Respiratory Self-Gating for Abdominal Imaging in Mice using the Phase Information of the central data point of Radial Encoded MRI

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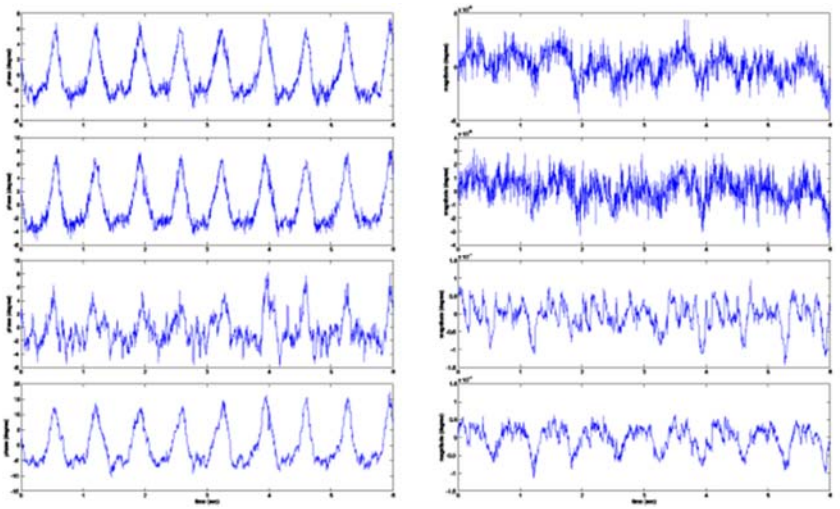
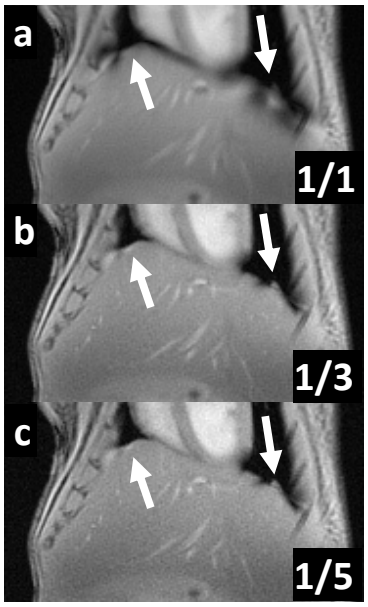
Target Audience: Physicians or physicists who are interested in imaging of the abdomen

Purpose: Magnetic resonance imaging (MRI) has the ability to generate high-soft-tissue-contrast images of the abdomen. However, the relative long acquisition time of an MRI experiment may lead to severe image artifacts originating from movements due to respiration, heart beats and intestinal peristalsis. So far, many methods have been introduced to overcome this limitation. In general these methods can be grouped into breath-holding and cardiorespiratory gating techniques. Although breath-holding techniques are well established methods for abdominal imaging in adult humans they are difficult to realize in animal studies and young children. Cardiorespiratory gated techniques can be divided into prospective methods that use an external trigger signal such as ECG or thorax movement and retrospective techniques which assign the MR-Signals to different phases of a periodic tissue motion afterwards. In case of Cartesian data sampling the latter strategy requires the acquisition of additional data and may therefore hamper very short echo times. In case of radial data sampling however, information of periodic movement can be extracted directly from the acquired echo. Although phase information may have its advantages here the majority of current retrospective gating in radial imaging is based on variations in signal intensity of the k space center [1]. The purpose of this study was to further optimize central-phase-driven data sorting in radial imaging and to compare the abilities of phase and signal variations for retrospective gating of abdominal imaging in small animals.

Methods: Adult female mice were intubated endotracheally and anesthetized by isoflurane (1.75% in ambient air). The respiration rate was set to 85 breaths per minute. All MRI experiments were performed on a 7 T 30 cm-bore MRI system (Bruker Biospin, Ettlingen, Germany). A 4-channel phased-array mouse coil array was used for signal detection (Bruker Biospin, Ettlingen, Germany). T1-weighted data sets were obtained using a gradient-delay-corrected, RF-spoiled radial FLASH (401 spokes, TR/TE = 5/2 ms, FOV = 32 × 32 mm², flip angle = 5°, spatial resolution = 125 × 125 × 500 µm³ and 150 repetitions). System specific, spoke dependent phase-offsets due to eddy-current effects were compensated as described previously [2]. Retrospective gating was performed either based on the variation of signal magnitude or phase of the central data point of every spoke. Based on a simple peak detection algorithm different numbers of respiration phases were reconstructed.





Results: Phase and magnitude of the central data point of each acquired spoke and for each of the 4 channels are shown in **Fig.1.** In contrast to changes in signal intensity (right) the eddy current corrected phase (left) clearly reflected the respiratory movement. Using this phase information different numbers of images per respiration cycle have been reconstructed. Compared to the blurred averaged image (**Fig. 2a**), higher numbers of reconstructed images per respiration phase (**Fig. 2b** three respiration phases**, Fig. 2c** five respiration phases) revealed – as expected – more detail information especially in regions of strong tissue movement such as the upper part of the liver (white arrows) but at the prize of a decreased signal-to-noise ratio.

Discussion: Radial encoding combined with self-gating allowed to obtain artifact-free images of the abdomen in mice without the use of external gating units. By correcting the central phase for eddy current effects [2] the remaining phase variation provides stable and robust gating information that are superior to changes in signal intensity. The signal phase is sensitive to changes of the magnetic field independent of the acquired spoke. The signal magnitude corresponds to the sum of transverse magnetization. Magnitude changes caused by a movement of the object may, however, be modulated by spoke depended signal variation related to a shift of the echo peak position relative to the k-space center which eventually alter the requested gating information.

Conclusion: Radial imaging in combination with a self-gating technique based on the phase information of the central data point allows for the acquisition of artifact-free images of the moving abdomen in mice.

References: [1] Hiba et al., MRM 2006;55:506-513. [2] Moussavi et al., MRM 2014;71:308-312.