

From Routine to Rapid: Implementing Two-Minute Deep-Learning-Enabled Protocols for Enhanced Clinical Efficiency

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Introduction

Deep learning reconstruction in MRI enables high-resolution imaging while significantly reducing scan times, thereby striking a balance between speed and image quality [1]. This study explores the clinical deployment of the Deep Resolve image reconstruction technique on a 3T MAGNETOM Vida MRI scanner (Siemens Healthineers, Erlangen, Germany) in combination with both conventional and the latest acceleration techniques. We performed a multi-anatomy comparative analysis between Deep-Resolve-based protocols and traditional acceleration techniques like GRAPPA on the 3T MAGNETOM Verio scanner (Siemens Healthineers, Erlangen, Germany). Our focus was to examine the diagnostic viability, spatial resolution, and workflow impact.

Protocol strategy and acceleration techniques

Image data selection on the MAGNETOM Verio was done retrospectively from the available database, which was limited to conventional acceleration techniques such as parallel imaging (e.g., iPAT and GRAPPA) that rely on coil sensitivity profiles and undersampling of *k*-space data to reduce scan time.

On the MAGNETOM Vida, two protocol strategies were evaluated:

Set 1 included routine Deep Resolve protocols that were optimized to achieve very high image quality and efficiency;

Set 2 included ultra-fast protocols that were optimized to combine Deep Resolve with Simultaneous Multi-Slice (SMS, parallel excitation of more than one slice at a time) and PAT acceleration to reduce total acquisition times to

approximately 2 to 3 minutes per anatomy while preserving diagnostic image quality.

The latest deep-learning-based reconstruction technologies from Siemens Healthineers are collectively referred to as Deep Resolve. They include Deep Resolve Boost (DRB) and Deep Resolve Sharp (DRS). Deep Resolve is a sophisticated reconstruction algorithm that uses deep learning to enhance image quality and denoise undersampled acquisitions. It enables faster scans while simultaneously improving spatial resolution [2]. Together, these techniques leverage the full potential of modern hardware and deep learning software, helping to push the boundaries of fast, high-quality imaging.

We compared scans from the two MRI systems, focusing on six anatomies that represent a major portion of routine clinical workload (> 75% of MRI scans as per the IMV MR Market Outlook Report [3]): brain, spine (cervical, dorsal, and lumbar), shoulder, and knee joint.

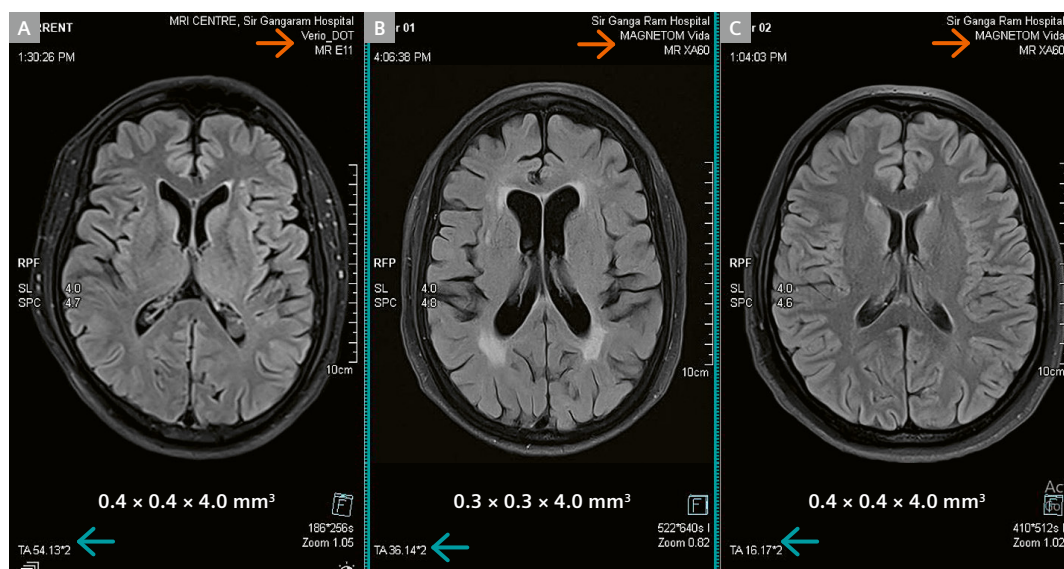
Results

MAGNETOM Vida with routine deep learning image reconstruction protocols vs. MAGNETOM Verio with conventional image recon

