Development of IVIM for Perfusion Measurement in Thermal Therapies

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***Abstract*— This study aims to find a feasible method of deriving relevant perfusion parameters from image data taken using Intravoxel incoherent motion (IVIM)-MRI. Parameters produced by the bi-exponential IVIM fit were used to calculate flow velocities within a flow phantom. The results showed that the IVIM method is feasible, but a better perfusion phantom is necessary to more accurately derive perfusion parameters.**

I. Introduction

Magnetic resonance guided laser induced thermal therapy (MRgLITT) is a minimally invasive tumor ablation alternative to surgery in which real-time MRI provides both soft-tissue contrast and quantitative temperature monitoring. The presence of vasculature in the target tissue often results in unpredictable heating patterns, and has led to the development of biothermal models. However, these models require accurate, patient-specific parameter data, most of which is difficult to procure. Here we investigate the potential of Intravoxel incoherent motion (IVIM)-MRI as a fast, reliable approach to quantify patient-specific perfusion parameters, which could then be fed directly into biothermal models and used for surgery planning. Both perfusion and diffusion are seen by IVIM, which then creates contrast between the two compartments by repeatedly imaging with magnetic diffusion gradients of increasing strength (higher 'b-values').

II. Methods

A complex flow phantom was constructed to mimic pseudo-random blood flow and test IVIM perfusion measurements. Diffusion weighted images were acquired on a 3T clinical MRI scanner. Signal strength data from regions of interest on the images were averaged across slices for each b-value. MATLAB was used to fit mono and bi-exponential IVIM models to the image data (as seen in Fig. 1). The fit parameters were used to calculate flow velocities, which were then compared to a measured velocity.

III. Results and Discussion

Velocities derived from the apparent diffusion coefficient given by the IVIM fit were close to the measured velocity, which indicates that IVIM can ideally provide accurate diffusion and perfusion values. However, velocity calculations derived using the perfusion coefficient parameter proved to be inaccurate, possibly due to inadequate perfusion in the phantom. This indicates that a phantom with a faster flow rate is needed to differentiate perfusion from diffusion, from which the process of acquiring IVIM perfusion data could be further perfected.

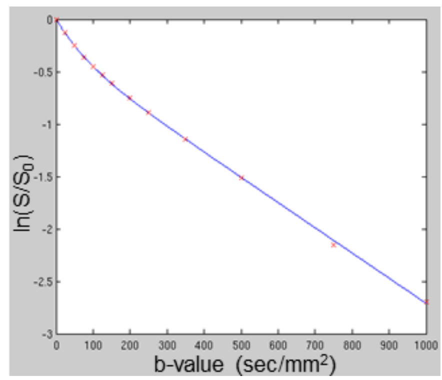

Figure 1. Bi-exponential fit of IVIM data from a region of interest in the flow phantom. The trendline created by the bi-exponential model closely fits the data points. As the b-value surpasses 200 sec/mm^2, the signal contributed by perfusion is dephased significantly and the remaining signal strength has a visibly linear profile.

Acknowledgment

The authors would like to thank Ryan Bosca for providing source code and troubleshooting assistance for his QUATTRO program, and we would also like to thank Florian Maier for his suggestions and feedback.

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