Purpose: Advanced imaging techniques have been developed to facilitate patient setup and target localization for advanced prostate radiotherapy. These techniques work well for translational, interfractional organ motion but may result in poor target coverage for some cases where the effects of rotational motion and organ deformation are not corrected. This work investigates the feasibility of the use of 3D dose distributions to match the target volume to improve target coverage and critical structure sparing.

Methods: Fifteen previously treated prostate patients were selected for this retrospective study. Siemens CT-on-rails scans were performed before and after the IMRT treatment weekly. Ninety-eight post-treatment CT-on-rails scans were used to reconstruct the dose distributions. The isodose distributions and DVH were compared with those of the original plans. Target localization was also performed using the prescription isodose surface from the original plan to match the target volume and a new isocenter shift was applied in the dose reconstruction, which was evaluated against the original plans and the reconstructed dose distributions using the standard contour-based target-localization technique.

Results: The results show that for contour/anatomy matching, 7.1% of the 98 treatment fractions exhibit poor target coverage (D_{min}<65\text{Gy}). For the rectum, 27.6% fractions violated our rectal criterion of V_{65}<17\% and 26.5% fractions violated the criterion of V_{40}<35\%. After the isocenter realignment based on 3D dose/target volume matching, all the fractions delivered >65\text{Gy} to the target, and the percentages of fractions that violated the rectal criteria (V_{65}<17\% and V_{40}<35\%) were reduced to 14.3\% and 18.4\%, respectively.

Conclusions: The current IGRT procedure for isocenter alignment based on contour/anatomy matching is not ideal due to poor soft-tissue contrast, residual translational/rotational organ motion and organ deformation. Target localization based on 3D dose/target volume matching provides better target dose coverage and critical structure sparing that reduces the need for adaptive re-planning.