# Exploring Alternative Contrast in the Uterus at High Magnetic Fields

**A. L. Styczynski Snyder[1], T. Liimatainen[1], U. Goerke[1], M. Garwood[1], and S. Michaeli[1]**
[1]Center for Magnectic Resonance Research, University of Minnesota, Minneapolis, MN, United States

**Introduction:** The rotating frame relaxation mapping method in magnetic resonance imaging (MRI) is an attractive candidate to probe body pathology. The utility of longitudinal ($T_{1\rho}$) and transverse ($T_{2\rho}$) relaxation measurements to investigate molecular motion was recently extensively studied (1). In the body, the application of the conventional continuous-wave spin-lock rotating frame relaxation methods to generate tissue contrast is limited because of several technical obstacles, including $B_0$ inhomogeneity and frequency offset artifacts. Recently, we have shown that adiabatic pulse sequences allow generation of contrast based on the rotating frame relaxations during adiabatic full passage (AFP) pulses, which require significant peak-power to satisfy the adiabatic condition. Here a new rotating frame method entitled **R**elaxation **A**long a **F**ictitious **F**ield (RAFF) has been employed for the imaging of the endometrium at 7 Tesla (7 T) (2). Since this method has lower peak-power requirements than other rotating frame relaxation methods, it is of particular interest at very high magnetic fields where increased specific absorption rate (SAR) limits maximum peak-power. The method is based on frequency swept (FS) pulses with sine and cosine amplitude and frequency modulation functions with equal amplitudes, operating in the sub-adiabatic regime. Because low RF power is utilized for the RAFF technique, the rotating frame relaxations during the RF pulses probe slow motional components of the spectral density function and thus may provide greater sensitivity in differentiating tissue microstructure at high magnetic fields. This technique may offer an alternative contrast to $T_1$ and $T_2$-weighted imaging techniques which are typically utilized in imaging of the female pelvis. Here we evaluate the potential for applying RAFF imaging to the uterus and compare RAFF to conventional contrast methods.

**Methods:** Studies were conducted on a 7 T whole-body magnet (Magnex Scientific, Oxfordshire, UK) with an Avanto gradient system and TIM console (vb13, Siemens Medical Systems, Erlangen, Germany). A 16-channel TEM/stripline flexible body transceiver array was used for imaging, each channel driven by a 1-kW amplifier with phase and gain control (3). The transmit power envelope was monitored in real-time on all transmit channels using an in-house built 16-channel RF monitoring system to ensure that FDA SAR limits were never exceeded. An algorithm for $B_1^+$ shimming was employed for the removal of destructive interference from the area of interest (4). $T_1$, $T_2$, and RAFF maps were collected in the sagital plane or along the long axis of the uterus. Both $T_1$ and $T_2$-weighted maps were collected using inversion recovery turbo spin echo and spin echo sequences, respectively, as provided on the scanner by the manufacturer (Figure 1). The RAFF maps were obtained using FS pulses having sine/cosine amplitude $\omega_1(t)=\omega_1^{max}\sin(\omega_1^{max}t)$ and frequency $\Delta\omega_1(t)=\omega_1^{max}\cos(\omega_1^{max}t)$ modulation functions. Here $\omega_1^{max}$ is the maximum amplitude of the RAFF pulse. The decay of the signal intensity (SI) was obtained by incrementing the number of RAFF pulses in the pulse train. The SI decay times used for the RAFF mapping were: 18, 36, 54, and 72 ms. The pulse length = 1.13 ms and $\omega_1^{max}$ = 25 Hz. Sagital images or transverse images along the long axis of the uterus were collected, and the comparison between RAFF, $T_1$, and $T_2$ maps was performed.

**Results:** In Figure 1 the RAFF, $T_2$, and $T_1$ maps (top) and images (bottom) are shown. The endometrium can be clearly distinguished in these images. It can be seen that the RAFF images and maps are artifact-free. Additionally, the differentiation between endometrium and myometrium is comparable in the $T_2$-weighted and RAFF images and maps. The $T_1$-weighting shows less uterine layer contrast as compared to $T_2$ and RAFF, though $T_1$-weighted images remain important for their role in fast DCE applications.

**Discussion:** We present here for the first time the application of the RAFF rotating frame relaxation method to the imaging of endometrium. The RAFF technique may provide a unique contrast from $T_1$ and $T_2$ in MR imaging of cancer and other uterine pathologies, possibly improving diagnostic accuracy.

**References:** 1) Michaeli S, et al., CAC 2007, in press; 2) Liimatainen, T, et al., abstract submitted to ISMRM 2008; 3) Snyder CJ, et al., ISMRM 2007; 4) Van de Moortele P-F, et al., MRM 2005

**Acknowledgments**: This work was supported by NIH-123 4567890, NIH-098 7654321 and P41 RR008079.

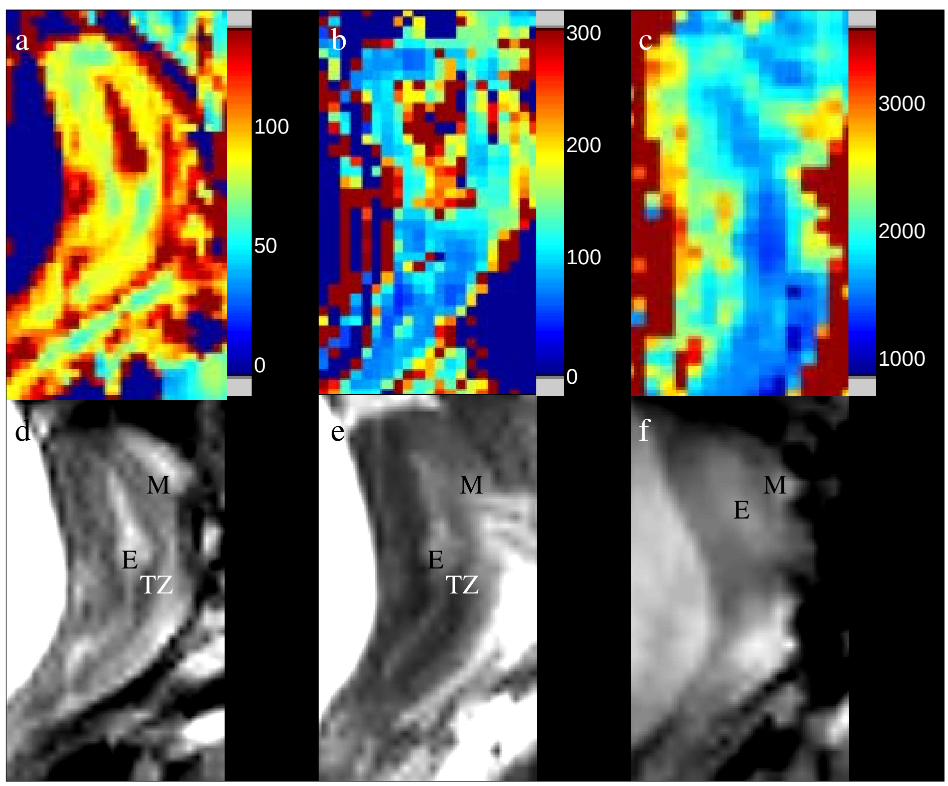


**Figure 1** – Sagital maps and images collected at 7 T a) RAFF map, b) $T_2$ map, c) $T_1$ map, d) RAFF image, e) $T_2$-weighted image, f) $T_1$-weighted image. Visible structures include endometrium (E), myometrium (M), and transitional zone (TZ).