# Better Fat Saturation Employing DRFS

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## Introduction

In MRI scan, lipid signals often appear bright in both T1 and T2-weighted images, which may degrade the diagnostic value of images. Clinically, it is often desirable to suppress the lipid signal. A chemical shift selective (CHESS) radiofrequency pulse is commonly used for fat saturation (FATSAT). The performance of the CHESS pulse highly depends on the uniformity of both excitation RF field (B1) and static magnetic field (B0). As a result, CHESS is often ineffective in suppressing lipid within a large field of view (FOV) due to the presence of B0 inhomogeneity, e.g. in abdomen, spine and pelvis scans. Although a shimming gradient is may be applied during lipid saturation, the effectiveness of a single shimming value is often limited across a large FOV.

Here we propose a new method to suppress lipid signal, Dual-Region Fat Saturation (DRFS), which has better performance with the presence of B0 field inhomogeneity. DRFS divides a scan region into multiple sub-regions and perform fat saturation independently. Shimming for the sub-regions could then be applied independently, which leads to better B0 field homogeneity and consequently better fat saturation. DRFS does not require additional saturation time.

## Method

The basic idea of DRFS is to use a dual-band spectral-spatial RF pulse [1] to enable 2 independent shimming. Although similarly-natured approaches have been previously reported [2, 3], there lies key difference that makes this new approach more advantageous. Firstly, in prior work, the spatial locations of the 2 spatial bands are non-overlapping, the regions in-between the two spatial bands are simply left out. This is fine in certain applications such as bilateral breast scan, in which the region between breasts is not of imaging interest. However in other cases, such as in abdomen scan, this approach will lead to inferior fat saturation in the uncovered region. In our approach, the spatial bands are made to overlay with each other and the RF pulse is designed to achieve good fat saturation in the overlapped region. Secondly, the dual-band SpSp pulse used previously is an excitation pulse, whereas in our approach a saturation pulse is used instead. The benefit of doing so is the fact that imperfect combination of the different bands only impact fat signal rather than water signal, which is more tolerable. Another benefit of using a saturation pulse is the feasibility of having another short duration excitation pulse, which allows this method to be used in short TE/TR sequences, such as the Fast GRE sequence.

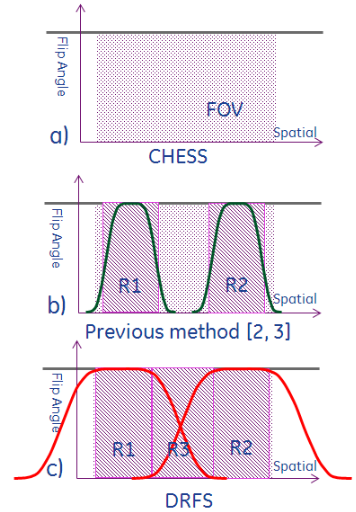


***Figure 1*** *Comparison of different fat saturation approaches :(a) CHESS (b) method in [2,3] (c) DRFS. In comparison to other approaches, DRFS offers (1) independent shimming in R1 and R2, (2) achieves good fat saturation in R3.*

The key point in DRFS is to achieve good fat saturation in overlapped region, and there are two challenges to this: 1) excitation profile of the overlapped region; 2) achieving appropriate shimming in the overlapped region. Because magnetizations in this region experience 2 different shims switching one to another during fat saturation. To handle 1), the slice profile in transition width should be taken into consideration for sub-pulse design, so that slice profile is suitable for overlapped region. Phase of sub-pulses are modulated so that the phases are identical at iso-center. This ensures that in overlapped region, flip angles from 2 regions are acting as a adding up manner. To handle 2), the target B0 field for the 2 regions should be same as the B0 field at center of FOV. By doing this, the center of FOV is completely NOT affected when switching 2 shim values and the impact to area nearby the center is reduced. Also, the envelope of SpSp pulse is designed as a maximum phase pulse, of which main power of the pulse locates at the beginning, where the phase dispersion due to shim gradient is not big yet.

## Results

In vivo experiment using the proposed method is conducted using a GE 1.5T whole-body scanner. Consent form has been obtained prior to scan. A 40cm FOV sagittal spine scan is performed using the traditional CHESS technique and DRFS, and the resulting images are shown in Figure 2. It can be seen (Fig.2.(a)) that the fat saturation failed at the edges of the FOV (arrow 1) and also the water signal has been mistakenly suppressed (arrow 2) if the product CHESS is used. On the other hand, the use of DRFS solves these issues. Also notice that the fat signal in the center region on S/I direction (overlapped region) is also well saturated when DRFS is used.


***Figure 2*** *Spine image employing a) CHESS(L) and b)DRFS(R)*

**Conclusion** DRFS uses two independent shimming to achiever robust fat saturation with the presence of B0 inhomogeneity in a large FOV. While previously reported methods are limited to be used in breast scan, DRFS has much broader application such as spine, abdomen and pelvis.

**Reference** [1] J. M. Pauly, et al., 966, ISMRM 2003 [2] C. H. Cunningham, et al, 1849, ISMRM 2005 [3] M. Han, et al, 580, ISMRM 2009