AbstractID: 8933 Title: Performance of dual layer micro MLC versus standard single layer MLC for IMRT delivery

Purpose

To evaluate the performance characteristics of a first-of-its-kind dual layer micro multi-leaf collimator (DmMLC) and compare it dosimetrically with standard, single layer MLCs for use in intensity modulated radiation therapy (IMRT).

Method and Materials

The DmMLC performance was studied using a cross shaped field generated by both a single layer MLC and the DmMLC. The DmMLC by Initia Medical Technologies was mounted on a Varian 600C linac unit. Film measurements were obtained using a 6 MV x-ray beam and EDR2 film at a depth of 5 cm in solid water at 100 cm source to film distance. Film analysis was performed using the RIT V5 software. The leaf-end transmission of the single bank and dual bank of mMLC was measured. The maximum and average leaf-end transmissions for the cross pattern were compared for both modes of operation of the mMLC and for the standard Varian MLC.

Results

The leaf-end transmission for the single layer of the DmMLC was at its maximum 22.4% with an average value of 15.4% The transmission was reduced to a maximum of 2.4% and an average of 2.1% when both layers of the DmMLC leaves were used. Dual layer MLC provided more conformal field edge as compared to the standard single layer MLC with approximately ten fold less transmission at the leaf end.

Conclusion

The results of this study indicate that the DmMLC provides more precise field shaping at field edges than the standard MLC. The DmMLC reduces the leaf-end transmission to about 2.1%. The dual layer MLC offers more accurate IMRT delivery to the planned target volume and spares the underlined surrounding health tissue from increased transmission and leakage dose.

Conflict of Interest

The work was partially supported by a research grant from Initia RT.

INTRODUCTION

The application of single layer MLCs in the delivery of intensity modulated radiation therapy (IMRT) have been shown to produce leaf-end transmission of up to 20 – 30 %[1,2]. Such a design can lead to hot spots between neighboring beam segments during step and shoot IMRT dose delivery [1] which could become significant [2] as large number of monitor units are delivered. Stepped field edge effect is another problem inherent in the application of a single MLC layer in beam shaping.

We demonstrate these effects by the illustration in Fig. 1 where three segments of a single beam in an IMRT plan are shown. The leaf-end transmission is denoted by the ellipses and we can see the unavoidable jagged field edges in shaping the field.

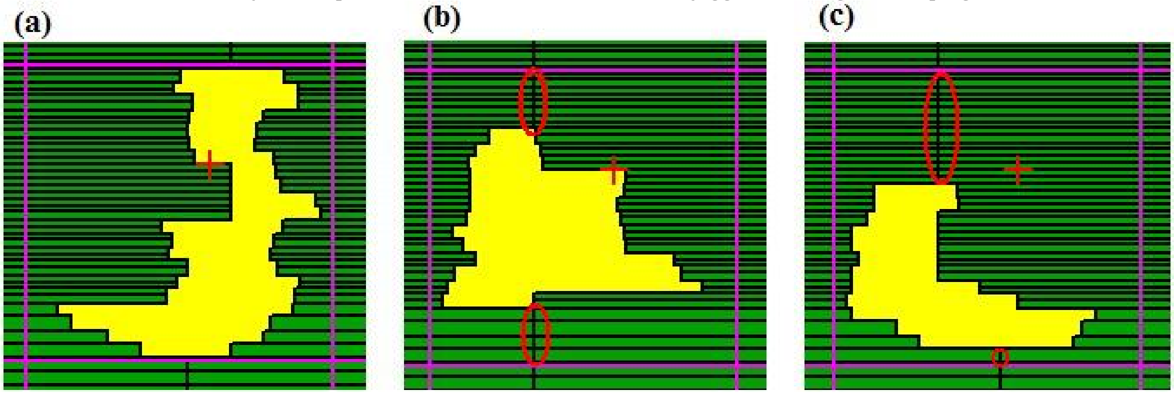

Figure 1: MLC-120 IMRT three segmentations in one field, (a) A segmentation of IMRT field matching the jaws setting, (b-c) Additional two segmentations in the same IMRT field

To improve the accuracy of field shaping and to reduce leaf-end transmission, a novel dual-layer micro multi-leaf collimator (DmMLC) device has been developed[3]. It consists of upper and lower layers of dual-layer MLC leaves that travel orthogonally to each other and perpendicularly to the central axis. By having two orthogonal layers of MLCs, the DmMLC unit greatly reduces the overall leaf-end transmission since the transmitted intensity from the upper layer will be attenuated as it passes through the second layer. This is illustrated in figure 2 where the leaf-end transmission effects for one segment of an IMRT beam is decomposed into the effects from the two MLC layers (a-1, a-2). As can be seen, the overall transmission when overlaid is negligible (Fig 2 a-3). The stepped field edge effect is considerably reduced in this case as well (a-3).

