MAGNETOM Sola: Adaptive and anticipatory, predictive and profitable

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Radiology in a changing environment

Today's radiology departments operate in a changing environment.

A. The demographic change means that the number of elderly, multimorbid patients is increasing.

B. Economic pressure is growing worldwide, making cost-efficiency a major topic in healthcare.

C. For personalized treatment and precision medicine, institutions increasingly require robust and consistent imaging data as input for quantifying imaging data and characterizing tissue.

Along with data from deeper levels of information, right down to the genomic level, imaging is the foundation of precision medicine. Merging imaging data with genomic data and molecular information will provide new insights for developing targeted therapies and personalized treatment. Due to the specificity of the data it produces, MRI will play a major role in precision medicine. As well as providing high-resolution anatomical and morphological information, it also supplies functional and molecular data. However, if MRI is to be the key enabler for radiomics and precision medicine, its data must be robust, reproducible, and of a high quality. Until recently, variations in patient anatomy and physiology have been

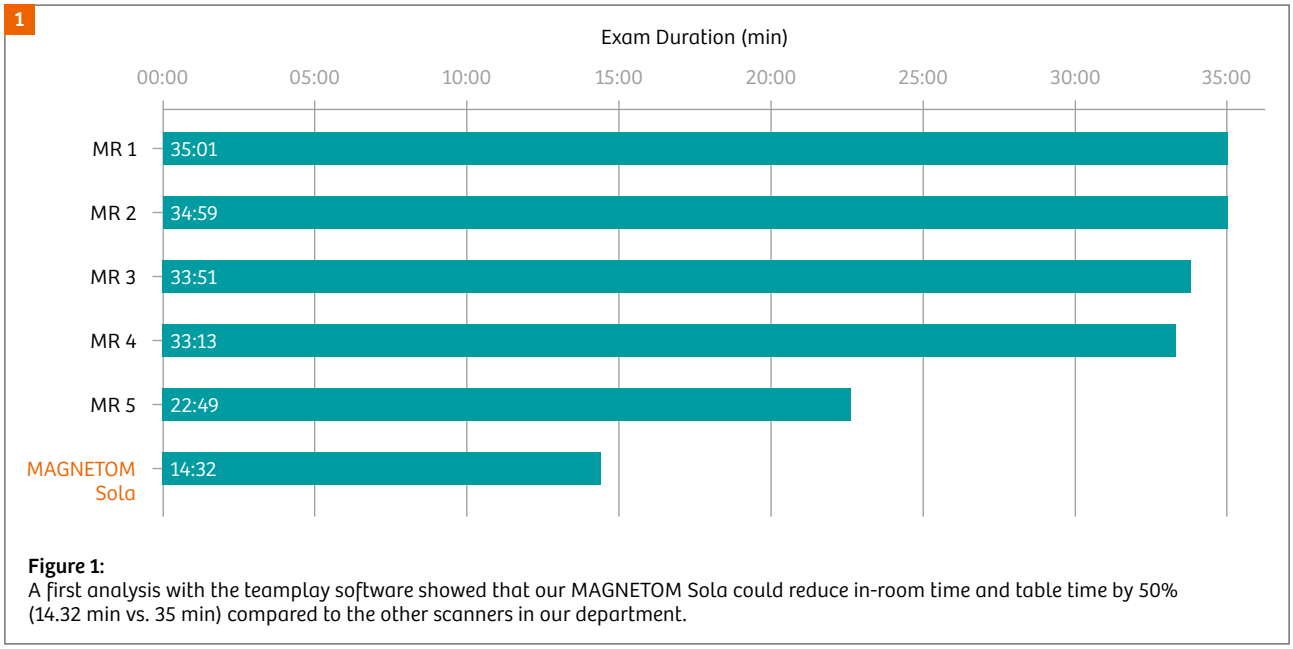

Figure 1:
A first analysis with the teamplay software showed that our MAGNETOM Sola could reduce in-room time and table time by 50% (14.32 min vs. 35 min) compared to the other scanners in our department.

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 users will achieve the same results.

a major obstacle to this. In addition, every technician in a radiology department has a different skill level and an individual way of interacting with the patient and the scanner. This often reduces the reproducibility of scans and leads to repeat scans, both of which are significant cost factors for the institution itself and the healthcare system as a whole. In view of all these aspects, radiology departments seeking to expand precision medicine need highly reliable and productive MRI scanners that deliver standardized, high-quality imaging.

