; slice thickness 6 mm), T1w TSE WARP (TR 500 ms, TE 7 ms; slice thickness, 6 mm), and T1w TSE WARP sequences show the reduction of metal artifacts of tumor prosthesis.

4A 4B

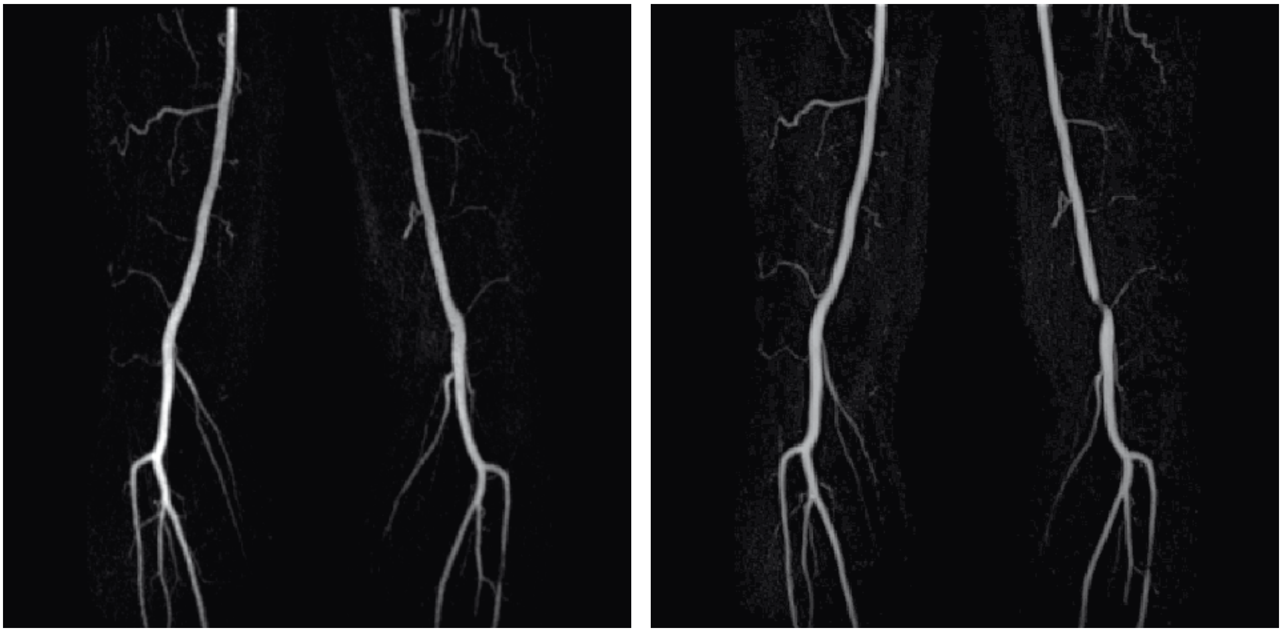


Figure 4. MIP (maximum intensity projection) of a TWIST angiography in neutral and provocation positions on the MAGNETOM Avanto[fit]. The images show an entrapment on the left side.

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.

References

[1]Zangos S, Vogl TJ. MAGNETOM Trio upgrade to Prismafit better imaging technique ccombined with higher throughput in clinical practice. MAGNETOM Flash no. 58, 3(2014): 32-38.

Contact
Stephan Zangos
stephan.zangos@af-k.de

The fit Experience in Canada

Nancy Talbot, MAppSc, M.R.T.(R.)(M.R.)
Princess Margaret Cancer Center, University Health Network, Toronto, Canada

Introduction

Canada has a large number of MAGNETOM Avanto 1.5T scanners, and a growing number of MAGNETOM Avanto^fit 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^fit 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^fit and MAGNETOM Skyra^fit systems in late 2013. These included two MAGNETOM Avanto 1.5T scanners to Avanto^fit, and two MAGNETOM Verio 3T scanners to the Skyra^fit 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.

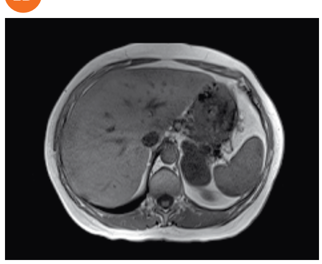
The upgrade itself included all components except the gradient coil and the magnet for all four of the systems. Each scanner was already equipped with the SQ gradients

Figure 1. Liver imaging.

