Basis for Contrast Enhanced T_1- Weighted Imaging Using SE at High Field

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Introduction: For contrast enhanced imaging, non-contrast sources of bright signal should be reduced. This is commonly achieved by fat suppression. At high field, fat suppression can significantly reduce the number of slices per unit time due to SAR limitations. In addition, the most commonly used gradient echo methods result in very bright signal from inflowing blood. This study evaluates the use of different bandwidth RF-pulses in a SE sequence for reduction of blood and fat signal [1] without increased SAR.

Materials and methods: In spin echo imaging, blood flowing through the slice is effectively suppressed. The use of different pulse bandwidths for excitation and refocusing leads to suppression of fat signal. The spatial location of the shifted fat signal is different for the two pulses due to different gradient strengths.
All experiments were performed on a 7T MR scanner (Siemens, Erlangen, Germany) using a 24 channel head array coil. SE measurements in phantoms and in vivo were performed with refocusing pulses of variable duration. For excitation a VERSE modulated 2 ms RF-pulse was used [2] and the duration of the refocusing pulse was varied between 2.56 and 10.24 ms. Other sequence parameters were: TR = 300ms, TE = 16 ms and matrix size 512. Signal of fat and water in selected ROIs was evaluated.

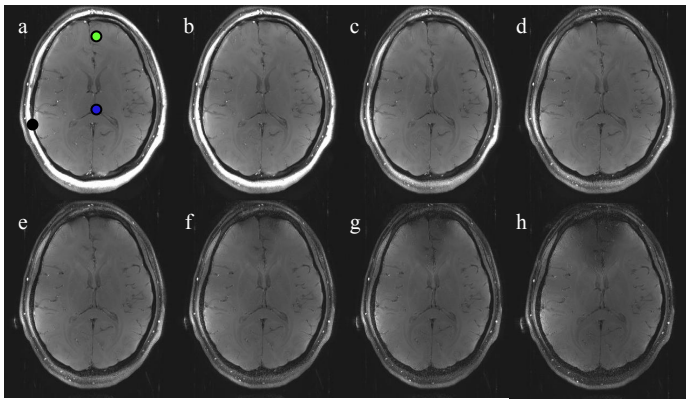

Fig.1. SE images acquired with 2.04ms excitation pulse and variable refocusing pulse lengths: from a) to h) 2.56ms, 3.07ms, 4.09ms, 5.12ms, 6.01ms, 7.04ms, 8.06ms and 10.24ms respectively. The reduced fat signal with longer refocusing pulse duration is evident. Off resonance effects lead to signal reductions, such as in the frontal cortex for very long refocusing pulses.

Results: Fig. 1 shows SE images with different duration of the refocusing pulse. All images were acquired at identical slice position in a single subject without fat saturation pulse. Quantitative evaluation shows that the fat signal is reduced with longer refocusing duration (Fig. 2). These long refocusing pulses also reduce SAR at the price of longer minimum echo times. The water signal is not affected. Only in some frontal regions (green line) signal loss occurs due to strong off-resonance effects. Due to the VERSE modification and longer duration of the pulses, up to 15 slices can be acquired typically with 4.09 ms refocusing pulse duration allowing reasonable SE coverage at 7T.

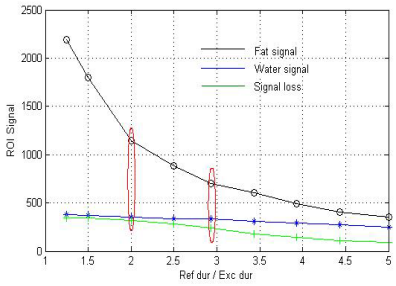

Fig.2. The experimental signal intensity of fat (black) water (blue) and water in regions of strong off-resonance (green).

Discussion: Modification of the refocusing pulse length allows SE-based T1-weighted imaging with suppressed fat and blood signal at high field strength. This is a prerequisite for the detection of contrast enhancement, e.g. in the vessel wall. A major advantage is the suppression without increased SAR. However, signal in regions of strong off-resonance is reduced due to the same mechanism as for fat as in most chemical shift selective suppression methods. A good compromise between sufficient fat suppression for contrast enhanced T1-weighted imaging and signal loss in the brain is a ratio of 2 to 3 between the excitation and refocusing pulse bandwidth.

Conclusion: Lengthening of the refocusing pulse allows suppression of fat signal without increased SAR in high resolution SE imaging for T1-weighted contrast enhanced imaging as had previously been shown for SE-EPI [1].

Acknowledgement: The study was supported by the INUMAC project (BMBF grant 13N9208 and 01 EQ0605)

Reference: [1] D. Ivanov et al. Proc. ISMRM, 2009: 1547.
[2] S. Conolly et al. Variable-rate selective excitation. J Magn Reson, 1988; 78:440– 458.