SWI of the Cervical-Spinal Cord with Respiration Noise correction using Navigator Echo

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Target Audience: Researchers interested in SWI of the spinal cord.

Introduction: Susceptibility Imaging can be useful for assessing structural integrity in the spinal cord, which plays an important role in many neurological disorders.[1] However, physiological noise from respiration causes artifacts in in-vivo images. This phenomenon is particularly evident in the Cervical-spinal (C-spine) cord because the distance between the C-spine and the lungs is closer than other regions [2]. In order to characterize and correct these respiration-induced artifacts of images, navigator echo approaches have been widely used in functional MRI, Diffusion Imaging etc [3]

In this study, B0 shift due to respiration is analyzed and this effect is compensated using navigator echoes. Susceptibility weighted image (SWI) of the C-spine is obtained using the correction scheme.

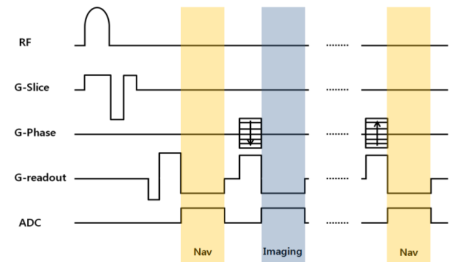

Fig. 1. Sequence diagram for the acquisition of a navigator echo and imaging

Methods: Five healthy volunteers were scanned on a 3T scanner (Tim Trio, Siemens Medical Solutions, Erlangen, Germany) with a 4 channel neck coil. The T2* weighted imaging is based on a multi-echo 2D GRE sequence shown in Fig. 1. Navigator echoes were placed at the first and last echo so as to confirm which navigator echo is effective for correction. The imaging parameters were as follows: FOV 160×160 mm^2, spatial resolution 0.5×0.5 mm^2, TR = 1210 ms, TE = 7.38, 13.69, 20, 26.31, 32.62 ms, 70° flip angle, 20 slices, 2mm slice thickness, GRAPPA factor 2 (ACS 32), and flow compensation. The acquisition time was 4 min 13 sec. Axial and sagittal images were obtained separately and analyzed. SWI was made using all other multi-echo signals to increase signal to noise ratio (SNR).[4] A negative phase mask was used which was multiplied four times to the original magnitude image.

Result: Fig. 2 shows the field shifts from the navigator echo signals from axial (a,b) and sagittal (c,d) acquired data. Respiratory related field modulation is seen in all orientations. However, the field differences between the first and last echo show that axial navigators have bigger change compared to sagittal navigators (b,d). This suggests that the quality of compensation might depend on the location of the navigator echo. This might be due to the fact that late echo signals are more dominated by signals with longer T2*. After correcting for these echoes separately, compensation using the late navigator brought better results in terms of SNR(for instance 0.1223(using first nav.), 0.1464(using late nav.) at second echo image).

In case of sagittal oriented images, a spatially varying field change (in z direction) was observed in addition to the DC field changes, which seems to be in accordance with previously reports [2]. Fig. 3 shows field variations for two different locations and the difference between these two locations is plotted. Therefore, respiration-related motion correction using navigator echo was implemented for both zero order and 1st order phase compensation for sagittal data. On the other hand, compensation in the axial data was sufficient using the zero order correction. Fig.4 and 5 illustrate the results from in-vivo studies. Fig. 4 show the T2*-weighted images with and without correction. Fig. 5 shows conventional SWI and compensated SWI using navigator echo and multi-echo data. T2* weighted images and SWI with navigator correction gives higher SNR and contrast than uncorrected images, and reduces the contamination from the surrounding structure.

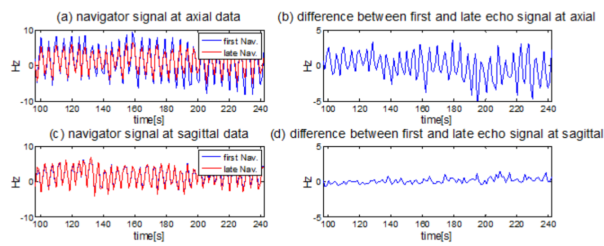

Fig. 2. A plot of the phase of the navigator signals (a)at axial oriented and (c)at sagittal oriented data. (b),(d) are the differences between signal using first echo and using late echo of axial and sagittal respectively.

