Optimizing SPIR and SPAIR fat suppression

Application Tip

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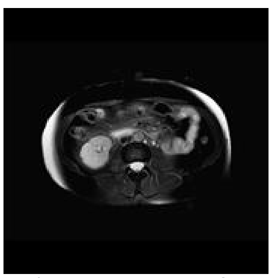
Fat tissue appears bright in many types of MR images. Being able to selectively suppress fat signal helps distinguish other tissues or lesions from a fat-containing environment in the body. Fat suppression is particularly essential in the breast, pelvis and knee.

Frequency-selective fat suppression methods such as SPIR and SPAIR (SPectral Attenuated Inversion Recovery) make use of Larmor frequency differences between fat and water spins. This application tip deals with approaches for optimizing SPIR and SPAIR fat suppression.

Optimizing B0 homogeneity improves fat suppression

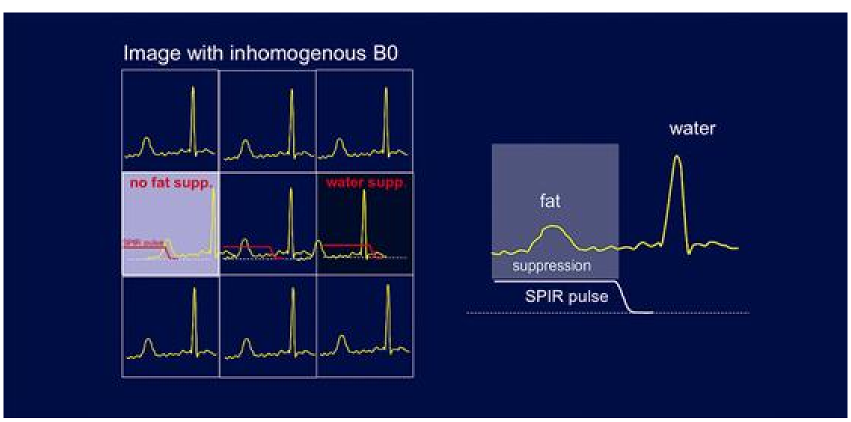
Since the Larmor frequency is proportional to B0, SPIR and SPAIR require a homogeneous B0 field, so that the frequencies of fat and water are constant over the whole field-of-view. Inhomogeneity in the B0 field results in inhomogeneous fat suppression.

B0 homogeneity is achieved by good magnet design and proper shimming. However, even in a perfectly homogenous B0 field, introducing a patient generates B0 inhomogeneity that may lead to fat suppression imperfections. Suppressing fat in anatomies far away from the magnet's isocenter, in particular, may be a challenging task.



In this TSE SPIR image, fat suppression is inhomogeneous, containing areas of incomplete fat suppression (bright fat) and areas of water suppression (dark areas).

Due to an inhomogeneous B0 field, the water-fat spectra shift in some locations, so that the SPIR pulse will not suppress fat (left) or suppress water instead of fat (right).



Inhomogeneous B0

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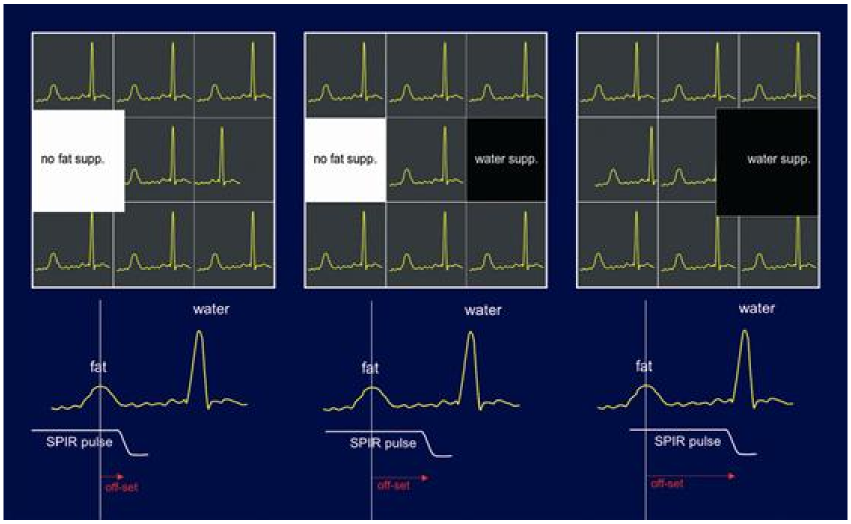
Shimming is recommended to counter this effect. Shimming fine-tunes the B0 field homogeneity, minimizing the local shift of water fat frequency spectra.

