MR/Clinical Case Study

High-resolution MSK MRI with Advanced intelligent Clear-IQ Engine (AiCE) Deep Learning Reconstruction (DLR) and Compressed SPEEDER (CS)



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Introduction

For musculoskeletal (MSK) MRI, high Signal-to-Noise Ratio (SNR) and spatial resolution are desired to accurately assess fine pathological details. High-resolution MRI requires high-frequency k-space data to be collected, lengthening scan time. The extra scan time is required not only to acquire high-frequency data but also to compensate for SNR reduction due to smaller voxel size associated with high-resolution MRI.

The scan time and SNR tradeoffs inherent to high-resolution MRI can be alleviated with the introduction of Advanced intelligent Clear-IQ Engine (AiCE), the world's first 510(k)-cleared, fully integrated Deep Learning-based Reconstruction (DLR) technology for MR. AiCE DLR is seamlessly integrated into the MR reconstruction pipeline to effectively remove noise from MR images, thereby improving SNR. Through the denoising process, image quality and SNR gain could provide clinicians flexibility in scan parameters, improving resolution and shortening scan times when used in combination with one of Canon's accelerated scanning features.

Compressed SPEEDER (CS) is an accelerated MRI technique that can speed up the MRI acquisition by applying the compressed sensing theory into MRI acquisition and reconstruction. To accelerate scan time, the data is partially collected in a pseudo-random fashion. The under-sampled data then undergoes a non-linear iterative reconstruction, in which data consistency is enforced at each iteration while sparsity is promoted in the wavelet-transformed domain. As a result, the reconstructed images are free of aliasing artifacts.

In this case study, we demonstrate that AiCE, in combination with Compressed SPEEDER, allows acquisition of high-resolution MSK MRI in clinically relevant scan times, which in turn improves visualization of pathologies that otherwise might be difficult to detect.

Images were acquired using a Canon's Vantage Galan 3T MRI scanner.

Case 1: Shoulder MRI

Chief Complaint: Right shoulder pain persisting for more than one year and adhesive capsulitis clinically.

Findings: A small amount of fluid is present within the subacromial-subdeltoid bursa, consistent with mild bursitis (medial arrow, coronal image). The supraspinatus tendon demonstrates mild bursal-sided fraying (lateral arrow, coronal image), without significant tendon tear. The glenoid labrum is intact. The coracohumeral ligament is thickened with infiltration of the rotator interval fat, a finding consistent with adhesive capsulitis (arrow, oblique sagittal image).

Discussion: With AiCE, the expected decrease in signal-to-noise ratio associated with thin-slice acquisition was effectively mitigated, allowing clearer depiction of the bursal surface of the supraspinatus tendon as well as improved characterization of the coracohumeral ligament. As a result, the subtle bursal-sided fraying of the supraspinatus tendon and the thickening of the coracohumeral ligament and rotator interval fibrosis were clearly delineated, providing imaging-based evidence supporting the clinical diagnosis of adhesive capsulitis.

