Title:  Do dominant intraprostatic lesions receive sufficient dose in high dose rate brachytherapy?

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Structured Abstract:

Introduction: Prostate cancer is clinically understood to be a heterogenous disease. It ranges from being very indolent with chronic, slow progression, to extremely aggressive and potentially lethal. The management of prostate cancer is made more difficult by two additional facts: 1) low-volume, sub-clinical disease is often located throughout the entire prostate, with additional foci of higher grade/aggressive disease, and 2) prostate biopsy, which is a common method used to identify regions of disease, has a notoriously high false-negative rate. Given these two facts, once the decision is made to treat, the standard approach is to treat the entire prostate gland as uniformly as possible (e.g. through complete surgical resection, or through radiation therapy). Current evidence indicates that local recurrence most often occurs at these foci of higher grade disease, termed the dominant intraprostatic lesions (DILs). Therefore, we hypothesize that the current clinical approach to prostate high dose rate (HDR) brachytherapy may provide suboptimal radiation doses to DILs in certain patients and thus contribute to treatment failure in those cases.

Methods: To measure the hypothetical radiation dose delivered to realistic DIL(s) within the prostate, 21 prostate cancer patients with DILs segmented by radiologists on magnetic resonance imaging (MRI) were each deformably mapped to treatment plans of three different prostate cancer patients who underwent transrectal ultrasound (TRUS)-guided HDR brachytherapy. An iterative closest point transformation was first performed to align the surface of the prostate on the MRI to the surface of the prostate on the TRUS. Next, a thin plate spline transform was used to deform the MRI prostate surface to match the shape of the TRUS prostate surface. The two transforms were applied to the DIL segmentations, thus placing the DIL(s) within the intra-procedural TRUS plan. In certain cases, the transformed DILs had to be cropped so that they were entirely contained within the TRUS-defined prostate. These transformations were automated using custom scripts written for 3D Slicer 4.6.2 (www.slicer.org). Treatment plans were imported into MIM 6.6.9 (MIM Software Inc, Cleveland, OH, USA) and the dose each DIL received was determined. Overall, 53 DILs with a minimum size of 0.15 cc were evaluated.

Results: Of the 53 different DILs evaluated, ten did not receive the prescribed dose (15Gy) to the entire DIL volume. Eight of the DILs also did not receive the prescribed dose to 95% of the DIL volume (at least 5% volume of the DIL was underdosed). The ten different DILs stemmed from ten different MR patients evaluated on seven different clinical plans.

Discussion: This study suggests that the current whole-gland approach to HDR brachytherapy may leave patients susceptible to under-treatment of DILs and may be a potential cause of treatment failure.