RA Journal of Applied Research
||Volume||1||Issue||09||Pages-337-351||Oct -2015|| ISSN (e): 2394-6709
www.rajournals.in DOI : 10.18535/rajar/v1i9.01

Quality Control For Two Types Of Radiotherapy Multileaf Collimators

Rehab Omar[1*], Tamer Dawod[1], E. M. Abdelrazek [2], Mostafa Mosad[1], Sabbah I. Hammoury[3], Mohamed Osama[4]

[1]Clinical Oncology and Nuclear Medicine Department, Mansoura University Hospitals, Mansoura, Egypt
[2]Department of Physics, Faculty of Science, Mansoura University, Mansoura, Egypt
[3]Medical Physics Department, Alexandria Ayadi Almostakbl Oncology Center (AAAOC), Alexandria, Egypt
[4]medical engineering, ON medical company

Corresponding Author's Name and Address: Rehab Omar
Clinical Oncology and Nuclear Medicine Department, Mansoura University Hospitals, Mansoura, Egypt.
ro_elsayed@yahoo.com

ABSTRACT:

The purpose of our study was to describe the performance characteristics of two MLC systems (Elekta and Siemens) having different leaf width respectively to improve the available data. Furthermore, the work suggests an adequate QA program to be performed during routine treatment delivery.

Methods and Material: The Leaf leakage, tongue-and-groove effect, identification between light field and radiation field , measurement of penumbra for all borders of MLC leaves, Penumbra measurements in the direction of leaf motion, Penumbra measurements for stepped MLC edges, Precise position of MLCs of a high-energy photon (6 MV) Elekta and Siemens linear accelerator were measured using Kodak X-Omat V film.

Results : The results of leaf transmission agree with literature data dealing with the same MLC. The value obtained of the dose reduction for the tongue-and-groove effect is greater than other reports .Measurements of identification between light field and radiation field showed that, the difference between them ranged from 2 mm to 3mm. The penumbra width is independent of leaf position. For stepped edge, the measured penumbra width for MLC is larger than custom blocks about 2mm for erect edge and 2 mm for 45^{o} angled edge, there is small difference in position accuracy of leaves due to the effect of gravity.

Conclusions: The results showed that, it is important to know the dosimetric characteristics of MLC to know its effect in the treatment process.

KEY-WORDS: Radiotherapy, MLC, linear accelerator

INTRODUCTION

In new linear accelerators, customl blocks changed bymultileaf collimators to create non uniform fields.MLC used to protect the healthy tissue from excessive dose and at the same time to give the target the maximum dose, so the treatment process become more effective

. [1], [2],[3],[4]

Multileaf collimator (MLC) systems are available on most commercial linear accelerators, for intensity-modulated radiation therapy (IMRT) treatment techniques, and many of these MLC systems utilize designs with rounded leaf ends to

improve the dose profile of the geometric and transmission penumbra. The general designs of rounded leaf end MLC systems have already been described in detail by many researchers.[5] MLC mechanical stability and characteristics should be known and verified during the acceptance testing of the machine which has been reported for various manufacturers.In general, MLC commissioning data depend on the clinical usage but more importantly on the TPS. [6][7], [8]

Some MLCs displace the x – jaws as Siemens linear accelerator or Y- jaws Elekta linear accelerator ,others found below the conventional jaws, as a tertiary collimatoras Varian linear accelerator. [9],[10]

The main advantages of MLCs are: the saving of treatment time, the possibility of treatment information transfer, and providing a clean environment. However, MLCs are not very expensive, but they are also more complicated; it is preferred to use conventional methods to protect organ at risks (OARs), and normal tissues in developing countries. They are also not complicated software and computer dependency; radiation beam can easily shaped using a simple machine. There is also no serious concern for interleaf and intraleaf leakages routinely can be addressed as one of the main disadvantages of MLCs. In addition the penumbra regions created using MLCs are generally reported to be larger than those generated by Cerrobend blocks. [11]

Midleaf transmission and interleaf leakage may considerably affect the dose distribution of the IMRT fields. Consequently, the most of treatment planning systems needsthe mean transmission value and the measurements should span a large enough area of the radiation field to allow adequate sampling of inter and intraleaf transmission. [12]Penumbra depends on the designing of the MLC borders; measurements of penumbra with a high resolution detector gives accurate modeling of the penumbra by the treatment planning system. tongue-and-groove design used to decrease the interleaf leakage between adjacent leaves. [13] Finally, the accuracy of the relative MLC leaf position represents a key aspect of segmental IMRT.[14]

In this paper, we described the performance characteristics of the MLC systems to improve the available literature data. Furthermore, the work suggests an adequate QA program to be performed during routine treatment delivery.

SUBJECTS AND METHODS

High-energy photons (6 MV) from Elekta Precise andArtiste Treatment System Linear Acceleratorwere used. For Elekta precise, the

||Volume||1||Issue||09||Pages-337-351||Oct -2015|| ISSN (e): 2394-6709
www.rajournals.in DOI : 10.18535/rajar/v1i9.01

machine head is provided with conventional collimators in x-direction and multileaf collimator (MLC) of two opposing sets, each having 40 leaves and two backup diaphragms in y-direction. The MLC leaves have a pitch of 1 cm at the isocenter plane that provide the capability to define irregularly shaped fields. The maximum field size attainable is 40 x 40 cm2 at 100 cm source axis distance (SSD).For Artiste, the machine head is provided 160 MLC comes with a unique 80 on each side. With a leaf thickness of 5 mm over the full field, the leaves provide incredibly accurate conformity to the actual tumor shape for homogeneous dose coverage.Kodak X-Omat V film was used for the measurement of the MLC characteristics.The films were placed at the buildup depth in a solid RW3 phantom and 100 cm SAD.

