Measurements to predict the time of target replacement of a helical tomotherapy.

Abstract:
Intensity-modulated radiation therapy (IMRT) requires more beam-on time than normal open field treatment. Consequently, the machines wear out and need more spare parts. A helical tomotherapy treatment unit needs a periodical tungsten target replacement, which is a time consuming event. To be able to predict the next replacement would be quite valuable. We observed unexpected variations towards the end of the target lifetime in the performed pretreatment measurements for patient plan verification. Thus, we retrospectively analyze the measurements of our quality assurance program. The time dependence of the quotient of two simultaneous dose measurements at different depths within a phantom for a fixed open field irradiation is evaluated. We also assess the time-dependent changes of an IMRT plan measurement and of a relative depth dose curve measurement. Additionally, we performed a Monte Carlo simulation with Geant4 to understand the physical reasons for the measured values. Our measurements show that the dose at a specified depth compared to the dose in shallower regions of the phantom declines towards the end of the target lifetime. This reproducible effect can be due to the lowering of the mean energy of the X-ray spectrum. These results are supported by the measurements of the IMRT plan, as well as the study of the relative depth dose curve. Furthermore, the
simulation is consistent with these findings since it provides a possible explanation for the reduction of the mean energy for thinner targets. It could be due to the lowering of low energy photon self-absorption in a worn out and therefore thinner target. We state a threshold value for our measurement at which a target replacement should be initiated. Measurements to observe a change in the energy are good predictors of the need for a target replacement. However, since all results support the softening of the spectrum hypothesis, all depth-dependent setups are viable for analyzing the deterioration of the tungsten target. The suggested measurements and criteria to replace the target can be very helpful for every user of a TomoTherapy machine.

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