MAGNETOM Free.Max Simulator: First Impressions

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Modern radiotherapy (RT) relies on accurate tumor volume delineation. Utilizing the best imaging has become the standard of care for contouring and simulation. One tool that has entered the standard of care is multiparametric MR imaging (MRI) for routine RT planning. Today, nearly every case of definitive central nervous system (CNS) tumors or prostate cancer uses MRI for RT planning.

Of the clinics that use MRI for planning, many still rely on diagnostic MRI obtained either prior to CT simulation or in parallel to simulation, and then fuse the images for the purposes of contouring MR-based anatomy. However, in recent years, the use of MRI simulators with a dedicated RT setup, workflow, and positioning devices has proven superior to the use of fused diagnostic images [1]. There are a number of reasons for this, including the acquisition

1 Patient simulated on MAGNETOM Free.Max with a custom MRI-compatible thermoplastic mask and a head coil.

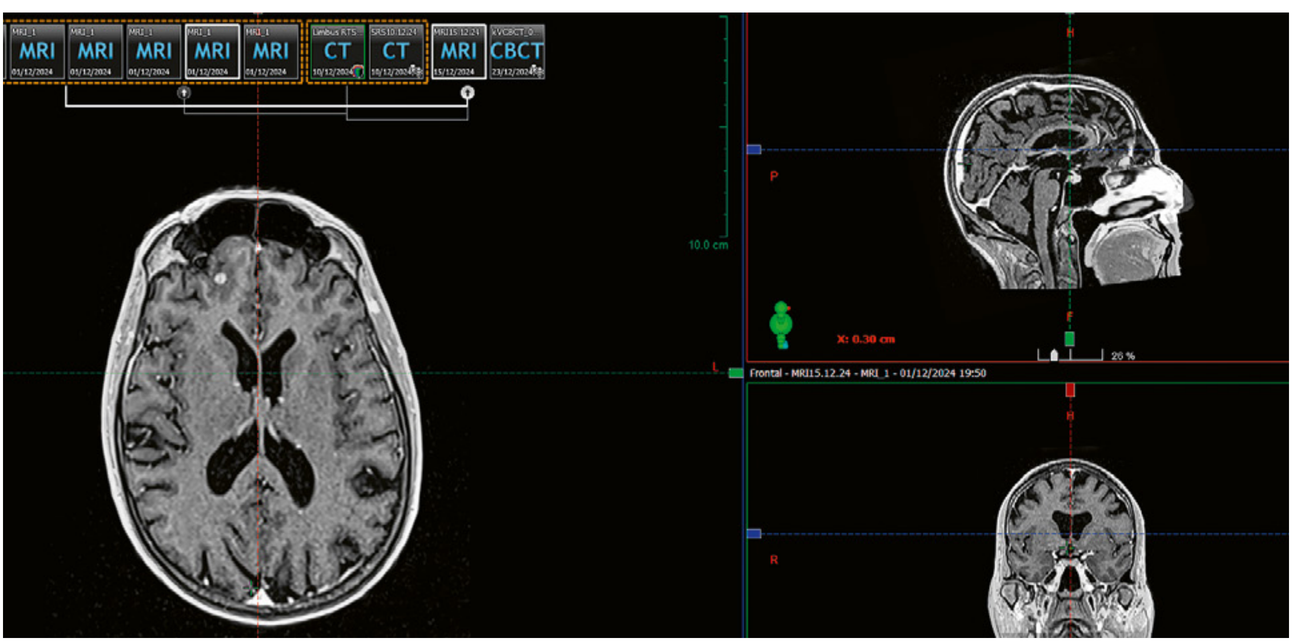
of images with an RT-standard flat tabletop and the ability to scan the patient with RT positioning devices such as thermoplastic masks, wing boards, and abdominal compression. In addition, the choice of imaging sequences for RT simulation purposes is often different to those needed for diagnostic imaging. Finally, synthetic CT produced by MRI simulators can obviate the need for CT simulation, saving the patient and the department additional time and procedures.

