

Dosimetric impact of intra-fraction prostate motion during moderate hypo-fractionated radiation treatment: a population-based study varying CTV-to-PTV margins

Evaluation de l'impact dosimétrique des mouvements intrafraction de la prostate durant le traitement de radiothérapie en fonction des marges CTV-PTV utilisées.

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Introduction: Intrafraction organ motion during external beam radiotherapy can cause dosimetric inaccuracies. In particular, intrafraction prostate motion can be important for some patients (>1cm). An accurate motion characterization may help determining the best compromise between optimal margins to increase tumor control and normal tissues' sparing. The aim of this study was to investigate the dosimetric impact of intra-fractional motion during prostate radiation therapy providing a population-based margin for CTV-prostate based on volumetric coverage.

Methods: Prostate intra-fraction 3D translations were evaluated in 2400 sessions from 96 prostate cancer patients treated by radiation therapy in our institution with intra-fraction motion monitoring using Clarity transperineal ultrasound (TP-US) probe (Elekta AB, Stockholm). All patients underwent volumetric modulated arc therapy. The prescribed dose was 60 Gy in 20 fractions to the Clinical-Target-Volume (CTV) prostate and the treatment goal was that 100% of the prescribed dose must cover 99% of the CTV-prostate. Treatment durations ranged between 200-600s. For 18 randomly selected patients of the cohort (346 sessions) treatment plans were recomputed using 0, 3, 4, 5 and 6 mm CTV-to-PTV margins, with an auto-planning optimization algorithm implemented in a research version of Monaco TPS (version 5.59.11, Elekta AB). This enabled assessing the impact of intrafraction motion on CTV coverage without operator variability in the planning process. Then, the voxel shifting method was used to move the CTV prostate structure every second of treatment, according to the movements retrieved by the TP-US. The integrated shifting was then applied to the dose distribution maps and Dose-Volume Histograms (DVH) of the perturbed dose distributions were computed.

Results: Mean intra-fraction prostate displacements observed were (0.02±0.39) mm, (0.38±0.74) mm and (-0.71±0.64) mm in left-right, supero-infero and antero-posterior directions, respectively. Mean displacements >3, 5 and 7 mm were observed for 16%, 5%, and 1% of the total fractions. Rare large deviations >8 mm were detected with a frequency <1%. On average, the largest displacements were observed in inferior and posterior directions. Perturbed dose distribution results showed that, after 5 minutes of treatment, the prescription constraint on the CTV-prostate was achieved in 70%, 79%, 84%, 91%, 97% of fractions using 0, 3, 4, 5 and 6 mm margins, respectively. After 10 minutes, the percentage of fractions decreased to 56%, 58%, 69%, 78%, 90%, respectively. Finally, DVH showed that the motion influence the dose amount to the organs at risk: increment in rectum and bladder D_{mean} of 3.0 Gy and 1.5 Gy were respectively registered.

Conclusions: Prostate movements impact dose distribution and target coverage. Anisotropic margins would be required to optimally take into account intrafraction motion. Further work is in progress to evaluate those margins.

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