1A

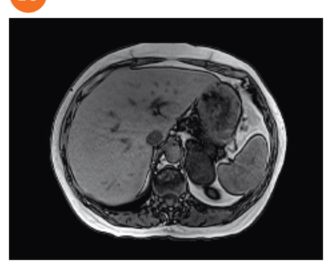
3T DWI, 2013
(8 slices / 1.6 mm gap,
FOV 380 x 285, matrix 192 x 115)

1B



3T in-phase, 2013
(5/0, 340 x 276, 320 x 169)

1C

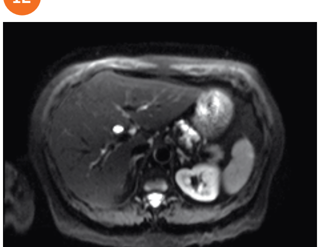


3T out-of-phase, 2013

1D

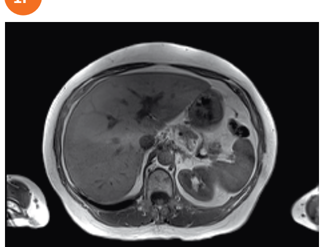
3T arterial phase, 2013
(5/0, 340 x 287, 320 x 189)

1E



3T DWI, 2016
(5/1, 400 x 350, 336 x 384)

1F



3T in-phase, 2016
(3/0, 440 x 399, 320 x 218)

1G

3T out-of-phase, 2016

1H

3T arterial phase, 2016
(3/0, 440 x 358, 320 x 195)

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 Skyra 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.

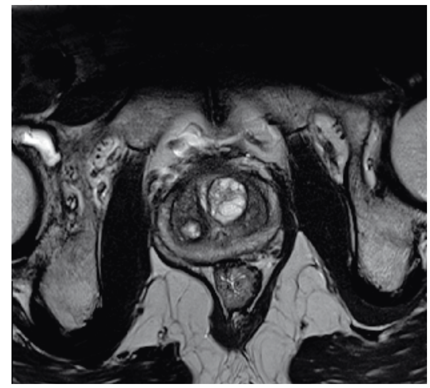
Figure 2. Prostate imaging. After the 3T system upgrade (2016) we gained equivalent image quality as previous exams done with the endorectal (ER) coil (2010).

2010 Scan done with endorectal coil	2016 Scan done with 18-channel Body coil

2A

3T axial T2w, 2010
(3/0, 140 x 140, 320 x 256)

2B



3T axial T2w, 2016
(3/0.6, 160 x 160, 320 x 310)

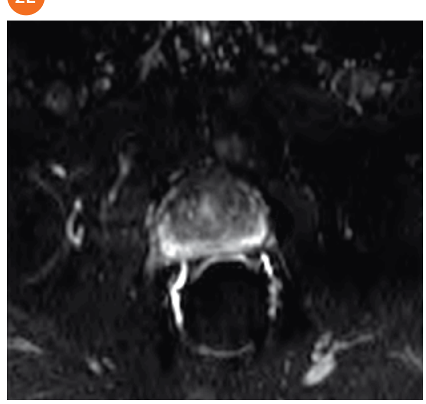
2C

3T sagittal T2w, 2010
(4/0, 140 x 140, 320 x 192)

2D

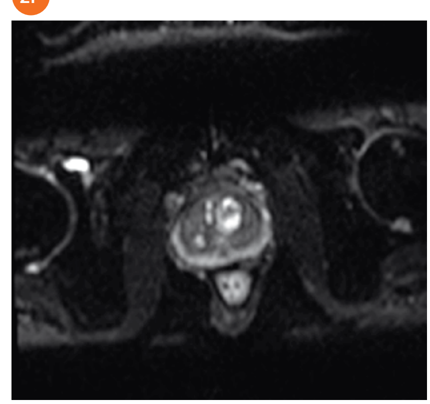
3T sagittal T2w, 2016
(3/0.6, 200 x 200, 320 x 310)

2E



3T DWI, 2010
(3/0, 184 x 184, 128 x 128)

2F



3T DWI, 2016
(3/0, 200 x 200, 128 x 128)

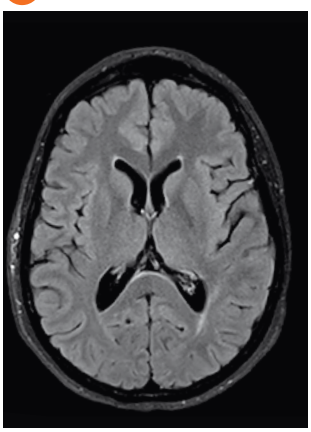
From an exam quality perspective, there were improvements in imaging across the entire body. Time is needed to work through site protocols to optimize to radiologists preferences, however, there is no doubt that the upgrade has been well worth it. Some examples following will show improvements to the 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).

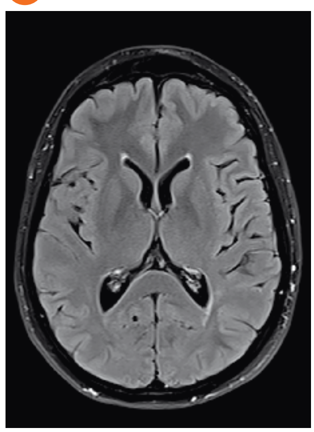
Figure 3. Brain imaging at 1.5T shows improved SNR (note: the resolution for FLAIR is decreased).

