PhD Thesis title: 'Volumetric modulated arc therapy for stereotactic body radiotherapy: planning considerations, delivery accuracy and efficiency**'**

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ABSTRACT:
Intensity modulated radiotherapy (IMRT) is now a standard technique for radiation dose delivery for most tumors. Although it is capable of delivering highly conformal dose distributions, it suffers from drawbacks, including long treatment times, high integral doses and difficulty in selecting optimal beam orientations. RapidArc™ (Varian Medical Systems) is a form of volumetric modulated arc therapy, which is IMRT delivery during a 358° gantry rotation. During delivery, a conformal dose distribution can be generated by varying dose rates, gantry speeds and leaf apertures created using a dynamic multi-leaf collimator (MLC). A fast delivery using RapidArc is particularly attractive for stereotactic body radiotherapy (SBRT) treatment which features precise delivery of high radiation dose in only one (or a few) fraction(s). With the introduction of the RapidArc approach, it became essential to optimize the treatment planning process, and to evaluate plan quality. The purpose of this work was to investigate the planning considerations, delivery accuracy and efficiency of RapidArc for SBRT.

We compared the dose distributions and delivery times between RapidArc and other common SBRT delivery techniques for stage I non-small cell lung cancer (NSCLC). We also investigated early clinical toxicity in patients treated for larger early stage tumors using RapidArc SBRT, and correlated toxicity with different dosimetric parameters. The outcomes of these studies are taken into account during the treatment planning process in order to overcome issues such as the calculation accuracy in the optimizer, the dose homogeneity in the target and the priority of sparing different organs at risk. We also evaluated the accuracy of RapidArc delivery and the calculated dose distributions using the Anisotropic Analytical Algorithm (AAA). For most of clinical RapidArc plans, AAA can accurately calculate the dose distributions. However for plans consisting of a large number of small MLC segments, or target volumes, containing a relatively large volume of low density tissue, calculation using 1 mm grid resolution is recommended. In addition, we have shown that the dose deviations due to the interplay effect between the tumor motion and the MLC leaves motion during RapidArc lung delivery can be ignored if the large SBRT fraction doses are delivered using 2 arcs over at least 33 breathing cycles.

The last part of the thesis concentrated on RapidArc delivery using high dose rate flattening filter free (FFF) beams. We compared RapidArc SBRT plans of NSCLC and vertebral metastases generated using FFF beams with those generated using standard flattened (FF) beams. Our findings suggest that faster delivery using FFF beams is feasible as plan quality is not compromised, while SBRT fraction doses of up to 18 Gy can be delivered within 4 minutes. However, with high dose rate delivery, a stringent patient monitoring protocol, during beam delivery, is required, as high doses can be delivered over a short period of time. Possible dosimetric deviations caused by intra-fraction shifts for short period of times were studied to underscore the importance of accurate patient positioning and position monitoring during fast treatment delivery using a high dose rate FFF beam.

The research described in this thesis explored the technical aspects of RapidArc delivery for SBRT. A better understanding of plan quality, delivery accuracy and toxicity patterns for patients treated using this technique can better assist the process of treatment planning.

References to author publications that relate specifically to the dissertation:

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