

# Through-Plane Chemical Shift Correction in Rf-Power Reduced Sequences at High Field Strength

Mathias Nittka<sup>1</sup>, Vladimir Jellus<sup>1</sup>, and Lars Lauer<sup>1</sup>  
<sup>1</sup>Siemens Healthcare, Erlangen, Germany

## Introduction

The application of rf-power intensive routine sequences like (turbo-)spin-echo at high field strength of 3 Tesla and above is often limited by the maximum allowed power deposition in the patient (SAR). A straight forward approach to reduce the power of the applied rf-pulses is to reduce their peak amplitude, e.g. by increasing the pulse duration, changing the pulse shape or the use of VERSE pulses [1]. However, these methods result in a reduction of the rf-excitation bandwidth, which makes the sequence more sensitive to off-resonance effects. In particular in non fat suppressed sequences, the chemical shift artifact from fat may become a problem in terms of through plane chemical shift.

## Analysis and Methods

Example: in a main magnetic field of 7 T, the frequency of fat signal is approx. shifted by 1 kHz compared to water signal. Thus, if a slice selective rf-pulse of 1 kHz bandwidth is applied, the excited fat signal is dislocated by one slice thickness perpendicular to the slice plane (z-position), i.e. the fat signal seen in the image does not originate from the same spatial slice position as the water signal. In order to have at least 50% overlap of the fat and water slice positions, the rf-bandwidth would have to be doubled to 2 kHz, e.g. by shortening the pulse duration by 50%. However, this would double the power deposition, if all remaining imaging parameters were kept constant.

In order to correct for the chem. slice shift the following method is proposed: applying a sequence which provides fat/water separation, such as the Dixon technique [2], setting the rf-bandwidth such that the fat/water shift matches the distance of the measured slices and finally recombining water and fat signals from matching spatial slice positions (fig. 1).

As a proof of concept the following experiment was carried out: a 2-point Dixon TSE sequence was implemented on a 3 Tesla scanner (MAGNETOM Verio, Siemens Healthcare, Germany), using an excitation rf-bandwidth of 350 Hz. A volunteer's knee was scanned (20 slices, 4mm thickness, 0.5 mm slice gap). The rf-bandwidth of 350 Hz leads to 4.5mm chem. shift of fat, i.e. the real spatial position of the fat signal acquired by slice #1 corresponds to the position of the water signal acquired with slice #2. In addition to generating the separated fat/water images, the image reconstruction software generated an additional image series, which is calculated as the sum of water signal from slice #1 plus fat signal from slice #2 and so on. For one slice at the boundary of the slice stack the fat component is not present, consequently this slice cannot be reconstructed.

## Results

Fig. 2 shows the Dixon-separated water and fat images. The combined image in the upper row does not correct for the chem. shift of fat and corresponds to the result one would get when scanning with a conventional, non fat-suppressed PD-weighted TSE sequence. Due to the low rf-bandwidth, an obvious mismatch of fat and water signal positions is present. The lower row shows the combined image with corrected fat position, resulting in an image without through-plane chemical shift artifact. The rf-power of the used rf-pulse is about 35% of that of a comparable 1 kHz rf-pulse (which would still show a fat shift of 1.4mm).

## Conclusions and Discussion

The presented method provides non fat suppressed images without through-plane chem. shift artifacts despite the use of low power rf-pulses. Since it requires the acquisition of separated fat and water images, the scan time is increased. However, in particular the water-only images may contain valuable additional diagnostic information. Furthermore, since conventional spectral fat suppression is challenging at high field strengths, the presented method may be favorable since it provides both robust fat suppressed as well as non-suppressed, chem. shift corrected images within a single measurement.

## References

- [1] Conolly S et al., J Magn Res 1988;78:440-458.
- [2] Dixon WT, Radiology 1984;153(1):189-94.

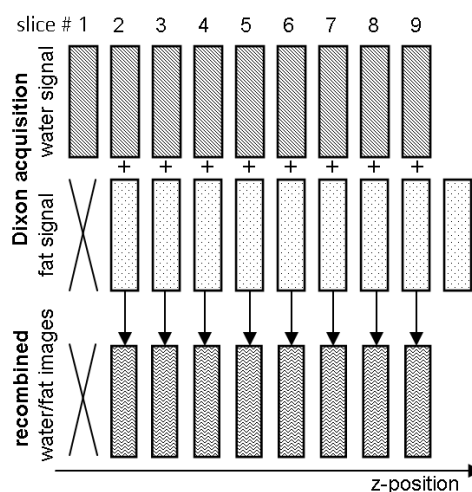


Fig1. Illustration of the fat/water separated acquisition and image reconstruction. Fat images are shifted due to the use of low-power, low bandwidth rf-pulses. Recombined fat/water images are generated for matching slice positions. Note that slice#1 cannot be reconstructed since no fat signal is present at this location.

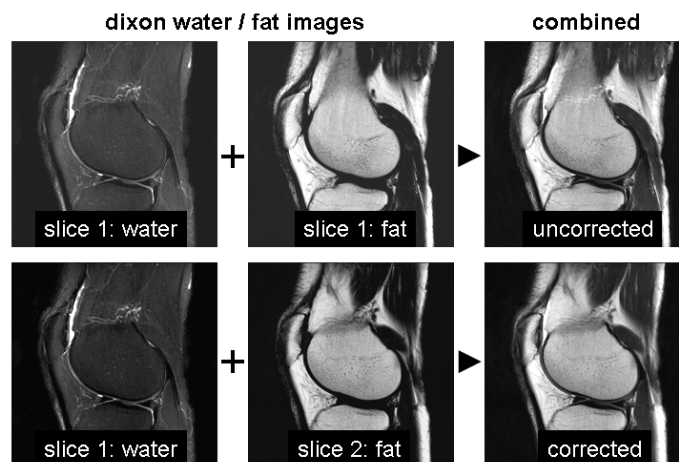


Fig2. Upper row: water and fat signal for slice index 1 show different slice positions due to the chemical shift of fat, the combined image corresponds to a non fat suppressed conventional acquisition with severe chem. shift artifact. Lower row: combining water and fat images from chem. shift corrected positions results in a non-fat suppressed image without chem. shift artifact.