Enabling Cardiac MRI at 0.55T: Early Results from MAGNETOM Free.XL

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Cardiac magnetic resonance imaging (CMR) is crucial in the diagnosis and management of many cardiovascular diseases. The newly released 2025 ESC Guidelines for the management of myocarditis and pericarditis now include Class 1 recommendations for the use of CMR as a first-line diagnostic tool [1]. However, the availability of CMR remains limited, mainly due to cost, siting requirements, and lack of experienced personnel [2].

With the advancement of technical innovations such as minimal helium inventory, strong gradients, improved receiver coils, and deep learning-based image reconstruction algorithms, a renewed interest in lower field strengths is emerging in the MRI community [3]. Following the launch of the first 0.55T system – MAGNETOM Free.Max – in 2020, the worldwide CMR community immediately put it to the CMR test. Although the system was not released for cardiac applications, several research sites have highlighted its great potential for nearly all CMR contrasts and acquisitions [4, 5]. The large 80 cm bore has additionally allowed imaging in challenging cases, such as obese or claustrophobic patients who would not have had access to CMR [6]. A study using an animal model has even demonstrated the feasibility of using this system in an interventional CMR setting [7] Yet two limitations of the MAGNETOM Free.Max configuration for CMR, namely the limited gradient performance and the lack of a physiological triggering unit for ECG synchronization, were still to be overcome.

With the arrival of the newest 0.55T system from Siemens Healthineers, MAGNETOM Free.XL[1] (Fig. 1), comprehensive CMR exams can now be performed at 0.55T. Thanks to the integrated physiological monitoring unit and stronger gradient performance, users will be able to take full advantage of the benefits of scanning at 0.55T. Shorter echo times can reduce B_0 artifacts around devices[2]. Furthermore, the stronger gradients allow shorter acquisition times of single-shot-based CMR images, such as myocardial mapping, real-time cine, and myocardial perfusion imaging. The system will be presented to the CMR community at SCMR 2026 in Rio de Janeiro, Brazil. With its 100 cm flared opening, MAGNETOM Free.XL is also designed to support the workflow of interventional procedures. Its widespread application in diagnostic CMR has been eagerly awaited, especially due to the stronger gradient performance compared to MAGNETOM Free.Max.

1 MAGNETOM Free.XL has a 100 cm flared opening and is fully equipped to allow unprecedented CMR imaging at 0.55T.

Field strength	0.55T
Bore size	> 100 cm flared opening with 80 cm bore
Max. amplitude per axis	34 mT/m
Max. slew rate per axis	160 T/m/s
Spine coil (table-integrated)	18 elements
Body surface coil M	12 elements
Body surface coil L	6 elements

Table 1: MAGNETOM Free.XL is equipped with hardware that allows users to take advantage of the physics at 0.55T.

[1]Work in progress. The application / the system is currently under development and is not for sale in the U.S. and in other countries. Its future availability cannot be ensured.
[2]The MRI restrictions (if any) of the metal implant must be considered prior to patient undergoing MRI exam. MR imaging of patients with metallic implants brings specific risks. However, certain implants are approved by the governing regulatory bodies to be MR conditionally safe. For such implants, the previously mentioned warning may not be applicable. Please contact the implant manufacturer for the specific conditional information. The conditions for MR safety are the responsibility of the implant manufacturer, not of Siemens Healthineers.

The hardware specifications of MAGNETOM Free.XL are listed in Table 1.

