PhD Thesis Title: Dynamic couch rotation during volumetric modulated arc therapy (DCR-VMAT)

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ABSTRACT:

This thesis proposes a non-coplanar dynamic couch rotation volumetric modulated arc radiotherapy (DCR-VMAT) technique, develops methods to optimize patient and gantry rotation, and evaluates its clinical potential and delivery accuracy.

Firstly, a trajectory optimization technique for DCR-VMAT is developed and evaluated for organ at risk (OAR) sparing against coplanar VMAT using four clinical cases. Trajectory optimization combines a beam scoring technique with Dijkstra's algorithm to determine a trajectory that geometrically avoids OARs while irradiating the planning target volume (PTV). DCR-VMAT plans are shown to reduce dose to the OAR specified in trajectory optimization compared with coplanar VMAT.

Secondly, DCR-VMAT is evaluated for a cohort of 15 patients with primary brain tumours. Plans are produced using three trajectory optimization techniques that spare multiple OARs according to their relative clinical importance. In the first technique, a geometric heuristic technique (GH) is used to minimize the importance-weighted sum of OAR volumes irradiated. In the second, a fluence-based local search (FBLS) technique evaluates alternative trajectories starting from a coplanar plan. In the third, FBLS is applied to GH trajectories to produce FBLS+GH. The GH technique is found to produce the best balance of PTV coverage and OAR sparing for this cohort of patients.

Finally, the delivery accuracy of DCR-VMAT with GH trajectories is investigated and compared against coplanar VMAT for five patients with primary brain tumours. Measurements are performed using a linear accelerator capable of delivering DCR-VMAT in a programmable research mode. Point dose measurements within the PTV and radiochromic films in the sagittal and coronal planes are found to agree well with plan predictions. Delivered machine parameters are compared with expected values using linac log files and their dosimetric effect is found to be small.

This thesis shows trajectory optimized DCR-VMAT improves OAR dosimetry and is delivered accurately with a commercial linear accelerator.

References to author publications that relate specifically to the dissertation:

1. **G Smyth**, J C Bamber, P M Evans, J L Bedford. Trajectory optimization for dynamic couch rotation during volumetric modulated arc radiotherapy. Phys. Med. Biol. 58: 8163-77 (2013)
2. **G Smyth**, P M Evans, J C Bamber, H C Mandeville, L C Welsh, F H Saran, J L Bedford. Non-coplanar trajectories to improve organ at risk sparing in volumetric modulated arc therapy for primary brain tumors. Radiother. Oncol. 121: 124-31 (2016)
3. **G Smyth**, P M Evans, J C Bamber, H C Mandeville, A R Moore, L C Welsh, F H Saran, J L Bedford. Dosimetric accuracy of dynamic couch rotation during volumetric modulated arc therapy (DCR-VMAT) for primary brain tumours. Phys. Med. Biol. 64: 08NT01 (2019)
4. **G Smyth**, P M Evans, J C Bamber, J L Bedford. Recent developments in non-coplanar radiotherapy. Br. J. Radiol. 92: 20180908 (2019)