A Motion Monitorred SPACE Sequence for Isotropic Cardotid Wall Imaging

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Introduction

Three-dimensional (3D) MR black-blood imaging has emerged as an appealing technique for carotid atherosclerosis study [1-3]. One common problem for this kind of techniques is the long scan time, which means swallowing/throat motion is likely to occur during the acquisition. In this work, a self-navigated 3D measurement paradigm is proposed and tested with a three-dimensional turbo spin-echo (SPACE) sequence. Compared with conventional cross-paired navigator [4], sequence of this work requires no navigation bar, skips the manual positioning and leaves no dark-band on final image. With volunteer test, this work makes motion blurring reduced and definition of vessel wall increased.

Methods

In a SPACE sequence, the first echo in each echo train is used as a navigator echo. (Fig 1) By comparing the phase correlation between the navigator echo and its predecessor navigator echoes, all acquisition echoes in the same echo chain will be accepted/rejected. If a echo chain is rejected, a re-acquisition of these echoes is immediately rescheduled.

The very first few navigator echoes are averaged and used as a reference. After which, each navigator echo are compared with this reference. When a navigator echo arrives, signal form different coil are first combined by simply complex averaging. Phase information is then extracted and unwrapped. The correlation efficient is calculated between the unwrapped phase array and that from reference echo. A empirical value is set as a threshold, if the correlation efficient is smaller than the threshold, this echo chain will be rejected.

Volunteer examinations are performed on a 3T scanner with 4-channel carotid coil (Siemens AG, Elangen, Germany). A T1 weighted volume selective 3D SPACE sequence is used for validation. Space resolution is set to isotropic as 0.8*0.8*0.8mm, FoV is 200*150*51.2 mm. Imaging slab is positioned at coronal and make readout encoding direction along the carotid. In this way, the readout gradient will have the effect of blood suppression and throat motion encoding. The total measurement time is 5m24s. Other protocol parameter include: TE = 21, TR = 650, NEX = 2, ETL=28 and iPAT factor = 2.

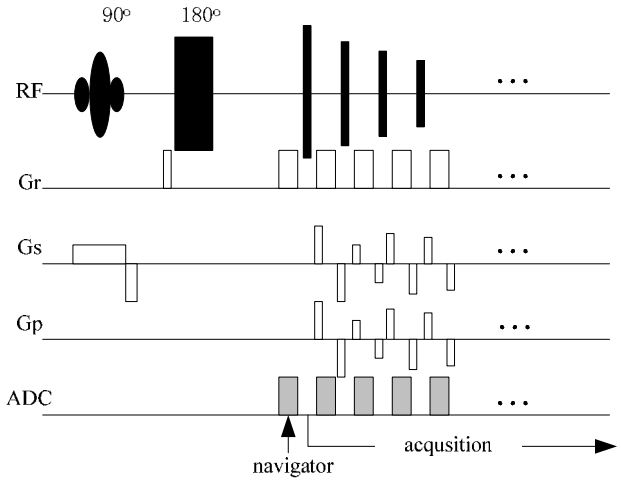

Fig 1. Sequence diagram of the navigated SPACE sequence

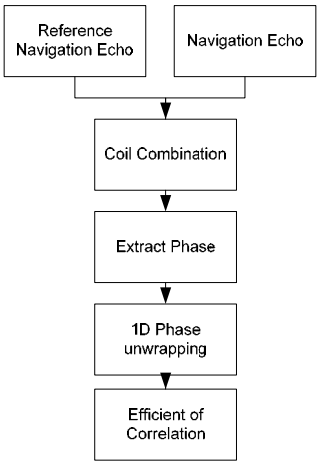

Fig 2 motion determine algorithm

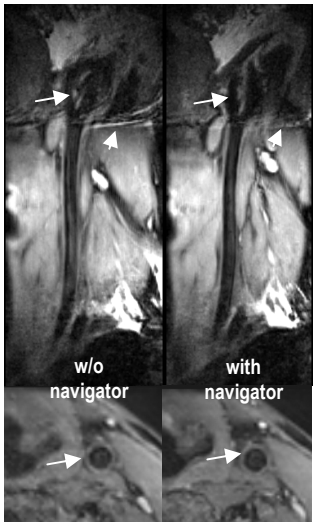

Fig 3. Volunteer Exam results

Results

Carotid exams are performed on 2 Volunteers. During each scan, volunteers are told to swallow 4 times via intercom. With navigator, trace information is written into log each time a throat motion detected. Confirm by savelog inspection, all movements are recognized successfully. 10 – 20 additional echo chains are re-acquired in the navigated case, the measurement time in increased by 10s around.

A compare is made between images with and with out navigator. An MPR is made since the data is isotropic. In the un-navigated exam, motion artifact is notable especially at the carotid bifurcation, as motion from tongue root is usually dramatic. In the navigated exam, motion artifact is significantly reduced, and the contrast between vessel wall and lumen is increased.

Discussion and Conclusion

In carotid wall imaging, T1 weighted contrast is most commonly used, the echo chain duration of the sequence, 140ms in our test case, is typically shorter than a swallowing cycle. Therefore one navigator for each echo chain is enough for the motion detection. In the case of long-TR application, two navigator echoes can be put to the front and rear of each echo chain for better motion control.

Cross-paired navigator can also have the effect of motion detection [4]. Nevertheless, a manual positioning of the navigator is required. Also the navigator bar will excite part of the tissue and leave a dark band in the final image. Our work with phase navigator [5] does not track tissue or object boundaries. The positioning and the dark band are therefore avoided.

Swallowing and throat motion degrades the clarity of vessel wall. If a double Inversion recovery (DIR) pulse or Flow-Sensitive Dephasing (FSD) [3] gradient is used for dark blood, motion will further reduce the image quality [4]. With this motion-monitored paradigm, such problems can be reduced.

Reference:[1]Ye Qiao etc al, JMRI 2011; 34:22–30. [2]Niranjan Balu etc al, JMRI 2008;27:918–924 [3]Zhaoyang Fan etc al, JMRI 2010;31:645–654 [4]Lindsey A. Crowe, JMRI 2005;22:583–588 [5] A. Stemmer, ISMRM2010# 5022