ABSTRACT 15 **BEST ABSTRACT AWARD**

INTRAOPERATIVE GUIDANCE FOR ROBOTIC PARTIAL NEPHRECTOMY USING SURFACE-BASED REGISTRATION: INITIAL MODEL ASSESSMENT

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Introduction: While robotic partial nephrectomy can improve long-term outcomes when treating renal cell carcinoma [1], it remains underutilized because of its technical challenges [2]. Effective image guidance has the potential to increase utilization of partial nephrectomy by reducing challenges associated with locating critical subsurface anatomy. We have created a new image guidance system for the da Vinci Surgical System for this purpose. We present a preliminary phantom experiment to evaluate accuracy of our image guidance system and demonstrate its utility in localization of subsurface features.

Methods: A silicone kidney phantom made based on patient imaging was cast with a spherical exophytic tumor model. Prior to experiments, the kidney was attached to a rigid platform containing optical tracking markers. The phantom was imaged with CT, and the kidney and tumor were segmented. In the operating room, a layer of synthetic fat was placed over the area of the phantom containing the tumor. Our image guidance interface was displayed through the da Vinci's surgeon console, alongside the endoscopic camera view. Surgeons used the image guidance system to collect surface data by lightly tracing over the exposed kidney surface with the da Vinci's instruments (Fig. 1-A). Using this data, our system computed a globally optimal surface registration [3] to the segmented kidney image. After registration, surgeons used image guidance to place the tip of an optically tracked needle probe through the layer of fat, into the tumor model (Fig. 1-B). An optical tracking system provided probe position data and post-operative evaluation of registration accuracy.

Results: Using the image guidance system, surgeons easily identified the surgical target. After needle insertion, the fat layer was lifted for visual assessment of needle placement accuracy (Fig. 1-C). Figure 1-D shows the surface-based registration of the kidney overlaid with the ground-truth image location (measured by optical tracking). The distance between the centroid of the tumor model in the registered image and the ground-truth image serves as a preliminary measure of target registration error for our method (1.9 mm).

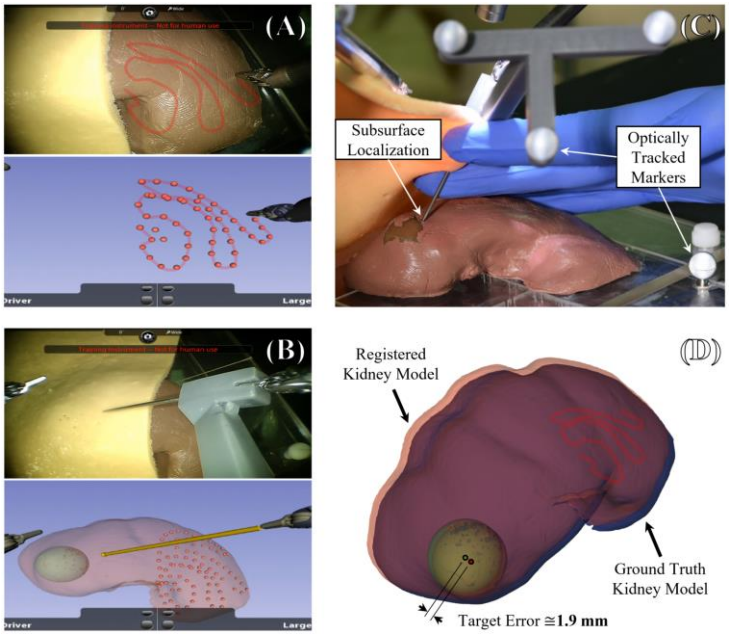

Figure 1: A. Kidney surface data collection. B. Needle insertion task with image guidance. C. Fat lifted to view results of needle insertion. D. Registration result vs. tracked ground truth phantom.

Conclusion: These preliminary results suggest that a surface-based registration technique enabled by lightly tracing da Vinci instruments over a portion of the kidney surface is sufficiently accurate for intraoperative image-to-anatomy registration using the da Vinci Surgical System. Additionally, the success of the needle placement task demonstrates the utility of image guidance for locating subsurface features during surgery. The lack of additional hardware makes touch-based registration an attractive option for fast implementation and adoption in the operating room. Full quantitative analysis of the image guidance system, including *ex vivo* and i*n vivo* experiments, is ongoing.

