Correction of Slice Profile Distortion from Metallic Devices

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Introduction

Metallic devices such as total joint replacements, pins, screws, and interventional devices remain a source of image artifacts in MRI. Two major contributors to these artifacts are in-plane shifts of off-resonance spins and distortion of the slice profile. These are often problematic in fat-suppressed T2-weighted imaging where bright signal intensity from artifacts are hard to distinguish from subtle T2 increases from pathology. Increasing the receiver bandwidth can improve these images, but artifacts remain.[1,2]

Previously, we and others[3-7] have demonstrated the use of view angle tilting (VAT) to remove in-plane distortions of spins adjacent to metallic devices. We additionally demonstrated a high bandwidth, multiple readout VAT sequence (MR-VAT) that maintained signal to noise, ratio while reducing blurring often seen with VAT.[7] While in-plane shifts were eliminated with this sequence, distortion of the slice profile remained. Slice profile distortions stem from both potato chipping of the slice and intensity modulations from variations in slice thickness.

The purpose of this work was to demonstrate the feasibility of correcting for slice profile distortions. This is done by acquisition of very thin slices, acquisition of a field map, and correction in post processing. Since VAT images have no in-plane shifts, this data need only be used to correct for the slice profile distortion.

Methods

A spin echo MR-VAT sequence with the flyback trajectory was used to image a gel phantom with an embedded hip prosthesis. All imaging was performed in the head coil of a 1.5T GE Signa Scanner (GE Healthcare, Milwaukee, WI). The sequence acquired 1.3 mm sections, with a skip of 0.2 mm, TE/TR=14.3/800, and a FOV of 30 cm. Two acquisitions were acquired, with the second offset in time by 60 µs. The three echoes acquired from each MR-VAT acquisition were combined into one with a sum of squares algorithm. A field map was calculated from the phase difference between the two acquisitions. With the field map, signal was remapped to the correct location in the slice direction using a linear interpolation in MATLAB. The derivative of the field map was used to determine the modulation of the slice thickness. The image was then normalized by this value. Three thin slices were averaged to form a 4.3 mm effective slice thickness.

Results

Figures 1 and 2 demonstrate the improvement in imaging of the prosthesis phantom. In both figures, the images on the left are already extremely high quality since they were acquired with a thin slice MR-VAT sequence. However, in both sets of images, there are significant additional improvements from the correction of the slice profile distortion.

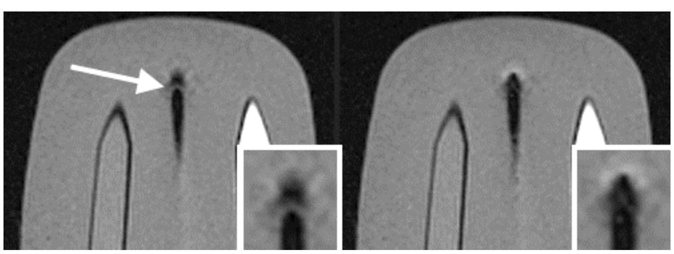

Figure 1. A slice profile distortion seen as an apparent fracture of the metal rod (arrow, left) is corrected (right).

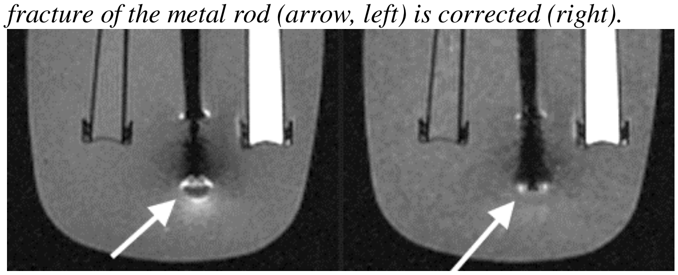

Figure 2. Slice profile distortions are the result of shifts in the slice direction and image intensity moduations (left). Both are corrected in the image on the right where details of the metal rod are much better visualized.

Discussion

Although the method was demonstrated with a spin echo sequence, it can be implemented within a fast or turbo spin-echo sequence. There is a reduction in SNR efficiency due to the acquisition of very many thin slices. However, a slight loss in SNR may an acceptable tradeoff to improve depiction of the tissue near metal implants.

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References

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