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CONTENTS

On the transit dose from motorized wedge treatment in Equinox-80 telecobalt unit

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ABSTRACT

Purpose: To estimate the transit dose from motorized wedge (MW) treatment in Equinox-80 telecobalt machine.

Materials and Methods: Two plans were generated in Eclipse treatment planning system with universal wedge (UW) and MW each for 10x10 cm^2. The transit dose was measured with 0.6 cc cylindrical ion chamber and thermoluminescent dosimeters (TLD) chips at a depth of 5 cm with source to axis distance (SAD) 80 cm.

Results: The measured dose with ion chamber was in well agreement with the calculated dose from Eclipse within ± 2%. The planned dose was 100 cGy while the measured absorbed dose with ion chamber for 15º, 30º, 45º and 60º MW treatment was found to be 100.94, 101.04, 100.72 and 99.33 cGy respectively. For 15º, 30º, 45º and 60º UW treatment, the measured absorbed dose was 99.33, 97.67, 97.77 and 99.57 cGy respectively. Similarly the measured absorbed dose with TLD was within ± 3% with the planned dose for universal wedge (UW) and MW. From the experimental measurements, it was found that there was no significant contribution of transit dose during MW treatment.

Conclusion: The actual measurements carried out with ion chamber in Equinox-80 machine for UW and MW revealed no variation between the doses delivered. The doses were comparable for both UW and MW treatments. The results from TLD measurements additionally confirmed no variation between the doses delivered with UW and MW. It was also demonstrated that the observed excess or less transit dose with MW does not have any significant clinical impact. This assured the safe dose delivery with MW.

KEY WORDS: Motorized wedge, telcobalt, transit dose

INTRODUCTION

The recent introduction of a new telecobalt Equinox-80 (MDS Nordion, Canada) at Tata Memorial Centre stimulated an appraisal of the optimum usage of the new technology, specifically the motorized wedge (MW) facility. Equinox-80 was recently commissioned at our center in June 2006 with a ^{60}Co source (398 TBq). Prior to the acquisition of the motorized wedge in Equinox-80, standard individualized and universal wedge (UW) filters were being used on other telecobalt machines and linear accelerators respectively. The motorized wedge systems is favored over the standard wedges because of the ease with which treatment plan optimization could be effected by varying the proportion of treatment delivery through an open portal and the 60° wedge portal. In principle, a similar technique is achievable with hard wedge filters; however, implementation would double the number of radiographer interventions in the treatment room and considerably increase treatment delivery time.

MW in Equinox-80 provides a 60º nominal wedge angle and has the capability of modifying the isodose characteristics of the radiation beam as desired by the user. The details of MW drive mechanism have been reported elsewhere.[1] MW travels between two fixed positions: wedge In and Wedge Out. The source is exposed twice during MW treatment.

The transit time is the time required for the source carrier to travel from the Fully Shielded position to the Fully Exposed position and also from the Fully Exposed position to the Fully Shielded position. It is normally factory set and ranges between 1.5 and 2.0 seconds. Should the transit time from the Fully Shielded position to the Fully Exposed position exceed 2.5 seconds, the control system will discontinue the treatment and return the source to the Fully Shielded position.

Transit dose is the dose delivered at the normal treatment distance, on the radiation beam axis, during the proportion of the transit time for which the source is exposed (shutter error). Transit dose is machine-dependent and may be calculated for a given treatment setup as follows:

Transit dose = shutter timer error x unit output x output correction factors for field size and treatment distance

Shutter error is an inherent discrepancy between the intended exposure time and the actual time of the source or its part, being exposed. This time discrepancy is due to the interaction of the source travel mechanism with the source control circuit actuators and depends on the therapy head shield structure.

When the source is new and dose rate of the machine is quite high, the transit dose is an important aspect. Shutter timer error, which is a measure of transit dose in telecobalt machines is normally quantified in the range of 0.01 to 0.02 minutes (0.6 to 1.2 seconds). It is recommended to correct the dose rate of the machine periodically with respect to the shutter error for accurate treatment delivery.[2]

Source is exposed twice during MW treatment. To signify here whether it contributes in excess or less to the dose delivered (more or less); it was needed to exactly quantify the effect of dual source transfer during MW treatment. Purpose of this study was to measure the transit dose during MW treatment in Equinox-80 to establish it as a viable mode of treatment delivery.

MATERIALS AND METHODS

A water phantom ($30\times30\times10$ cm^3) was scanned (slice thickness of 0.5 cm) in Somatom Emotion Computed Tomography (CT) Simulator (Siemens Medical Systems, Germany). The scanned images were then transferred via DICOM to Eclipse (V 7.3.1 Varian Medical Systems, Palo Alto, USA) three-dimensional treatment planning system (3DTPS).

A single isocentric ^{60}Co (1.25 MeV) photon beam of 10x10 cm^2 for Equinox-80 was placed at the depth of 5 cm. The source to axis (SAD) and source to surface (SSD) distance was 80 and 75 cm respectively. A standard universal wedge (UW) of 15^o was inserted in the plan as a beam modifier. A dose of 100 cGy was prescribed at the isocentre and the calculation was performed with the grid size of 0.25×0.25 cm^2. The treatment time calculated by Eclipse was verified manually and noted.[3] This procedure was repeated for UW with other wedge angles 30, 45 and 60^o. In a similar manner, the plans were carried out with MW for 15, 30, 45 and 60^o. The effective wedge angle was determined by the ratio of time the wedge is in the beam and total treatment time. The appropriate beam weight was used to create the desired wedge effect. The treatment time for MW plan was noted and compared with that of UW.

