Contribution ID: **36** Type: **Oral**

Comparing dry-run and delivery modes for dynamic trajectory radiotherapy

Thursday, 27 October 2022 10:25 (10 minutes)

Purpose
Dynamic trajectory radiotherapy (DTRT) extends VMAT with dynamic table and collimator rotations during beam-on. Dry-runs are needed for safety purposes, as for example to check treatment plans for potential collisions. This study investigates if DTRT dry-runs accurately simulate the machine motion of DTRT via log-file analysis.

Methods
Eight DTRT treatment plans for clinically motivated head-and-neck cases were created for a TrueBeam system. Trajectory data were recorded every 20 ms during dry-runs and deliveries (with beam-on) and log files were retrieved after each run. Collimator rotation speed was used as a surrogate for application speed as it is rarely restricted by its maximum rotation speed but modulated down to wait for slower dynamic axes. Deviations between expected and actual values for gantry, table and collimator angles were determined.

Results
Three measurement sessions were available for analysis with 56 dry runs and 23 deliveries of 20 different trajectories. Dry-runs were faster, as indicated by a larger median absolute collimator rotation speed of 2.27°/s compared to 1.51°/s for deliveries.
Overall, deviations of the analyzed axes were within clinical and interlock tolerance. Maximum gantry-angle deviations were larger in dry-runs (root-mean-square (RMS) 0.06°, max. 0.59°) than in deliveries (RMS 0.06°, max 0.33°). The same was found for table-angle deviations in dry-runs (RMS 0.11°, max. 0.26°) vs. deliveries (RMS 0.10°, max. 0.22°) and collimator-angle deviations in dry-runs (RMS 0.04°, max 0.43°) vs. deliveries (RMS 0.03°, max. 0.17°).
A high correlation was found between speed and deviations of the table-angle (Spearman correlation coefficient 0.85 for dry-runs and -0.96 for deliveries, $p<0.05$) as well as for collimator-angle (-1.00 for both, $p<0.05$). Correlation was weaker for gantry-angle (-0.71 for dry-runs and -0.75 for deliveries, both $p<0.05$).

Conclusion
The analyzed machine uncertainties are highly correlated to speed. Due to higher speed, deviations are larger in dry-runs than in deliveries, but overall small and still within interlock tolerance, indicating that dry-runs can be used for mechanical simulations of DTRT deliveries.

Disclosures
This work was partially supported by Varian Medical Systems.

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Session Classification: Session I: QA, Dosimetry, Treatment Planning

Track Classification: Radiation Therapy