Feasibility of 350 Micron Resolution Coronary MR Angiography at 3T

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Introduction:

Coronary magnetic resonance angiography (MRA) is emerging as a valuable non invasive tool for the evaluation of coronary artery disease (CAD) without exposing patients to radiation or potentially nephrotoxic contrast agents[1, 2]. However, to achieve maximum accuracy in detection of CAD, contemporary MRA methods may benefit from a higher spatial resolution to approach that of the current gold standard x-ray coronary angiography (0.15mm). To date the commonly used in-plane spatial resolution at 1.5T and using gradient echo sequences is ~$0.7 \times 1\text{x}3\text{mm}^3$[1]. A smaller voxel size of $0.4\text{x}0.4\text{x}2\text{mm}^3$ has been reported using black-blood fast spin-echo imaging but its clinical utility has not been established[3]. With the increased signal-to-noise (SNR) at 3T, early implementations have led to high SNR images with a voxel size of $0.6 \times 0.6 \times 3\text{mm}^3$. In the present study, we investigated the feasibility of acquiring coronary MRA with a voxel size of $0.34 \times 0.35 \times 1.5\ \text{mm}^3$ on a commercial 3T scanner.

Methods and Materials:

A total of 12 coronary arteries were imaged in 10 healthy adult subjects. Images of the right coronary artery (RCA, n=6), left main (LM) and left anterior descending (LAD) coronary arteries combined (n=3) and left circumflex artery (LCX, n=3) were acquired. All subjects were scanned on a commercial 3.0T MR scanner (Intera, Philips Medical Systems, Best, the Netherlands) using a 6-element cardiac phased-array receiver coil, and vector electrocardiographic gating (VCG). Initial scout scans were performed as previously described by Stuber et al[4]. This was then followed by a free-breathing navigator gated and corrected segmented k-space 3D gradient echo (TR=7.2ms, TE=2.4ms, α=20°, FOV=270mm, matrix=800) imaging sequence[4]. These 3D volumes had an effective slice thickness of 1.5mm (20-25slices) and an acquired in-plane resolution of ~350μm^2. In order to optimize volumetric coverage, scanning was performed in a double -oblique orientation parallel to the coronary arteries.. Fat saturation was employed and neither parallel imaging (SENSE) nor T2 pre-pulses were used. The soap bubble tool [5] was used for multiplanar reformatting, signal-to-noise (SNR), contrast-to-noise (CNR), vessel length and vessel sharpness measurements of each vessel.

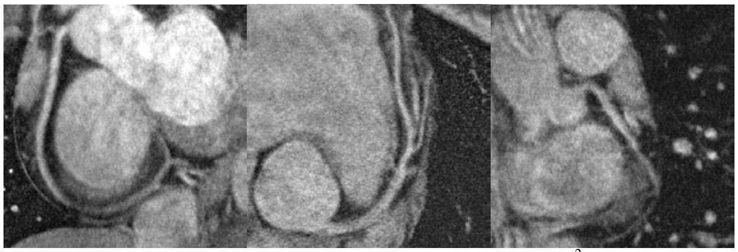

Figure 1: representative images with in-plane resolution of 350μm^2. (left) RCA, (middle) LAD, (right) LCX

	Length (mm)	SNR	CNR	Sharpness
RCA	97	18.9	9.2	22.9%
LAD	74	7.5	1.2	27.8%
LCX	42	18.0	7.4	25.6%
Mean total	77	15.0	6.5	24.8%

Table 1: Mean vessel lengths, SNR, CNR and sharpness

	Length (mm)	SNR	CNR	Sharpness
RCA	122	22	17	44%
LAD	83	34	19	49%
LCX	52			42%

Table 2: Mean vessel lengths, SNR, CNR and sharpness previously reported at 3T using voxel size of $0.7 \times 1 \times 3$mm [5].

Results:

High resolution ($0.35 \times 0.35 \times 1.5$ mm voxel size) images were successfully obtained in all of the 12 targeted vessels. The scan time for each 3D volume was approximately 7 minutes depending on the subjects' heart rate. When accounting for a navigator efficiency of 40%-60%, the total effective scan time ranged from ~12-16 minutes for each vessel. Mean qualitative image parameters are displayed in table 1. Example images of the RCA, LAD, and LCX are shown in figure 1.

Conclusion and Discussion:

This study demonstrates the feasibility of obtaining high resolution images of the coronary arteries with an acquired in-plane resolution of 350μm^2 (**figure 1**). This is approximately a 6-12 fold reduction in voxel size from previously reported studies at 1.5T and 3T[1, 4]. In comparison to SNR (12.5) and CNR (6.3) values reported for coronary MRA at 1.5T[6], these measurements for coronary MRA with twice the resolution (350 µm) at 3T are comparable . Thus can effectively improve resolution by factor of 2 (without loss in CNR) consequent to field strength difference is possible provided that technique is optimized for 3T. Not surprisingly, the measured vessel sharpness, CNR and SNR are reduced by approximately 50% compared to prior data obtained at 3T[4]..The visualized vessel length is also affected but less dramatically (table 2). Nevertheless, this is a step forward in approaching spatial resolutions attained by conventional angiography and coronary CTA. Further optimization of navigator techniques to improve motion suppression may allow for better utilization of the signal advantage at 3T which would advance coronary image quality at this hundreds micron level resolution.

References:

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