MAGNETOM Free.XL as a Strategic System for Diagnostic Imaging and MRI-Guided Interventions

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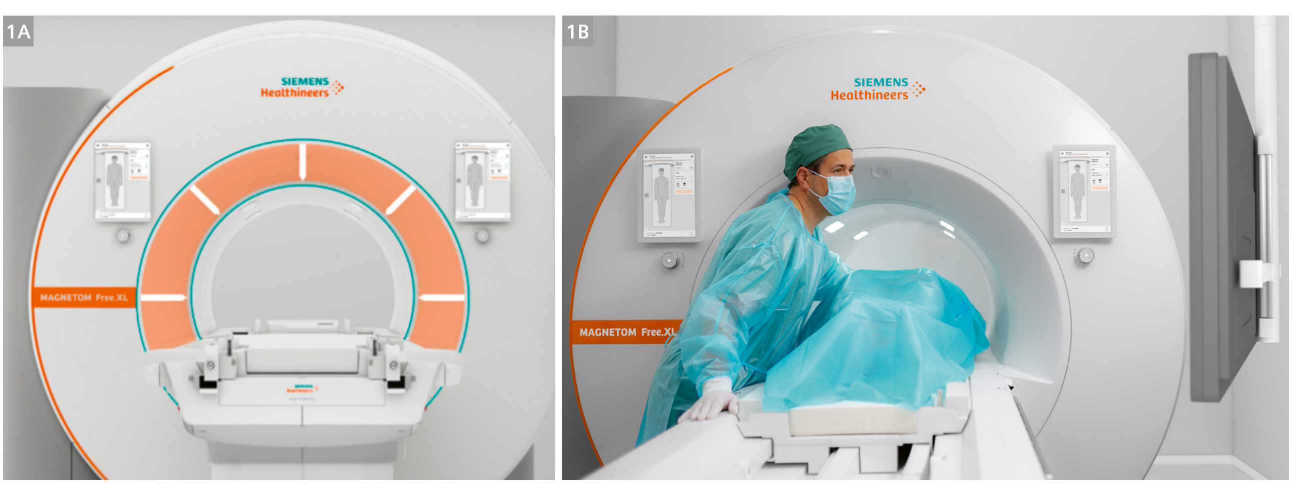
Abstract

Magnetic resonance imaging (MRI) is increasingly expected to support not only diagnosis but also treatment planning, procedural guidance, therapy monitoring, and longitudinal patient follow-up. This evolution is particularly apparent in oncology, neurology, cardiovascular medicine, women's and men's health, and image-guided interventions, where diagnostic imaging has become an integral component for clinical decision making for physicians throughout the patient journey. Hence, features such as patient access, workflow integration, procedural usability, and patient experience are becoming more relevant for healthcare providers. Recent advances in gradient performance, acquisition strategies, and deep-learning-based image reconstruction have renewed interest in lower-field MRI. Contemporary 0.55T systems have demonstrated diagnostic image quality across a broad range of neurological, musculoskeletal, abdominal, pelvic, and cardiovascular applications. At the same time, wide-bore system designs may facilitate access for image-guided procedures [2, 4–6]. In particular, the MAGNETOM Free.XL system (Siemens Healthineers, Erlangen, Germany) is a platform designed around these emerging clinical requirements. By combining modern lower-field imaging capabilities with a 100 cm flared bore and a workflow-oriented design approach, the system seeks to bridge diagnostic imaging and image-guided intervention. This article explores the clinical rationale for such a platform.

The products/features mentioned herein are not commercially available in all countries. Their future availability cannot be guaranteed.



1 The MAGNETOM Free.XL system showing the 100 cm flared bore **(1A)** and the importance of patience access **(1B)**.

Introduction

For much of its history, magnetic resonance imaging (MRI) has been evaluated primarily through the lens of diagnostic performance. Technological innovation focused on improving image quality through higher magnetic field strengths, faster acquisitions, stronger gradients, and sophisticated coils. Clinical success was largely measured by signal-to-noise ratio, spatial resolution, and diagnostic confidence. Today, however, the role of MRI is changing. Across multiple clinical disciplines, imaging has become deeply integrated into treatment planning, procedural guidance, therapy assessment, and longitudinal disease monitoring. In interventional oncology, MRI provides imaging information to support clinical assessment throughout the patient pathway, from diagnosis through follow-up, when interpreted by a healthcare professional. In neurology, it supports not only disease characterization but also emerging image-guided therapies. In cardiovascular care, MRI combines structural, functional, and tissue characterization capabilities. Similarly, image-guided interventions rely on MRI to provide precise soft-tissue visualization without exposure to ionizing radiation [1–6].

