Professor Dr. med. Michael Uder graduated from Saarland University in 1992. He trained in radiology and subsequently became Professor of Radiology at Friedrich-Alexander-University Erlangen-Nürnberg, Germany. Since 2009, Professor Uder has led the Institute of Radiology.

Professor Dr. Frederik Laun and **Professor Dr. Armin Nagel** both head MRI physics research groups at the Institute of Radiology. Professor Laun has a strong research focus on diffusion-weighted imaging and quantitative susceptibility-weighted imaging. The research interests of Professor Nagel are predominantly in ultra-high field and non-proton MRI.

Dear readers and colleagues,

We have been asked to introduce this RSNA edition of MAGNETOM Flash by talking about the possibilities of high-performance, 0.55 Tesla magnetic resonance imaging (MRI). At first glance, a move to lower field strengths seems to be counterintuitive, given the fact that there have been tremendous efforts during the past decades to design MRI systems with higher magnetic field strengths. Undoubtedly, many diagnostic imaging applications clearly benefit from high magnetic field strengths such as 3T or even 7T. The latter has become a clinical field strength with the clinical approval of the MAGNETOM Terra system in 2017. MRI at 7T enables unprecedented spatial resolution, improved spectral resolution, and efficient detection of non-proton nuclei such as sodium and phosphorous. Therefore, a number of diagnostic applications – particularly neurological and musculoskeletal imaging – clearly benefit from ultra-high-field MRI [1]. In addition, most methodology-oriented MRI research is currently being performed at field strengths ≥ 3T [2].

However, lower field strength MRI (< 1T) could potentially benefit from many of the technical developments that have been achieved at higher field strengths [3]. Several articles in this edition cover a broad range of new technical innovations that also enable high-performance MRI at low field strengths. Here, advanced-design, low-field systems and innovative magnet designs, as presented by Val Runge and colleagues (page 11), will not only contribute to improved image quality, but will also facilitate installation and improve accessibility and reach of MRI. Sophisticated algorithms and artificial intelligence (AI) are now aiding slice positioning, and as image reconstruction increasingly involves AI and deep learning, we can expect to see more developments in the future that will further mitigate concerns about reduced image quality at lower field strengths. Alexis Vaussy et al. combined parallel imaging acceleration with a modern iterative denoising reconstruction algorithm (page 26). For 3D neuroimaging, they achieved submillimeter spatial resolution at 3T in clinically acceptable acquisition times, this is usually only feasible at ultra-high magnetic field strengths. In the future, these techniques will also help to improve image quality at low field strengths. Adrienne Campbell-Washburn and colleagues show the potential of high-performance 0.55T MRI for cardiopulmonary imaging (page 35). In addition, some MRI-guided interventions might become possible at low field strength, largely due to reduced device heating as compared to field strengths ≥ 1.5T [4].

Thus, imaging at higher field strengths is not always advantageous (see also André Fischer on page 6). Although 1.5T and 3T MRI systems have replaced older low-field systems (< 1T) in most hospitals, low-field MRI has regained popularity over the past few years [5]. At higher field strengths, susceptibility artifacts increase, imaging near implants is challenging or in some cases even impossible, and last but not least, installation costs increase with magnetic field strength. One benefit of low-field systems is their cost-effectiveness: Compared with conventional 1.5T, 3T, or 7T systems, the costs of

MAGNETOM Free.Max is currently under development and is not for sale in the U.S. and in other countries. Its future availability cannot be ensured.

In the future, 0.55T MRI will hopefully help to increase accessibility to MRI examinations for many patients and could potentially be used for identifying patients that require dedicated examinations in high- or ultra-high-field systems. Therefore, MRI systems at all field strengths will contribute to high-end imaging and optimal patient care.

manufacturing, transporting, and operating the scanner and its magnet are much lower. MRI is one of the most advanced and versatile diagnostic imaging modalities available today, yet this also renders it one of the most expensive – both in terms of initial investment and the lifetime running costs. This is partly due to the high structural demands that accompany the installation of an MRI system. In addition to needing a large amount of space and very strong floors, hospitals also have to arrange for the installation of major components such as quench pipes. This limits access to MRI examinations not only in developing countries, but also in smaller, poorly funded hospitals.

Costs can be reduced by reducing hardware costs and by simplifying infrastructure requirements. MAGNETOM Free.Max benefits from the new DryCool magnet technology, where the magnet is fully sealed and only requires 0.7 liters of helium. This means, there is no need for helium refills, and no quench pipe is required.

In addition to the accessibility issues mentioned, access to MRI is also often limited by the availability of qualified staff. This is true everywhere, including in industrialized nations, where shortages of MRI technologists are a frequent problem. Thus, there is a need for true push-button workflows based on sophisticated, intelligent automation. As presented by Tanja Dütting et al. (page 40), autopilot systems will allow users to perform what were previously complex and error-prone MRI examinations at the touch of a single button. At the same time, it is important that there remains access to a state-of-the-art user interface that enables advanced settings and a high degree of flexibility for more experienced technologists.

Choosing the counterintuitive route and going lower instead of higher will offer clinical benefits for many applications: Longer T2* relaxation times will reduce blurring artifacts for echo-planar imaging (EPI) readouts (e.g., in diffusion scans), and will also enable improved MRI of tissues and organs with short relaxation times, such as tendons and the lung. The specific absorption rate (SAR) can be much lower, which will also enable safer imaging of implants. In addition, the reduction in susceptibility artifacts will enable improved passive metal implant imaging.

At University Hospital Erlangen, we operate MRI systems with field strengths of 0.55T, 1.5T, 3T, and 7T. We are convinced that – at least for large centers such as university hospitals that have to cover the whole range of diagnostic applications – there is not merely one "optimal" magnetic field strength that fits best for all scenarios. Some patients will benefit from imaging at 3T or even 7T. However, for most patients, diagnostic quality at 1.5T or 0.55T will most likely be sufficient. For some applications (e.g., lung imaging, imaging near implants, and interventions), low-field MRI might even enable improved image quality. In the future, low-field MRI will hopefully help to increase accessibility to MRI examinations for many patients and could potentially be used for identifying patients that require dedicated examinations in high- or ultra-high-field systems. Therefore, MRI systems at all field strengths will contribute to high-end imaging and optimal patient care. Furthermore, close collaboration between radiologists, manufacturers, and basic scientists such as MRI physicists and data scientists is crucial for further expanding the diagnostic possibilities of MRI at all field strengths.

We hope that the new 0.55T MAGNETOM Free.Max platform will provide more people with access to MRI examinations (e.g., in developing countries and emerging markets). Even for industrialized countries, the factors mentioned above can restrict the flexibility necessary to provide MRI where it is needed – at the point of care in emergency departments (see also, e.g., the work of Vincent Dunet and associates (page 20), in rural community hospitals, and in orthopedic practices and the like.

We hope you enjoy reading this issue!



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