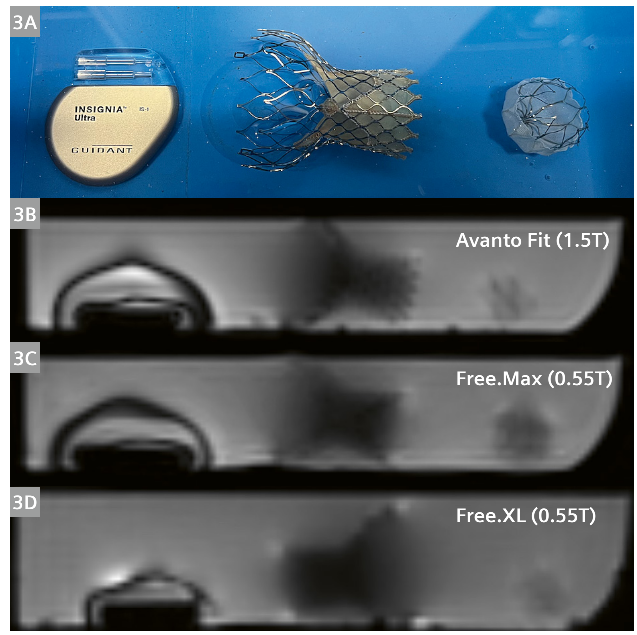
In this article, we present our initial experience of performing CMR scans in volunteers at 0.55T without contrast administration using a MAGNETOM Free.Max system and a MAGNETOM Free.XL system with its stronger gradients.

Due to the system's lower field strength and corresponding **reduced magnetohydrodynamic effect**, ECG synchronization is greatly simplified, as the ECG curve shows fewer artifacts. This can be seen in Figure 2, which shows an ECG signal outside the magnet, in a 3T system, in a 1.5T system, and in the 0.55T MAGNETOM Free.XL magnet.

The reduced main magnetic field and subsequent **reduction in B_0 distortions** can now be exploited with stronger gradient performance. In Figure 3, we show example images of three devices: a pacemaker[2], a transcatheter aortic valve replacement device[2], and a left atrial appendage closure implant[2], all acquired on a MAGNETOM Avanto Fit (1.5T), a MAGNETOM Free.Max (0.55T) and a MAGNETOM Free.XL (0.55T). Acquisitions were performed using a balanced steady-state free precession (bSSFP) contrast, as typically used for cine functional CMR assessment. Especially for the pacemaker, the banding artifacts (dark rim around the device) are reduced with the MAGNETOM Free.XL system.

The gradient performance and its influence on several CMR protocols can be seen in Table 2, which compares MAGNETOM Free.Max to MAGNETOM Free.XL.

2 The native ECG signal (top row), is barely distorted at 0.55T, whereas distortions become stronger with increasing magnetic field strengths (1.5T and 3T).



3 **(3A)** from left to right: pacemaker, transcatheter aortic valve replacement device, and a left atrial appendage closure implant. **(3B)** 1.5T MAGNETOM Avanto Fit; **(3C)** 0.55T MAGNETOM Free.Max; **(3D)** 0.55T MAGNETOM Free.XL.
The pacemaker exhibits fewer banding artifacts on MAGNETOM Free.XL, due to the combination of lower field strength and stronger gradient performance.

