The quality assurance of Varian enhanced dynamic wedges using Daily QA Check 2

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SUMMARY

Background: *Clinical implementation of enhanced dynamic wedges (EDW) requires, as any other dynamic treatment, very serious quality assurance (QA) program. In this work, we presented the results of six-month evaluation of Varian enhanced dynamic wedges and detailed QA program for those wedges.*

Methods: *The Sun Nuclear Daily QA Check 2 was used for QA purpose. The QA program included daily and monthly checks. The daily QA program included central axis dose and wedge angle measurements. Within the monthly QA program wedge factors and delivered STTs from the Dynalog files were checked.*

Results: *Our daily QA measurements of dose and wedge angle showed the reproducibility error less than ±1.5%. On the other hand, monthly QA measurements of wedge factor the reproducibility error was less than ±0.5%. The monthly QA check of delivered STTs showed excellent agreement.*

Conclusion: *During the six-month quality control we observed a good reproducibility in the delivery of EDW treatment. Also, the Sun Nuclear Daily QA Check 2 showed to be very satisfying in QA of the EDW treatment.*

Key words: *Quality Assurance; Health Care; Particle Accelerators; Radiotherapy, Conformal; Radiotherapy Planning, Computer Assisted; Radiometry*

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INTRODUCTION

With the technological progress of computer controlled linear accelerators in the early 1990s it has become possible to generate wedge-shaped isodose distribution dynamically without the use of the physical wedge. A further step in obtaining wedged isodose distribution was made in 1995 by the introduction of the enhanced dynamic wedge on the Varian linear accelerators (1).

Dynamic wedge is created by the continuous movement of the collimator jaw during the time of radiation. The wedge-shaped isodose distribution is the result of the integration of the dose delivered during the period of time in which the jaw sweeps the field from open to closed position. Dose rate and jaw speed vary during the treatment period which enables the dose to be delivered in the optimal time (2). The relation between dose delivered and jaw position in the dynamic wedge treatment is based on STT which is the tabular representation of the jaw position versus the fraction of dose delivered. In the case of the enhanced dynamic wedge treatment two STTs independent of the initial field size and wedge angle are used. Those two tables correspond to the data obtained for the largest possible field width for open field (STT_0) and largest possible field width for wedge angle 60˚ (STT_{60}). The details of STT generation and delivery have been explained by Varian (3).

New linear accelerator Varian 600DBX with photon energy of 6MV and the option of enhanced dynamic wedge has been used at the Institute of Oncology of Vojvodina in Novi Sad since March 2006. This accelerator has seven enhanced dynamic wedge angles available: 10˚, 15˚, 20˚, 25˚, 30˚, 45˚, and 60˚.

The EDW option requires a reliable quality assurance program (QA program). The QA procedures described in this paper are introduced to provide quality control during the EDW treatment delivery. An important advantage of these procedures is that they can be easily performed in the everyday clinical environment (4,5).

With such quality assurance program we performed daily and monthly checks including the recording of dose value on the central axis and deviation of the EDW angle from the calibrated value, as well as WF measurements and Dynalog files check.

The collimator jaws position before dose delivery, as well as their position and dose delivered during treatment delivery are checked by means of the linear accelerator software. Initial position interlock (IPSN) assures that the treatment delivery does not start until the jaws are placed within 0.1cm from their proper starting position. Dynamic position interlock (DPSN) interrupts the treatment if the dose and jaw position during the treatment differ from their STT values for more than 0.3 MJ or 0.5 cm respectively. Due to the existence of this independent control mechanism as a part of the linear accelerator software, we have decided not to perform additional dose and jaw position control before and during treatment (3,6).

METHODS

Daily QA

Three fields with different EDW angles were added to the morning checkout list. Chosen EDW angles were 10º, 30º and 60º. The wedge angle of 60º was chosen because it enables the calculation of all the other wedge angles, using the data from STT_{60} (so-called "golden" STT corresponding to the angle of 60º) and from STT_0 (corresponding to the open field). The wedge angles of 10º and 30º as the minimal and average wedge angle were taken as a check of the integrity of the algorithm in calculation of the STTs for any of the possible wedge angles.

