# Enhancing Lipid Signals With SWIFT

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## Introduction

Many body tissues have a very short transverse relaxation time $T_2$, e.g. tendon, cartilage and cortical bone. Components such as lipids in cell membranes and cell organelles are likely to have even shorter $T_2$ values due to the semisolid like structure. In several pathological conditions the cell membrane composition is altered. Nowadays, these changes are detected indirectly through the water signal. Thus, it is of interest to detect the signal directly from the lipids. With common imaging sequences, such as spin-echo or gradient echo, signal detection from components with extremely short $T_2$s is virtually impossible due to the signal loss of the short $T_2$ compounds during relatively long echo times (TEs) of the sequences. Imaging sequences with short TEs have been proposed, e.g. ultra short TE (UTE) techniques [1]. Typical TEs of UTE are in the range of 50-200 µs [2], but even shorter TEs can be reached with SWIFT (Swept Imaging with Fourier Transformation) [3]. SWIFT is an imaging technique based on virtually simultaneous excitation and detection with gapped adiabatic frequency swept pulses. Few microsecond (3-12 µs) TE can be reached with SWIFT, limited only by T/R switch hardware and coil ringdown since no gradient or spin echo is formed.

In this study we demonstrate in phantoms a proof of principle experiment for using SWIFT to enhance the signal of lipid components with extremely short $T_2$s. This was based on an expectation that the lipid components with short $T_2$ values would also have a short $T_1$. The average $T_1$ of the imaging target is likely to be smaller than the $T_1$s of components with low $T_2$. Hence by going beyond the Ernst angle based on average $T_1$ we decrease the signal of components with relatively long $T_1$ and increase the signal from the short $T_1$ components. This is possible with SWIFT due to its short TE.

## Materials and Methods

A phantom containing different lipid mixtures was built by using butter, peanut oil and vitamin-E oil (soy). The lipid mixtures were poured into tubes and the tubes were sunk into agar and sodium azide mixture (a preservative). Imaging was carried out with SWIFT (TR = 4.9 ms, dead-time=7 µs) at 4 T, while FLASH (TR = 13.5 ms, TE = 4 ms) provided a control measurement. The flip angles (θ) for SWIFT were 2°, 5° (Ernst angle), 8°, 10° and 15° and for FLASH 5°, 13° (Ernst angle), 22°, 30° and 42°. The FLASH flip angles were chosen so that the θ / TR relation would match with SWIFT. Mean signal intensities were calculated from equal size ROIs placed inside the tubes and agar. Contrast ratio here is defined to be the ratio of the mean fat and mean agar signal intensity. Finally SWIFT's percentile contrast ratio difference compared to FLASH was calculated for each flip angle and lipid mixture:

$$\Delta\text{Contrast ratio} = \left( \frac{\text{SWIFT}_{\text{lipid/agar}}}{\text{FLASH}_{\text{lipid/agar}}} - 1 \right) * 100\% .$$

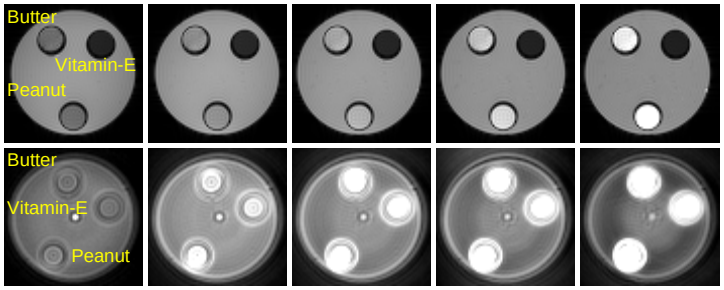


**Figure 1:** FLASH (upper row) and SWIFT (lower row) fat phantom images with increasing θ / TR relationship.

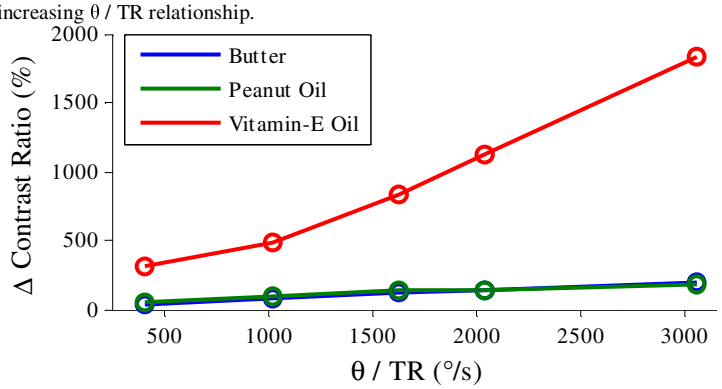


**Figure 2:** Difference of SWIFT contrast ratios compared to FLASH with increasing θ / TR relationship.

## Results and Discussion

Figures 1 and 2 clearly show that with increasing flip angle the signal of the fat is increased with SWIFT where as for FLASH the difference is small. The vitamin-E oil signal is almost completely relaxed in FLASH images because of longer TE of FLASH. The circular artifacts in the SWIFT images are caused by chemical shift differences between the short $T_2$ polymers and lipid mixtures. The blurring and the center artifacts are due to broad linewidths of different short $T_2$ components of the phantom [4].

## Conclusions

The results show that SWIFT could be able to detect signals from lipids with short $T_2$s of cells inflicted by certain pathologies. Since signals from short $T_2$ compounds are likely to be much weaker *in vivo* compared to phantoms, future developing may contain suppression of the long $T_2$ compounds and the optimization of lipid signal enhancement in tissue with SWIFT.

## References

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