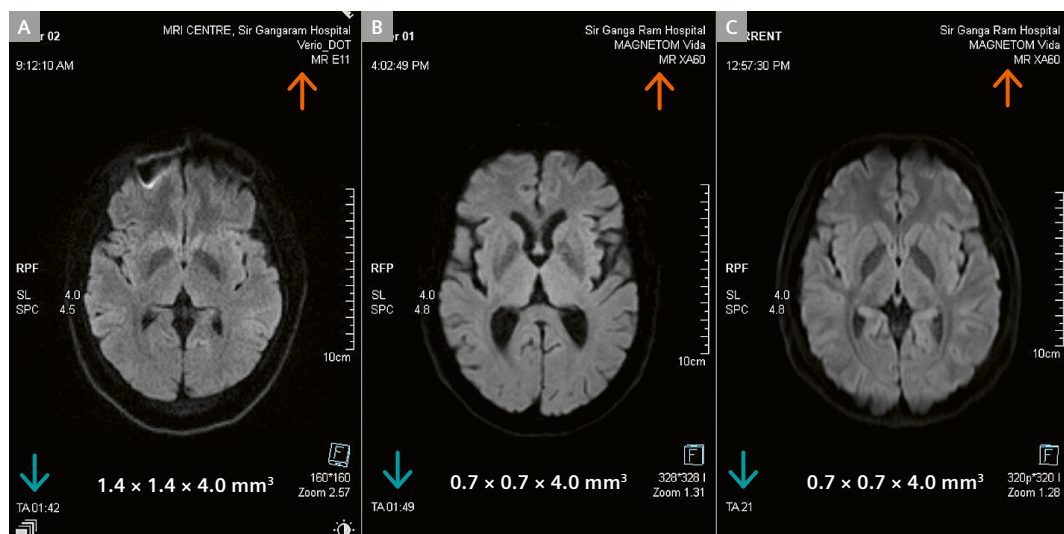
Comparing images from the two scanners, it was consistently observed that the Deep Resolve protocols on the MAGNETOM Vida delivered superior image quality and spatial resolution across all anatomies studied. Structures that typically require high detail – such as cortical gray matter (Figs. 1–3), spinal nerve roots (Figs. 4 and 5), and cartilage, meniscus, and ligamentous structures (Figs. 6–10) were more clearly visualized on MAGNETOM Vida scans in both protocols, courtesy of higher resolution, higher signal-to-noise ratio (SNR), and improved image contrast.

Figures 1 through 10 are direct comparisons of individual sequences from the MAGNETOM Verio (Image A) and from the MAGNETOM Vida with routine Deep Resolve protocols (Image B) and ultra-fast protocols of 2–3 minutes enabled by Deep Resolve (Image C). Scanner identification can be verified at the top right of each image with the orange arrow, while the acquisition time (TA) can be verified at the bottom left of each image with the petrol arrow.

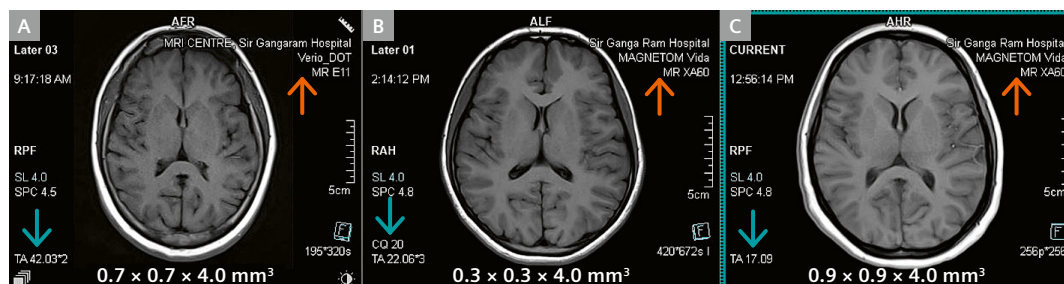
We observed that the images acquired on the MAGNETOM Vida, even with ultra-fast protocols, were crisper and had better edge definition and lower background noise compared to those acquired on the MAGNETOM Verio. This suggests that the deep-learning-based reconstruction capabilities do more than just match conventional methods – they enhance them to a degree that redefines diagnostic clarity, even in shorter scans.



