Local inversion spiral coronary vessel wall imaging: A comparison between 1.5T and 3T

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Introduction & Purpose: X-ray coronary angiography is the gold standard for the assessment of lumen encroaching coronary stenoses, but provides little information on the presence or magnitude of atherosclerotic plaque burden. From interventional studies it is known that approximately 60-70% of acute coronary syndromes are caused by < 50% luminal diameter stenoses.[1] Thus, a non-invasive approach for coronary plaque imaging would be desirable. Two-dimensional (2D) cross-sectional imaging of the right coronary artery (RCA) and left anterior descending (LAD) vessel walls at 1.5T have been reported using a dual inversion (Dual-IR) 2D fast spin echo[2,3] technique. This approach has been extended to three-dimensional (3D) in-plane imaging of the coronary vessel wall using a local inversion technique and a spiral imaging readout.[4-6] In this study we sought to implement and optimize the 3D in-plane local inversion pre-pulse technique on both a 1.5 and 3T system and to compare image quality and signal-to-noise ratio (SNR).

Methods: Free-breathing 3D coronary vessel wall imaging using a local inversion technique and spiral image acquisition was implemented. Ten healthy adult subjects were examined in supine position on a 3T Achieva clinical scanner using a 32-element cardiac coil. Five of these subjects were also imaged on a 1.5T Achieva clinical scanner using a 5-channel coil. (Philips Healthcare, Best, NL). The local inversion pre-pulse was applied immediately after the R-wave and cross-sectional and in-plane imaging data were acquired in mid-diastole. This allowed maximum blood exchange by taking advantage of rapid early systolic RCA flow whilst maintaining black blood properties. A coronary MR angiogram of the RCA was used to plan the in-plane local inversion vessel wall scans. A non-selective 180° inversion pre-pulse was immediately followed by a 2D selective 180° pencil beam local inversion pre-pulse (diameter=30mm), which was planned along the path of the RCA. To facilitate navigator detection on the right hemi-diaphragm, a 2D selective 180° navigator restore pulse was applied. The inversion time of approximately 600-800ms was sufficient to allow for complete blood exchange in the imaging volume and was followed by a spiral imaging sequence, which was preceded by a right hemi-diaphragmatic navigator (3mm gating window) and a chemical shift selective (SPIR) fat suppression pre-pulse. The imaging sequence consisted of 1 spiral interleave (flip angle=90°) every other heart beat. 3D in-plane images consisting of 5 slices (8 reconstructed) were acquired with a 23ms acquisition window and 24 spiral interleaves/slice with a measured slice thickness of 2mm. (FOV=220x220mm, TR/TE=29/2.2ms). Imaging time was approximately 8 minutes for a navigator efficiency of 50% at a heart rate of 60bpm. 2D cross-sectional images were also acquired with a 21ms acquisition window and 26 spiral interleaves/slice with a slice thickness of 8mm. (FOV=220x220mm, TR/TE=25/1.1ms). Imaging time was approximately 2 minutes for 50% navigator efficiency at a heart-rate of 60bpm. The in-plane resolution was set between 0.69mm to 0.76mm. ECG triggered f0 determination and shimming was performed during the quiescent phase of the cardiac cycle for all images. The number of cycles used for the local inversion was reduced from 16 to 8 at both field strengths to account for the increased B0 inhomogenity at 3T. Vessel wall thickness, length visualized, vessel wall sharpness, SNR(vessel wall), CNR(vessel wall/blood) were calculated for each image using Soapbubble Software (Philips Healthcare, Best, NL). Image quality was assessed by a blinded, independent, experienced observer and given a visual score from 1-4 (1. Not visible, 2. Fair, 3. Good, 4. Excellent) and an artifact score 1-3 (1. Severe, 2. Moderate, 3. No artifacts.)

