The use of Fast Field-Cycling technique with Magnetization Transfer Contrast MRI

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Introduction: It is well known that the use of fast field-cycling (FFC) with MRI affords access to new contrast mechanisms [1]. In this work, we have applied the FFC technique to magnetisation transfer contrast (MTC) MRI. An off-resonance irradiation pulse (MT pulse) is typically employed for MTC experiments to saturate the bound protons, without directly affecting the free protons [2]. This is, conventionally, achieved with applying a constant specified RF magnetic field strength (B_1) over a range of RF offset frequencies (A and B in Fig. 1). However, B_1 is apt to decrease considerably with increasing offset frequency, particularly at low field, because of the limited bandwidth of the RF transmit system, in turn requiring B_1 calibration (Fig. 2). The range of offset frequencies available may be also limited. Here, we investigate an alternative off-resonance method, using FFC, which permits one to counter these complications. The MT pulse is applied at a constant frequency, but the external magnetic field (B_0) is altered by FFC in order to achieve off-resonance irradiation (C and D in Fig. 1). This method provides the same off-resonance effect as the conventional method, but without the complications.

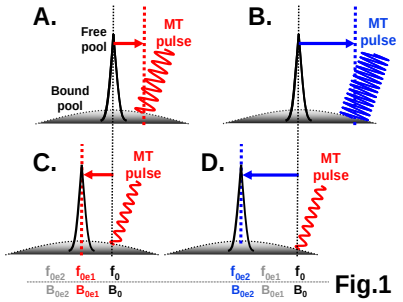

Fig.1

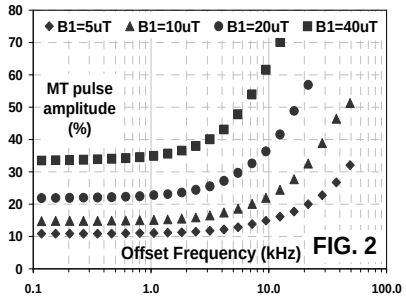

FIG. 2

Methods: Experiments were carried out using a whole-body field-cycling MRI scanner [3] (detection at 58.7 mT) with 1%, 2%, and 4% agarose gels (samples A, B and C in Fig. 4). In order to achieve an effective 11 kHz off-resonance irradiation, for example, the MT pulse was irradiated at 2.499 MHz but the applied magnetic field was set to 58.44 mT (equivalent to 2.488 MHz). The magnetic field was switched between the levels within 5 ms.

Results and discussion: The Z-spectra [4] and the MT ratios ($1\text{-}M_s/M_0$) obtained from both methods were compared. Fig. 3 shows the Z-spectra of a 2% agarose gel, where the difference between the results is less than 3%. Fig. 4 illustrates the images acquired by means of the FFC method (top row) and the conventional RF method (bottom row), with MT irradiation (right column) and without (left column). Due to the absence of bound protons in the control sample, the MT effect (or MT ratio) is almost zero while MT effects increase with increasing concentration of the agarose. This result also shows excellent agreement between the measurements obtained by the two different methods.

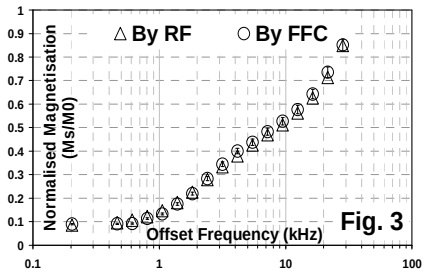

Fig. 3

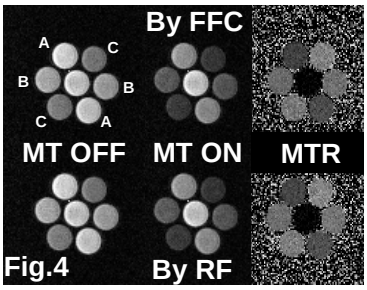

Fig.4

Conclusions: We have demonstrated the applicability of the new off-resonance technique for MTC MRI with the important progress that re-calibration of B_1 is not required. Experimental results obtained by the FFC technique agree well with those obtained by the RF off-resonance method.

References: [1] Lurie DJ, Proc. 7th ISMRM, p. 653 (1999). [2] Wolff SD, Balaban RS, MRM, 10, p. 135-144 (1989). [3] Lurie DJ et al., Phys. Med. Biol. 43, p. 1877-1886 (1998). [4] Grad J, Bryant RG, JMR 90, p. 1-8 (1990).