ACCELERATED SUB-MM WHOLE-HEART CORONARY MRI: COMPRESSED SENSING VS. PARALLEL IMAGING

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INTRODUCTION: Even with significant advances over the past decade, coronary MRI still faces major challenges, including lengthy acquisition time, low signal-to-noise-ratio (SNR), and limited spatial resolution. A higher spatial resolution will improve visualization of smaller vessel and could potentially increase diagnostic accuracy of coronary MRI. However, higher spatial resolution also results in lower SNR and increased acquisition time: A whole-heart (WH) coronary MRI with 1mm isotropic resolution has a nominal acquisition time of 16 mins assuming a heart rate of 70 bpm and 100% navigator gating efficiency, hindering its practicality. In this study, we sought to investigate whether an improved compressed sensing (CS) technique [1] can be applied to highly-accelerated sub-mm isotropic WH coronary MRI.

METHODS: IMAGE ACQUISITION: 7 healthy subjects (4 females, 30.3±12.1 years) were recruited for WH coronary MRI on a 1.5T Philips Achieva magnet with a 32-channel cardiac coil. A free breathing ECG-triggered SSFP sequence with T_2 Prep and fat saturation was utilized. A navigator placed on the dome of the right hemidiaphragm was used for respiratory motion compensation with a 5 mm gating window. An isotropic resolution of 0.9×0.9×0.9 mm^3 was used with a truncated RF excitation pulse with TE/TR/α=4.0/2.0/90°. Image acquisition was performed coronally with right-left encoding and FOV=290×290×100 mm^3. Saturation bands were used to reduce fold-over artifacts in the phase encode direction. 6-fold acceleration was utilized with random k_y-k_z undersampling for CS, and with uniform undersampling for SENSE (3x2 acceleration) [2]. For the CS acquisition, central k-space corresponding to 3% of the k-space was fully-sampled, and the edges were randomly undersampled. A modified radial k_y-k_z phase reordering was used to mitigate flow and eddy current artifacts [3].

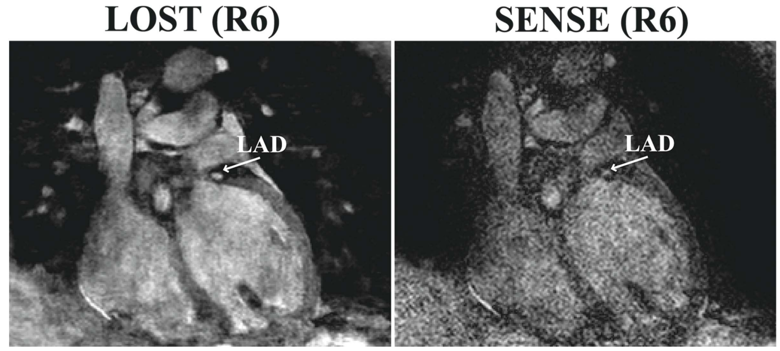

Figure 1: *Example coronal slices from 6-fold accelerated scans with random undersampling reconstructed with a B1-weighted LOST approach (left), and with uniform undersampling reconstructed with SENSE (right). A cross-section of the LAD is visualized clearly with the proposed technique, whereas noise amplification is apparent in the SENSE-reconstructed image.*

IMAGE RECONSTRUCTION: A B_1-weighted approach [4] was used for CS reconstruction, combining parallel imaging and an advanced CS reconstruction technique called LOST [1]. Coil sensitivity maps were generated from the fully-sampled central k-space. At every iteration: (1) The current combined-coil image estimate was thresholded using LOST, (2) The combined image was mapped to individual coils via multiplication with the sensitivity map of that coil, (3) Data consistency with the measured data was enforced, (4) The data-consistent coil images were combined using the coil sensitivity maps to generate the next image estimate. The algorithm was run for 25 iterations. Comparison images with SENSE were generated using the commercially available scanner software. Images were qualitatively scored (1=poor, 4=excellent) by a blinded experienced reader.

RESULTS: **Figure 1** depicts example coronal slices from a 6-fold accelerated scan using the two approaches. The left anterior descending (LAD) is visualized with the B_1-weighted LOST approach with random undersampling, whereas noise amplification is apparent using SENSE with uniform undersampling. **Figure 2** shows reformatted coronal images from another subject, showing the left circumflex (LCX) and the right coronary artery (RCA). The proposed approach allows visualization of both arteries, which cannot be tracked using SENSE due to high noise amplification in proximal LCX. **Table 1** depicts the subjective image scores for the two approaches. The proposed approach is significantly better than SENSE in terms of overall score (P=0.03) and perceived SNR (P=0.03).

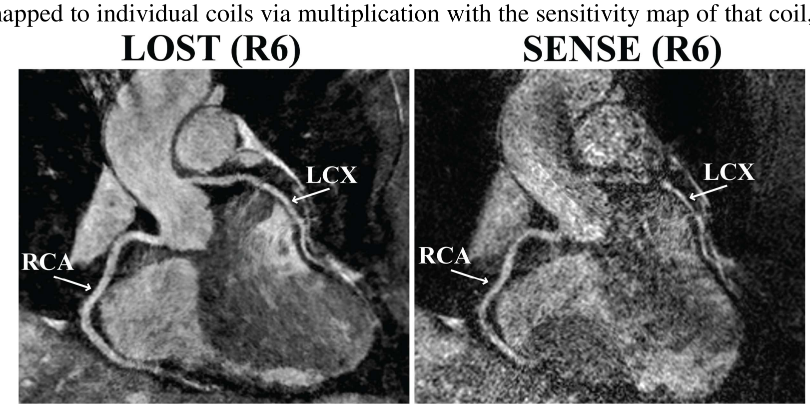

Figure 2: *Reformatted coronal slices from 6-fold accelerated scans. RCA and LCX are visualized clearly in the B1-weighted LOST approach with random undersampling (left). For SENSE with uniform undersampling (right), the RCA is still visualized albeit with noise amplification. However, the proximal LCX cannot be tracked due to the high noise level in the reconstruction.*

CONCLUSIONS: We have demonstrated that a B_1-weighted LOST technique may provide 6-fold acceleration for sub-mm WH coronary MRI, resulting in scan times of ~6 mins. Furthermore, for such low SNR applications, the proposed approach with random undersampling may be better-suited than parallel imaging with uniform undersampling.

	PROXIMAL			MID			DISTAL					
	RCA	LAD	LCX	RCA	LAD	LCX	RCA	LAD	LCX	LM	OVERALL	PERCEIVED SNR
SENSE	3.1±0.9	2.4±1.3	2.4±1.3	2.3±1.1	2.6±1.3	1.9±0.9	2.3±1.1	2.3±1.0	1.7±1.0	2.7±1.1	2.1±0.9	2.4±1.1
LOST	3.6±0.5	3.7±0.5	3.4±0.8	3.0±0.8	3.1±0.7	2.7±0.8	2.6±1.1	3.0±1.2	2.0±1.3	3.7±0.5	3.1±0.7	3.4±0.8

Table 1: *Subjective image scores for SENSE and B_1-weighted LOST approaches. LOST is significantly better than SENSE in terms of overall score (P = 0.03) and perceived SNR score (P = 0.03).*

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REFERENCES: [1] Akçakaya, MRM, 2011; [2] Pruessmann, MRM, 1999; [3] Akçakaya, MRM, 2012; [4] Otazo, MRM, 2010.