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James is a musculoskeletal radiologist working with Castlereagh Imaging since 1999 and is currently the CEO. He is a consultant radiologist for a number of professional sporting teams, has an active research program, and is director of the musculoskeletal radiology fellowship program. James has 100 publications to his name and regularly presents at national and international meetings. He has been an examiner for the Royal Australian and New Zealand College of Radiologists, is a past president of the Australasian Musculoskeletal Imaging Group, serves on the editorial board of *Sports Health*, and is an active reviewer for several journals. In 2019, he was awarded a Medal of the Order of Australia for services to medicine in the field of radiology.

The Future of Musculoskeletal MRI has Arrived

Musculoskeletal MRI stands at a remarkable inflection point, where AI, ultra-fast sequences, low-field reinvention, and 7T explorations are converging to deliver a leap in imaging capabilities that was previously unimaginable.

Welcome to the first-ever International Skeletal Society (ISS) edition of *MAGNETOM Flash*, a special issue that brings together global experts to share advances that are reshaping musculoskeletal imaging. From accelerated protocols to super-resolution AI, the innovations captured here are opening new diagnostic frontiers.

MSK MRI is moving fast. Really fast. Whether it's pushing the limits of acquisition speed, unlocking the power of ultra-high-field imaging, or harnessing AI to enhance both image quality and workflow, one thing is clear: The tools and techniques we use are evolving – and so are the questions we ask.

This special issue is your panoramic view of that evolution. It's a curated journey through what's new, what's promising, and what's possible.

We kick off with Vosshenrich and Fritz [1], who show us how "fast" doesn't have to mean "compromise." Their deep dive into the acceleration toolbox, which consists of Simultaneous Multi-Slice, Compressed Sensing, and deep learning, makes a strong case for smarter imaging that's also quicker and more comfortable for patients.

What makes this speed possible? It's not just software magic. Hardware advancements and how we leverage them matter greatly. The synergy of high-performance gradients, rapid RF pulses, and wide receiver bandwidths is reshaping the turbo spin-echo frontier. Echo-train compaction plays a pivotal role here, allowing for shorter echo spacing and longer echo trains. In turn, these enable greater acceleration utilizing a synergistic combination of parallel imaging (SENSE/GRAPPA) and simultaneous multislice acquisition (SMS) with multi-channel surface coils, allowing multiplicative acceleration benefits whilst maintaining image quality through the use of AI-based denoising (Deep Resolve). Whether at 0.55T, 1.5T, 3T, or 7T these innovations deliver scan times once thought to be unattainable, without sacrificing diagnostic value. Deep neural networks are now capable of reconstructing SMS2-PAT3, SMS3-PAT3, and even SMS3-PAT4 datasets, potentially accelerating scan protocols beyond a factor of 10. These AI-powered gains redefine our ceiling for what's achievable in routine MSK MRI.

Feuerriegel and colleagues [2] continue the momentum, documenting their validation of a diagnostically equivalent alternative to contrast-enhanced imaging for demonstrating knee joint synovitis: a deep-learning-accelerated fat-suppressed T1 FLAIR sequence[1] that

[1] *The application is currently under development and not commercially available. It is for research use only. Not for clinical use. It is not for sale in the USA and its future availability cannot be ensured.*

demonstrates synovial thickening without gadolinium, in scan times under 2 minutes, with direct application in knee osteoarthritis research and in some clinical applications. Boudabbous and team [3] give us a sneak peek at what 7T imaging could mean for MSK radiology, showing impressive improvements in image quality over lower field strengths whilst not yet demonstrating a clear use case in clinical musculoskeletal MR imaging.

Meanwhile, Hallinan and Makmur [4] selectively address a different kind of challenge: the reporting bottleneck. Their work on AI-based grading of lumbar central canal and foraminal stenosis documents its accuracy and ability to significantly reduce reporting times, particularly amongst general radiologists and trainees, whilst not yet providing a comprehensive AI tool for diagnostic assessment of MRI lumbar spine. The lumbar spine AI application[1] is now available as a research prototype on *syngo*.via Frontier.