For many years, MRI development was largely associated with increasing magnetic field strength. While higher-field systems continue to provide important advantages for selected applications, advances in hardware and software have fundamentally changed the capabilities of modern lower-field MRI. Recent developments in gradient technology, accelerated acquisition techniques, and deep-learning reconstruction (i.e., Deep Resolve) have enabled contemporary 0.55T systems to achieve diagnostic image quality across a broad spectrum of clinical applications. Emerging evidence demonstrates the feasibility of routine neurological imaging, body imaging, musculoskeletal imaging, and cardiovascular applications at lower-field strengths, while also highlighting unique opportunities created by the underlying physics [2, 7–17]. Lower field strengths are associated with reduced susceptibility effects and decreased image distortion around metallic implants and devices, especially in musculoskeletal imaging. These characteristics may be advantageous in clinical situations involving implants and interventional devices. Furthermore, lower field strengths can provide favorable imaging conditions in environments where procedural flexibility and device compatibility are important considerations. The renewed interest in lower-field MRI therefore reflects more than a technical discussion about image quality; it reflects a broader recognition that future MRI platforms should consider not only diagnostic imaging performance but also accessibility, workflow integration, procedural usability, and adaptability to emerging therapeutic applications [18–26].

As healthcare systems move toward integrated and outcome-oriented care, imaging technologies are expected to contribute throughout the care pathway rather than at individual diagnostic time points. Consequently, clinicians are not only evaluating MRI systems by image quality, but also by the systems' ability to support broader clinical workflows and therapeutic strategies. This article illustrates the key features and diagnostic imaging capabilities of MAGNETOM Free.XL to demonstrate how this lower-field MRI system unlocks greater workflow potential. In this context, in-bore patient access, procedural usability, and workflow integration become strategic attributes alongside state-of-the-art metrics of imaging performance.

