

## MR phantom validation of adrenal adenoma signal intensity index normalization

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**Introduction** – In-phase and opposed-phase (IP/OP) chemical shift magnetic resonance imaging has been extensively used for differentiating between an adenoma and metastatic growth in the adrenal glands. Due to the range of different scan parameters used in these studies, the thresholds reported differ significantly. In this work, we present a method for normalizing signal intensity indices used to differentiate adrenal adenomas from metastases regardless of the clinical parameters used to acquire the IP/OP images.

**Materials and Methods** – Eight fat-water gelatin phantoms with fat/water (F/W) volume ratios ranging from 0-35% fat by 5% increments (with F/W signal ratios from ~0-25%) were constructed using the recipe used in Soher et al.[1]. The T1 and T2\* values of the water and fat components of each phantom were measured by acquiring three-echo SPGR data at different TR and TE times. The three-echo data was then analyzed with the MP-IDEAL algorithm[2] and the resulting F/W values were then fit for T1 and T2\*. The location of the spectral peaks of fat and their relative amplitudes (used in MP-IDEAL) were determined from single voxel spectroscopy. Finally, five sets of IP/OP SPGR images of all eight phantoms in a water bath were acquired with different scan parameters on a 1.5T GE Signa HDX scanner. The signal expected from a fat-water voxel in the adrenal gland being imaged from a spoiled gradient echo sequence is

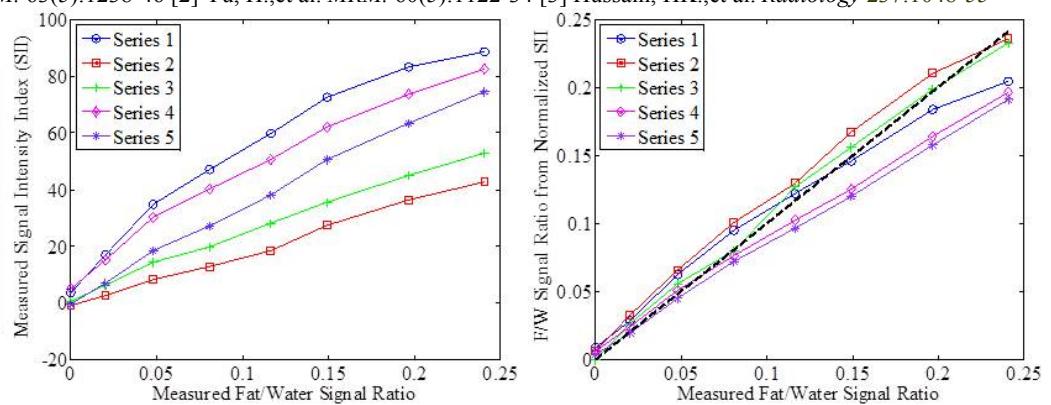
$$S = A_w E2_w \frac{(1 - E1_w) \sin \alpha}{1 - E1_w \cos \alpha} + \sum_{n=1}^3 A_{f_n} E2_{f_n} \frac{(1 - E1_{f_n}) \sin \alpha}{1 - E1_{f_n} \cos \alpha} e^{2\pi i TE \varphi_{f_n w}}$$

where  $E1 = \exp(-TR/T1)$ ,  $E2 = \exp(-TE/T2^*)$ ,  $\alpha$  is the flip angle,  $\varphi_{fw}$  is the frequency difference between fat and water, and  $A_w$  and  $A_f$  are the  $M_0$  amplitudes of water and fat respectively. N corresponds to the numerous fat peaks, which were grouped into three combined peaks for simplicity. The five sets of IP/OP signals were then used to calculate the signal intensity index (SII) using  $SII = (IP-OP)/IP$ . To calculate the F/W signal ratio from the SII, simulated SII values were calculated using the signal equation for F/W signal ratios from 0 to 25% fat (the range in the phantoms), creating a look-up table for all F/W signal ratios. The SII values were then compared to the look-up table to determine the calculated F/W signal ratio.

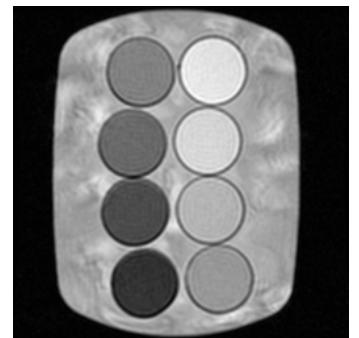
**Results and Discussion** – Figure 2 presents the measured F/W amplitudes (from MP-IDEAL) plotted against the measured SII values and calculated F/W signal ratio for the five sets of SPGR scan parameters. The normalization provided by the look-up table method reduced the percent difference between the results of the different series. Also, the calculated fat-water signal ratios for all series were close to the measured F/W signal ratios. While the parabolic nature of the SII curve can cause problems at high fat concentrations, this was not seen for the 0-25% F/W signal ratios seen here, which is considered a high range for adenomas. Correction of SII values has been previously investigated, but required several other IP/OP scans, not allowing for retrospective evaluation of IP/OP datasets[3]. Future work will involve the measurement additional series of data and monte carlo simulations of the robustness of the algorithm with variation of T1, T2\*, and flip angle. Also, validation of the method at 3T will be performed.

**References** – [1] Soher, BJ., et al. *MRM*. 63(5):1238-46 [2] Yu, H., et al. *MRM*. 60(5):1122-34 [3] Hussain, HK., et al. *Radiology* 237:1048-55

| Series | TR  | Flip Angle | TE       |
|--------|-----|------------|----------|
| 1      | 133 | 75         | 2.2, 4.4 |
| 2      | 100 | 20         | 11, 13   |
| 3      | 104 | 20         | 11, 9    |
| 4      | 150 | 70         | 6.7, 4.4 |
| 5      | 150 | 70         | 6.7, 8.9 |



**Fig 2:** (left) Scan parameters used for IP/OP imaging (middle) Uncorrected SII values (right) F/W ratio after normalization of SII values



**Figure 1:** SPGR MRI (TE=6.7ms) of the fat-water gelatin phantoms