# Phase Contrast of SWIFT in Rat Brain Ex Vivo

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**Introduction** Phase contrast in brain using gradient recalled echo (GRE) is based on phase accumulation during the TE time due to small frequency differences between gray matter (GM) and white matter (WM) [1]. SWIFT (sweep imaging with Fourier transformation) is a sequence that achieves an almost zero acquisition delay using gapped frequency swept pulses. However, even without TE, phase still accumulates during the acquisition, and due to SWIFT's radial nature, opposing spokes will create a phase effect [2]. In contrast to GRE, SWIFT does not require phase unwrapping due to its effectively self high-pass filtering properties. SWIFT has been shown to be able to image brain calcifications using its phase contrast. Here, a first look into the GM/WM contrast in the SWIFT phase is given.

**Materials and Methods** A healthy rat brain was perfused for *ex vivo* imaging. Imaging was conducted on a horizontal 9.4 T magnet equipped with Agilent DirectDrive console. The brain was positioned horizontally in the magnet. The SWIFT parameters were TR = 8.2 ms, sw = 31.125 kHz, α = 7°, FOV = $3^3$ $cm^3$, 128000 spokes and four averages. For comparison, the brain was imaged with 3D GRE with TE = 15.46 ms, TR = 20 ms, sw = 62.5 kHz, α = 9° and four averages. The brain was imaged in three orientations so that the axonal fibers of corpus callosum (cc) were at angles approximately 90°, 55° (magic angle) and 0° to B0 when looking at axial slices. GRE phase images were high-pass filtered using complex division by a gaussian (FWHM 8 pixels) smoothed image.

**Results** Both SWIFT and GRE exhibited orientation dependence of the phase contrast in white matter structures. Fig.1. shows the magnitude and phase (averaged over three slices) images of corpus callosum in different orientations. Phase profiles averaged along the x-direction (8 pixels) over the cc (arrow in Fig 1. (A)) from the phase images (Fig.1, B-C, F-H) are presented in Fig 2.

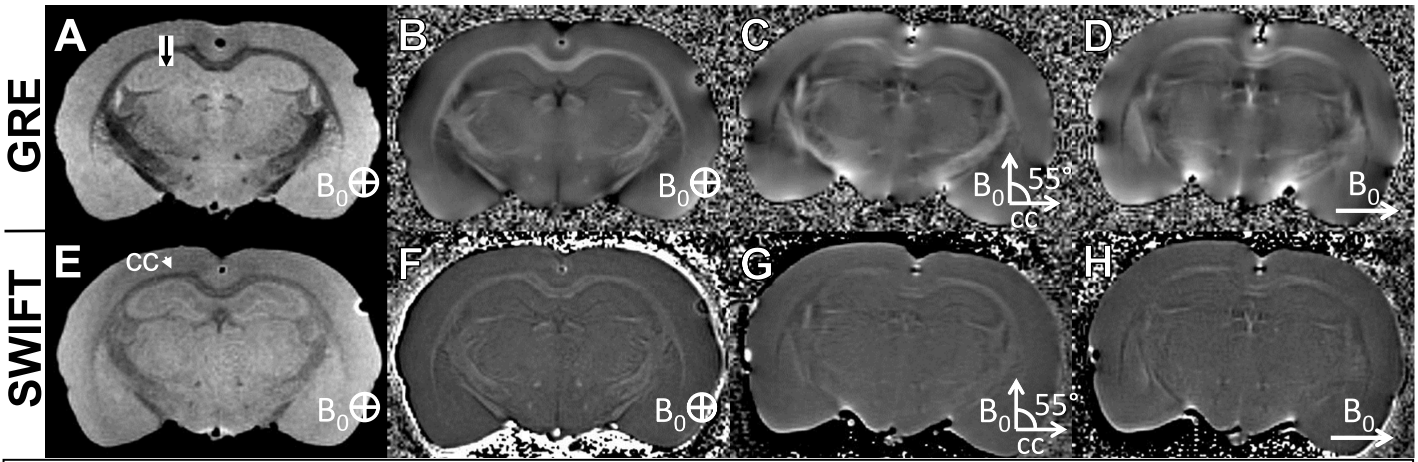


**Fig 1.** GRE (A-D) and SWIFT (E-H) magnitude and phase images with corpus callosum (cc) at 90°, 55° and 0° angle to B0, respectively. Phase images are averaged over three slices. Arrow in (A) indicates the profile direction of Fig. 2.

**Discussion and Conclusion** GM-WM frequency difference has been reported to be only a few hertz [3]. Even without TE, SWIFT phase contrast exhibits similar features as GRE. In comparison to high-pass filtered GRE phase images, the high-pass filtering property of SWIFT seems to be even stronger. This is seen as negative dips at the edges of cc in Fig 2. B. This may be partially related to neighboring WM structures with fiber orientations roughly perpendicular to cc. When comparing min-max phase difference, SWIFT phase contrast also appears to have a stronger orientation dependence (Fig 2).

The phase component of SWIFT is non-linear [2] and is likely to be dependent on size of the structure [4]. Using SWIFT, it may be possible through magnetization preparation and subtraction images to observe only the phase behavior of the short T2 components. With GRE, these components may be lost even with a short TE, which will subsequently decrease contrast. SWIFT may provide novel phase contrast of short T2 water interacting with macromolecules or even methylene groups of myelin lipids themselves [5].

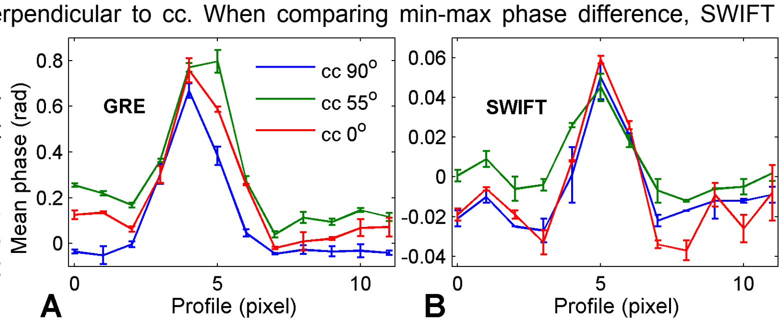


**Fig 2.** GRE (A) and SWIFT (B) phase profiles passing over corpus callosum (cc, Fig 1. (A,E)) averaged over 8 pixels in x-y direction when cc is at 90°, 55° and 0° angle to B0. Each point indicates mean ± sd of phase.

**References** [1] Haacke et al, Am J Neuroradiol, 2009 [2] Lehto et al. Submitted & ISMRM11 [3] Duyn et al. PNAS, 2007 [4] Carl et al. MRM, 2011 [5] Horch et al. MRM, 2011.

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