GESFIDE-PROPELLER for Simultaneous R2 and R2* Measurements in the Abdomen

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INTRODUCTION

Quantitative R2 and R2* maps are critical for a wide range of applications, such as the evaluation of oxygenation via blood oxygen level dependent (BOLD) contrast mechanisms (1), *in vivo* assessment of iron content (2), quantification of holmium-loaded microsphere concentrations (3) and vessel size imaging (4). The GESFIDE (gradient echo sampling of FID and echo) sequence, which samples both FID and spin rephrasing components, can provide simultaneous R2 and R2* information (5). However, for abdominal imaging, application of this method can be particularly challenging due to respiratory motion. Multi-shot PROPELLER techniques have been demonstrated to be less sensitive to motion artifacts due to oversampling at the center of *k*-space and segmental phase correction (6). In this study, we developed a GESFIDE-PROPELLER approach for simultaneous R2 and R2* measurements in the abdomen and demonstrated that GESFIDE-PROPELLER permits robust acquisition of abdominal R2 and R2* maps.

METHODS

Sequence Sequence diagram for GESFIDE-PROPELLER is shown in **Fig. 1**. 8 echoes were sampled on both sides of the refocusing pulse. Unlike conventional PROPELLER method, all 16 echoes were assigned the same phase-encoding value. Thus, a total of 16 individual images were produced when all shots were completed. For GESFIDE sequences, the voxel-wise magnitude of the signal as a function is described as follows: $S(t) = S0 \cdot \exp[-(R_2+R_2')t]$ for FID portion (t<T) (**Eqn. 1**) and $S(t) = S0 \cdot \exp[-(R_2-R_2')t]\exp(-2R_2'T)$ (**Eqn. 2**) for rephrasing portion (t>T).

MRI All imaging experiments were performed using 1.5T clinical MR scanner (Magnetom Espree, Siemens Medical Solutions). 10 agarose gel phantoms were constructed within Falcon® tubes containing either 0, 1, 3, 5, 7, 15, 30, 60, 120, 250 or 350 mg samples of SPIO-containing glass microspheres (~50k shperes/mg) to produced different R2 and R2* values. Spin echo (SE) and multiple-gradient-recalled-echo (MGRE) images were acquired to measure R2 and R2* values as reference standards. GESFIDE-PROPELLER measurements were performed with the following parameters: FOV = 200mm^2, matrix = 128, TR = 3000ms, BW = 600Hz/pixel, echo train length/blade = 40, blade number = 6, echo spacing = 3ms, slice thickness = 5mm. We performed GESFIDE-PROPELLER measurements to produce abdominal R2 and R2* maps in normal volunteers and compared these results to corresponding R2/R2*maps produced using conventional Cartesian sampling based GESFIDE methods. Free-breathing acquisition with respiratory bellows triggering was used for all volunteer studies.

Data Analysis For each acquisition, R2 and R2* maps were calculated by employing the non-linear Levenberg-Marquardt algorithm to fit acquired data to **Eqn.1** and **Eqn.2**. To reduce influence of noise, data with SNR<2 was excluded from these analyses. In the phantom studies, linear regression was used to compare R2 and R2* measurements between GESFIDE-PROPELLER and SE/MGRE reference standards.

RESULTS

In phantom studies, R2 (18~35 Hz) and R2* (21~207 Hz) of the 10 phantoms were measured with SE and MGRE as reference standards. Mean R2 and R2* measured with GESFIDE-PROPELLER demonstrated strong correlation to reference standards (**Fig. 2**). Representative abdominal images produced from 1st, 8th and 16th echoes and corresponding R2 and R2* maps for the conventional Cartesian sampling based GESFIDE (**Group A**) and GESFIDE-PROPELLER (**Group B**) sequences are shown in **Fig. 3**. Motion artifacts (ringing and blurring) were consistently observed within images acquired with Cartesian approaches, whereas GESFIDE-PROPELLER methods suppressed these artifacts producing sharper images clearly delineating the abdominal organs.