Measurement of Leaf end transmission:

The midleaf transmission and interleaf leakage were measured using films placed on the shadow tray. The film located perpendicular to beam central axis at SSD 98.5 cm in solid water phantom, we used energy 6 MV, 50 MU, field size 0.5 x 40 and 0.2 x 40 cm2 for Elekta precise and 0.5 x40 for Siemens Artiste linear accelerator respectively .

The transmission and leakage measurements:

In this test we used field size 10 x 10 cm2 made by collimator the closed MLC field related to open field (MLC retracted) of the same field size. The film located perpendicular to beam central axis at SSD 98.5 cm in solid water phantom, we used energy 6 MV. In this test we used to films first film exposed to 750 MU and MLC closed with the second film exposed to 50 MU and the MLC opened, the mean transmission obtained from the ratio between the two films values

The tongue-and-groove effect.

In this test we exposed a radiographic film to 2 complementary irregular fields and acquiring a dose profile perpendicular to the direction of the leaf travel passing through the central axis. The film located perpendicular to beam central axis at SSD 98.5 cm in solid water phantom, we used energy 6 MV. The junction between the 2 fields is defined either by (a) 2 adjacent leaves or (b) 2 opposite and adjacent leaves. The tongue-and-groove effect measured for 40 opposite leaf pairs using the same MU for each opposite leaf pairs. [15]

Identification between light and radiation field:

In this test we used field size 10 x10 cm2 The film located perpendicular to beam central axis at SSD 98.5 cm in solid water phantom, we used energy 6 MV, and 50 MU[16]

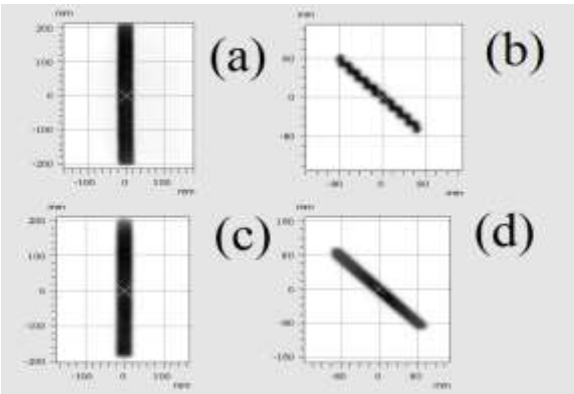
RA Journal of Applied Research
||Volume||1||Issue||09||Pages-337-351||Oct -2015|| ISSN (e): 2394-6709
www.rajournals.in DOI : 10.18535/rajar/v1i9.01

Penumbra measurement for the sides of the leaves:

This test made to measure the penumbra for the borders of the field, In this test the film located perpendicular to beam central axis at SSD 98.5 cm in solid water phantom, we used energy 6 MV, and 50 MU.

Penumbra measurements in the direction of leaf motion:

This test used to measure the penumbra for different beam offset,the film located perpendicular to beam central axis at SSD 98.5 cm in solid water phantom, we used energy 6 MV, and 50 MU. In this test we used five films to measure different beam offset (+15, +10, +5, 0, -5 cm) as shown in fig (1 a- d).



Figure(1): Field shapes used to measure a) leaf positional accuracy (fixed field technique); b) leaf positional accuracy (step-field technique).

Penumbra measurements for stepped MLC edges:

This test used to measure the penumbra from MLC and from custom blocks for both corner and straight border. We used field size 10 x 10 cm2we made two protections in the corners of the field, onemade by block and the other by MLC, the film located perpendicular to beam central axis at SSD 98.5 cm in solid water phantom, we used energy 6 MV, and 50 MU

Precise position of MLCs:

When accurate leaf positioning is lost, significant dose delivery errors can occur. Ensuring accuracy of the MLCs is necessary due to the extremely small field sizes and the great amount of MLC motion in IMRT. The MLC leaf positional accuracy was evaluated by means of 2 different methods. In the first method the film was exposed to 6MV with field sets using MLCs 4 × 40 cm2 at fixed collimator angle and gantry angle suggested by AAPM Report No. 72 TG-50. The film was placed at the depth of 1.5cm 100 cm SAD, and exposed 50 MU for each field., Fig [1: a, c] for Precise and Artiste linear accelerator respectively. In the second method, a radiographic film was exposed for different collimator and gantry angles to a step field set by leaves as shown in fig[1: b,d] for Precise and Artiste linear accelerator respectively. The position of the leaves covers the

RA Journal of Applied Research
||Volume||1||Issue||09||Pages-337-351||Oct -2015|| ISSN (e): 2394-6709
www.rajournals.in DOI : 10.18535/rajar/v1i9.01

full range of leaf bank motion. Dose profiles through each leaf pair were analyzed to determine the position of each leaf as 50% of the dose value on the central point of the open field .[17], [18], [19]

STATISTICAL METHODS:

Using SPSS 16 statistical program, numerical data were summarized using means and standard deviations , nonparametric test equivalent to the paired test to be used for small sample size. All p-values are two-sided. P values <0.05 were considered significant.

RESULTS AND DISCUSSION:

Measurement of Leaf leakage:

In this study, the leakage for 6 MV beam has been quantified as percentage for a delivery of 50 MU (about 50 cGy). The results of exposed films for measurement of interleaf leakage from Precise and Artiste showed in fig[2:a, c], and the for interleaf leakageprofilebetween leaf sides shown in figure (2-b, d). The mean transmission and leakage around 2.67 % ± 1.09 for precise and 1.35 % ± 0.04 for Artiste. The results agreed with the previously published. [20], [21], [22], [23], [24] for a 6 MEV beam within 4%, using film dosimetry. The transmission calculated from the following equation:

$$T(\%) = \frac{D_{blocked}}{D_{open}} \times 100 \qquad [1]$$

Where $D_{blocked}$ and D_{open} represent horizontal dose profiles across the blocked and open fields,respectively.

