

Coronary Vessel Wall Imaging Using Reduced Field of View Double Inversion Recovery Fast Spin Echo

H. Shen¹, G. Cao², Q. Zhao³, L. Cheng³, and C. Yuan⁴

¹Applied Science Laboratory, GE Healthcare China, Beijing, Beijing, China, People's Republic of, ²Applied Science Laboratory, GE Healthcare China, Hongkong, Hongkong, China, People's Republic of, ³Department of Radiology, Chinese PLA General Hospital, Beijing, Beijing, China, People's Republic of, ⁴Department of Radiology, University of Washington, Vascular Imaging Laboratory, Seattle, WA, United States

Introduction

Double inversion recovery (DIR) prepared fast spin echo (FSE) imaging can be used to identify and characterize carotid plaque^[1]. Applying the same technique to coronary arterial plaque remains challenging due to cardiac and respiratory motion, and demands on high spatial resolution and SNR. Navigator gating^[2,3] is one feasible approach to reduce the respiratory motion artifacts, however the scan time could be lengthened remarkably by double gating, especially to those patients with irregular breathing pattern and the image quality often depends on the navigator's accuracy and efficiency. Breath-hold is another effective approach to control motion, however, the SNR and spatial resolution is largely limited by the single breath-hold time.

In this study, we developed a fast black blood coronary vessel wall imaging technique with reduced field of view (rFOV)^[4] and evaluated the sequence under breath-hold scenario.

Methods

The sequence modification was based on a 2D ECG gated DIR FSE. Reducing FOV without foldover artifacts in FSE imaging can be achieved by applying orthogonal gradients for the 90° excitation and 180° refocusing pulses. The DIR for blood suppression was employed by using a 1ms non-selective hard inversion pulse followed by a 8.6ms selective adiabatic inversion pulse. A 8.6ms adiabatic SPIR chemical saturation pulse was applied 100ms prior to the FSE data acquisition for fat signal saturation.

All experiments were performed on a 1.5T clinical MR scanner (EXCITE HD TwinSpeed, GE Healthcare, Milwaukee). Phantom study was conducted to verify the effectiveness of the rFOV excitation using a phased array receiving only head coil. Human studies (7 volunteer and 2 patients suspected with RCA stenosis by CT exam) were performed under breath-hold using an 8-channel phased array cardiac coil. Scan parameters were optimized for balancing resolution and SNR: effective TE = 43.6ms, TR = 2 R-R, ETL = 8, receiver bandwidth = ±20.8kHz, ESP = 5.6ms, TI = 600ms (for heart rate = 60 bpm), slice thickness = 4~6mm. For rFOV scan, the FOV was 12 x 3 cm². The acquisition matrix was 128 x 128, then zero padded to 256 x 256. The actual phase encoding steps were 32, as a result, scan time had been able to be reduced to ¼ of original full FOV scan. For subjects with heart rate = 60 bpm, the breath-hold time was 8 seconds (8RR) for 1 NEX and 16 seconds (16RR) for 2 NEX acquisition. 3D bright blood coronary artery images had been used for localizing the black blood scan. 2D cardiac cine images had been acquired for determining delay time.

Results and Discussion

The image of a 24cm full FOV scan from a phantom is shown in Fig. 1a and the image of 3cm rFOV scan from the same phantom is shown in Fig. 1b which clearly demonstrated that FOV on phase encoding direction can be effectively reduced without aliasing artifacts. The center line profiles extracted from full FOV (red line) and rFOV (blue line) were plotted in Fig 1c. Because the excitation profile in rFOV scan was not ideally sharp at the edge, the excitation region was designed to be slightly narrower than the FOV in the phase encoding direction.

Fig. 2 were the images from a volunteer. The rFOV black blood scan plane was perpendicular to the proximal RCA. The coronary vessel wall was depicted well. Fig. 3 were the images from a patient, (3a-3b) are MR images and (3c-3d) were reconstructed CT images at the corresponding plane. Plaque can be observed in both MR and CT images as indicated by red arrow.

rFOV approach in black blood imaging is time efficient which can be potentially used in both breath-hold and navigator gated scan. The saved scan time can be used for increasing NEX to gain SNR or increasing spatial resolution with a higher SNR cardiac coil.

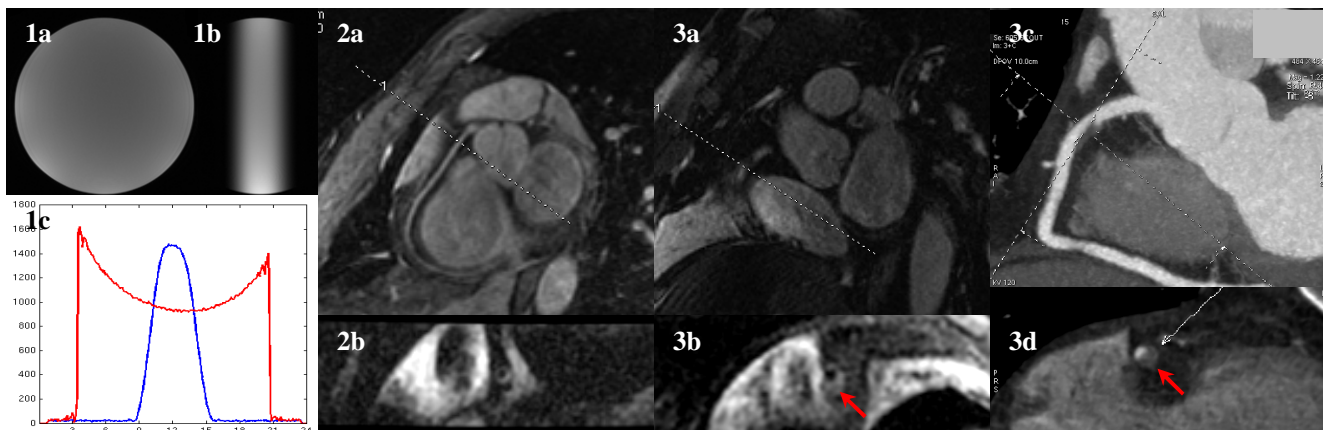


Fig. 1: Phantom images acquired by 8ch phased array head coil without surface coil intensity correction. (1a) full FOV scan; (1b) rFOV scan; (1c) the signal intensity profile from the center line: Red plot – full FOV, blue plot – rFOV.

Fig. 2: Coronary artery images acquired from a healthy volunteer. (2a) black blood imaging localization planed on a bright coronary artery image; (2b) T2 weighted vessel wall image with 6mm slice thickness.

Fig. 3: Coronary artery images acquired from a patient. (3a) black blood imaging localization; (3b) T2 weighted vessel wall image of the plaque with 4mm slice thickness. (3c) and (3d) are reconstructed CT images at the corresponding plane from the same patient.

References

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