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Intraoperative Guidance for Robotic Partial Nephrectomy Using Surface-Based Registration: Initial Model Assessment

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Introduction

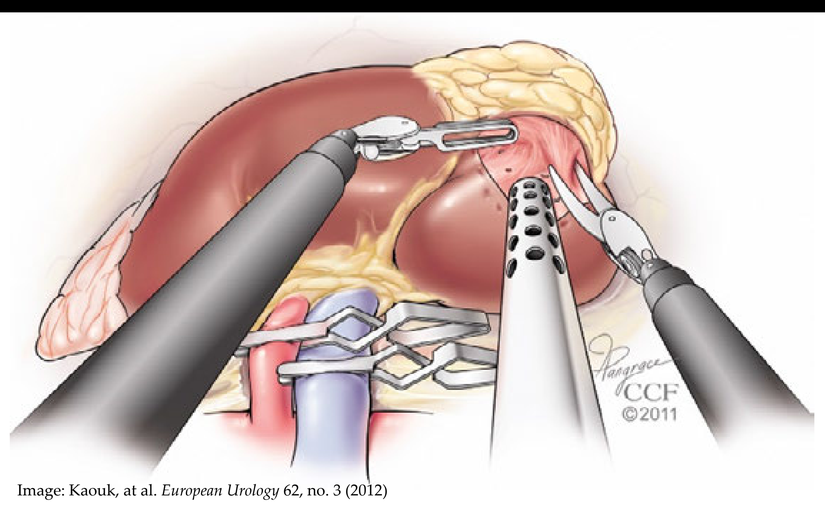
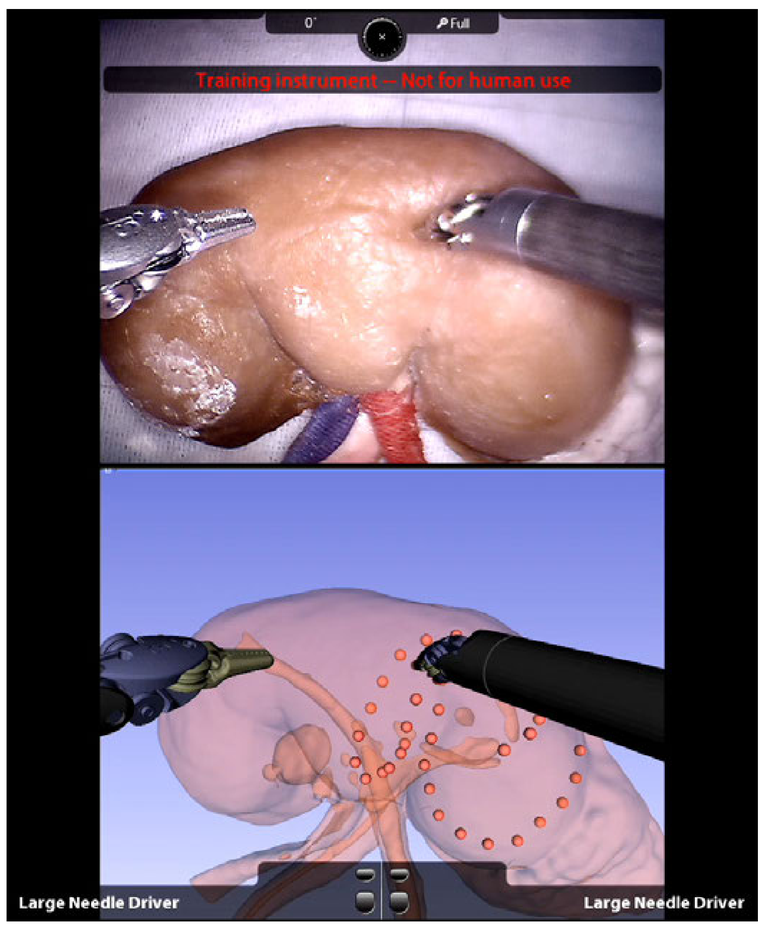


Image: Kaouk, at al. *European Urology* 62, no. 3 (2012)

Can image guidance improve partial nephrectomy?