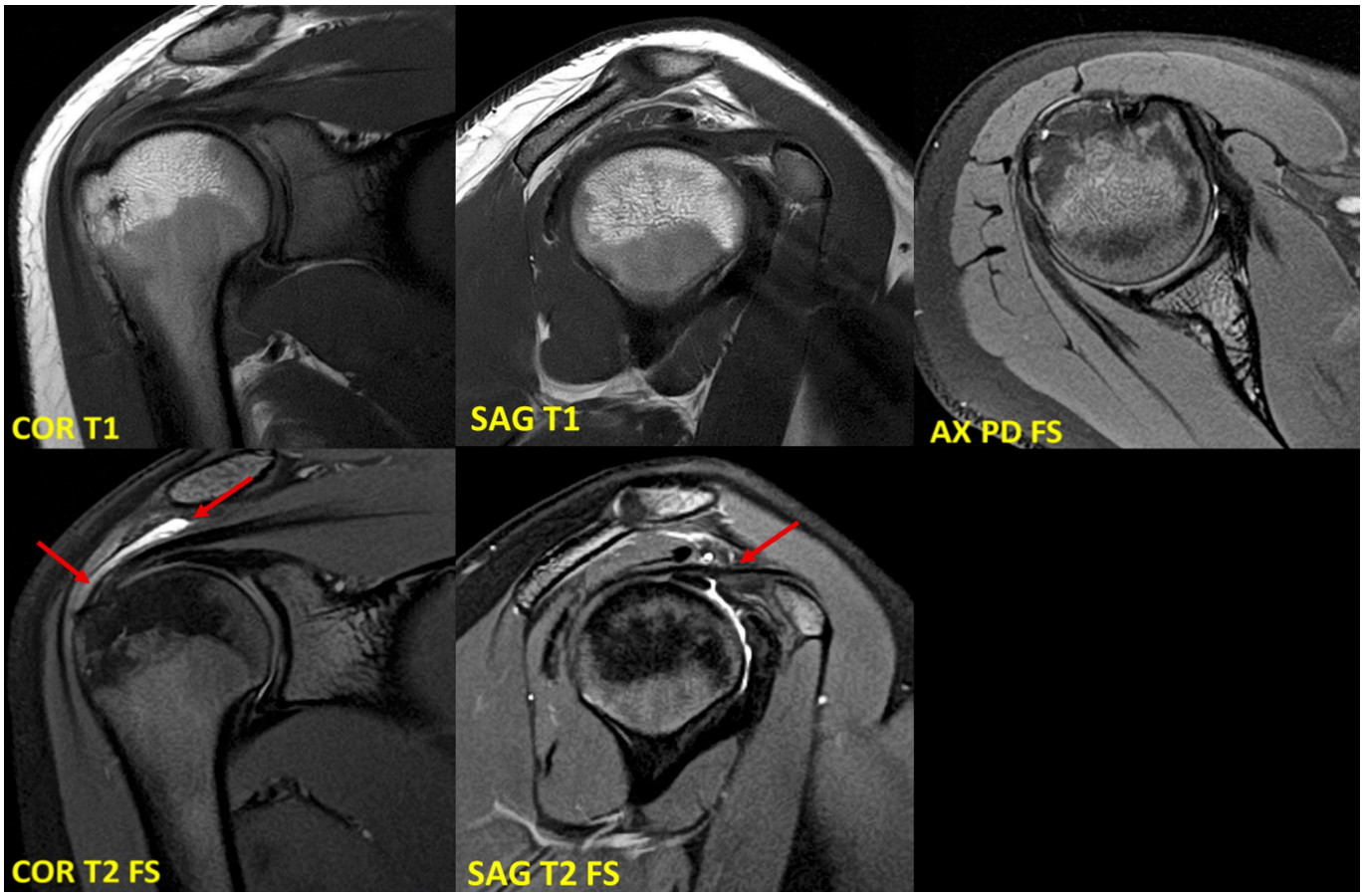


Figure 1: Right shoulder images of a patient with persisting pain and adhesive capsulitis. Coronal images show fluid within subaromial-subdeltoid bursa (medial arrow) and mild bursal-sided fraying (lateral arrow). Sagittal images reveal infiltration of the rotator interval fat (arrow), which is consistent with adhesive capsulitis (arrow, oblique sagittal image).

Case 2: Knee MRI

Chief Complaint: Left knee pain and instability following a skiing injury.

Findings: The anterior cruciate ligament shows disruption of fiber continuity near its femoral attachment, consistent with a complete tear (arrow, sagittal image). The posterior cruciate ligament is intact. Along the weight-bearing surface of the lateral femoral condyle, bone marrow edema is present together with a linear low-signal-intensity line approximately 6 mm in anteroposterior length, consistent with a nondisplaced subchondral fracture (lower arrow, coronal image). There is also a tear of the adjacent anterolateral ligament (upper arrow, coronal image). Joint alignment is preserved, and a small joint effusion is noted.

Discussion: Noise reduction with AiCE preserved the contrast of the linear fracture line, which would otherwise have been obscured against the high-signal background of the surrounding bone marrow edema, thereby enabling confident diagnosis of this subtle subchondral fracture. Submillimeter-resolution imaging, which conventionally required prolonged acquisition times, was obtained within a clinically practical scan time with AiCE and Compressed SPEEDER. The ability to evaluate both the morphology of the anterior cruciate ligament tear and the subchondral fracture line at high spatial resolution within a single examination directly contributed to treatment decision-making.

