

Phase Sensitive Dixon Inversion Recovery Imaging

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Introduction: Phase Sensitive Inversion Recovery (PSIR) is a commonly used approach for myocardial infarction detection and quantification. Benefited from the doubled dynamic range brought by phase sensitive reconstruction, PSIR technique is less sensitive to the choice of inversion time, eliminating the necessity of finding the accurate myocardial signal nulling time. Myocardial fat, however, can be a common cause of false-positive detection in PSIR cardiac images – both fat and scar present hyperintensive signals¹. Traditional approaches of suppressing fat signal can't be easily applied on PSIR images because of their incompatibilities with elevated local inhomogeneity and long acquisition echo train. Dixon based water-fat separation techniques² can separate fat from water images more reliably but they are not directly compatible with the existing PSIR acquisitions and may lead to extended scan time to acquire extra images. In this abstract, a recently developed reference-less phase-sensitive reconstruction technique (RAPID³) is combined with Dixon⁴ to achieve phase-sensitive water/fat imaging without sacrificing acquisition efficiency.

Methods: In phase-sensitive Dixon, two key things need to be considered in sequence design: an inversion pulse to take the advantage of the increased dynamic range from phase-sensitive reconstruction and multiple acquisition images for Dixon based fat signal saturation. Without losing generality, two-point Dixon acquisition scheme will be used as an example in this abstract. The flow chart of phase-sensitive Dixon reconstruction is outlined in Fig.1. In phase sensitive Dixon, the Dixon algorithm will be first utilized to separate water and fat images in a complex manner. What is also usually available is an inhomogeneity map that reflects the B_0 variation across images. In the following RAPID reconstruction, the B_0 image will be first applied to preprocess complex W/F images to eliminate large phase errors that may potentially challenge the phase-sensitive correction. Phase sensitive water and fat images will then be obtained from RAPID.

No cardiac patients were scanned due to the limited access to such patients at the present time. To evaluate the performance of the technique, abdominal images were acquired on 5 healthy volunteers instead. Images were acquired using 1.5 or 3T whole body scanners (Philips Achieva, R3.21, the Netherlands). After the scout scan, both phase sensitive Dixon and PSIR images with matched acquisition parameters were acquired. Detailed imaging parameters for phase sensitive mDixon were: IR TFE, TR/TE₁/TE₂ (1.5T: 7/1.74/3.46ms, 3T: 8/3.45/4.6ms), TI 500ms, FOV 300×300mm², resolution 2×2 mm², slice thickness 10mm, acquisition time 10-13s. PSIR was only done on 3T and the different parameters were: TR/TE 8/3.6ms, spectrally selective fatsat and scan time 16s.

Results and Discussions: Phase sensitive water and fat images were successfully obtained from the phase sensitive Dixon algorithm (Fig.2). Compared to the regular Dixon water output (Fig.2a), phase-sensitive reconstructed water image (Fig.2c) demonstrated significantly improved contrast between tissues with long T_1 (e.g. kidney) and short T_1 (e.g. liver) relaxation times. A phase sensitive fat image can also be generated but not shown here as fat magnetization has fully recovered to above zero at the 500ms TI.

When compared to regular PSIR with fat saturation, phase-sensitive Dixon demonstrated clear advantage on fat saturation efficiency (Fig.3). More homogenous fat signal removal is achieved nearly across the whole FOV, while residual fat signals were frequently identified on fat sat PSIR images (Fig.3b), as compared in arrows.

Only 2-point Dixon method was demonstrated in this abstract, 3 or more points of Dixon acquisition can be used, depending on the application and field strength, as they are also expected to be compatible with the technique proposed here. This is shown by 3-point measurements done at 1.5T, which are not shown here. Although phase-sensitive Dixon, shown here, relies on two image acquisitions to achieve fat sat, it can potentially provide higher acquisition efficiency than PSIR, as it does not require the reference acquisition. In this study, by acquiring two echoes in each TR, the scanning efficiency is even slightly higher than PSIR.

Conclusion: In this study, a phase-sensitive Dixon technique was proposed and tested *in vivo*. Taking the advantage of water/fat separation from Dixon and phase sensitive reconstruction from RAPID, this technique can provide full dynamic range images for both water and fat species, without compromising acquisition efficiency. It holds the potential to become a clinical tool for accurate myocardial scar detection.

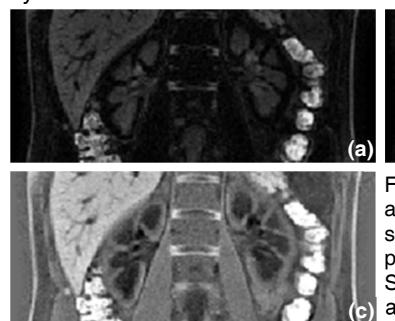


Fig. 2 Regular water (a), fat (b) images after Dixon reconstruction and phase-sensitive water (c) image obtained after phase-sensitive reconstruction. Significantly improved contrast was achieved after phase sensitive recon.

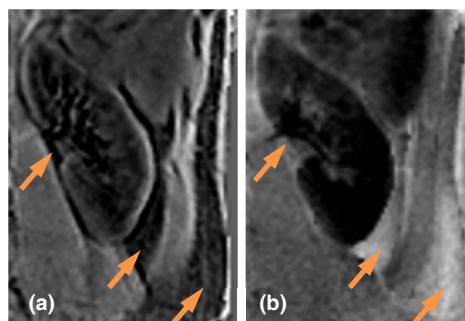


Fig. 3 Improved fat saturation in phase-sensitive Dixon image (a) when compared to PSIR with fat sat (b). Fat was more completely removed on phase-sensitive Dixon images (arrows).

References: 1. Kimura F et al. Radiographics 2010; 30:1587-602. 2. Dixon WT. Radiology 1984; 153:189-94. 3. Wang J et al. MRM 2013 (e-pub). 4. Eggers H et al. MRM 2011; 65:96-107.