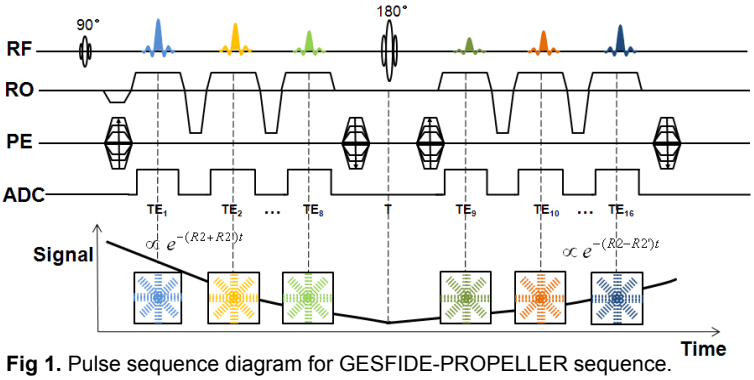

Fig 1. Pulse sequence diagram for GESFIDE-PROPELLER sequence.

CONCLUSION

GESFIDE-PROPELLER can provide accurate R2 and R2* measurements while reducing respiratory motion artifacts. GESFIDE-PROPELLER is promising new free-breathing method for simultaneous R2 and R2* measurements in the abdomen.

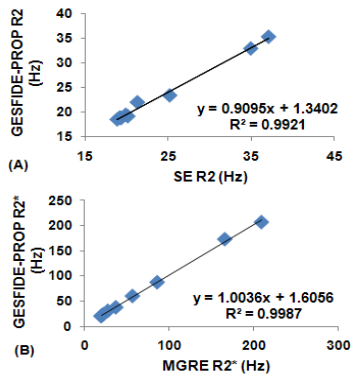

Fig 2. Regression plots demonstrate strong correlation between the R2 **(A)** and R2* **(B)** measured using GESFIDE-PROPELLER and reference standard sequences in the phantom studies.

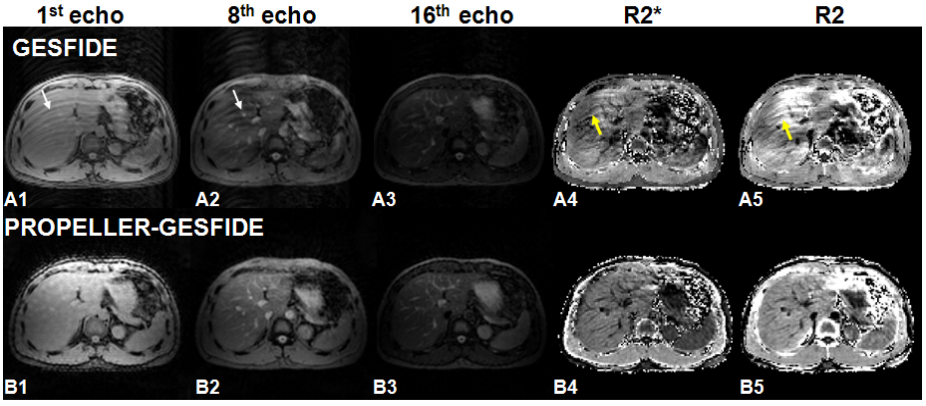

Fig 3. Representative abdominal images produced using the 1st, 8th and 16th echoes and the corresponding R2 and R2* maps from conventional Cartesian sampling-based GESFIDE **(A)** and GESFIDE-PROPELLER **(B)** sequences. Respiratory motion artifacts (**arrows**) present within images acquired with Cartesian sampling are suppressed within PROPELLER images.

References:

(1) Weisskoff et al. MRM, 31:601-610. (2) Song et al. JMRI, 26:208-214. (3) Seppenwoolde et al. MRM, 53:76-84. (4) Tropres et al. MRM, 45:397-408. (5) Ma et al. JMR, Series B 111, 61-69