Outcome Results of In-Bore MRI-Guided Laser Ablation for Malignant Renal Neoplasms: 1-Year Median Follow Up Analysis of 23 Treated Tumors

Sherif G Nour[1,2], Andrew David Nicholson[3], Tracy E Powell[2,3], and Viraj Master[3]

[1]Emory University, Atlanta, GA, United States, [2]Interventional MRI Program, Emory University, GA, United States, [3]Emory University, GA, United States

Introduction & Purpose: Percutaneous ablative treatment has become a viable treatment option for selected patients with localized malignant renal neoplasms. The primary ablative technologies used are cryoablation and radiofrequency ablation (RFA), commonly performed under CT or ultrasound guidance. The use of MRI guidance has shown an added value for intraprocedural confirmation of a tumor-free ablation zone, thereby reducing the incidence of residual /recurrent neoplasms [1, 2]. MRI guidance of these procedures has, in our experience as in others', been hampered by the cumbersome handling of cryoprobes and RFA probes and their cablings within the already limited room available within the MRI gantry, particularly when utilizing superconducting magnet designs. The aims of this investigation are to a) describe the technical aspects of using laser fibers to deliver ablative energy to renal tumors, circumventing the space constraints within the MRI environment; b) describe patient tolerance and complication rates; and c) report the long term efficacy of laser ablation of renal malignancies.

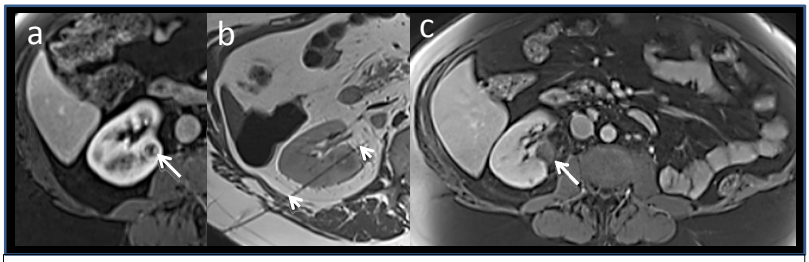

Fig 1: 48-year-old male with history of left radical nephrectomy for RCC and a new 1.7-cm enhancing lesion on gadolinium-enhanced VIBE in the interpolar segment of the right kidney (arrow, a). MRI-guided biopsy performed in the same ablation session confirmed a clear cell RCC. The laser fiber placement is confirmed on TSE-T2 prior to ablation (arrowheads, b). Venous phase post contrast VIBE scan obtained 3 weeks following ablation demonstrate a circumscribed non-enhancing ablation zone (arrow, c) without residual tumor or delayed complications.

Patients & Methods: 13 patients (6M, 7F, age=28-83y) with 27 renal masses underwent MRI-guided biopsies followed by laser ablations in the same session. Procedures were performed within an interventional MRI suite equipped with 1.5T wide bore scanner. Interventions were performed under general anesthesia, entirely within the scanner bore while viewing real-time image updates on an in-room monitor. Interactive visualization on a tri-orthogonal plane True-FISP sequence (TR/TE/FA=2700/84/170°) was used to guide a 14.5-cm-long, 14G MRI-compatible introducing needle into the targeted lesion. 20G FNA and, if inconclusive, 18G core samples were obtained. A laser fiber with 15mm diffusing tip encased in 5.5 F cooling catheter (Visualase, Texas, USA) was then introduced into the target lesion through the pre-existing short 14G introducing needle (Figs 1&2). The optic fiber and cooling tubing were extended through a waveguide to a laser generator located outside the MRI room. A test dose of diode laser energy (980nm,30sec,9W) was applied to verify the location of ablation nidus on real-time temperature and cumulative damage estimate mapping(TE/TE=24/10). Subsequently, ablative energy dose was delivered (27W for cycles of 90-271sec) with treatment endpoint based on on-line thermal monitoring of growing ablation. Fiber repositioning for additional ablation was conducted as needed. Final ablations were evaluated on a repeat set of pre-ablation scans consisting of TSE-T2 and pre- and post-contrast VIBE scans.