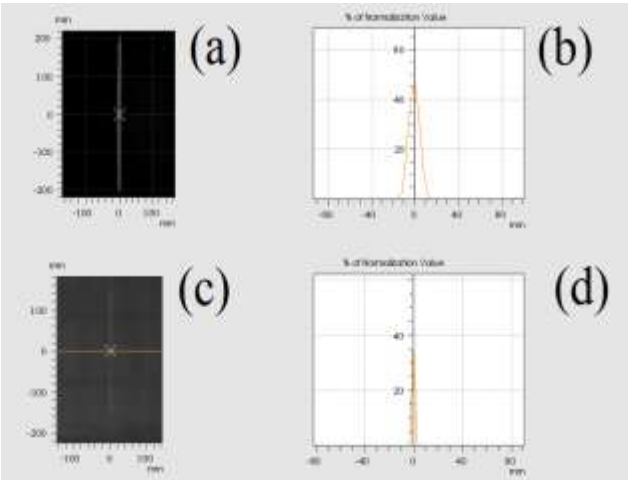


Figure (2): The interleaf leakage between leaf sides scanned in the direction Perpendicular to leaf motion.

Tongue and groove effect:

Fig [3:a, b]showed the Tongue and groove effectfor Precise and Artiste, proved not to be dependent on the configuration of the complementary fields. Fig [4], showed a dose profile normalized on a point located under a leaf, perpendicular to the direction of the leaf travel passing through the central axis of the digitalized image; the profile showed clearly a dose reduction at the overlap regions, allowing quantifying the tongue-and-groove effect in terms of average dose

RA Journal of Applied Research
||Volume||1||Issue||09||Pages-337-351||Oct -2015|| ISSN (e): 2394-6709
www.rajournals.in DOI : 10.18535/rajar/v1i9.01

reduction and width of the under dose region. fig [4:a – d] for right and left banks of MLC for Precise and Artiste linear accelerator showed decrease in density between the two fields according to the tongue and groove effect, and at the overlapping region,we showed a large deficit in dose. The result showed thatchanging inthe peak deficits for the measurement is not depending on the position of the overlap regions, this changes, variation, may be caused by littlevariationin the bulk of the leaf parameters within machining tolerance. For Precise linear acceleratorfig[4:a-b] the average peak deficit of the measured profile for right and lift bank of MLC were 38.13% ± 3.99% and 36.68% ± 3.65% respectively. For Artiste linear accelerator, fig[4: c- d] the average peak deficit of the measured profile for right and lift bank of MLC were 15.1% ± 1.50%, and 10.77% ± 1.35% respectively. This result agreed with the previously published, tongue and groove effect take place for some MLC application as the abutment of fields where the beam edges defined by the sides of the leaves.[25]

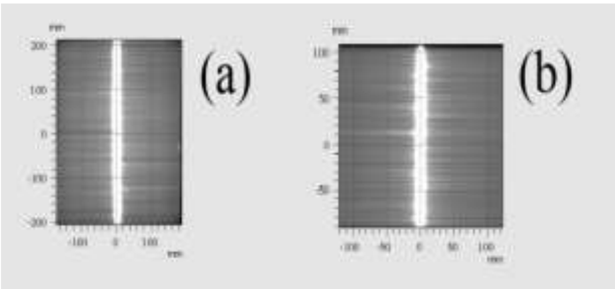
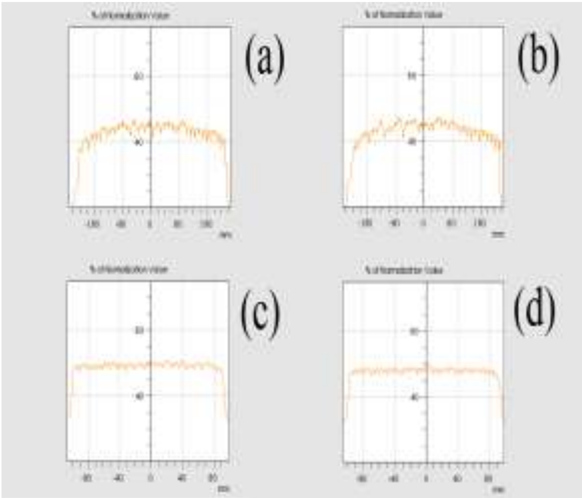


Figure (3): A double-exposed film showing the tongue and groove effect for : Elekta Precise linear accelerator (a) , Siemens Artiste linear accelerator (b).



Figure(4): Dose depression due to tongue-and-groove effect for 6 MV X-rays. Right and left bank of MLC for: Elekta Precise linear accelerator (a, b), Siemens Artiste linear accelerator (c, d) respectively.