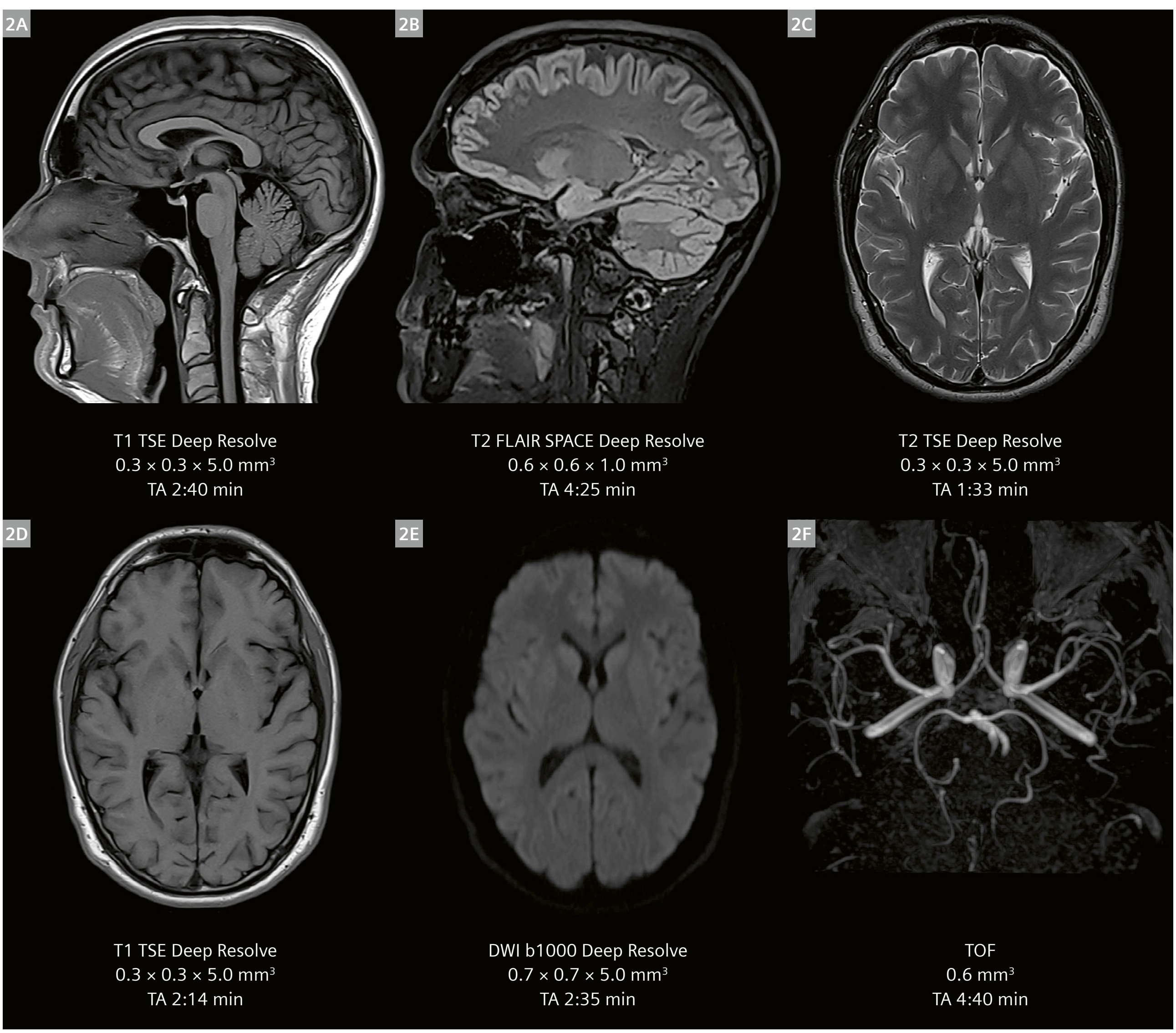
Accessibility as a clinical enabler

As MRI becomes more integrated into therapeutic pathways, physical access to the patient receives greater importance. Conventional MRI systems were primarily optimized for image acquisition where a 70 cm bore diameter was sufficient. Procedural interaction with the patient was therefore not necessarily a primary design consideration. However, larger MRI bores require substantially more energy because a larger magnetic field volume is needed to maintain field homogeneity across the larger bore volume. The emergence of MRI-guided therapies creates new clinical requirements: Physicians must maintain access for patient positioning, device manipulation, treatment delivery, monitoring, and anesthesia support. Procedural success may depend not only on image quality but also on the practical ability to work effectively around the patient within the imaging environment. Studies show that modern lower-field systems with 80 cm bores have reported favorable patient perceptions related to bore size, reduced acoustic burden, and overall examination tolerance when compared with conventional systems [4, 6]. These findings are clinically relevant because the patient's experience influences examination compliance, throughput, and access to MRI-based care. MAGNETOM Free.XL addresses and further advances these considerations with its 100 cm flared bore architecture that is designed to increase the usable working space around the patient (Fig. 1). While accessibility alone does not determine clinical value, it may facilitate positioning, improve procedural ergonomics, simplify integration of ancillary equipment, and potentially support future therapy-oriented workflows. Besides that, MAGNETOM Free.XL is part of the MAGNETOM Free. Platform. As such, it features a sealed-for-life, quench-pipe-free magnet design that requires only 0.7 liters of liquid helium, and it has a smaller footprint and lower weight. The system is further equipped with the

Nexaris Dockable Table to streamline patient positioning and transfer during image-guided interventions. Integrated within the multimodality Nexaris Therapy Suites, the Nexaris Dockable Table enables seamless workflows across MRI, CT, angiography, and intraoperative MRI.

Neurological imaging and beyond

Brain imaging is one of the most frequently performed MRI examinations. Accurate diagnosis and longitudinal monitoring require high-quality visualization of anatomy, pathology, treatment effects, and disease progression. MRI has therefore become indispensable throughout neurological care pathways (Fig. 2). Advances in acquisition and reconstruction techniques have enabled modern lower-field MRI to support a broad range of neurological examinations while maintaining workflow compatibility within routine clinical environments [1]. At the same time, neurological treatment strategies are evolving. Image-guided interventions, minimally invasive therapies, focused ultrasound procedures, and thermal treatment techniques rely on imaging before, during, and after the intervention. In these settings, MRI is expected to support the treating physician in therapeutic decision-making, procedural planning, treatment delivery, and patient follow-up. The growing integration of imaging and intervention suggests that future neurological MRI systems may be evaluated not only by their ability to characterize disease but also by their ability to facilitate emerging treatment pathways, such as high-focused ultrasound and stereotactic therapy to name only a few [6–9].