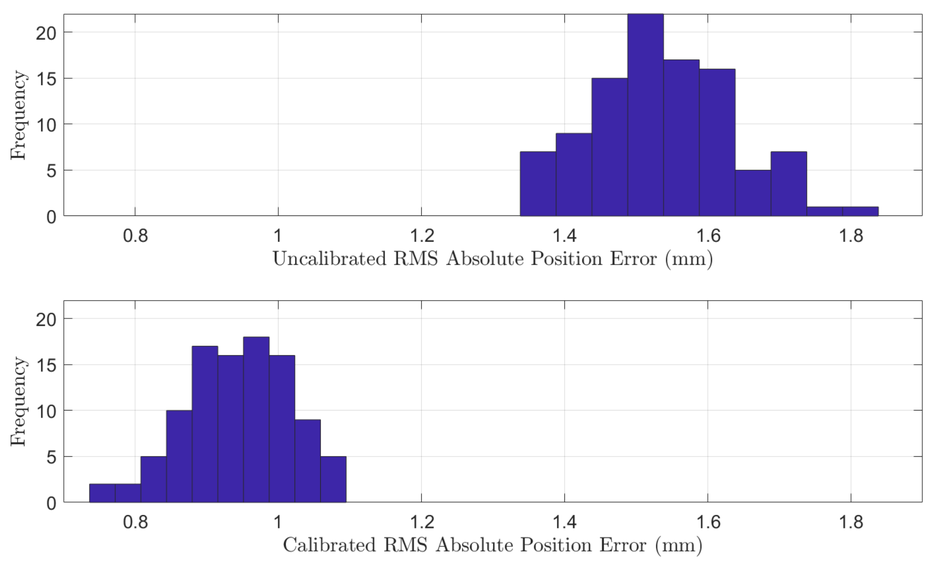
We present a preliminary phantom experiment to evaluate the accuracy of our image guidance system and to demonstrate its utility in localization of subsurface features during partial nephrectomy.

Real-Time Image Guidance



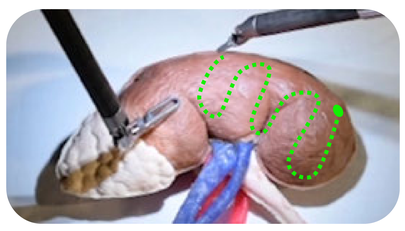
Kinematics-based tool tracking.
Preoperative image registration.