For sports imaging fans, Kassarjian [5] shares an update on hamstring imaging that's both practical and precise, with a focus on the biceps femoris. His insights are grounded in experience and guided by anatomy, providing some important tips in reporting progress MR scans of hamstring injuries where guidance on re-tear risk is sought by the team managing the rehabilitation of the athlete.

Sneag and colleagues [6] share their experience in optimizing brachial plexus MR imaging on a 3T MAGNETOM Vida, documenting their high-resolution approach. They dispense with the traditional approach of bilateral imaging, moving instead to a dedicated multi-coil, unilateral approach, harnessing prospective respiratory gating to minimize respiratory artifact. The use of optimally angled oblique sagittal respiratory-gated 2D Dixon fat-suppressed T2 sequencing affords high signal-to-noise ratio, high in-plane spatial resolution, and anatomic imaging of the individual constituents of the brachial plexus, providing evaluation of individual nerve fascicle signal and morphology. Constrained field of view volumetric SPACE STIR sequencing, optimally angled for unilateral plexus imaging provides higher through-plane spatial resolution imaging of the plexus, with specific modifications including: a C-shaped frequency offset corrected inversion (C-FOCI) pulse to provide more uniform fat suppression; a variable flip angle echo train tailored to B_1 inhomogeneity; and a deep-learning-based 3D reconstruction algorithm[1] tailored for CAIPIRINHA sampling, allowing reduction of slice thickness from 1 mm to 0.8 mm. Selective use of IV contrast to improve vascular suppression reduces venous contamination obscuration of small branch nerves of the plexus and allows oblique or curved multi-planar reconstructions along individual nerves of interest. The authors elegantly present the utility of this approach by demonstrating fibrous constrictions in the suprascapular nerve in a patient with Parsonage-Turner syndrome.

Quantitative imaging in routine clinical musculoskeletal MRI has historically imposed significant acquisition and post processing time constraints, limiting its uptake in clinical practice. In their article, Tan, Lu, and Sneag present a compelling overview of GRAPPATINI[1], a hybrid acceleration technique that integrates GRAPPA and MARTINI, offering the potential for fast, high-resolution T2 mapping in musculoskeletal and neuromuscular MRI. The authors detail its dual capacity to generate quantitative T2 maps alongside synthetic T2-weighted images within clinically feasible scan times, significantly enhancing both diagnostic efficiency and image quality. Through case-based applications in foot drop, Parsonage-Turner syndrome, lumbar disc degeneration, and cartilage imaging, they demonstate GRAPPATINI provides strong agreement with conventional techniques while offering additional biomarker quantification. These early clinical experiences underscore GRAPPATINI's potential to streamline imaging workflows and enable more precise assessment of nerve and musculoskeletal pathology, paving the way for broader adoption in both research and routine practice.

And what about patients with metal implants? Breit et al. [7] remind us that lower is sometimes better. Their work at 0.55T reveals how low-field imaging can rise to the occasion when high-field scanners fall short in imaging patients with metal[2] hardware.

Finally, Moran and Song [8, 9] describe the 3D bone imaging application of a sequence primarily designed for free-breathing body and pediatric imaging. The VIBE sequence has become a cornerstone of MR imaging of pars bone stress injuries, providing a CT-equivalent level of accuracy in demonstrating incomplete pars interarticularis stress fracture lines that would otherwise remain occult on conventional 2D spinal MR sequences. StarVIBE is a modified version of VIBE that uses radial sampling for in-plane imaging, and Cartesian sampling for through-plane imaging. The center of k-space is sampled multiple times due to the radial trajectory, making StarVIBE relatively motion-insensitive and thus of potential utility in situations where motion degradation of image quality would otherwise render a routine VIBE sequence non-diagnostic.

[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.

This issue of *MAGNETOM Flash* is a reflection of where musculoskeletal MRI is today – and, more importantly, where it is heading. It is appropriate that this edition is being published to coincide with the Annual Meeting of the International Skeletal Society – one of the leading international societies in the musculoskeletal MR imaging space. Recognition should go to the authors, the reviewers, and the team at Siemens Healthineers who made it possible.

Whether you're a radiologist, technologist, physicist, or engineer, I am sure you will find something in these pages that sparks your curiosity and propels your practice forward.

Sincerely,

Dr James Linklater, FRANZCR, OAM

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Guest Editor
International Skeletal Society Special Edition
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