Phase Based Navigator Echo Analysis with a Virtual Large Loop RF Coil

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Introduction

Navigator echo can detect respiratory motion by detecting the diaphragm position directly. Edge detection analysis based on navigator phase signal is insensitive to the saturation effect caused by image acquisition RF pulses, and this technique enables navigator gated T1 weighted imaging with considerably less motion artifacts [1][2]. However, phase signal of navigator echo is sometimes affected by an inhomogeneous sensitivity of a receiver RF coil when the navigator FOV is set near coil elements. In this work, we propose a method that uses virtual large loop coil to obtain a homogeneous phase background.

Methods

Navigator Data Analysis

We chose two adjacent rectangular RF coils aligned in the SI direction (fig.1a). Conventional phase based edge detection analysis uses one of the coils to acquire navigator echo signal. In the new method, two navigator data sets of these two coils were added vectorially so that the coil pair would compose a virtual single large loop coil. Phase data of acquired navigator echo were used to calculate the diaphragm position with the differential edge detection method described in [1] and [2].

Data Acquisition

We conducted 2D FSPGR with flip angle of 90 degrees as an imaging sequence and navigator echo was incorporated into the sequence. Cylindrical RF excitation across the right hemi-diaphragm was used for navigator sequence. We performed all scans on GE Signa 1.5T HDx MR imaging systems (GE Healthcare, Waukesha, WI, USA) and informed consent was obtained from volunteers.

Results

Coil sensitivity maps were calculated for a single coil and for a combined virtual large loop coil respectively with MATLAB. Sensitivity phase map of a single loop showed a sharp change of 180 degrees along the navigator data acquisition line (dotted line in fig.1b). For a virtual large loop, such a sharp phase change didn't occur (fig.1c) because disrupting sensitivity components of one loop coil were canceled by those of the other coil sensitivity in the navigator FOV.

The diaphragm position was calculated by applying phase based edge detection to navigator data sets acquired in volunteer scan. Navigator phase data of a single loop coil has discontinuity in the liver region due to the inhomogeneous coil sensitivity. This discontinuity caused misdetection of edges and lead to respiratory waveform degeneration (fig.2a). The virtual large loop combination eliminated this discontinuity and the phase based edge detection method could calculate the actual liver edge successfully, which resulted in accurate motion detection of the diaphragm (fig. 2b).

Discussion

The results of our work show that navigator data combination to make a virtual large loop coil eliminated phase discontinuity in the liver region and realized accurate diaphragm motion detection. We applied this technique to two elements of a phased array coil, but we can extend this method to a larger number of elements, for example, four elements of a 32-channel array. In some cases phase shifts might occur due to coil positioning, differences of cable length from the receiver coil to the MR system and so on. Such phase shifts cause an inhomogeneous phase in vectorially added coil sensitivity and lead to misdetection of the edge. Future work will involve the phase compensation to adjust to variety type of phased arrays.

Conclusions

The virtual large loop coil technique generated sensitivity with a homogeneous phase and resulted in accurate motion detection with navigator phase signal. The potential of this technique to apply to a larger number of elements remains to be studied in future work.

References

1. Kanda et al. ISMRM 2008, p1466. 2. Iwadate et al. ISMRM 2008, p1468.

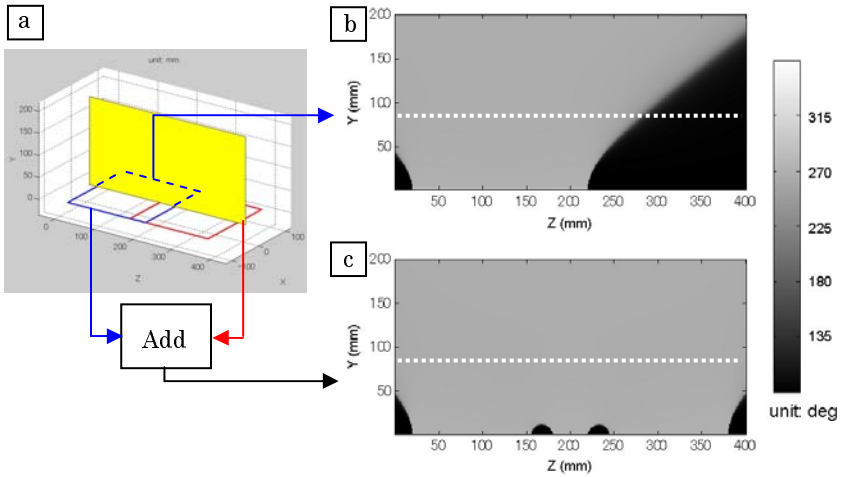

Fig. 1 (a) Sensitivity phase calculation condition and phase maps of (b) a single small loop coil and (c) a virtual large loop coil. Navigator data would be acquired around the dotted lines in the phase maps.

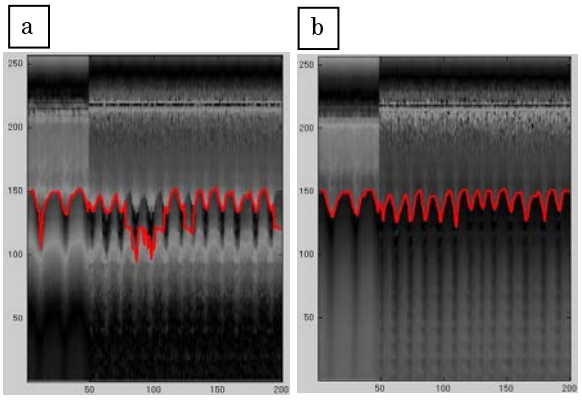

Fig. 2 Navigator echo phase signals and detected edges (red lines) acquired with (a) a single loop coil and (b) a virtual large loop coil.