

Water/Fat resolved Whole-Heart Dixon Coronary MRA: An Initial Comparison

Peter Börnert¹, Peter Koken¹, Kay Nehrke¹, Holger Eggers¹, and Peter Ostendorf²

¹Philips Research Laboratories, Hamburg, Germany, ²Centre of Preventive Medicine, Marienkrankenhaus, Hamburg, Germany

Introduction

Today's whole heart coronary MR angiography methods (CMRA) allow the entire coronary tree to be imaged in clinically acceptable scan times [1,2]. To improve coronary vessel visualization, fat suppression is typically applied. However, recent studies showed that cardiac fat can also have diagnostic value [3-6]. Fat around the heart is strongly associated with features of the metabolic syndrome (insulin sensitivity, triglycerides, cholesterol, risk of coronary heart disease [5]) and is associated with the presence of atrial fibrillation, its degree of severity and the outcomes after ablation [6]. Fat deposition in the myocardium can characterize chronic myocardial infarction and the risk of further complication [3]. Furthermore, the information about water / fat can help to clarify suspicious cardiac masses for instance to identify tumors or edema [4]. Recently, two-point Dixon protocols have been proposed to replace fat-sat based protocols for CMRA with no scan time penalty [7], providing a conventional CMRA (water) and an additional fat image that can be used for further analysis. In this paper a pilot study is reported to answer the question, whether water / fat-separated Dixon protocols are able to compete with the more conventional whole heart CMRA imaging protocols used in clinical practice.

Methods

Data were acquired in 24 non-symptomatic patients (male: 17, female: 7, mean age: 62.5 ± 13.5 (std)) on a 1.5T clinical scanner (Achieva, Philips Healthcare, Best, Netherlands) using a 32-element cardiac coil. Dixon CMRA was performed as an add-on to an established standard screening protocol comprising: morphology, cine (SA, LA, VC), whole heart CMRA, stress-perfusion and viability. Dixon CMRA was added after stress-perfusion in the patient's relaxation period before the final viability scan. Thus, Dixon data were acquired during the Gd-contrast washout. To facilitate a comparison under this condition, the order of the conventional / Dixon CMRA was reversed after 60% of the patients studied. Conventional magnetization prepared (REST, T₂Prep, fat-sat) whole heart CMRA using 3D bFFE ($\alpha:100^\circ$) was compared with a similar protocol without fat-sat, but using 3D two-point mDixon FFE imaging ($\alpha:15^\circ$), sampling two gradient echoes of reverse polarity after each excitation for chemical shift encoding [8]. The two protocols use the same pixel bandwidth (0.21 pixel), same voxel size $1.2 \times 1.2 \times 1.8 \text{ mm}^3$, almost the same TR (4.2/4.4ms) and cardiac sampling window (80/85ms). SENSE was used in two directions: for the bFFE scan ($R_{AP}=1.8$, $R_{SI}=1.4$) and for the mDixon ($R_{RL}=3.0$, $R_{SI}=1.4$). Both protocols used a comparable number of shots (211/252) which is 20% more for the mDixon due to a larger FoV chosen. Navigator gating with prospective motion correction (5mm acceptance window) and ECG gating (mid-diastole) was applied for both. Based on the SENSE unfolded mDixon images, iterative water/fat separation was performed [8]. All images were scored (according: 1: excellent - 5: very bad) by three different experienced readers. Furthermore, water SNR and CNR were compared in the arterial blood and in the myocardium estimating the corresponding noise in the lungs for reference.