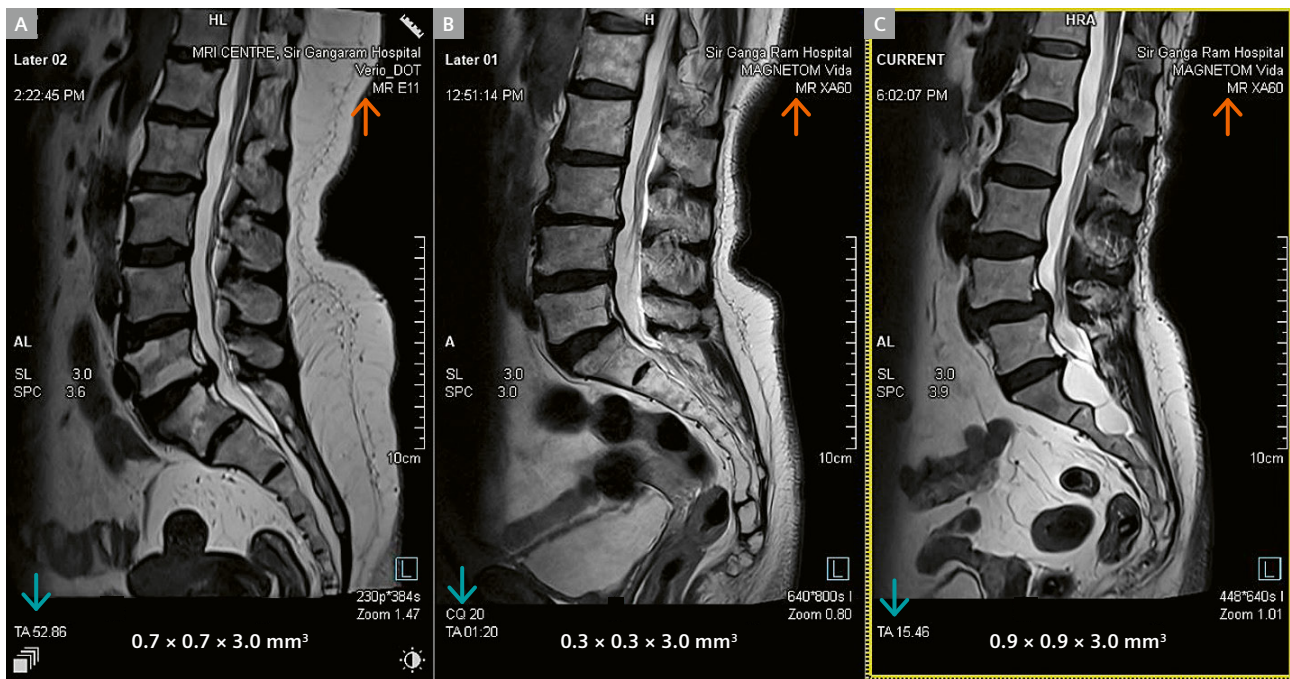
1 Image B has finer in-plane resolution than A, suggesting improved resolution. Images A and C have the same voxel size, but the image acquisition speed of C is 69% faster than A.



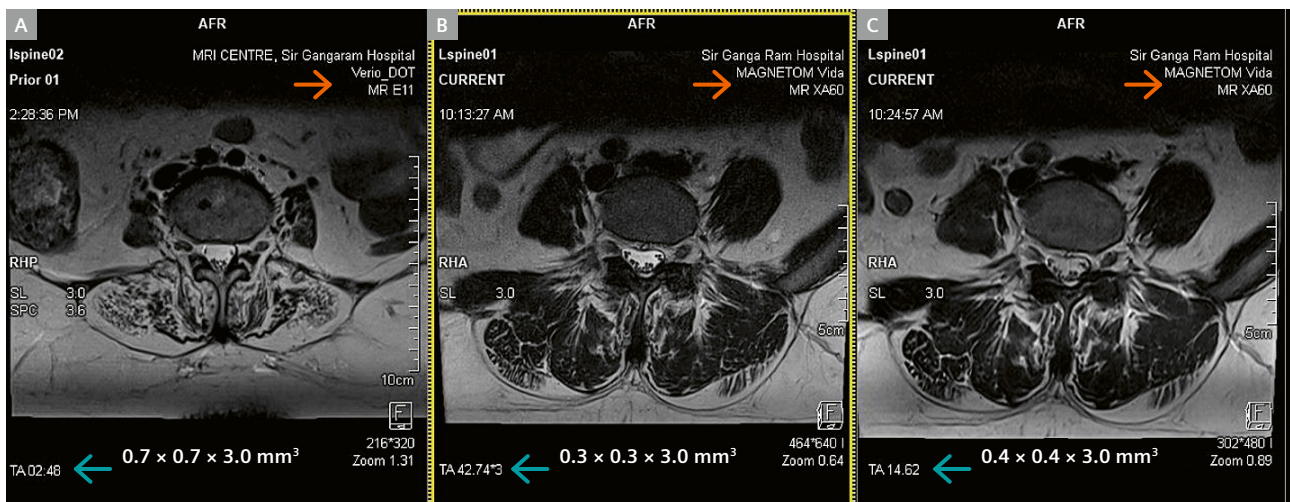
2 Both MAGNETOM Vida scans (images B and C) double the resolution compared to the MAGNETOM Verio scan (A), implying significant resolution gain. Meanwhile, the scan time for C is 79% shorter than for A.



