

# Preliminary Results of a Novel Prospective Respiratory Motion Correction Approach for free-breathing Coronary MR Angiography using a Patient-adapted Affine Motion Model.

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## Introduction

Coronary angiography is limited by cardiac motion as well as by breathing induced heart motion. Prospective respiratory motion registration helps to reduce blurring and ghosting artefacts. The purpose of the investigation was to test the feasibility of a novel patient-specific breathing artefact correction in a clinical environment for coronary MRA.

## Material & Methods

Fourteen healthy volunteers (average age 29, male and female) were investigated on a 1.5T Philips Gyroscan ACS-NT (23mT/m within 0.2ms) in combination with a vector-ECG and a 5 element-cardiac-phase-array-coil. For data acquisition of the right coronary artery (RCA) ECG-triggered, respiratory motion gated (3 navigators) 3D balanced-TFE (TrueFISP) sequences were applied (TR=6.2ms, TE=3.1ms,  $\alpha=60^\circ$ , FOV=270x270mm<sup>2</sup>, Matrix 272x218, Slice thickness 3mm, 10 slices). For homogeneity correction a reference scan (CLEAR) was used. The patient-specific adaptive technique was compared with the conventional slice-tracking approach, which is based upon a fixed correlation factor of 0.6 between diaphragm and heart [1]. For the patient-specific technique an extra measurement for calibration to an affine transformation model (rotation, shearing, scaling and translation) was performed prior to the coronary MRA scan [2]. To define trigger delay and acquisition window a multi heart phase cine scan was applied at the level of the right atrium. The heart motion was analysed with an automated cross-correlation method [3]. The standard slice tracking approach was performed with gating windows of 5mm and 20mm whereas the patient-specific respiratory compensation technique was used with 20mm. Three navigator pencil beams were placed on the dome of the right hemidiaphragm, the chest wall and the heart.

The acquired images were independently evaluated by two experienced radiologists in a blinded fashion. According to the American College of Cardiology/American Heart (ACC/AHA) a segmentation scheme was applied [4]. The RCA was subdivided into proximal, middle and distal segments. After segmentation the visibility of each coronary segment was graded in two grades (0 = not visualized, 1 = visualized). With an interactive tool ("soap-bubble-tool" [5]) the vessel length was measured. The signal intensities (S) and standard derivations ( $\sigma$ ) for blood and muscle were obtained by setting regions of interest (ROI) in the ascending aorta and respectively in the ventricular septum (RCA) and left ventricular wall (LM, LAD). CNR was calculated by  $CNR = 2*(S_{blood} - S_{muscle}) / (\sigma_{blood} + \sigma_{muscle})$ .

## Results

With all three sequences in all 14 volunteers the RCA was visualized in the proximal and middle segments. In one volunteer the distal segment could not be visualized with any of the sequences. A slight but not significant improvement in CNR was observed. With the standard slice tracking approach and gating window of 20 mm the visualized vessel length was shorter compared to the affine compensation model. Similar CNR and visualized vessel length was achieved with slice tracking with 5mm gating window and affine compensation at 20 mm.

Compensation model	Gating window /mm	Volunteers	Visibile RCA segments			CNR	Vessel length/mm
			proximal	middle	distal		
Factor 0.6	5	14	14	14	13	13.5 ± 1.2	113 ± 21
Factor 0.6	20	14	14	14	13	12.1 ± 0.7	100 ± 9
Affine	20	14	14	14	13	13.3 ± 1.1	112 ± 6

Table 1 Overview of results of standard slice tracking and affine motion compensation

## Discussion

The initial results obtained in this study indicate that similar results can be achieved with the affine approach using a bigger gating window as with the 5mm standard technique. An example of the standard and the affine approach with 5mm gating window and 20mm respectively can be seen in figure 1. It can be expected that the results for patients with cardiovascular disease will differ more than for healthy volunteers. Scan time reduction of around 50% will be an important factor as well. Further improvements can be expected by optimizing the calibration scan.

## Conclusion

Free breathing MRI-CA using a patient-specific adaptive model is a promising way to reduce respiratory motion artefacts. Patients will strongly benefit from scan time reduction.

## References

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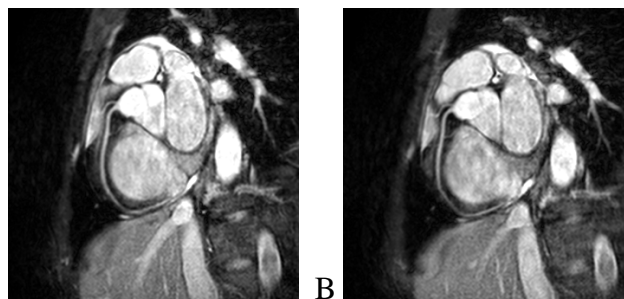


Figure 1  
RCA acquired with b-TFE sequence using (A) the standard gating with 5 mm gating window and (B) the affine compensation with 20mm gating window