METHOD FOR CORRECTING RESPIRATORY ARTEFACTS IN PARALLEL-ACCELERATED FIRST-PASS MYOCARDIAL PERFUSION IMAGING

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Introduction: Breath-holding is often applied for myocardial first-pass perfusion imaging (MPI), so that the same myocardial region is imaged through the first-pass. Breath-holding supports several advanced high-resolution techniques, but greater tolerance of motion (1) is desirable in practice. Alternatively, the patient may breathe gently during the first-pass, but this can induce aliasing artefacts due to inaccurate coil sensitivity calibration, particularly at higher acceleration factors and during stress imaging, for example due to adenosine induced hyperpnea. Coil sensitivity calibration for a series of single-shot images for MPI can be adapted for respiratory motion; However, auto-calibration ("integrated") methods (2) limit high acceleration, and temporal methods (3) can reduce SNR or cause temporal smoothing (4). This work evaluated a simple method of coil sensitivity calibration for free-breathing MPI aiming for high accuracy, even during deep breathing. While this method utilises a separate prescan, as in early parallel imaging work, the aim was to optimise a motion-tracking modification specific to MPI and evaluate its effectiveness.

Methods: Resting MPI (0.1mmol/kg GBCA) was acquired with the consent of 25 patients referred for late-enhancement imaging. The subjects were asked to breathe "slowly and deeply" (to mimic potentially increased motion due to stress) during MPI (Cartesian FLASH, GRAPPA rate 4, 48 measurements, 3 slices/cycle, 2.6x2.6x10mm). The new method obtained a series of prescans over the range of motion during free-breathing ("Multiple Free-breathing Prescans", MFP) before obtaining the free-breathing main MPI. For each frame of the MPI, a prescan at the closest respiratory position was selected for GRAPPA reconstruction of that frame. For the respiratory position selection process, an initial GRAPPA reconstruction of the MPI frame using any of the prescans was used, matching the anterior chest wall location to its location in the prescans through a semi-automatic image based algorithm. This enabled selection of the optimal coil prescan for each frame of a final GRAPPA reconstruction. The initial GRAPPA image of each MPI frame reconstructed using a Single Conventional Prescan is identified as "SCP", and was compared with the MPI frames reconstructed by MFP, using randomised blinded independent dual observer scoring of the parallel-imaging aliasing artefacts (0=none to 4=non-diagnostic). In 5 further patients, the MFP method was compared with other coil calibration techniques (SCP, Integrated, Temporal) at increasing acceleration (R=2 to 6) by retrospective subsampling of full k-space MPI acquisitions. The root-mean-square difference error (RMSE) over the FOV was used to compare accelerated against fully-sampled images.

Results & Discussion: Consensus artefact scoring of accelerated patient acquisitions showed significant ($p<0.02$; n=20; paired t-test) reduction by MFP (1.15±0.88) compared with SCP (2.40±1.31). Furthermore, retrospective subsampling at R=4 using MFP resulted in the lowest ($p<0.02$, n=5) mean RMSE (11.0±1.3) in comparison to Integrated (18.8±3.8), SCP (13.6±0.8) and Temporal (11.8±1.0) methods. The RMSE was consistently small by MFP (Fig 1), because it selected optimum coil sensitivity prescans for each MPI frame during deep respiration. SCP showed worsening artefacts at higher accelerations, which were suppressed by MFP (Fig 2). Improvement compared against a single coil prescan is a basic initial test; further work includes comparison (possible combination) with temporal methods, improved image-based position matching and application to advanced parallel MPI.

Conclusions: The correction of respiratory artefacts by MFP in the accelerated acquisitions demonstrated potential benefit by image-based selection of a matched prescan for free-breathing MPI.

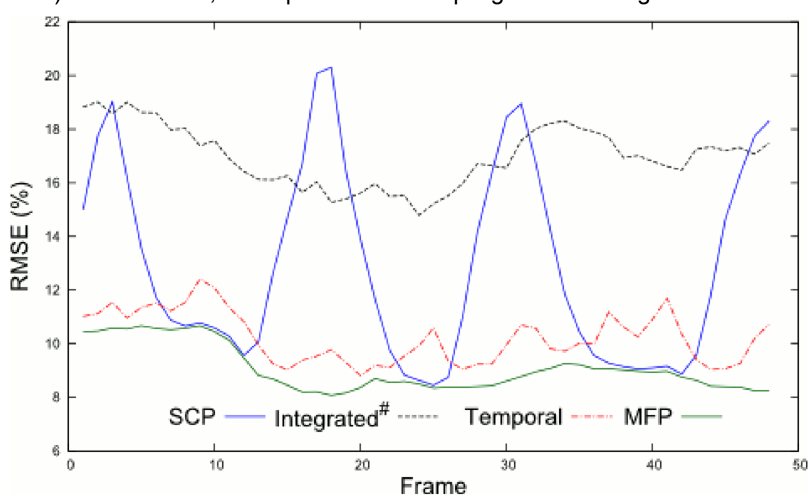

Fig 1 (above): Frame-by-frame RMSE of MPI series during deep respiration, using four coil-calibration methods. RMSE measure of parallel artefact and noise was consistently small by MFP selecting optimum coil prescans for each MPI frame. (#Integrated method had outer-reduction-factor and number of reference lines chosen to give the same true acceleration factor as in the other methods, R=4).

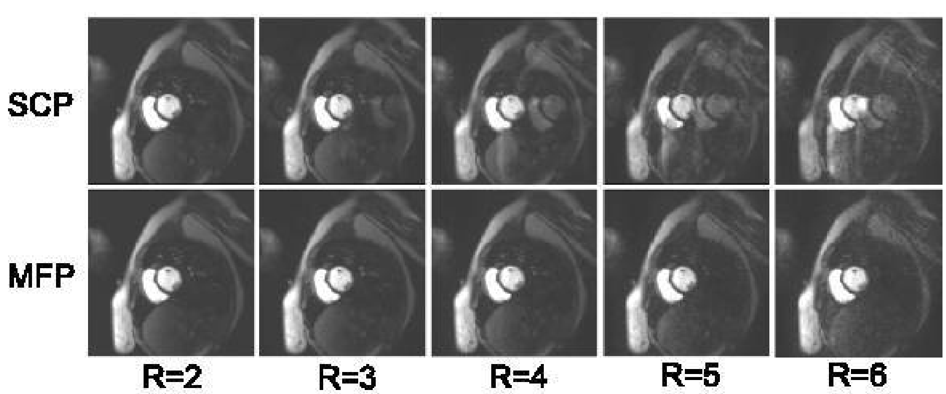

Fig 2 (left): Reconstruction at rates 2 to 6 (left to right) of a single MPI frame. Coil position mismatch by respiration causes artefact (SCP, top row) which is corrected using the MFP method (bottom row).

References: (1) Vitanis et al, MRM, 2011 (2) Jakob et al, MAGMA, 1998 (3) Kellman et al, MRM, 2001 (4) Blaimer et al, MRM, 2011