3D SPACE Arterial Wall Imaging with Prospective Self-Gating for Motion Compensation

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Introduction: Carotid vessel wall imaging using 3D variable-flip-angle TSE (SPACE, Siemens) has recently been shown to outperform 2D TSE in spatial resolution and coverage, time and SNR efficiency, and flexibility of retrospective visualization [1]. However, relatively long imaging time renders this technique more prone to image artifacts caused by motion such as swallowing. Navigator echo acquired through the epiglottis was previously used to eliminate data acquired during swallowing [2], but it requires scout scans and precise placement of the navigator bars. In this work, we investigated the use of a self-gating method in 3D SPACE acquisition and implemented real-time motion detection and data acceptance or rejection.

Theory: Fourier transform of central *k*-space line is a 1D projection of the entire imaging volume along the readout direction [3]. Bulk motion of the imaging volume can be detected by evaluating the projection profile changes during data acquisition. In SPACE imaging, the projection (self-gating line) is acquired once per TR (echo train), and a cross-correlation coefficient between each projection profile and the reference profile acquired at the beginning of the scan is calculated. Data acquired in each TR that have correlation coefficients of less than a pre-defined threshold will be rejected and re-acquired in next TR.

Figure 1. Self-gated SPACE sequence diagram. SG: self-gating

Materials and Methods: A clinically available SPACE sequence was modified by adding a self-gating readout prior to the imaging echo train (Fig. 1). One self-gating line was acquired at the beginning of each TR. The self-gating lines acquired during the first 5 TR intervals were used to create a reference projection. Online processing of the self-gating signal was performed during each TR, including Fourier transform, cross-correlation (CC) with the reference projection profile, and acceptance logic. The CC threshold used in the cross-correlation analysis could be designated via the system's user interface. Data with motion detected was saved as well and retrieved retrospectively to reconstruct a reference image.

Three healthy volunteers were scanned using a 3T MR system (MAGNETO Trio, Siemens AG Healthcare Sector, Erlangen, Germany). The self-gated SPACE was first applied as a brief scout scan to enable selecting an appropriate threshold value, and then performed as a 3D vessel wall imaging. For evaluating the feasibility of this method, subjects were given instructions during scanning to voluntarily swallow once every half minute. The imaging parameters include: TR/TE = 1600/153 ms, echo train length = 66, coronal acquisition with readout in superior-inferior, FOV = 150x136 mm^2, matrix=192x174, 64 partitions, slice thickness = 0.78 mm, acquisition time = 5.2 min without motion, parallel imaging (GRAPPA) acceleration factor = 2, average = 2, bandwidth = 457 Hz/pixel, spectral-selective fat saturation.

Results: In all three subjects, swallowing was detected with a CC threshold of 0.995 (Fig. 2a). The projection when motion was present deviated substantially from the reference projection (Fig. 2b & 2c). Swallowing motion resulted in severe artifacts, such as ghosting (solid arrow), vessel wall blurring (arrowhead), and residual signal in the lumen, on non-gated images (Fig. 3), which were considerably reduced by self-gating procedure.

Conclusions: Preliminary results have demonstrated the feasibility of self-gating technique used in 3D SPACE for motion compensation. Further evaluation of the effectiveness of this method in practical MRI is warranted. In addition, self-gating may have the potential to be combined with other 3D acquisition such as SSFP.

References : 1. Fan Z, et al. ISMRM 2008 Abstract.3610 . 2. Crowe LA, et al. JMRI 2005; 22:583-588. 3. Larson AC, et al. MRM 2005; 53:159-68
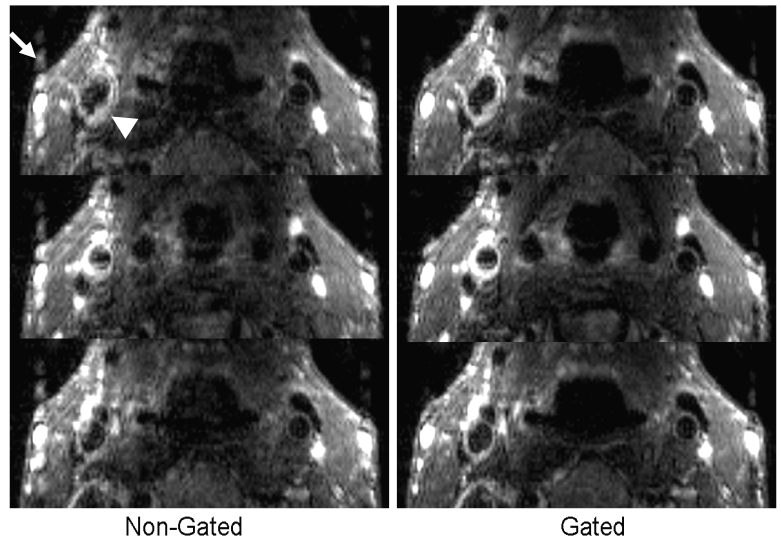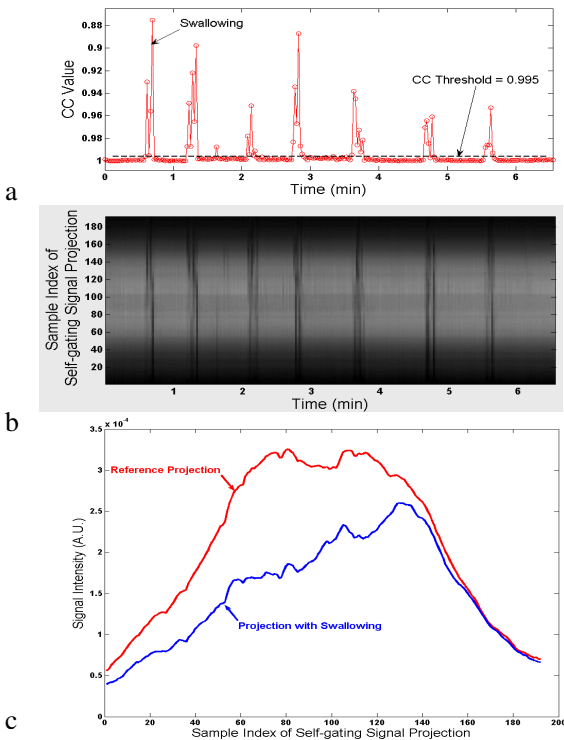
Figure 2. (a) Correlation coefficients calculated between each projection and the reference profile; (b) Self-gating projection signals of the neck as a function of time; (c) Two projection signals acquired with and without swallowing, respectively.

Non-Gated   Gated

Figure 3. Three cross-section reformatted images from non-gated and self-gated SPACE imaging. Note that images suffered from severe motion artifacts due to swallowing without self-gating motion compensation.