# An echo-dephased SPGR approach to generate positive contrast due to paramagnetic marker: an interventional MRI application

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**Introduction:** In endovascular MR-guided interventions, discrimination of signals from paramagnetic markers and background is a challenging task. Methods that are based on spectrally selective radio-frequency pulses (SSRF) [1] suffer from background fat signal enhancement and dephasing techniques [2,3] enhance unwanted field inhomogeneities such as air-tissue interfaces or water-fat edges. In this work, we propose a new method that is based on an echo-dephased RF-spoiled gradient double echo (echo-dephased SPGR) to generate positive contrast from paramagnetic susceptibilities. Our method is insensitive to unwanted inhomogeneity effects or fat signal contaminations.

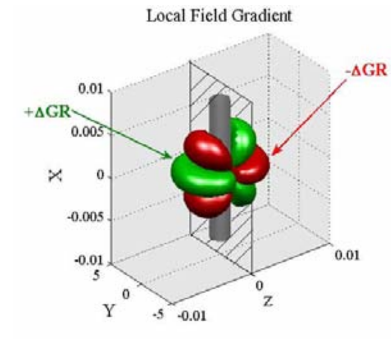


***Figure 1:*** *Isosurface of local field gradient variation as induced by a ring shaped paramagnetic marker. A coronal image is indicated by the shaded region (slice thickness along the z-axis).*

**Theory:** The local field perturbation of a ring-like paramagnetic material wrapped around a guidewire immersed in a static magnetic field $B_0$ was modeled by linear superposition of the fields from single spheres building up the ring. Each sphere generates a field gradient ΔGR with respect to x-direction according to

$$\Delta GR = \frac{-3B_0\Delta\chi Vx}{4\pi}\frac{x^2+y^2-4z^2}{(x^2+y^2+z^2)^{7/2}}$$

where Δχ is the susceptibility difference between the paramagnetic marker and the surrounding tissues, V is the volume of the marker and x, y and z are the spatial coordinates [2]. Simulation results (using MATLAB 7.0) are shown in Figure 1. The red and green surfaces indicate isovalues for negative (-ΔGR) and positive (+ΔGR) local field perturbations respectively.

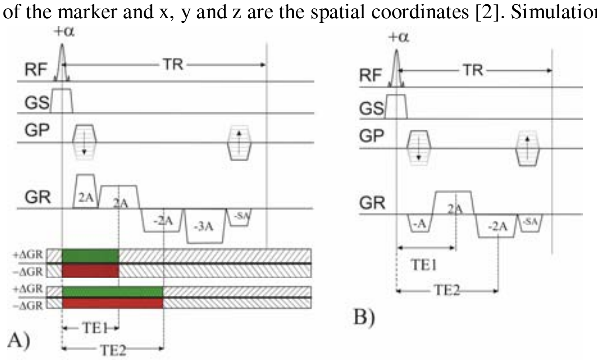


***Figure 2:*** *A) Pulse sequence scheme for the echo-dephased SPGR technique B) Resultant dephasing if the gradients from the marker (ΔGR) compensate the readout gradient. The area SA is the spoiling area.*

**Methods and Materials:** The echo-dephased SPGR sequence is shown in Figure 2A. In this scheme, echoes are dephased in the readout direction by addition of a dephasing gradient prior to readout. If no additional gradients are present then no echo is formed during the readout. However, if local field perturbations, ΔGR from the marker compensate the dephasing at the echo-times (TE1 or TE2), an echo is generated (shown in Figure 2B). Lower field perturbations are needed for compensation in the second echo. In addition, the dephasing gradient in slice-select direction was completely removed [2]. A custom-built phantom with 11 mm diameter tubes to model the blood flow in large vessels and to insert the guide wire was used. The tubes were immersed in a gadolinium (Gd)-doped water and were surrounded by a 2% agarose gel doped with 0.5 mM copper sulphate ($CuSO_4$) concentration to closely resemble the relaxation times of fat tissues. All the measurements were done on a Siemens Espree 1.5T scanner. The sequence parameters were: FOV 200×200 mm; matrix 256×256; slice thickness 40 mm. TE1/TE2/TR 2.78/5.12/11 ms. For comparison, images were also acquired using the proposed slice-select dephasing method [2] with TE/TR=2.78/6 ms.

**Results and Discussion:** An image of the experimental setup with a guidewire inserted in a tube is shown in Figure 3A using a FLASH sequence. In this image signal loss due to local field perturbations of the paramagnetic marker can be clearly identified. Figure 3B displays the image obtained using slice select dephasing. Residual background signal is clearly visible (see arrow) at the edges of the tubes and on the borders of water and fat tissues. Figure 3C displays the image at the echo time, TE1 using the echo-dephased SPGR approach. As anticipated, the local field perturbations induced by paramagnetic marker compensate the dephasing gradient to give rise to positive contrast. Background signal and other unwanted inhomogeneities are completely dephased and hence are clearly suppressed. Visualization of the marker in an image is in accordance with the theoretical expectations displayed in Fig. 1.

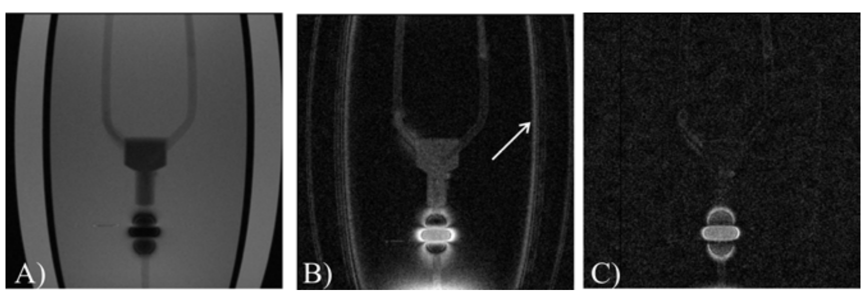


*Figure 3: Flow phantom images A) Simple FLASH image showing black void. B) Slice-select dephasing approach and C) Echo-dephased SPGR approach (second echo image not shown)*

**Conclusion:** Our initial results indicate that the proposed echo-dephased SPGR sequence performs superior to slice-select dephasing methods. Background signals from unwanted field inhomogeneities are clearly reduced but the positive contrast generated by the marker is preserved.

**References:** [1] Cunningham CH et al., MRM 53, p.999, 2005. [2] Seppenwoolde et al., MRM 50:784-790, 2003. [3] Bakker et al., 55:92-97, 2006.