BioMatrix @ 1.5T: Reducing unwanted variations with MAGNETOM Sola

The need for a new MRI scanner

In our MR department, we have two 3T scanners (a MAGNETOM Trio and a MAGNETOM Skyra) and three 1.5T scanners (two MAGNETOM Avantos and a now-replaced MAGNETOM Sonata). We perform a broad spectrum of examinations on these scanners, with a special focus on oncological (including whole-body studies), cardiac, breast, and neuro imaging. In recent years, we were using our dependable MAGNETOM Sonata system almost exclusively for cardiac and neuro imaging. At the same time, we were experiencing increasing demand for, in particular, MSK and oncological abdominal studies. The latter was driven by growth in targeted therapies and the need for frequent follow-up examinations. Eventually, this increase in MR examination requests meant that we had to upgrade. We needed a reliable scanner that would allow us to perform the full spectrum of MR examinations and provide high-quality, robust, and standardized results. In addition, as a university hospital, financial considerations played a significant role in our decision-making. This meant that, besides meeting the needs of our clinical departments regarding timely appointments for a large number of patients and fulfilling our demand for high-quality studies, we also paid particular attention to examination duration and patient throughput.

Against this backdrop, we had the opportunity to host the world's first installation of a MAGNETOM Sola[1], Siemens Healthineers' latest 1.5T MRI system, which promised to be the perfect match for our needs.

MAGNETOM Sola

MAGNETOM Sola is the first 1.5T system to be equipped with BioMatrix technology, and uses the latest advances in hardware and sequence developments. It features a 70 cm open bore, 204 channels (up to 64 of which can be used simultaneously within one FOV), a 45/200 XQ gradient system, a large FOV of 50 x 50 x 50 cm^3, and a dockable table with new BioMatrix Sensors for respiratory and cardiac motion. The *syngo* MR XA11 software platform provides compressed sensing acceleration for abdominal imaging with inline reconstruction of GRASP-VIBE, and for cardiac examinations with real-time cine imaging during free-breathing. Simultaneous multi-slice acceleration can be used in both TSE sequences and diffusion-weighted imaging, and can substantially shorten acquisition times in MSK and body imaging. Various Dot engines (e.g. Whole-Body, Cardiac, Large Joint, Spine, and Brain) provide consistent examination quality and scan times, so that even less-experienced technicians can perform complex studies in a standardized manner.

[1] MAGNETOM Sola is not commercially available in all countries. Due to regulatory reasons the future availability cannot be guaranteed.

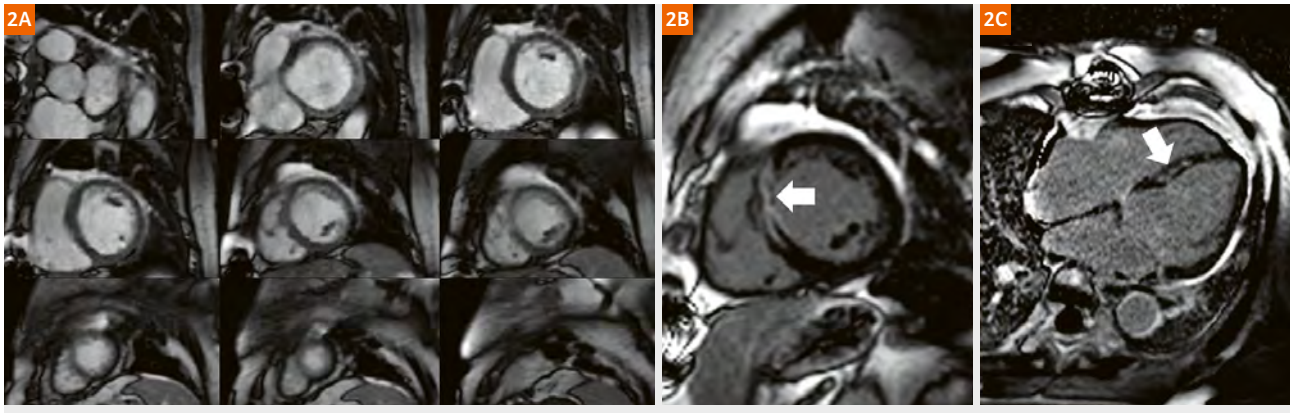

Figure 2:
Free-breathing cardiac MRI protocol with **(2A)** compressed sensing accelerated cine sequences and **(2B)** respiratory motion-corrected (MOCO) phase sensitive inversion recovery (PSIR) images with PSIR HeartFreeze. Gadolinium was injected prior to scanning, and acquisition of the entire protocol took 12 minutes. Both hypokinetic wall movement and septal late gadolinium enhancement (arrows) were consistent with post-ischemic scarring.