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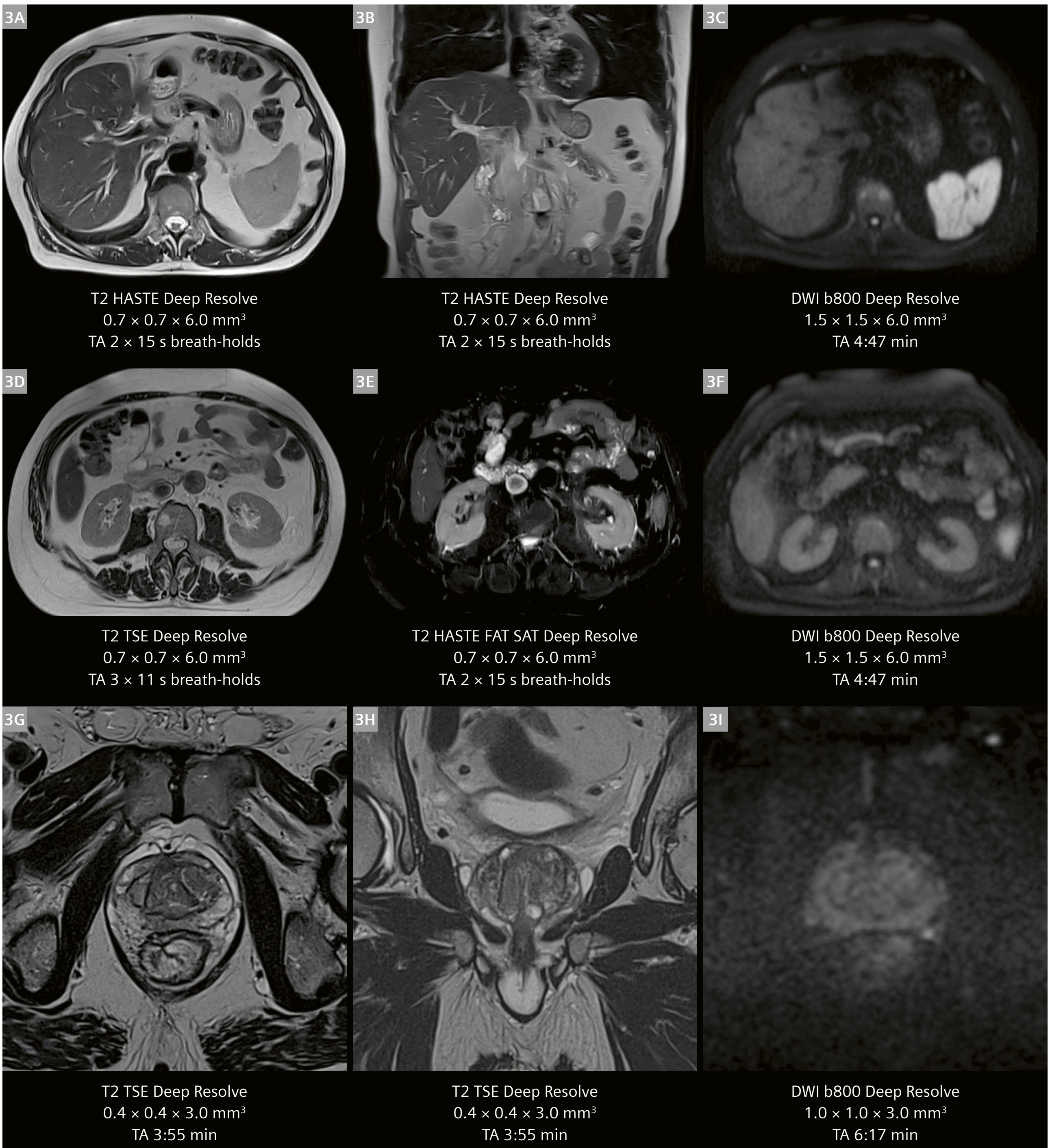
2 Routine brain imaging demonstrates that the scan times and imaging parameters meet the standard of care.