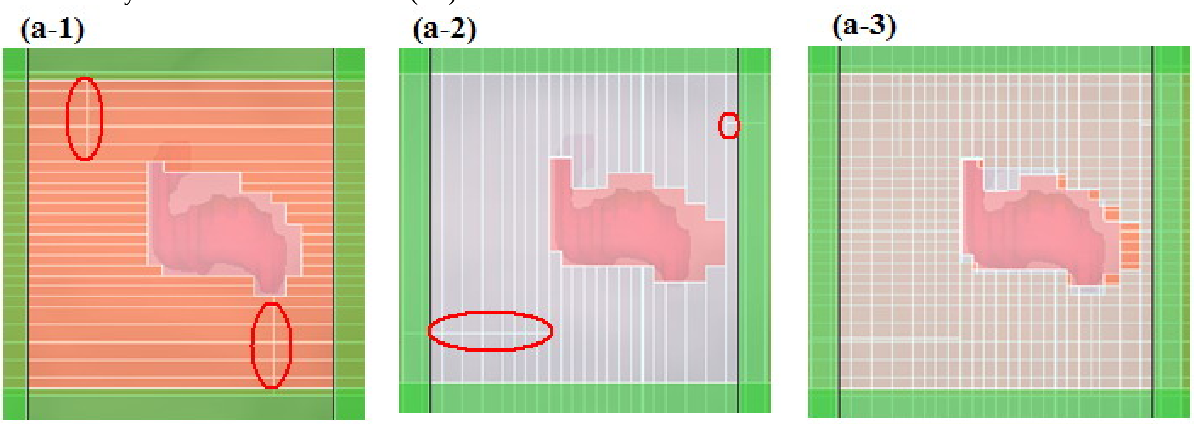

Figure 2: DmMLC IMRT in one segmentation, (a-1) BEV of the lower layer MLC, (a-2) BEV of the upper layer MLC, (a-3) BEV of the DmMLC

The goal of this work was to measure the performance characteristics on the leaf-end of the DmMLC and compare with standard single layer MLCs for use in IMRT delivery units.

METHOD AND MATERIALS

The performance was studied with a cross leaf-end field generated by a single layer MLC and a DmMLC. The cross leaf-end field was used to evaluate the leaf-end transmission of a single-layer and dual-layer closed leaf through the same device. The DmMLC by Initia Medical Technology (Canton, MA) was mounted on a Varian 600C linac machine that has no built-in MLC to form the IMRT delivery unit. The DmMLC studied in this work has 96 tungsten leaves divided into four banks, each consisting of 14 inner leaves and 10 outer leaves with leaf widths at isocenter of 3.2 mm (lower layer) and 3.6 mm (upper layer) for the 14 inner pairs and 5.5 mm (lower layer) and 6.2 mm (upper layer) for the 10 outer pairs of lower and upper leaves. Each leaf has a height of 37.5 mm and a length of 60 mm. Measurements were made with 6 MV x-rays and EDR2 film at 5 cm depth in solid water at 100 cm SAD.

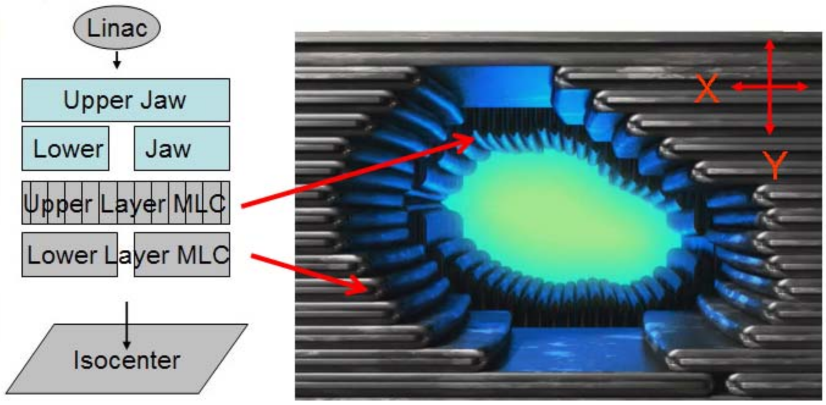

Figure 3: Schematic arrangement of dual layer MLC and a typical beam eye view of the DmMLC