3A



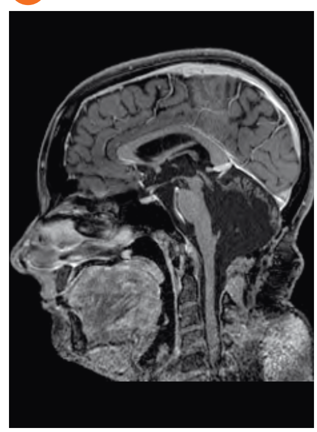
1.5T axial FLAIR, 2011
(4/1, 230 x 183, 512 x 408)

3B



1.5T axial FLAIR, 2016
(4/1, 230 x 180, 320 x 175)

3C

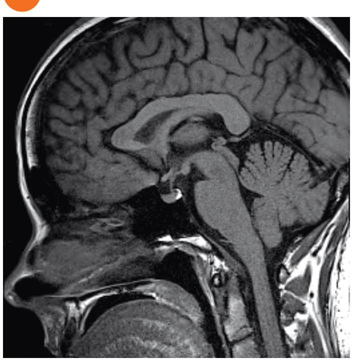


1.5T sagittal MPRAGE, 2011
(1 mm, 250 x 250, 256 x 256)

3D

1.5T sagittal MPRAGE, 2016
(1 mm, 250 x 250, 256 x 256)

4A

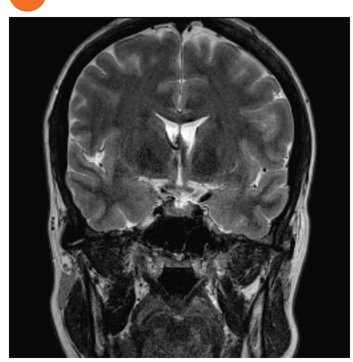


3T sagittal T1w, 2012
(2/0, 180 x 180, 384 x 384)

4B

3T coronal T1w, 2012
(2/0, 180 x 180, 320 x 320)

4C

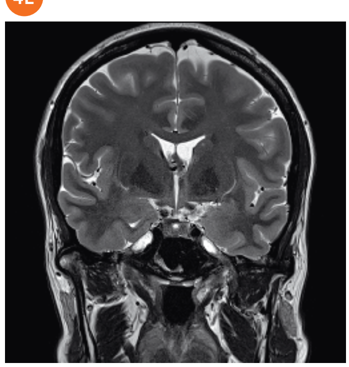


3T coronal T2w, 2012

4D

3T coronal T1w, 2016
(2/0, 180 x 180, 320 x 320)

4E



3T coronal T2w, 2016

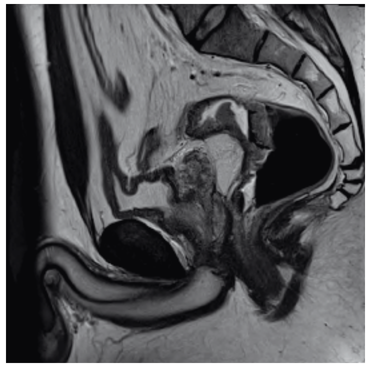
Figure 4. Sella imaging at 3T. The parameters are the same but note the significant increase in SNR throughout the images with the Skyra^{fit} upgrade.

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

5A

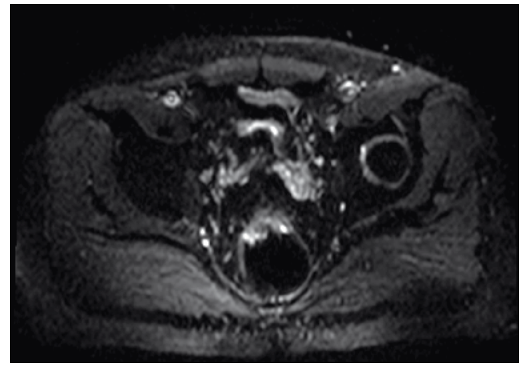
3T axial T2w, 2012
(4/1, 220 x 220, 320 x 320)

5B



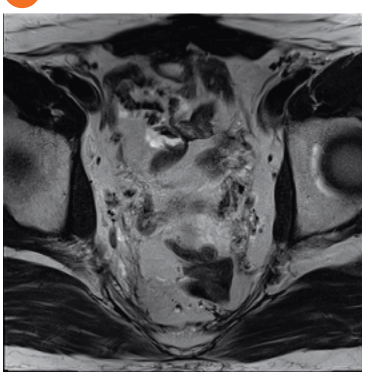
3T sagittal T2w, 2012
(4/1, 220 x 220, 320 x 320)

5C



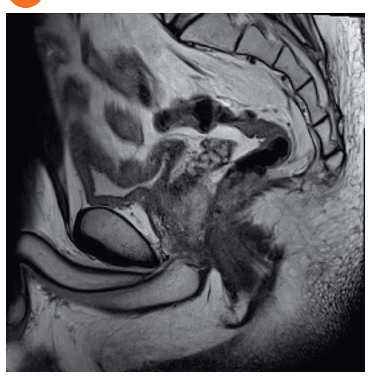
3T axial DWI, 2012
(4/0.8, 278 x 370, 384 x 230)

