ANALYSIS OF THE DOSE-RATE DEPENDENCE OF THE ARCCHECK® DEVICE

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INTRODUCTION

The ArcCHECK® device (Sun Nuclear) is an array formed by 1386 SunPoint™ diode detectors and arranged in a helical geometry, designed to verify IMRT and VMAT treatments. During its commissioning, a dose-rate dependence higher than the specified in the user manual [1] (±1% over the range 50-1400 cGy/min) was observed. This was also observed in a previous work by Li et al. [2]. This dependence may be relevant when performing VMAT verifications, as the dose-rate varies in these treatments. Therefore, some tests were performed to study the dose-rate dependence of the ArcCHECK® device and to estimate its influence in VMAT verifications.

MATERIAL AND METHODS

The ArcCHECK® device was irradiated using beams with an energy of 6 MV provided by an linear accelerator Elekta Infinity. The measures were corrected with the measurements of a cc13 ionization chamber (Iba Dosimetry), allocated in the center of the system through a cavity, and its associated electrometer, Dose One (Scanditronix-Wellhöfer)

The work was divided in two phases:

- First, to determine the dose-rate dependence of the system. It is important to note that in a previous work [1], they only considered the dose measured by one sole diode; while in the present work the measures of all the diodes forming the array were taken into account. The device was irradiated with a sequence of beams of a field size of 5 cm x 25 cm varying its gantry angle from 0° to 356° in 4° steps, receiving all the detectors the same absorbed dose. Nominal dose-rates over a range of 50 to 600 MU/min were employed. Then, the measurements of each diode were fitted with the dose-rates by a fitting function.
- Second, to study the influence of having different dose-rates in the same treatment. The device was irradiated in two ways: first, one arc of 360° with maximum dose-rate (597 MU/min) and then with an arc divided in two sectors, one of 280° with a dose-rate of 74 MU/min and another of 80° with 597 MU/min. Then, the influence of the dose-rate dependence for this case was estimated as the ratio between the sum of the response of all the diodes in both cases :

$$\Delta(\%) = 1 - \frac{M_{sec}}{M_{tot}}$$

Where $\Delta(\%)$ is the difference expressed as a percentage between both irradiations, M_{sec} is the measure, integrated over all the diodes, in the sectored case and M_{tot} is the response, integrated over all the diodes, in the maximum dose-rate irradiation.

RESULTS

The response of the system was higher as the dose-rate increased, having a difference of 2.4±0.7% (k=2) over the range from 50 to 600 MU/min. The measurements were fitted by a function in the form:

$$M = \frac{a \cdot R}{b + R^c}$$

M is the response of the device, R the dose-rate and a, b and c fitting parameters. The measurements along with the fitting function are represented in figure 1.

The sectored measure in the second test was 0.7±0.4% (k=2) lower than the maximum dose-rate arc, indicating the relevance of correcting the measures in VMAT verifications.

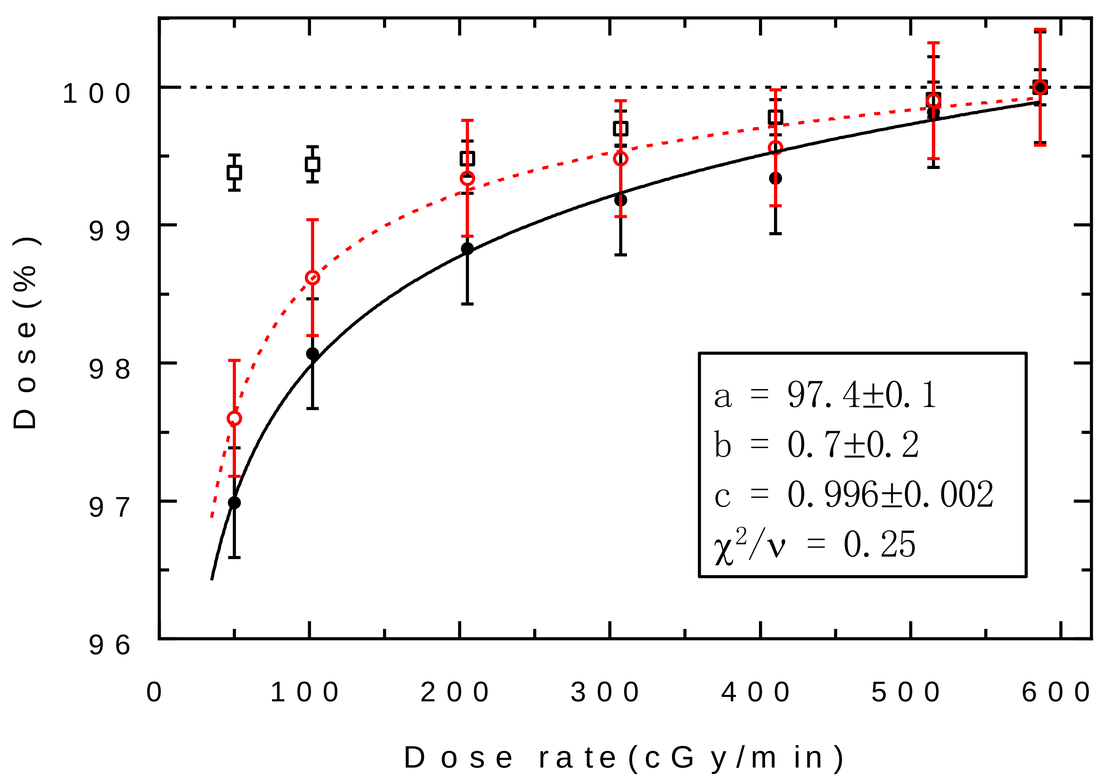

Figure 1. Normalized values of the response with the dose-rate of the ArcCHECK® device (black circles), cc13 chamber (white squares) and its ratio (red circles) are represented. The uncertainties are calculated as the standard deviation over three measures and are showed with a coverage factor of k=2. Black and red lines correspond to the fit function of the measures of the ArcCHECK® and the ratio, respectively. Fitting parameters corresponding to the red line are also shown in the figure.

CONCLUSIONS

The dose-rate dependence of the ArcCHECK® device is higher than the specified in the user manual and the measures must be corrected when performing VMAT verifications. Further tests using real VMAT treatments shall be done to do a better estimation of the influence of this dependence.

REFERENCES

[1] Sun Nuclear. User's Guide, ArcCHECK®. Document 1220012, Rev M, 21 November 2014.

[2] Li G et al. Evaluation of the ArcCHECK QA system for IMRT and VMAT verification. Physica Medica 2013;29:295-303.

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