Results and Discussion

All scans were successfully performed and yielded sufficient and consistent image quality. Figure 1 shows data of one selected patient for comparison. In this pilot study mDixon was found to have overall significantly ($p=0.0001$) better image quality (score: 2.0 ± 0.7) compared to bFFE (2.5 ± 0.8). The CNR, but not the scorings are influenced by the temporal order of both scans (before / after Gd administration) as shown in Tab. 1. Dixon should be performed after Gd administration in this particular protocol. The data show the potential of the mDixon approach compared to bFFE, which is known to suffer from the reduced signal inflow in 3D applications [9]. mDixon image quality is better due to reduced ghosting, as a consequence of the AP read-out vs. the RL read-out used in

bFFE and due to the better fat suppression. Some ghosting in bFFE also stems from not sufficiently suppressed chest wall fat. The major coronary vessels can be depicted clearly with the Dixon scan. No ΔB_0 - and/or ΔB_1 -problems are visible as seen for fat-sat. Due to the almost binary and very strong contrast in the fat images, the location of small epi-cardial vessel structures and tissue boundaries are sometimes easier to find in the fat image than in the water image. This can augment vessel reformatting (see Fig. 2), vessel characterization and can provide new and helpful diagnostic information. Furthermore, the fat images can be used for the quantification of the peri-/epi-cardial fat burden in 3D, which potentially represents additional diagnostic information of interest. Corresponding quantification has not been done in this study yet. In the patient cohort studied so far, no significant intra-myocardial fat deposition has been detected by means of mDixon.

Conclusion

Two-point Dixon protocols can potentially replace conventional fat-sat-based protocols for CMRA with no scan time penalty. The fat information additionally available can help to answer clinical questions in more detail. Further investigations are necessary e.g. with respect to contrast optimization.

References

- [1] Nehrke K, JMRI 2006;23:752. [2] Niendorf T, MRM 2006;56:167. [3] Goldfarb JW, MRM 2008;60:503. [4] Kellmann P, MRM 2009;61:215. [5] Sicari R, J Am Soc Echocardiogr 2011;24:1156. [6] Wong C, J Am Coll Cardiol 2011;57:1745. [7] Koken P, ISMRM 2011;117. [8] Eggers H, MRM 2011;6:96. [9] Nezafat R, JMRI 2008;28:1273.

	bFFE	2p Dixon
Image quality	2.5 ± 0.8	2.0 ± 0.7
SNR _{blood} (total)	42 ± 17	38 ± 15
SNR _{myocard} (total)	22 ± 9	18 ± 7
CNR _{blood/myocard}	20 ± 9	20 ± 10
CNR _{before Gd}	21 ± 10	13 ± 5
CNR _{after Gd}	17 ± 8	25 ± 10

Table 1. Comparison bFFE/mDixon. (mean \pm standard deviation)

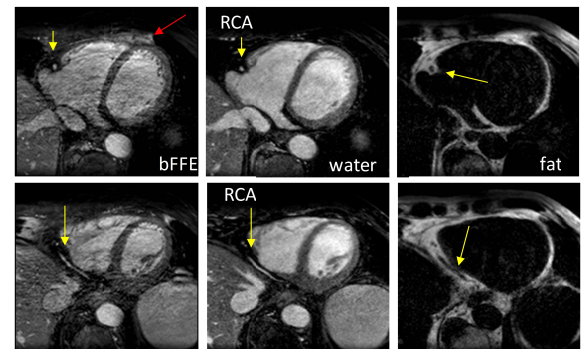


Fig.1. 3D whole heart CMRA. Selected slices of (left) bFFE, (middle) mDixon-water and (right) -fat in a patient (83 years). Note reduced ghosting due to the different phase-encoding direction and improved fat suppression in mDixon (red arrow).

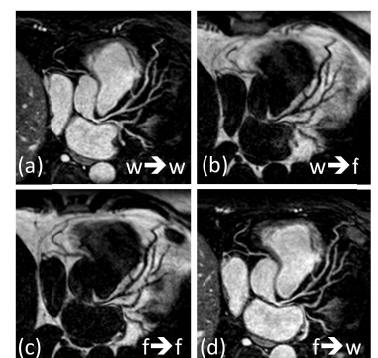


Fig.2. Coronary mDixon reformats (44 year patient). (a) reformat using the water image, (b) coordinates from (a) transferred to the fat data, (c) reformat using the fat image, (b) coordinates transferred from (c) to water data (d).