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Guidance software for MR-guided focal laser thermal therapy of prostate cancer

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Efficacious focal therapy of prostate cancer requires accurate targeting of the index tumour, in both the placement of treatment devices and in the delivery of therapeutic energy. Magnetic resonance imaging (MRI) provides excellent soft tissue contrast, clear visualization of devices during insertion, and monitoring of temperatures during thermal therapy. Images alone, however, are often insufficient to achieve the accuracy required to achieve oncologic control without significant morbidity. Software tools are required to enhance the information provided by imaging. We present a software application developed to support MR-guided focal laser thermal therapy of prostate cancer. The software is currently in use in an ongoing Phase I/II clinical trial[1] of focal laser ablation in men with low to intermediate risk prostate cancer.

The tools provided by the software fall under three broad categories: Target Identification, Insertion Guidance, and Treatment Monitoring. Underlying all the tools is the ability to load and visualize multiple DICOM image series in two different coordinate spaces: pre-treatment and intra-treatment.

Target Identification: A manual segmentation interface allows contouring of anatomical structures. In the current trial protocol, a baseline multi-parametric MRI study is conducted several weeks prior to treatment to define the full extent of a biopsy-proven tumour. The baseline prostate boundary is contoured on axial T2-weighted images. The baseline tumour contours are delineated on T2-weighted images, apparent diffusion coefficient (ADC) images and T1-weighted dynamic contrast enhanced (DCE) images. At the start of treatment, the prostate is contoured on a set of intra-treatment T2-weighted images. A registration algorithm then compares the baseline and intra-treatment prostate contours to register the baseline tumour to the intra-treatment images. Intra-treatment ADC maps are acquired to confirm tumour registration.

Needle Guidance: Images of a novel mechatronic needle guidance device[2] are acquired. MR-visible fiducials on the device are identified in the guidance software to register the device to the MRI coordinate space. A target point and insertion path are defined in the software and used to align the device along the desired trajectory. MR images are acquired intermittently during insertion of a hollow cannula and trocar. These images are displayed in the guidance software along with 3D representations of the prostate and tumour. Projections along the observed insertion path can be generated to determine whether the insertion is on target. Measurement tools determine the remaining insertion depth.

Treatment Monitoring: MRI thermometry series are acquired during laser ablation. Temperature data can be displayed in the guidance software in 2D superimposed on the prostate and tumour contours or as a 3D block, which provides optimal visualization of the spatial correlation between the heated volume and the target. Thermal damage predictions are obtained from the temperature data using an Arrhenius damage model and predict the percentage of tumour ablated. A DCE series is acquired at the end of the treatment to determine the true region of tissue destruction and to calculate the actual target coverage.

The tools provided in focal therapy guidance software are essential for the optimal delivery of focal therapy.

References:

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