Impact of Localization Technique on the Accuracy of Daily Repositioning of Prostatic Isocenter during Radiotherapy

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Purpose

In prostate cancer radiotherapy, it is important to know the minimum PTV margin that is just sufficient to account for isocenter setup errors and intra-fraction motion of the prostate. In this study, we assessed the magnitude of inter-fraction isocenter displacements using four isocenter setup techniques: 3-point skin marks, CBCT with bony and implanted fiducial marker registration, and implanted Calypso electromagnetic transponders.

Materials

Fifteen patients under treatment for prostate cancers were selected for this study. The prostate of each patient was implanted with three electromagnetic transponders from Calypso system. Each patient was CT-scanned in supine position followed by IMRT treatment planning. The treatment beam isocenter position was transferred to each patient through 3-point skin marks. On the treatment machine, the isocenter position was localized in four different techniques respectively: (1) aligning the skin marks to room lasers; (2) CBCT using Varian OBI system with bony registration; (3) CBCT with implanted fiducial marker registration; and (4) implanted electromagnetic transponders localized using Calypso system. Calypso system has a sub-milimeter localization accuracy. The implanted Calypso electromagnetic transponders were also used as the fiducial markers for CBCT to planning CT registration.

Methods

Individual patient was set up on treatment machine first by aligning the 3-point skin marks to room lasers. Calypso system was then used to localize the three electromagnetic transponders in prostate, from which the isocenter displacements were determined. Couch shifts predicted by Calypso system were made to align the target isocenter to the machine isocenter. At this position, a CBCT was made. The isocenter displacements were determined by registering the three transponders on CBCT with the planning CT. The isocenter displacements were also determined by fusing the pelvic bone anatomy on CBCT with planning CT. Isocenter displacements predicted by different setup techniques were presented with reference to the isocenter position localized by Calypso system.

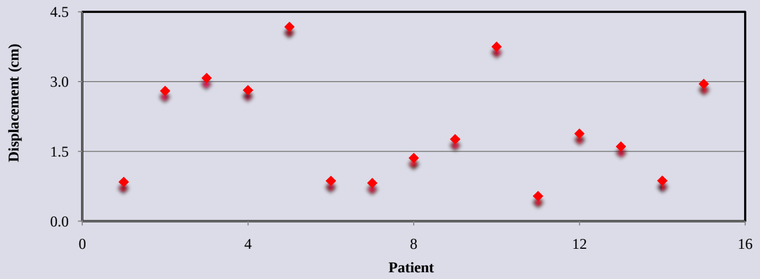

Fig. 1 Mean isocenter displacement vectors among the 15 studied patients observed in skin mark setup technique.

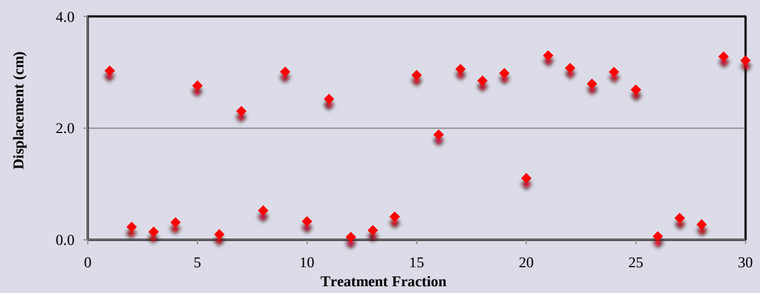

Fig. 2 Isocenter displacement vectors over multiple fractions for a single patient observed in skin mark setup technique.

Results

The mean inter-fraction target isocenter displacements in cm (± SD) for the skin mark technique (n = 15) were -0.2±0.6, 1.8±1.3 and 0.3±0.9, respectively along lateral, vertical and longitudinal directions. The mean target isocenter displacements predicted by CBCT with implanted fiducial marker registration (n = 15) were 0.0±0.1, 0.1±0.2 and 0.0±0.1 respectively. Those predicted by CBCT with bony anatomy registration (n = 3) were found to be 0.8±0.2, 1.1±0.3 and 1.0±0.3 respectively. In the skin mark technique, the mean isocenter displacement vectors among the 15 studied patients were as large as 4.2 cm (Fig. 1), while for a single patient, the isocenter displacement vectors were found up to 3.3 cm over various fractions (Fig. 2).

Conclusions

This study confirmed the minimum PTV margin depends on the technique adopted for isocenter setup. 3-point skin mark technique desires the largest PTV margin (mean 1.8 cm) which is consistent with 1.5 cm generally adopted for prostate. Least PTV margin is desired when adopting Calypso system or CBCT with prostate fiducial marker registration. The desired PTV margin is relatively larger (mean 1.1 cm) when adopting CBCT with bony anatomy registration since prostate motion is not accounted for in this technique.

Presented at:
American Society for Therapeutic Radiology and Oncology (ASTRO)
Boston, MA
September 21-25, 2008