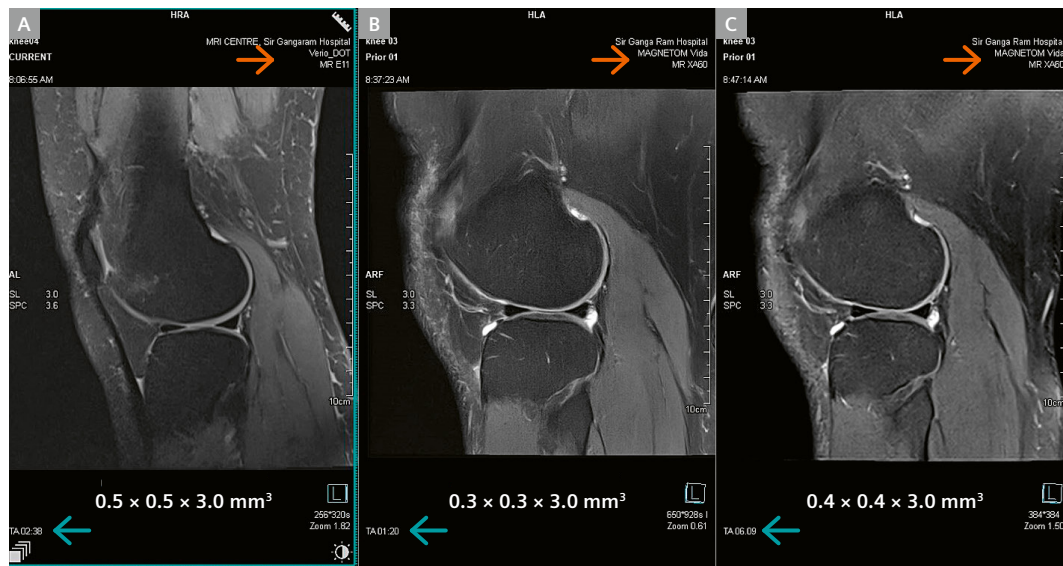
3 Image B shows higher resolution here, while the acquisition time for C is 79% faster than for A.



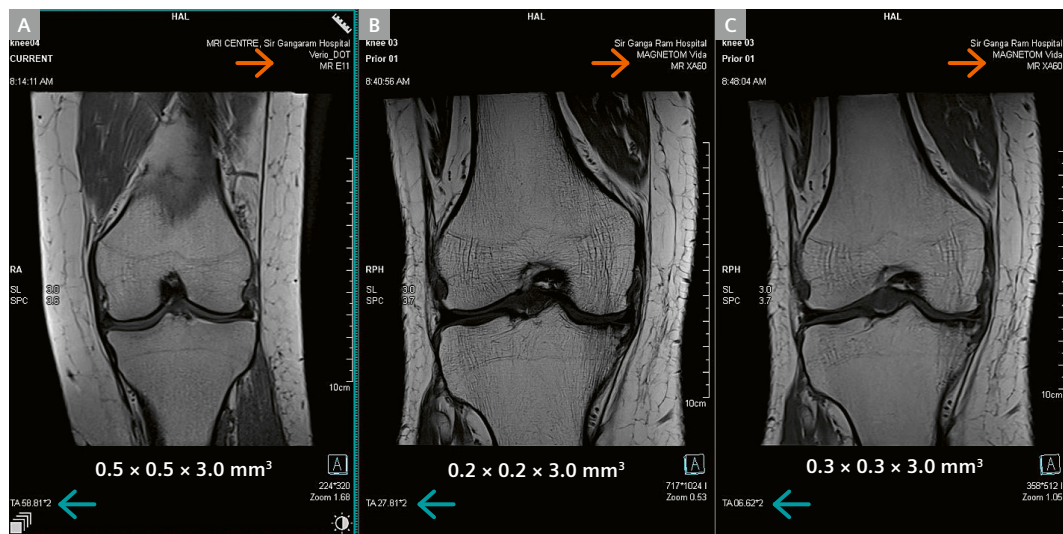
4 Images B and C offer higher resolution than A. The acquisition time for C is 70% faster than for A.



