# ROBOGYN: Robotic gynecological brachytherapy

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Gynecological cancers and especially cancers of the cervix are one of the most devastating forms of cancer in the western hemisphere as well as worldwide. The condition is effectively treated with brachytherapy that entails implanting radioactive sources into the cancer to kill it with radiation. The success of the procedure depends on the accurate visualization of the cancer and precise placement of the sources. Faulty source delivery may result in insufficient dose to the cancer and inadvertent radiation of healthy nearby tissues. The former causes a failure of treatment while the latter results in adverse side effects, such as ulceration, incontinence and chronic pain. The host group at the Medical University of Vienna previously developed a surgical applicator to deliver brachytherapy needles (**Figure 1**). This device is cumbersome to use and unable to treat patients whose cancer has spread through the uterine wall.

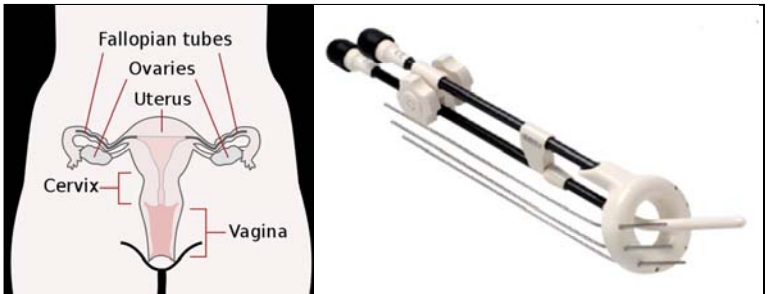


**Fig. 1:** Female anatomy (left) and the Vienna Applicator (right)

OBJECTIVE: We proposed to develop the proof of concept prototype of a robotic device to allow for precise implantation of brachytherapy sources into gynecological cancers with direct magnetic resonance imaging (MRI) guidance.

ACTIVITIES AND RESULTS: Functional specification was derived from observation of clinical procedures. Key features were identified and reduced to functions essential to demonstrate feasibility. In this concept, the cervix harboring the cancer is accessed through the vaginal cavity. The surgical applicator that delivers the brachytherapy needles is manipulated inside the cavity, mimicking conventional manual technique, with a combination of rotations and translations. We designed a new surgical applicator to provide optimal access route to the target anatomy and full coverage of the cancer that often spreads through the uterine wall.

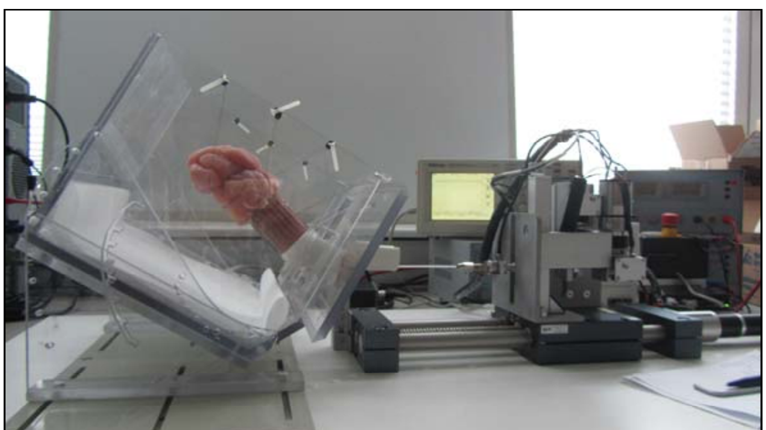

**Fig. 2:** Testing of the integrated surgical applicator and needle placement robot platform in ex-vivo tissue experiment.

We have recreated an ex-vivo model of the female anatomy and experimented with different robotic needle driving scenarios with the new surgical applicator and compared its performance to the conventional method. Initial results with the robotic needle driver were promising and showed that friction forces need to be reduced inside the surgical applicator (**Figure 2**).

In order to be able to navigate the surgical applicator with the robot, we developed an automatic method for recovering the full pose (position and orientation) of a brachytherapy ring applicator in MR images, which in turn allows us to compute inverse kinematic commands for the robot to deliver the needles to the target. We implemented the method on the 3D Slicer open source medical visualization and image analysis platform (**Figure 3**.) The feasibility of applicator pose reconstruction was successfully demonstrated. The registration works robustly on synthetic images with an excellent accuracy and an acceptable execution time.

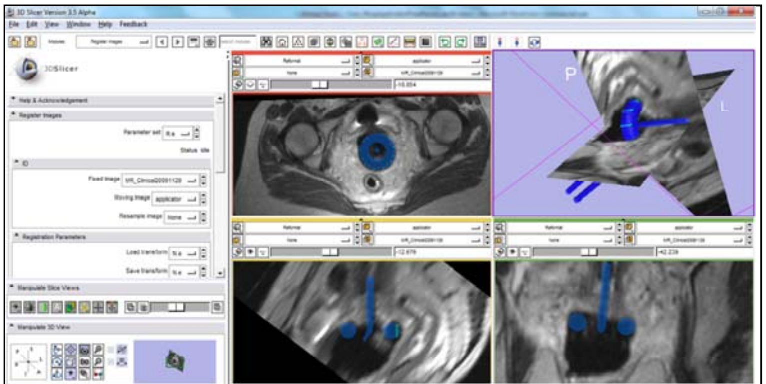

**Fig. 3:** Registration of the applicator image to the patient image in 3D Slicer open source software

We believe that this system, when fully implemented, will lead to better clinical outcomes by simultaneously improving cancer control and reducing radiation toxicity in surrounding healthy tissues.