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Poster presentation

Motion correction using coil arrays (MOCCA): applications to CMR

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Introduction

Cardiac and respiratory motion compensation in CMR remains challenging. We present a novel motion correction method (MOCCA) based on additional motion-sensitive signals acquired from multiple coil arrays to extract and compensate for cardiac or respiratory motion. With multiple-element coil arrays, each coil has localized sensitivity profiles. Motion of the object relative to the coils causes variations in the received signal. The amount and polarity of those variations are different between the coils depending on the geometric configuration of the coil array. These coil-dependent motion-related signal variations are used in MOCCA for cardiac or respiratory motion compensation in CMR.

Theory

Figures 1 and 2 summarize the proposed MOCCA algorithm for cine segmented acquisition. The k-space center line (no phase-encoding) was acquired at the beginning of each imaging segment for all cardiac phases. The non-phase-encoded lines (magnitude only) from all coils were stacked into a column vector (MOCCA-echo). In the basic form of MOCCA, the correlation-coefficients between the MOCCA-echoes and a reference MOCCA-echo are calculated. These CCs represent the motion-related signal change and are used in self-gating in cardiac MRI.

Methods

[Cardiac Self-Gating]

Left ventricular short-axis cine data was acquired on healthy adult subjects using a breath-held retrospectively ECG-gated SSFP sequence to demonstrate the extraction of a cardiac self-gating signal. The algorithm for deriving the self-gating signal is shown in Figure 1.

[Respiratory Self-Gating]

Free-breathing cine imaging was performed using a retrospectively ECG-gated SSFP sequence with four sequentially acquired averages as shown for cardiac self-gating. A MOCCA-echo reference, which corresponds to the end-expiration, is calculated as follows: the average of the cross-correlation between the MOCCA-echo in each heart-beat with the corresponding echo acquired in all remaining heart-beats is calculated. The MOCCA-echo with the maximum calculated average corresponds to the end-expiration respiratory cycle, and is selected as the MOCCA-echo reference. The subsequent self-gating step is shown in Figure 2. For comparison, the conventional breath-held cine imaging was performed on the same subject.

Results

Figure 3 shows typical cardiac self-gating signals derived using MOCCA and cine images reconstructed using MOCCA in comparison with conventional ECG-triggering. Figure 4 shows example cine images acquired with

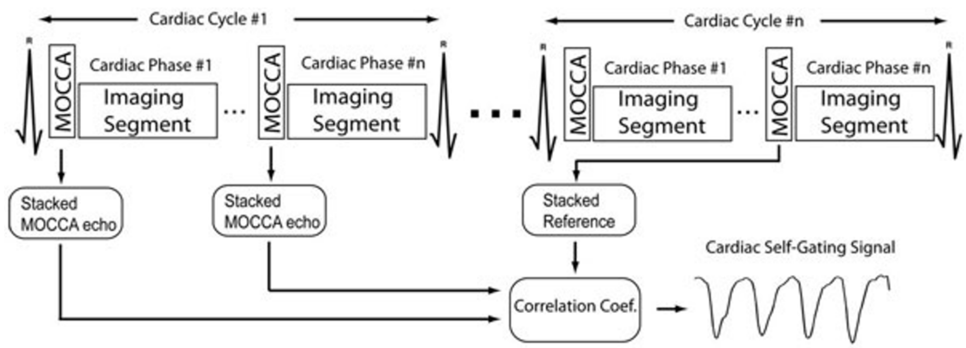

Figure 1
MOCCA cardiac self-gating. The correlation coefficient between the reference, which is chosen as the last acquired MOCCA-echo, and all other MOCCA-echoes was used as a cardiac self-gating signal. The 30-point moving averaging of the self-gating signals is subtracted to remove baseline drifting.

