Dixon and Chimera: Two methods for fast separation of PFC compounds with small chemical shift difference

T. C. Basse-Luesebrink[1,2], T. Kampf[1], G. Stoll[2], and P. M. Jakob[1]
[1]Experimental Physics 5, University of Wuerzburg, Wuerzburg, Germany, [2]Neurology, University of Wuerzburg, Wuerzburg, Germany

Introduction

Perfluorocarbon (PFC) emulsions have been widely used for cell tracking studies [1,2] and many other biological applications [3]. In contrast to conventional ^{1}H contrast agents, ^{19}F markers provide unambiguous signal *in vivo* due to the low natural abundance of fluorine in living organisms. Furthermore, fluorine markers can possess a unique spectral signal, a further advantage of ^{19}F MR. Therefore, chemical shift imaging (CSI) methods can be used to distinguish between targets labeled with different fluorine markers. Certain PFC compounds, however, have only a small difference in the chemical shift and thus spectrally selective imaging or standard CSI methods are difficult to apply.

This study focuses on two alternative methods to separate PFC compounds with a small chemical shift difference: a TSE sequence based on Dixon's method [4], often used to separate fat from water signal, and a recently presented ssfp Chimera method [5] providing a specific off-resonant behavior.

Materials and Methods

For all experiments, two PFC compounds were used with a chemical shift difference of the main peaks of approximately 270Hz at 7T.

A two-point Dixon-TSE method was implemented on a 7T animal MR scanner. Two experiments were performed with the frequency set on-resonant on the PFC1 peak. In the second experiment, a delay of 3.9ms was implemented to acquire a phase difference of π between both PFC compounds. Imaging parameters: TE_{eff}/TR = 5000ms; TSE-factor = 48; FOV = 30x30mm; MTX = 48x48; NA = 1. Frequency selective datasets were calculated using phase sensitive summation and subtraction of both acquired datasets.

The Chimera method was implemented on a 7T animal MR scanner. Two experiments were performed, one on-resonant on the PFC1 peak and the other on the PFC2 peak. Imaging parameters: TE/TR1/TR2 = 3/6/12ms; FOV = 30x30mm; MTX = 96x96; NA = 20. TrueFISP experiments with the same parameters were performed. Since no second TR cycle exists in TrueFISP experiments, measurement time was half the time of the Chimera experiments. In the second TR cycle of the Chimera experiments, the magnetization is prepared in order to provide the specific off resonant behavior of the sequence [5].

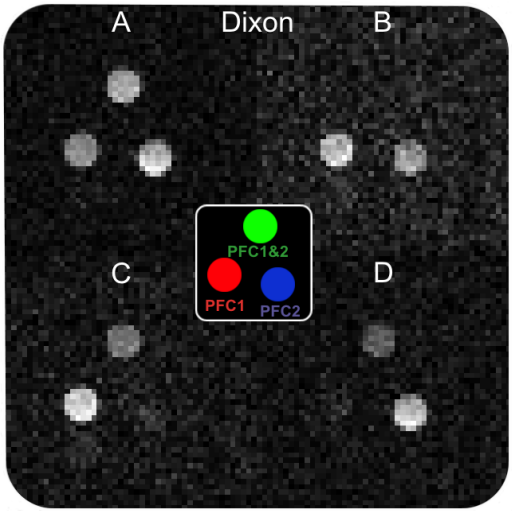

Fig. 1. Results from the Dixon experiments. A) In phase image, B) Out of phase image, C) PFC1 selective image, D) PFC2 selective image.

Results

Results from the Dixon experiments are presented in Fig.1. Fig. 1A shows the in-phase image and Fig. 1B the out-of-phase image. Since the tube with PFC1 and PFC2 contained equal amounts of both compounds, their signals canceled each other out in Fig. 1B. Only the PFC1 compound provides signal in Fig. 1C and only the PFC2 compound provides signal in Fig. 1D.

In Fig. 2, the results from the Chimera and TrueFISP experiments are displayed. While Chimera provides good signal cancellation of the unwanted signal (Fig. 2A and B), TrueFISP fails (Fig. 2C and D).

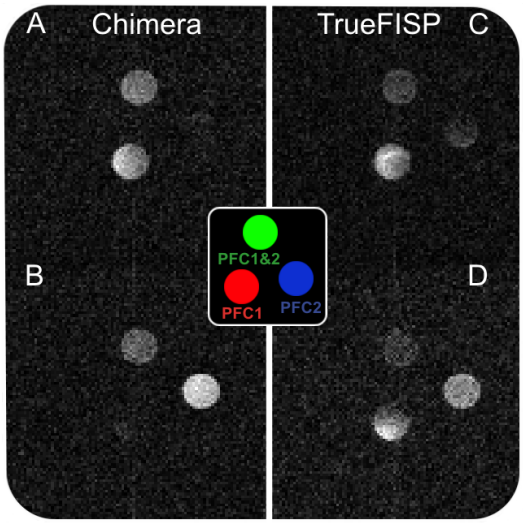

Fig. 2. Results from the Chimera and TrueFISP experiments. A) PFC1 selective Chimera image, B) PFC2 selective Chimera image, C) PFC1 selective TrueFISP image, D) PFC2 selective TrueFISP image.

Discussion

Both of the presented methods allow a distinct and fast separation of the examined PFC compounds *in vitro* at 7T. This is of special interest since both compounds have only a shift difference of ~270 Hz at 7T. The presented methods, however, both require a good shim, making the application of the proposed methods challenging for *in-vivo* experiments at high field strength. Furthermore, regarding the Dixon method, a correction of the B_0 shift and a more robust three-point Dixon method should be used for *in vivo* application.

References

[1] Ahrens et al., Nature Biotech., V.23, 983-987(2005)
[2] Partlow et al., FASEB J 21(8):1647-1654 (2007)
[3] Kodibagkar et al., Magn. Reson. Med., 24(7), 959-962(2006)
[4] Dixon et al., Magn. Reson. Med., 3, 454-462
[5] Bieri et al., Proc. ISMRM, V.17, 2767 (2009)

Acknowledgements

This work was partly supported by the Deutsche Forschungsgemeinschaft SFB 688 (B1, B3, B5) and the IZKF Würzburg Project F25.