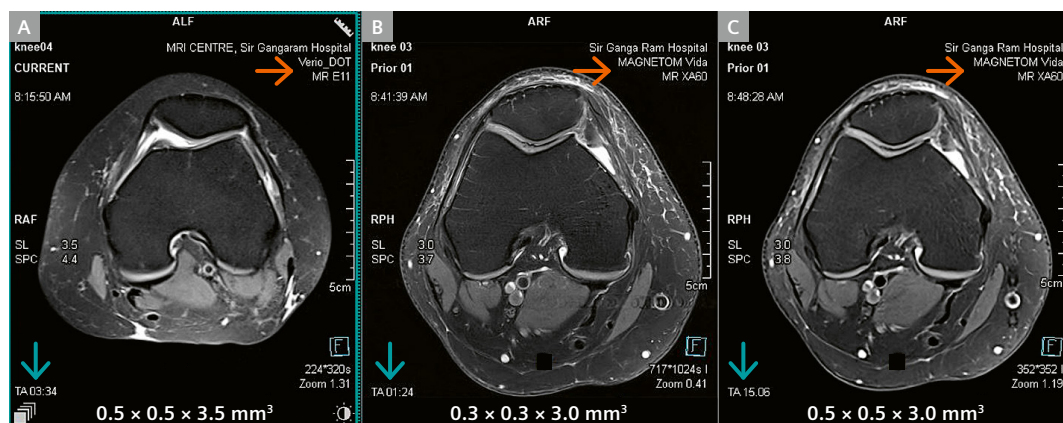
5 Images B and C have markedly better resolution than A. The acquisition time for C is 91% faster than for A.



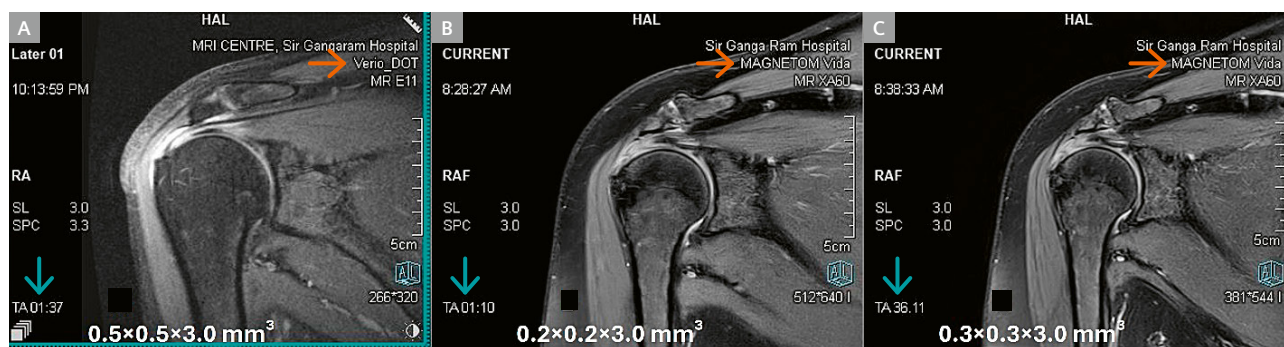
6 The acquisition time for C is 95% faster than for A.