The check was performed by Sun Nuclear Daily QA Check 2 (QA2) which has six plane-parallel ionization chambers with the cavity volume 0.6 cm^3 and sensors for the automatic correction of pressure and temperature calibration factors (7). By means of QA2 dose on the central axis for all three wedge angles was measured, as well as the flatness used for determination of the angle of EDW. Using the QA2 software, analysis of all measured data can be performed, including graphic presentation of differences between measured and calibrated values in percentage terms. The software also enables the tracking of measured data trend. The allowed difference between measured and calibrated values was ±1.5%. The data were measured under the following conditions: field size 20 x 20 cm^2, 100 cm source to surface distance (SSD) and collimation of 90º.

If the deviations from the calibrated values exceeded ±1.5%, an absolute dosimetry and re-adjusting of the accelerator was needed.

Monthly QA

The monthly quality control included measurement of the wedge factors for all available enhanced dynamic wedge angles and Dynalog files checks. The wedge factors were measured in water phantom under following conditions: the field size was 20 x 20 cm^2, source to axis distance (SAD) was 90 cm, and depth was 10 cm. Those conditions were dictated by EDW angle definition. Measured WFs were compared to WFs used for the daily QA Check 2 calibration.

The information on EDW treatment was stored in Dynalog files which contained date and time of the treatment and its parameters, and the calculated and actual STTs of the treatment. In the linear accelerator computer 199 Dynalog files are saved and constantly updated. In order to assure quality control the files for the treatment with same parameters (energy, field size, EDW angle, and monitor units number) are saved and checked. Hence, the reliability of the linear accelerator and the calculation and delivery of STTs for the specific treatment can be controlled. To this end, treatment parameters used in Daily QA Check 2 were taken.

RESULTS

Daily constancy checks of dose and wedge angle deviations from the calibrated values were performed over a six-month period. In Figure 1, we present the data obtained during that period of time for the wedge angle of 60º. These data show reproducibility error less than 1.5%.

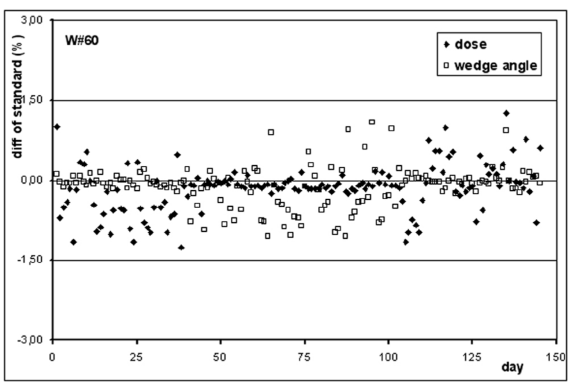

Figure 1. Daily variation of dose on the central axis and wedge angle during six month period for EDW angle of 60º for energy of 6 MV, field size 20 x 20 cm^2 and 100 cm SSD

In Figures 2 and 3 we present the data obtained during the same time period for the wedge angles of 10º and 30º. These data also show reproducibility error to be less than 1.5%, while the errors in the algorithm of STT calculations have not been noticed.

In the framework of monthly QA WFs for all wedge angles were measured. WFs for the angles of 10º, 30º and 60º were compared to the calibrated values. The results of the analysis of these measurements were: for wedge angle of 10º the WF of 0.876(1) was obtained, while for the wedge angles of 30º and 60º the WFs were 0.685(2) and 0.420(2), respectively. For all three angles relative uncertainty was less than 0.5%.

