MRI-Guided Focal Laser Ablation for Localized Prostate Cancer: A Single Center Report on Technique and Intermediate-Term Outcomes

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Purpose: Current options for patients with prostate cancer include whole gland treatments, hormonal therapy, or active surveillance. These options represent a dilemma for patients with localized low-grade cancer who are offered a choice of either observation or disproportionately aggressive therapy resulting in significant complications including urinary incontinence and erectile dysfunction. We report the technical aspects and outcome results of a minimally-invasive focal treatment using laser ablation under MRI guidance and monitoring to treat localized low-intermediate risk prostate cancer while preserving the rest of the gland.

Methods: 11 male patients (age=51.8–73.8y, mean=61.8) with 14 foci of localized prostate cancer underwent 13 MRI-guided focal laser ablation procedures. Procedures were performed within a 3T MRI suite (Magnetom Trio, Siemens, Germany) under conscious sedation (*n=4*) or general anesthesia (*n=9*). Patients were laid in the prone position and a transrectal MR-compatible needle guide was inserted. It was attached to a trans-rectal interventional MR positioning device (DynaTRIM®, Invivo, FL, USA) and imaged with a fast sagittal T2-weighted sequence (TR/TE/FA°/NSA=6340/96/150°/1). A midline image was used to calibrate the needle guide position to the localization software (DynaLOC, Invivo, FL, USA). Axial and sagittal sequences were used to target the lesion. A 1.0-cm (n=4) or 1.5-cm (n=9) active-tip diode laser fiber (Visualase, TX, USA) was introduced within an internally cooled catheter through a 14-gauge introducing sheath. The catheter tip location was confirmed on TSE-T2WIs (TR/TE/FA= TR/TE/FA°/NSA=4320/101/150°/3). A test laser dose of 5 watts was applied for 20s. Definitive ablation was then conducted utilizing 12 (n=2), 15 (n=1), 21 (n=9), or 24 (n=2) watts. Simultaneous temperature maps and cumulative damage maps were obtained, co-registered and overlaid on anatomical imaging to obtain real-time monitoring of extent of ablation zones (Fig.1). Fiber repositioning for additional ablation was conducted as needed. The procedures were concluded when the cumulative damage maps were noted to encompass the entire tumors. Final ablations were evaluated on TSE-T2 and pre- and post-contrast VIBE and TSE-T1 scans.

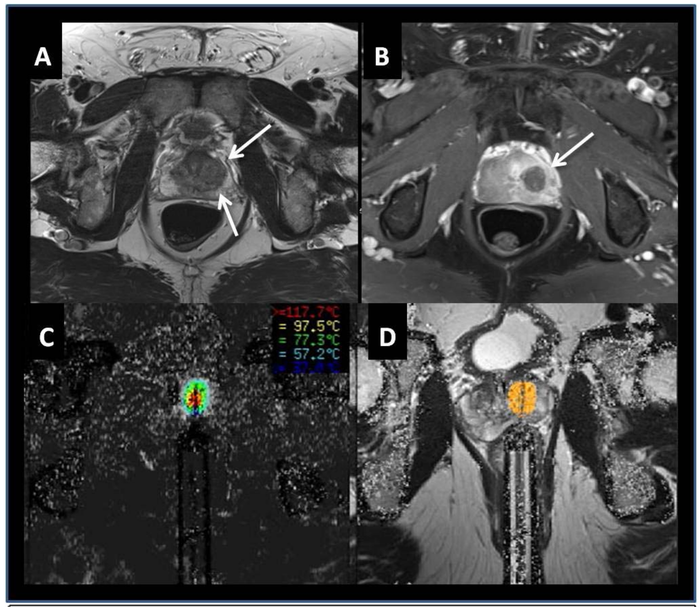

Figure 1: (a) Pre-treatment TSE-T2 scan showing a 1.7-cm left central midgland localized prostate cancer (Gleason 3−3=6) (arrows). (b) Post-treatment gadolinium-enhanced TSE-T1 scan showing the generated laser ablation zone, replacing the target tumor. (c) and (d) Intra-procedural real-time temperature (c) cumulative damage d) maps allowing interactive online assessment of the extent of ablation and determination of treatment endpoint.

Results: All targeted tumors were treatment-naïve Gleason 3+3=6 (n=10), 3+4=7 (n=3), or 4+3=7 (n=1) prostate adenocarcinomas. Target tumor sizes were 1.0 - 2.8 cm (mean = 1.7 cm). Individual lesion locations and sizes are listed in table 1. Access to the desired part of the prostate gland was feasible in all cases. The applied laser energy was 2856- 8820J (mean = 4431J) per treated tumor, with dosage calibrated based on real time feedback of tumor response to ablation. Treatments required 1-4 ablation cycles/laser fiber positionings and resulted in complete tumor necrosis in a single session in all cases as shown on intraprocedural Gadolinium-enhanced MRI. Laser ablation zones demonstrated central iso-to-hypointense signal surrounded by hyperintense/enhancing rim on T2&T1, respectively (Fig.1). The patients tolerated the procedures well and were discharged 4-6 hours after procedure. No immediate or delayed complications were encountered. Follow-up durations ranged between 0-31 months (mean=8.5 months). Significant drop of pretreatment PSA level occurred in all cases (Fig.2). One of the 6 patients had a 5mm focal recurrence at the edge of the ablation zone at his 24-month follow-up time point and was successfully re-treated was another cycle of laser ablation. No recurrence was noted in the remaining 13 lesions.

Patient ID	Procedure Number	Lesion Number	Lesion Location	Maximum Diameter (cm)
1	1	1	L- central- mid	1.7
2	2	2	R- central- mid/base	2.2
3	3	3	L- central- mid	1.3
4	4	4	R- central- mid	1.7
5	5	5	L- periph- apex/mid	2.5
6	6	6	R- periph- mid	2.0
7	7	7	L- periph- apex	1.0
7	7	8	L- central- apex/mid	2.8
1	8	1 (recurrence)	L- central- mid	1.0
8	9	9	R- central- mid	1.5
9	10	10	L- periph & central- mid	2.0
9	11	11	R- central- mid	1.2
10	12	12	R- periph- apex	1.7
11	13	13	L- periph- apex	1.6
11	13	14	L- central- base	1.6

Table 1:
List of individual patients, procedures, and targeted tumor locations and sizes.

Conclusion: This report describes a technique for MRI-guided and monitored focal laser ablation for minimally-invasive targeting of localized prostate cancer. The technique is feasible and well tolerated as an outpatient procedure. This small series indicates a promising efficacy for up to 24-month recurrence-free follow-up durations. Prospective assessment of safety and efficacy awaits further evaluation on a larger cohort of subjects.