Slice Encoding for Metal Artifact Correction (SEMAC) MRI: Initial Clinical Experience

+Gold, G1•2•3; Vasanawala, SS1; Braun, H1; Pyaul, KB1•2; Chen, CA1; Pyaul, JM1; Warters, P1; Goodman, SB2; Hargreaves, BA1.

1 Radiology, Orthopedic Surgery, Bioengineering, Electrical Engineering, Stanford University, CA USA
gold@stanford.edu

Introduction: Metallic implants are increasingly common in our aging population, including joint replacement, fracture fixation, or complex reconstruction after tumor resection. These implants are typically evaluated by x-ray or CT with limited soft tissue contrast. Recently, two methods were introduced to reduce artifacts from MR images near metal implants - Slice Encoding for Metal Artifact Correction (SEMAC) [1] and Multi-Acquisition Variable Resonance Image Combination (MAVRIC) [2]. Here we describe our initial clinical experience comparing SEMAC with 2D-FSE in a diverse population of patients with metallic implants.

Methods: A total of 29 patients (age 35-68) with metallic implants (Table 1) were imaged on 1.5T GE scanners using a combination of SEMAC and 2D-FSE, with and without inversion-recovery for fat suppression. Imaging was performed with 2D-FSE optimized for imaging around metal using a ± 125 kHz bandwidth with T1-weighted, proton-density weighted, and inversion-recovery contrast. SEMAC was performed with similar resolution and contrast, and multi-channel coils were used in all subjects. To reduce imaging time, SEMAC used parallel imaging (R=2) and half-Fourier acquisition [3]. We reconstructed the SEMAC images using a sum-of-squares combination [2].

On the central slice through the implant, we measured the area of a region of interest that encompassed the implant and surrounding artifact with OsiriX. Two fellowship-trained radiologists compared the SEMAC images with the 2D-FSE images for artifacts, blurring, and bone/implant interface visibility on a nine-point scale (-4 for 2D-FSE much better than SEMAC; 0 for equal; +4 for SEMAC much better than 2D-FSE). Ratings were analyzed with a Wilcoxon signed rank test. Changes in management after imaging of the patients such as surgery or follow-up were recorded.

Results: Bland and Altman analysis of artifact area showed that SEMAC had a significantly smaller artifact area than 2D-FSE (correlation 0.7; R² = 0.545, p < .003). Qualitative image grades showed a significant decrease in artifact and improved visibility of the bone/implant interface (3.6 ± 0.6; p < .01) on the SEMAC images compared with 2D-FSE. 2D-FSE images showed slightly less blurring than SEMAC (-0.8 ± 0.7; p < .01). Representative changes in patient management as a result of the SEMAC images are shown in Table 1. Findings on the SEMAC images that were not visible or mistaken for artifacts on 2D-FSE images resulted in surgery, biopsy, or joint aspiration. One subject who was referred after 2D-FSE failed to visualize the tumor bed showed a recurrence with SEMAC and had limb-sparing surgery. Another subject (Figure 1) with a painful total knee replacement was diagnosed with a tibia stress reaction. Measurements of the epicondylar axis (to confirm proper alignment of the implant) for all of the painful total knee replacements were done using SEMAC.

Conclusion: Imaging around metallic implants with SEMAC showed considerable reduction of image artifacts. Our initial experience shows that SEMAC is a valuable imaging method that significantly contributes to clinical management of symptomatic patients with metal implants.

<table>
<thead>
<tr>
<th>Subject Population (number)</th>
<th>Imaging findings and change in management</th>
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</thead>
<tbody>
<tr>
<td>Painful total knee replacements</td>
<td>Patella tendon tear on MRI confirmed at surgery; Epicondylar axis for alignment</td>
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<tr>
<td>Cancer follow-up</td>
<td>Tumor seen on imaging; confirmed at surgery or sent to biopsy. No tumor seen: stable for follow-up</td>
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<tr>
<td>Painful total hip replacements</td>
<td>Fluid detected at imaging; hip aspiration performed to exclude infection</td>
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<tr>
<td>Painful elbow after biceps tendon repair</td>
<td>Failed biceps repair detected at metal insertion anchor; confirmed at surgery</td>
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<tr>
<td>Neck pain following spine fusion</td>
<td>No recurrent disc pathology on imaging; clinical follow up</td>
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Table 1: Representative changes in patient management

![Sagittal 2D-FSE](image1)

![Sagittal SEMAC](image2)

![Coronal IR FSE](image3)

![Coronal IR SEMAC](image4)

Figure 1: Sagittal and coronal 2D-FSE and SEMAC images in a patient with a painful total knee replacement. Decreased artifact is seen on the SEMAC images (arrows). Bone marrow edema is seen on the SEMAC IR image under the medial tibial component, indicating a stress reaction (dashed arrow).

References:

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