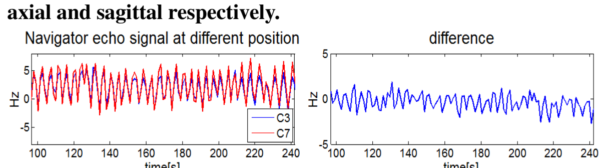

Fig. 3. The left graph is a plot of the phase of the navigator signals of two different location C3, C7 (location are indicated at a Fig.4(d)). The right plot means difference of signal from C3 and C7.

Discussion and Conclusion: The navigator echo approach for C-spinal cord presented in this work demonstrated to be effective in reducing signal fluctuations. In case of early navigator echo, signals from muscle/fat are non-negligible. However, in the case of a late navigator echo, most signal come from the C-spinal cord because muscle/fat has shorter T2*. Therefore, using late navigator echo seems more suitable for respiratory correction of C-spinal cord. Also, for sagittal acquisitions, addition of a first order correction improves the navigation.

References: **1.** M. Wang, et al., MRI 2011;29:365-373. **2.** T. Verma, et al., MRM 2014;e-pub. **3.** X. Hu, et al, MRM 1994;31:495-503. **4.** U. Jang, et al., NeuroImage 2013;70:308-316

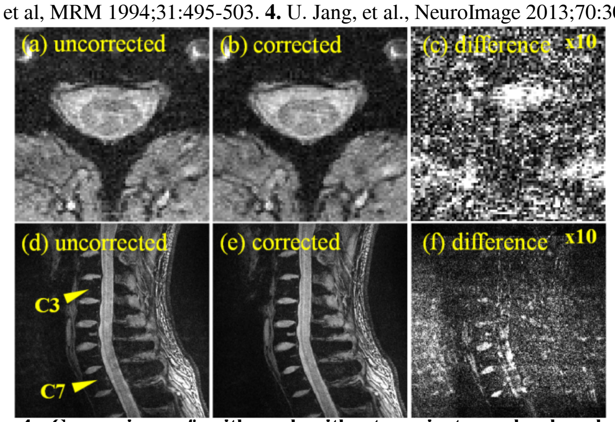

Fig. 4. Comparison of with and without navigator echo based motion correction from T2*-weighted images. (a) is uncorrected axial image. (b) is corrected axial image. (c) is differences between corrected(b) and uncorrected(a) images of axial image.(scaled by a factor of 10 to visualize details) (d)-(f) correspond to the sagittal images.

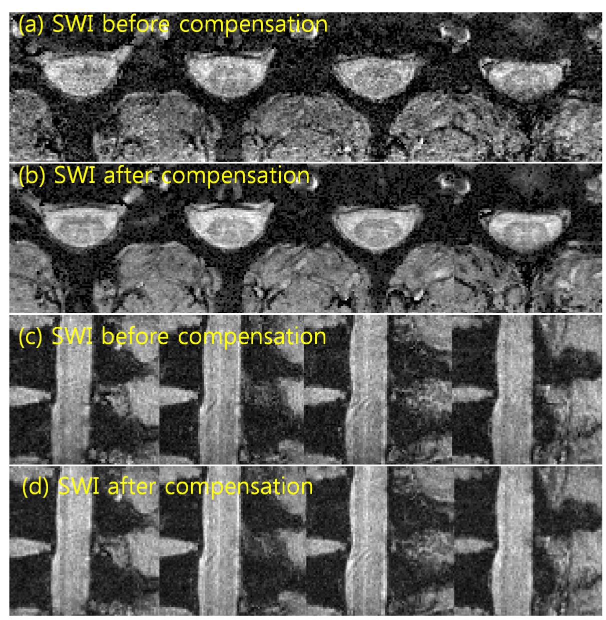

Fig. 5. Successive slices of the conventional SWI(a)(c), and the SWI using multi-echo and after compensating respiration-related noise with navigator echoes (b)(d).