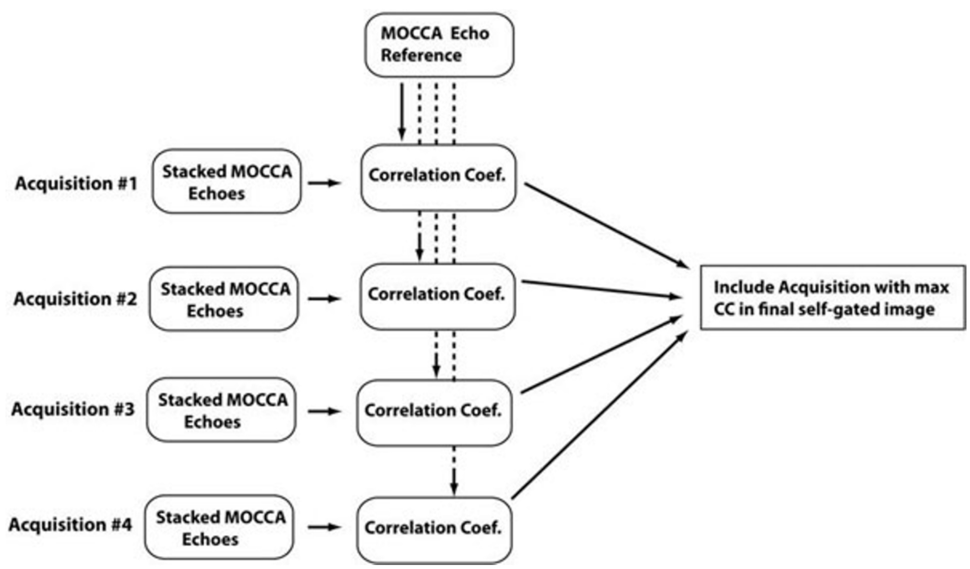

Figure 2
MOCCA respiratory self-gating. Stacked MOCCA echoes acquired prior to each cardiac phase are compared to a reference echo by calculating the correlation coefficient (CC). The reference, which corresponds to an echo acquired at the end-expiration, is calculated as follows: the average of the cross-correlation between the MOCCA-echo in each heat-beat with the corresponding echo acquired in all remaining heart-beats is calculated. The MOCCA-echo with the maximum calculated average corresponds to the end-expiration respiratory cycle, and is selected as the MOCCA-echo reference. Subsequently, in self-gating step, for each imaging segment, the acquired data following the MOCCA-echo with highest correlation coefficient among four acquisitions is included in the final respiratory self-gated cine image. MOCCA-reference calculation and data selection among four averages as described above is repeated for each cardiac phase.

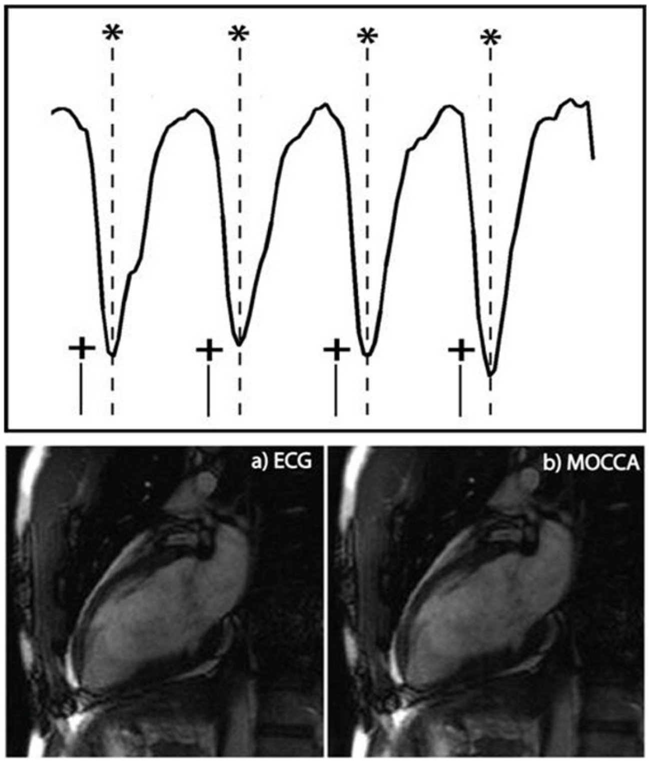

Figure 3
(top) Representative cardiac self-gating signal derived using MOCCA (*) and the ECG R wave position (+0. (bottom) Long axis images reconstructed using traditional ECG triggering (a) and using MOCCA self-gating (b).

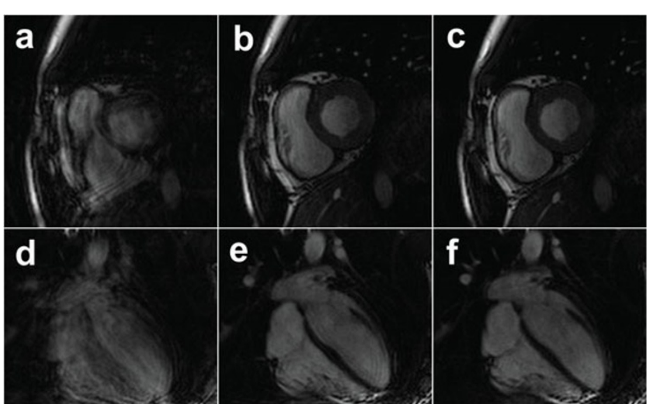

Figure 4
Example cine images in short axis (a, b, c) and four-chamber views (d, e, f). The free-breathing images without motion correction (a, d) is corrupted by respiratory motion, related artifacts and blurring. These are removed in the MOCCA cine images (b, e). Relatively similar image quality can be observed between the MOCCA images and the reference images (c, f) acquired using the conventional breath-held cine MRI.

free breathing (a, d), MOCCA (b, e), and breath-hold (c, f).

Conclusion
We presented a novel cardiac self-gating method that can be used to measure and compensate for cardiac or respiratory motion. Though presented for cardiac applications, the approach could be adapted to other anatomic regions in which motion compensation is important.