

Consistency of Signal Intensity and R2* in Frozen Porcine Kidney and Liver

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Introduction MR-guided cryoablation is a promising method for the minimally invasive therapy of prostate, liver, and kidney tumors. MRI beautifully depicts the iceball edge as the frozen tissue has decreased signal intensity. Although it is known that the relaxation rate R2* increases in frozen tissue, it is not known how consistent these MR parameters are between tissue types. The purpose of this work was to quantify and compare the MR parameters of freshly excised *ex vivo* frozen tissue of two different types, kidney and liver.

Methods Three liver and four kidney tissue samples were imaged in a Signa SP 0.5T interventional scanner. A receive only endorectal coil was placed adjacent to the tissue samples of dimensions 10x10x25mm which were placed on a plexi-glass plate between two 12x12x65mm copper blocks 25mm apart. A cryo probe (Oncura Medical Ltd.) was inserted 35mm into each copper block. Four fiber-optic temperature sensors (Luxtron, Santa Clara, CA) were placed into the tissue sample 5 mm apart.

A non slice-selective pulse sequence was used for imaging (TR = 200ms, FOV = 200mm, flip angle = 60° and BW of 31.25 kHz). Images were acquired at echo times of 210us, 310us, and 610us. Imaging was repeated as the tissue was cooled from room temperature to -40°C in 5°C increments.

Signal Intensity (SI) and R2* were calculated from a region of interest surrounding each temperature sensor. The SI data was corrected for noise and normalized to the signal intensity of the sample at room temperature.

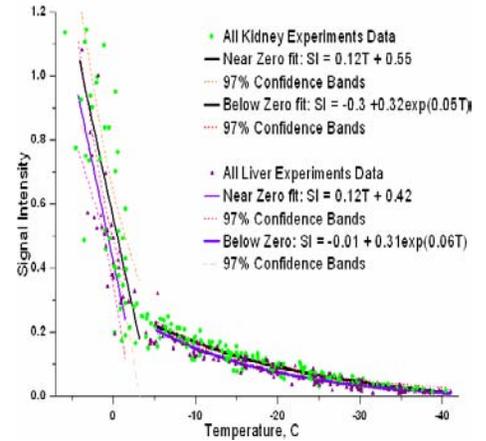


Figure 1. Signal Intensity as a function of temperature for all kidney and liver experiments.

	Signal Intensity near 0°C	Signal Intensity -42°C – near zero	R2*, ms ⁻¹
Kidney	(0.12 ± 0.02)T + (0.35 ± 0.04)	(-0.03 ± 0.02) + (0.32 ± 0.01)exp((0.05 ± 0.01)T)	(-0.07 ± 0.003)T + (0.27 ± 0.07)
Liver	(0.12 ± 0.02)T + (0.42 ± 0.03)	(-0.01 ± 0.01) + (0.31 ± 0.01)exp((0.06 ± 0.01)T)	(-0.07 ± 0.004)T + (-0.15 ± 0.09)

Table 1. SI(T) and R2* fits for all kidney and all liver experiments.

Results SI data from the four kidney experiments were grouped together as well as data for the three liver experiments, as shown in Figure 1. SI was fit to separate curves between 0°C and -4°C (linear fit) and below -6°C (exponential fit). The curves fits for the kidney and liver SI data are given in Table 1.

R2* values are shown in Figure 2. For this data, a linear fit was used, with values provided in Table 1. The difference between the slopes is within one standard deviation. However the intersects for two curves had a greater variability.

Consistency of SI and R2* values was also studied within tissue types. The R2*(T) linear fits for three liver experiments and for four kidney experiments had little variability in slope, but considerable uncertainty in intersect values between the subjects. The data and the linear fits for each experiment are presented in Figure 2.

Discussion The results of this study indicated a high degree of similarity between frozen kidney and liver MR parameters. The variations in R2* intersects between the tissue types and within each tissue type need to be investigated further. Additional experiments with different tissue types and different animals are recommended. R2* values for porcine liver tissue are similar to R2* values for bovine liver tissue presented previously [2]. R2* (T) slopes of bovine liver [2] and porcine liver had values within one standard deviation from each other. Since the experimental setup for the previous bovine liver experiments was different, for fair comparison we need to use our setup for more experiments with that tissue type.

References:

- [1] Wansapura JP, Daniel BL, Vigen KK, Butts K, In vivo Thermometry of Frozen Tissue Using R2* and Signal Intensity. Acad Radiol. 2005 Sep;12(9):1080 - 4
- [2] Butts K, Sinclair J, Daniel BL, Wasanpura J, and Pauly JM, Temperature Quantitation and Mapping of Frozen Tissue. J Magn Reson Imaging 2001;13(1):99-104

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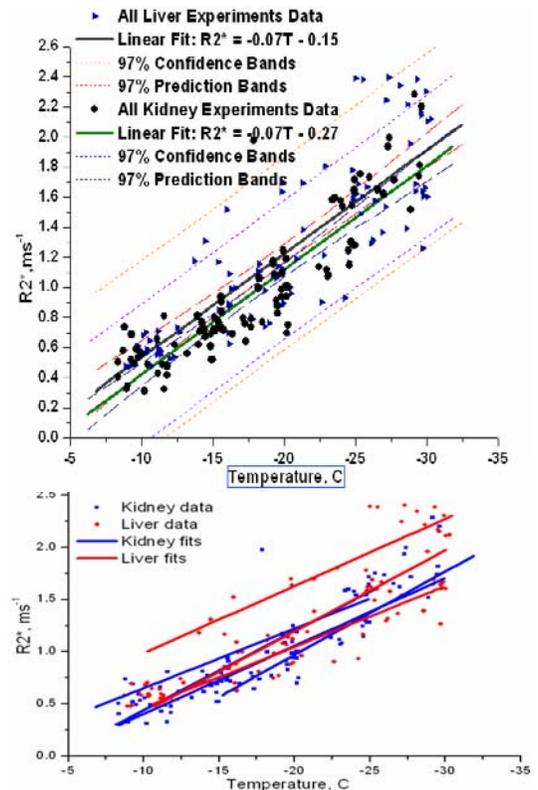


Figure 2. R2* as a function of temperature for top combined kidney and liver experiments; bottom individual kidney and liver experiments.