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Effect of fluence smoothing on the quality of intensity-modulated radiation treatments

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Radiation therapy uses ionizing radiation to inhibit the functioning and multiplication of tumor cells. The objective of radiation therapy is to deliver a prescribed amount of lethal radiation dose to the tumor while minimizing the dose to surrounding normal tissues. This has been achieved with the help of a technique called intensity-modulated radiation therapy (IMRT), which generally uses inverse planning with an optimization algorithm to reach the desired dose distribution to the planning target volume (PTV) and a low dose to the surrounding organs at risk (OARs). Depending on the geometry of the PTVs and the OARs, the demands for conformity to the PTV, and the tolerance of the OARs, the treatment plans can be correspondingly complex. However, more complex plans result in a large number of monitor units (MUs) which causes greater practical difficulties such as long-term secondary cancer induction, increased skin dose, a longer treatment time, and uncertainties during treatment delivery. Commercially available treatment-planning system (TPS) typically includes a fluence-smoothing function for reducing the complexity of a treatment plan. In this study, we investigated the consequences of fluence smoothing on the quality of highly complex and inhomogeneous plans in a TPS, EclipseTM. The smoothing function was applied both in the direction of leaf travel (X) and perpendicular to leaf travel (Y). Twenty IMRT plans from patients with cancer of the nasopharynx and lung were selected and re-optimized with use of various smoothing combinations from X=0, Y=0 to X=100, Y=100. Total MUs, dose-volume histograms, and radiobiological estimates were computed for all plans. The study yielded a significant reduction in the average total MUs from 2079±265.4 to 1107±137.4 (nasopharynx) and from 1556±490.3 to 791±176.8 (lung) while increasing smoothing from X, Y=0 to X, Y=100. Both the tumor control and normal tissue complication probabilities were found to vary, but not significantly so. No appreciable differences in doses to the target and most of the OARs were noticed. The doses measured with the I'MRT MatriXX 2-D system indicated improvements in deliverability of the plans with higher smoothing values. Hence, it can be concluded that increased smoothing reduced the total MUs exceptionally well without any considerable changes in OAR doses. The noted differences of about 23.0% and 23.9% in the respective treatment MUs are outstandingly high. The transformation of smoothing values from default to X=70, Y=60 saved around 390 MU (nasopharynx) and 290 MU (lung) per fraction. This will result in a reduction of approximately 32 and 21 minutes, respectively, in the total radiation-beam-on time for the entire course of a patient treatment. In addition, the observed progress in plan deliverability in terms of the gamma index strongly supports the recommendation of using smoothing levels up to X=70 and Y=60, at least for the anatomic regions studied. In spite of all practical advantages, IMRT often results in delivery of large number of MUs which is of great concern in radiation oncology. Our study strongly recommends the up gradation of vendor default smoothing levels of Varian Eclipse™ treatment planning system to the stated values. This is significant because of the large scale reduction in MUs which minimizes the potential consequences of long term effects such as secondary cancer induction and other radiation induced issues. This study contains important data for clinical staffs and would be particularly helpful for Eclipse users. The paper should be of interest to researchers in the areas of radiation oncology, medical physics and medical dosimetry. Radiobiological models were proved to be effective in predicting treatment outcome precisely by use of DVH data when compared to the uncertainty of using physical dose metrics alone for plan evaluation. This study not only is limited to physical dose evaluation, but also investigates the impact of fluence complexity on radiobiology based plan quality parameters. Also, this publication verifies the deliverability of treatment plans by actual measurement based on a larger set of data. Hence, this paper discloses the method of radiobiological plan evaluation and dosimetric measurements clearly and the audience will be able to use these in their clinical practice. Thus this study of nasopharynx and lung IMRT treatment plans with different scenarios of fluence levels will help them to understand the effect of user-interfaced fluence smoothing with the EclipseTM TPS in detail.

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