Film analyses were performed using the RIT software. The leaf-end transmission of the single layer leaf-end and the cross leaf-end were measured. The maximum and average leaf-end transmissions for the cross pattern were measured and compared.

RESULTS

The leaf-end transmission was measured as 22.4% (maximum) and 15.4% (average) when a single layer of DmMLC was closed, and 2.4% (maximum) and 2.1% (average) when both layers were closed. In Figure 4(b), the nominal maximum leaf-end transmission is 4.3%. For the DmMLC, the cross point is always inside the field. The effective maximum leaf-end transmission is therefore the second maximum leaf-end transmission in Figure 4(b), which is 2.4%.

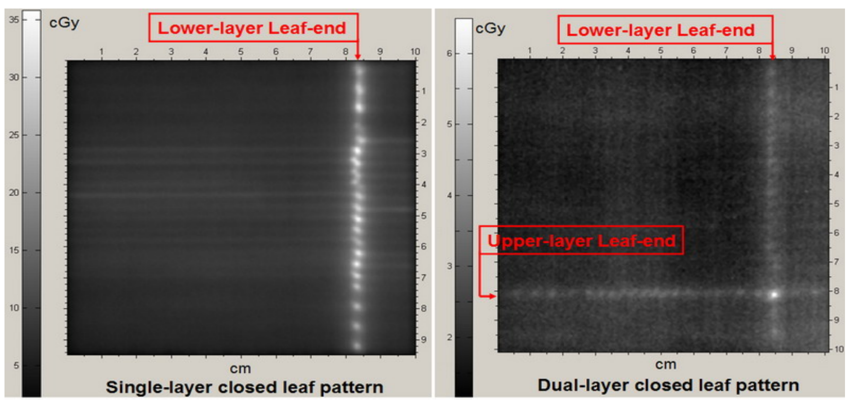

Figure 4: Radiographic films for single-layer and dual layer MLC leaf-end dose leakage with 6 MV X-ray (a) Single-layer closed pattern with a maximum leaf-end transmission of 35.5 cGy, (b) Dual-layer closed pattern with a maximum leaf-end transmission of 6.5 cGy

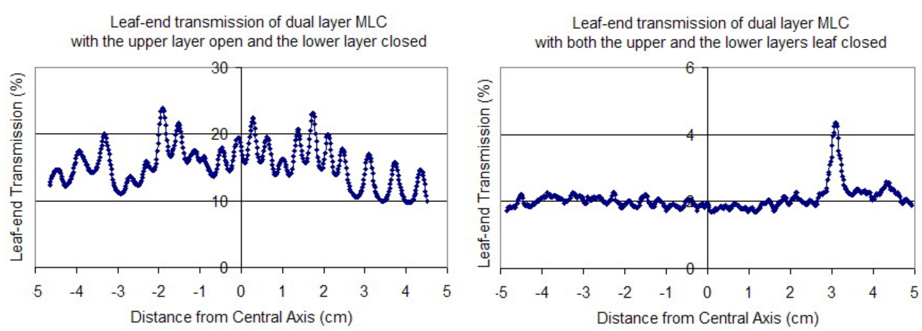

Figure 5: Leaf-end transmission of MLC and DmMLC, (a) Single-layer closed pattern, (b) Dual -layer closed pattern

CONCLUSIONS

In summary, the DmMLC retains the general advantages of MLCs for use in IMRT while offering advantages in reducing field stepped edge effect and reducing leaf-end transmission. It also enhances the capacity for complex field shaping by single segmentation. The disadvantage when compared to single layer MLCs is the smaller field size of DmMLC which is 10cm by 10cm thus limiting its use to relatively small tumors.

REFERENCES

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