Purpose: To quantify and compare differences in localization when aligning proton therapy patients using carbon fiducials versus bony-anatomy and to evaluate the dosimetric consequences of these differences.

Methods: 250 pairs of AP and lateral daily kV images were obtained for 16 prostate cancer patients treated at our institution. Prior to treatment 2-3 carbon fiducials were implanted in each patient. Patients were treated to 76 Co-Gy-Equivalent in 38 fractions, and immobilized with a knee-foot cradle. A water-filled endorectal balloon was used to suppress prostate motion. Before each fraction, therapists aligned patients on fiducials and acquired a set of post-shift images to confirm alignment. Residual errors for fiducial alignment were collected from post-shift images using a point alignment tool; for bony-anatomy alignment, a 2D-3D method was used. The dosimetric implications were analyzed using verification plans offset by the maximum difference between couch shifts determined using the two methods.

Results: The average systematic component of residual shifts was less than 0.1 cm for fiducials and bony-anatomy in all directions. The standard deviation of systematic components was less than 0.1 cm for fiducials and was 0.23, 0.26, and 0.08 cm for bony-anatomy in the AP, SI, and RL directions respectively. The random component of residual shifts was less than 0.1 cm for fiducials and was 0.16, 0.17, and 0.05 cm for bony-anatomy. Incorporating the maximum difference in shifts into verification plans, CTV coverage was found to be minimally compromised with no less than 96% of the CTV receiving full dose in any plan and V70 of the rectum/bladder varied by a maximum of 13 percentage points in either direction.

Conclusions: Systematic error for each method was small, while random error was larger in the AP and SI directions for bony-anatomy than fiducials. Verification plans revealed minimal CTV coverage degradation for the maximum shift differences.