Kinematic Calibration

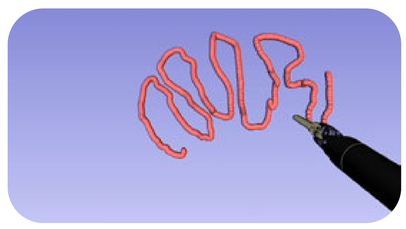


Submillimeter tracking accuracy

Surface-Based Registration



Lightly trace curve on kidney surface

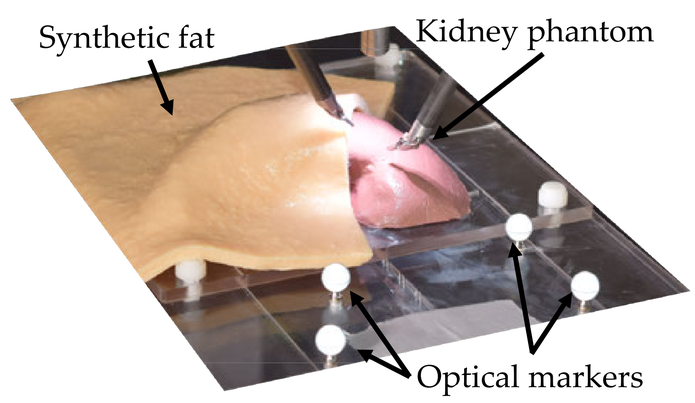


Track curve in robot workspace with calibrated kinematic model

Automatically calculate optimal registration of curve to 3D kidney image

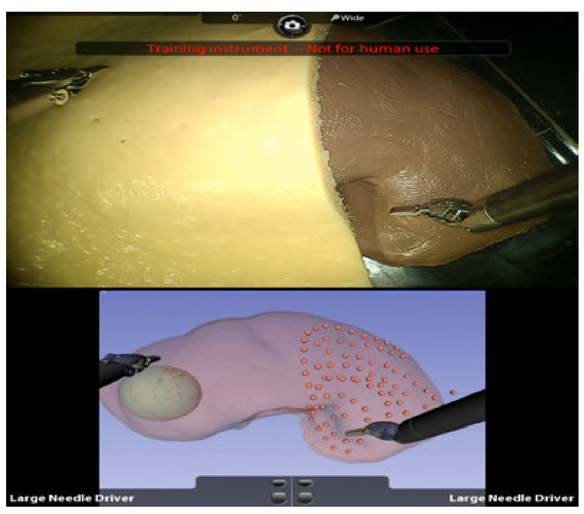
Digitize kidney surface using robot manipulators

Phantom Trial Setup

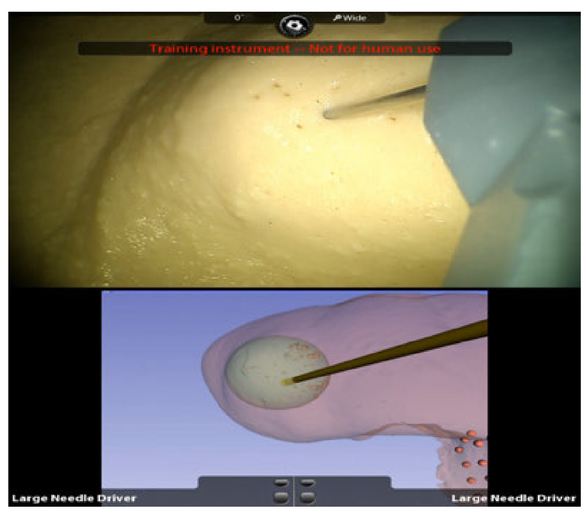


Accuracy validated with optical tracking

Phantom Trial Experiments

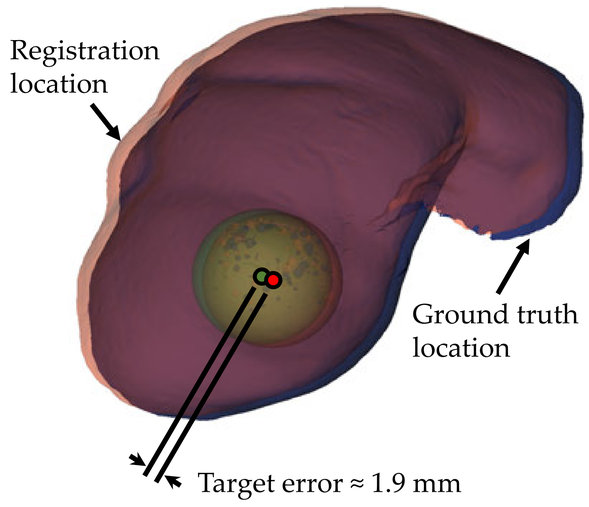


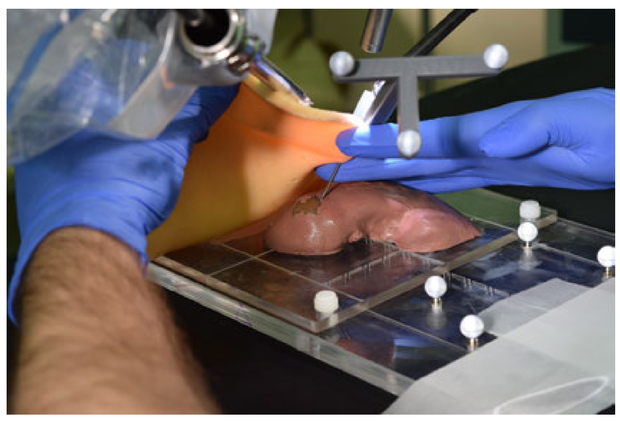
Registration



Subsurface feature localization

Phantom Trial Results





Initial results suggest that a surface-based registration technique can be sufficiently accurate for intraoperative image-to-anatomy registration. This approach does not require additional hardware, making surface-based registration an attractive option for fast implementation and adoption in the operating room.

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