

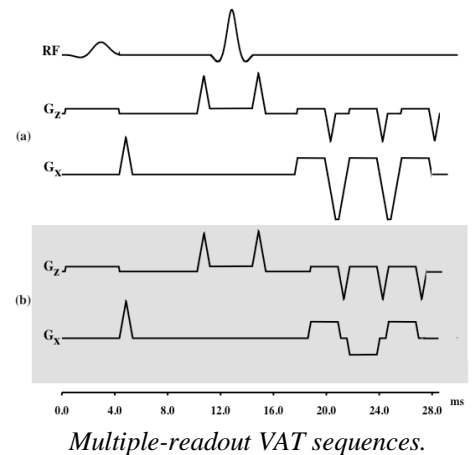
Reduction of Blurring in View Angle Tilting MRI with Multiple VAT Readouts

K. Butts¹, L. Pisani¹

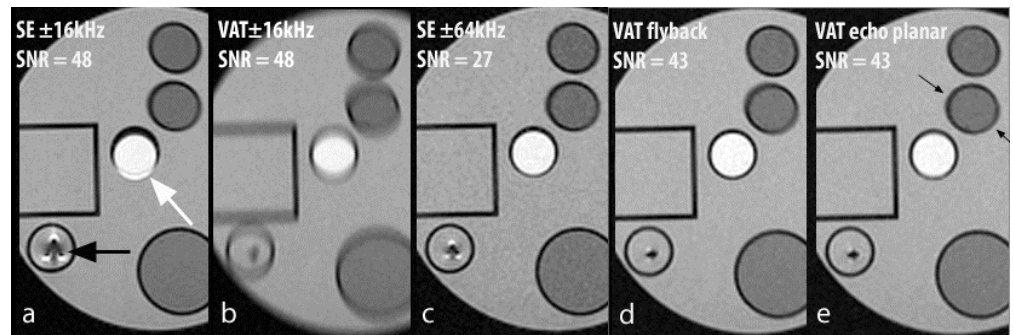
¹Radiology, Stanford University, Stanford, CA, United States

Introduction View angle tilting (VAT) [1] reduces in-plane distortion of metallic objects through the use of a gradient on the slice select axis during readout. The slice is effectively viewed at an angle such that shifts in the slice selection plane compensate for shifts during readout. However, VAT images have suffered from blurring in the frequency direction that has hindered its widespread use. We previously showed [2] that the major source of blurring in VAT MRI is from a slice profile modulation of the data and demonstrated reduction of blurring when the readout duration is matched to that of the main lobe of the RF pulse. In this work, we demonstrate a method to do this, while efficiently using the transverse magnetization with the use of multiple high bandwidth readouts.

Methods Two pulse sequences with multiple high BW ($\pm 64\text{kHz}$) readouts were designed: the first refocuses both the frequency and VAT gradients in a “flyback” trajectory (Fig. 1a); the second refocuses only the VAT gradients, while the echoes are readout under alternating polarity of the readout gradient, in an “echo planar” trajectory (Fig. 1b). Three readouts were acquired each TR with the second readout at the spin echo and with a total readout time of 10ms (including refocusing gradients). Images were reconstructed separately and combined in Matlab. In pixels where the difference between the second and first image was positive (ie. pixels where $T2' \gg T2$), this difference was added to the first and third images, followed by a sum-of-squares operation performed on all three images. Images were acquired of a gel phantom with gel and oil inclusions and a 22 g MRI-compatible biopsy needle (EZEM). Parameters included a 1.5T GE Signa scanner, TE/TR of 20/500, 5 mm slice, 24 cm FOV. Average SNR values from five locations in the acquired conventional spin echo and multiple readout VAT images were obtained.



Results Conventional spin echo imaging (a-c) and multiple-readout VAT (d-e) images. Chemical shift of the lipid signal (white arrow) and distortion adjacent to the needle (large black arrow) are eliminated (d-e). Combination of images from the multiple readouts provides most of the SNR of the original spin echo image.



Discussion This work demonstrates that multiple-readout view angle tilting provides images without in-plane distortions and more efficiently samples the transverse magnetization than a single high bandwidth readout. The method can be applied with either the flyback or echo planar trajectories, as long as the VAT gradient is fully refocused. Imaging during application of a VAT gradient with the opposite polarity increases the apparent distortions of off-resonant spins. The two multiple-readout VAT methods demonstrate a subtle difference: with the flyback trajectory, all three individual images were acquired at the same view angle. However, with the echo planar trajectory, the second readout was acquired with a different view angle since this readout gradient was of inverted polarity. The appearance of most of the phantom is the same for both trajectories. A difference can be seen in the two upper tubes (small black arrows) that were oriented obliquely through the phantom. The tubes acquired with the echo planar trajectory have an appearance most similar to that of the conventional spin echo images. These methods could easily be adopted into a FSE sequence.

References

1. Cho, Z., D. Kim, and Y. Kim, *Total inhomogeneity correction...* Medical Physics, 1988. **15**: p. 7-11.
2. Butts, K. and J.M. Pauly. *Reduction of blurring in View Angle Tilting MRI*. in ISMRM. 2002. Honolulu.

Acknowledgements NIH RO1 77677