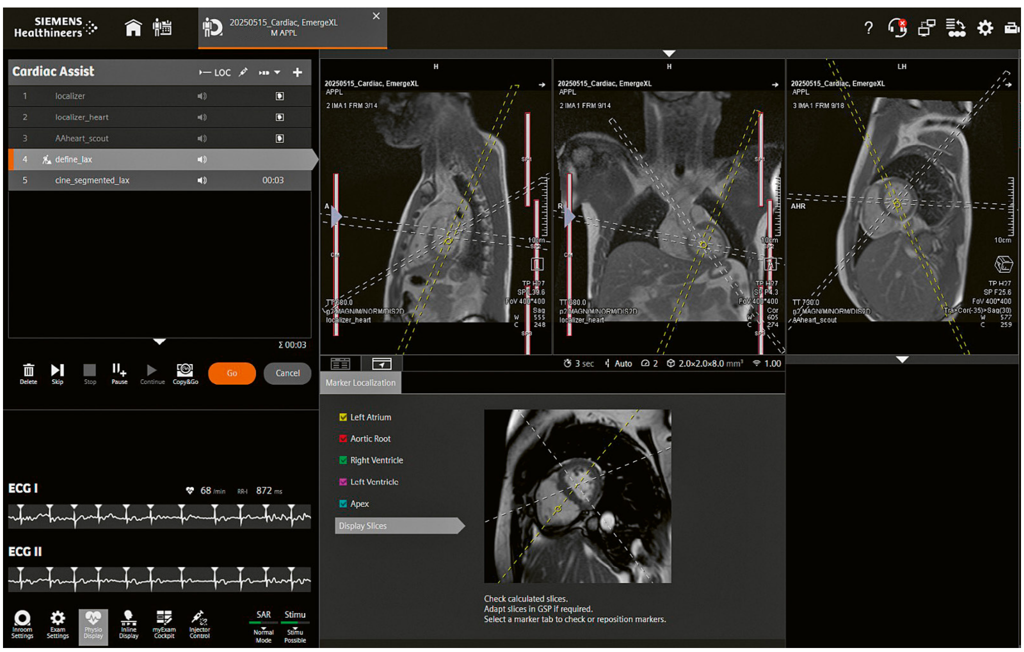
		MAGNETOM Free.Max	MAGNETOM Free.XL
Segmented cine	TE	1.7 ms	1.05 ms
	TR	4.2 ms	2.6 ms
	Breath-hold duration	9 s	5.2 s
Dynamic perfusion (3 slices)	TE	1.78 ms	1.1 ms
	Frame duration	252 ms	157 ms
	Maximum heart rate	79 bpm	125 bpm
3D bSSFP	Segments	28	39
	Acquisition duration	6.6 min	5.6 min
Interactive real-time cine	Frame duration	221 ms	132 ms
	Frame rate	4 fr/s	7 fr/s

Table 2: A comparison of several acquisition parameters achievable on the MAGNETOM Free.XL and MAGNETOM Free.Max systems. The 3D bSSFP is a T2-prepared 3D morphological acquisition with fat saturation, as typically used for coronary MR angiography (MRA). The interactive real-time cine is used for interventional imaging and allows real-time acquisition and inline reconstruction.

For all imaging protocols, the stronger gradients allow a **reduction in the echo times** (TE) and therefore in the echo spacing (TR). This time-reduction can be used for **shorter acquisition times** in the case of segmented cine or 3D bSSFP, or for **higher frame rates** for single-shot applications such as real-time cine or perfusion imaging. In the case of perfusion imaging, the stronger gradients allow the acquisition of three slices per heartbeat, even in situations of high (< 125 bpm) heart rates.

MAGNETOM Free.XL comes with the full portfolio of **planning and workflow features** from Siemens Healthineers. These include automatic cardiac view planning using myExam Cardiac Assist as shown in Figure 4.

Similarly, the resting phase is automatically detected based on a 4-chamber cine as part of the AutoMate Cardiac functionality. This is shown in Figure 5 for the automatic parametrization of a 3D iNAV-based acquisition on MAGNETOM Free.XL.



4 Scout images and planning results in a healthy volunteer. Landmarks and planes are automatically found using myExam Cardiac Assist.

