

# Real-Time Slice Tracking for Free-Breathing Cardiac MR Stress Perfusion after Physical Exercise

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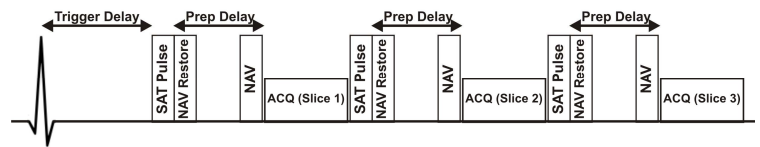
**INTRODUCTION** In patients with coronary artery disease, CMR stress perfusion using either pharmacological or physical exercise allows assessment of the functional significance of stenosis. In perfusion sequence, respiratory motion will adversely impact the image quality. To mitigate the respiratory-induced artifacts especially in accelerated k-t approaches [1], CMR perfusion is usually performed during a breath-hold. CMR perfusion after exercise is an alternative approach to the pharmacological stress with added benefit of providing physiologic and hemodynamic data. However, the respiratory rate and intensity increases after physical exercise, making breath-hold acquisition impossible. In this study, we propose to use an optimal leading navigator, placed immediately before data acquisition, for tracking of respiratory motion and updating the slice location in real-time for free-breathing CMR perfusion after physical stress.

**MATERIALS AND METHODS** In order to obtain a navigator with sufficient SNR for prospective slice tracking, a short 2D spatially selective RF pulse (flip angle=90°, duration=10msec, with a block shape spatial selection) is applied to restore the liver signal in the right hemi-diaphragm (RHD) area, directly after each saturation pulse in the perfusion sequence (Figure 1). Then, the navigator signal is measured, using a 2D pencil beam NAV positioned on the RHD, directly before starting each slice acquisition. The slice location was changed in real-time using the RHD NAV signal with a constant scale factor of 0.6. The time interval required for the restore pulse and navigator signal acquisition is calculated within the delay time between the saturation pulse and the data acquisition. All images were acquired on a 1.5T Philips Achieva using a 32-channel phased array coil (Philips Healthcare, Best, The Netherlands). To demonstrate the feasibility of the proposed sequence, CMR perfusion experiments were performed during free breathing with and without physical stress. For stress, a supine ergometer (Lode B.V., Groningen, NL), mounted at the end of the MRI tabletop, was used. After initial imaging for scan prescription, patients were slide out of the scanner bore to perform exercise. An exercise protocol was performed with initial ergometer resistance=25-50W (increase step=25W/2min, with ECG rhythm and blood pressure monitoring) to reach a target heart rate of ~140 bpm. The table was then slid back into the magnet before initiating the post-exercise imaging. For CMR perfusion, a saturation-recovery GRE sequence (TR/TE/ $\alpha$ =2.6/1.3ms/50°, resolution=2.5x2.5x10 mm<sup>3</sup>, SENSE factor=2, 90 dynamics) was used to acquire 3 slices/heart beat.

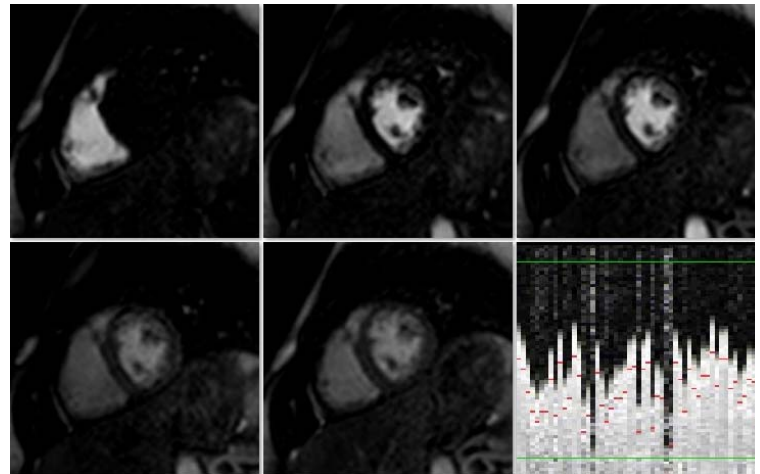
**RESULTS AND DISCUSSION** Figure 2 shows multiple dynamics from a representative slice in a subject who was instructed to take deep breath at different rate and amount to simulate the maximum motion that we may encounter in patients in post physical exercise. Figure 3 shows a single slice through different dynamics from a perfusion dataset acquired post physical exercise. The corresponding navigator signals in both exams are shown in the bottom right corner of each figure. The results show consistency in visualizing the same slice location throughout the scan. Figure 4 shows a sample slice from a patient with known coronary artery disease. The perfusion defect can easily be detected through the shown time frames.

**CONCLUSION** A novel real-time navigator-based slice tracking method was proposed to reduce the effect of the respiratory motion in CMR perfusion after physical exercise.

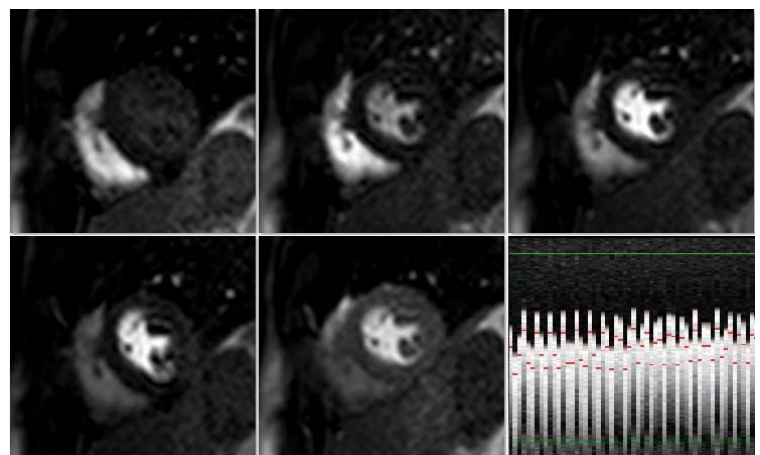
**REFERENCES** [1] Plein, MRM 2007.



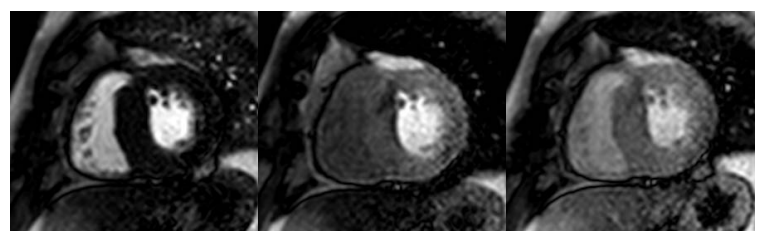
**Figure 1.** Pulse sequence diagram for slice tracking in CMR perfusion using the navigator signal. For each 2D slice acquisition, a 2D selective restore pulse is applied directly after the non selective saturation pulse. The navigator signal is then acquired before each acquisition.



**Figure 2.** Selected dynamics for a representative short-axis slice from a person who was asked to breath heavily to simulate the breathing pattern after a physical exercise. The corresponding navigator signal is shown in the bottom right corner.



**Figure 3.** Selected dynamics for a representative short-axis slice post exercise. The corresponding navigator signal is shown in the bottom right corner.



**Figure 4.** Representative dynamics for the same slice from a patient with known coronary artery disease. With the breathing motion compensated, the perfusion defect is clearly shown.