

Beam start-up stability for step-and-shoot IMRT of a 6 MV photon beam

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Introduction

Beam start-up stability has been discussed a lot and the effect on total dose distribution seems very small [1, 2]. However, our weekly routine measurements of symmetry showed for 6 MV photon beam a considerable varying of the symmetry in the range up to 30 or 40 monitor units. For static fields this can be neglected, as not many fields of this size will be applied to a patient. But for step-and-shoot IMRT, there are many segments of a size between 1 and 20 monitor units. So, this effect on such field sizes is studied here.

Material and Methods

To define the range of interest for measurements a systematic statistic analysis of our applied IMRT-Fields has been made. This shows that measurements in a range from 1 to 25 MU in a field size of 25x25 cm² covers nearly all cases. The time delays between different segments during an irradiation are set to 0.1 up to 12 seconds.

All measurements on our linacs (Synergy, Elekta) are made using a 2D-Array seven²⁹ (PTW Freiburg) with PMMA-plates for build-up.

Results

To analyse the difference over the whole two dimensional profile, a relative dose distribution $r(x,y)$ was determined for each measurement by $r(x,y) = D_m(x,y)/D_{m_0}(x,y) \cdot m_0/m$, where D_m and D_{m_0} are the dosimeter readings for m resp. m_0 monitor units. As reference a field with $m_0 = 250$ monitor units had been applied. A value of $r = 1$ is expected for a perfect stability.

These profiles of relative dose show clearly a remarkable start-up behaviour and a varying stability: in the upper left part directed to the gun of the field the dose is higher than in the lower right part directed to the target. These differences are reduced continuous by increasing the number of monitor units. So, for 1 monitor unit the differences show values up to 6%, for 3 monitor units they are reduced to 3%. For 6 monitor units and more the differences are smaller the 2%, from 11 monitor units on the relative dose shows only differences below 1%. Segments with 50 monitor units or more do not show a significant difference any longer.

Discussion

According the SSRMP Recommendations [3, 4] tolerances for symmetry and the linearity of the dose output are 2% resp. 1%. For segments with up to 5 monitor units, which are used in nearly 25% of all cases differences to a reference profile can be measured of more than 2%. So, obviously this is out of tolerance. But regarding that all measurements have been made for 25x25 cm² fields and real IMRT segments are normally much smaller, these differences may be reduced for smaller fields. For the total dose distribution of several fields with 12 to 15 segments which have mostly about 8 or 9 monitor units, the total difference is reduced again. To make a more accurate conclusion of for a total dose distribution more analysis is needed.

To close this discussion it has to be mentioned that our IMRT verifications are in most cases within the recommended tolerances. So the effect of the start-up behaviour on IMRT still seems to be small.

References

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- [3] SSRMP Recommendations No 11, September 2007, Quality Control of Medical Electron Accelerators, ISBN 3 908 125 41 3
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