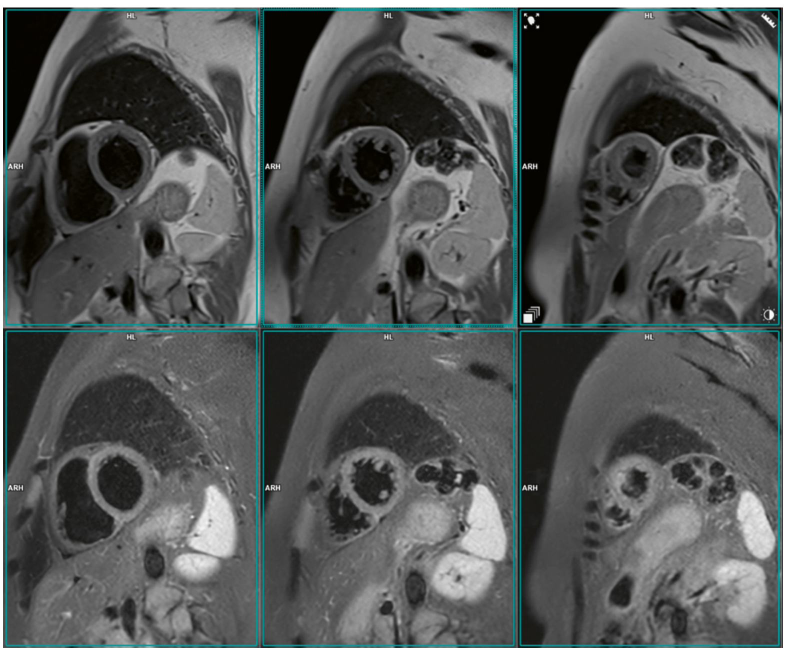
5 Example of AutoRestingPhase detection in the AutoMate Cardiac feature of MAGNETOM Free.XL.

Figure 6 shows morphological short-axis dark-blood images using a TSE-based sequence with Deep Resolve (upper row: T2; lower row: turbo inversion recovery magnitude, TIRM) on MAGNETOM Free.XL.

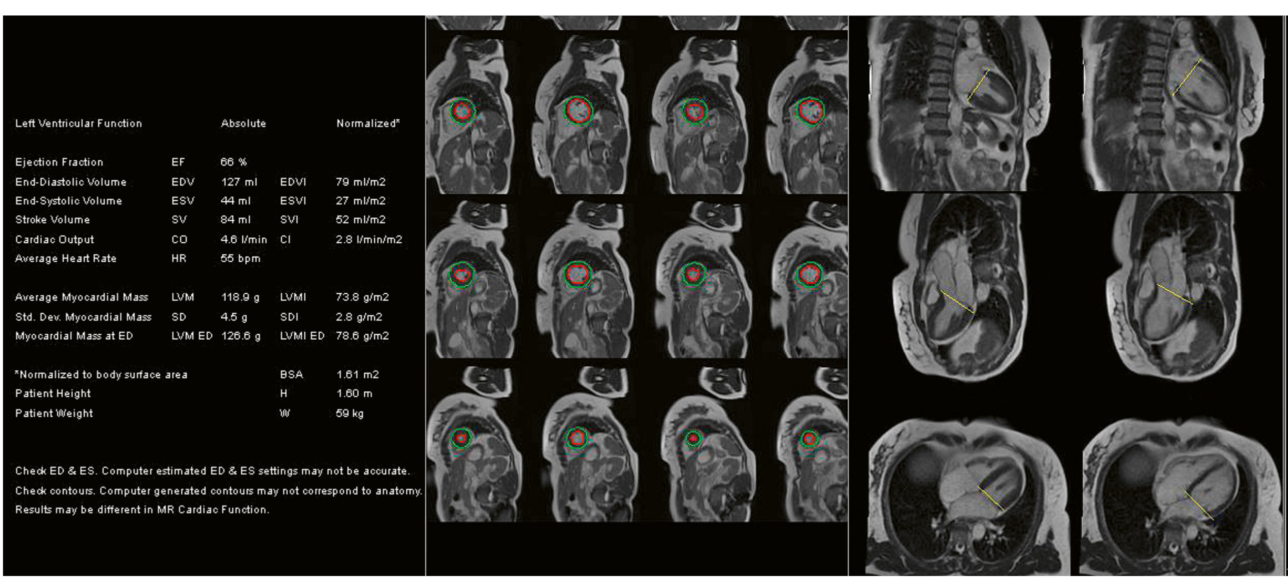
Figure 7 shows functional cardiac assessment, including the automatic inline segmentation and ventricular function calculation on bSSFP cine imaging.

