

Purpose: Dose-rate-regulated tracking (DRRT) is a tumor tracking strategy that programs the MLC to track the tumor and adapts to breathing irregularities during delivery using dose rate regulation. Constant-dose-rate tracking (CDRT) adjusts the MLC motion based on real-time detection of tumor displacement. The purpose of this study is to illustrate the differences in the effectiveness and delivery accuracy between these two tracking methods when dealing with breathing irregularities.

Methods: Step-and-shoot IMRT plans optimized at a reference phase were extended to the remaining phases to generate 10-phased 4D-IMRT plans using segment aperture morphing (SAM) algorithm, where both tumor displacement and deformation were considered. A SAM-based 4D plan has been demonstrated to provide better plan quality than plans not considering target deformation. However, delivering such a plan requires pre-programming of the MLC aperture sequence. Delivery of the 4D plans using DRRT and CDRT tracking approaches was simulated assuming the breathing period is either shorter or longer than the planning day. In DRRT, dose rate was regulated to speed-up or slow down delivery as needed such that each planned segment is delivered at the planned breathing phase. In CDRT strategy, MLC is separately controlled to follow the tumor motion, but dose rate was kept constant.

Results: Delivery of preprogrammed 4D plans by the CDRT method resulted in an average of 5% increase in target dose and noticeable increase in OAR dose when patient breathing is either 10% faster or slower than the planning day. In contrast, DRRT method showed less than 1% reduction in target dose and no noticeable change in OAR dose under the same breathing irregularities.

Conclusions: In delivery of SAM-based 4D-IMRT treatment plans considering tumor deformation as well as motion irregularities, the DRRT tracking method was found to be much more effective and more accurate than the CDRT strategy.

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