ROBOTIZATION OF A URETEROSCOPE FOR AUTOMATIC LITHIASIS VAPORIZATION

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ABSTRACTS

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Introduction: During laser lithotripsy, sweeping the surface of the stone with the laser fiber is required for an effective vaporization of the stone. However, this is made difficult by the poor maneuverability of the ureteroscope. We propose the robotization of a ureteroscope to perform this task semi-automatically, under surgeon control.

Methods: In the proposed system, the operating process remains unchanged for the surgeon : after introduction of the device into the kidney, he locates the lithiasis, inserts the laser fiber in the operating channel and points towards the lithiasis with it. Hence, when the surgeon pushes the laser pedal, the fiber points towards the lithiasis. The detection of the laser red spot then gives the location of a group of pixels inside the lithiasis. An algorithm using this information was developed for the segmentation of the lithiasis on the video image at 30 frames/s. Once knowing the place of the lithiasis on the image we can plan a path for the laser spot to smoothly sweep the surface of the lithiasis. We developed an actuating system composed of three shape memory alloy wires integrated to the distal tip of the ureteroscope (fig.1) and commanded through electrical heating. Their length and diameter have been calculated to allow the sweep of a 20 mm wide lithiasis with the laser fiber.

Results: The algorithm accuracy and robustness was validated on 910 images coming from 10 different videos, presenting calculi of four different chemical compositions and sizes varying from 9 to 19 mm. Comparison with the ground truth traced by hand showed that the algorithm is robust and more than 90% effective. The actuators were tested on a 13mm wide lithiasis : we were able to point at every point of the lithiasis surface, using combinations of the three actuators. Then, a visual servoing application was developed, showing that the actuated system can be commanded to point at every designated point in its field of view in less than one second.

Conclusion: Semi-automatic laser lithotripsy can be made possible by our system, which would benefit to the surgeon and the patient. Integration of the visual servoing scheme with path planning is the next step to provide a fully operating prototype.

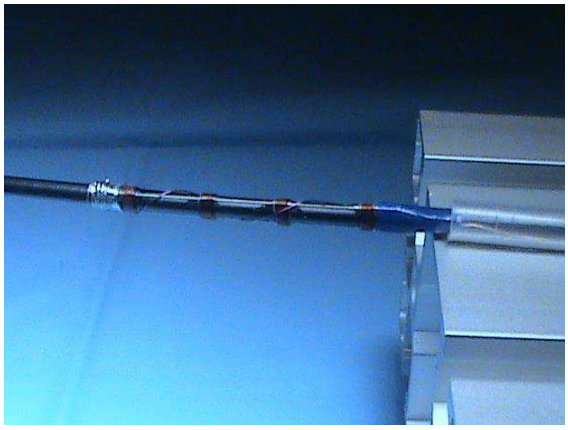

Fig.1 - Integration of the SMA wires to the distal tip of the instrument

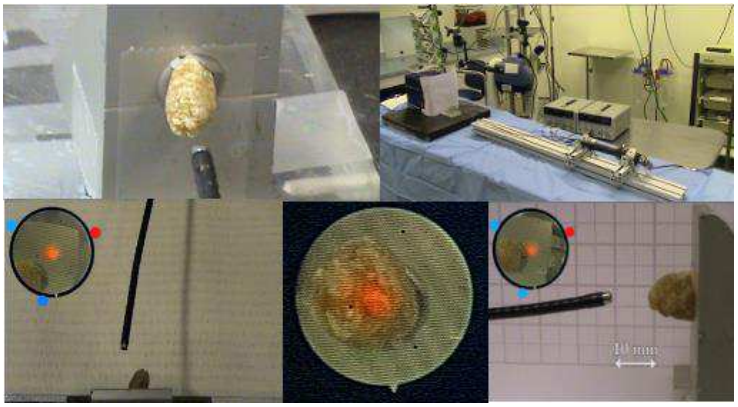

Fig.2 - Validation of the range of movements accessible to our system