Frequency offset in SPIR



Frequency offset in SPIR
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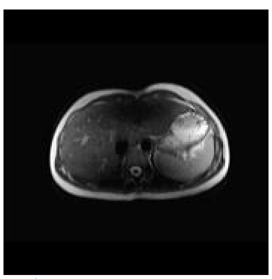
With a lower frequency offset, the SPIR pulse is further spaced from the water peak, so that water suppression is avoided, but the area of incomplete fat suppression may be larger (left situation). With a higher offset, fat suppression is obtained everywhere, but the SPIR pulse is closer to the water peak, so that water signal reduction appears in a larger area (situation on the right side in figure).

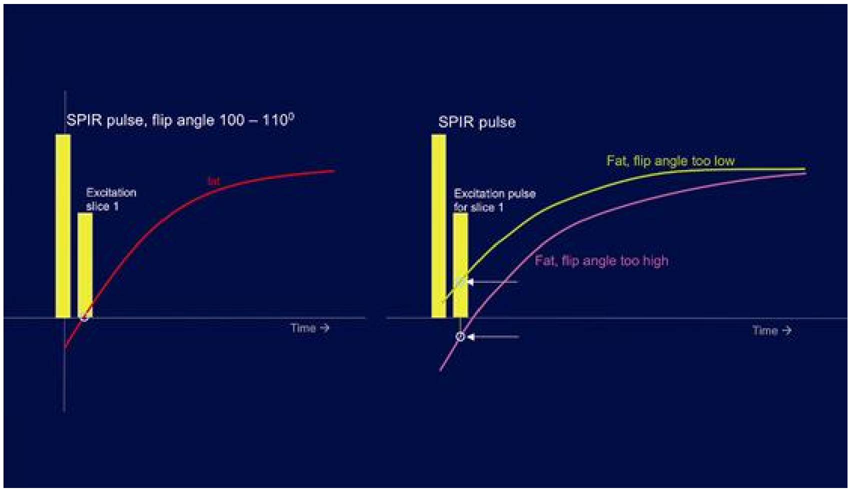
SPAIR method less sensitive to B1 uniformity

Fat suppression homogeneity is also related to B1 field uniformity. At system level, tuning the Body coil optimizes B1 uniformity. However, a patient's body also affects it. Its influence on the receive field may cause variation in signal intensity. Its influence on the transmit field determines the uniformity of the RF pulse's angle over the FOV.



Without compensation a non-uniform B1 field may lead to inhomogeneity as intentionally amplified in this 3.0T image.

A SPIR pulse saturates fat magnetization. Directly after that, fat signal is zero and the slice is excited and measured, so that fat is dark in the image. If B1 is non-uniform, the flip angle will vary over the excited slice and in some areas, the relaxation curve does not cross zero at the moment of excitation, so that fat signal is not zero and thus locally still visible in the image. This is especially apparent in breast, pelvis and knee.



