Dixon Fat-Water separation by dual-TR bSSFP sequence

T-Y. Huang[1]

[1]Dept. of Electrical Engineering, National Taiwan University of Science and Technology, Taipei, Taiwan, Taiwan

Introduction

In the previous work of Scheffler et al.[1], it was shown that the balanced SSFP(bSSFP) images exhibit spin-echo-like behavior. This property led to the use of in-phase and out-phase images for Dixon addition/subtraction to separate fat/water in bSSFP by adjusting system resonance frequency in our previous study[2]. However, achieving phase change by altering system frequency (e.g. 80Hz in [2]), the bSSFP images turned out to be more sensitive to shimming condition (loss of 80Hz at the plateau of bSSFP frequency response). In this study, we proposed an alternative design of fat/water separation by dual-TR bSSFP sequence while maintaining the system frequency.

Materials and Methods

Figure 1 shows the phase behavior presented in our previous paper for muscle and fat at 3.0 Tesla as a function of TR and center frequency offset. Abbreviations "ip" and "op" represent in-phase and out-of-phase behavior for muscle and fat, respectively. Note that phase behavior of muscle and fat changes according to TR selection of bSSFP sequence for the on-resonance condition. Using this property, we can acquire bSSFP images with two different TRs to acquire in-phase and out-of-phase images for Dixon separation processing while maintaining system on resonance (i.e. off-resonace frequency=0Hz). Furthermore, the tolerance of shimming condition also varies according to TR. For example, an image acquired with TR of 4.55ms is anticipated to be in-phase while tolerating the shimming linewidth of about 200Hz (length of the right red bar). And out-of-phase image can be obtained by using TR of about 2.5ms while keeping similar shimming tolerance (length of the left red bar) as TR of 4.55ms. Combining the phase property of dual-TR and the fact that bSSFP signal is almost identical under the condition (TR<<T1, T2), Dixon fat/water separation can be achieved by post-processing with the bSSFP images acquired with two TRs (4.55ms and 2.5ms).

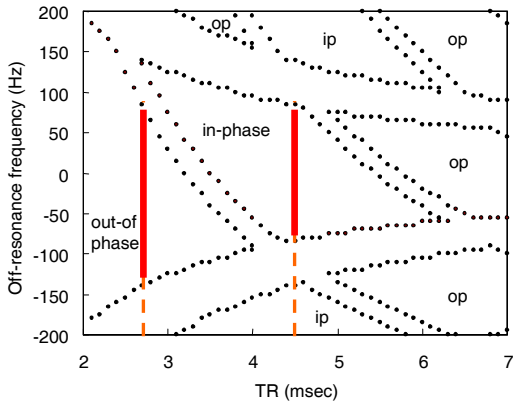

Figure1: phase behavior of fat and muscle as a function of TR and center frequency. The length of the red bars indicated the off-resonance tolerance for the selected TR.

Three subjects underwent three-dimensional dual-TR bSSFP scan on a 3.0 Tesla MR system(Siemens Trio, Erlagen, Germany) with imaging parameters (TR:4.55ms/2.8ms, TE=TR/2, Flip angle=24 degrees, matrix=192x128, FOV=360x360mm) and a T/R head-coil. A 3D volume covering lower calves were acquired. The acquired k-space raw data were transferred to personal computer with Matlab® system (Mathworks, Natick, MA, USA) for Dixon post-processing.

Results

Figure 2 shows the Dixon-separated fat(fig.2a) and water(fig.2b) images collected from one of the volunteers. Note that the subcutaneous fat and the bone marrow were almost separated from the muscle. Slight artifacts were found on the upper-end of the calf due to low signal outside the head-coil.

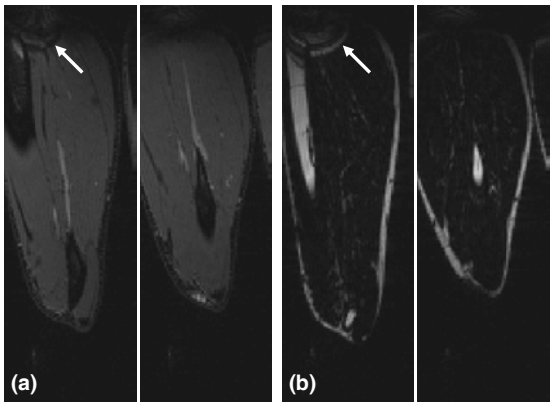

Figure2: Lower calf images obtained from one of the subjects (a) water component and (b)fat component ,separated by the proposed two TR scheme.

Discussion and Conclusion

In this study, a novel dual-TR bSSFP scheme was proposed for the Dixon fat/water imaging. Using two specially selected TR, the in-phase and out-of-phase phenomena between fat and water can be achieved while tolerating a wider off-resonance condition then the previous report[2]. In 3T, TR around 4.55ms was optimized for in-phase condition whereas TR less than 2.5ms was optimized for out-of-phase condition. However, due to system limitations, even RF length was already shorten by using 3D acquisition, TR of 2.8ms was the shortest possible repetition time we could achieve at this moment. Nonetheless, the preliminary results of the proposed technique still showed promising. Since the dual-TR scheme does not require the sophisticated sequence modifications, we thus anticipated that this method can be useful in clinical practice.

References

[1] Scheffler K, et al Magn Reson Med 2003;49:395-7. [2]Huang TY et. al. Magn Reson Med. 2004 Feb;51(2):243-7.