Body imaging and precision medicine

Body MRI has become an essential component of modern oncology and precision medicine. Applications in prostate cancer, liver disease, renal lesions, and pelvic disorders support treatment selection, procedural planning, and long-term patient management. The role of MRI in men's health continues to expand, supporting prostate lesion detection, risk stratification, biopsy guidance, treatment planning, and surveillance [3, 7, 10, 11, 12]. This evolution is particularly important because prostate MRI supports diagnosis and during interventional procedures (Fig. 3).



3 MAGNETOM Free.XL supports diagnostic imaging and selected abdominal workflows.

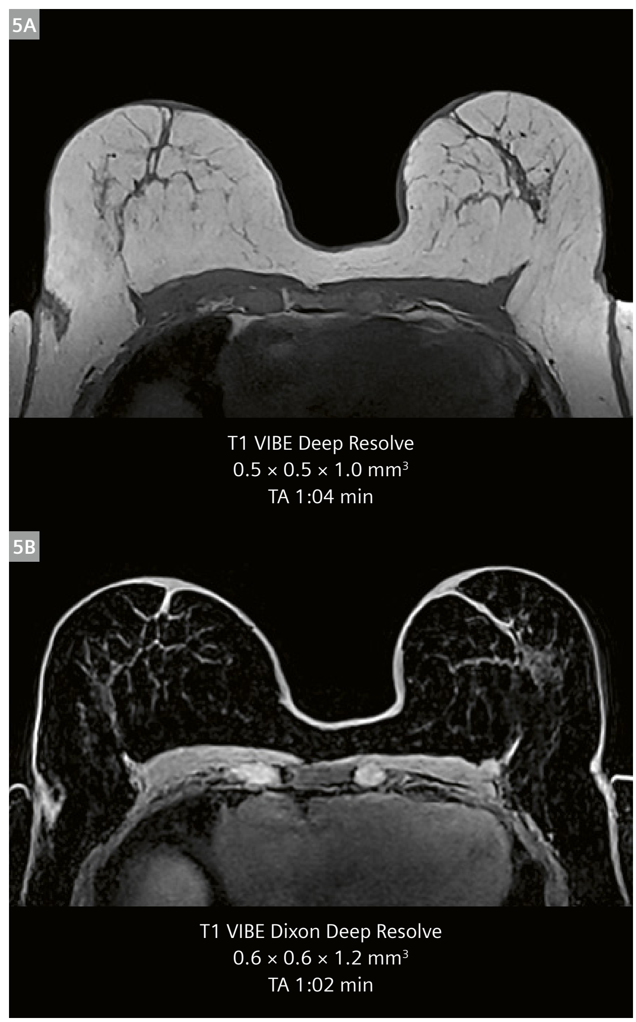
4 MRI in women's pelvic health can support disease mapping, treatment planning, and follow-up in endometriosis and uterine fibroid care.

Recent work has demonstrated the clinical feasibility of MRI-guided in-bore prostate biopsy at 0.55T, illustrating how modern lower-field MRI can contribute to image-guided interventions [4, 7, 8]. Similarly, MRI has become indispensable in liver imaging, where its ability to characterize focal lesions and diffuse disease influences therapeutic decision-making across a broad range of clinical scenarios [12]. MAGNETOM Free.XL may therefore enable new opportunities for supporting complex oncologic workflows.

Women's health and pelvic imaging

In women's health, MRI is integrated into comprehensive care pathways for conditions requiring detailed soft-tissue characterization, such as deep infiltrating endometriosis, adenomyosis, and gynecologic malignancies [19, 20] (Fig. 4). Beyond diagnosis, MRI contributes to treatment planning and assessment, particularly as minimally invasive therapeutic approaches continue to expand. Image-guided ablation techniques have already demonstrated feasibility in selected endometriosis-related applications, illustrating how advanced imaging can become integrated into therapeutic workflows [17]. These developments align with a broader trend in which imaging technologies are expected to support clinical decision-making across the entire treatment continuum rather than solely during initial diagnosis.

