MRI near Metallic Implants using a MAVRIC-SEMAC Hybrid at 3T

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INTRODUCTION: Metallic implants are routinely used in orthopedic surgery. However, MR imaging of symptomatic patients with orthopedic hardware is often severely limited by susceptibility artifacts, particularly at higher field strengths. Two MR methods have recently been introduced to reduce these artifacts: Slice Encoding for Metal Artifact Correction (SEMAC) [1] and Multi-Acquisition Variable Resonance Image Combination (MAVRIC) [2]. We describe our initial clinical experience with Hybrid [3] at 3T, a novel MR sequence that utilizes strengths of both SEMAC and MAVRIC techniques, in patients with metallic implants.

METHODS: A total of 11 patients (ages 22-74) with 12 metal implants (4 hip replacements, 3, dynamic hip screws, 1 femoral neck pin, 1 femoral rod, 2 spinal instrumentations, 1 ACL reconstructed knee) were imaged on a 3T scanner (MR750, GE). Conventional 2D FSE and Hybrid sequences were acquired with proton density and inversion recovery (IR) contrast using similar scan parameters, and a readout bandwidth of BW±125kHz. The acquisition matrix and resolution varied by anatomic location. Scan times were 3 – 5 minutes for 2D FSE compared with 8 – 10 minutes for PD Hybrid and 12 minutes for IR Hybrid. Hybrid images were acquired using 22 2.25kHz spectral bins separated by 1 kHz and were reconstructed using bin-overlap deblurring [3] followed by sum-of-squares combination of the spectral bins. Hybrid images were compared with 2D-FSE by 2 experienced MSK radiologists for extent of in-plane and through plane metal artifact, visualization of bone-implant interface, visualization of surrounding soft tissues, blurring and overall image quality using a 5-point scale (much worse; somewhat worse; no difference; somewhat better; much better). The ratings of the 2 readers in were compared and analyzed using a two-tailed paired Wilcoxon test. The maximal artifact penumbra size was also measured for each implant. Subsequent changes in management, such as surgery or follow-up, were recorded for each patient. All statistical analyses were performed with Stata release 9.2 (Stata Corp., College Station, Texas).

RESULTS: Less in-plane (p=0.0024) and through-plane artifact (p=0.0024) was seen on Hybrid images for all 12 implants, allowing better visualization of the bone-implant interface (p=0.0024) and surrounding soft tissues (p=0.0036) (Figures 1-3). Blurring was slightly worse on Hybrid (p=0.02). Hybrid images also show slightly different IR contrast than 2D-FSE IR, which is result of the spectral bin combination process. Despite these limitations, overall image quality was much better with Hybrid (p=0.0024). Inter-observer agreement was high, with a kappa score of 0.96. The use of Hybrid decreased the penumbra size by a mean of 41% compared to 2D FSE; the decrease in penumbra size was most marked in the hip. In 4 of 12 implants, findings on Hybrid images that were either not visible or mistaken for artifacts on 2D FSE images resulted in surgical interventions, with significant improvement in pain. Hybrid also ruled out the need for surgical intervention in 7 cases. In the patient with an ACL reconstruction, the relevant pathology was seen with both sequences.

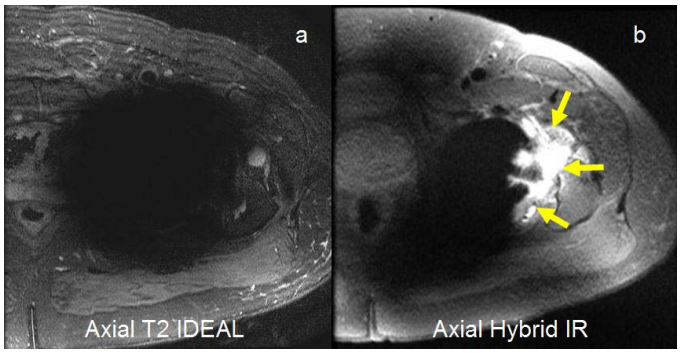

Figure 1: (a, b) Axial MR images in a 64 year old man with bilateral hip replacements and chronic hip pain demonstrate a large hip effusion, only clearly seen on Hybrid (arrows). The patient was subsequently managed conservatively.

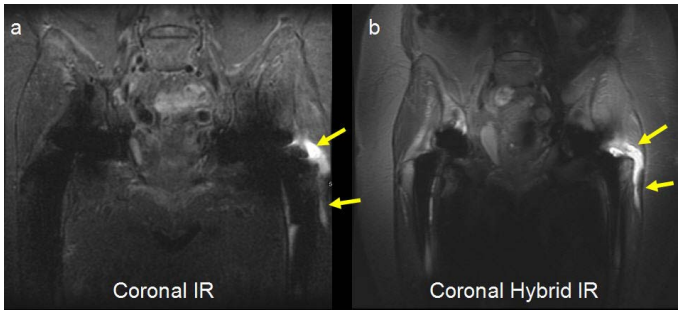

Figure 2: (a, b) Coronal MR images in a 74 year old woman with bilateral total hip arthroplasties presenting with left hip pain. A large fluid collection is seen in the left trochanteric bursa in both (arrows) but significantly less metallic artifact is seen on Hybrid.

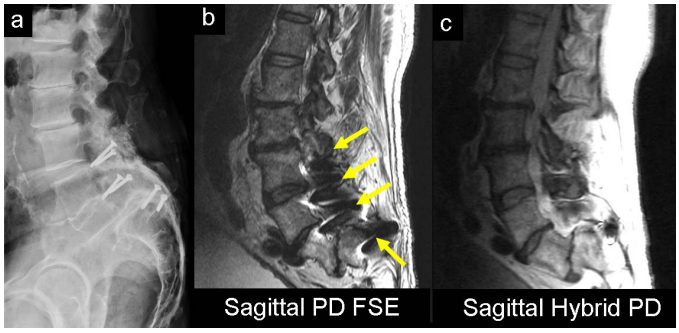

Figure 3: (a) Lateral xray and (b, c) Sagittal MR images in a 73 year old man with 3-level spinal fusion for grade III isthmic spondylolisthesis of L5 on S1 presenting with low back pain for 1 week. Prominent through plane artifact is seen on PD FSE (arrows). No significant neural compromise was seen and the patient was treated conservatively.

DISCUSSION: Imaging around metal implants with Hybrid resulted in a dramatic decrease in image artifacts compared to conventional 2D FSE, allowing improved visualization of tissues around the implant. Disadvantages of Hybrid include slightly longer scan times and blurring. The in-plane resolution of Hybrid is worse than conventional 2D FSE, in order to limit scan time, which may be perceived as blurring. Hybrid is also based on a 3D FSE acquisition with a longer echo train resulting in blurring. Despite these limitations, overall diagnostic image quality was significantly better with Hybrid. Further investigations will seek to improve the scan time, resolution, and IR performance of Hybrid at 3T.

CONCLUSION: This study shows that Hybrid at 3T reduces artifacts, improves visualization of interfaces and soft tissues at some cost of blurring. Our overall experience suggests that Hybrid can play a key role in the management of patients with metal implants.

REFERENCES: [1] Lu, MRM 2009; 62:66076. [2] Koch, MRM 2009; 61:381-90. [3] Koch, MRM 2011; 65:71–82. **Research Support:** GE Healthcare.