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MRI-guided focal laser ablation of prostate cancer using a mechatronic needle guidance system: Experience in seven patients

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Purpose: To present our initial experiences in using a mechatronic system to accurately place catheters for MRI-guided focal laser ablation of prostate cancer.

Background & Methods: Focal therapy of localized prostate cancer is receiving increased attention due to its potential for providing an optimal level of cancer control in select patients, with a minimal amount of treatment-related side effects. Focal laser ablation is an attractive modality for the delivery of this therapy. In this procedure, the accurate placement of laser fibers to their planned locations is critical to ensuring that the full volume of tumor is destroyed. For this reason, we have developed a mechatronic system for the accurate placement of catheters to the prostate within the bore of a clinical MR scanner.

In an ongoing institutional research ethics board approved phase I/II clinical trial, men were treated for localized prostate cancer with MRI-guided focal laser ablation. For the most recent seven patients in this trial, placement of catheters was performed using a newly developed Health Canada approved MRI-compatible mechatronic needle guidance system. The system provides the ability to precisely target regions in the prostate, and allows needles to be inserted transperineally with the patient remaining in-bore. In contrast to the conventional grid template approach, our system can guide needles to any arbitrary target point within the prostate through angulated trajectories (+/- ~20 degrees). The system's accuracy and repeatability in aiming its needle guides at MRI-identified targets in air has been rigorously quantified as 1.1 +/- 0.3 mm. In each treatment, MR images of needles in their final locations were acquired, allowing quantification of the error in needle guidance achieved using the system *in vivo*.

Results: A total of 26 catheters were placed using the system. The needle guidance error was 4.7 +/- 3.5 mm (mean +/- standard deviation), and the time required to successfully guide each needle to its intended target was 8 +/- 3 minutes. After gaining familiarity with ideal patient positioning in the first two patients (in which device-patient interference was encountered), the needle guidance error reduced dramatically and was much more consistent (3.3 +/- 1.6 mm for the 17 most recent needle insertions). It was also found that needles were able to be inserted with much greater ease than in previous patients in this trial, for which they were inserted either freehand or using a grid template. In addition, the ability to insert needles without removing the patient from the scanner was found to be extremely valuable in reducing the procedure time and minimizing patient motion. Finally, the system's ability to target arbitrary points within the prostate and provide angulated needle trajectories assisted in ensuring an ideal conformation of the ablation regions to tumor shapes.

Conclusion: By using a mechatronic system for guiding needles, it was found that MRI-guided prostate focal therapy could be accurately performed with much greater reliability and ease than the previous approach.