RESEARCH ARTICLE OPEN ACCESS

Dynamic MLC-QA Based On Portal Dosimetry

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Abstract
Purpose: Intensity modulated radiotherapy using dynamic delivery method requires accurate verification of MLC, its position and speed of motion. These parameter have major impact on dose delivery on patients. For quality assurance (QA) procedure requires more time consumed in a radiotherapy department. The main purpose of this study was to investigate the potential use of amorphous silicon based EPID portal dosimetry for dMLC QA

Methods and Materials: A varian Clinac_iX with On Board Imager (OBI) and Rapid Arc facility (VMAT) equipped with 120 leaf Millennium MLC and with Amorphous Silicon Based EPID (aSi-1000, varian) mounted on a Exact Robotic Arm is used. The dMLC QA consists of different dynamic MLC pattern provided by varian for checking positional accuracy, MLC gap, Leaf speed and complex dynamic field.

Results and Discussion: Various dMLC tests were done using portal dosimetry. All results are within the tolerance limit. Picket fence test shows that leaf position errors of upto 0.2mm can be detected which are within the tolerance limit. Complex dynamic field were exposed to EPID, which shows the leaf speed and are within the tolerance limit.

Conclusion: dMLC QA test takes no longer than 5 minute in the linac room with EPID. So we can considerably reduce the time for dMLC QA procedures in a busy department and these tests can be include as a daily QA programme.

I. 1.Introduction

IMRT treatments are generally delivered using linear accelerators equipped with MLC's. During the treatment, the MLC leaves move over the area of interest instead of defining the outer boundaries [1]. The gap between leaf pairs is variable and can also be small, so the gap width must be carefully controlled. For dynamic MLC treatment (dMLC), the leaf speed accuracy is very important.

Leaf positioning is after assessed by imaging a series of MLC defined opening (or dose strips) along an opposing leaf pair track, designed overlap or to about or to have a 1 mm gap between them [2]. Images of these dose strips may be acquired by an EPID. Differences from the expected positions can be visualised with a threshold of 0.5 mm at isocenter [3-6]. The assessment can be quantified using scans across the images, by positioning the leaf edges using an EPID [7-11].

The total time spending for QA procedures is always an issue for a busy department. By considering this, EPID based portal dosimetry is very helpful for daily dMLC QA test for saving time by comparing other QA modalities such as ionization chamber, film dosimetry or detector array system. EPID provides images with high spatial resolution, fast, directly stored in the system, no need of separate system and easy analysing tools.

The purpose of this study is (1) to investigate the use of EPID for detecting small errors in dynamic MLC QA and (2) the potential use of EPID for routine daily QA procedures and thus to save time.

II. 2. Materials and methods

In this study, a varian Clinac_iX with OBI and Rapid Arc equipped with an 120 leaf Millennium MLC has been used. This MLC consists of two carriages of 60 leaves each, with leaf width 0.5 cm at isocenter for 20 X 20 cm field size and 1 cm width for remaining leaves. The leaves can be travel upto 14.5 cm maximum relative to the carriage. During IMRT delivery only leaves are moving and carriages are fixed. The maximum leaf speed is 2.5 cm/S. For IMRT treatments photons of 6 MV with a dose rate of 400 MU/Min are used.

Amorphous silicon based EPID is attached to the exact arm of clinac_iX. aSi-1000 (varian medical systems) calibrated for hardware and dosimetric purpose for different energies and various dose rates. The active area of EPID consists in a matrix 1024 X 768 for 40 X 30 cm^2 at source to detector distance (SDD) of 100 cm with 30fps having resolution 0.39 mm. The result analysis done in portal dosimetry Eclipse version 10 software. For the measurement we used 100 cm SDD and 400 MU/Min for preventing saturation problems and for better resolution. The

dosimetric characteristics of aSi based EPID's have been widely discussed in literature [12-16].
The following dMLC QA plans are provided by varian, and the QA procedures are explained below.

2.1. Picket Fence: This test is to verify leaf positions and carriage movement accuracy and calibrations [17]. The picket fence test comprises eight consecutive movements of a 5cm wise rectangular field. We can examine of the match lines between the 5 cm wide fields to detect a 0.5mm displacement in leaf positioning.

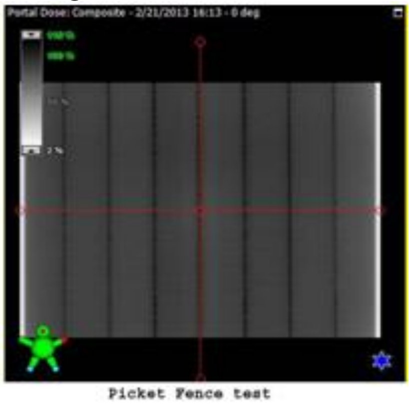

Figure-1: Picket fence test

2.2. Synchronized segmented strips: The segmented strips test to verify the accuracy and calibration of the leaf position and carriage movement when some adjacent leaf pairs are closed during beam delivery [17]. This test detects possible effects of inter leaf friction on leaf positioning and the ability of the leaves interdigitate. There are six consecutive movements of a 4 X 24 Cm^2 rectangular field is divided into a series of horizontal strips. The leaves between the 4cm wide field on the EPID image to detect a 0.5mm displacement in the leaf positioning.

