MR Fingerprinting : Fat-Water separation imaging

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Introduction

The concept of MR fingerprinting (MRF) has recently been introduced [1] to generate various quantitative parameter maps in a single image acquisition. In MRF the acquisition parameters such as flip angle, TR, and RF phase, are randomly changed to create an MR signal evolution in a series of images that is unique for each set of tissue parameters (e.g., T1 and T2). The tissue parameters are then found by matching the signal evolution in the image series with a pre-computed database using pattern recognition methods. So far, MRF has been successfully applied to generate maps of the parameters T1, T2, off-resonance, and spin density.

In this study, we apply the MRF method to additionally separate fat and water components in tissue.

Materials and Methods

As proposed in [1], a fully balanced MRF pulse sequence was implemented on a clinical 1.5 T MR system (Magnetom Symphony, Siemens). A series of 512 images was acquired, during which TR was varied between 15 ms and 40 ms, and the excitation flip angle was smoothly changed between 0° and 60° (Fig. 1). An inversion pulse was added in the first excitation, and the RF phase was alternated in every other repetition.

Nine fat-water emulsions were created fat fractions between 0% and 70% in volume. Vegetable oil and water were mixed with soap, Gd-DTPA (Magnevist, Schering) was added to lower T1, and the mixtures were heated after adding 3% agar. The emulsions were imaged with the MRF sequence with the following parameters: FOV = 220×220 mm², slice thickness = 2.8 mm, matrix size = 256×256.

For MRF data analysis a signal dictionary was calculated using the Bloch equations. In the calculations, T1 was varied between 100 and 2000 ms, T2 between 20 to 1000 ms, and the off-resonance from -300 to 300 Hz. The Orthogonal Matching Pursuit (OMP)[2] method was applied to compare measured signals with the dictionary. The iteration number of OMP is set to 3 to find the first 3 significant components containing a set of T1, T2 and off-resonance values and the corresponding weighting in each pixel. All components are assigned to two groups using fuzzy c-means according to their off-resonance value. Fat and water components can be identified as they have a 220 Hz off-resonance (i.e., 3.2 ppm at 1.5 T). For comparison, fat/water fractions were also determined from MRS data.

Results and Discussion

Figure 2 shows maps of the water and fat fraction in the emulsion phantoms. In the water map the large water bottle (top) can be clearly identified. A quantitative comparison between the MRF method and the spectral measurements is shown in Fig. 3. For fat fractions of more than 10% a linear increase of the MRF data is seen.

These preliminary results indicate that MRF can separate fat and water in addition to acquiring parameter maps of T1, T2. In the future we aim to use this application of MRF in the frequency domain to separate white and brown fat.
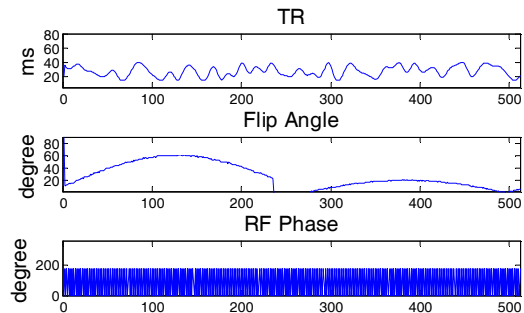

Fig.1 Imaging parameters TR (top), flip angle (center) and RF phase (bottom) as a function of image repetition.

Fig.2 The calculated fat and water fraction maps.
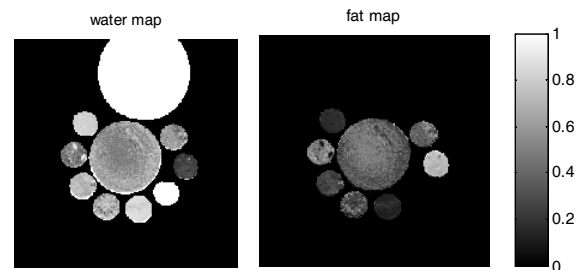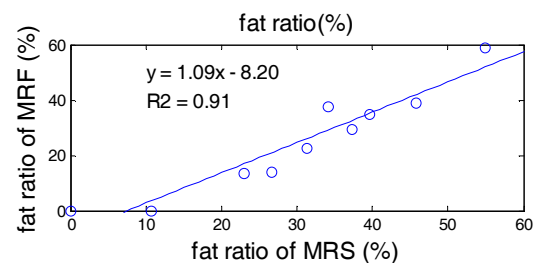

$y = 1.09x - 8.20$
$R2 = 0.91$

Fig. 3: The fat ratio from MRF compared with the fat ratio from MRS

Acknowledgements

References

[1] Ma D, et al. Nature. 2013; 495(7440): 187–192.   [2] Tropp JA, et al. IEEE Trans Inf Theory 2007; 53(12): 4655-4666.