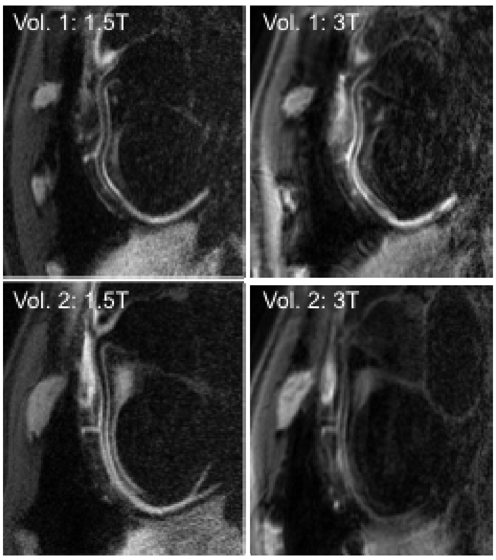
Results & Discussion: Representative images at 1.5T and 3T are shown in Figure 1. Imaging at 1.5T resulted in consistent image quality and good blood suppression. Images at 3T showed improved SNR but also exhibited more image artefacts and off-resonance blurring due to increased B0 inhomogenities. While SNR and CNR were improved at 3T, vessel wall thickness was higher and visualized vessel length and vessel wall sharpness were lower than at 1.5T (Table 1). As spiral imaging is sensitive to off-resonances e.g. inaccurate f0 determination or shimming, which are larger at higher fields strengths, the use of conjugate phase reconstruction (CPR) may improve image quality at 3T.

Conclusion: 3D spiral vessel wall imaging was successfully performed both at 1.5 and 3T. While SNR was improved at 3T, image quality was more consistent and artefact level lower at 1.5T. Although excellent coronary vessel wall images can be acquired at 3T, improvements in shimming, f0 determination and use of CPR seem to be essential to improve overall robustness compared to 1.5T.

References: *(1) Little WC. et al Circ. 1988;78:1157-66, (2) Fayad ZA et al. Circ. 2000; 102:506-510, (3) Botnar RM et al. Circ. 2000; 102:2582-2587, (4) Botnar RM et al. MRM 2001; 46:848-854, (5) Priest, AN et al., MRM, 2005. 54(5): p.1115-22 (6) Lagemaat MW et al, ISMRM. 2009(599.)*

Table 1: Comparison of in-plane coronary vessel wall images taken at 1.5T and 3T

	Vessel wall thickness (mm)	Length visualised (mm)	Vessel Wall Sharpness (%)	SNR (vessel wall)	CNR (Vessel wall/blood)	Image quality	Artefact score
1.5T	1.48 ± 0.14	5.46 ± 1.02	58.87 ± 4.97	24.62 ± 5.37	5.99 ± 2.63	3.75 ± 0.46	2.88 ± 0.35
3T	1.70 ± 0.19	3.63 ± 1.38	40.89 ± 11.94	27.12 ± 14.04	7.51± 2.95	1.94 ± 0.83	1.41 ±0.51



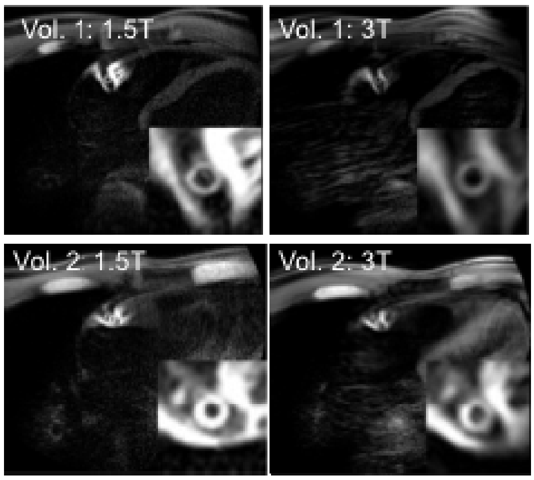


Figure 1) Reformatted 3D in-plane and 2D cross-sectional RCA images in two volunteers at 1.5T and 3T.