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Feasibility and mechanical accuracy of gated dynamic trajectory radiotherapy

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Purpose: To experimentally assess the technical feasibility and quantify the mechanical accuracy of respiratory gating during dynamic trajectory radiotherapy (DTRT) plan delivery. DTRT extends VMAT by dynamic table and collimator rotation during beam-on.

Methods: An HexaMotion motion stage positioned on the treatment table of a TrueBeam system is used to reproduce four different breathing motion traces recorded in patients typical, high frequency, predominantly left-right and baseline shift, each with combined motion in superior-inferior, anterior-posterior, and left-right directions.

A DTRT plan for a clinically motivated lung case is delivered both with and without gating on a TrueBeam system in Developer Mode. For gating, the real-time positioning management system is used to trigger amplitude gating based on the main motion axis (either superior-inferior or anterior-posterior) with gating window between 4 and 6 mm depending on the motion trace.

Mechanical accuracy is assessed from TruBeam trajectory log files as the deviation between actual and expected machine positions of gantry, table and collimator angle and positions of moving MLC leaves.

Results: DTRT delivery was successfully gated with the gantry, table and collimator rotating back during beam-hold and resuming motion at beam-on (i.e., when entering the gating window). The mean root-mean-square deviation between expected and actual position for DTRT delivery with (resp. without) gating were 0.04° (0.03°) for gantry angle, 0.05° (0.09°) for table angle, 0.02° (0.03°) for collimator angle and 0.002 mm (0.002 mm) for moving leaves'positions. Maximum deviations were 0.13° (0.10°) for gantry angle, 0.14° (0.15°) for table angle, 0.08° (0.08°) for collimator angle and 0.003 mm (0.004 mm) for moving leaves positions.

Conclusion: A gated DTRT plan was successfully delivered on a TrueBeam system with machine accuracy in gantry table and collimator angle and MLC leaf positions similar to un-gated delivery.

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