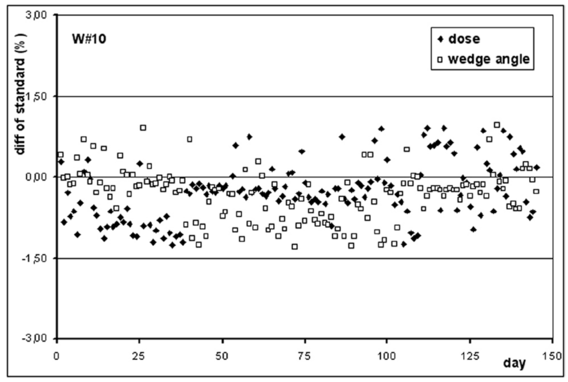

Figure 2. Daily variation of dose on the central axis and wedge angle during six month period for EDW angle of 10º for energy of 6 MV, field size 20 x 20 cm^2 and 100 cm SSD

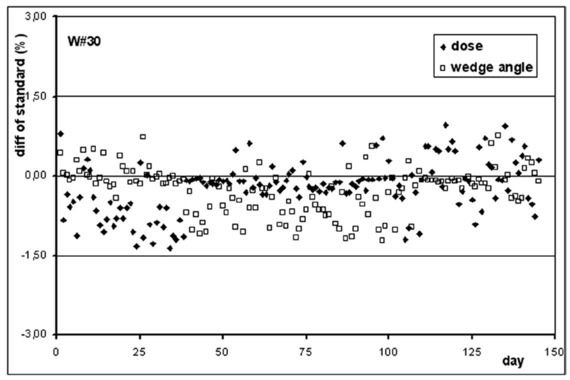

Figure 3. Daily variation of dose on the central axis and wedge angle during six month period for EDW angle of 30º for energy of 6 MV, field size 20 x 20 cm^2 and 100 cm SSD

In Figure 4, we plotted the delivered STTs from the Dynalog files obtained during the six-month period for the wedge angles of 10º, 30º and 60º. The analysis of this figure shows that the curves are completely superimposed.

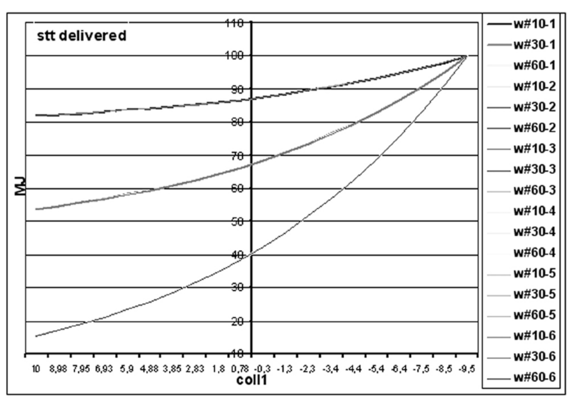

Figure 4. Comparison of delivered STTs on the monthly bases during six month period for all three EDW angles for energy of 6 MV, field size 20 x 20 cm^2 and 100 cm SSD

DISCUSSION

The clinical implementation of EDW is considered to be complete only after the corresponding QA procedures for EDW are introduced. These procedures have to be timesaving, reliable, and easy to apply. To this end, Sun Nuclear Daily QA Check 2 has been successfully used. Its efficiency is reflected in the fact that in a few minutes period all necessary measurements can be performed. Daily measurements of the dose on the central axis and of the wedge angles for all three wedges showed reproducibility error of than 1.5%. Those slight fluctuations of the measured data were predominantly caused by imperfections in QA2 adjustment during measurements. The other sources of fluctuations are variations in linear accelerator output. With this kind of measurements on daily basis and following the trend of the measured data, absolute dosimetry was needed only when QA2 showed some irregularity.

With monthly QA we compared, measured, and calibrated WFs and obtained the relative uncertainty of 0.5% which presented a slightly better result than in other papers (6,8).

The analysis of the data stored in Dynalog files showed an excellent reproducibility of delivered STTs. Thus, the reliability of linear accelerator computer in calculating and delivering STTs was confirmed (4).

CONCLUSION

In this paper QA procedures enabling fast and efficient quality control were suggested. The data obtained during the six-month quality control were presented and showed good reproducibility in EDW treatment delivery. We may conclude that the Sun Nuclear Daily QA Check 2 is satisfying in quality assurance of the EDW treatment, and that can point out the possible problems in the linear accelerator work during EDW treatment.

Conflict of interest

We declare no conflicts of interest.

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