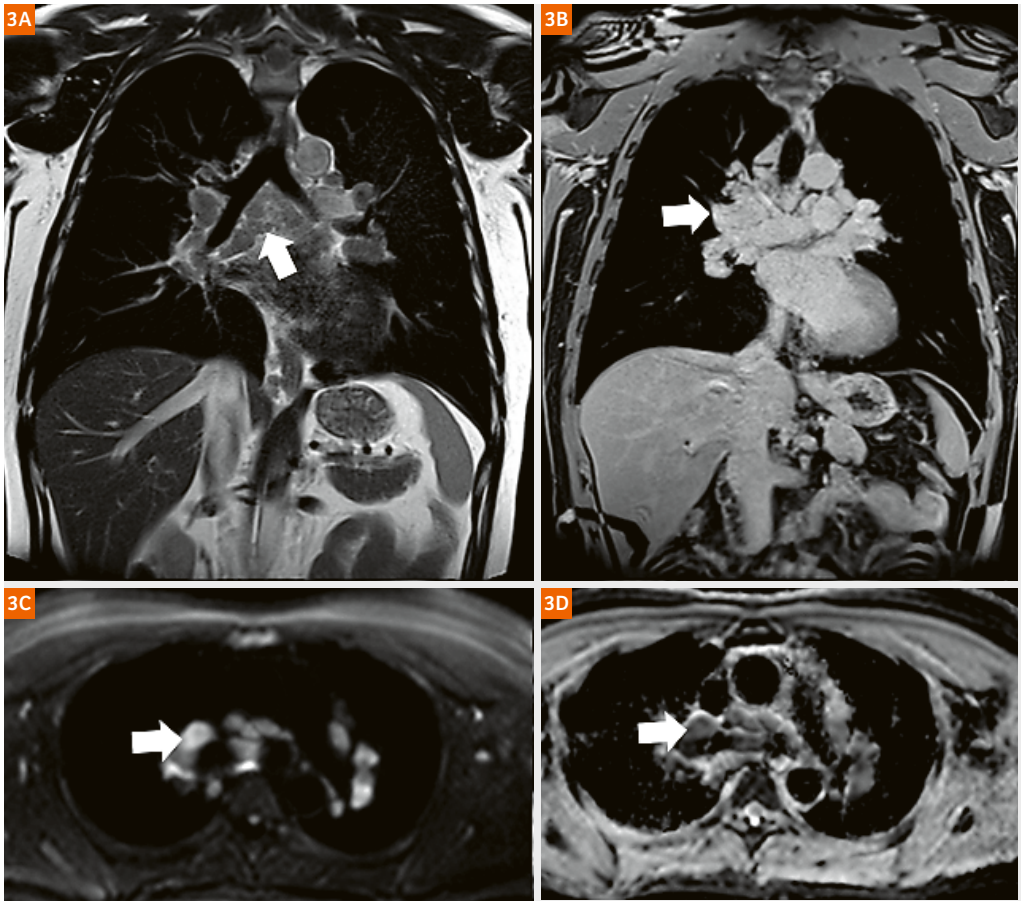

Figure 3:
Thoracic MRI of a patient with known sarcoidosis. Morphological (**3A**: T2-weighted; **3B**: T1-weighted) and diffusion-weighted imaging shows significant mediastinal and hilar lymph node enlargement (arrows). Total examination time for the entire protocol (including Trufi and axial morphological sequences) was 12 minutes.

In the first two months after the MAGNETOM Sola was installed, we performed the mandatory CE certification study. During this time, patients undergoing a clinically indicated examination on one of our MAGNETOM Avanto 1.5T systems were scanned for a second time using the MAGNETOM Sola. We compared image quality between both systems, and patients were asked to report on their experience (e.g., on noise and comfort levels).