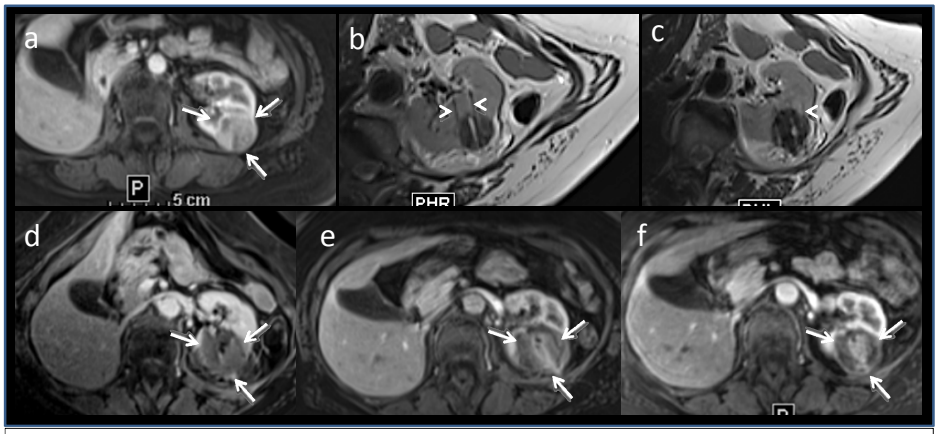

Fig 2: 83-year-old female with history of right radical nephrectomy for RCC. A 3.8-cm mildly enhancing left kidney lesion is noted on gadolinium-enhanced VIBE (arrows, a). MRI-guided biopsy performed in the same ablation session confirmed a oncocytic RCC. Multiple laser fiber placements were necessary based on initial size and on actual thermal damage maps obtained during ablation. The laser fiber placements are confirmed on intraprocedural TSE-T2 (arrowheads, b&c). Post contrast VIBE scans obtained immediately following ablation (d), after 5 weeks (e), and after 5 months (f) demonstrate a circumscribed non-enhancing ablation zone (arrows, d-f) without residual tumor or delayed complications.

Results: 3 biopsies revealed benign masses. One lesion was not biopsied. This analysis therefore includes 23 laser ablations of renal tumors. Biopsy results showed 22 RCCs (16 clear cell, 2 chromophobe, 1 oncocytic, 1 papillary, 2 not specified) and one renal metastasis from lung cancer. Target tumor sizes were 0.7-3.8 cm (15 right-, 8 left-sided). 5 patients had a single kidney, 3 patients had prior ipsilateral partial nephrectomy, 2 patients had prior contralateral ablations, and 2 lesions were recurrent masses at prior cryoablation margins. Access to the desired part of the kidney using the 14.5-cm-long introducing needle was feasible in all cases, including one morbidly obese patient, with no space constraints encountered within the 70-cm magnet bore. The flexible nature of optic laser fibers eliminated the complexity of handling bulky ablation probes, and the traction exerted by their cablings and fitted the MRI environment. The short ablation cycle facilitated accurate temperature mapping during controlled suspended ventilation without the need to implement motion correction algorithms. Applied laser energy was 4050- 79380J per lesion, with dosage calibrated based on real time feedback of tumor response to ablation. One patient had a moderate self-limited perinephric hematoma related to the biopsy part of the procedure. Otherwise, no early or delayed complications were encountered. Follow-up durations ranged between 1.6 - 32.7 months (mean = 12.5 months, median = 12.8 months). No residual or recurrent neoplasm was identified in any patient.

Discussion & Conclusion: This investigation reports the improved access for interactive guidance and real time monitoring of renal ablation procedures performed entirely within an interventional MRI suite via the use of a short introducing needle and a flexible laser fiber. The technique represents a considerable departure from the complex handling of cryo- and RFA probes within the MRI environment and is likely to facilitate a better future dissemination of MRI-guided renal ablation as a mainstream technology. The procedure is well tolerated with a high safety profile. Long-term follow up results for up to >32 months also point to an efficacious ablative technique with no residual or recurrent neoplasms in our series. Further assessment of long-term efficacy in a larger cohort of subjects is ongoing.

References:

[1] Lewin JS, Nour SG, Connell CF, et al. Radiology. 2004; 232(3):835-45.
[2] Silverman SG, Tuncali K, vanSonnenberg E, et al. Radiology. 2005; 236(2):716-24.