

## FAT SUPPRESSION USING RANDOM ENCODING PULSE SEQUENCES

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**TARGET AUDIENCE:** researchers interested in fat suppression and pulse sequence design

**PURPOSE:** The brighter signal from fat in tissues is often a hindrance for diagnosis in MR imaging. Lots of methods <sup>1-3</sup> for fat suppression have been developed, but at the cost of either high computational complexity or sequence durations. In this abstract, we present a fat suppression method using a novel technique of non-Fourier random encoding <sup>4-6</sup>, named as Hybrid. The proposed method exploits a special pulse sequence to generate inhomogeneous  $B_1$  field, thus the image contrast of fat and other tissues is different from that using the conventional Fourier-encoded method. The in vivo human knee experiments demonstrate that the proposed method enhance the signal contrast by suppressing the fat signal without lengthening the imaging time or the computational complexity.

**METHODS:** As to the theory of the typical saturation pulse <sup>3</sup>, fat saturation pulses are highly effective in regions where both the main magnetic field ( $B_0$ ) and the transmit RF field ( $B_1$ ) are relatively homogeneous. Spatially varying flip angles across the FOV may lead to  $B_1$  inhomogeneity that results in an insufficient fat-saturation (fat-sat) pulse and thus leads to incompletely saturated fat signal. Therefore, if a random RF pulse is applied to generate an inhomogeneous  $B_1$  field, it will result in spatially varying flip angles for protons as similar as the effect of fat-sat pulses. This is because the constant difference between fat and other tissues in a number of different flip angles generated by a random RF pulse differs from that with the conventional SINC RF pulses. Although, the theory of fat saturation illustrates that a wider spectral bandwidth of RF energy, or shorter RF pulses in the time domain, may result in overall improved fat suppression <sup>3</sup>, the random RF pulses actually lead to a partial saturated fat signal similar to what some fat saturation pulses do. The Bloch equation simulations of single-point “species” show that the proposed method can suppress fat signal and enlarge muscle signal. To reduce computation and storage, a circulant matrix, one kind of special Toeplitz matrix, was used as the encoding matrix <sup>7</sup>. The decoding computational complexity of the proposed method is as same as the conventional Fourier-encoded method. The proposed 2D and 3D Hybrid pulse sequences (see Fig.1) are implemented based on the previous works <sup>4-6</sup>.

**RESULTS:** We conducted two in vivo human knee experiments to compare the proposed method (Hybrid) and the conventional Fourier encoding method without fat saturation. In the 1st Axial experiment( Fig. 2A), knees were scanned on a 1.5T MRI scanner (GE Healthcare, Waukesha, WI) with 8-channel standard knee coil using the proposed 3-D hybrid pulse sequence (RF pulse duration: 2.144 ms) and the 3D GRASS pulse sequence <sup>8</sup> (TE/TR: 5/26 ms; RBW: 5.96 kHz; FOV: 15 cm<sup>2</sup>; Flip angle: 5°). The decoded image sizes are 256 × 256 × 34. The sum of square (SoS) method is applied to combine decoded 8-channel data. In the 2nd Sagittal experiment (Fig. 2B), knees were scanned on a 3.0T MRI scanner (GE Healthcare, Waukesha, WI) with 8-channel HD knee coil using the proposed 3D hybrid spoiled pulse sequence (RF pulse duration: 2.144 ms) shown in Fig. 2.B and the 3D SPGR pulse sequence <sup>8</sup> (TE/TR: 5/26 ms; RBW: 31.25 kHz; FOV: 20 cm<sup>2</sup>; Flip angle: 18°). The decoded image sizes are 256 × 256 × 32. The SoS method is used to combine decoded 8-channel datasets. The proposed method has the same acquisition time as that using the conventional methods. All decoding schemes were implemented in MATLAB (MathWorks, Natick, MA) on an HP XW8400 workstation with 2.33GHz CPU and 2GB RAM. The results, as seen as Fig. 2, illustrate that fat signals are partially removed by the proposed method (average decoding computational time of 100 trials: A: 10.28s; B: 9.72s) when compared those from the conventional method (average decoding computational time of 100 trials: A: 10.21s; B: 10.02s) with the same decoding computational complexity.

**CONCLUSION:** In this work, a novel fat suppression method is presented to suppress the fat signal and enhance the contrast between other tissues. The in vivo experiments show the proposed method is able to suppress most fat signals that are obvious with the conventional method without compromising the acquisition time and the computational complexity.

**REFERENCES:** 1. Haacke M, et al., Wiley-Liss Press. 1999; 2. Delfaut E, et al., Radiographics. 19:373-382, 1999; 3. Thorsten B, et al., JMRI. 31:4-18, 2010; 4. Wang H, et al., ISMRM. p.2669, 2009. 5. Wang H, et al., ISMRM. p.73, 2012; 6. Wang H, et al., ISBI. pp.398-401, 2012; 7. Yin W, et al., VCIP. 2010; 8. Bernstein M, et al., Elsevier Academic Press. 2004.

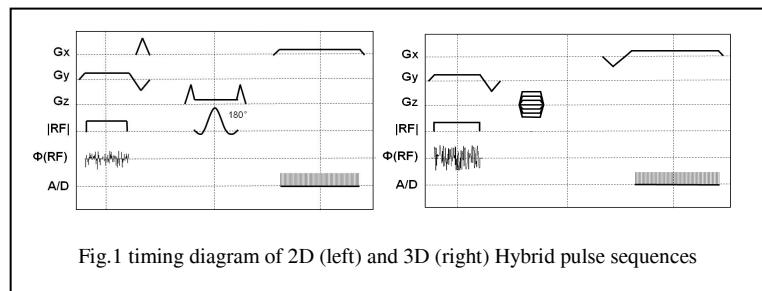


Fig.1 timing diagram of 2D (left) and 3D (right) Hybrid pulse sequences

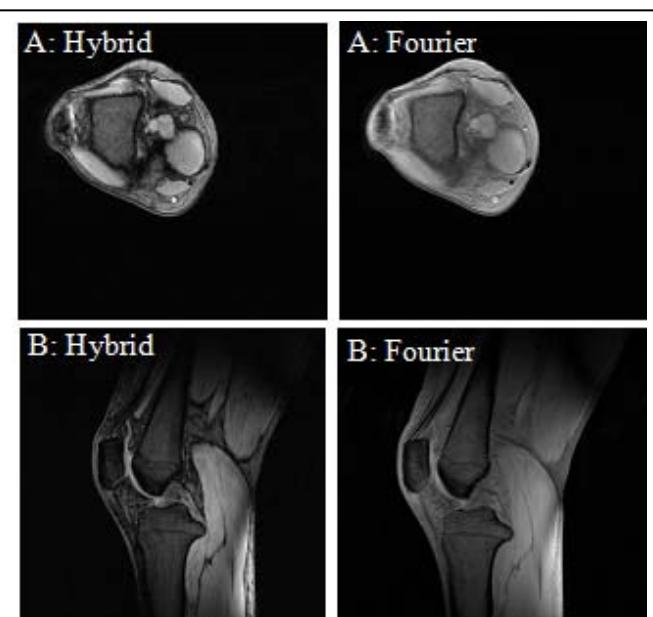


Fig.2 Comparison of two corresponding slices among two 3D data with Hybrid (left) and Fourier without fat-sat pulse (right)