A Novel Computer Program to Support MR-guided Gynecologic Brachytherapy

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Purpose

To describe a novel computer program designed and implemented to provide an overall system for supporting MR-guided gynecologic brachytherapy

Material/Methods

From September 2011 to January 2012, 10 gynecologic-cancer patients requiring brachytherapy underwent image-guided applicator insertion in a multimodal operating suite with integrated MR scanner, ultrasound and PET/CT scanner. In order to increase the physician's speed and monitor the consequences of inserting interstitial catheters in real time, a novel computer program was designed and implemented and is described here.

Results

The overall system starts with pre-implant imaging and the integrated software permits measurement of relevant sizes for intervention leading to automatic inventory control and specific applicator request. Next, a device is selected (e.g., tandem and ring/ovoid +/- interstitial needles or interstitial needles alone) that is modeled in the preoperative images. Virtual modeling and visualization of several instruments for direct device comparison is enabled to identify the optimal one. In the intraoperative stage, the patient is imaged using 3 Tesla MRI with legs in the insertion position. The computer-visualized template allows guidance to an optimal position for dose delivery. Serial imaging examinations are superimposed on the visualization of the modeled device. With this interactive novel software program, the physician can select which interstitial needles may best benefit the patient, and at what depth they should be inserted, as determined by the MRI image viewed during the insertion process. The physician then inserts the correct interstitial needle into the necessary applicator hole based on the tumor location as visualized on intra-operative 3T MRI.

Conclusion

Novel software was developed that aids in the integration of preoperative assessment, intraoperative 3T imaging and applicator insertion. Novel features include 1) linking a diagnostic imaging set in real-time to a 3D CAD model of a medical device; 2) precise identification of catheter location in the 3D imaging model with real-time imaging feedback and 3) the ability to perform patient specific pre-implant evaluation by assessing in the computer the placement of interstitial needles prior to an intervention via virtual template matching with a diagnostic scan.

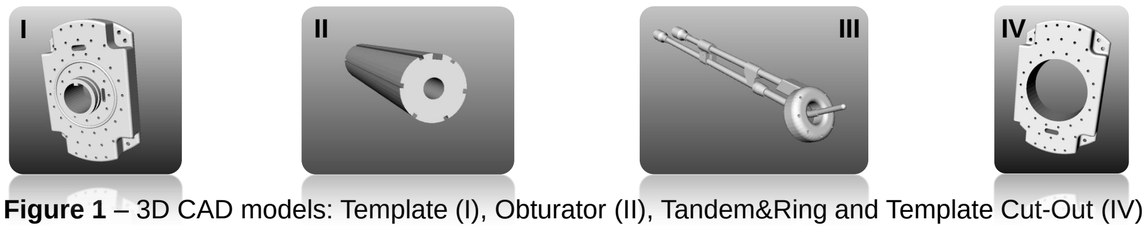


Figure 1 – 3D CAD models: Template (I), Obturator (II), Tandem&Ring and Template Cut-Out (IV)

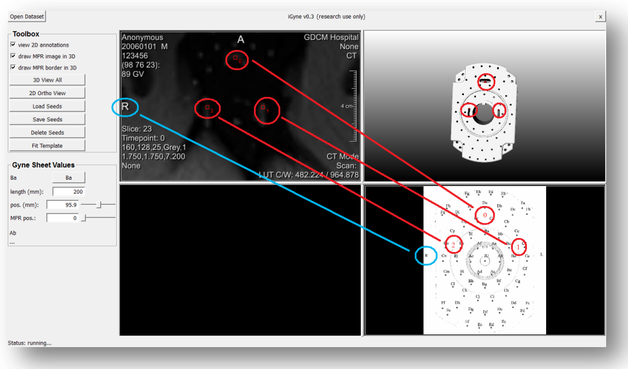


Figure 2a – Principle for fitting a gynecological template for brachytherapy with an initial CT image. The three red circles indicate corresponding needle holes in the template and the patient image. The fitting is realized via a rigid transformation between these corresponding point sets. The blue circles are used to ensure that the left and right sides of the patient and the template are matched correctly.