5D



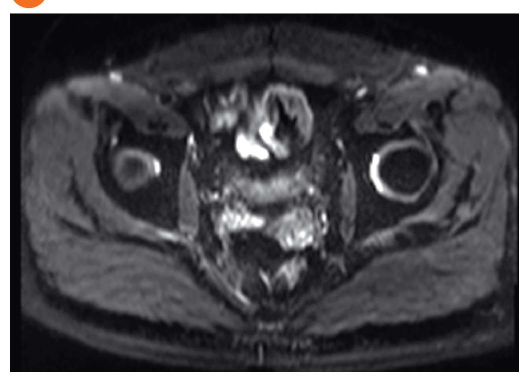
3T axial T2w, 2016
(4/1, 200 x 200, 320 x 320)

5E



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

5F



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 haveall the features and software of the Aera system."

Nancy Talbot, MRI Supervisor
Princess Margaret Cancer Centre

Contact
Nancy Talbot, MAppSc, M.R.T.(R.)(M.R.)
nancy.talbot@uhn.on.ca

The Skyra^{fit} Experience in Basel

Thomas Egelhof, M.D.; Georg Katz, M.D.; Claudia Maise
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.

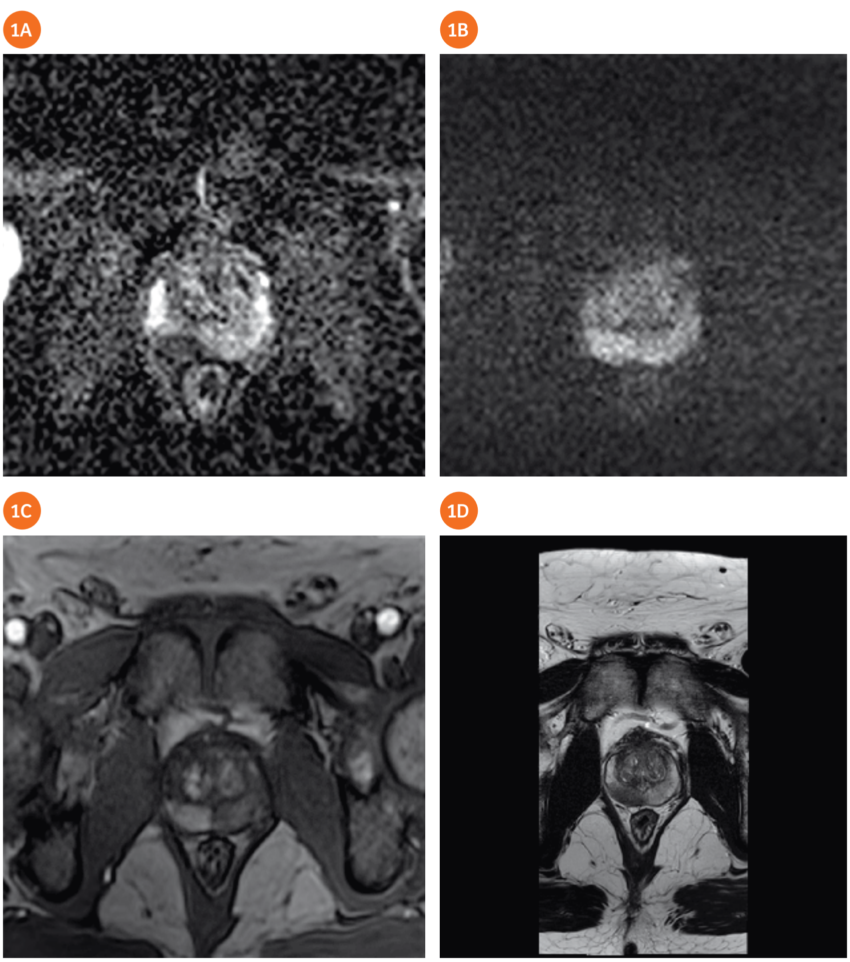


Figure 1. Prostate images.
(1A) ADC RESOLVE b50, 800, 1500 transversal, SL 3 mm, FOV 150 x 150, matrix 100 x 100. (1B) DWI b 800 transversal, SL 3 mm, FOV 150 x 150, matrix 100 x 100. (1C) T1-weighted VIBE transversal post-contrast, SL 3.5 mm, FOV 180 x 180, matrix 122 x 160. (1D) T2w TSE transversal,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

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 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^fit, 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.

