



Time-Resolved Measurements of Induced Activity in Accelerator Components and Treatment Rooms

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mean range shifts were measured to be smaller than the applied margins [Xie et al, IJROBP 99:210-218 2017]. In this study, we present the PG imaging results of a patient treated at the base of skull within a heterogeneous region. We evaluated the impact of changes in sinus filling on individual proton spot range retrieval to access the efficacy of the PG camera in detecting the anatomical change. Additional data analysis was conducted to evaluate strategies on how to visualize and interpret PG based range measurement data.

Material and Methods

The patient was treated for a malignant neoplasm of the brain near the base of skull receiving 54 Gy in 30 fractions. During the course of treatment, an evaluation CT scan identified anatomical change in the nasal cavity (Figs. 1a and 1b) and the treatment plan was revised accordingly. Both the initial and revised plans consisted of three equally weighted fields. PG imaging data was recorded for eight fractions, including six with the initial plan and two with the revised plan. The knife-edge slit camera records the PG emission profile along the beam direction. The measured PG profiles were analyzed on a spot-by-spot level and compared to simulations.

Results

Based on PG emission simulations, two fields should exhibit over-ranges due to anatomical change. The PG based range measurements revealed over-ranges of up to 4 mm in individual spots passing through the nasal cavity (Fig 1c), which agreed with the simulations from patient CT and initial treatment plans. Meanwhile, no over-ranging was observed for the field that was not impacted by the anatomical change. For the revised plan, smaller range shifts were identified (Fig 1d). The data is presented in 3D to better visualize and identify the range deviations.

Conclusion

In this study, we presented patient PG measurements for a highly heterogeneous target volume, and identified over-ranges in the treatment volume corresponding to the anatomical change identified during an evaluation CT during the course of treatment. Smaller range deviations were observed using the revised plan. By using a 3D image of the range deviation map, we improved the visualization of PG data to identify range deviations relative to regions of anatomical change. PG imaging is a feasible tool to identify range deviations for heterogeneous targets.

EP-1802 Time-Resolved Measurements of Induced Activity in Accelerator Components and Treatment Rooms

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Purpose or Objective

The induced activity in linear accelerator components and treatment rooms is of importance when considering safety aspects concerning engineers and physicists performing measurements and maintenance at the accelerators. The literature is lacking studies on the effects of FFF (Flattening Filter Free) radiation and MLC (Multi-Leaf Collimator) parking, which we present in this work.

Material and Methods

Induced activity was measured using a pair of LUDLUM dosimeters (model 9DP with data logging), positioned as shown in Figure 1, at two Elekta linear accelerators with MLC160 (Agility) and MLCi2. The dosimeters were set to log data every five seconds. Following the day's treatments, 5000 MU (monitor units) were given with a 10x10 cm² field size. The dosimeters were outside the treatment room during the 5000 MU radiation and were

placed as Figure 1 shows immediately after the 5000 MU had been given. One of the dosimeters was positioned as close as possible to the exit window, with the centre of the detector approximately 50 cm from the accelerator's X-ray target. The other dosimeter was placed outside the X-ray target at approximately 44 cm laterally from the target and 100 cm below the isocentre. The gantry angle was 180° during all measurements. Energies of 6 and 18 MV were applied, in addition to 6 MV FFF at the MLC160. Measurements were also made with the MLCs in parked position.



Figure 1: The measurement set-up.

Results

Figure 2 shows the results of the measurements. For 18 MV at the MLCi2 (Figure 2a)), higher dose rates are measured at the exit window initially, compared to target level, until after about 45 minutes, when the dose rates are the same. The target level dose rate is slightly higher than at the exit window thereafter. Figure 2b) shows the sudden drop in dose rate when parking the MLCs after 5000 MU at 18 MV at the MLCi2. Figure 2c) shows the results at the exit window of the MLC160, where the MLC was parked twice at 6 MV FFF. Figure 2d) shows the target level results for the MLC160.

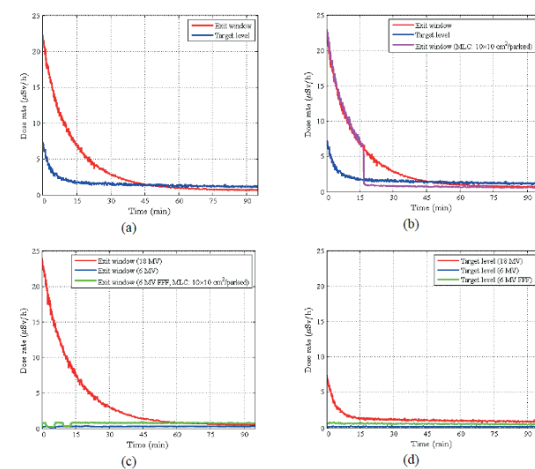


Figure 2: a) 18 MV, MLCi2. b) 18 MV including measurements during the MLCi2 parking after 16-17 minutes. c) Comparison of 18 MV, 6 MV, and 6 MV FFF, d) Target level results for the MLC160.

exit window, MLC160. The MLC160 was parked twice during the 6MV FFF measurements. d) target level at the MLC160 for 18 MV, 6 MV, and 6 MV FFF.

The maximum induced dose rate was 23 $\mu\text{Sv/h}$ for 18 MV at the exit window. The dose rate with the MLCs in the parked position is approximately 3 $\mu\text{Sv/h}$ after applying 5000 MU at 18 MV. For lower photon energies, the maximal dose rate was 1 $\mu\text{Sv/h}$ for 6 MV FFF.

