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Magnetic resonance guided intra-urethral high intensity focused ultrasound treatment of prostate tissue in preclinical model

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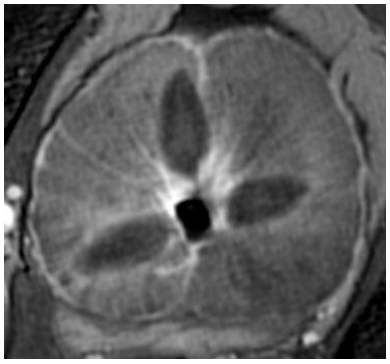
Introduction: There has been a paradigm shift in the treatment of prostate cancer toward minimally invasive options that may achieve acceptable oncological efficacy with minimal morbidity. Using a novel intra-urethral high intensity focused ultrasound (HIFU) device, MR-guided focal ablations in canine prostates were evaluated for feasibility and correlation of MRI ablative volumes with histology.

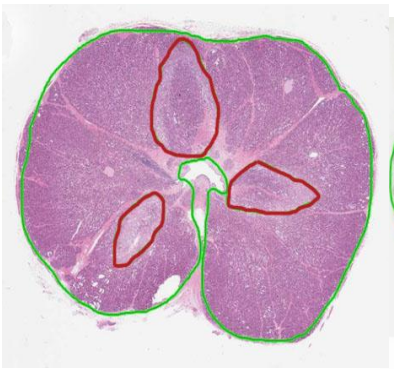
Methods: A MR-compatible HIFU prototype was developed in collaboration with Philips Medical Systems. Approved by the Animal Care and Use committee, two canines were treated with 3-4 ablations each. Prior to the procedure, a perineal urethrostomy was performed to allow for direct advancement of the device to the level of the prostate. In-gantry MRI provided images for planning, target selection, and real time assessment of temperature elevations during therapy. Target ablative temperature was set at a minimum of 55C. Real time thermal dose (CEM43 > 240 = ablated) volume estimates based on MR-thermometry were provided by the custom software. Temperature-sensing markers automatically shut off the device to prevent inadvertent heating of tissues beyond the preselected targets. Following the procedure, the animals were euthanized for specimen procurement. Cytokeratin-8 and H&E stains were utilized to determine the extent of necrosis and cell viability.

Results: MR-guided focal HIFU ablation of prostatic tissue was feasible. Thermal dose volume estimates positively correlated with those determined by histopathological analysis (0.935cm^3 vs. 0.639 cm^3, respectively, r^2= 0.89, p=0.004). Post-procedural contrast-enhanced MRI demonstrated an improved correlation with histopathological analysis (0.60cm^3 vs. 0.639 cm^3, r^2= 0.94, p=0.001). Additionally, a positive correlation between ablated volumes determined by MRI thermal dose and MRI contrast enhancement was found (r^2= 0.88, p=0.057).

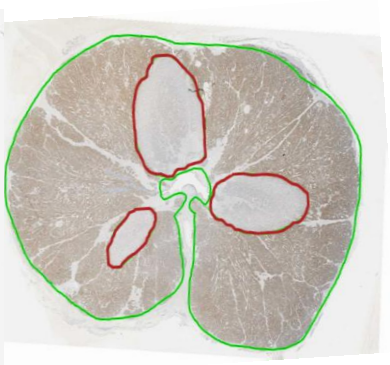
Conclusion: This novel prototype allows for precise, targeted treatment of preselected lesions in canine models. However, further preclinical data is required prior to human trials to demonstrate its feasibility, safety, oncological control, and functional outcomes.



A. Visible ablations on post procedure post- contrast imaging



B. Areas of hemorrhage and necrosis on H&E staining of the whole mounted specimen



C. Areas of cellular non-viability on Cytokeratin-8 staining of the whole mounted specimen