Identification between light and radiation field:

Fig [5] showed the coincident of light and radiation field defined by MLC, while fig [6]showed the profiles scanned along the leaf sides and leaf ends of MLC. For Precise and Artiste linear accelerator, the difference between light and radiation field ranged from (2 to 3) mm and (1 to 2) mm respectively. The results for both Precise and Artiste linear accelerator are agreed with the

RA Journal of Applied Research
||Volume||1||Issue||09||Pages-337-351||Oct -2015|| ISSN (e): 2394-6709
www.rajournals.in DOI : 10.18535/rajar/v1i9.01

previous results, which ranged from 1to 3 mm. [16], [26], [27], [28], [29], [30], [31]

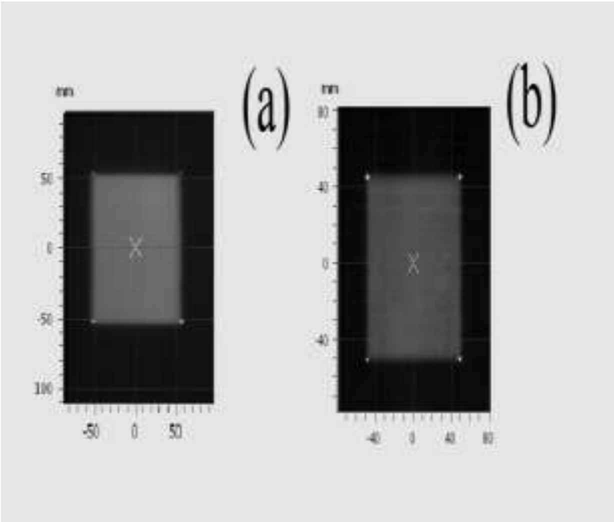


Figure (5): The coincidence of exposed film of light field and radiation field defined by MLC at gantry angle of $0^0$for: Elekta Precise linear accelerator (a) , Siemens Artiste linear accelerator (b).

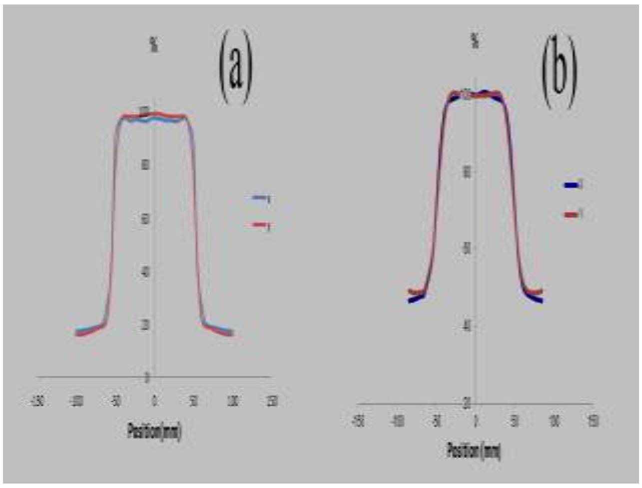


Figure (6): The profiles scanned along the leaf sides and leaf ends showed the field width at gantry angle of $0^0$for: Elekta Precise linear accelerator (a), Siemens Artiste linear accelerator (b).

Penumbra measurement for the sides of the leaves:

Table [1] showed the penumbrain the direction of MLC and jaws obtained by. Fig [7] showed the isodose line for film exposed with a field size of 10x 10 cm^2, fig [7: a , b] showed the penumbra for Precise linear accelerator. The results show that the penumbra for both bank A and bank B are 0.57- 0.51cm respectively, and for superior border and inferior border are 0.52-0.41 cm respectively. Statistical difference in cross-plane penumbra between the 2 leaf banks was found (N = 7, $P <0.01$, 2-sample t test); the mean value of the leaf end penumbra are 5.47 mm ± 0.42 mm, for superior and inferior border the statistical difference was found (N=7, $P<0.01$, 2- sample t test); the mean value of the jaw end penumbra are 4.65mm ±0.81mm.

Table (1): The variation of penumbra for field size (10 x 10) cm^2 defined by the MLC as the field asymmetrically offset with respect to the central axis. The penumbra measured for 6 MV at 1.5 cm depth and SAD of 100 cm.

RA Journal of Applied Research
||Volume||1||Issue||09||Pages-337-351||Oct -2015|| ISSN (e): 2394-6709
www.rajournals.in DOI : 10.18535/rajar/v1i9.01

80%-20% Penumbra (mm)

Position (mm)	Elekta precise				Siemens Artiste			
	Bank A	Bank B	Superior Border	Inferior Border	Bank A	Bank B	Superior Border	Inferior Border
40	5.80	4.60	5.60	4.00	5.00	4.00	5.50	5.00
30	6.20	4.40	5.00	4.60	5.00	4.50	5.10	5.00
20	5.60	5.10	4.20	4.60	4.50	4.00	5.50	4.50
0	5.70	6.20	5.00	3.40	4.00	3.50	5.00	5.00
-20	5.70	5.10	5.60	4.00	4.00	4.00	5.80	5.00
-30	5.70	5.70	5.60	4.00	3.50	4.00	5.00	5.00
-40	5.70	5.10	5.60	3.90	4.50	5.00	5.30	5.00

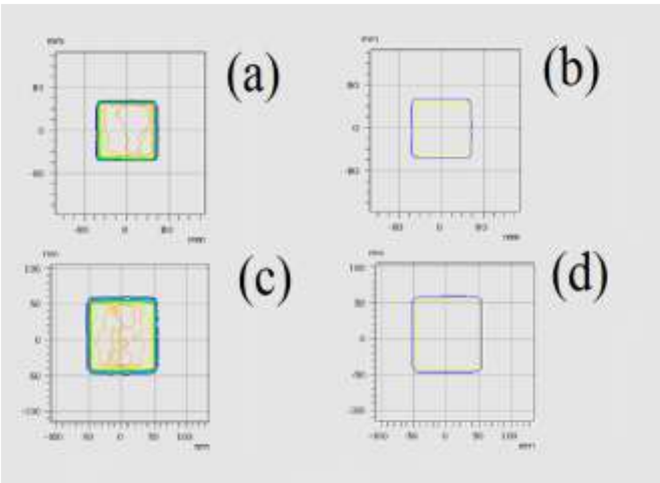


Figure (7): The isodose line for film exposed with a field size of 10x 10 cm used for determined the penumbra in the direction of leaf motion and the penumbra for the side of the leaf. (a) All the isodose lines distributions, (b) isodose lines 80% and 20% respectively for Elekta Precise.(c) All the isodose lines distributions, (d) isodose lines 80% and 20% respectively for Siemens Artiste.