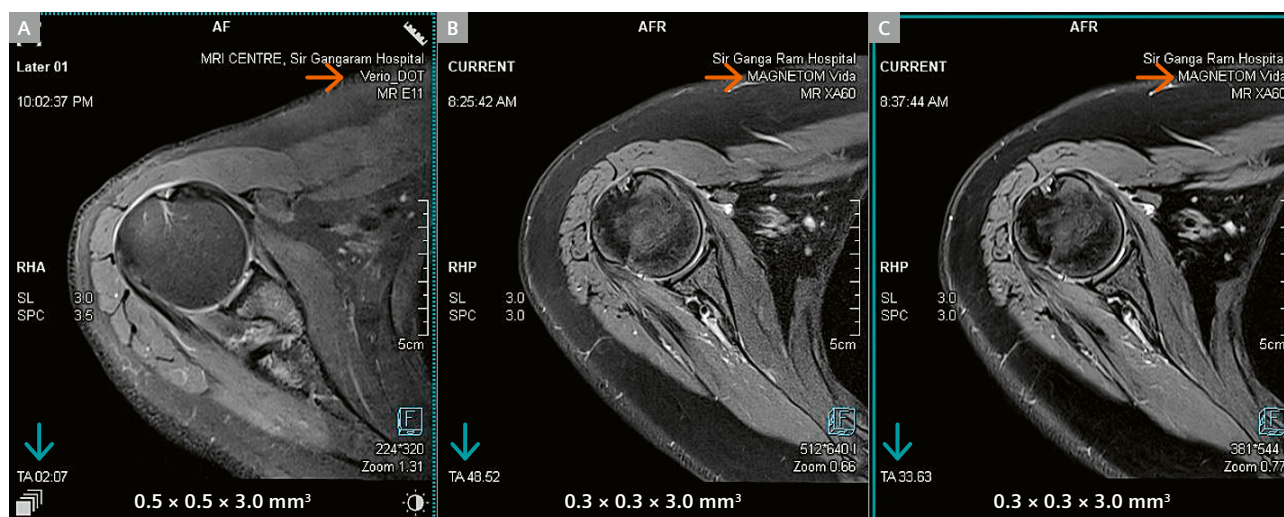
7 Substantial voxel gain in B and C compared to A, with scan time efficiency. The acquisition time for C is 88% faster than for A.



8 The acquisition time for C is 92% faster than for A.



9 Images B and C outperform A in resolution and scan time efficiency. The acquisition time for C is 61% faster than for A.



10 Images B and C outperform A in terms of resolution. The acquisition time for C is 73% faster than for A.

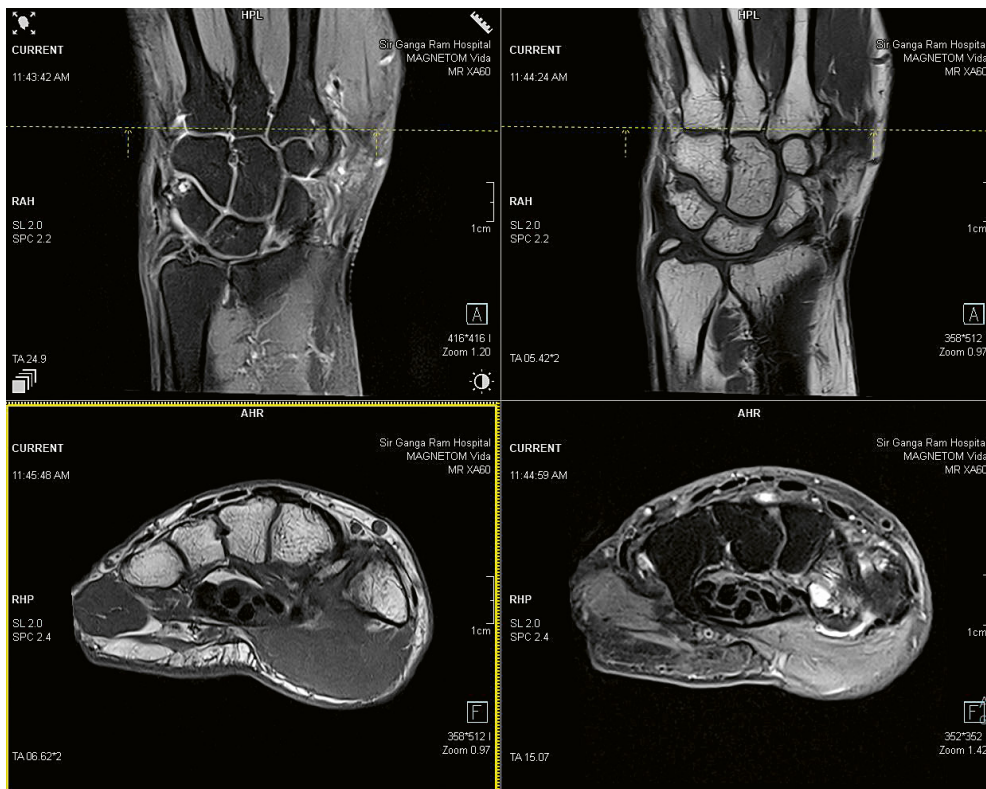
Routine deep learning reconstruction protocols vs. ultra-fast 2-minute protocols on the MAGNETOM Vida

Comparing the routine deep learning protocols with ultra-fast 2-minute protocols produced compelling results. Although the ultra-fast protocols were designed with aggressive SMS acceleration factors, they maintained a surprisingly high level of diagnostic integrity. There was only a marginal difference in image sharpness and noise. Importantly, there was also no significant loss in the ability to interpret clinical findings accurately (Figs. 1–10).