Conclusion

We confirm that induced activity primarily occurs at photon energies above 10 MV (Perrin et al, Phys. Med. Biol. 48, N75-N81, 2003), as we measure the greatest activity at 18 MV. After 45 to 60 minutes the induced activity is greatest at the target level. The dose rate for the MLCs in the parked position is more than 7 times lower than for a 10x10 cm² field. Higher dose rates are measured with FFF, suggesting a filter shielding effect.

EP-1803 Dosimetric and radiobiological validation of Acuros XB algorithm in thoracic radiation therapy

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Purpose or Objective

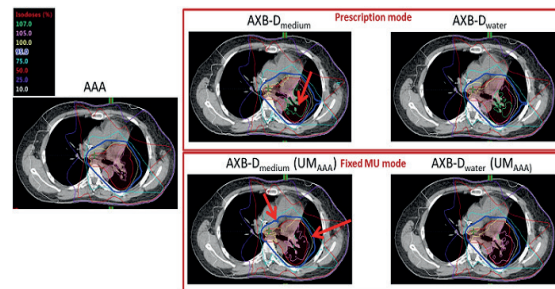
Acuros-XB (AXB) algorithm has been introduced several years ago in order to improve the accuracy of dose calculation in radiotherapy, especially in the presence of tissue heterogeneities. This type (c) algorithm is based on the deterministic resolution of the linear Boltzmann transport equation and offers results close to Monte Carlo simulations.

This study aims to evaluate the clinical impact of a new algorithm by comparing the dosimetric and radiobiological results of the AXB algorithm for its two reporting modes (dose to water AXB-Dw and dose to medium AXB-Dm), compared to a reference algorithm: the Anisotropic Analytical Algorithm (AAA). **Material and Methods**

Ten cases of patients treated for lung cancer with conformational radiotherapy were studied. For each patient, five treatment plans were generated. The dose in plans 1, 2 and 3 was respectively calculated with AAA, AXB(Dm) and AXB(Dw), using the same prescribed dose (PD). In plans 4 and 5, the dose was calculated using the two AXB calculation modes with the same number of monitor units (MU) derived from the AAA calculation (plan 1). The dosimetric evaluation was based on the comparison of dose volume histograms (HDV) and quality metrics (i.e. Conformity, Coverage and Homogeneity indices). Radiobiological assessment was based on the comparison of tumor control probabilities (TCP) and toxicity probabilities (NTCP) for organs at risk (OARs), including lungs, esophagus and heart. Wilcoxon and Spearman's rank tests were used to calculate p-values and the correlation coefficient (ρ).

Results

Using the same PD, we observed a significant increase in the number of MU (1%-4%), depending on the choice of AXB-Dm or AXB-Dw. In dosimetric terms, dose calculated with AXB is more heterogeneous. This introduces a significant decrease in the minimum dose to the PTV and in the quality indices. These elements can influence the therapeutic results. In addition, the dose to OARs was increased from +2% to + 10%. The increase in dose to target volumes and OARs with AXB, using the same PD, explains the increase in TCP (+1% to 2%) and in NTCP (+2%) ($p < 0.01$).



Conclusion

AXB algorithm is known to provide improved calculation accuracy. However, a special attention is required in order to safely implement its clinical use. Depending on the medium density, the technique and the treatment field size, MU can increase as well as the dosimetric values and the NTCPs. Radiation oncologists and medical physicists should define together the attitude to be adopted regarding these dosimetric shifts. A reasonable approach would be to keep the same PD while increasing the sparing of the OARs.

EP-1804 Skin dose measurements in SBRT and IMRT treatments

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Purpose or Objective

The AAPM TG176 shows examples of dramatic unexpected skin effects. This work is aimed to:

1. Measure maximum doses delivered to skin by current SBRT and IMRT treatments and compare them to doses calculated by the TPS at the same points, and to the calculated maximum dose for the skin structure (5 mm thickness inwards from body surface).
2. Compare measured 3DCRT vs IMRT skin doses in breast irradiation as well as breast IMRT to head-and-neck (H&N) IMRT.
3. Determine whether current SBRT and IMRT treatments could trigger toxicities such as those reported in literature.

Material and Methods

- We selected 78 patients undergoing radiation therapy. The distribution of patients and the most frequent dose prescriptions were: 17 3DCRT breast [25x2Gy], 20 IMRT breast [27x1.88@breast, 27x2.31Gy@boost], 21 IMRT H&N [33x2.12Gy@high-risk; 33x1.8Gy@medim-risk; 33x1.6Gy@low-risk], 16 lung SBRT [5x11Gy], 4 liver SBRT [3x20Gy].

- Skin doses were measured with EBT3 radiochromic films + FilmQAPro Software + EPSON EXPRESSION 10000XL scanner. 2 cm² square pieces were mounted in line inside sleeves of low-density polyethylene of 50 μm thickness that had been cut into strips of 40-80 cm length. Strips were fixed onto the patient skin along a section perpendicular to the gantry axis including the area of maximum calculated dose by the TPS.

- Readout of film pieces (average of a 1x1 cm² ROI) was repeated thrice with random position to account for scanner and film non-uniformities.

- Calculations were done in Eclipse13.5 with maximum resolution (1 mm). We recorded 1) Calculated dose @1mm depth at the point corresponding to the maximum measured dose, and, 2) Maximum calculated dose for the skin structure

Results

- Fig1a-e: Measured and calculated doses were different but differences were not significant. Calculated doses to the skin structure were systematically higher than