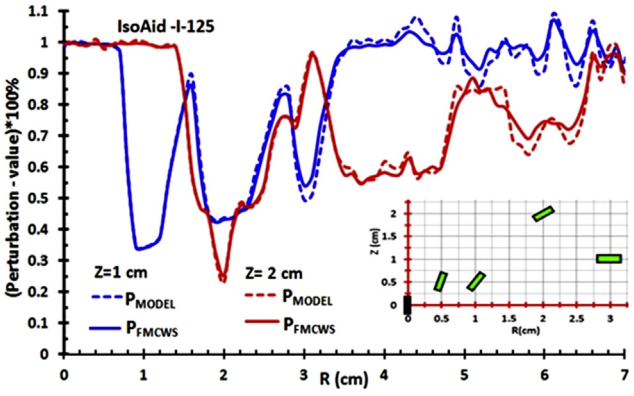
seeds or ISA in multiple seed implants are neglected up to day. The goal of this project is to determine a novel method to solve the impact of the dose perturbations (P-value) and/or inter-seed attenuation (ISA-value) effect in BTPS based on MC simulation and Artificial Neural Networks (ANN). This method was validated for LDR I-125 to Ir-192.

Materials and Methods: In this model, perturbation and ISA of dose distribution from one source by the surroundings sources are calculated using the MC pre-calculations 3D kernels of P-values for a set of binary groups of one active and one inactive source. These kernels were obtained for different radial distances and angular positions. The total P-value model is equal to the product of the P-value of the binary groups of the one active and inactive source. The accuracy of this model have been examined by a comparison of the calculated P-value and ISA-value with this model by the values, which are directly obtained using full Monte Carlo water simulations (FMCWS) for some multiseed implants. These implant configurations are: single active source in the center and (1) inactive sources on four different sides, (2) inactive sources are parallel to each other on the along source axis "r," and (3) more inactive sources are parallel to each other on the away axis "z." The P-value MC simulations from binary groups of active-inactive sources was used to train the Artificial Neural Networks (ANN) in MATLAB software. Base on this approach, once trained the network generalizes, to produce ISA correction response for any unknown binary group source combination. Then the ANN ISA correction data for any unknown combinations of an active and inactive source which it has not been obtain directly by MC, imported to the BTPS base on the total ISA-value formulation model.

Results: Figure 1 shows comparison between Model and FMCWS for I-125 (Isoaid) source. The active source are placed in center and the inactive sources are in (0.5, 0.5), (1, 0.5), (2, 2), and (3, 1) for angles of 20, 40, 60, and 90 degrees, respectively. For all cases, the total perturbation and ISA formulisms model agree with FMCWS. These new P and ISA formulism have better accuracy for Ir-192 than the I-125 due to Compton scattering. The differences between the trained ANN and MC were up to 1%. The I-125 ISA formalism accuracy for case one, two, and three are 0.8%, 5%, and 5%, respectively. These corresponding values for Ir-192 are less than 0.5%, 3.5%, and 3%, respectively.

Conclusions: This new model provide inputs for brachytherapy planning software to correct the ISA effect in dose calculations for multi-seed implants based on TG-43U1 algorithm using ANN and MC methods.



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Monte Carlo Simulation of HDR Ir-192 Brachytherapy Cancer Treatments

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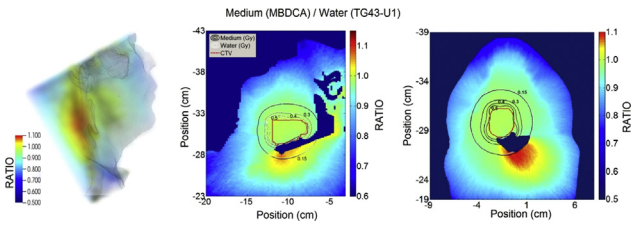
Purpose: Modern treatment planning systems (TPS) for brachytherapy are now available that are based on model-based dose calculation algorithms (MBDCA). They enable heterogeneity corrections which are needed to replace the TG-43U1 water dose formalism with a more accurate approach. With the aim of evaluating the impact of the transit dose, applicators, body boundaries and tissue composition in clinical cases, several HDR Ir-192 brachytherapy treatment cases including prostate, gynecological (Gyn), arm and head and neck cases were evaluated.

Materials and Methods: A MBDCA, AMIGOBrachy based on the Monte Carlo code MCNP6, was used to import brachytherapy treatment plans provided by four different hospitals planned using commercial TPS, BrachyVision™ and Oncentra™. These plans were then edited through an interactive graphical interface. CT images were segmented into tissues and the applicators (needles or Gyn cylinders) were included to evaluate their impact on the dose distributions. The treatment plans were selected to provide an overview of brachytherapy treatments since there is a considerable range in the number of dwell positions, needles and type of application. Some treatments were performed with dwell positions within soft tissue at a few millimeters from bone tissue. The transit dose impact was evaluated using a continuous source distribution defined through the source trajectory with probability distribution weighted by the instantaneous source speed at each position.

Results: The differences between the results obtained using a MBDCA based on the TG-186 formalism and TG-43U1 water dose formalism are case dependent with dose differences ranging from negligible (<0.5%) up to 20% even within the target volume. For the majority of the cases this impact cannot be fully represented by clinical parameters as DVH or D90, e.g., inter needle attenuation can cause up to 6% underdose at shadow regions that do not impact significantly when averaging the dose over the target. Figure 1 shows a dose ratio for a head and neck case with differences up 10% behind the esophagus. The transit dose was independently evaluated since it could be as relevant as the tissue composition. Particularly for interstitial implants the proximity of the dwell positions and the target volume reduces the dwell time making the transit dose more significant. The results obtained for two prostate cases with similar target volume and prescribed dose can lead to a 10% overdose to the urethra for one case, with only half the overdose for the second case. This highlights the importance of an adequate catheter distribution and of the transit dose.

Conclusions: The effect of tissue heterogeneities and applicators can be significant, while the transit dose effect depends of the catheters and dwell position distribution. Those aspects are relevant due to the various types of applicators commercially available and due the wide variety of brachytherapy treatments.



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Dynamic Modulated Brachytherapy for Cervical Cancer

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