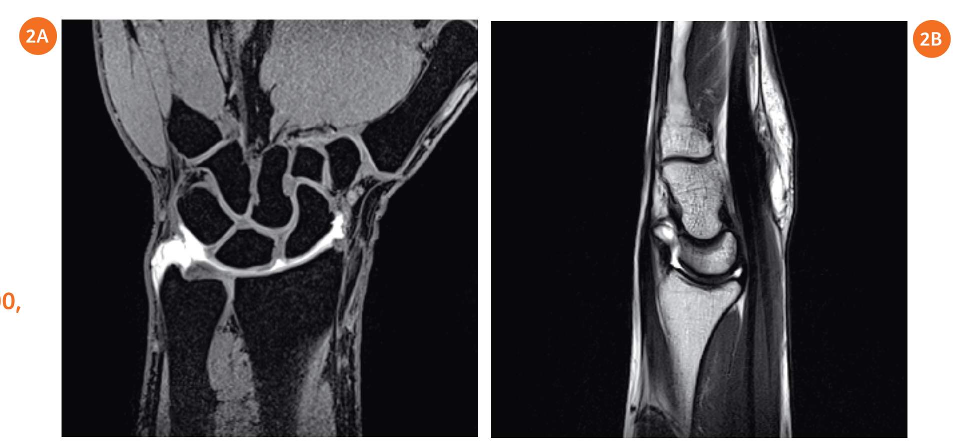


Figure 2. Wrist images.
(2A) T1w VIBE coronal, FOV 90 x 100, matrix 273 x 320. (2B) T2w TSE sagittal, SL 3 mm, FOV 100 x 100, matrix 307 x 384.

Results

The improvements introduced with our Skyrafit 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 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, Technolgosist 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.

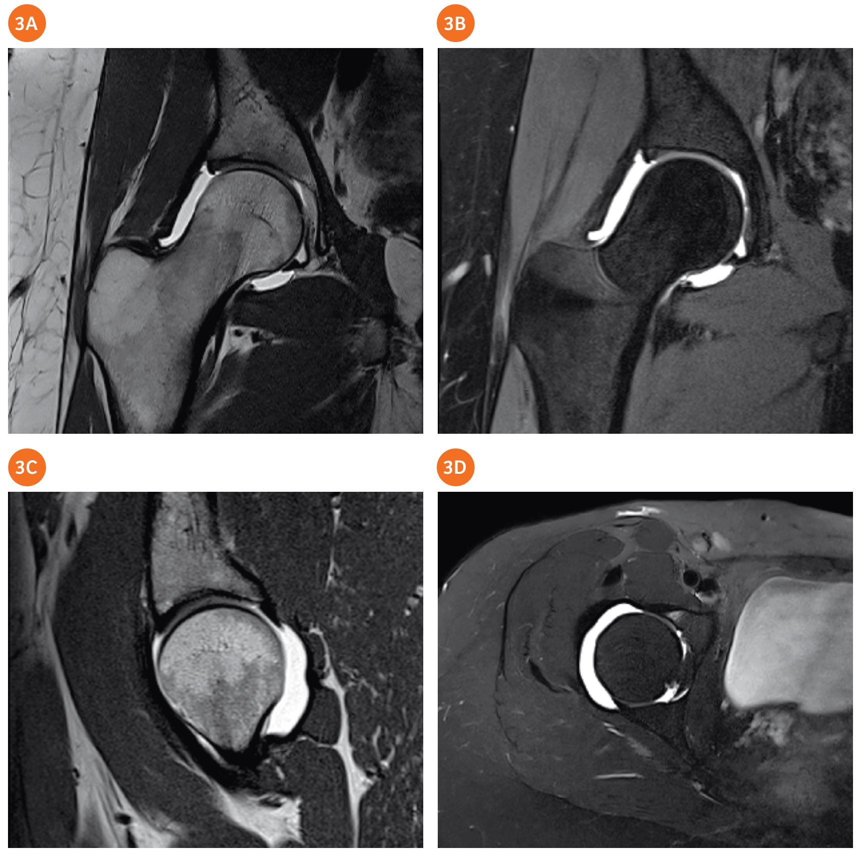


Figure 3. Hip images.
(3A) T1w TSE coronal, SL 3 mm, slices 20, FOV 160 x 160, matrix 269 x 448, A 3:56 min. (3B) PDw TSE FatSat coronal, SL 3.5 mm, slices 20, FOV 150 x 150, matrix 272 x 320, TA 2:42 min. (3C) PDw TSE sagital, SL 2 mm, FOV 130 x 130, matrix 230 x 256. (3D) T2w TSE FatSat transversal,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

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.

Contact
Dr. med. Thomas Egelhof
thomas.egelhof@merianiselin.ch

Dr. med. Georg Katz
Georg.Katz@merianiselin.ch

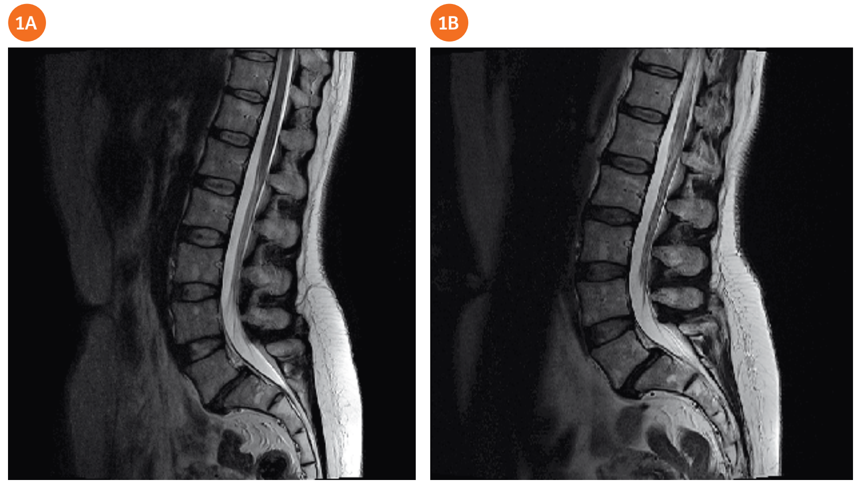
Long-term Experience with MR Upgrades

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.

