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Spine imaging in the decubitus position

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Access to MR exams has become increasingly limited due to the rising demand for diagnostic MR. At many institutions, MR appointments are booked many weeks or more in advance, underscoring the need to optimize scanner utilization.

In particular, MR imaging of the spine can be challenging. Interviews have revealed that many patients find lying supine on a rigid spine coil for extended periods extremely uncomfortable. This discomfort often leads to excessive motion, degrading image quality and necessitating repeat scans, which reduces clinical workflow efficiency. Our technologists attempt to make the patient comfortable, incorporating pillows, cushions or adjustable supports to ease their discomfort and anxiety. Technologists may also eliminate non-critical sequences and reduce imaging time wherever possible (e.g., reducing slices, parallel imaging). In some cases, the supine position is intolerable, resulting in cancelled exams and unused gaps in the limited scanner schedule. In some cases, the MR examination may need to be rescheduled with sedation.

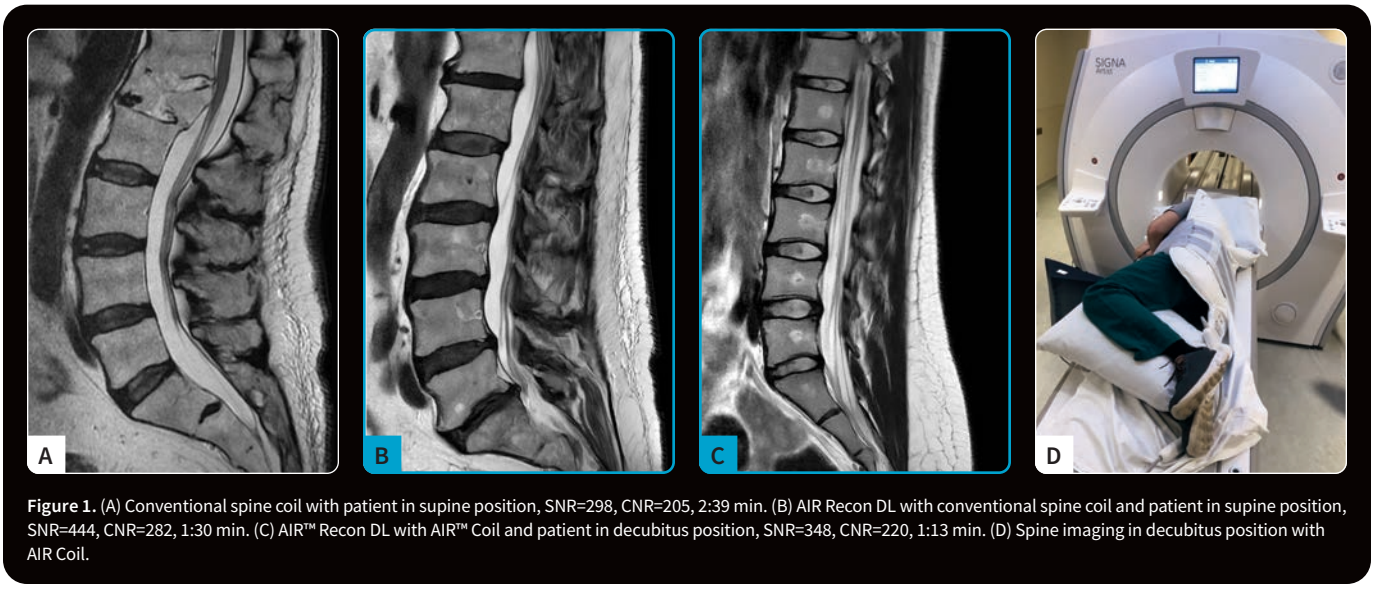

Figure 1. (A) Conventional spine coil with patient in supine position, SNR=298, CNR=205, 2:39 min. (B) AIR Recon DL with conventional spine coil and patient in supine position, SNR=444, CNR=282, 1:30 min. (C) AIR™ Recon DL with AIR™ Coil and patient in decubitus position, SNR=348, CNR=220, 1:13 min. (D) Spine imaging in decubitus position with AIR Coil.