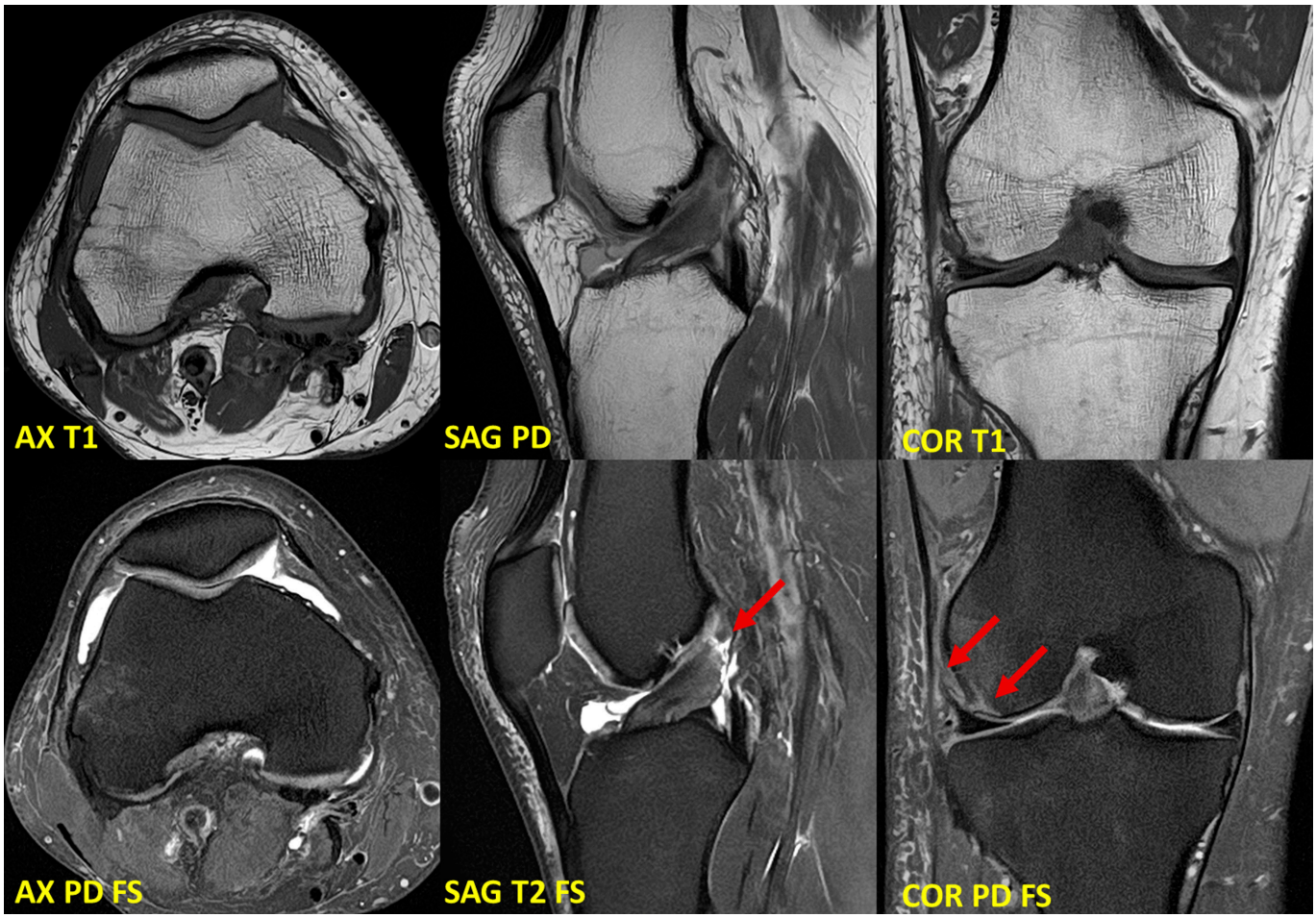


Figure 2: Left knee images of a patient with knee pain and instability following a skiing injury. Sagittal images show disruption of fiber continuity near its femoral attachment (arrow). Coronal images show a nondisplaced subchondral fracture (lower arrow) and a tear of the adjacent anterolateral ligament (upper arrow).

Case 3: Ankle MRI

Chief Complaint: Chronic pain in the posterolateral aspect of the left ankle. The patient had a known history of a fracture of the lateral tubercle of the posterior process of the talus, and the pain had persisted despite six months of physical therapy.

Findings: At the healing fracture site of the lateral tubercle of the posterior process of the talus, persistent bone marrow edema is noted (upper arrow, sagittal image). Immediately beneath this site, the articular cartilage shows surface irregularity (lower arrow, sagittal image). In addition, a longitudinal split tear of the peroneus longus tendon is identified distal to the peroneal tubercle (arrow, axial and coronal images).

Discussion: This case most clearly illustrates the clinical benefit of AiCE. Evaluation of small structures such as the posterior process of the talus and the articular cartilage of the posterior subtalar joint is inherently challenging. A high-resolution image is desired for this purpose but has been limited by the trade-off between signal-to-noise ratio and acquisition time. With AiCE and Compressed SPEEDER, submillimeter resolution imaging was obtained within a clinically practical scan time, enabling detection and confident diagnosis of the subtle cartilage irregularity located directly beneath the lateral tubercle of the posterior process of the talus. Furthermore, the high-resolution data clearly demonstrated the longitudinal split tear of the peroneus longus tendon in the axial and coronal planes, allowing comprehensive assessment of multiple sources of chronic posterolateral ankle pain.

