# Enhanced DC Self-Navigator with Multi-Slice Signal Combination Method

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**Target Audience:** Scientists, engineers and radiologists who have an interest in free breathing abdominal imaging.

**Purpose:** Respiratory navigator gating using a pencil-beam navigator excitation enables free breathing with minimal motion artifacts in T1-weighted abdominal imaging.[1] But high imaging flip angles (e.g. 90°) cause low signals in the 1D navigator profiles and can result in inaccurate motion detection, as is the case for the widely used 2D spoiled gradient-recalled echo (SPGR) sequence. The self-navigator gating technique samples the k-space center (DC) signal to obtain the sum of all data from the imaged slice,[2] so there is less concern for navigator deterioration even if the imaging flip angle is high. When this technique is applied to 2D imaging, however, the DC signal of a single slice is sensitive to motion-induced spin saturation differences,[2] which can complicate respiratory motion detection. The purpose of this work was to develop a DC-based self-navigator (DC navigator) sequence with improved respiratory motion detection and correction.

**Methods:** We focused on axial imaging and started with a previously reported 2D SPGR sequence with DC navigator, which acquires the DC signal for 20 μs immediately after slice refocusing.[2] In order to decrease the DC signal's sensitivity to spin saturation differences, we utilized the fact that the sensitivity highly depends on the slice position. We acquired the DC signal from each slice, and combined the data from the superior half of the imaging slices to average spin saturation effects (Figure 1), whereas the original method utilized the DC data from a single slice. Combination was performed by summing up the DC signal amplitude acquired with the conventional multi-slice excitation method. Superior slices were chosen because the liver volume change by respiration is greater than inferior slices. We refer to this enhanced DC navigator technique with multi-slice signal combination as eDC navigator.

Acquired imaging data was prospectively accepted or rejected on the basis of the DC signal, with a narrow acceptance window placed at DC waveform peaks, assuming that the DC signal increases during expiration with increased liver volume in the imaging planes. The acceptance window was defined as one-tenth of the range of DC values acquired during the learning period (~10 s) played at the beginning of the scan.

A human volunteer scan was performed on GE 1.5 T Signa HDxt MR imaging system (GE Healthcare, Waukesha, WI, USA) with an 8-channel cardiac coil. 2D SPGR scan was conducted with the original DC and eDC navigators for comparison. Sequence parameters included: parallel imaging using ASSET with an acceleration factor of 2, TR/TE = 200 ms/4.8 ms, α = 90°, BW = ±62.5 kHz, FOV = 34 cm x 27.2 cm, slice thickness = 8.0 mm, matrix = 256 x 224, number of slices = 20, NEX = 1.

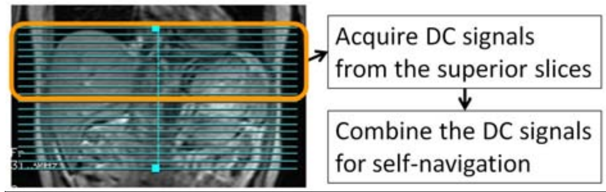


**Fig. 1** Outline of DC signal combination for eDC navigator.

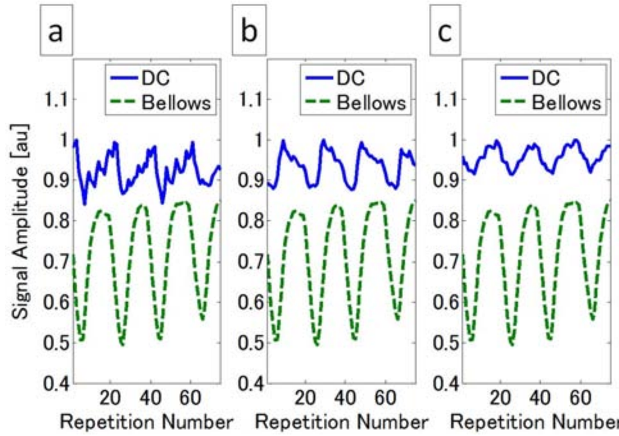


**Fig. 2** Representative waveforms of bellows and DC data. **a:** DC navigator with superior edge slice. **b:** DC navigator with inferior edge slice. **c:** eDC navigator.

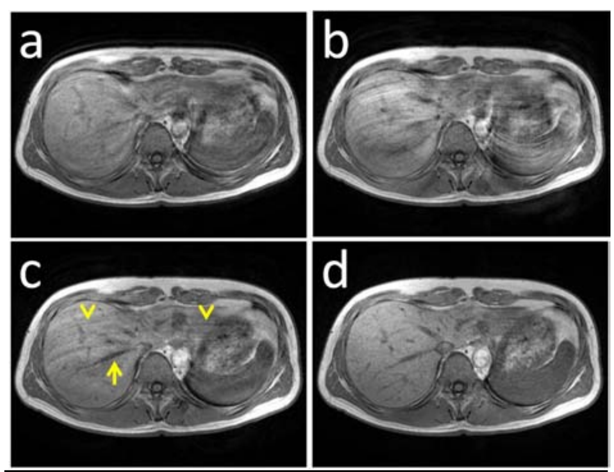


**Fig. 3** SPGR images acquired during free breathing (a) without and (b-d) with DC self-gating. **b:** DC navigator with superior edge slice. **c:** DC navigator with inferior edge slice. **d:** eDC navigator.

**Results:** Figure 2 shows representative waveforms of the DC signal acquired during free breathing. The respiratory bellows signal is plotted for comparison (the signal increased in expiration, and decreased in inspiration). The DC waveforms with a single slice (Fig. 2a and b) were well correlated with the bellows signal, but the DC signal waveform peaked on the rising or falling edges of the bellows signal, because motion-induced spin saturation differences were large at the beginning of inspiration or expiration. Furthermore, high frequency fluctuations caused by cardiac motion were exhibited with the superior edge slice (Fig. 2a) because part of the heart is contained within the slice. The DC signal of eDC navigator had peaks at almost same time points with the bellows signal, by averaging spin saturation and cardiac motion effects. Figure 3 shows the imaging results from an axial acquisition of the liver during free breathing. DC navigator with the superior slice (Fig. 3b) did not show notable image quality improvement compared to no gating method (Fig. 3a), since both spin saturation differences and cardiac motion corrupted the DC waveform. DC navigator with the inferior slice (Fig. 3c) improved the delineation of the blood structure in the liver (arrow) because of less sensitivity to cardiac motion, but motion-related ghosts still remained in anterior regions (arrow heads). eDC navigator (Fig. 3d) reduced such motion artifacts remarkably.

**Discussion:** The respiratory waveform of eDC navigator was visibly consistent with the bellows waveform, averaging spin saturation sensitivity and cardiac motion which were seen in single-slice DC signals. The accuracy of motion detection was proven in reduced artifacts in the resultant image. To ensure the actual image quality for variety of liver diseases, further clinical evaluation with a large number of subjects is required.

**Conclusion:** We have demonstrated that the eDC navigator sequence improved respiratory motion detection and correction. The results suggest that the proposed method is a promising technique in clinical abdominal imaging with free breathing subjects.

**References:** 1. Vasanawala SS, Iwadate Y, Church DG, et al. Navigated abdominal T1-W MRI permits free-breathing image acquisition with less motion artifact. Pediatr Radiol. 2010;40(3):340-344.

2. Brau AC, Brittain JH. Generalized self-navigated motion detection technique: Preliminary investigation in abdominal imaging. Magn Reson Med. 2006;55(2):263-270.