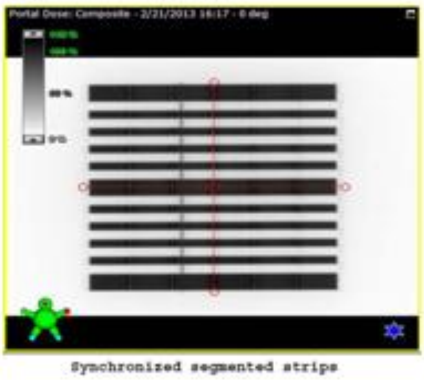

Figure-2: Synchronized segmented strips

2.3. Non synchronized segmented strips: This test is to verify leaf position accuracy and calibration and detect possible effects of interleaf friction in case of non synchronized leaf motion.

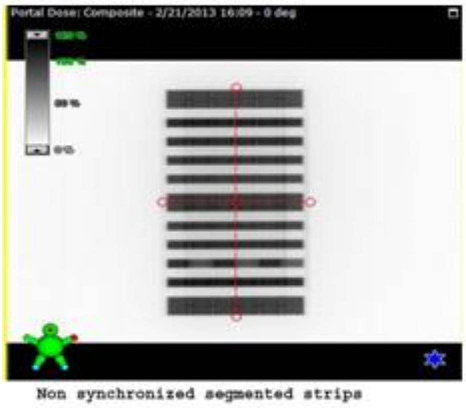

Figure-3: Non synchronized segmented strips.

2.4 X wedges: X-wedge test to verify the accuracy and calibration of the leaves in producing an X-wedged field. Two leaf sequence files produce the X wedged field and the inverted X wedged field respectively. The intensity pattern of both fields complements each other so that the total exposure is of uniform intensity everywhere inside the field.

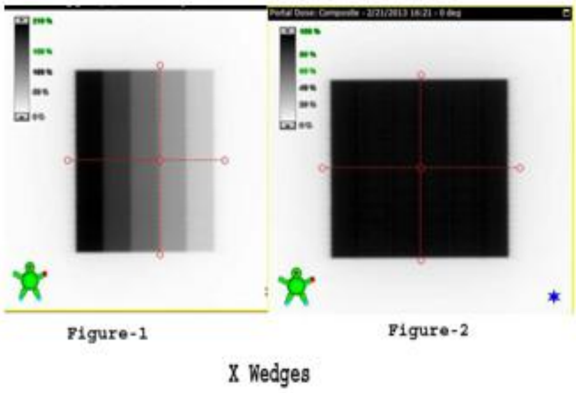

Figure-4: X wedges

2.5. Y wedges: This test is similar to X wedge except that the wedged field is oriented in the Y direction.

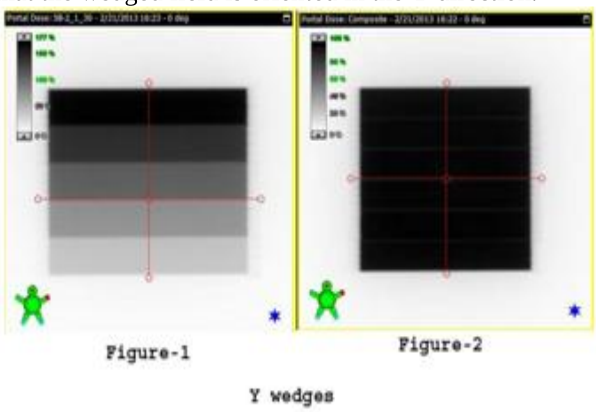

Figure-5: y wedges

2.6. Pyramids: Pyramids test to verify the accuracy and calibration of the leaves in producing complex pyramid fields. Two leaf sequences files produce the pyramid and inverted pyramid fields. Super position of the two fields creates a rectangular field with uniform intensity everywhere inside the field.

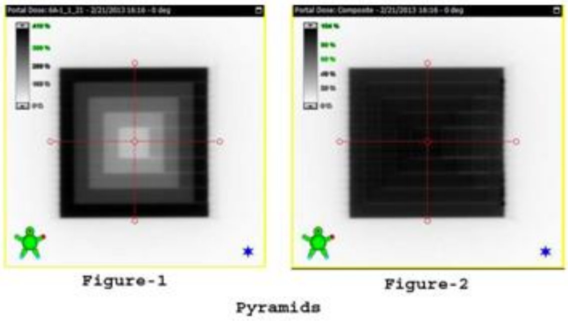

Figure-6: Pyramids

2.7. Complex field A: This test is to verify the accuracy and calibration of the leaves and to evaluate the ability of dMLC to produce complex intensity modulated patterns. We can evaluate how well the system produces complex intensity pattern by examining the field boundaries and symmetries.