For the examination protocols, we aimed to limit total examination time to a maximum of 20 minutes with highly standardized setups. We used the Dot engines to design different imaging strategies for different patient groups. With the Dot engines, the technician chooses a strategy (e.g., whole abdomen in a patient with limited breath-holding capabilities) and the protocol is automatically adapted to the patient's specific needs (e.g., by reducing the maximum breath-hold time or automatically choosing free-breathing sequences). The various protocol steps provide guidance for technicians who are new to the system so that they can perform reproducible, high-quality exams.

Using simultaneous multi-slice acceleration in diffusion-weighted imaging means that state-of-the-art DWI is available in all oncological imaging protocols and at reasonable acquisition times. The same acceleration technique allowed us to set up very short, high-quality MSK protocols.

With the semiautomatic Cardiac Dot Engine and the compressed sensing accelerated acquisition of the function module (i.e., the long- and short-axis cine sequences), comprehensive protocols including late gadolinium enhancement can be acquired in under 15 minutes. Moreover, both the examination time and image quality are less dependent on the individual technician's experience.

Even during the CE certification process, feedback about average examination times per protocol has allowed us to identify outliers and optimize the protocols to improve both image quality and acquisition speed. A first analysis indicated that the MAGNETOM Sola will allow us to shorten our average examination time by 50%. As we are approaching the end of the certification process and are on the verge of having the MAGNETOM Sola as part of our scanner fleet for clinical routine, we now feel very well prepared to face the challenges of the future.

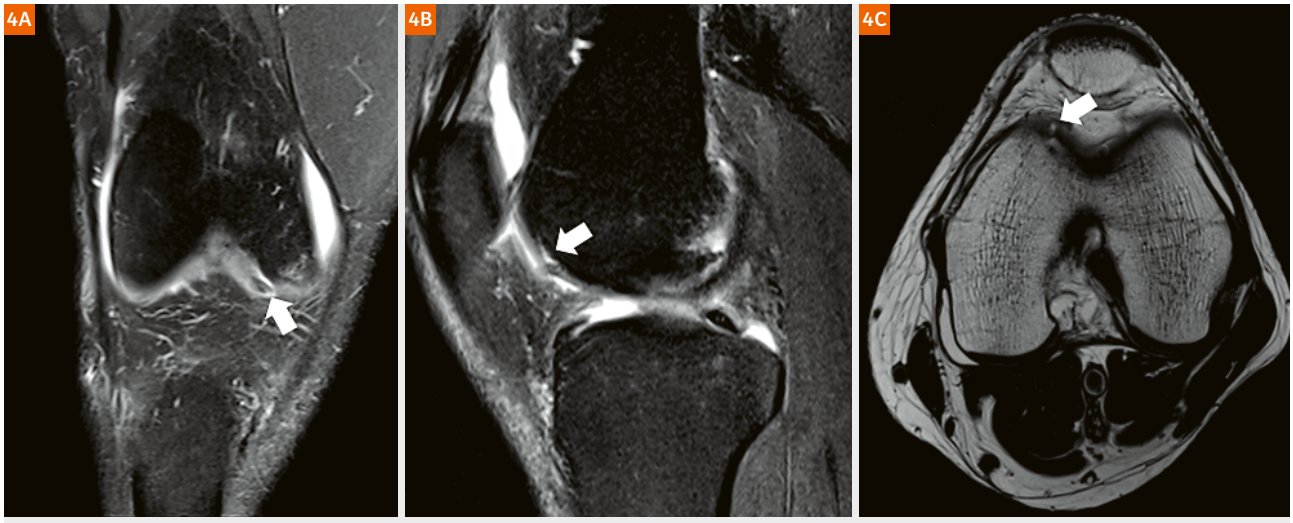

Figure 4:
Time-efficient, 10 minute knee protocol acquired with the Knee Dot Engine. A small chondral defect with minimal delamination in the medial femoral condyle is clearly visible in the PD (**4A**: coronal; **4B**: sagittal) and T2-weighted sequences.

The technician's perspective

Katrin Koziel

The idea behind installing the MAGNETOM Sola in Mannheim was to improve image quality and comparability at 1.5T, and to introduce young and inexperienced technicians to a tool that would guide them through all examinations.