SPIR
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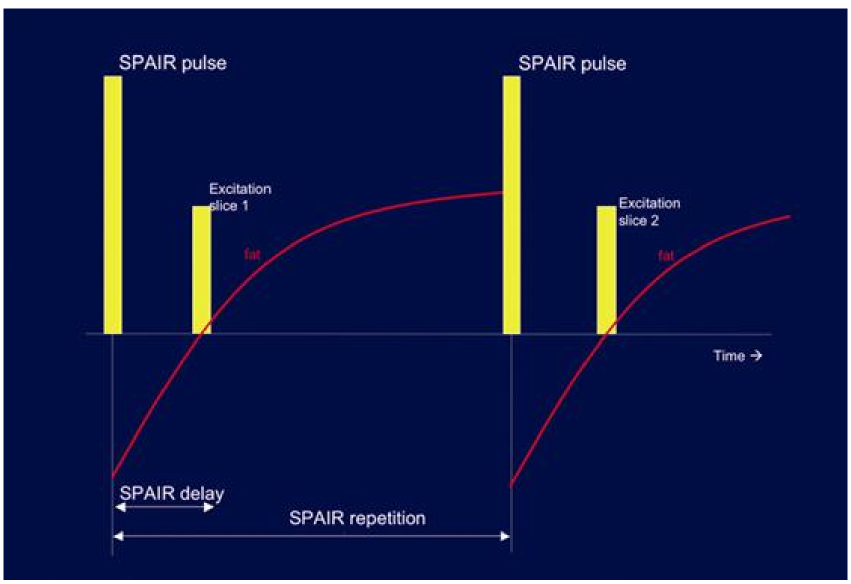
Philips SPAIR (SPectral Attenuated Inversion Recovery) method helps solve this. SPAIR uses a true 180 degrees inversion pulse, frequency-selective and independent of B1. It results in STIR-like contrast for fat only. Another advantage is the possibility to perform **partial fat suppression**, favorable for some orthopedic applications.



SPAIR
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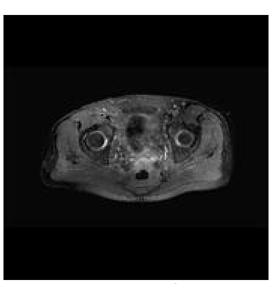
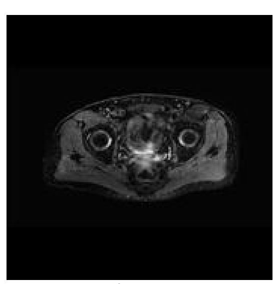
SPAIR allows adjustment of the delay time as defined in this graph. The SPAIR repetition time is displayed on the info page.



Fat suppression in this T2W TSE SPIR image is



T2W TSE with SPAIR. Fat suppression is more uniform inhomogeneous, due to B1 non-uniformities.

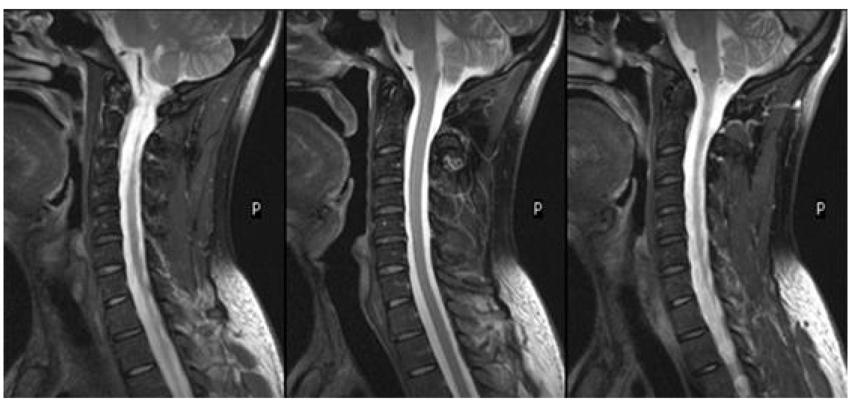
over the whole field-of-view.

Fat suppression quick overview	Fat suppression – fine-tuning parameters
STIR (Short tau Inversion recovery) / **IR-TSE** • independent of B1 and B0 variations • relatively low signal-to-noise ratio • mixed T2 / T1 contrast **ProSet** • sensitive to B0, independent of B1 • WATS = water selective, may be f(luid) or c(artilage)-optimized • limited slice thickness in mulislice, increased pulse length, increased minimum TE • ideal for 3D non-turbo sequences **SPIR** (Spectral Presaturation Inversion recovery) • sensitive to B0 and B1 • ideal for T1w TSE **SPAIR** (SPectral Attenuated Inversion Recovery) • sensitive to B0, independent of B1 • partial fat suppression possible • longer prepulse time compared to SPIR • ideal for T2W TSE	**Volume shim** • to optimize B0 homogeneity **High order shim** (available for 3.0T only) • for specific applications **Selectable frequency off-set** for SPIR and SPAIR • based on image domain (is more precise than one average spectrum)

From default settings to optimized fat suppression

In practical imaging, B0 and B1 influences may play a role at the same time. This example shows how to optimize fat suppression in a practical case.