In 2023, our institution decided to acquire an MRI simulator and we were tasked with choosing the best vendor and solution to meet our clinical and departmental needs. We reviewed the options in the market and the various vendors. We chose to acquire a novel product from Siemens Healthineers: the 0.55T MAGNETOM Free.Max RT Edition (Siemens Healthineers, Erlangen, Germany). Several factors led to this decision. First, the smaller footprint and helium-free magnet without the need for a quench pipe matched the space and design of our department and made installation and start of clinical work much easier and quicker. Second, the 80 cm large bore would allow us to scan all RT patients (even breast cancer patients) in the same position as they would be in for treatment on our linacs. Finally, we were impressed with the examples of image quality shown on MAGNETOM Free.Max diagnostic systems and were convinced it would be a significant addition to our RT planning environment. Our institution has multiple higher field MRI systems for diagnostic purposes, and the lower cost of the MAGNETOM Free.Max system would enable us to fully dedicate this system to RT planning without the need to share it with diagnostic radiology.

In September 2024, we completed installation and commissioning of the MAGNETOM Free.Max RT Edition in our department and began clinical use. This was the first installation worldwide. Our institutional plan was to begin using it with CNS patients (with brain metastases) and prostate patients, who would also undergo diagnostic imaging, and then compare the MAGNETOM Free.Max images with the diagnostic images, as well as the time and the use of RT immobilization devices and coils. Below, we detail some of the clinical examples and results from these early patients.

Central nervous system patients

Patients were simulated with a thermoplastic mask (Klarity Medical, Heath, OH, USA) and connected to the custom head rest. The scan was performed with a specialized head coil (Fig. 1). The patients chosen for the initial planning scans were patients with brain metastases set to undergo stereotactic radiosurgery. Again, nearly all of these patients underwent a diagnostic scan to detect the disease; however, the utility of MRI simulation in these patients was the ability to obtain recent MR images within one to two days of treatment in the same orientation and immobilization as the CT simulation.



2 Sample of an axial T1 post-gadolinium scan obtained on the MAGNETOM Free.Max system and loaded into the Eclipse treatment planning software (Varian, a Siemens Healthineers Company, Palo Alto, CA, USA).

The CNS patients had a single sequence: a T1 3D gradient echo sequence in the axial plane with injection of contrast medium prior to scanning. The average acquisition time of this scan is 12 minutes. The following parameters were used (Table 1).

One of the patients treated is shown in Figure 2. This patient had non-small cell lung cancer and was sent to the department for stereotactic radiosurgery.

CNS sequence parameters	
FOV read	245 mm
FOV phase	80%
TR	9.44 ms
TE	3.50 ms
Matrix	224
Voxel size	0.5 × 0.5 × 1 mm
Number of excitations	3
Phase encoding direction	L>R
Bandwidth	130 Hz/Px
Scan time	11 min

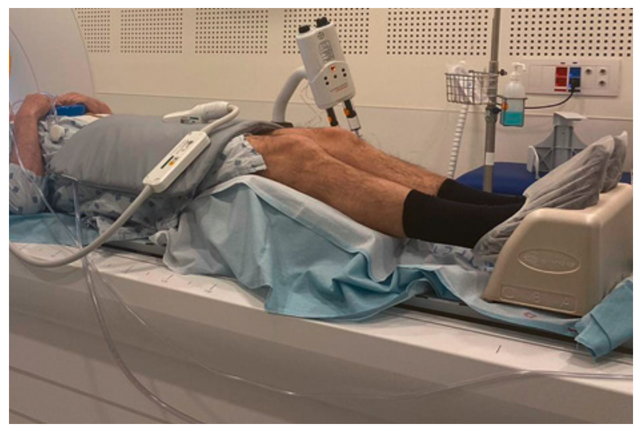
Table 1: CNS sequence parameters.

