Purpose: To build, from grounds up, a novel dynamic modulated brachytherapy (DMBT) system for treating intracavitary tumors, such as rectal, breast, and vaginal cancers. The key component of the innovation is in enabling “dynamic” modulation (i.e., Ir-192 source is highly collimated and dynamically moved during delivery) to create an unparalleled dose conformality compared with the currently available commercial systems/applicators. We show that our proposed prototype system (both soft- and hard-ware) is extremely efficient in maximizing target volume coverage while minimizing dose to healthy tissues.
Methods: Our system uses a 1.9-cm diameter tungsten-shield, with density of 18.5g/cc, to create a highly collimated Ir-192 source radiation profiles. Various window openings in the shield have been simulated with the MCNP code for planning. The code itself was validated against TG43 parameters. The shield is controlled by an in-house built, computer-controlled, robotic arm which allows for 360° rotations and 1-D translational motions. An in-house coded planning system with the simulated annealing algorithm was used to design optimal plans on ideal rectal anatomies and patient cases. The optimal DMBT plans were then compared with the state-of-the-art commercial Intracavitary Mold Applicator (ICMA)-based plans.
Results: The various simulations encompassing target sizes up to 5-cm longitudinal and radial directions, with circumferential volumes from 45-degree to 360-degree were simulated. Results consistently show that the DMBT system yields broader shoulder past prescription dose in target DVH initially and drops off quicker at higher doses, compared with ICMA, which reflects better dose conformality. More spectacularly, however, up to 50% decrease in normal tissue dose across all dose range were observed. This will translate into clinically observable reduction in acute/late toxicities.
Conclusions: Our preliminary results show that DMBT offers exceptional degrees of dynamics for achieving unparalleled dose conformality in brachytherapy. Further research is needed to validate our work in various clinical sites.