Title: Can we boost the radiation dose to prostate lesions with high dose rate brachytherapy using dwell time adjustment alone?

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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 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 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 1) the current clinical approach to prostate high dose rate brachytherapy (HDR-BT) may provide suboptimal radiation doses to DILs in certain patients and 2) that through dwell time adjustment alone we could significantly improve DIL dosage.

Methods: To evaluate the radiation dose delivered to realistic simulated DILs, 20 PCa patients with DILs segmented by radiologists on magnetic resonance imaging (MRI) were mapped to treatment plans of 19 different PCa patients who underwent transrectal ultrasound (TRUS)-guided HDR-BT. An iterative closest point transformation followed by a thin-plate spline transformation aligned and then deformed the prostate surfaces on MRI to the TRUS context. The two transforms were applied to the DIL segmentations placing the DIL(s) within the HDR-BT plans. The dose that each DIL would have received from the original clinical plans were calculated. We then created a new set of treatment plans that were designed by manually altering dwell times in attempt to provide maximal dose to each DIL while staying within the bounds of acceptable dosage to surrounding organs at risk. In total, 40 boosted plans were designed to treat 49 DILs.

Results: The whole-gland clinical treatment plans would have provided the DILs with a mean dose of 16.32 Gy, whereas the boosted treatment plans would have provided a mean DIL dose of 20.26 Gy. With regards to potential treatment failure, the clinical plans would have treated 9/49 DILs with less than the prescription dose of 15 Gy. The boosted plans were able to treat all DILs with the prescription dose except for one DIL that was located next to the urethra.

Discussion: This study has demonstrated that dwell time adjustment can provide patient specific treatment plans that conform to toxicity constraints while achieving superior DIL dose. The addition of preprocedural mpMRI and dwell time adjustment to HDR-BT has shown the potential to significantly reduce undertreatment of DILs, and thus could potentially reduced treatment failure rates.