SAR-Efficient Breath-Hold T2-Weighted Abdominal MRI at 3.0 Tesla

M. L. Lauzon[1,2], H. Mahallati[1,2], R. Frayne[1,2]
[1]Radiology, University of Calgary, Calgary, AB, Canada, [2]Seaman Family MR Research Centre, Foothills Medical Centre, Calgary, AB, Canada

Introduction

Clinical abdominal MR imaging requires extended anatomic coverage (18-20 cm) in a breath-hold (20-25 seconds) to minimize motion artifact and spatial mis-registration of small lesions. T2-weighted images are needed to characterize lesions such as cysts, hemangiomata, and metastases [1]. Fast spin echo (FSE) and single-shot FSE (ssFSE) [2] sequences are most often used for this purpose.

High field 3.0 Tesla MRI can potentially provide (a) further increases in SNR, resolution and/or coverage, and (b) minimized scan times. These benefits, however, come at the cost of greater energy (SAR) deposition [3], a limitation exacerbated for FSE-based techniques. Recent work using VERSE pulses [4,5] that modify the rf/gradient waveforms and modulate the flip angles of the echo train can reduce power deposition by 50%, but this requires significant rf design and signal demodulation during image reconstruction.

Our approach is based on the realization that minimum slice-to-slice time is dictated by gradient timing limitations (T_{GRD}) and the 6 minute average SAR requirement (T_{6MIN}), namely that SAR deposition ≤2.0 W/kg for body imaging [6]. Interestingly, SAR deposition may not exceed 6-8 W/kg during any 10 seconds interval [6]; this means that T_{10S} is effectively 1/3 to 1/4 of T_{6MIN}. For breath-hold MR, then, we maximize coverage/resolution by choosing the maximum of T_{GRD} and T_{10S} (as opposed to T_{6MIN}). Next, we satisfy the 6 minute average SAR deposition requirements with a "cool down" time after the breath-hold (T_{WAIT}) which is simply the total scan time had we used the greater of T_{GRD} and T_{6MIN} minus the breath-hold time.

Methods

We modified the vendor-provided FSE/ssFSE pulse sequences (General Electric Medical Systems, Waukesha, WI; software release 8.5M38). The changes included: (a) calculating T_{10S}, (b) setting the slice-to-slice time accordingly (*i.e.*, selecting the greater of T_{GRD} and T_{10S}), (c) displaying breath-hold and total scan times by modifying the user display, (d) adding T_{WAIT} time to satisfy the 6 minute SAR requirements, and (e) adjusting the reported SAR deposition values to account for the T_{WAIT} time.

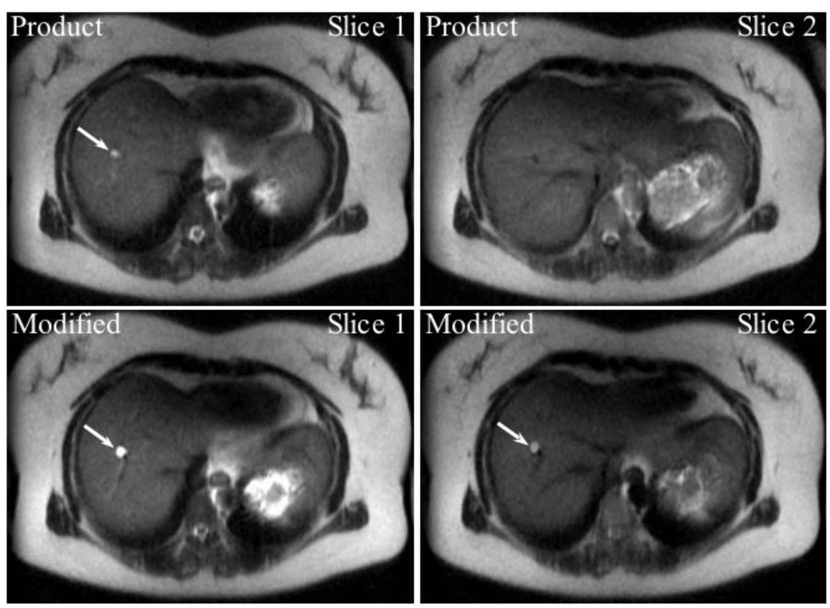
We scanned the abdomen in ten volunteers with both the product and the modified ssFSE sequences using the same parameters (body coil, axial/coronal orientations, effective TE of 90-95 ms, 7.0/1.0 mm slice thickness/gap, 21 slices, 38x38 cm^2 FOV, 256x160 matrix, ±62.5 kHz receive bandwidth, 140^o refocusing pulses). Depending on patient weight, the product sequence had a slice-to-slice time of 2250-3100 ms, so the images had to be acquired during free breathing. By comparison, the modified sequence allowed for all slices to be acquired within a 16-23 seconds breath-hold (slice-to-slice time of 780-1100 ms) followed by T_{WAIT} of 30-45 seconds.

Results

Volunteers stated that the modified ssFSE acquisitions consistently felt slightly warmer than the product ssFSE, with coronal scans more so than axials, but none experienced any discomfort or adverse effects. Since the echo spacing was not modified (only the slice-to-slice time changed), the SNR and contrast characteristics were identical between ssFSE sequences. The free breathing product sequence can potentially lead to spatial mis-registration and/or underestimation of the lesion size; this limitation was exemplified when imaging an incidentally observed hepatic cyst (arrows) for two identically prescribed, consecutive slices in a volunteer (see figure). Only on slices using the modified sequence was the cyst clearly and more accurately depicted.

Conclusions

Minimizing the slice-to-slice time with respect to T_{GRD} and T_{10S} followed by SAR wait time permits efficient breath-hold abdominal T2-weighted scans at 3.0 Tesla. In this study, we simultaneously exploited coverage and resolution benefits and minimized slice mis-registration errors. Moreover, we have successfully applied this method to most acquisitions within our abdominal protocol, including T1-weighted, IR-Prep, and Gradient Echo acquisitions.



References

1. J Wittenberg, *et al*. *AJR* 1998; 151:79-84.
2. J Hennig, *et al*. *MRM* 1986; 3:823-833.
3. JP Felmlee, *et al*. *Proc ISMRM* 2000; 2002.
4. RF Busse, *et al*. *Proc ISMRM* 2003; 206.
5. Y Zur, *et al*. *Proc ISMRM* 2003; 958.
6. US Dept of Health and Human Services (FDA). Washington DC, Nov 1998.