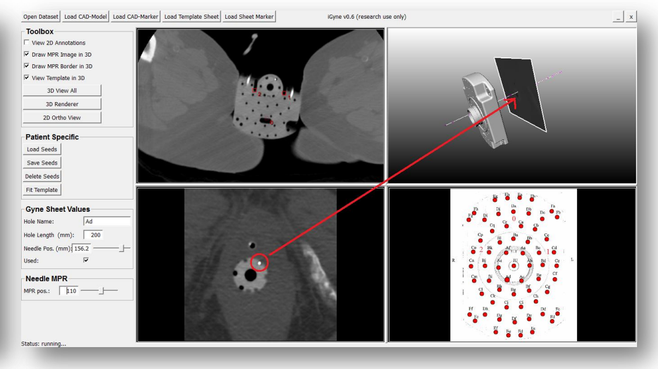


Figure 2b – Needle (white line in the upper right window) that has been selected for visualization of multiplanar reconstructions (MPR) along the needle path (lower left window). The MPR at the position of the arrow (tip of red arrow in the upper right image) is displayed in the lower left window as a 2D slice. In the MPR of the lower left window the needle cross section (white) is surrounded by a red circle.

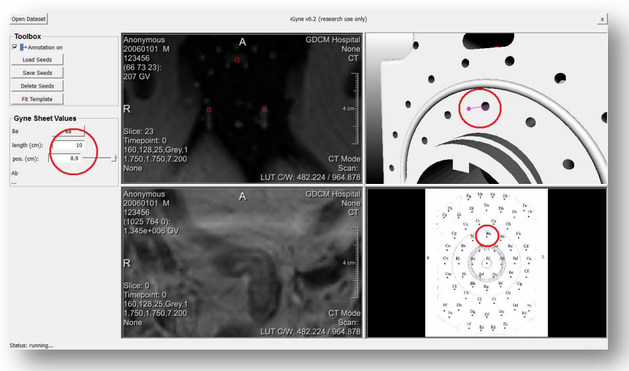


Figure 2c – Virtual fitted gynecological brachytherapy template and selection of a specific interstitial needle (Ba, red circles in the screenshot). As shown on the left side of the prototype interface, individual needle insertion can be planned by defining parameters such as the needle length and depth.

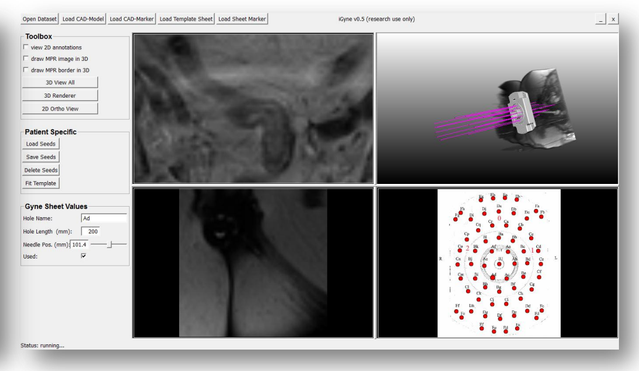


Figure 2d – Virtual placement of several interstitial needles (purple) with different lengths and depths as shown in the settings in the menu in the left column. This allows the radiation oncologist to plan the placement of needles.