The transit dose was measured in Equinox-80 machine with 0.6 cc cylindrical ion chamber with UNODOS electrometer (PTW, Frieburg, Germany) with the same experimental setup as in Eclipse TPS. All measurements were additionally carried out with Thermoluminescent dosimeters (TLD) chips (LiF: Mg,TI, dimensions $0.32\times0.32\times0.09$ cm^3). The TLD chips were irradiated at a depth of 5 cm with SAD 80 cm. The TLDs were kept in a matrix designed at our centre. A matrix jig of 10×10 cm^2 on a perspex sheet was designed indigenously in our department. Holes of 3 mm diameter (depth of 2 mm) were drilled on this perspex sheet to accommodate the thin TLD chips inside these holes at 1 cm apart at left, right, superior and inferior from the center. The main purpose of this matrix was that one can place TLDs in these holes to measure central axis and off-axis doses simultaneously. The centre of the matrix was aligned with the isocentre. In our study, 2 TLDs were kept in a central hole only. Measurements were carried out at central axis. The TLDs were evaluated using a commercial TLD-reader system (REXON Model UL-320 reader, Ohio, USA) after 24h and the average of the readings was estimated. Measured doses with TLD for MW and UW at central axis were then compared and also with that one calculated from Eclipse.

RESULTS AND DISCUSSION

Table 1 depicts the comparison of measured dose for UW and MW with both 0.6 cc ion chamber and TLD. The planned dose was 100 Gy while the measured dose with ion chamber for 15^o, 30^o, 45^o and 60^o MW treatment was found to be 100.94, 101.04, 100.72 and 99.33 cGy respectively. Similarly for 15^o, 30^o, 45^o and 60^o UW treatment, the measured dose was 99.33, 97.67, 97.77 and 99.57 cGy respectively. The measured dose with ion chamber for MW and UW was comparable. The measured dose with ion chamber was also in good agreement with the calculated dose within ±2%. As shown in Table 1, maximum of 1.04 and minimum of 0.67 cGy (field) was noticed (compared to planned dose of 100 cGy) as excess and less transit dose during MW treatment when measured with ion chamber. The dosimeters (ion chamber and electrometers were calibrated at BARC under the reference conditions. The uncertainty in the calibration factor at 95% confidence level (2 σ) has been is ± 1.5%. This has perhaps a little contribution to the difference between the calculated and the measured doses but within the acceptable range of standard dosimetry of ± 2%.

The measured dose with TLD for MW was found to be 98.6, 97, 97.4 and 98.3 cGy for 15^o, 30^o, 45^o and 60^o respectively. Similarly, the measured dose with TLD for UW was 98, 96.9,

Table 1: Comparison of measured doses for universal wedge and motorized wedge with ion chamber and thermoluminescent dosimeters. The planned dose was 100 cGy

Wedge angle	Measured dose (cGy)			
	Ion chamber		TLD	
	UW	MW	UW	MW
15^o	99.33	100.94	98	98.6
30^o	97.67	101.04	96.9	97
45^o	97.77	100.72	98.1	97.4
60^o	99.57	99.33	97.9	98.3

TLD - Thermoluminescent dosimeters, UW - Universal wedge, MW - Motorized wedge

98.1 and 97.9 cGy for 15º, 30º, 45º and 60º respectively. The measured doses measured with TLD for MW and UW were in good agreement. The measured dose with TLD was also in good agreement with the calculated dose within ±3%. However, there was no excess dose measured with TLD for MW. The transit dose was as low as 3 cGy when measured with TLD. The uncertainty in TLD measurements was ±3% in TLD. This excess or less transit dose is unlikely to create any complications throughout the treatment regime. From actual measurements, it was found that MW does not contribute any excess or less dose significantly. Both the measurements from ion chamber and TLD revealed the same results.

Wedge-shaped dose distributions are very useful in radiotherapy planning for many treatment situations. Computer-controlled treatment modalities generate wedge dose distributions through the synchronization of jaw motion with dose rate.[4] Concept of MW in a linear accelerator has also been discussed.[5]

In telecobalt machines, so far, there was no development in wedges from computer-controlled point of view. The concept of MW was first used in Equinox-80 machine. The clinical utility and characteristics of MW with telecobalt machine has not been reported yet. However, the configuration of MW in treatment planning system has been discussed elsewhere.[6]

The shutter timer error in a conventional telecobalt machine could be positive or negative and accordingly the dose rate or the output of the machine is corrected. For the Equinox-80, the shutter error was found to be 0.6 seconds. Exposure time was corrected accordingly for the shutter error.

In our center, we measure the Co-60 output (cGy/min) in water periodically for all the square filed sizes ranging from 4x4 to 35x35 cm^2 and also estimate the shutter error. The output of the machine is accordingly corrected for the shutter error. From the experimental measurements, it was confirmed that the MW does not contribute significant excess or less transit dose for any wedge angle. Thus MW delivers same radiation dose as the UW.

CONCLUSION

The transit dose for motorized wedge treatment was estimated. This study was attempted to exactly quantify the transit dose due to MW treatment. The actual measurements carried out in Equinox-80 machine for UW and MW revealed no variation between the doses delivered and that one planned. The measured doses were comparable for both UW and MW treatments. It was also demonstrated that the observed excess or less transit dose with MW does not have any significant clinical impact. Thus MW can safely be used for the accurate clinical treatment as for the planned doses as desired.

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