A similar trend is evident in breast imaging, where MRI is an established pillar of comprehensive care. Leveraging high tissue contrast, MRI enables precise lesion detection, staging, and monitoring, particularly in women with dense breast tissue or in high-risk screening cohorts [22, 23]. The American College of Radiology Appropriateness Criteria recommend breast MRI for high-risk women and selected women with dense breast tissue, reflecting established



5 Breast images of high soft-tissue contrast for lesion assessment and visualization of breast, chest wall, and axillary anatomy, using T1 VIBE and T1 VIBE Dixon, both with Deep Resolve.

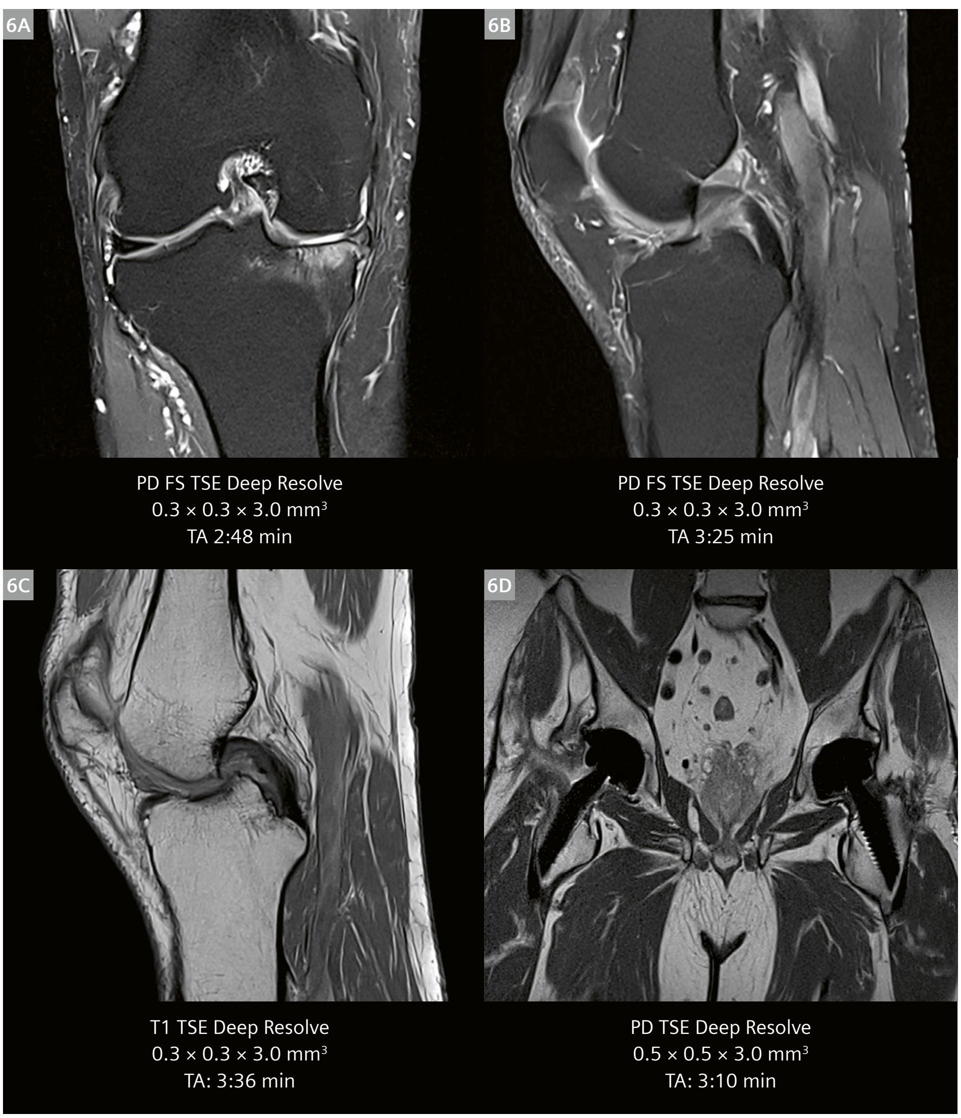
evidence that MRI provides superior sensitivity for early breast cancer detection compared with mammography alone in these populations [24] (Fig. 5).