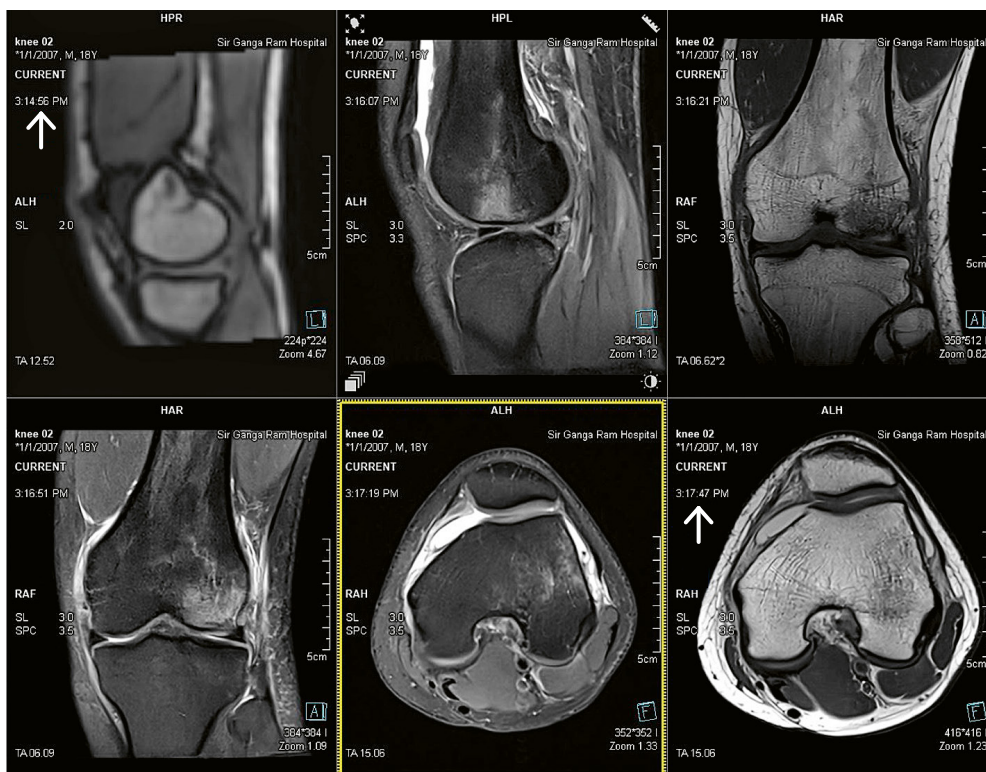
These 2-minute protocols offer a strategic advantage in real-world clinical settings. For instance, they are highly beneficial for imaging pediatric¹ and elderly patients, two

groups who often struggle with long MR scan times (Fig.11). Similarly, claustrophobic individuals can benefit from dramatically shortened scan durations (Fig. 12). Perhaps most critically, these protocols open up the possibility of avoiding general anesthesia or sedation in patients who would otherwise require it to undergo MRI (Fig 13). In high-throughput or emergency settings, where scan time is often a bottleneck, ultra-fast protocols enabled by Deep Resolve provide a game-changing opportunity to increase patient turnover without sacrificing diagnostic quality. These use cases strongly position 2-minute protocols not merely as a backup, but also as a primary option for specific patient populations and workflow scenarios.

