IMPROVEMENT IN NAVIGATOR ECHO DISPLACEMENT ACCURACY USING A PRE-SATURATION PULSE

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INTRODUCTION

Navigator Echo has been used in cardiac and abdominal imaging to directly detect the position of the right hemi-diaphragm and prospectively gates the acquisition during a free breathing scan. If the imaging slab intersects with the navigator tracker, the tracker will be partially saturated. As most of the displacement detection algorithms rely on the integrity of the navigator spatial profile, the reduction of partial saturation effects will help increase the accuracy of the displacement detection.

PURPOSE

The proposed technique aimed at reducing these partial saturation effects by applying an additional saturation sequence at the end of each image acquisition period to saturate the entire navigator tracker region, thereby allowing uniform recovery of longitudinal magnetization along the entire length of the navigator column for the next imaging period.

METHODS

The proposed sequence was performed on five volunteers on a GE 1.5T EXCITE MR scanner using 8-element cardiac phased array coils. An axial imaging slab was positioned across the heart or liver and the navigator tracker was positioned across the dome of the right hemi-diaphragm. A 2D selective navigator echo segment (pencil beam navigator with 40º flip angle) was applied prior to a segmented k-space 3D fat-suppressed FIESTA imaging sequence. The imaging segment was then followed by the proposed navigator pre-saturation segment, comprising of:

1. Dephaser gradients in x,y,z to dephase any residual transverse magnetization
2. A navigator saturation pulse of 90-degree flip angle to saturate all the spins within the navigator tracker region to ensure a uniform recovery of longitudinal magnetization for the next imaging period. The spatial excitation diameter of this 2D selective saturation pulse was 2 to 3 times larger than that of the navigator pulse to effectively saturate all the spins within the tracker region.

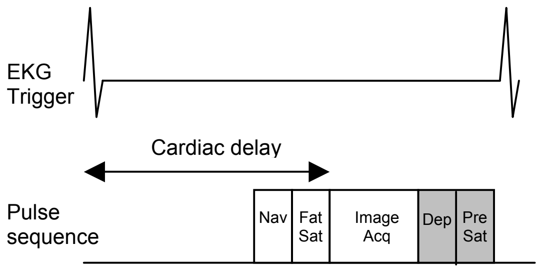


Figure 1. Pulse sequence diagram of navigator sequence with pre-saturation pulse

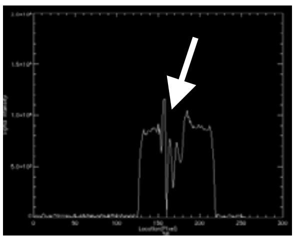
Navigator echoes collected were then Fourier-transformed into 1-D spatial profiles and least-square error technique was applied to detect diaphragm displacements. The results were compared with the true displacements of the diaphragm and lung interface, defined as the position of half maximum signal intensity in the navigator spatial profile [1].

RESULTS

The proposed sequence reduced the saturation effect on the shape on the navigator spatial profile in both phantom studies (Fig 2) and volunteer studies (Fig 3). In cases without the saturation pulse, the profiles were partially distorted by the imaging slab (shown in arrow in Fig2a & 3a). The application of the proposed navigator saturation sequence successfully reduced the saturation effects (Fig 2b & 3b). The improvement in profile quality obtained with the proposed technique yielded lower displacement RMS error in volunteer studies as shown in Fig 4.

DISCUSSION

It has been demonstrated that the navigator saturation sequence reduces the impact of the imaging slab on the navigator spatial profile and therefore yields more accurate displacement detection. This improvement in accuracy is especially important for slice-tracking applications where the imaging slab location is adjusted based on the diaphragm position. Moreover, we have observed that the improvement in profile quality is more critical for displacement detection algorithms that are based on the shape of the profile (e.g. linear phase shift, least-square error or cross-correlation) than for those that are based on specific features in the profile (e.g. edge detection).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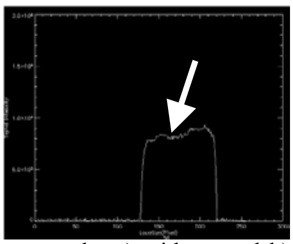
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Figure 2. Navigator spatial profile on phantom study, a) without and b) with navigator pre-saturation pulse. The partial saturation effect caused by the imaging slab (arrow) is not visible in b).


a

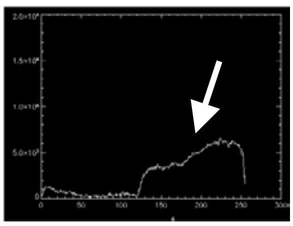
b

Figure 3. Navigator spatial profile on volunteer study, a) without and b) with navigator pre-saturation pulse. The partial saturation effect caused by the imaging slab (arrow) is reduced in b).

REFERENCE

[1] Du, JCMR, Vol. 6, No. 2, pp. 483–490, 2004

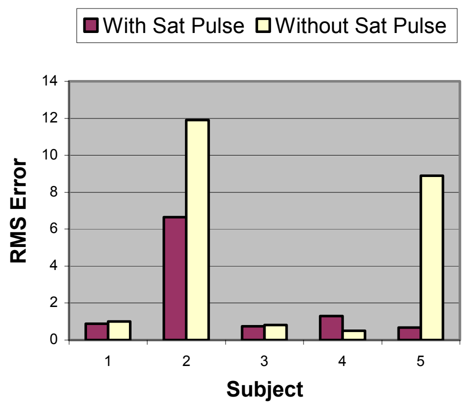

Figure 4. Comparison of displacement RMS error with and without the proposed saturation technique in 5 volunteer studies. Robustness of displacement detection increases with the application of the pre-saturation pulse.