Musculoskeletal imaging

In musculoskeletal MRI, system performance is best reflected by the ability to depict both fine anatomy and clinically relevant pathology with diagnostic confidence. Representative examinations should provide clear assessment of cartilage, menisci, ligaments, tendons, muscle, and marrow, as well as abnormalities such as edema, osteochondral injury, occult fracture, and soft-tissue lesions. MAGNETOM Free.XL is of interest in this context because contemporary 0.55T MRI systems (i.e., MAGNETOM Free.Max) with deep-learning reconstruction have demonstrated diagnostic image quality for routine knee imaging, while the lower field strength may reduce metal-related artifacts (Fig. 6) [2, 3, 4, 18]. MRI-guided interventions in musculoskeletal cases have been shown to deliver standard of care in nerve root infiltration therapy, but with higher soft-tissue contrast than CT imaging [25].

Cardiovascular imaging

Cardiovascular MRI and MRI-guided interventions are among the most technically demanding applications for diagnostic imaging. However, they are highly clinically valuable because they provide comprehensive assessment of cardiac characteristics without exposing patients to ionizing radiation [2, 15]. This radiation-free imaging is particularly important for pediatric patients and for

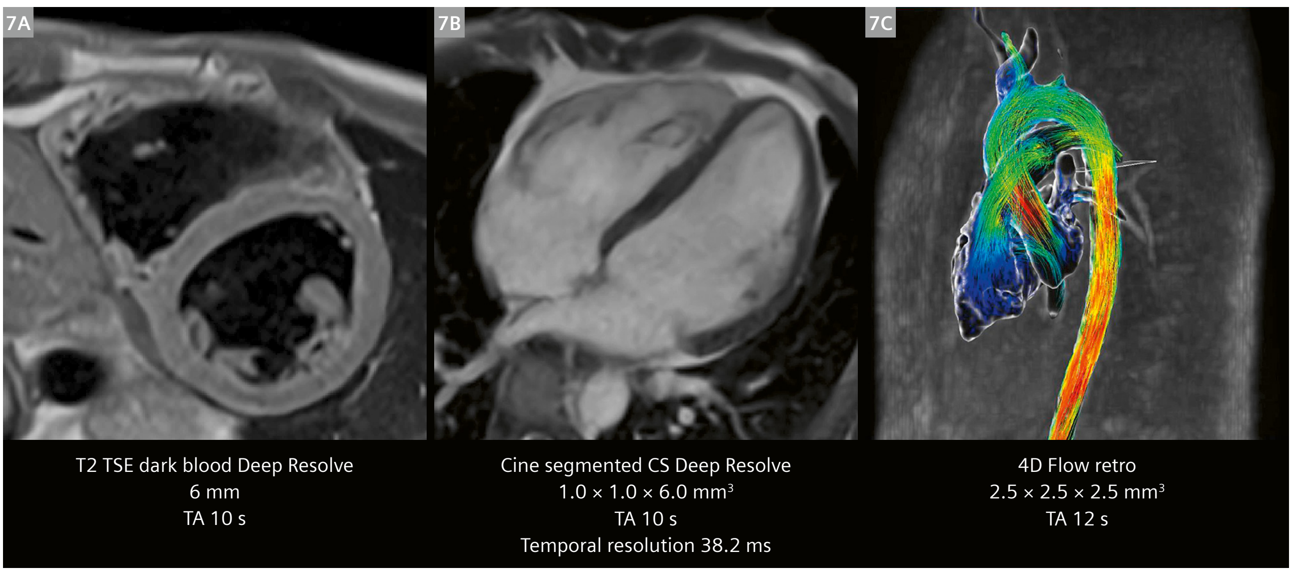


6 Images that support confident assessment of joint anatomy and potential pathology (e.g., **6D**) in a patient with bilateral hip replacement.