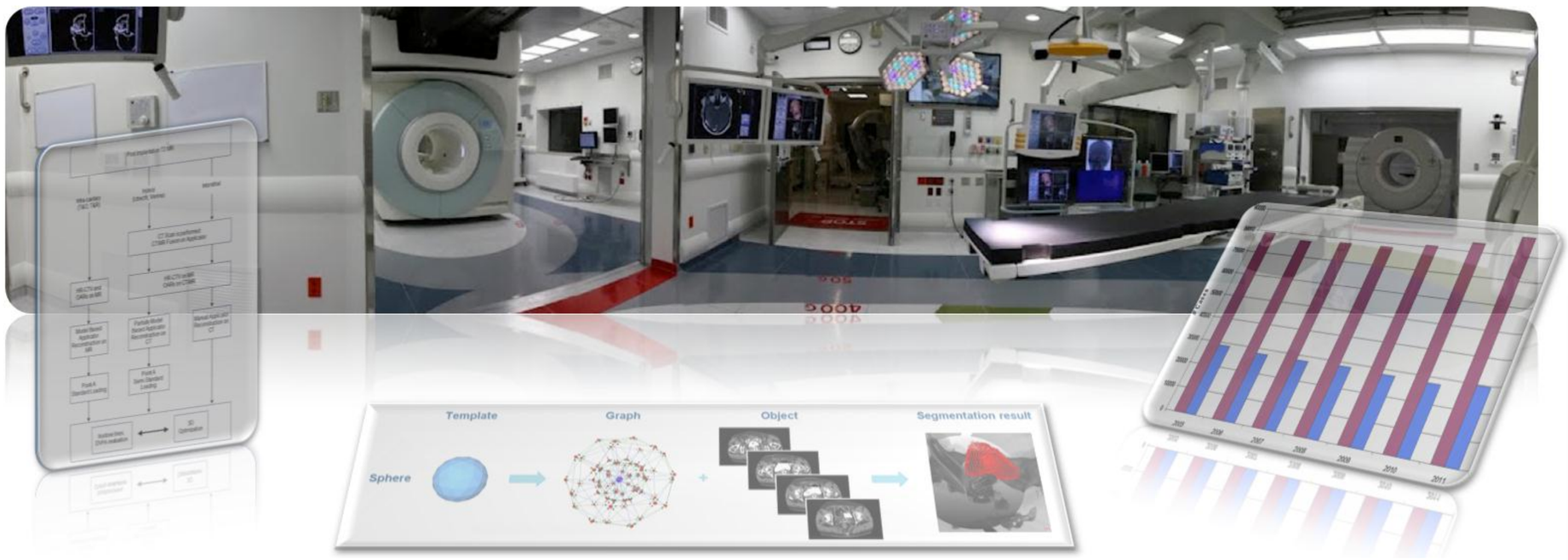
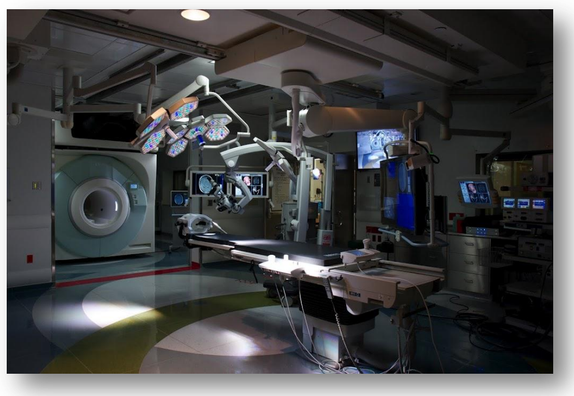


Figure 3 – The Advanced Multimodality Image Guided Operating (AMIGO) Suite was launched in 2011 as a multimodal successor to the original 0.5T Signa SP (GE Healthcare) magnetic resonance therapy (MRT) unit at Brigham and Women's Hospital, in which interstitial gynecologic brachytherapy was performed from 2002 to 2006. AMIGO is an integrated operating suite in which multidisciplinary patient treatment may be guided by x-ray, ultrasound, intra-operative 3T MRI, and/or positron emission tomography/computed tomography (PET/CT).



Acknowledgments

The authors would like to acknowledge the support of the AMIGO clinical staff in enabling this clinical study, Sam Song, PhD for generating the CAD models of gynecologic devices and Junichi Tokuda, PhD for the AMIGO photo. We thank Prof. Dr. Horst K. Hahn and Fraunhofer MeVis in Bremen, Germany, for their support by providing an academic license for MeVislab software. The work was supported by NIH grant P41EB015898, P41RR019703, R03EB013792, and U54EB005149. Dr. Viswanathan receives support from NIH grant K07CA117979.

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