These c-spine images are acquired on Achieva 3.0T, using T2-weighted TSE, TR 3000 ms, TE 70 ms, fat suppression with default SPIR settings.



Default SPIR

Fat suppression improves by compensating for B0 inhomogeneities by adding **volume shim** and **high order shim** (only available for 3.0T) to the SPIR sequence.

SPAIR also compensates for B1 effects. The SPAIR image shows the most homogenously suppressed fat.

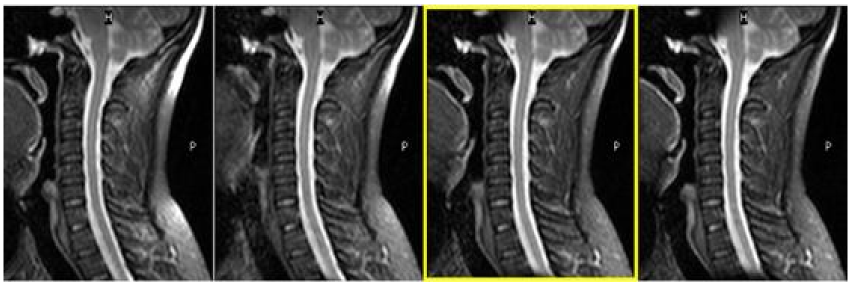
SPIR, volume shim **SPIR, high order shim** **SPAIR, high order shim**

SPIR SPIR SPAIR Volume shim High order
shim High order shim

Setting the frequency offset

Additionally, users can adjust the frequency offset for SPIR or SPAIR to fine-tune fat suppression in an inhomogeneous B0 field. Looking at an average spectrum to determine how to adjust the frequency offset will not yield optimized results. Because the frequency offset affects the whole slice, fat suppression should be optimized in the area of interest. The recommended way to do this is to compare images from different offsets.

Four 20-seconds T2W TSE SPAIR scans with different offsets are compared to determine the optimal frequency offset. In this example, the 200 Hz image provides the best balance between fat suppression homogeneity and signal loss on top and bottom due to water suppression.



optimize freq offset
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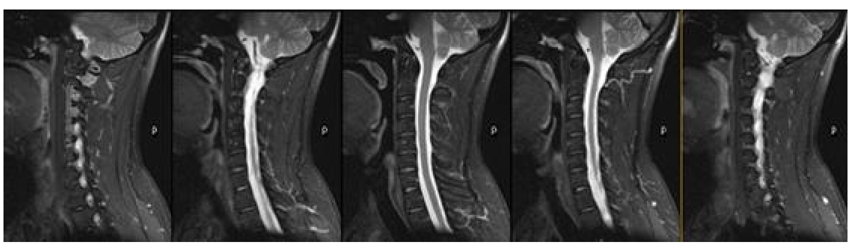
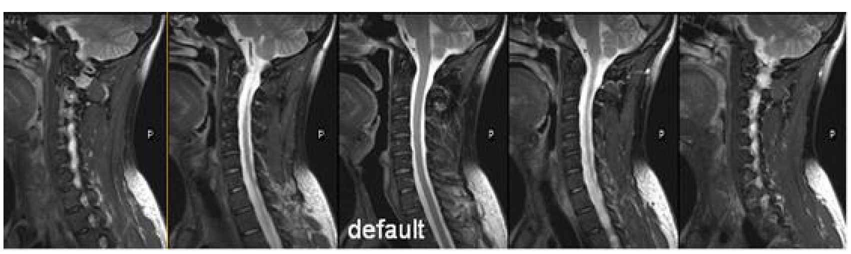
100 Hz **150 Hz** **200 Hz** **250 Hz**

The benefit of fat suppression optimization is evident from this comparison of the optimized scan with the default settings scan.



FS24 optimized fat supp



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