Genitourinary patients

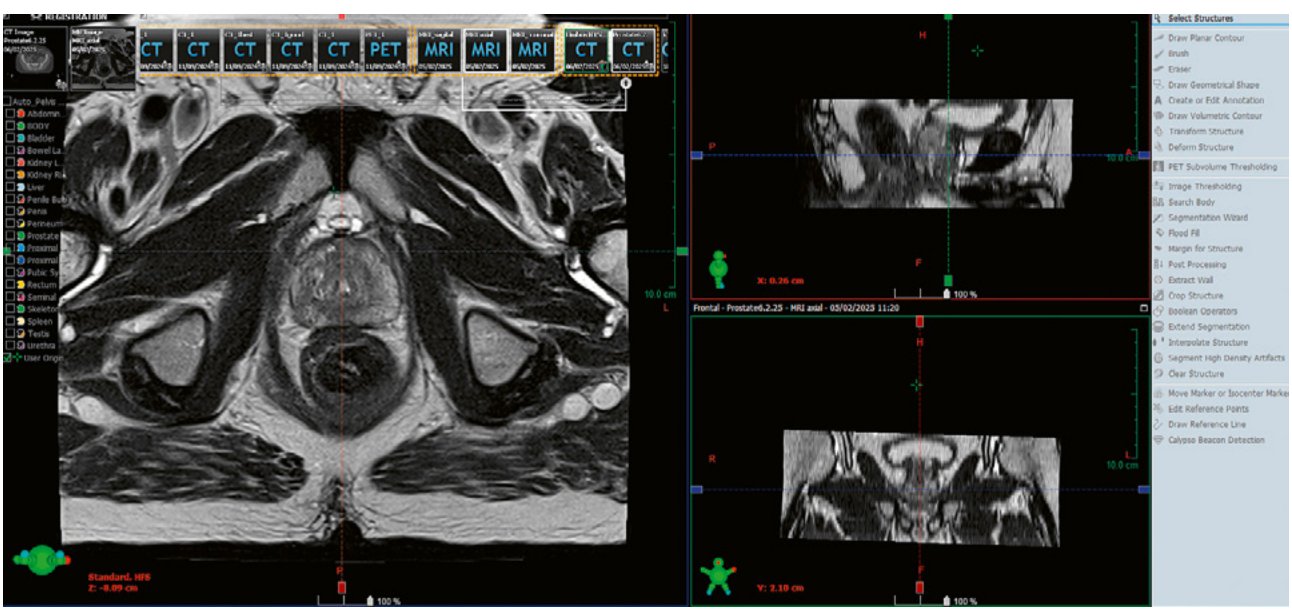
Patients with prostate cancer also underwent diagnostic MRI at diagnosis. After the decision to treat with RT, patients selected for stereotactic radiotherapy underwent gold seed placement and/or spacer insertion under ultrasound guidance. The patients then underwent CT simulation as well as MRI simulation.

For MRI simulation, patients were placed supine with knee rests and ankle immobilization as shown in Figure 3. Patients were scanned with T2-weighed imaging in three planes (axial, sagittal, and coronal). The entire procedure took an average of 20–25 minutes.

A representative case is shown in Figure 4.



3 Patient setup for prostate cancer. Patient supine with knee and ankle support, and pelvic coil.



4 Example of a patient with prostate cancer simulated on MAGNETOM Free.Max with a T2 axial scan, loaded into the Eclipse treatment planning software (Varian, a Siemens Healthineers Company, Palo Alto, CA, USA).