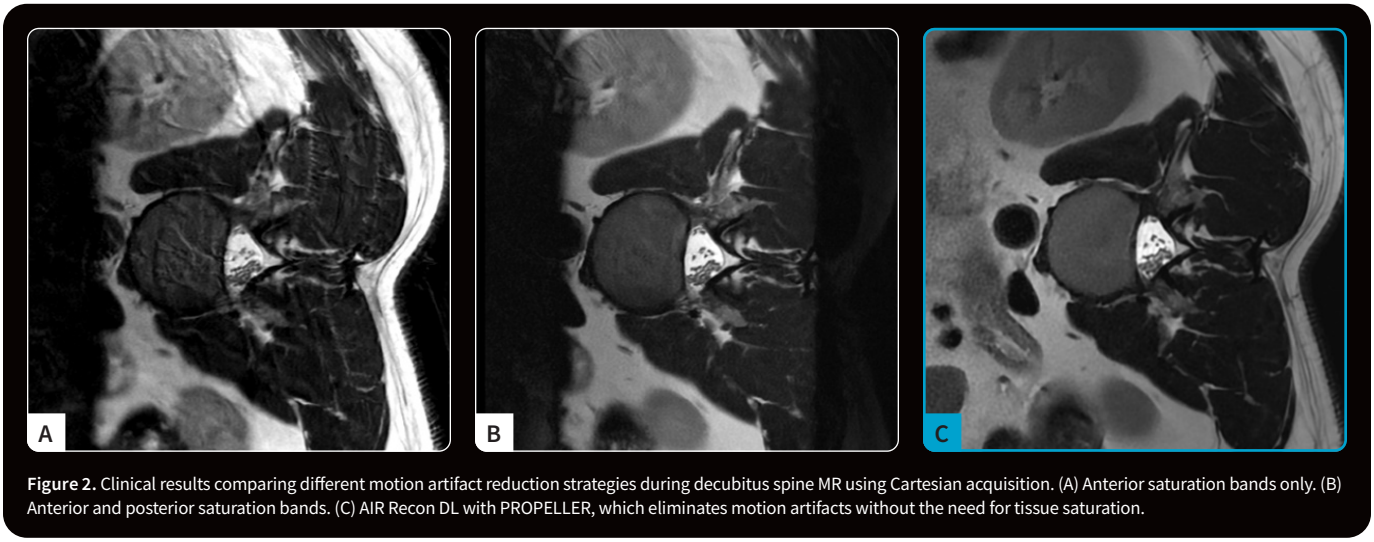

Figure 2. Clinical results comparing different motion artifact reduction strategies during decubitus spine MR using Cartesian acquisition. (A) Anterior saturation bands only. (B) Anterior and posterior saturation bands. (C) AIR Recon DL with PROPELLER, which eliminates motion artifacts without the need for tissue saturation.

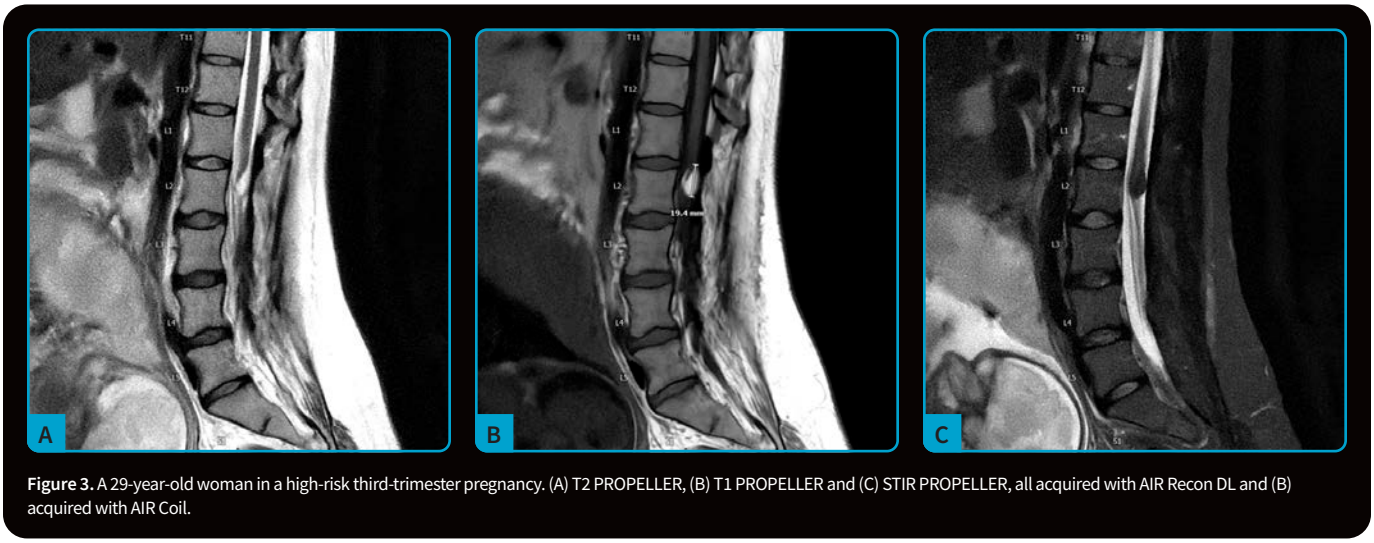

Figure 3. A 29-year-old woman in a high-risk third-trimester pregnancy. (A) T2 PROPELLER, (B) T1 PROPELLER and (C) STIR PROPELLER, all acquired with AIR Recon DL and (B) acquired with AIR Coil.

As an effort to use our scheduled MR slots more efficiently, we initiated a quality improvement project aimed at reducing the number of cancelled spine exams. Prior to starting the quality improvement project, we tracked the number of MR exams that were cancelled. During a three-month period, we identified 77 spine MR exams that were cancelled due to pain or discomfort. Therefore, we began exploring alternative strategies to mitigate patient discomfort while ensuring we are collecting all sequences necessary for diagnosis.

