FSE Cusp artifact removal using novel saturation method

Yongchuan Lai[1], Weiwei Zhang[1], Baogui Zhang[1], and Bing Wu[1]
[1]*GE Healthcare, Beijing, China*

Introduction FSE cusp artifacts, fold-over artifacts, etc., are a common types of artifacts in FSE MR imaging, and are caused by collective effects of the gradient non-linearity and B0 inhomogeneity in regions distant from the magnet center. This can present as the so-called feather-like artifacts associated with sagittal plane FSE images when the phase encoding is along the S/I direction, such as is commonly the case for spine imaging. Several methods [1,2] have been proposed to cope with these feather-like artifacts, however they all feature a complex nature and have not been able to fully address this issue. In this work, we propose a simple yet effective method to eliminate the root cause of the artifacts by spatial saturation and further improve its practical implementation.

Method The origin of the feather-like artifacts is the so-called star intensity region, which is formed by the mutual effects of field inhomogeneity and gradient non-linearity so that the neighboring signals are condensed into a small spatial region. Due to nature of FSE acquisition, this high signal condensed region causes ghosting artifacts with a feather-like appearance within the FOV along the phase encoding direction despite being outside the imaging FOV. A straight-forward approach is to suppress the star intensity signal via spatial saturation prior to FSE acquisition, and hence no feather artifacts would be formed. The drawback of this approach in practice is that usually a very high saturation RF bandwidth is needed as the star intensity has a very board spectrum attributed to field inhomogeneity and gradient non-linearity need to be suppressed. The high RF bandwidth proportionally increases the specific absorption rate (SAR) and may lengthen the minimum TR. We propose to break the spatial saturation into two stages, namely frequency saturation and spatial saturation to respectively address the field inhomogeneity component and gradient non-linearity component of the star intensity, which are referred as BW_1 and BW_2 for brevity (**Fig.1**). In conventional spatial saturation, the total bandwidth needed for suppressing the star intensity is $2*BW_1 + 2*BW_2$, due to the fact that spatial encoding via gradients doubles the bandwidth of the spectral contents of star intensity (to differentiate spatial location of one end of the magnet from the other end). In the two-stage approach, we first saturate the field inhomogeneity without slice encoding, which only requires a bandwidth of BW_1. In the second spatial saturation stage, as the spectral contents due to field inhomogeneity has already been suppressed, a much reduced level of slice selection gradient is needed, which leads to a much reduced spectral content of gradient non-linearity of BW_2'. The overall bandwidth needed in this two stage approach is now $BW_1 + 2*BW_2'$, which is usually much smaller than the original $2 * BW_1 + 2*BW_2$.

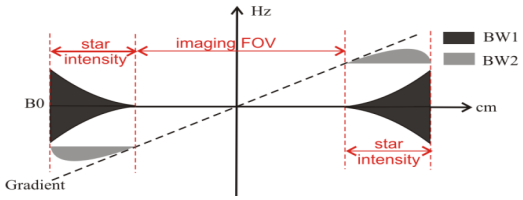

Figure 1 spatial-spectral plot of star intensity

Experiments and results The proposed method and the direct spatial saturation approach were implemented on a GE 1.5T whole body scanner. Phantom experiment was first setup to verify the validity of the approach. As illustrated in **Fig.2.a**, two phantoms are placed at the locations of the star intensity outside the normal FOV (arrow 1) and sagittal FSE scan led to obvious feather-like artifacts (arrow 2). Direct spatial saturation (**Fig.2.b**) and the two stage saturation (**Fig.2.c**) both successfully eliminate the feather-like artifacts, whereas the total bandwidth used in the two cases were 30 kHz and 14 kHz respectively. In the latter case, a scan time reduction of 20% was achieved due to decreased SAR level. In-vivo experiment has been performed by imaging the spine of a heathy volunteer with prior consent form. As shown in **Fig.3.a**, conventional FSE imaging has shown visible feather-like artifacts (arrowed), whereas the feather-like artifacts have been eliminated using the proposed method without degrading the image quality (**Fig.3.b**).

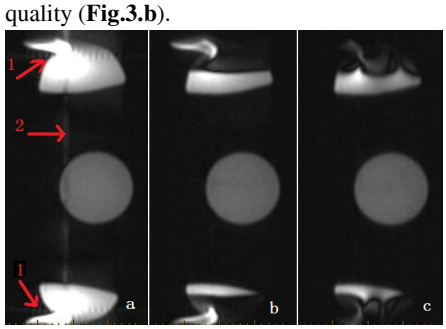

Figure 2 phantom imaging (a) without , (b) with direct saturation (c) with two-stage saturation

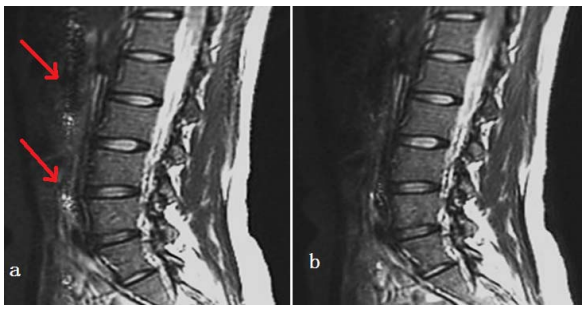

Figure 3 in-vivo imaging of spine (a) without saturation; (b) with proposed two stage saturation of star intensity region

Discussion and conclusion A simple and effective method based on spatial saturation has been proposed to eliminate the feather-like artifacts in FSE acquisition, its practical implementation has been modified into a two-stage suppression to reduce overall SAR value.

Reference

[1] N. Rangwala, et al, MRM, 2010
[2] P. Frederick, et al, US 6134465