Title: Does MRI Prostatic Lesion Targeting using High Dose Rate Brachytherapy lead to Elevated Dose in Corresponding Histologic Lesions?

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Structured Abstract:

Introduction: Post-radiotherapy prostate cancer recurrence often occurs at dominant intraprostatic lesions (DILs), motivating focal dose escalation. Multiparametric magnetic resonance imaging (mpMRI) has demonstrated potential for DIL localization. We addressed the question: when targeting dose escalation to mpMR-defined DILs, what is the dose increase to the cancer defined on corresponding histology?

Methods: We registered annotated prostatectomy mid-gland histology sections from 12 patients to pre-prostatectomy mpMRI scans that were each interpreted by four radiologists. To simulate realistic high-dose-rate brachytherapy (HDR-BT) treatments, we registered each observer’s interpretation of mpMRI to two transrectal ultrasound images of other HDR-BT patients, thus registering mpMRI-defined DILs and underlying cancer histology to treatment plans with a 15-Gy whole-gland prescription. We used a volume-dose optimization system to adjusted dwell times for focal dose escalation to the mpMRI-DILs. We compared dosimetry the histopathology would have received if treated with whole gland treatment plans to the dose that would have been delivered through mpMRI targeting. The histopathology was broken down into different sub groups: high grade cancer (Gleason 4 or greater), low grade cancer (Geason 3), true positive (TP) (histopathology within 2mm of mpMRI calls), and false negative (FN) (histopathology further than 2mm mpMRI calls).

Results: We analyzed 209 mpMRI-DIL targeted HDR-BT plans. For high grade histology the whole gland plans achieved a mean dose of 17.02 ± 1.96 Gy (SD), while the mpMRI targeted plans achieved a mean dose of 17.25 ± 2.02 Gy. Low grade histology for the whole gland plans achieved a dose of 15.30 ± 1.62 Gy and the targeted treatment plans achieved 15.54 ± 0.92 Gy. The TP high grade histology received a mean dose of 18.68 ± 2.70 Gy in whole gland plans and 20.72 ± 2.33 Gy in targeted treatment plans (p<0.0001). FN high grade histology received a mean dose of 18.74 ± 3.90 Gy in whole gland plans and 18.48 ± 3.12 Gy in mpMRI targeted treatment plans (not significantly different). TP low grade histology received a mean dose of 19.03 ± 3.06 Gy in whole gland treatment plans and 20.86 ± 3.68 Gy in mpMRI targeted plans (p<0.0001). FN low grade histology received a mean dose of 16.40 ± 2.24 Gy in whole gland treatment plans and 16.49 ± 2.53 Gy in mpMRI targeted treatment plans (not significantly different).

Conclusion: This study is the first to use digital histology to confirm the effectiveness of mpMRI HDR-BT dose escalation. Based on the findings of this study mpMRI dose escalation does lead to increased dose to the ground truth histology. However there is still much work to be done to improve the delineation capabilities of mpMRI as much of the ground truth cancer is still not being detected to the accuracy required to deliver an escalated dose to all pathologically defined cancer.