A direct comparison of cine images, acquired in the same volunteer on MAGNETOM Free.XL and MAGNETOM Free.Max, is shown in Figure 8. The images depict a single time frame of two segmented acquisitions with bSSFP contrast in the same volunteer. The images demonstrate that the stronger gradient performance allows the **reduction of flow-related dark-band artifacts** due to shortened echo spacing.

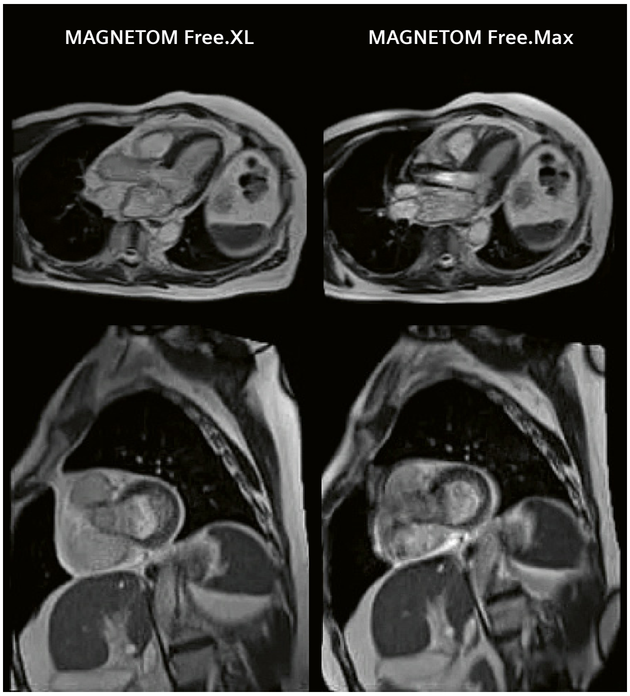
Figure 9 shows real-time cine images acquired on both systems. In real-time cine applications, where interactive slice modifications and inline reconstruction and visualization are needed, the improved gradient performance of MAGNETOM Free.XL helps to achieve substantially **higher frame rates**. For example, with the protocol settings for real-time cine with an in-plane resolution of 2.4 × 2.4 mm



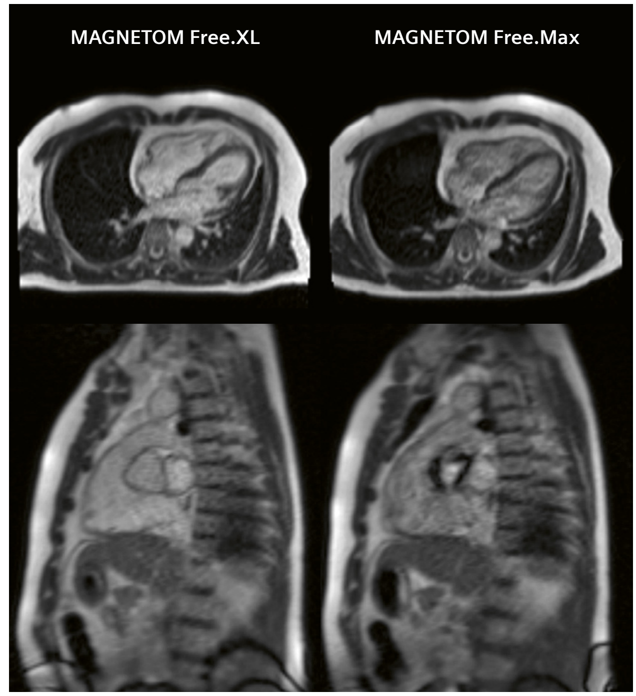
6 T2 TSE (top row) and TIRM (bottom row) acquisition with Deep Resolve on MAGNETOM Free.XL.



7 Results of the inline ventricular function assessment with automatic generation of a report (left) and visualization of the segmentation results (middle and right).