The results confirmed by the measurements performed with the ionization chamber in the

RA Journal of Applied Research
||Volume||1||Issue||09||Pages-337-351||Oct -2015|| ISSN (e): 2394-6709
www.rajournals.in DOI : 10.18535/rajar/v1i9.01

water phantom (6.62±0.14) for MLC, and for superior and inferior border (6.54±0.19). Fig (7- c and d) showed the penumbra for Artiste linear accelerator. For both bank A and bank B are 0.43-0.41cm respectively, and for superior border and inferior border are 0.55-0.49 cm respectively. statistical difference in cross-plane penumbra between the 2 leaf banks was found (N = 7, P <0.01, 2-sample t test); the mean value of the leaf end penumbra are 4.25 mm ± 0.2 mm, for superior and inferior border the statistical difference was found (N=7, P<.01, 2- sample t test); the mean value of the jaw end penumbra are 5.21mm ±0.56mm. The results were confirmed by the measurements performed with the ionization chamber in the water phantom (6.85±0.16) for MLC,and for superior and inferior border (6.15±0.01). The penumbra of the leaf pair nearest to the central axis is shown in fig [8]. These results supported by previous literatures. [14], [16], [27]

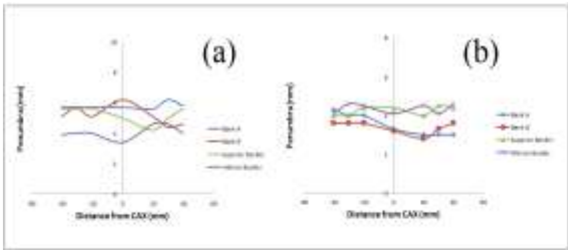


Figure (8): penumbra as a function of distance from the CAX for: Elekta Precise linear accelerator (a), Siemens Artiste linear accelerator (b).

Penumbra measurement in the direction of leaf motion:

The beam profile extending from the center at the 10x10 cm^2 field are shown in fig [9] for Precise and Artiste linear accelerator at 6MV photon energy, 1.5 cm depth, 10x10 cm^2 field size and various positions of the field edge relative to the beam central axis. The negative positions were for the leaves extending over the beam central axis and for the leaves withdrawn from the center.

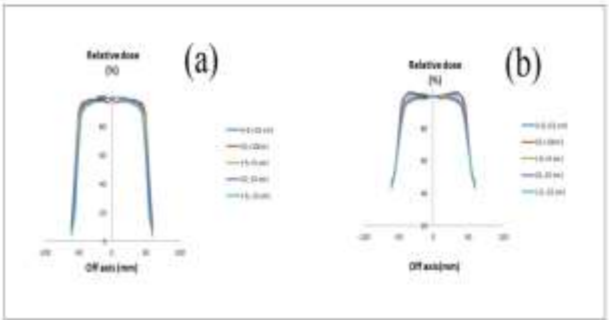


Figure (9): Comparisons of the edge distribution for the 6 MV beam and five different positions of the edge defined by the leaves of the MLC system. The depth of measurement for this figure is 1.5 cm and the field size is 10 × 10 cm^2.Elekta Precise linear accelerator (a), Siemens Artiste linear accelerator (b).

Table [2] showed the 80%-20% penumbra for the side of the leaf obtained by for Precise and Artiste linear accelerator. For Precise linear accelerator, the data ranged from 0.52 to 0.77 cm for bank A and 0.62 to 0.72 cm for bank B. The penumbra

RA Journal of Applied Research
||Volume||1||Issue||09||Pages-337-351||Oct -2015|| ISSN (e): 2394-6709
www.rajournals.in DOI : 10.18535/rajar/v1i9.01

ranged from 0.42 to 0.64 for superior border and from 0.34 to 0.53 for inferior border. For Artiste linear accelerator, the data ranged from0.32 to 0.4 cm for bank A and 0.3 to 0.4 cmfor bank B. The penumbra ranged from 0.36 to 0.5 for superior border and from 0.32 to 0.55 for inferior border.

Table (2): The variation of penumbra for a field size of 10 x 10 cm2 defined by the MLC as the field asymmetrically offset with respect to the central axis. The penumbra is measured for 6 MV at 1.5 cm depth and SAD of 100 cm.

80%-20% Penumbra (cm)

Position cm	Elekta Precise				Siemens Artiste			
	Bank A	Bank B	Superior Border	Inferior Border	Bank A	Bank B	Superior Border	Inferior Border
-10	0.77	0.72	0.64	0.40	0.35	0.30	0.41	0.44
-5	0.68	0.69	0.42	0.53	0.35	0.30	0.36	0.40
0	0.57	0.62	0.50	0.34	0.40	0.35	0.50	0.55
5	0.58	0.63	0.63	0.46	0.32	0.32	0.40	0.32
10	0.52	0.74	0.49	0.44	0.40	0.40	0.41	0.40

Fig [10] showed the penumbra for different offsets distance (+10, +5, 0,-5,-10) cm from the CAX. Fig [F11]and fig [12] showed the isodose distribution for the different examined off axis for bank A and B respectively. The data showed that there is little change in the results as the beam offsets changed, and this indicated that the penumbra not depends on the beam offsets .The differences were in good agreements with the results stated in earlier reports. [3],[19], [27], [32]

