

Introduction

Laser interstitial thermal therapy (LiTT) is changing our management of brain tumors, by providing a minimally-invasive surgical option. Although advances in MRI thermometry enable real time monitoring of the ablation's progress, tumor responses to thermal energy vary, likely as a result of differences in individual tumor anatomy and pathology. The goal of this study was to measure whether brain tumor laser ablation thermodynamics are correlated with variables measured from preoperative MRI sequences.

Methods

- 69 patients at the University of Miami who underwent LiTT for treatment of brain tumors were considered
- Preoperative MRI tumor pixel intensities (T1, T1 GAD, T2, Flair signal), patient demographics (age, treatment history), LiTT treatment parameters (laser power, duration) were collected
- Of the 69 patients, 52 patients also had MR perfusion imaging data
- Intraoperative thermal damage estimate (TDE) videos for all patients were analyzed on a pixel by pixel basis
- Total pixel counts were modelled using first order dynamics in MATLAB
- Ablation dynamics were tested for correlations with dependent variables using multivariate analysis and stepwise linear regression.

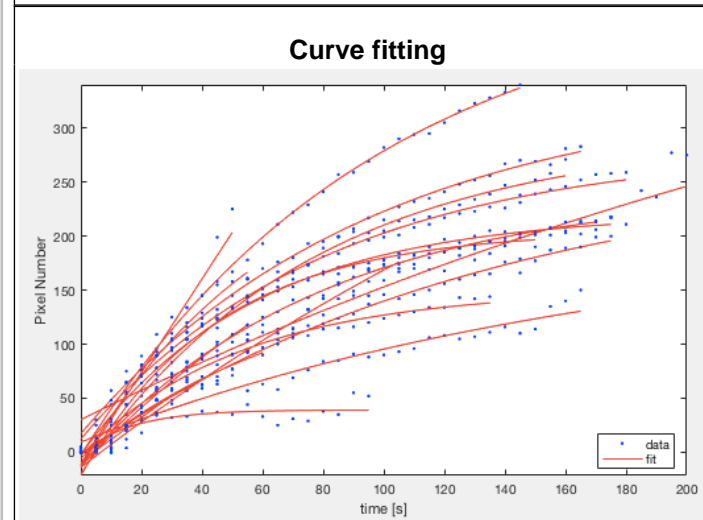
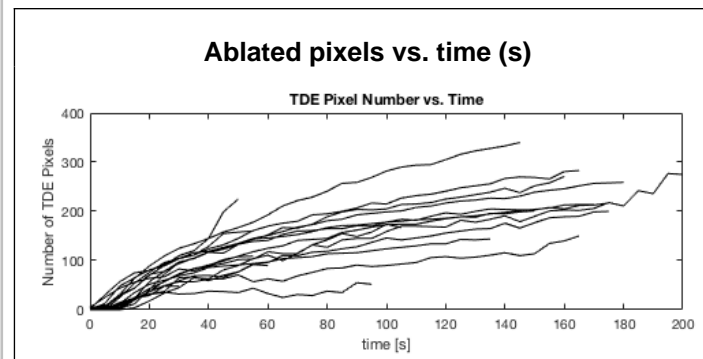
Results

For the 69 patients

- Scale factor was positively correlated with T2 average FSE signal ($p=0.0037$) and laser power ($p=0.029$)
- Ablation time constant was positively correlated with duration ($p=0.022$)

For the 52 patients with perfusion data

- Ablation time constant was negatively correlated with Tumor/Control blood volume ($p=0.039$)



No Perfusion			Perfusion		
	Coefficients	P-value		Coefficients	P-value
Intercept	0.0230315	0.1200139	Intercept	0.0233919	9.15473E-09
T1+C FS SE average signal	-2.06E-06	0.8400056	Tumor/Control blood volume	-0.005552	0.038744788
T1 SE average signal	-1.18E-05	0.4331907			
T2 FSE average signal	-1.01E-05	0.3224246			
T2 FSE FLAIR average signal	3.188E-05	0.2337746			
Age	7.668E-06	0.9537829			
Gender (1 = male)	-0.002096	0.5709922			
Radiosurgery (0=no, 1=yes)	0.0024288	0.5091608			
First duration	-1.3E-05	0.022032			
MvgAvg P	1.346E-05	0.9130799			

Explanation

The inverse relationship between Tumor/Control blood volume and the time constant ($1/t$) indicates that tumors with greater perfusion require longer times to ablation.

Conclusions

Data from preoperative MRI appears to be predictive of brain tumor responses to thermal energy. By developing image analysis pipelines that streamline the acquisition and normalization of LiTT imaging data, it may eventually be possible to improve to use this information to improve preoperative planning of LiTT procedures.

Learning Objectives

- 1) Describe the relationships between preoperative variables and brain tumor responses to thermal LiTT
- 2) Understand the importance of preoperative planning of LiTT procedures for patient care
- 3) Discuss the approach towards incorporating these identified relationships into the preoperative planning protocol.

References

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