8 A single time frame of segmented bSSFP images in a 3-chamber view (top) and basal short-axis view (bottom) acquired in the same volunteer on MAGNETOM Free.XL and MAGNETOM Free.Max. The reduction in flow artifacts is visible on the MAGNETOM Free.XL images, due to decreased echo spacings.



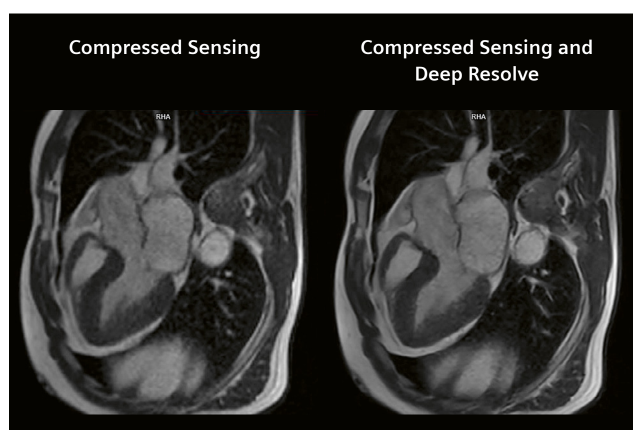
9 Single time-frame bSSFP images (in-plane: 2.4 × 2.4 mm, slice thickness: 7 mm) in 4-chamber view (top) and right ventricular outflow tract (bottom) in the same volunteer on MAGNETOM Free.XL (left) and MAGNETOM Free.Max (right). This demonstrates the improvement in image quality, e.g., reduced flow artifacts, obtained with the shorter acquisition times (132 ms with MAGNETOM Free.XL vs. 221 ms with MAGNETOM Free.Max).

and a slice thickness of 7 mm, the acquisition time of a single frame was reduced from 221 ms on MAGNETOM Free.Max to 132 ms with MAGNETOM Free.XL.

The ability to acquire **real-time cine at high frames rates** is an important step toward achieving applications that go beyond purely diagnostic examinations, e.g., interventional cardiac procedures such as right heart catheterizations. These applications require visualization of the device and the surrounding anatomy at high frame rates for safe navigation and procedural success. Together with the advantages of the lower field strength for device safety (e.g., reduced radiofrequency (RF)-induced heating), and improved patient access from the larger bore opening, this might pave the way for using MAGNETOM Free.XL as a versatile diagnostic and interventional[3] platform.

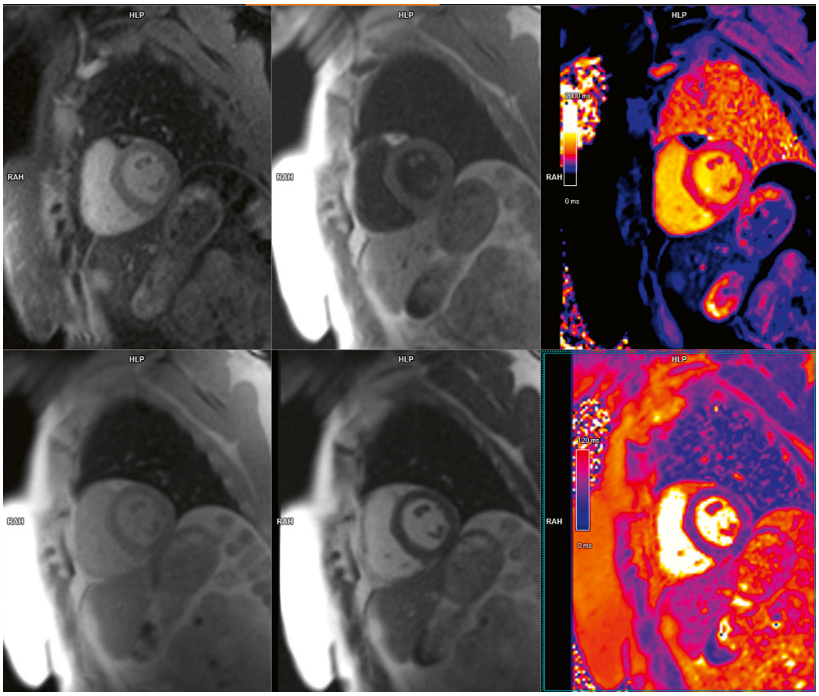
The combination of **Deep Resolve with Compressed Sensing** for cine bSSFP imaging on MAGNETOM Free.XL can be appreciated in Figure 10, which demonstrates a clear improvement in sharpness and reduced level of noise.