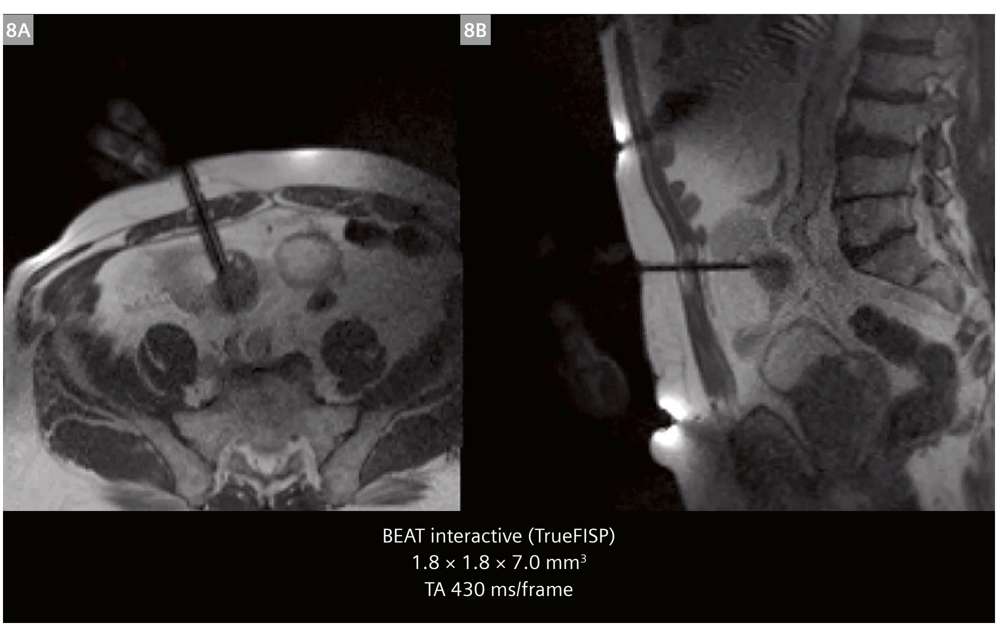
individuals who require repeated follow-up examinations, for whom cumulative radiation exposure is a significant concern. Lower-field cardiac MRI has recently attracted renewed interest because lower field strengths may offer several intrinsic advantages for cine and blood flow imaging (Fig. 7). For patients with implants, lower-field MRI can reduce artifacts. These advantages also support MRI-guided cardiac interventions, where accurate real-time imaging is critical for catheter movement and procedural success.

Interventions with real-time imaging

MAGNETOM Free.XL combines the inherent advantages of 0.55T MRI with high-performance "XL gradients" (59 mT/m at 277 T/m/s slew rate [along single axis 34 mT/m at 160 T/m/s]), Deep Resolve, and a patient-centered flared bore design, creating a system that balances image quality, patient accessibility, and workflow efficiency. Strong gradient performance plays a central role by enabling faster spatial encoding, shorter acquisition times, and



7 Various contrasts show that cardiac imaging with MAGNETOM Free.XL can be routine. **(7A)** T2 TSE dark blood with Deep Resolve, **(7B)** Cine with Compressed Sensing and Deep Resolve, **(7C)** 4D Flow velocity-encoded blood-flow information.



8 Real-time imaging guidance with BEAT interactive (TrueFISP contrast) sequence during a needle biopsy of a lymphatic lesion in the abdomen. *Images courtesy of Matthias May, M.D., EBIR; Universitätsklinikum Erlangen, Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen, Germany.*

improved temporal resolution, which are essential for real-time imaging during percutaneous needle-guided and catheter-guided interventions. The XL gradients enhance temporal resolution by significantly compressing the acquisition time, resulting in a higher fame rate [1, 5–7, 17, 19]. This integration means that MRI can support targeting, verification, intervention, and follow-up, within a single environment (Fig. 8).

Discussion

The future of MRI will ultimately be defined less by magnetic field strength and more by its ability to integrate into patient care pathways. Healthcare systems increasingly seek technologies that support diagnosis, treatment planning, intervention, therapy monitoring, and longitudinal follow-up within a unified clinical framework [26]. This transformation is already visible across oncology, neurology, cardiovascular medicine, women's health, and interventional radiology. As imaging becomes progressively more essential for intervention, MRI systems must provide not only diagnostic performance but also accessibility, workflow flexibility, and procedural adaptability. The MAGNETOM Free.XL system reflects this evolving paradigm. Its significance lies not simply in operating at 0.55T, but also in combining excellent diagnostic imaging that meets the standard of care with a platform designed around patient access, procedural usability, workflow, and convenient institutional integration. Such characteristics are becoming more important as MRI-guided interventions continue to expand across multiple clinical disciplines.

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