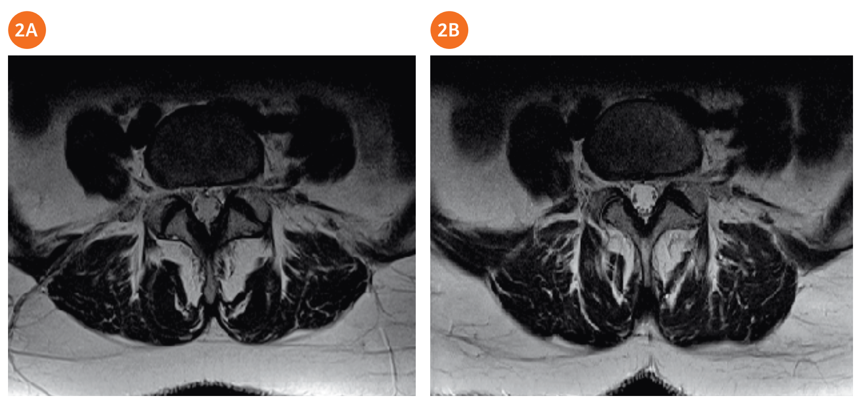
In 2007 the decision was made to acquire a MAGNETOM Avanto 1.5T MRI system (Siemens Healthineers, Erlangen, Germany). This scanner worked consistently over the years to provide very good image quality. Nevertheless, always aiming to optimize our image quality and performance, in 2013 we became one of the first MRI centers in Switzerland to perform a fit upgrade, accompanied by a Dot upgrade. Notwithstanding the acquisition of additional diagnostic tools during the first years (such as spectroscopy, perfusion imaging and susceptibility-weighted imaging), this



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 Avantofit 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^{fit} upgrade. In 2B note the possibility to reduce the FOV and therefore improved image resolution, in shorter acquisition time (i.e. the nerve roots).

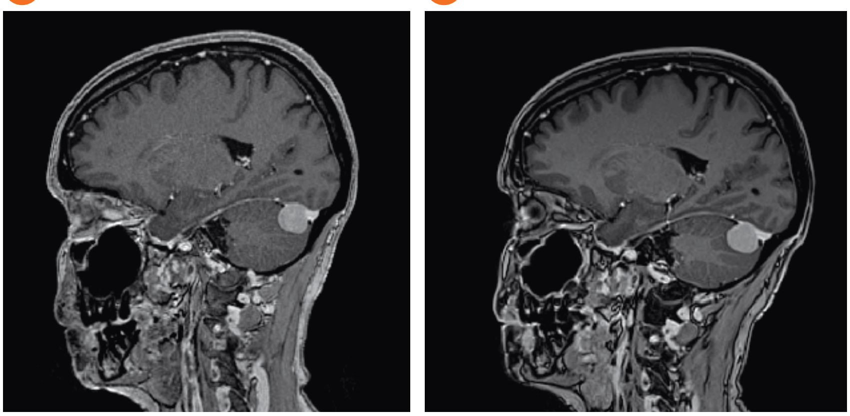
fit upgrade was our first major MR upgrade. A second major step has been our update to software version *syngo* MR E11C. A milestone in this context was our participation as a CPF ("Customer Preference Feedback") reference center for the *syngo* MR E11C software version in 2015/2016.

Avanto^{fit} 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 Avantofit 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.

3A 3B

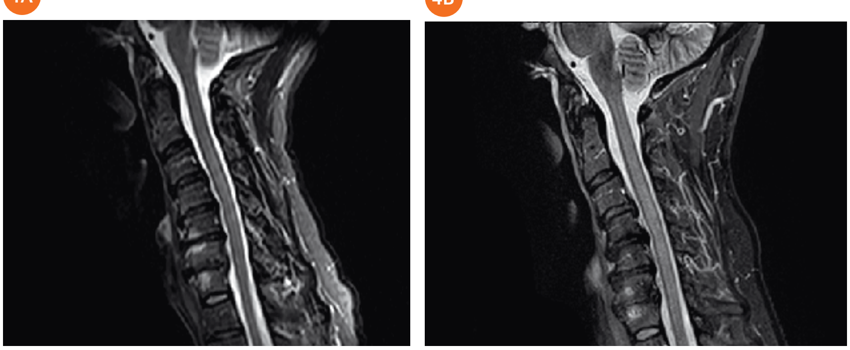


3A: TR 2060 ms, TE 3.4 ms, TI 1100 ms, TA 5:11 min, 208 slices, FOV 250 x 250, matrix 320 x 320, SL 0.9 mm

3B: TR 2000 ms, TE 2.5 ms, TI 900 ms, TA 5:01 min, 208 slices, FOV 250 x 250, matrix 288 x 288, SL 0.9 mm

Figure 3. 54-year-old female patient. 3D-MPRAGE-sequence of the brain after contrast administration before (3A) and after (3B) MAGNETOM Avanto^{fit} 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).