A decubitus spine imaging protocol offers a more comfortable alternative for patients who cannot tolerate supine positioning. However, this approach also introduces unique technical challenges. First, traditional spine coils are embedded in the table, making them impractical for decubitus imaging, as the spine is no longer positioned directly over the coil. The flexible, blanket-like nature of AIR Coils addresses this issue by comfortably conforming to the decubitus patient's body to provide excellent SNR and enable high acceleration rates during imaging (Figure 1).

Patient motion is a second concern in the decubitus position, as patients can more easily shift or rotate. To reduce this, we employ compression bands and padding for stabilization. We also investigated several strategies for minimizing motion artifacts. Using standard Cartesian pulse sequences, we tried using saturation bands to suppress ghosting caused by the movement of bright peripheral fat. A single anterior saturation band, typical of supine spine MR, was insufficient because motion is equally likely in the posterior direction since there is no spine board to restrict motion like in supine imaging. Additionally, since the posterior fat has higher signal intensity than the anterior due to its proximity to the AIR Coils, we found using both an anterior and posterior saturation were necessary to robustly reduce motion artifacts. However, these saturation bands also eliminate signal from surrounding tissues, potentially obscuring findings in these areas. The extra saturation bands also increase SAR, which can already be problematic for this patient population where spinal hardware is common.

PROPELLER imaging is an alternative which is inherently insensitive to motion artifacts. The challenge in PROPELLER

imaging is that the longer acquisition time can be challenging for patients in discomfort. AIR Recon DL complements PROPELLER by significantly accelerating imaging scan times while maintaining image quality. Our radiologists preferred PROPELLER images because the saturation bands in Cartesian pulse sequences could obscure pathology, whereas PROPELLER would image the full FOV. By combining AIR Coils and AIR Recon DL PROPELLER, we have developed a robust decubitus spine MR protocol that enhances patient comfort while minimizing motion-artifacts.

Clinical results

We compared different motion artifact reduction strategies during decubitus spine MR using Cartesian acquisition. Figure 2A, anterior saturation bands alone left residual motion artifact from posterior peripheral fat. Figure 2B, adding both anterior and posterior saturation bands reduced motion artifacts but increased SAR and scan time, while obscuring potential underlying pathology in the saturated tissues. Figure 2C, AIR Recon DL with PROPELLER imaging, inherently motion-insensitive, eliminated motion artifacts without the need for tissue saturation.

Figure 4. A 75-year-old female with a history of COPD, hypertension, prior spinal fusions and lung cancer presented after a fall. (A-C) Prior imaging with spine coil and supine protocol, (A) sagittal STIR, (B) sagittal T2 and (C) sagittal T1. (D-F) AIR Coil with AIR Recon DL and decubitus protocol, (D) sagittal STIR, (E) sagittal T2 and (F) sagittal T1.

Case 1

Non-contrast intradural lumbar spine MR of a 29-year-old woman in a high-risk third-trimester pregnancy. The patient was undergoing evaluation for spina bifida repair surgery. The patient refused standard supine positioning due to discomfort from pregnancy but was able to tolerate decubitus positioning (Figure 3).

The exam revealed a 0.8 x 1.0 x 2.0 cm hyperintense lesion on both T1- and T2-weighted images, involving the spinal cord and cauda equina, dorsally extending from the conus. Post-surgical changes, including spinal cord detethering and a spina bifida repair with laminectomy at L5, were evident. The conus medullaris terminated at L2, with an associated lipoma measuring up to 2.0 cm.

Case 2

A 75-year-old female with a history of COPD, hypertension, prior spinal fusions and lung cancer presented after a fall, reporting diffuse musculoskeletal pain and distal upper extremity weakness. Supine protocol was refused due to discomfort. Decubitus MR protocol revealed a 3-column T8 vertebral fracture with 33% height loss, along with chronic T3 compression and cervical spine degenerative changes, but no spinal cord compression (Figure 4).

Discussion

In today's world of limited MR access, hospitals need solutions that shorten scan times, reduce rescans and provide additional scan slots for patients. After our recent upgrade, we accelerated our routine lumbar spine with/without gadolinium protocol using AIR Recon DL from 20:14 minutes to 13:21 minutes.

The flexible positioning of AIR Coils in decubitus orientation, combined with the motion robustness of PROPELLER and the acquisition speed afforded by AIR Recon DL, has allowed us to develop a non-sedated decubitus spine protocol for patients who cannot tolerate supine positioning in a comparable scan time of 14:47 minutes. As a result, we are obtaining rapid, high-quality scans with few artifacts in a challenging patient population. These technologies have helped us to reduce the need for repeat imaging and have made our workflow more efficient.

We are currently rolling out this protocol to our technologists to make them aware that this is a new optional protocol for patients where motion/pain is an issue. Over time, we may consider using a PROPELLER sequence as the default acquisition, especially in the axial plane where we see the most motion artifacts.