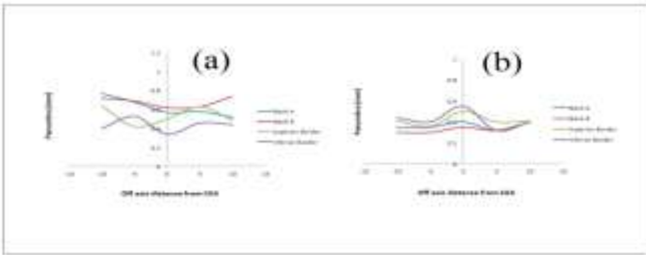
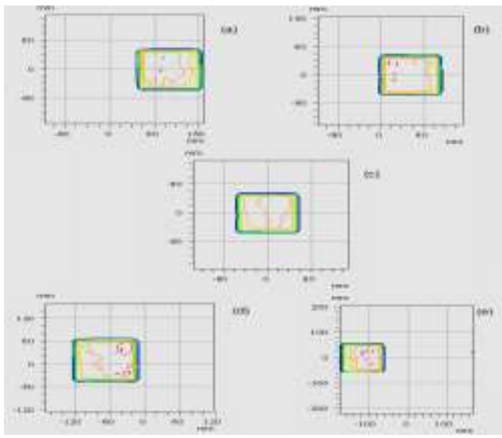
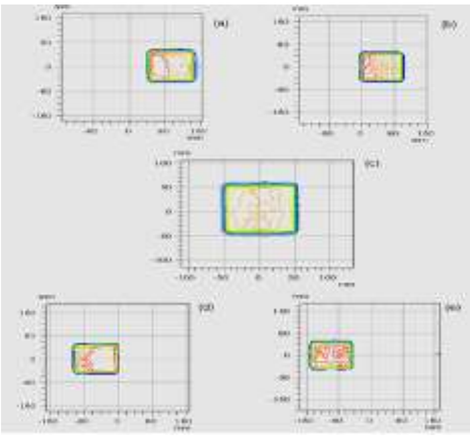


Figure (10): penumbra as a function of off distance from the central axis for: Elekta Precise linear accelerator (a), Siemens Artiste linear accelerator (b).



Figure(11): Comparison of the isodose distribution for the 6 MV photon beam and five different positions of MLC,(+10,+5,0,-5,-10) cm, for Elekta Precise linear accelerator.

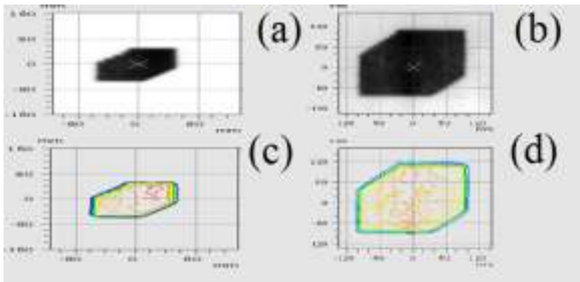
RA Journal of Applied Research
||Volume||1||Issue||09||Pages-337-351||Oct -2015|| ISSN (e): 2394-6709
www.rajournals.in DOI : 10.18535/rajar/v1i9.01



Figure(12): Comparison of the isodose distribution for the 6 MV photon beam and five different positions of MLC,(+10,+5,0,-5,-10) cm, for Siemens Artiste linear accelerator.

Penumbra measurement for stepped MLC edges:

Fig[13] showed the isodosedistribution for straight and angled border (45^0) respectively, and the data presented in table [3]. For both Precise and Artiste linear accelerators the width of penumbra for custom blocks found to be lower than the MLC, it equals to 2mm for Precise and 0.7 mm for Artiste. Also the width of penumbra for straight borders found to be lower than the angled borders, it equals to 2mm for Precise and 1.3 mm for Artiste.The results indicated that, due to the MLC form it leads to stair stepping effect with the same range as the width of the MLC, so as the width of the leaf decreased the stair stepping effect decreased and this data agreed with the other published data.[20], [33], [34]

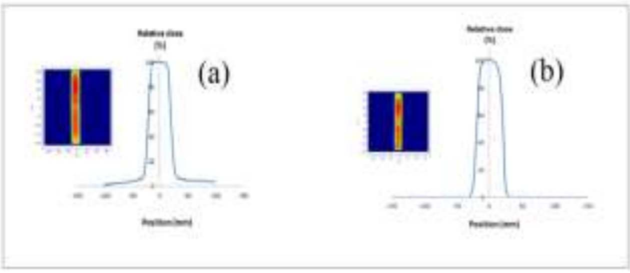


Figure(13): (a, b) the Radiographic film irradiated with 6 MV X-rays and exposed with a field size of 10x10 cm2 shaped by the MLC and custom block with 45^0 corner border. (c, d) isodose distributions for 45^0 corner border shaped by the MLC and custom block.

Table (3): The 80%-20% penumbra for straight edge field and 45o corner edge defined by custom block, and MLC. The penumbra is measured for 6 MV at 1.5 cm depth and field size of 10 x 10 cm^2.

Linear accelerator	80%-20% Penumbra (mm)			
	Straight edge		45 degree corner edge	
	MLC	block	MLC	block
Elekta Precise	9.00	7.00	10.00	8.00
Siemens Artiste	7.00	6.30	7.80	7.10

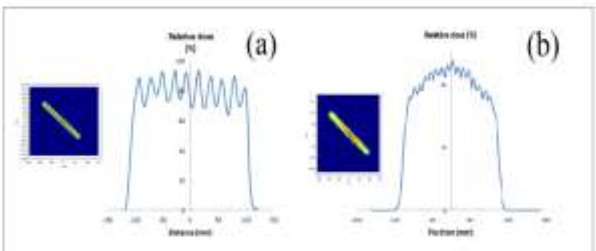
RA Journal of Applied Research
||Volume||1||Issue||09||Pages-337-351||Oct -2015|| ISSN (e): 2394-6709
www.rajournals.in DOI : 10.18535/rajar/v1i9.01



Figure(14): profile (fixed field technique) for: Elekta Precise linear accelerator (a), Siemens Artiste linear accelerator (b).

