Reduction in Artifacts in the Liver at 3T Using a 3D T2-Weighted Variable Flip-Angle Sequence (SPACE)

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Introduction: 3T MRI systems provide an inherent increase in SNR that can be used for gains in spatial and/or temporal resolution. However, a limitation of imaging at 3T is an increase in specific absorption rate (SAR), particularly in sequences with large flip angles and many refocusing pulses, as occurs with many 180º refocusing pulses of a turbo spin echo sequence. A recently developed sequence termed Sampling Perfection with Application Optimized Contrasts using different Flip Angle Evolutions (SPACE) uses variable flip angles to maintain a low SAR while performing many refocusing pulses. This technique allows a 3D T2-weighted acquisition with high SNR and spatial resolution. In the past year, several studies have demonstrated the benefit of using SPACE at 3T to obtain a 3D MRCP with improved overall image quality, reduced artifact, and improved bile duct visualization[1-3]. However, to our knowledge, no study has assessed SPACE liver imaging at 3T. In this study, we aim to quantitatively and qualitatively compare image quality of 3D T2W SPACE and 2D T2W TSE for liver imaging at 3T.

Methods: 20 consecutive patients underwent MRI of the liver at 3T which included frequency selective fat suppressed 2D T2W TSE (TR/TE 4081/104, flip angle (FA) 120º, ETL 33, slice thickness (ST) 5 mm, FOV 254 x 350 mm, matrix 162 x 320, GRAPPA 2, bandwidth 505 Hz/voxel, NSA 1, 2 16-second breath-hold concatenations (TA=32s)), and 3D SPACE (TR/TE 4250/282, FA variable, ETL 159, ST= 4 mm, FOV 305 x 380 mm, matrix 294 x 384, GRAPPA 2, bandwidth 620 Hz/voxel, NSA 2, respiratory-navigated acquisition with mean TA= 4:24 min). A retrospective qualitative and quantitative comparison of both data sets was performed. SNR of the posterior right lobe of the liver and right renal cortex were obtained for each sequence by calculating the ratio of mean signal intensity to standard deviation of an ROI placed by a single observer over a homogeneous area free of artifact. Two observers subjectively rated each sequence on a 1-4 scale (4=highest quality) for 10 different parameters (see Table 1). Each reader also performed a side by side comparison of the sequences and graded preference (1: Strongly prefer 2D TSE, 2: slightly prefer 2D TSE; 3 no preference; 4 slightly prefer SPACE; 5 strongly prefer SPACE). SNR measurements and average image quality scores of the two reviewers were compared between 2D T2W TSE and 3D SPACE using a Wilcoxon matched-pairs signed rank test.

Table 1

Parameter	SPACE	2D TSE	p-value
Overall image quality	3.08	3.13	0.79
Sharpness of liver edge	3.35	3.45	0.65
Sharpness of lesion(s), if present	3.25	2.91	0.13
Sharpness of vessels	3.33	2.83	**0.03**
Blood flow signal suppression	3.33	2.83	**0.001**
Fat suppression	3.33	2.85	**<0.001**
Free of B_1 inhomogeneity (dielectric effect)	2.78	3.28	0.06
Free of ghosting	3.93	3.05	**<0.001**
Free of motion	3.4	3.8	**0.03**
Free of pulsation	3.8	3.2	**<0.001**
Liver SNR	7.91	8.74	0.21
Kidney SNR	17.93	19.61	0.34

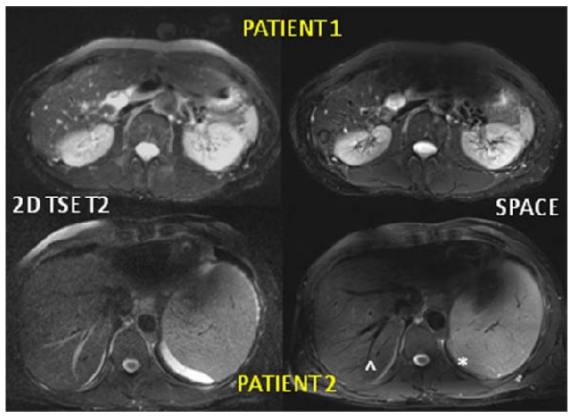

Fig. 1: T2W 2D TSE images show increased ghosting and pulsation artifact. 3D SPACE images show improved fat (*) and flow signal (^) suppression.

Results: There was no significant difference between 2D T2W TSE and SPACE for scores assigned for overall image quality, sharpness of liver edge, and sharpness of lesions. SPACE was deemed significantly better for sharpness of vessels (p = 0.03), flow signal suppression (p=0.001) fat signal suppression (p<0.001), ghosting artifact (p<0.001), respiratory motion artifact (p=0.03), and pulsation artifact (p<0.001). 25% of SPACE cases received the worst possible score for dielectric effect, compared with no cases for 2D TSE. However, an overall worse dielectric effect score for SPACE did not quite reach statistical significance. In a side by side comparison, both readers had a slight preference for SPACE (average preference for the two readers of 3.65 and 3.30 using the scale outlined under Methods). There was no significant difference in SNR in the liver and kidney between sequences.

Discussion: Our findings show significantly reduced artifacts (ghosting, motion, and pulsation) as well as improved flow and fat signal suppression when 3T liver MRI is performed using SPACE compared with standard 2D T2W TSE. There were no significant differences in scores for overall image quality, sharpness of liver edge, or sharpness of lesions. Similar SNR was achieved despite the differences in imaging parameters. The reduced ghosting artifact and trend toward increased dielectric effect with SPACE is in agreement with a recent study of SPACE MRCP at 3T[1]. We believe the reduction in several artifacts resulted in the slight preference of both readers for SPACE. The trend toward increased dielectric effect with SPACE may be reduced by using a "dielectric pad"[4] which was not used in this study. An additional limitation of SPACE was the substantially longer acquisition time. Ongoing technologic improvements such as higher order parallel imaging and parallel RF transmission coils may be used to further reduce scan time and B_1 inhomogeneity artifact. The improved flow signal suppression of SPACE, possibly related to strong dephasing by variable refocusing pulse flip angles, may assist in distinguishing T2-bright lesions from flow artifact. While SPACE showed a reduction in artifacts at 3T, future studies are needed to assess differences in diagnostic ability of the two sequences for identifying and characterizing focal liver lesions.

References: 1. Haystead CM, et al. Radiology 2008;246(2):589-595. 2. Arizono S, et al. JMRI 2008;28:685-690.
3. Arizono S, et al. Eur J Radiol 2008 (in press) 4. Franklin KM, et al. JMRI 2008;27:1443-1447.