4A 4B



4A: TR 3500 ms, TE 91 ms, TA 3:27 min, 12 slices, FOV 280 x 280, matrix 384 x 512, SL 3.5 mm

4B: TR 3500 ms, TE 29 ms, TA 3:47 min, 12 slices, FOV 220 x 220, matrix 515 x 512, SL 3.0 mm

Figure 4. 45-year-old male patient. STIR sagittal images of the cervical spine, before (4A) and after (4B) MAGNETOM Avanto^{fit} 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).

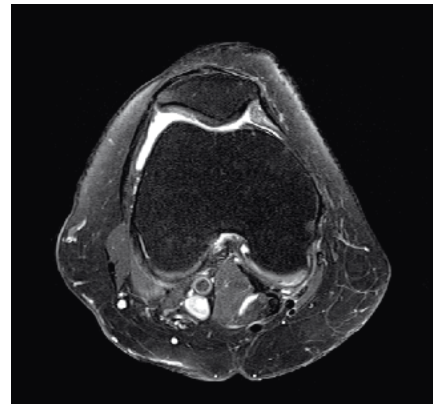
In brain-imaging specifically the 3D-MPRAGE-sequence became much crispier and clearer (Fig. 3) and the RESOLVE-diffusion showed significantly less artifacts in comparison to the standard EPI diffusion. In spine-imaging we were able to reduce the field-of-view (FOV) and therefore increase the resolution 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 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.

5A

TR 2120 ms, TE 41 ms, TA 2:14:2 min, 32 slices, FOV 160 x 160, matrix 240 x 320, SL 3 mm

5B



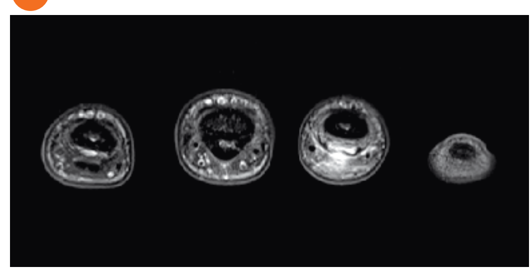
TR 3600, TE 45 ms, TA 3:10 min, 30 slices, FOV 160 x 160, matrix 269 x 448, SL 3 mm

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^{fit} upgrade, using the new 15 channel knee coil. Note the much better image quality in 5B (i.e. in the retropatellar cartilage).

6A

TR 3010 ms, TE 26 ms, TA 2:09 min, 20 slices, FOV 186 x 220, matrix 345 x 512, SL 2 mm

6B



TR 4200 ms, TE 28 ms, TA 3:31 min, 25 slices, FOV 96 x 110, matrix 353 x 448, SL 3 mm

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 rectracted tendon and (6B) axial PDfs image showing the empty space, where the tendon should be.

Definitely one of the biggest steps of evolution and advantage of the new system is the standardization of the exam 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/mm2. This modification was initially scrutinized by the Siemens-developers, who were quickly

7A 7B 7C 7D

TR 4000 ms, TE 64 ms, SL 5 mm, TA 1:34 ms, 25 slices, b-value 1000 TR 3000 ms, TE 83 ms, SL 2.5 mm, TA 2:40 ms, 40 slices, b-value 2000

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.)

8A 8B 8C 8D

TR 4000 ms, TE 64 ms, SL 5 mm, TA 1:34 ms, 25 slices, b-value 1000 TR 3200 ms, TE 83 ms, SL 2.5 mm, TA 2:51 ms, 40 slices, b-value 2000

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.)

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

	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
System adjustments		
B1 Shim mode	TrueForm	None
Diffusion mode	4-scan trace	4-scan trace
Diffusion scheme	bipolar	monopolar
Diffusion-weightings		
b-value 1	0 s/mm^2	0 s/mm^2
b-value 2	1000 s/mm^2	2000 s/mm^2
Sequence part 1		
Echo spacing (ms)	1.04	0.91
Bandwidth (Hz/Px)	1042	1240
TA (min)	1:17	2:51

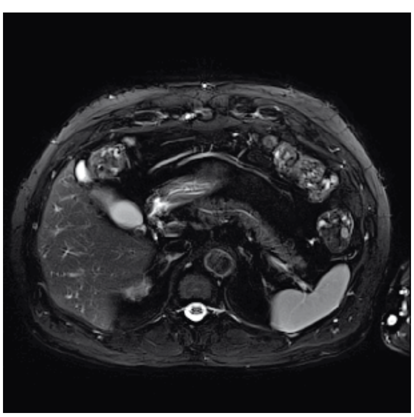
convinced of the advantages of this modification. With such a high b-value the conspicuity of acute ischemic lesions increased dramatically. Using the very robust RESOLVE diffusion (b-value 1000 s/mm², 5 mm slice thickness) as a standard sequence, we sometimes doubted the interpretation of our findings 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 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 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 the assistance of Siemens Healthineers creating a test-version of a dynamic StarVIBE sequence, which enabled dynamic liver imaging with decent image quality even with totally uncooperative patients (Fig. 10, Tab. 2). LiverLab software was used to evaluate iron content and quantify MR fat signal fraction with HISTO (single voxel spectroscopy) for completing an advanced evaluation of liver pathologies.

