Simple method for free-breathing multi-slice T2w-TSE liver imaging without PACE

S-Y. Zho[1], J. Park[2], and D-H. Kim[1,2]

[1]Electrical and Electronic Engineering, Yonsei University, Shinchon-Dong, Seoul, Korea, Republic of, [2]Radiology, Yonsei University, Shinchon-Dong, Seoul, Korea, Republic of

Introduction: Free breathing MR imaging technique such as Prospective Acquisition CorrEction (PACE) enables liver imaging for patients who have difficulty holding their breath. PACE technique which directly measures the position of the diaphragm has been shown to be robust and provides high quality free-breathing abdominal MR images [1] using T2 weighted Turbo spin echo (TSE) sequence. One limitation of PACE technique however is its relatively long scan time since it gates the expiration period. For T2-weighted TSE multi-slice 2DFT liver imaging, although 2 to 3 seconds TR is sufficient to get the desired image contrast, the respiration period is normally about 4 to 5 seconds. In addition, irregular respiration can also increase the total scan time because irregularity can change diaphragm position to outside the acceptance window. An alternative would be to do imaging liver without PACE, reducing the total scan time to approximately half. One major problem of this approach is how to control the respiratory motion. Here, we propose one possible method to multi-slice 2DFT T2w-TSE liver imaging without using the PACE technique. The method observes projection of image itself to identify the respiratory states.

Methods: We modified the view ordering scheme of the conventional TSE sequence to acquire projection lines (k_y=0 lines) by inserting additional k-space samplings during the echo-trains. The inserted k_y=0 line therefore serves as a navigator. The position of this line is placed near TE for all echo trains because the effects due to motion are most prominent for k-space center data [2]. The phase encode direction was set to left-to-right (LR). Therefore, the navigator obtains motion information of the liver moving in the anterior-posterior (AP) direction [3]. The modified view ordering scheme is shown in Fig. 1. The small dots represent conventional k-space samplings and the large dots are the inserted projection navigator views. Echo-trains of only one slice separated by dashed lines for each TR are shown here for simplicity.

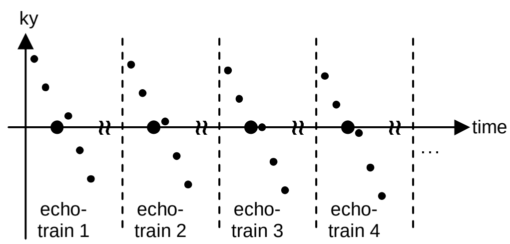

Figure 1: additional projection lines (large dot) in TSE

With this acquisition scheme, we acquired free breathing data using fixed TR value and without PACE. We acquired three acquisitions of the same multi-slice data set. From these three acquisitions, we find the echo-trains which have similar respiration state, which was identified from the acquired navigator data. We used an edge detection algorithm based on least-squared [4] from the part of the anterior wall to determine the acquisitions within a predetermined region. These images were then selected for reconstruction while others whose navigator data were beyond the threshold were discarded. We used only one of four coil images closet to the region to detect anterior wall edge [5].

Liver image of healthy volunteers (N=5) were acquired using Siemens 3T scanner with modified multi-slice TSE sequence with the following parameters. TR=2700ms, TE=73ms, readout (AP), phase encode (LR), FOV=360x400mm, slice thickness = 5mm, ETL=20, echo-train/slice=10, echo spacing=7.33ms and scan time of 81 seconds for 14 slices with 3 repetitions. For comparison, we acquired data using PACE with same parameter except TR_{eff}=4501ms, concatenation=3 and scan time of 81 seconds for 17 slices. Therefore, the total volumetric coverage achieved by PACE was slightly larger than our modified sequence.

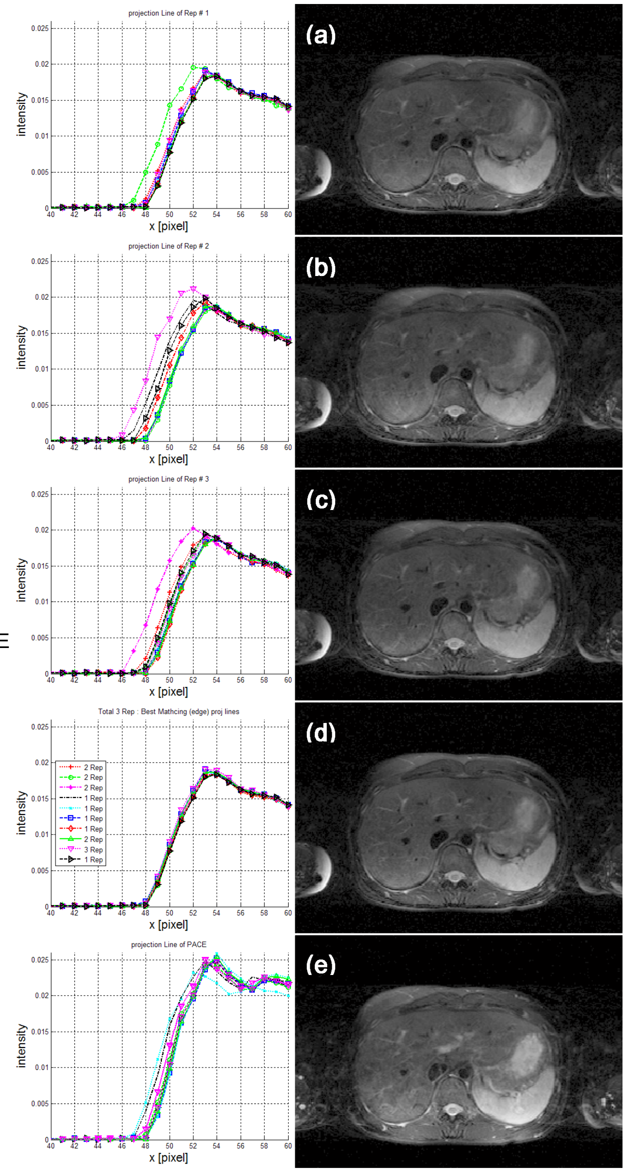

Figure 2: Projection line profile near anterior wall (left column) and its image (right column). (a-c) images obtained from the three acquisitions. (d) Image extracted from best matched echo-trains, (e) PACE image for comparison.

Results: Figure 2 shows projection line profiles obtained from the navigators near the anterior wall (left column) and its image (right column). Images of free-breathing (a-c) from individual acquisitions show mismatch of the edge wall. After extracting those whose edge wall mismatch were minimal, the edge wall is well aligned and image artifact was markedly reduced (d). In the left column, an x-axis grid represents 2.5mm displacement. For comparison, image acquired with PACE is for the corresponding slice is shown in (e). Even though PACE was used, there are residual artifacts.

Conclusion: We have proposed a method for “free” breathing liver imaging without the use of PACE technique. By using interleaved navigator acquisitions during echo train readout and retrospective processing, high quality images can be obtained. In our experience, the method can be more effective than PACE for subjects who can generally control their breathing patterns to within a certain degree. A calm breathing pattern suffices. We can expect further enhancement in image quality and reduction in scan time if the navigator data can be expanded to prospective acquisition.

References : [1] C. Klessen, et al., JMRI, 21:576-582, 2005 [2] J. Maclaren, et al., Proc. Intern. Conf. IEEE EMBS, 2053-2056 [3] M von Siebenthal, et al., Phys. Med. Biol. 52:1547-1564, 2007 [4] Y. Wang, et al., MRM, 36:117-123, 1996 [5] M. Buehrer, et al., MRM, 60:683-690, 2008