MRI-GUIDED FOCAL LASER ABLATION OF PROSTATE CANCER: COMPARISON OF TARGETED AND ABLATED VOLUMES

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Introduction:

Prostate cancer affects 1 in 6 adult males in the western world and is a leading cause of cancer-related deaths. Focal therapy options are gaining immense interest, due to their potential to target treatment to the cancerous tissue while preserving quality of life. In particular, MRI-guided focal laser ablation (FLA) combines the excellent soft tissue contrast of MRI with real-time MRI temperature mapping to accurately and precisely control laser energy for focal treatment [1]. In this work, we investigate the workflow, safety, feasibility, and initial imaging assessment of MRI-guided prostate FLA. The lesion region-of-interest (ROI) volumes targeted under FLA were compared to the final ablation volumes on post-FLA MRI to better understand the performance of MRI-guided FLA.

Methods:

Five men with biopsy-confirmed low-intermediate grade prostate cancer (Gleason $\leq$ 3+4), were recruited in an IRB-approved pilot study of MRI-guided FLA. Diagnostic multi-parametric (mp) MRI exams were performed on 3 T scanners (Trio and Skyra, Siemens) within 6 months before FLA, and scored according to standardized guidelines [2, 3]. Targeted biopsies of lesion ROIs identified on mp-MRI were performed using MR-ultrasound fusion in addition to 12-core systematic biopsy, and tracked in 3D. All MRI-guided FLA procedures were performed on a 1.5 T MR scanner (Avanto, Siemens), using a fiber-coupled 15W laser and thermal therapy workstation (Visualase, Medtronic). A transrectal needle guide (DynaTRIM, Invivo) was used to direct the laser fiber to planned ablation sites encompassing the targeted lesion ROI. MRI temperature maps were acquired in orthogonal axial and sagittal 2D planes every 6 seconds, aligned with the laser fiber tip to monitor FLA progress and avoid damage to critical structures. A damage estimation map was created for each laser application during the procedure. After concluding laser application at all ablation sites, a contrast-enhanced (CE) T1-weighted (T1w) image was acquired to assess non-perfused volumes (NPV). The number of ablation sites, laser power, application time, laser fiber position, and pre-/post-treatment contours were recorded.

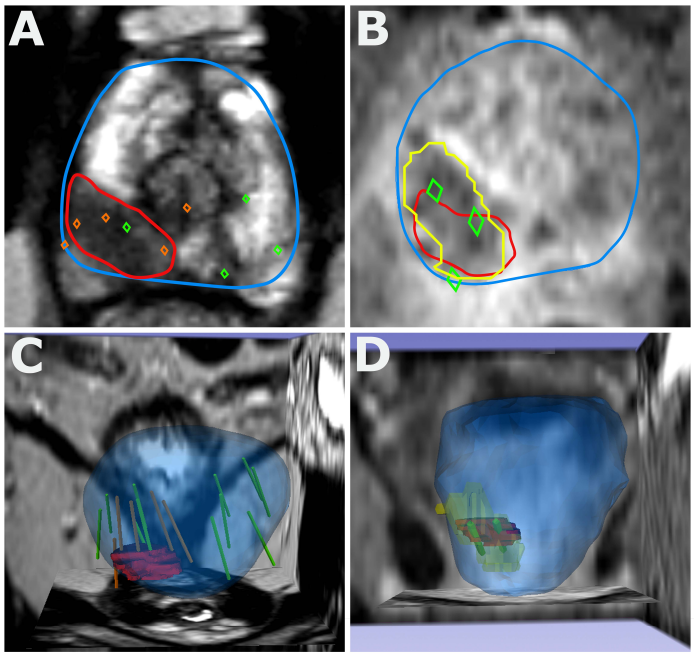

Figure 1: Target lesion ROI on diagnostic T2w (left) and post-FLA NPV ROI on CE T1w (right) images in a patient's prostate. In panels A and C, the prostate is blue, the tumor is red, positive biopsy cores are orange, and negative biopsy cores are green. In panels B and D, the prostate is blue, the tumor is red, the NPV is yellow, and the laser fiber locations are green.

Results:

MRI-guided prostate FLA was successfully and safely completed in all five patients without any adverse events. Average procedure time was 4.5 hours from patient check-in to end of post-FLA MRI. Images from a representative case (patient 4) are shown in Fig. 1. The targeted lesion ROI volume (based on diagnostic mp-MRI), number of ablation sites, and NPV on CE T1w MRI are reported in Table 1. For patient 1, the favorable location of the targeted lesion ROI allowed us to extend the ablation margins considerably. For patients 2 to 5, ablation margins were established with consideration of the prostate capsule. A clear positive correspondence is noted between the increasing target ROI volume and ablated NPV for patients 2 to 5, indicating the ability to monitor and adapt MRI-guided FLA to the target lesion size.

Patient	Target ROI volume	Ablation sites	NPV on CE T1w MRI
1	0.29 cc	4	5.1 cc
2	0.17 cc	4	1.6 cc
3	0.38 cc	4	2.2 cc
4	0.66 cc	7	2.4 cc
5	0.97 cc	7	3.0 cc

Table 1: Summary of five MRI-guided prostate FLA cases.

Discussion and Conclusion:

In a preliminary cohort of prostate cancer patients, we have established a reproducible workflow for MRI-guided FLA and demonstrated its feasibility and safety. In addition, we have demonstrated the ability to monitor and adapt MRI-guided FLA to targeted lesion ROIs identified on diagnostic mp-MRI. Further investigation is required to evaluate the efficacy of MRI-guided FLA and clinical outcomes.

References:

[1] Oto et al., Radiology 2013; 267: 932-940. [2] Sonn et al., J Urol 2013; 189: 86-91. [3] Barentsz et al, Eur Radiol 2012; 22: 746-757.