Precise position of MLCs(MLC field dependence of leaf stepping angle):

As described by the AAPM report, exposure was done to determine the positional accuracy of the leaves. Fig[14] showed the net optical density along the field and the profile. The results obtained with the step-field technique and its profile is shown in fig[15] for different collimator and gantry angle. For Precise linear accelerator, the measured penumbra width between the 20% and 80% isodose for fixed field is 6 mm and for step field is 7 mm. For Artiste linear accelerator, The measured penumbra width between the 20% and 80% isodosefor fixed field is 2.5mm and for step field is 3mm.



Figure(15): leaf positional accuracy profile (step-field technique) for: Elekta Precise linear accelerator (a), Siemens Artiste linear accelerator (b).

CONCLUSION:

The properties of radiation leakage and transmission, tongue-and-groove, coincidence of light field and radiation field, Penumbra, and Precise position of MLC for Elekta and Siemens multileaf collimators have been studied.The results concerning the leaf transmission agree with literature data dealing with the same MLC. The average value is higher than the threshold value specified in the Elekta precise acceptance testing procedures (2%). For Siemens Artiste the average value is higher than the threshold value specified in acceptance testing procedures (1.5%).

For Elekta precise, the decrease in dose for the tongue-and-groove effect is greater than Sykes et al [35] and lower than Massimo et al. [14] For Siemens Artiste linear accelerator, the variation in tongue and- groove measurements may be due to many factors such as the variation in the size and position of focal spot between the machines , also it can be due to the properties of the MLC which differed from manufacture to another, little shift in the MLC may be also affect the results.

Research & Analysis Journals

RA Journal of Applied Research
||Volume||1||Issue||09||Pages-337-351||Oct -2015|| ISSN (e): 2394-6709
www.rajournals.in DOI : 10.18535/rajar/v1i9.01

Measurements of identificationbetween light and radiation field showed thatthe difference between light and radiation field ranged from (2 to 3) mm.

The penumbra width measured perpendicular to the jaw face is nearly similar to the penumbra measured perpendicular to the MLC side.

Measurements of Penumbra in the direction of leaf motion showed a little change in the penumbra with different beam offsets, and this is indicated that the penumbra not depends on the beam offsets or leaf position.

For stepped edge, the width of penumbra for custom blocks lower than the MLC. Also there is direct relation between the leaf width and stair-stepping.

The results obtained for the step field show accuracy less than the tolerance level of the Elekta MLC as specified by the manufacturer (1 mm) with the gantry and collimator angles set to 0°. The results are confirmed by the analysis suggested by the AAPM report, which leads to a maximum deviation of the net optical density along all the match lines less than the suggested threshold value of ± 20%. Even if the analysis of the optical density profiles along the match lines of the method suggested by the AAPM is simple and fast, we believe that the step-field method should be preferred because of its better reproducibility and accuracy When the gantry and collimator angle changes, we observe small difference in position accuracy of leaves due to the effect ofgravity, this effect is magnified by the distance of the Elekta MLC from the isocenter. From our results it is recommended that the multileaf designed should be modified by decrease the leaf width to decrease stepping the edge of radiation field. We thought that this will protect healthy critical organs form radiation. Also, It is highly recommended that: at the time of commissioning of the MLC in the Elekta linear accelerator, inter and intra leaf leakage, tongue and groove effect, penumbra at the end of the leaf must be determined carefully and must be incorporated into the calculation system to avoid overdose to critical organs or sub dose to the tumors.

REFERENCES:

1 Georg D and Dutreix A. 1997. A formalism to calculate the output ratio in a mini-phantom for a GE multileaf collimator. Phys. Med. Biol. 1997;42: 521–36.

2 Pawlickia T and Mundt A J. 2007. Quality in radiation oncology. Med. Phys.2007; 34: 5.

3 Galvin J M, Smith A R, Moeller R D, Goodman R L, Powlis W D, Rubenstein J, et al. Int. J. Radiat. Oncol. Biol. Phys.1992; 23 : 789.

4 Ezzell GA, Galvin JM, Low D, Palta JR, Rosen I, Sharpe MB, et al. 2003.Guidance document on delivery, treatment planning, and clinical implementation of IMRT: Report of the IMRT subcommittee of the AAPM radiation therapy committee. Med.

Phys. 2003;30(8):2089-115.

5 Kairn T, Kenny J, Crowe S B, Fielding A L, Franich R D, Johnston P N, et al 2010. Modelling a complex micro-multileaf collimator using the standard BEAMnrc distribution. Medical Physics.2010; 37(4): 1761-7.

6 TG-106, American Association of Physicists in Medicine Radiation. 2008.Accelerator beam data commissioning equipment and procedures: Report of the TG-106 of the Therapy Physics Committee of the AAPM .Medical Physics Publishing.

7 Hwang I-M, Lind S-Y, Lee M-S, Wang C-J, Chuang K-S, Ding H-J. 2002.An effective method for smoothing the staggered dose distribution of multi-leaf collimator field edge. Nuclear Instruments and Methods in Physics Research .2002; 495: 132–8.

8 Kotb O M, Elshahat K M, Eldebawi N M and Mansour N A.2013. Dosimetric evaluation of the multileaf collimator for irregular shaped radiation fields. IOSR-JAP. 2013, 5(3):57-63.