Multiparametric mapping using MyoMaps is also fully supported on MAGNETOM Free.XL. Due to the reduced T1 values at 0.55T, the acquisition scheme on MAGNETOM Free.XL for native T1 mapping is currently set to 4-3-2-2 (as compared to 5-(3)-3 at 1.5T and 3T). Figure 11 shows example T1 and T2 images and maps acquired on MAGNETOM Free.XL.

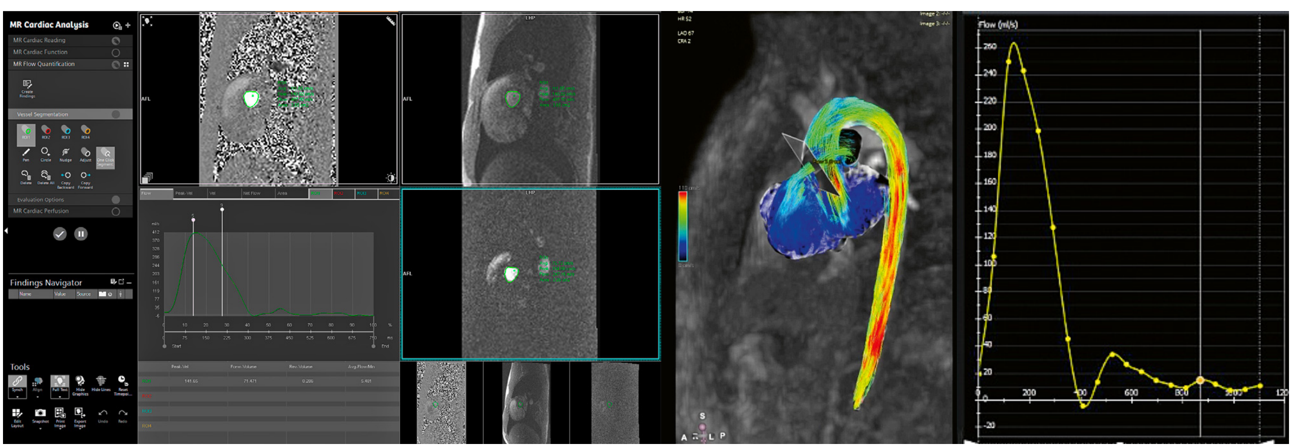


10 While Compressed Sensing allows the acceleration of cine acquisitions, the addition of Deep Resolve increases sharpness and reduces noise.

[3]*Work in progress. The system is currently nor released for cardiac interventions.*



11 T1 and T2 mapping on MAGNETOM Free.XL is feasible. Nevertheless, reference values still need to be collected at 0.55T and this is a prerequisite for clinical use of MyoMaps.