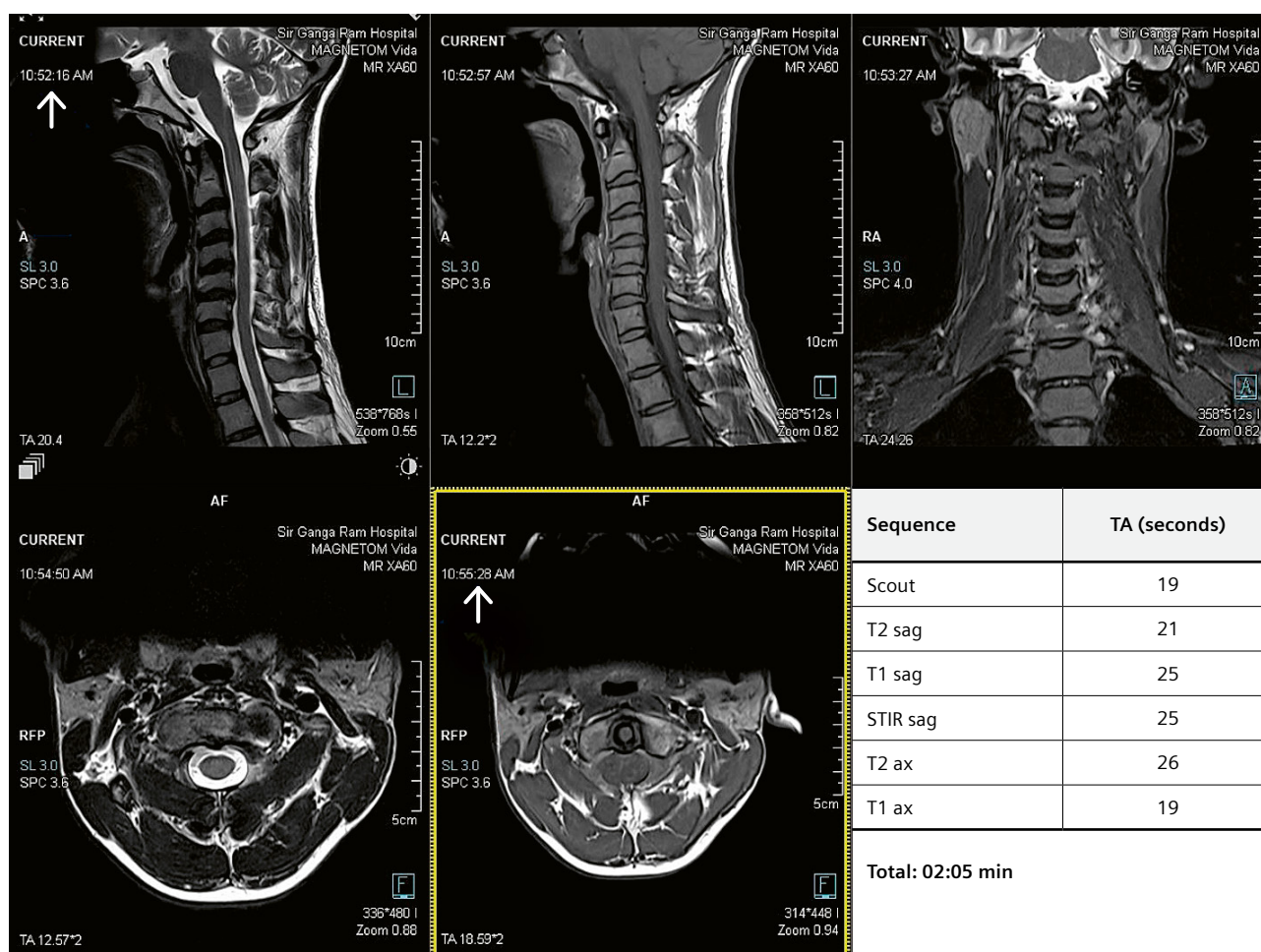
¹MR scanning has not been established as safe for imaging fetuses and infants less than two years of age. The responsible physician must evaluate the benefits of the MR examination compared to those of other imaging procedures.



- 11** A wrist MR scan of a 53-year-old patient, done in under three minutes. Longer scan times often result in motion.



- 12** A knee MR scan of a claustrophobic patient. The white arrow shows the first localizer acquisition time at 03:14:56 p.m., with a scan time of 12 seconds, followed by a Pd_fs_sag of 7 seconds, a T1 cor of 13 seconds, a Pd_fs_cor of 7 seconds, a Pd_fs_tra of 16 seconds, and a PD_tra of 16 seconds. The knee exam was completed at 03:17:47 p.m., meaning it took less than three minutes. A 3-minute knee scan was previously a dream wish in clinical practice.



13 A cervical spine scan done in under three minutes, with a highly uncooperative patient. The white arrow shows the clock time stamp from the console. TA for T2 sag was 21 seconds, T1 sag was 25 seconds, Stir Cor was 25 seconds, T2 axial was 26 seconds, T1 axial was 19 seconds, and the localizer was 19 seconds. This makes a total scan time of just 2 minutes 5 seconds.

Conclusion

This study highlights the advantages of the Deep Resolve technique on 3T MAGNETOM Vida over the conventional acceleration methods on 3T MAGNETOM Verio. The combination of four distinct features (Deep Resolve Boost + Deep Resolve Sharp + Simultaneous Multi-Slice + GRAPPA) in the ultra-fast protocols can potentially transform MR

imaging with less need for sedation and with the possibility of scanning uncooperative patients.

Acknowledgments

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References

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