Motion Measurement using Echoes during SSFP dummy cycles for Whole-Heart MR Coronary Artery

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Introduction:

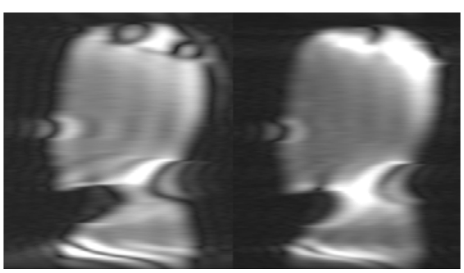
In non-contrast-enhanced whole heart MR coronary angiography (HW-MRCA), the respiratory motion correction using 1D navigator echoes was widely used. In order to suppress motion artifacts in a short acquisition time, a wide window of navigator gating and motion information are required. In this study, a new 2D navigator projection method is proposed using echoes data from the dummy cycles of balanced SSFP to estimate cardiac motion.

Methods:

The sequence applied for HW-MRCA is ECG-gated segmented balanced SSFP using Cartesian sampling with T2 preparation and fat suppression pulses. Imaging plane is acquired on sagittal and the read-out direction is superior-inferior (SI). During about 20 dummy cycles of SSFP, phase encoding (PE) gradients are added along the anterior-posterior (AP). After the dummy cycles, actual imaging data are acquired. The echo data from the dummy cycles are reconstructed, and then a 2D projection of the imaging slab is obtained from every cardiac cycle until all of segmented k-space is filled. From these projections, respiratory translations are estimated. Typical parameters were 256 read-out, 16 phase encoding steps, a 28-cm FOV, and 5.2/2.6 TR/TE. Since various SSFP startup methods affect transient response of signal, two types of SSFP startup methods, half alpha [1] and the linear ramp [2], were evaluated. Both startup preparations were performed using 16 pulses. The conventional 1D navigator method on diaphragm was also studied to compare the estimated translation with the 2D projection data method from dummy cycles.

Results and Discussion:

Figure 1 shows the sagittal 2D projections of a head-shaped phantom acquired using a) the half-alpha startup and b) the linear ramp method. Notes that signal distribution and artifacts are different between the two methods, especially banding artifacts, i.e. regions with large magnetic field inhomogeneity. The projection of the linear ramp method (Fig. 1b) shows better image quality to trace the shape of the phantom, as compared to that of the half-alpha method (Fig. 1a). Projections of a volunteer heart were acquired using the linear ramp method, as shown in Fig. 2. Translation in the SI and AP directions was estimated around the apex of the heart from the 2D projection images using cross-correlation and plotted against the diaphragm position calculated from the conventional 1D navigator, as shown in Fig.3. The SI translation hysteresis was clearly shown, as reported by ref. [3]. Exact respiratory phase can be determined by combining the SI translation with the diaphragm position. The local motions were estimated using several regions of the projection. The amount and hysteresis of the estimated motion differed depending on the location.



a) b)

Fig. 1 Projections of a phantom using a) half-alpha and b) linear ramp

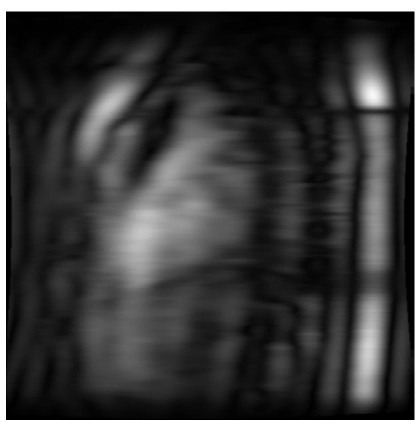


Fig. 2 Projection of a volunteer heart

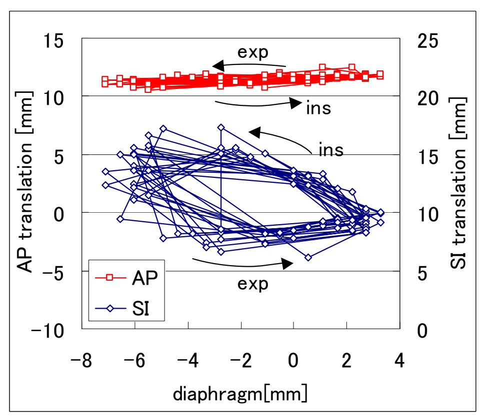


Fig. 3 Estimated 2D translation from the projections vs. diaphragm position calculated using the conventional navigator.

Conclusion:

2D projections acquired during SSFP startup phase are useful to estimate displacement of respiratory motion and to correct coronary MRA images retrospectively. More complex motion such as linear transformation will be estimated using the projection images.

References:

[1] Deimling M and Heid O, Proceedings of the 2nd Annual Meeting of ISMRM, p495, 1994

[2] Deshpande VS et al., Magn Reson Med, 49:151-157, 2003

[3] Manke D et al., Magn Reson Med, 50:122-131, 2003