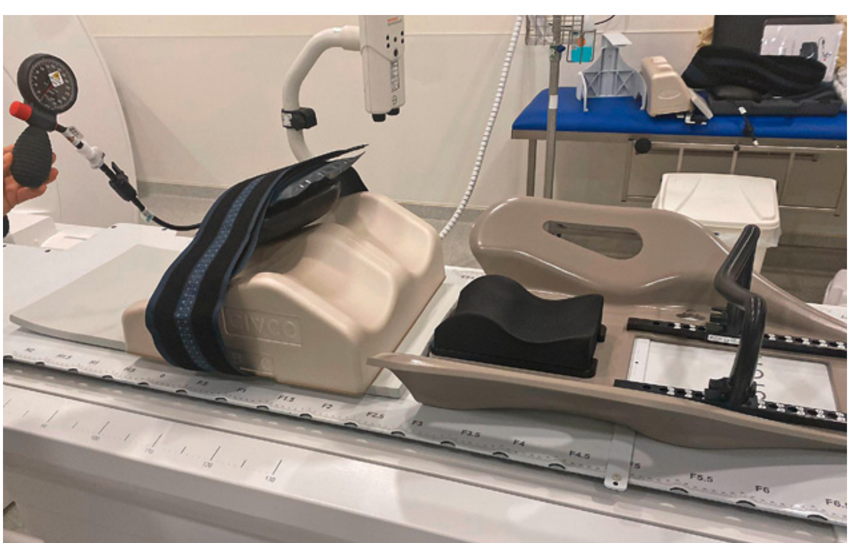
Sequence	Axial T2 TSE	Coronal T2 TSE	Sagittal T2 TSE	T1 VIBE Dixon
TR	3100 ms	3100 ms	6200 ms	9.74 ms
TE	83 ms	83 ms	83 ms	2.6 ms
Field of view	220 mm	220 mm	220 mm	400 mm
Slice thickness	3 mm	3 mm	28 mm	3 mm
Gap	0	0	0	20%
Averages/NEX	7	8	7	1
Phase encoding direction	R>L	R>L	A>P	A>P
Phase oversampling	200	200	160	0 Slice oversampling 11%
Base resolution	256	256	256	192
Voxel size	0.4 × 0.4 × 3 mm	0.4 × 0.4 × 3 mm	0.4 × 0.4 × 3 mm	1 × 1 × 3 mm
Bandwidth	155 Hz/Px	155 Hz/Px	155 Hz/Px	330 Hz/Px
Scan time	5 min	5 min	5:50 min	18 sec

Table 2: Sequence parameters.

