MRI near Metallic Implants using SEMAC: Initial Clinical Experience

G. E. Gold[1], S. S. Vasanawala[2], W. Lu[3], C. A. Chen[2], W. Chen[4], J. M. Pauly[5], K. Butts Pauly[2], S. B. Goodman[6], and B. A. Hargreaves[2]
[1]Radiology, Bioengineering, Orthopaedic Surgery, Stanford University, Stanford, CA, United States, [2]Radiology, Stanford University, Stanford, CA, United States, [3]Electrical and Electronic Engineering, Nanyang Tech., Singapore, [4]Applied Science Laboratory, GE Healthcare, Menlo Park, CA, United States, [5]Electrical Engineering, Stanford University, Stanford, CA, United States, [6]Orthopaedic Surgery, Stanford University, Stanford, CA, United States

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 14 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 $\pm$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 artfact 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: Analysis of artifact area (Figure 1) showed that SEMAC had a significantly smaller artifact area than 2D-FSE ($p < .003$). Qualitative imaging grading showed a significant decrease in artifact and improved visibility of the bone/implant interface (3.6 $\pm$ 0.6; $p < .01$) on the SEMAC images compared with 2D-FSE. 2D-FSE images showed slightly less blurring than SEMAC (-0.8 $\pm$ 0.7; $p < .01$). Changes in patient management as a result of the SEMAC images are shown in Table 1. In six of the fourteen cases, 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 2) was sent to biopsy. Two subjects with fluid near total hip replacements were aspirated, and two tendon ruptures were diagnosed prior to surgery with SEMAC. Measurement of the epicondylar axis (to confirm proper alignment of the implant) for all of the painful total knee replacements was done using SEMAC.

Subject Population (number)	Imaging findings and change in management
Painful total knee replacements (7)	Patella tendon tear on MRI confirmed at surgery (1); Epicondylar axis for alignment (7)
Cancer follow-up (3)	Tumor on imaging; confirmed at surgery (1); sent to biopsy (1); stable for follow-up (1)
Painful total hip replacement (2)	Fluid detected at imaging; hip aspiration performed to exclude infection (2)
Painful elbow after biceps tendon repair	Failed biceps repair detected at metal insertion anchor; confirmed at surgery
Neck pain following spine fusion	No recurrent disc pathology on imaging; clinical follow up

Table 1: Change in patient management as a result of SEMAC images

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.

References: [1] Lu W, et al. MRM 2009; 62:66–76. [2] Koch KM, et al. MRM 2009; 61:381–390. [3] Hargreaves BA, et al. ISMRM 2009 p.258.

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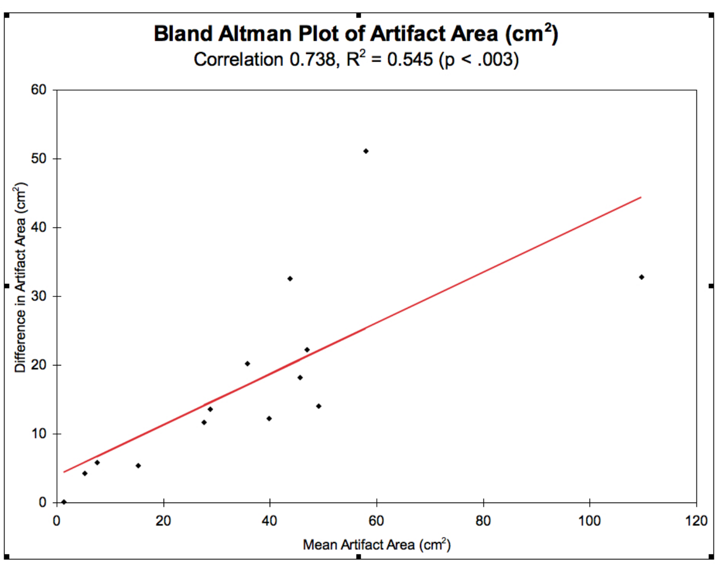

Figure 1: Bland Altman Plot of mean artifact area in cm^2 (x-axis) versus difference in artifact area (2D-FSE – SEMAC; y-axis). A strong correlation (0.738) was found, with $R^2 = 0.545$ ($p < .003$). SEMAC images showed consistently reduced artifact levels compared with 2D-FSE, regardless of implant size or composition.

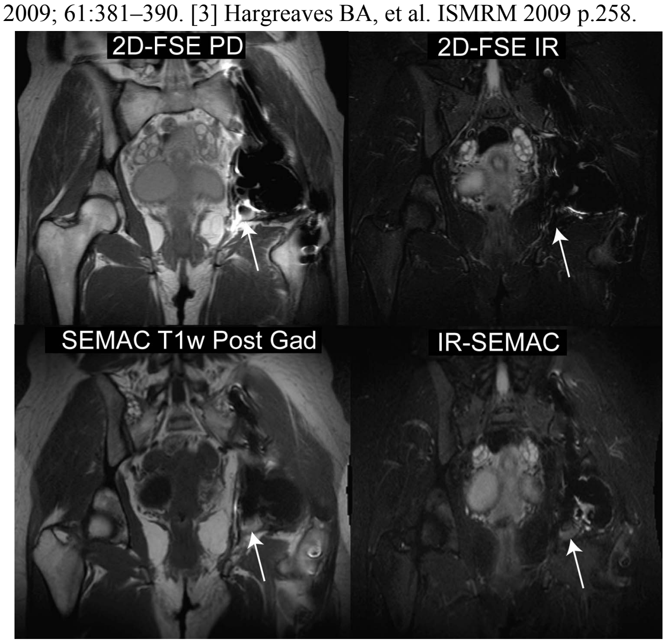

Figure 2: 35 year-old patient after resection and left total hip replacement for chondrosarcoma. The 2D-FSE PD and IR images show artifact inferior to the hip replacement (top row, arrows). In the same location on the SEMAC images, an area of enhancing tissue and bright signal is seen (bottom row, arrows). This area is suspicious for tumor recurrence.