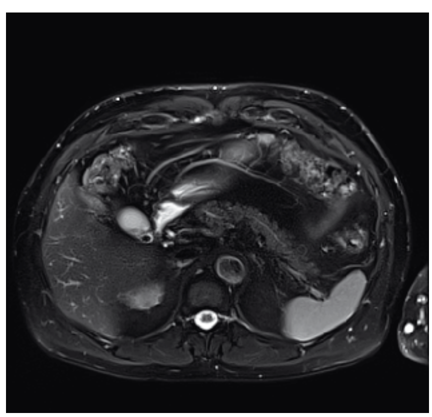
A new innovative technique with the potential to revolutionize MR-Angiography is the Quiescent-Interval Single-Shot (QISS) sequence. This is the first reasonable alternative to contrast-enhanced angiography, in particular peripheral angiography of lower extremity arteries (Fig. 11). Furthermore the QISS 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.

9A



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

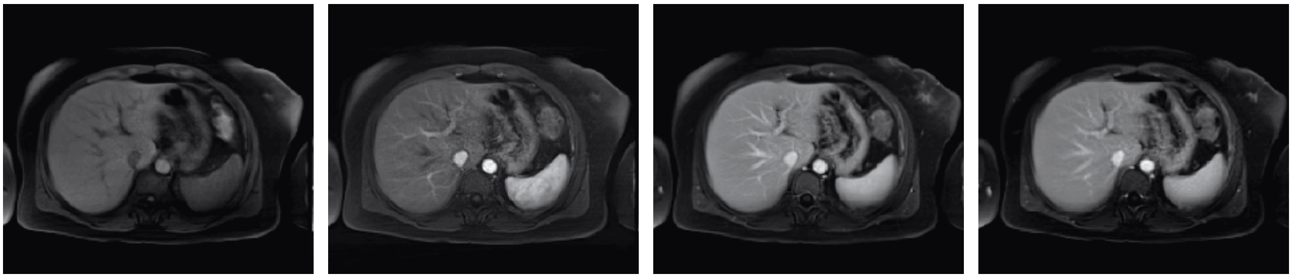
9B



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.

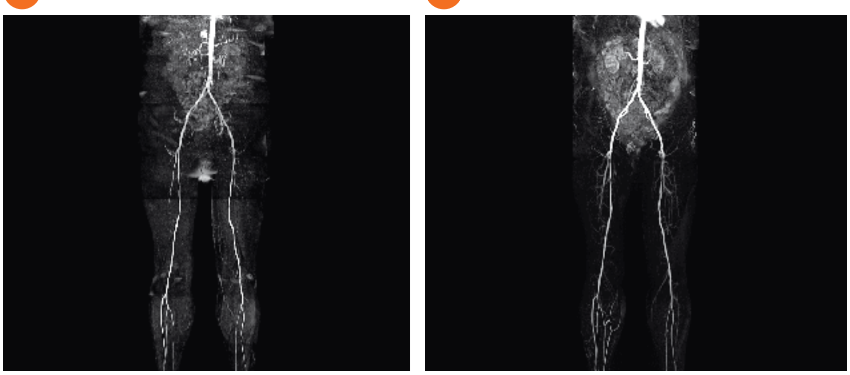
10A 10B 10C 10D



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)

11A 11A



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.

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

	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
Slab group		
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
Contrast – Dynamic		
Multiple series	Each measurement	Off
Resolution		
Base resolution	320	224
Radial views	680	220
System adjustments		
B1 Shim mode	TrueForm	Off
Sequence part 1		
Bandwidth (Hz/Px)	820	600
Sequence Assistant		
Allowed delay	60 s	–
TA (min)	2:53	0:21

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.

Contact
Christos Loupatatzis, M.D.
c.loupatatzis@spitalmaennedorf.ch

Siemens Healthineers Headquarters
Siemens Healthcare GmbH
Henkestr. 127
91052 Erlangen, Germany
Phone: +49 9131 84-0
siemens-healthineers.com

Local Contact Information
Siemens Medical Solutions USA, Inc.
40 Liberty Boulevard
Malvern, PA 19355-9998, USA
Phone: 1-888-826-9702
usa.siemens.com/healthineers

Order No. 24-18-11515-01-76 · Online Pdf · 04-2018 · ©Siemens Medical Solutions USA, Inc., 2018