RESPIRATORY SELF-NAVIGATED SSFP

J. M. Li[1,2], J. A. Stainsby[3], L. Biswas[4], N. Merchant[1,2], M. S. Sussman[1]

[1]Medical Imaging, University of Toronto, Toronto, Ontario, Canada, [2]University Health Network, Toronto, Ontario, Canada, [3]Applied Systems Laboratory, GE Healthcare Canada, Toronto, Ontario, Canada, [4]Integrative Biology, Hospital for Sick Children, Toronto, Ontario, Canada

INTRODUCTION

The SSFP pulse sequence typically requires some form of respiratory compensation when imaging the heart. One common method is the use of diaphragmatic navigator echoes. However, the acquisition of a diaphragmatic navigator within an SSFP scan requires one to break out of the steady state. This reduces efficiency, and makes it difficult to acquire data toward the beginning and end of the cardiac cycle. Also, if a contrast preparation pulse has been applied previously, the stored contrast is affected. Additionally, since conventional navigators monitor diaphragmatic position, only an *indirect* measure of the respiratory-induced motion of the heart is provided. This has been shown to limit image quality [1]. In this abstract, a respiratory self-navigated SSFP technique is presented. It uses the SSFP data itself, rather than a separate diaphragmatic navigator echo, to compensate for motion. Unlike conventional navigators, respiratory self-navigated SSFP directly monitors the motion of the heart, and maintains a continuous steady state.

THEORY

In the self-navigated SSFP technique, a conventional cardiac-gated acquisition is performed. However, at the beginning of each RR-interval, an additional phase encode line through the centre of k-space (=k_0) is acquired (Fig. 1). The Fourier Transform of a k_0 line provides a 1D projection image of the anatomy [2]. By comparing projections acquired from different cardiac cycles, the respiratory-induced motion of the heart can be observed directly (Fig. 2). Motion compensation is achieved by selecting only data acquired during RR-intervals where minimal displacement occurs.

The acquired k_0 lines can be orientated at any angle in k-space. However, an orientation along the direction of maximal respiratory displacement provides the largest sensitivity for motion detection.

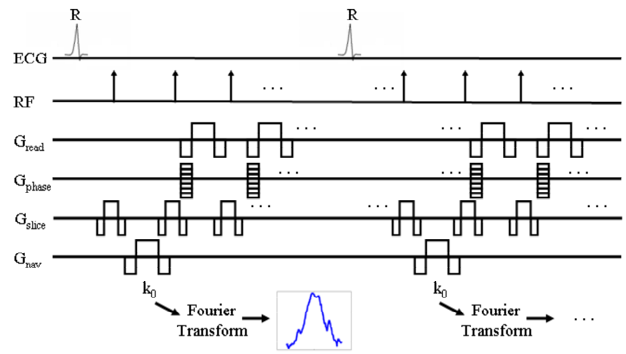

Figure 0: Respiratory self-navigated SSFP timing diagram. On each RR-interval, a k_o line is acquired with the G_{nav} gradient (which may be any combination of the G_{read}, G_{phase}, G_{slice} gradients). The Fourier Transform of a k_0 line represents a 1D projection image of the anatomy. Displacement between projections on different RR-intervals corresponds to respiratory motion.

RESULTS

Figure 3 is an example of a free-breathing SSFP image acquired with the respiratory self-navigation technique. The absence of blurring or ghosting artifact indicates the effectiveness of the motion compensation. Note that this image was one in a series of cine images that spanned the entire cardiac cycle. This was possible since the steady state could be maintained continuously.

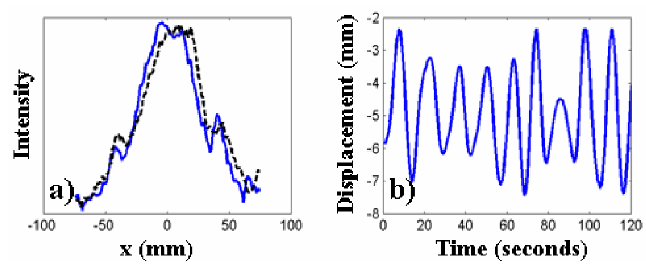

Figure 2: (a) 1D projection images from two different timepoints. The shift between them indicates respiratory displacement. (b) The relative displacement of the projections over time.

DISCUSSION AND CONCLUSIONS

The results indicate that the self-navigation technique *is* effective in suppressing the effects of motion. Note that, although the dominant source of motion in the experiments is likely due to respiration, the self-navigation technique will more generally correct for *any* motion that occurs between RR-intervals. Therefore, in addition to respiratory compensation, the self-navigation technique may also correct for other superimposed sources of motion such as timing variations between RR-intervals, or gross patient motion. Due to this property, as well as its ability to maintain a continuous steady state, the self-navigation technique may provide an improved method for motion compensation with SSFP, and potentially other cardiac-gated pulse sequences.

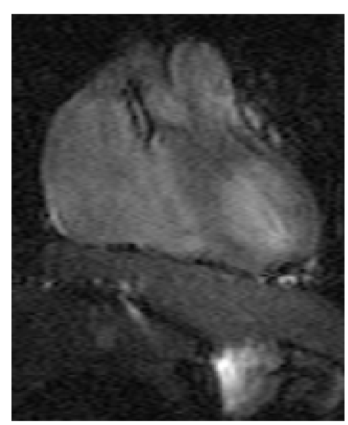

Figure 3: Respiratory self-navigated SSFP image of the heart.

REFERENCES

[1] Wang Y. *et al*., *MRM*, 1995, 33, p. 713-719.
[2] Sussman M.S. *et al*., *ISMRM*, 2004, p. 2152.