Thinking back to my first introduction to Dot engines and my immediate dislike of them, I was skeptical about the idea. As a senior technician, I have reservations about whether automated processes in MRI examinations that require no memorization, no knowledge of sequences, and no details about the technical context of the patient's clinical picture and feasible imaging options are really as easy as they sound. However, my years in clinical routine have taught me that there is a not-so-fine line between using one's knowledge and overachieving without thinking. It is easy to get lost in details that are of no use to making a diagnosis when you are good at your job but bored by routine scanning. Also, we tend to welcome a new technique if it fits our needs, but might reject the same technique if we feel threatened by it. So I told myself to keep an open mind, see what improves, and then decide if it is useful.

First, the hardware: The built-in BioMatrix interfaces are a great feature for accurate patient positioning (Select&GO). Both myself and all the attending junior and senior technicians were hooked immediately. The dockable table with eDrive support and AutoDocking is much easier to control and use than the dockable table we know from older systems. The new design also has fewer grooves so it is easier to clean and disinfect. Also, the open-bore design with light strips inside the bore is always helpful with the patients.

The new "control center" with a two-monitor system is a great innovation. Planning the examination on the left monitor while simultaneously being able to work with the images on the right monitor without changing platforms is a big improvement. Learning to use all the features on the right monitor will take some time, but it is definitely worth the effort. We're still discovering new tricks every day. As for the new BioMatrix Sensor for respiratory motion, we are really impressed with the image quality possible for non-breath-hold sequences, especially for heart examinations with compressed sensing. This is also where the DotGO workflow comes in. The new possibilities offered by systems equipped with AI is really superb. In the whole-body workflow, for example, we can finally plan using the overview images – just as we have been able to do with CT for decades. The "mother engine" creates the number of stacks needed to cover the entire region of interest, and even names the stacks correctly (chest I, chest II, abdomen, pelvis). This is a relief for all junior technicians, who initially struggle to get their sequences right, fully cover the scanning area, make sure the patient is breathing as instructed, and name the sequences. The scanner also counts and renames the sequences with the vertebrae in all spine examinations, which makes our radiologists very happy because technicians sometimes forget the naming.

Yet although these are great innovations, we still have to remember to encourage our young technicians to keep learning so that they can eventually do themselves what the technology is doing for them now. I want my coworkers to be able to scan without fear of failing. The new techniques on this high-end scanner allow them to do so without having years of experience in MRI. Eventually, though, they will have to use an older scanner without this support, and they will need to do their job just as well.

Nonetheless, I am looking forward to discovering even more features as we continue to learn with our scanners. I want to embrace the possibilities of the new techniques and continual progress in technology without losing the strategic understanding of how important it is to have well-trained technicians.

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Future perspectives: workflow optimization with BioMatrix technology @ 1.5T and teamplay

A major goal linked to our MAGNETOM Sola will be to reduce the department's in-room and table times to 30 and 20 minutes respectively, regardless of the type of exam. The combination of technologies such as BioMatrix and the Dot engines, and acceleration techniques such as compressed sensing and simultaneous multi-slice will make the MAGNETOM Sola the highly efficient workhorse for our clinical routine. What is more, we want to go even further and use the software product teamplay to continuously benchmark our in-room times with the MAGNETOM Sola against our best practice and achieve further optimization. In-depth, real-time feedback about protocol performance down to the sequence level will allow us to adjust every protocol step regarding the balance of acquisition time and, e.g., image resolution. Using teamplay data and a standalone version of the Dot Cockpit means we can efficiently identify protocols that require improvement, and directly adjust protocols or even sequence parameters without having to interrupt the clinical workflow at the scanner itself. The updated protocols will be delivered to our MAGENTOM Sola via the teamplay cloud, and teamplay can then deliver direct feedback on the impact of protocol adaptations. This closes the loop of monitoring/benchmarking, identifying areas for improvement, adapting the protocols, and integrating the modifications into clinical routine. We will focus on shortening our slot times and increasing our patient throughput while achieving consistently high quality. With teamplay, we can constantly measure our productivity growth and calculate the financial benefit. This will allow us to continually optimize and adjust our scanning strategies so that we can better address the challenges of the future.