SWIFT detection of SPIO labeled stem cells grafted in the myocardium

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Introduction Superparamagnetic iron-oxide (SPIO) labeling of stem cells allows their detection by MRI with high sensitivity via their T2* effect. Consequently, T2/T2* weighted GRE detection leads to negative contrast with low SNR and poor specificity because similar signal void would occur at tissue boundaries or in hemorrhagic region. A number of methods have been proposed to convert such negative contrast to positive one and have been applied to track SPIO labels in cardiovascular system (1, 2). Since the on-resonance water signal is suppressed (or not excited), a separate anatomical image is usually necessary to register with the image containing SPIO signals. Such requirement might pose a limitation in cardiovascular system, where tissue motion is likely to induce errors for co-registration. While the sweep imaging with Fourier transformation (SWIFT) technique (3) was introduced to image spins with extremely fast transverse relaxation rate, its potential in visualizing SPIO labeled cells has not been explored. Here we examine whether SWIFT technique could reverse the susceptibility artifacts leading to a higher SNR.

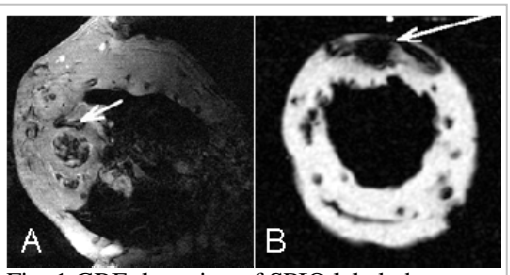

Fig. 1 GRE detection of SPIO labeled stem cells (arrows) in vivo (A) and ex vivo (B).

Methods Murine embryonic stem cells were labeled with Feridex (5.2 ± 0.7 pg iron per cell) and 2 millions of such labeled cells were grafted directly into the myocardium of a rat. In vivo detection was achieved using a fast GRE sequence with cardiac and respiratory gating. Short and long axis cine images of the heart were acquired at 4.7T Varian INOVA interfaced with a transmitting volume coil and a receiving surface coil; in-plane resolution of 156^2 μm^2 and 1 mm thick slice was obtained. The heart was harvested after in vivo imaging, perfused with 4% formalin and suspended in Fomblin oil (Thorofare, NJ). Two-dimensional GRE and 3D SWIFT imaging of the heart was performed sequentially on 4.7T and 9.4T magnet (Varian) respectively. In-plane resolution of 100^2 μm^2 with 500 µm slice thickness was achieved with GRE while an isotropic resolution of 98^3 μm^3 was achieved with SWIFT. Bandwidth of 125 kHz, flip angle of 20°, TR of 2 ms and TE of 6 µs were used in SWIFT acquisition, and the 3D data was acquired in 15 min with 4 averages.

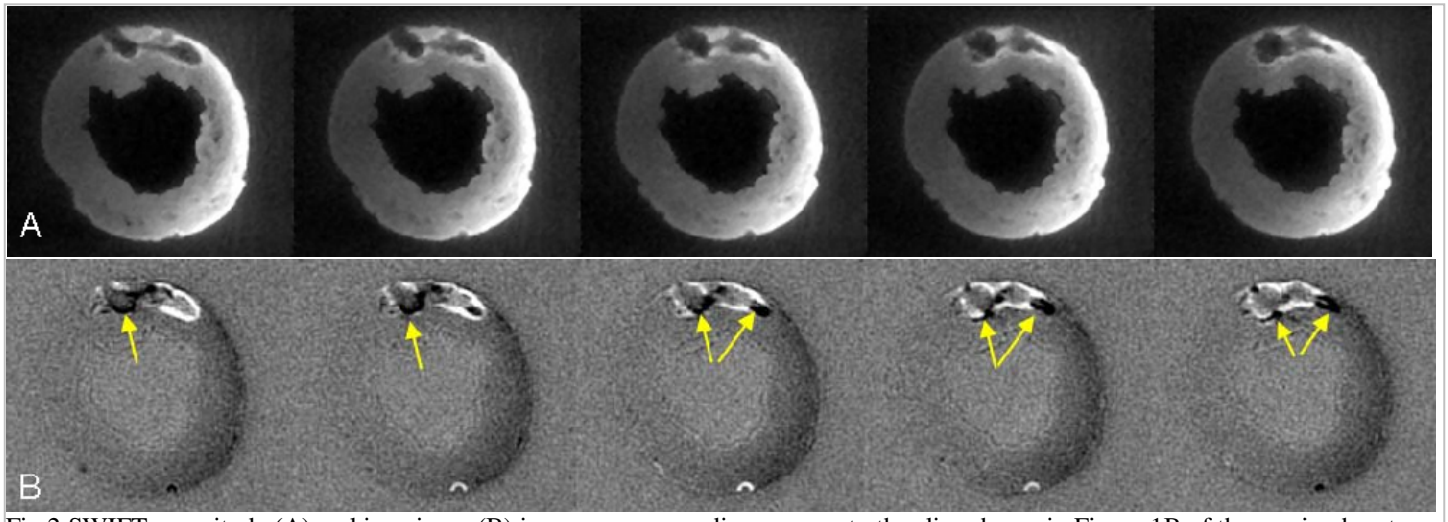

Fig.2.SWIFT magnitude (A) and imaginary (B) images corresponding approx. to the slice shown in Figure 1B of the ex vivo heart.

Results Fig 1 shows in vivo (A) and ex vivo (B) GRE image of a short axis view of the same heart. Figure 2 is the magnitude (A) and imaginary (B) SWIFT images corresponding approx. to the slice shown in Fig 1B (note that slice thickness of ex vivo GRE is 5-fold of SWIFT). While the GRE image of Fig 1B shows the typical "blooming effect" associated with susceptibility, such artifacts are suppressed by SWIFT: the hypointense region in the magnitude images is well defined with enhanced boundaries (Fig 2A), which are shown clearly on the phase images (Fig 2B). There are imperfections in refocusing signal in certain boundary region (yellow arrows), and a method utilizing iterative frequency shift is implemented for such corrections and reported separately. The magnitude images provide T1W signals of the myocardial wall. Therefore, it is not necessary to acquire any reference image for coregistration.

Discussion These preliminary results suggest that SWIFT method might be an alternative to currently available positive contrast methods, attractive especially in cardivascular applications. Further in vivo studies are justified.

References 1.J Am Coll Cardiol., 2008. **52**: p. 483-91. 2. Magn Reson Med., 2008. **60**: p. 73-81. 3. J Magn Reson., 2006. **181**: p. 342-9.