Comparison of Fat-Water Separation by 2D RF Pulse and Dixon method in Balanced Steady-State Free Precession

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Introduction: It is essential to eliminate the fat signal in b-SSFP imaging, however, the strict requirement of short TE and TR make this challenging. The Dixon method has been proposed for fat-water separation in b-SSFP by modifying the central frequency offset [1] or by dual-TR acquisition [2]. A 2D RF pulse excitation could also be used for fat-water separation based on the large chemical shift along the blipped gradient direction. Fat-water separation could be accomplished by shifting one excitation profile (fat or water) out of the FOV but maintaining the other one in the FOV. Compared to the Dixon method, the 2drf method has the advantage of single acquisition and no post-processing. In this study, both methods were evaluated for fat-water separation in b-SSFP.

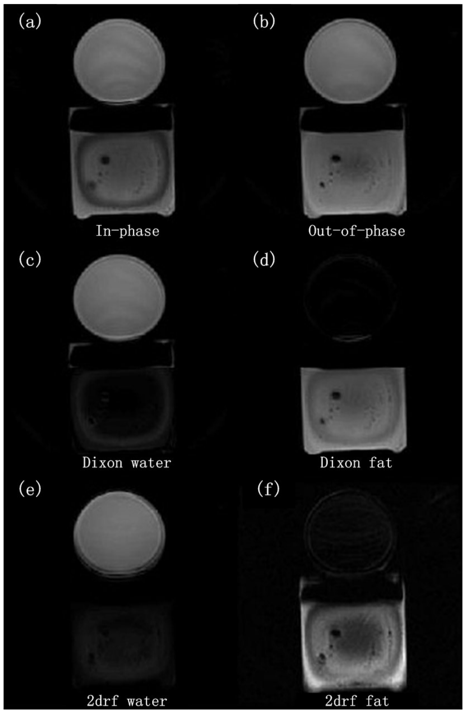

Fig.1.Fat-water separation comparison in phantom

Methods and Results: The design of the 2drf pulse is based on [3]. A 2drf pulse with 5 sub-pulses of 700us each was designed. The Dixon method is based on 2-point acquisition of in-phase and out-of-phase images. The two methods were implemented on a 3T GE Signa scanner with maximum slew rate of 150T/m/s and maximum gradient strength of 4G/cm. A circular water phantom and a cubic fat phantom made of vaseline was prepared. FOV=21cm, matrix=256*256, slice thickness=8mm, flip angle=35^{o}, bandwidth=125KHz were used for both methods. For the Dixon method, in-phase image (TE=2.1ms, TR=4.8ms) and out-of-phase (TE=0.9ms, TR=3.3ms) images were acquired using the GE product FIESTA sequence, as shown in Fig.1(a) and (b). Water and fat images obtained by the Dixon method are shown in Fig.1 (c) and (d). By adjusting blip gradient areas and applying appropriate phases for the 2drf sub-pulses, fat and water images (both TE=3.1ms, TR=5.7ms) were acquired separately, as shown in Fig.1 (e) and (f). The suppressed fat and water signal intensities are plotted in Fig.2 normalized to the unsuppressed out-of-phase image. The results show the average fat signal has been suppressed by 90% using the Dixon method and 80% using the 2drf method and the water signal was suppressed by 80% with the Dixon method and by 90% using the 2drf pulse. Comparison of these two methods when imaging a meat tissue phantom is shown in Fig. 3.

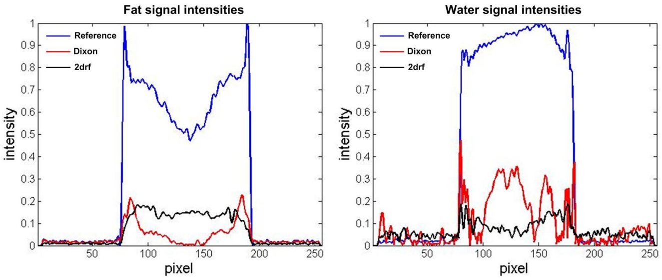

Fig.2. Plots of suppressed fat and water signal intensities

Discussion: Although the 2drf method has the advantage of requiring only a single acquisition, other performance factors need to be considered for application in b-SSFP. For example, though only one scan is needed, the increase in minimum TE and TR has an effect on scan time. The minimum TE is increased by about the half duration of the 2drf pulse, and the TR by the total duration. In our phantom comparisons, the TR of 5.7ms for 2drf method was still less than the sum of TRs (8.1ms) for in-phase and out-of-phase images. Due to the difference of TE and TR for in-phase and out-of-phase images, different banding patterns are combined in the Dixon fat and water images. In the 2drf method other banding artifacts may occur due to the increase of minimum TR. Although banding artifacts could be alleviated by CISS technique [4] for both methods, it is still necessary to carefully select TE and TR to avoid fat and water passband mismatch. Since water is always on resonance, TR selection would not be a big issue when the 2drf method is used for fat suppression. Using the method for water suppression would be a bit more difficult because the gradient blip areas and subpulse phases need to be accurately calculated to shift the excitation profiles and remove the residual water signal. The 2drf method is more dependent on hardware configuration than Dixon method. The 2drf method works better at 3T than 1.5T due to the larger off-resonance at higher field. In addition, high slew rate and high maximum gradient strength are also needed in the 2drf method in order to reduce the pulse duration for fast imaging.

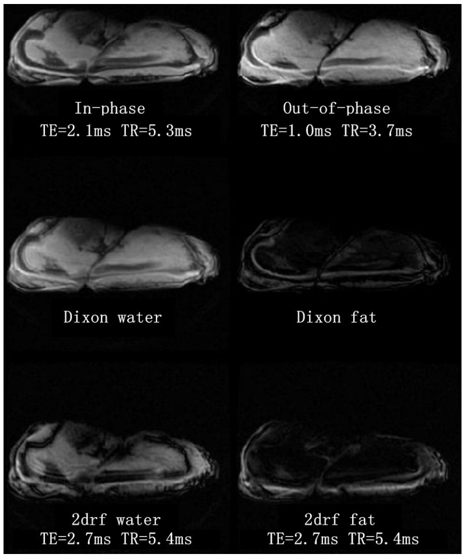

Fig.3 Fat-water separation comparison in meat

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References: [1] T-Y Huang et al, MRM 51:243-247(2004); [2] T-Y Huang, 5th ISMRM 1626 (2007)ISMRM; [3] J. Pauly et al, JMR 81:43-56 (1989); [4] J.W. Casselman et al, Am. J. Neuroradiol 14:47-57.