Improved Frequency Selective Fat Suppression using Tissue Susceptibility Matched Pyrolytic Graphite Foams

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Introduction: Frequency selective fat suppression methods exploit the 3.5 ppm chemical shift between fat and water to suppress the fat signal in MRI. B_0 field homogeneity must be ~1 ppm for robust fat suppression. Unfortunately, the field homogeneity near the skin is typically ten times worse than 1 ppm (±5 ppm) due to air near the skin. Field shimming methods cannot reliably shim out the steep field patterns induced near certain parts of the body (e.g., breast, foot, or shoulder). Here we target more robust fat suppression using pyrolytic graphite foams (PG) for contrast-enhanced musculoskeletal, body, and brain MRI. We have previously demonstrated that the PG foams are nonconductive and do not heat, so are safe for patient use [1-2]. Here we demonstrate improved *in vivo* susceptibility matching in the hand and neck, improved frequency selective fat suppression and that the foams do not affect SNR.

Methods: Pyrolytic graphite (PG) foam cushions and phantoms (Figs. 1-2) were created by dispersing PG powder (4.0% by volume) into two-part polyurethane foams [1]. PG foam is magnetically isotropic and matches the susceptibility of water, fat, or tissue [1-3]. *In vivo* 3T field maps in the hand and head were acquired with/without PG cushions. Signal and noise measurements of water phantoms (N=15) with/without >3.5L of packed PG foam in a standard head coil were acquired with a standard gradient echo (GRE) sequence to test no SNR loss. 3T field maps were acquired with an automated IDEAL pulse sequence to verify susceptibility matching for air, water, and PG foams in oil/fat phantoms. 3T GRE images (256x256 matrix, FOV 22.4x22.4 cm^2, 3.75 mm thick TR/TE = 600/3.5 ms) with and without frequency selective fat suppression were compared for the same phantoms.

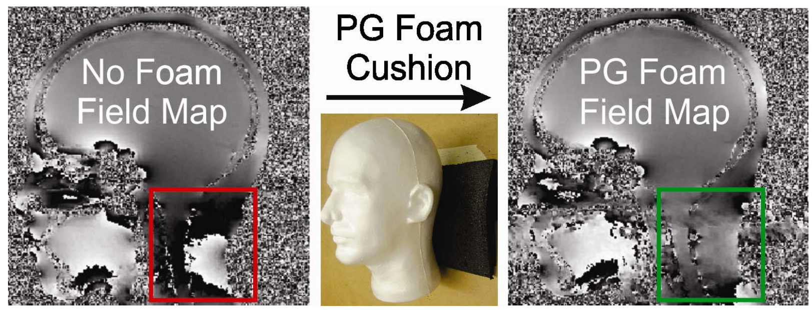

Figure 1: Qualitative 3T field maps of the head. Prototype molded PG foams shift the B_0 field inhomogeneity in the neck outside of the ROI.

Results: The PG foam cushions demonstrate significantly improved *in vivo* susceptibility matching and reduce inhomogeneities in the off-resonance field maps for both the hand and the neck (Figs. 1-2). The PG foam packed phantoms lead to virtually identical SNR to the unpacked phantoms, 101 ± 4.6 compared to 102 ± 4.8 (mean ± SD), indicating that no noise was added by the PG foams. Field maps (Fig. 3) show a classic dipole pattern of field gradients outside the air phantom, despite the auto-shims, while the water and PG foam blocks are well-matched with $|\Delta B_z|<1$ ppm. Figure 4 shows the regions of poor field homogeneity (from Fig. 3) in the air/fat phantoms lead to unsuccessful fat suppression, while the PG foams significantly improve the fat suppression.

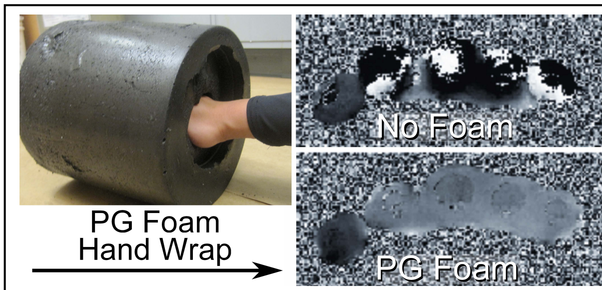

Figure 2: Qualitative 3T field maps of the hand. PG hand wraps dramatically reduce the field perturbations in the hand.

Discussion: PG foams demonstrate excellent susceptibility matching, produce no MRI signal, are safe for patient use, and compared to other potential fluid matching agents, are inexpensive, lightweight, and compatible with embedded RF coils. The foam also adds no extra noise to the receiver coil. In addition to improved susceptibility matching, we believe that PG foams could have many practical applications, such as improved frequency selective fat suppression for contrast-enhanced *in vivo* body, musculoskeletal, brain, or breast MRI or spectroscopy [4].

References: [1] G. Lee et al. JMRI 32:684-691 (2010). [3] J. Schenck. Med Phys 23:815-50 (1996). [3] Jelínek et al. Studia Geophysica et Geodaetica 22:50-62 (1978). [4] F. Sardanelli et al. Radiol Med 112:1244-1251 (2007).

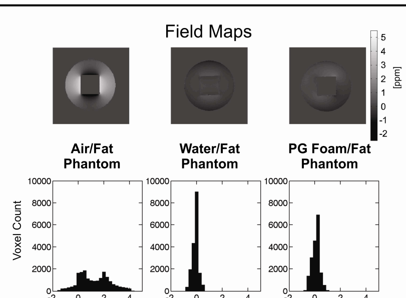

Figure 3: 3T off-resonance field map of air, water, and pyrolytic graphite (PG) foams in oil phantoms. PG foams show reduction in off-resonance effects down to ~1 ppm, relative to air at the material interface and thus improved susceptibility matching.

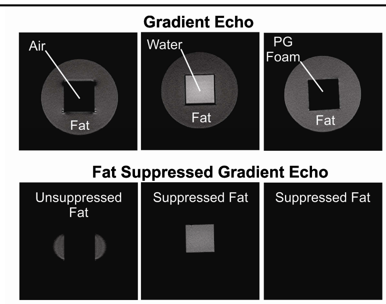

Figure 4: Qualitative 3T GRE images of the air, water, and PG foams in oil phantoms with and without chemical selective fat suppression. Fat suppression in the air/oil phantoms was unsuccessful in the regions with poor B_0 field homogeneity, but successful for the matched water and PG foam block phantoms.