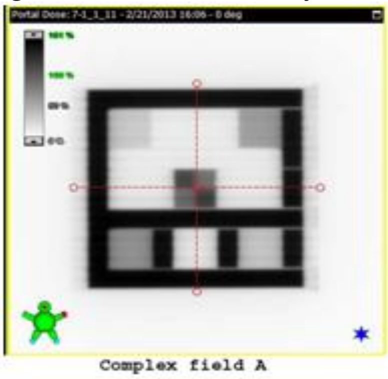

Figure-7: Complex field A

2.8. Complex field B: This test is to verify the accuracy and calibration of leaves, and to evaluate the ability of dMLC to produce complex intensity modulated patterns.

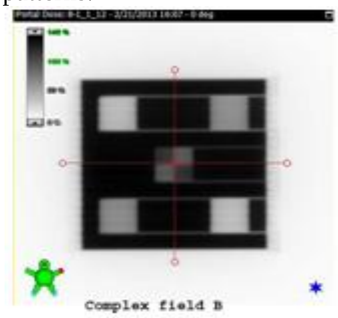

Figure-8: Complex field B

2.9. Continuous strips: This test is to verify the stability and calibrations of leaf positioning, stability of leaf speed, possible effects of interleaf friction, and possible effects of finite acceleration and deceleration of the leaves as they move from one segment to the next.

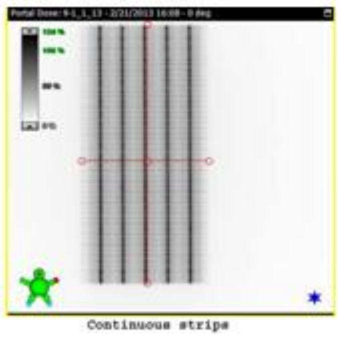

Figure-9: Continuous strips

III. Results and Discussion

In the following, results of the implemented tests are presented.

3.1. Picket fence: The match lines between 5cm wide field should be straight and approximately equal in intensity. In the figure, each match line includes a 1mm gap. The match line appears at -15.0 ± 0.1cm, -10.0 ± 0.1 cm, - 5.0 ± 0.1cm, 0.0 ± 0.1cm, 5.0 ± 0.1cm, 10.0 ± 0.1cm and 15.0 ± 0.1cm from the centre of the field.
All the match lines falls within 0.5 mm, the QA test indicates that the MLC is operating properly.

3.2. Synchronized segmented strips: The match lines between 4 cm wide fields should be straight and approximately equal in intensity. The match lines appeared at -12.0 ± 0.1cm, - 8.0 ± 0.1cm - 4.0 ± 0.1cm, 0 ± 0.1cm, 4.0 ± 0.1cm, 8.0 ± 0.1cm and 12.0 ± 0.1cm from the centre of the field.
Intensity of all exposed strips are uniform, and the non exposed strips are clear without exposure. The results thus obtained, clearly indicate that dMLC is operating properly.

3.3. Non synchronized segmented strips: The match line between 2cm wide field segments appears straight and approximately equal in intensity. The match line segments appear at – 4.0 ± 0.1cm, – 2.0 ± 0.1cm, 2.0 ± 0.1cm and 4.0 ± 0.1cm from the centre of the field. The match lines are within 0.5 mm, so the QA test indicates that the dMLC is operating properly.

3.4. X wedges: For the first image, the match lines between the 2 cm wide field segments are straight. The match lines appear at – 4.0 ± 0.1cm, – 2.0 ± 0.1cm, 0 ± 0.1cm, 2.0 ± 0.1cm and 4.0 ± 0.1cm from the centre of the field. The results are within the tolerance limit, QA test indicates that the dMLC is operating properly. On the second image, the intensity of each line segment are uniform and shows no areas of irregular under exposure or over exposure.

3.5. Y wedges: For the first image, the match lines between 2 cm wide field segments are straight and coincide with the interface between the adjacent leaves. The match line segments appear at – 4.0 ± 0.1cm, – 2.0 ± 0.1cm, 0 ± 0.1cm, 2.0 ± 0.1cm and 4.0 ± 0.1cm are from the centre of the field. The intensity is uniform everywhere on the combined image.

3.6. Pyramids: For the first image, the match lines between the squares with different intensity levels are straight. The match lines are appear at – 4.0 ± 0.1cm, – 3.0 ± 0.1cm – 2.0 ± 0.1cm, – 1.0 ± 0.1cm 0 ± 0.1cm, 1.0 ± 0.1cm, 2.0 ± 0.1cm, 3.0 ± 0.1cm and 4.0 ± 0.1cm from the centre of the field. The intensity of each line segment are uniform on the combined image.

3.7. Complex field A: The field boundaries and match lines between different segments are straight.

3.8. Complex field B: The field boundaries and the match lines between different intensity segments are straight.

3.9. Continuous strips: The intensities of all the exposed match lines are uniform, and the non exposed vertical strips are clear without exposure. The match lines are straight.

IV. Conclusion

Because of the high efficiency and resolution of EPID, we can reliable on EPID portal dosimetry and can be reduce the time for complex QA procedure compared with other QA modalities. Any complex dynamic fields can be test with EPID very fast and accurately.

We can do complete dMLC QA with EPID and a lot of time can be saved and thus we can ensure the information about position, speed of MLC and confidentially can go on with dynamic MLC treatments.

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