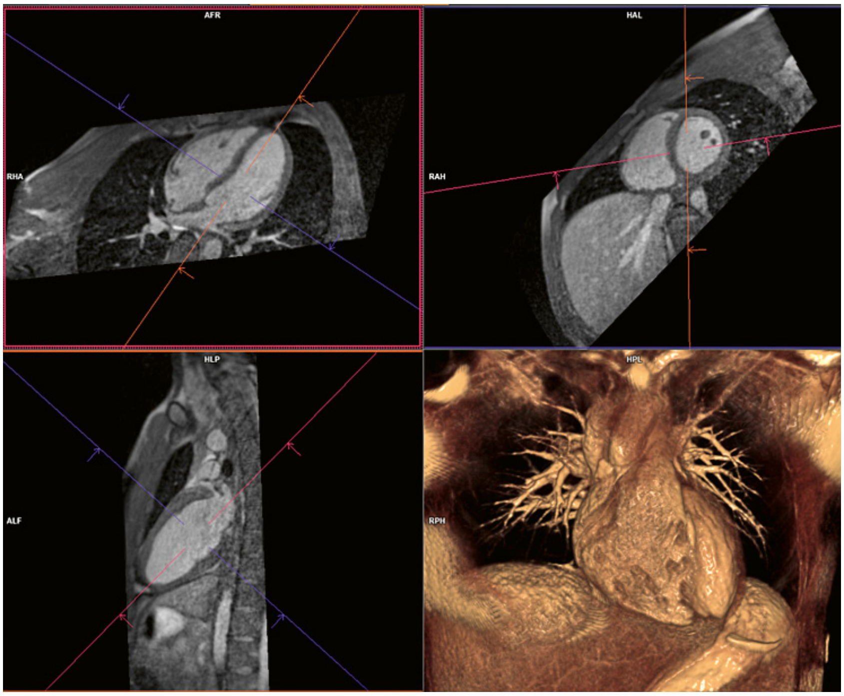


12 Phase-contrast imaging on MAGNETOM Free.XL. Although signal-to-noise ratio (SNR) is reduced at 0.55T compared to 1.5T and 3T, the values for 2D Flow and 4D Flow match, and advanced visualization on 4D Flow (here using cvi42) is feasible.

Although phase-contrast imaging is known to benefit from higher field strengths, Figure 12 demonstrates that classical **2D Flow** imaging is possible on MAGNETOM Free.XL, as is **4D Flow**, which was processed using cvi42 (Circle Cardiovascular Imaging, Calgary, Canada) in this case.

Finally, an image-based navigated 3D bSSFP with fat saturation using the **WholeHeart Pro** sequence is shown in Figure 13. This demonstrates high resolution, a large homogeneous signal, and good fat saturation.

In conclusion, MAGNETOM Free.XL showed consistent performance across all relevant CMR applications that we could test natively (imaging with contrast media is not permitted in volunteer scans at Siemens Healthineers). Not only was the image quality stable and met expectations throughout the image contrasts, but all AI-based workflow-support applications are also available and were shown to work successfully. These can be integrated into the examination, if needed. Workflow automation includes user support in planning the cardiac views, adapting protocols to the patient's physiology, and assuring a comparable, robust, and excellent image quality independent of the user. The AutoMate Cardiac AutoPositioning feature further supports users with automatic positioning of the heart in the isocenter and with planning of additional protocol parameters and geometries such as saturation bands, navigators, and coronal or transversal 2D or 3D slices or slabs. Additionally, AutoTI (which we are yet to test on the 0.55T system in patients after contrast agent



13 Acquisition of the 3D WholeHeart Pro sequence on MAGNETOM Free.XL exhibits excellent contrast and good fat saturation using 3D bSSFP.

administration) suggests an optimal inversion time (TI) for maximum signal intensity differentiation between healthy myocardium and scar. Finally, the AutoRestingPhase detection feature automatically detects the quiescent cardiac phase to enable optimized motion-free image acquisition. AI-based Deep Resolve Sharp is now also available in several CMR applications, including cine and black-blood imaging. This achieves improved sharpness and reduced noise, which is especially useful at 0.55T. Compared to 0.55T MAGNETOM Free.Max, the improved gradient performance of MAGNETOM Free.XL can improve speed, reduce artifacts, and enable all typical CMR acquisitions.

With its combination of the inherent advantages of low-field imaging, enhanced gradient performance, and advanced AI-driven automation and reconstruction, the MAGNETOM Free.XL system is well positioned for clinical adoption in cardiac MRI.

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