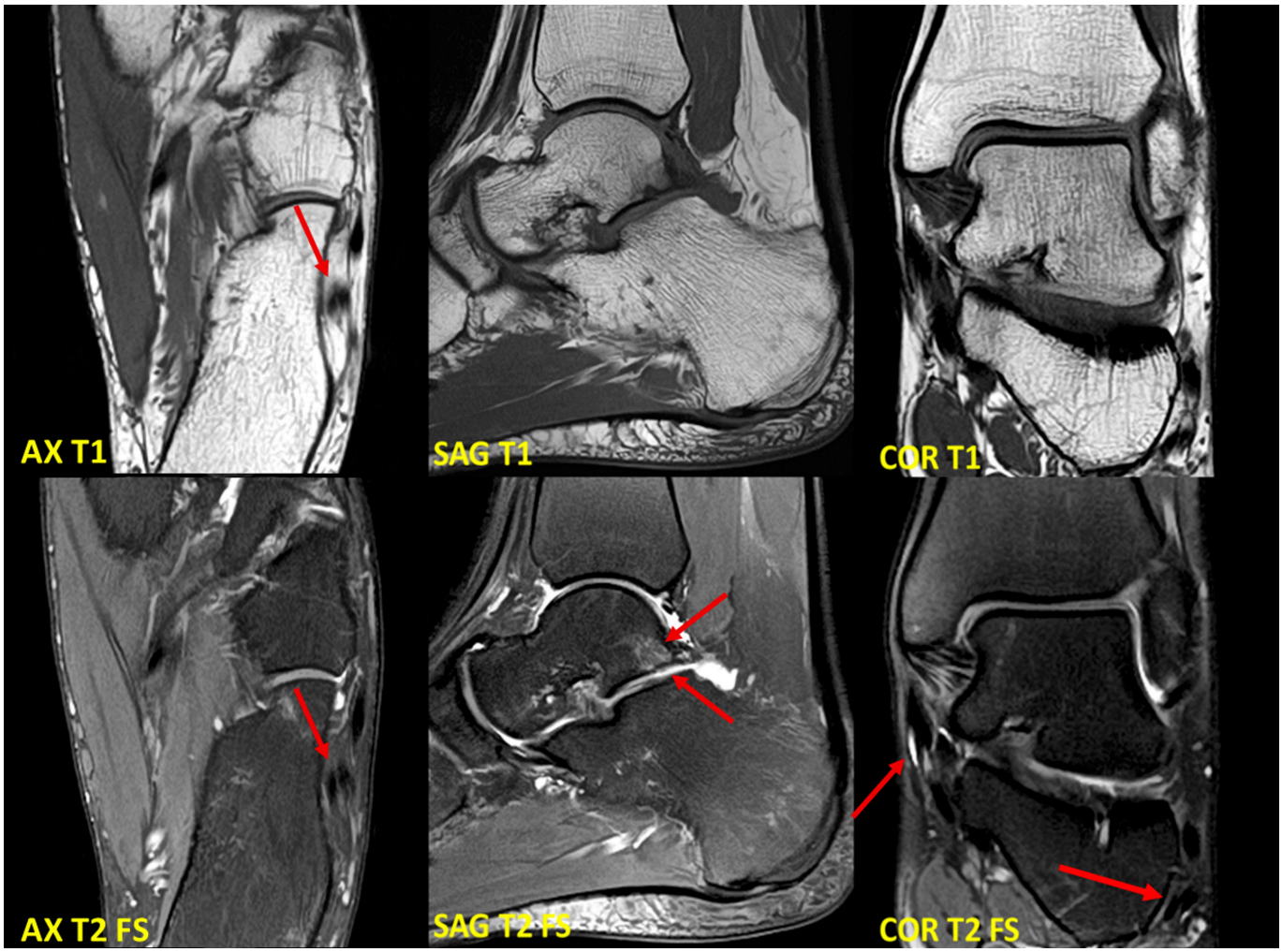


Figure 3: Images of a patient with chronic pain in the posterolateral aspect of the left ankle. Axial images show a longitudinal split tear of the peroneus longus tendon distal to the peroneal tubercle (arrows). Sagittal images show a persistent bone marrow edema (upper arrow) and surface irregularity of articular cartilage (lower arrow).

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AiCE provides higher SNR compared to typical low pass filters.

The clinical results, performance and views described in this paper are based upon the experience of the authors. Results may vary due to clinical setting, patient presentation and other factors.

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