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Patient-Specific Quality Assurance for VMAT-Based Fractionated Intracranial Stereotactic Radiotherapy with Intra-Fraction Motion Monitoring

Sergei Zavgorodni [1]

1. Medical Physics, BC Cancer Agency- Vancouver Island Center

Corresponding author: Sergei Zavgorodni, szavgorodni@bccancer.bc.ca

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Abstract

Objectives: To establish robust quality assurance (QA) program for VMAT-based SRT with intra-fraction patient motion control. In patient-specific QA we aim to remove dose point measurements replacing them with Monte Carlo dose calculation on patient CT dataset and EPID-based dose reconstruction in a virtual cylindrical phantom. Intra-fraction patient position QA includes optical surface monitoring and post-treatment CBCT. Objectives in this are to ensure consistency between these two independent methods.

Methods: Open face mask is used for patient immobilization. Plans with two coplanar arcs are calculated with AAA at 1.25mm resolution. Patient-specific dosimetry QA includes Monte Carlo (MC) verification of the dose distributions calculated on patient CT data and 3D EPID-based verification in a virtual phantom. In-phantom point dose measurements have been performed for the first thirty patients and are now performed only as required. Two pre-treatment CBCT acquisitions with 6D followed by 4D-couch corrections are performed; optical "reference" image is taken post CBCT corrections and patient monitoring during the treatment is performed using optical system. Post-treatment CBCT is also taken and reviewed off-line to compare CBCT patient positions with those acquired using optical system.

Results: Ninety-eight patients were treated since the start of our program in June 2015. Mean point dose difference between MC and microDiamond detector was 0.3% (1.6%SD). Mean PTV dose difference between MC and AAA calculations was 0.4% (1.2%SD). For EPID verification, mean point dose difference was -0.6% (1.4%SD), mean 1mm /3% pass rate was 97.7% (4.9%SD). Mean radial treatment setup error was 0.2mm (0.2mm SD), mean radial treatment positioning error was 0.4mm (0.2mm SD). Intra-fraction optical surface monitoring has been introduced in January 2017. In over 90% of CBCT-based post treatment patient position verifications agreed with those from surface monitoring within 1mm and 1 degree rotations.

Conclusions: Rigorous QA through each step of SRT is essential. MC calculations and EPID-based 3D dosimetry provide efficient 3D dose verification and make it possible to avoid patient specific point dose measurements. Optical surface monitoring allows efficient intra-fraction patient position control, and its accuracy in clinical setting has been confirmed using pre-and-post treatment CBTCs.

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