9 Xia P and Verhey L J.2001. Delivery systems of intensity-modulated radiotherapy Using conventional multileaf collimators. Medical Dosimetry.2001;26(2): 169–77.

10 Jeraj M, Robar V.2004. Multileaf collimator in radiotherapy. RadiolOncol 2004; 38(3): 235-40.

11 Taherkhan A, Mohammad M, Saboori M S, Changizi V.2010. Evaluation of the physical characteristic of Cerrobend blocks used for radiation therapy. Iran. J. Radiat. Res., 2010; 8 (2): 93-101.

12 LoSasso T, Chui C-S, and Clifton Ling C.1998. Physical and dosimetric aspects of a multileaf collimation system used in the dynamic mode for implementing intensity modulated radiotherapy. Med. Phys.1998; 25:10.

13 Den J, Pawlicki T, Chen Y, Li J, Jiang S B and Ma C-M.2001. The MLC tongue and groove effect on IMRT dose distributions. Phys. Med. Biol.2001; 46: 1039–60.

14 Pasquino M, Borca V C, Catuzzo P, Ozzello F, and Tofani S. 2006.Transmission, penumbra and leaf positional accuracy in commissioning and quality assurance program of a multileaf collimator for step and shoot IMRT treatments. Tumori.2006; 92: 511-6.

15 Sykes J R, Williams P C.1998. An experimental investigation of the T&G effect for the Philips multileaf collimator. Phys Med Biol.1998; 43: 3157- 65.

16 Garwood P.2007. World Health Organization's Fight against Cancer: StrategiesThat Prevent Cure and Care. World Health Organization. Geneva, Switzerland; 2007.

17 AAPM (American Association of Physicists in Medicine): Basic applications of multileaf collimators. Report 72 of AAPM Radiation Therapy Committee Task Group 50. Medical Physics Publishing, Madison, WI, 2001.

18 Bucciolini M, BanciBuonamici F, Casati M.2004. Verification of IMRT fields by film dosimetry. Med Phys.2004; 31: 161-8.

19 Lee M-S, Liao W-T, Lo S-H, Chen F-L, Wong S-W, Sheng C-H, Hsu W-L.2004. Characterization of Delivery Systems for Intensity Modulated Radiation Therapy

RA Journal of Applied Research
||Volume||1||Issue||09||Pages-337-351||Oct -2015|| ISSN (e): 2394-6709
www.rajournals.in DOI : 10.18535/rajar/v1i9.01

Using a Step-and-Shoot Approach. Tzu Chi Med J. 2004.16(6).

20 García-Garduño O A , Celis M A, Manue J , Gutiérrez L, Moreno-Jiménez S, Martínez-Dávalos A, and Rodríguez-Villafuerte M.2008. Radiation transmission, leakage and beam penumbra measurements of a micro-multileaf collimator using GafChromic EBT film. Jacmp..2008; 9(3).

21 Hounsell A R, Jordan T J.1997. Quality control aspects of the Philips multileaf collimator. Radiotherapy and Oncology.1997; 45: 225–33.

22 Arnfield M R, Siebers J V, Kim J O, Wu Q, Keall P J, Mohan R. A method for determining multileaf collimator transmission and scatter for dynamic intensity modulated radiotherapy. Med. Phys. 200; 27 (10).

23 Podder T K, Bednarz G , Yu Y, Galvin J M. 2011.Physical characterization and comparison of two commercially available micro-MLCs. PhysicaMedica .2011; 27:52-7.

24 Sharma D S, Dongre P M, Mhatre V, Heigrujam M.2011. Physical and dosimetric characteristic of high-definition multileaf collimator (HDMLC) for SRS and IMRT. Jacmp.2011; 12(3): 3475.

25 Klein EE, Harms W B, Low D A, and Purdy J A.1995. Clinical implementation of a commercial multileaf collimator: dosimetry, networking, simulation, and quality assurance.Int J Radiat. Oncol.Biol. Phys.1995; 33: 1195-208.

26 Njeh CF, Caroprese B, Desai P. 2012.A simple quality assurance test tool for the visual verification of light and radiation field congruent using electronic portal images device and computed radiography. Radiation Oncology 2012, 7:49.

27 Jordan T J, and Williams P C. 1994.The design and performance characteristics of a multileafcollimator.Phys Med Biol.1994;39:231-51.

28 Yu C X, Symons M J, Du M N, Martinez AA, and Wong J. 1995.A method for implementing dynamic photon beam intensity modulation using independent jaws and a multileaf collimator. Phys. Med. Biol. 1995; 40: 769– 87.

29 Khan F M. Treatment Planning in Radiation Oncology,2nd Edition. Baltimore: William & Wilkins, (2007):99-116.

30 Khan F M.The Physics of Radiation Therapy, 4th Edition. Baltimore: William & Wilkins, (2010).

31 ICRU report 24. Washington (DC), (2000)54.

32 El-Maraghy K A, Metwaly M, El-Sayed E M, Sallam A M. 2014.A quality assurance technique for the static multileaf collimator mode based on intrinsic base lines.JRRAS.2014;7(2):230-40.

33 E.B. Podgorsak, P. Metcalfe, and J.V. Dyk, Int. J. Radiat. Oncol. Biol.Phys., 2(1999)371.

34 Liu Y, Shi C, Tynan P, Papanikolaou N. 2008.Dosimetric characteristics of dual-layer multileaf collimation for small-field and intensity-modulated radiation therapy applications. Journal of Applied Clinical Medical Physics.2008; 9(2):2709.

35 Sykes J R, Williams P C.1998. An experimental investigation of the T&G effect for the Philips multileaf collimator. Phys Med Biol.1998; 43: 3157- 65.