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Dosimetric comparison between modulated electron radiotherapy, mixed beam radiotherapy and volumetric modulated arc therapy

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Purpose: Treatment plans with photon beams typically rely on photon multi-leaf collimators (pMLC) in clinical routine which enable techniques such as volumetric modulated arc therapy (VMAT). Intensity and energy modulated electron beams are facilitated by the usage of pMLCs instead of cut-outs in so-called electron modulated arc therapy (EMAT) and modulated electron radiotherapy (MERT). In mixed beam radiotherapy (MBRT), intensity modulated photon and electron beams are combined. In this work, EMAT, MERT and MBRT plans are compared to VMAT plans.

Methods: EMAT, MERT, VMAT, and MBRT plans are created for two breast cases and three head and neck (H&N) cases. For this, electron arcs, electron fields and photon arcs are set up within a treatment planning system and intensity modulation optimisation is performed using an in-house optimizer. The treatment plan quality of the created EMAT, MERT, VMAT and MBRT plans is assessed via dose-volume histograms, dose distributions and dose statistics. The dosimetric accuracy is validated with radiochromic film measurements for a selection of plans.

Results: For the investigated breast cases, the generated MERT/EMAT plans show an improved treatment plan quality compared to VMAT plans. For the H&N cases, however, the VMAT plans outperformed the MERT/EMAT plans in terms of treatment plan quality. Overall, the results for the MERT plans are similar to the EMAT plans in terms of their dose distributions. Further, the treatment plan quality is improved using MBRT in comparison to MERT/EMAT/VMAT plans. The gamma passing rate between measured and calculated dose distributions are above 97.1% for all investigated plans using a 3%(global)/2mm criterion.

Conclusions: The generated MERT and EMAT plans are similar in terms of dosimetric treatment plan quality. In comparison to VMAT, the EMAT and MERT plans have improved treatment plan quality for the breast cases, but worse treatment plan quality for the H&N cases, while the MBRT plans achieved best treatment plan quality overall.

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