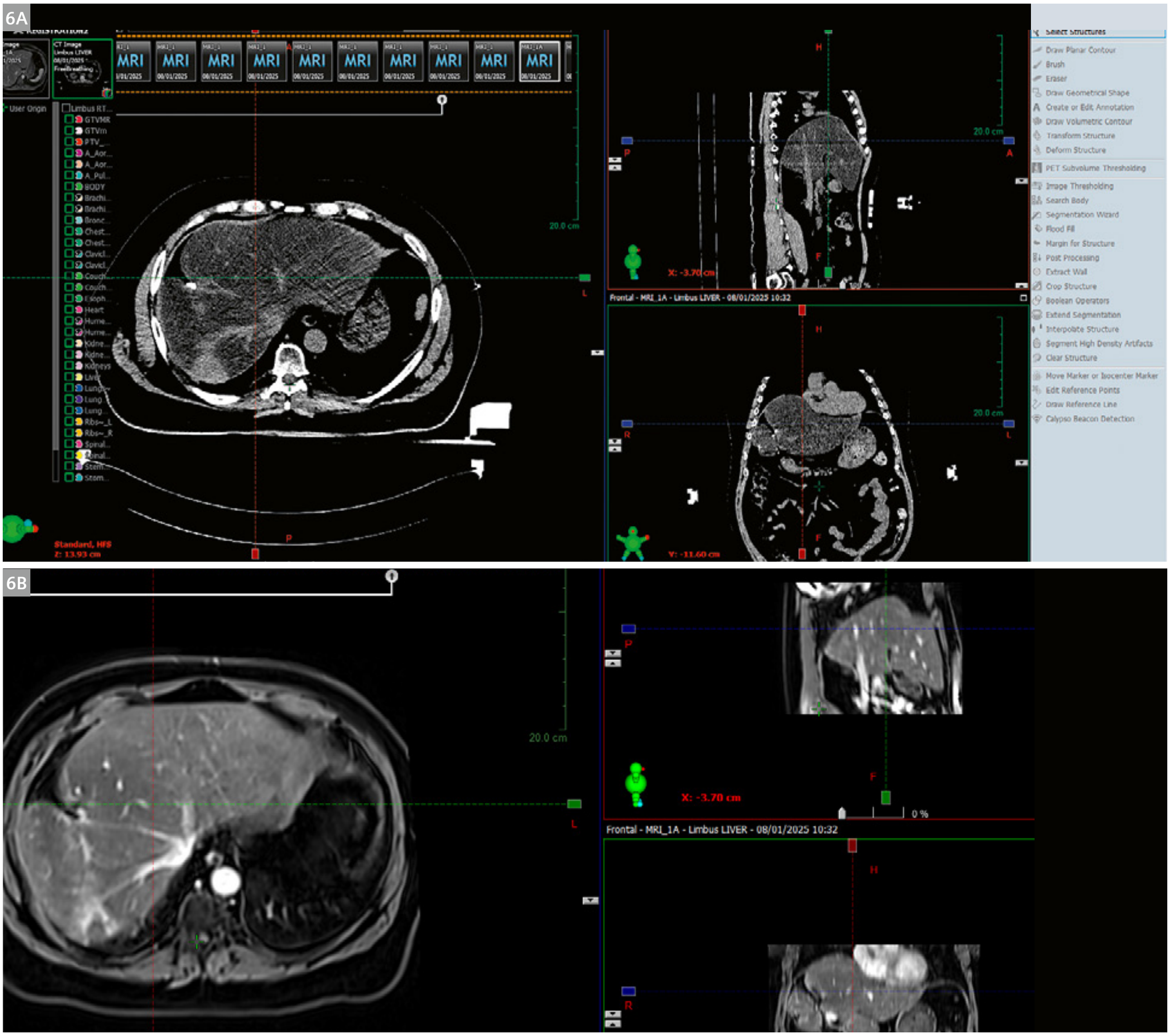
Liver

Many patients scheduled for liver-directed RT did not (unlike the brain metastases or prostate cancer patients) have a diagnostic MRI prior to RT planning. This was especially true for patients with colorectal liver metastases, who are traditionally imaged with CT and PET/CT imaging. For these patients, it was the availability of MRI within the department that prompted the additional simulation. For these patients, images were generated supine with arms raised and immobilized with a WingSTEP device (IT-V, Innsbruck, Austria). Again, the large bore of the MRI simulator enabled this positioning comfortably for all patients. In addition, since our departmental standard for stereotactic radiotherapy to the liver includes abdominal compression, we also used an abdominal compression device when scanning liver patients. An example of the setup is shown in Figure 5.

For liver patients, we used T1 VIBE Dixon sequences and T2 STIR with and without contrast media injection. These studies took an average of 30 minutes of scanning time.



5 Setup design for simulation of abdominal (liver) patient. This includes the WingSTEP device and an abdominal compression belt.



6 Example of a patient with colon cancer metastases to the liver simulated on MAGNETOM Free.Max, with **(6A)** CT images, and **(6B)** T1 VIBE Dixon postcontrast loaded into the Eclipse treatment planning software (Varian, a Siemens Healthineers Company, Palo Alto, CA, USA).

A representative image of a patient with colorectal liver metastases can be seen in Figure 6. In these cases, the definition of the lesion was much improved compared to CT simulation and PET/CT fusion.

In summary, the 0.55T MAGNETOM Free.Max RT Edition provides a novel tool to assist in RT planning. This article describes the first patients worldwide scanned with this system. The early results are promising, but much work will be needed to improve the protocols and procedures, and to determine the overall clinical effect.

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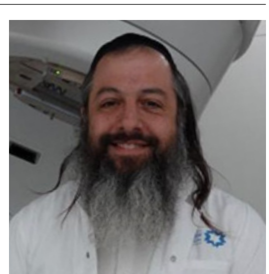

Reference

1 Rostami A, Robatjazi M, Javadinia SA, Shomoossi N, Shahraini R. The influence of patient positioning and immobilization equipment on MR image quality and image registration in radiation therapy. J Appl Clin Med Phys. 2024;25(2):e14162.