RF Magnetic Signal Localization at Very High Magnetic Field Systems

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The impetus of this work originated from the advent of high magnetic field magnetic resonance imaging scanners with B0 fields of 4T, 7T, and 9.4T. These ultrahigh magnetic field systems generally improve the signal to noise ratios. However, B1 field non-uniformity also occurs due to the increased RF field frequencies when wavelengths in the head become shorter than its size. As interest in multiple channel transmission line coils increases, the control of the amplitude and phase of individual coil elements is required in order to develop desired B1 field. The choice of the excitation of the coil elements may be determined by convex optimization. Convex optimization is used provides results very fast, when the problem is formulated globally. In addition, convex optimization provides better signal to noise (SNR) ratio when anatomic specific regions are investigated. In this paper, simulation and experimental results are discussed at 9.4T systems based on the number of elements. The primary objective of this study is to increase the signal in a specific target region and decrease the signal and noise in the outside region termed the suppression region. The convex formulations are minimizing the maximum field point in the suppression region while keeping the center of target maximum. Based on this min-max optimization criterion, an iteration method which modifies the selection of suppression fields is also performed to produce better results. The results of the localization on FDTD human data at 9.4T are shown in Fig. 1. In these figures, the axial slices of the center of human head model provided by XFDTD are used after manipulating with MATLAB and the 16 channel head coil is excited. Figure 1 shows an improvement of the homogeneity in the suppression region when the target region is at center. In Fig. 2, received signal localizations are obtained for three different regions of interest (ROI) after using the convex optimization. Note that the selection of ROI is limited by the geometric setting of phantom in the 8-channel TEM head coil. Convex optimization with an iterative method was performed on both the human head and phantom models with operating frequency 400 MHz to design coil channel excitation parameters. By applying the iterative method to the convex optimization, more homogeneous B1 fields are obtained in the suppression region for 9.4T system.

KTP High Power Laser-Tissue Interactions: In Vitro Experiment and Simulation

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Benign prostatic hyperplasia (BPH) is one of the most common disorders and the most common cause of lower urinary tract symptoms (LUTS) in elderly men. Transurethral resection of the prostate (TURP) is considered the gold standard treatment for BPH; however, laser prostatectomy has several advantages over TURP with regard to reduced catheterization and morbidity particularly in high-risk patients. Of the many lasers that can be used in the laser prostatectomy, the GreenLight potassium-titanyl-phosphate (KTP) laser is one of the most commonly used. The optimum outcome of this laser procedure is ablation with minimal coagulation. Our objective was to experimentally and theoretically characterize the KTP laser-tissue interactions in order to understand the laser and tissue parameters that lead to an optimal outcome. The rat hind limb muscle was used as a model for the in vitro study. Q-switched 532 nm laser (GreenLight PV, American Medical Systems, MN) was used and the laser was allowed to scan over the tissue with controlled speed and working distance, distance from the tip of the optical fiber to the tissue's surface. Injury was assessed by digital images of the tissue's cross section in terms of ablation, zone of removed tissue, and coagulation, zone of thermally denatured protein, zones. Ablation simulation was done in Matlab R2008a and the ablation was assumed to be a vaporization process. Thermal properties of water were assumed for the basic first run, where the ablation energy of tissue was assumed to be the vaporization energy of water. Parametric study involving changing the ablation energy, thermal conductivity, and absorption (attenuation) coefficient of tissue was performed. Ablated tissue volume increased with decreased scanning speed and trended to saturate at higher values of working distance and lower scanning speed. The optimal therapeutic outcome (minimal coagulation volume and maximal ablation volume) was achieved at 0 mm working distance and 1 mm/s scanning speed. The simulation was able to capture and predict the effect of the tested parameters (ablation energy, thermal conductivity, and absorption coefficient) on the therapeutic outcome. Notably, decreased ablation energy and thermal conductivity, and increased absorption coefficient were predicted to enhance the KTP laser ablation therapeutic outcome (i.e., reduce coagulation volume and increase ablation volume). This will open avenues to improve KTP laser prostatectomy by modulating optical, thermal, and mechanical properties of prostatic tissue.

