# Model-free slice following using the cardiac fat navigator: enhanced gating efficiency for 3D SSFP coronary magnetic resonance angiography

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**INTRODUCTION** Free-breathing coronary MRA (CMRA) typically uses a diaphragm navigator (NAV) for respiratory motion suppression, which is an indirect measure of the respiration-induced cardiac motion (1, 2). Slice tracking (3, 4) can be used to widen the acceptance window to improve navigator efficiency, but relies on a linear motion model to derive heart displacement. A linear correction factor of 0.6 is often used, despite high inter-subject variability (5). Subject dependent motion models have been proposed, but require a separate calibration (6). When the correlation between diaphragmatic and cardiac motion is poor due to hysteresis (7), the effectiveness of NAV gating and the slice tracking is not optimal. The cardiac fat navigator (FATNAV) can provide a direct measurement of bulk cardiac motion using the epicardial fat signal and does not require the use of correction factors (6). This study investigates the effectiveness of cardiac fat navigator slice tracking without correction factors for free-breathing 3D SSFP coronary MRA.

**MATERIALS AND METHODS** Experiments were performed on 5 healthy volunteers (33 ± 11 years) at 1.5T (GE Excite HDx 14.0). Imaging parameters were: TR/TE/FA/BW = 4.7 ms/ 1.8 ms/ 90°/ ±62.5 kHz, resolution = 1.0x1.0x3.0 mm$^3$, 32 echoes per heartbeat. A custom navigator gating program was implemented to control data acquisition in real time using the Phase Ordering with Automatic Window Selection (PAWS) algorithm (9), which automatically selects the optimal gating window. The cardiac fat navigator consisted of a spectrally selective axial slab excitation combined with spatial saturation bands to suppress chest wall and a cranial-caudal readout using a 13 cm FOV. The real-time derived displacements were used to prospectively correct the slab position. Each coronary artery was imaged twice: A) using a 5 mm gating window with slice tracking and B) using a 2.5 mm gating window without slice tracking. Image quality was assessed by an experienced reader blinded to the imaging technique using a 5-point scale (0=non-diagnostic 1=poor 2=fair 3=good 4=excellent).

**RESULTS** All experiments were performed successfully. A total of $N = 9$ coronary artery segments were imaged (5 right (RCA), 2 left anterior descending (LAD), 2 left circumflex (LCX) coronary arteries). Figure 1 shows examples of free-breathing CMRA, demonstrating excellent image quality with negligible motion artifacts. Slice tracking provided similar image quality at higher navigator efficiency. While the difference in image quality score was non-significant (3.4 ± 0.5 vs. 3.4 ± 0.7), slice tracking resulted in significantly higher scanning efficiency (69% vs. 47%, P<0.0005). This represents a 45% relative increase in scanning efficiency or a 28% decrease in scanning time.

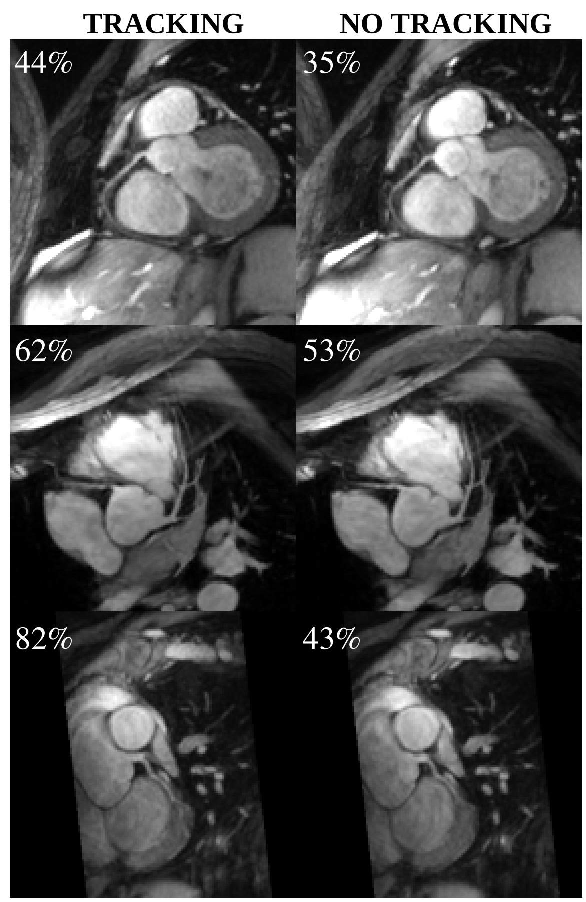


Figure 1. Reformatted images of the RCA (left), LAD (middle) and LCX (right) with slice tracking ON (left) and OFF (right). Slice tracking provided similar image quality in significantly shorter scan times. Insets are the corresponding scanning efficiencies.

**DISCUSSION AND CONCLUSION** The cardiac fat navigator combined with model-free slice tracking allowed an enlarged gating window to increase scan efficiency, without affecting image quality.

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