Analysis of openings and wide of leaf on multileaf Colimators Using Gafchromic RTQA2 Film

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Abstract. The research determined an existence of correction openings leaf for treatment, and the distribution dose using Gafchromic RTQA2 film. This was about MLC’s correction based on result of movement leaf and field irradiating uniform was done. Methods of research was conduct an irradiating on Gafchromic RTQA2 film based on the index planning homogeneity philosophy, openings leaf and wide leaf. The result of film was lit later in scan. It was continued to include image of the software scanning into matlab. From this case, the image of films common to greyscale image and analysis on the rise in doses blackish films. In this step, we made a correlation between the doses and determine the homogenity to know film dosimetri used homogeneous, and correction of openings leaf and wide leaf. The result between pixel and doses was linear with the equation \( y = (-0.6)x + 108 \) to low dose and \( y = (-0.28)x + 108 \) to high doses and the index of homogeneity range of 0.003 – 0.084. The result homogeneous and correction distribution doses at the openings leaf and wide leaf was around 5% with a value still into the suggested tolerance from ICRU No.50 was 10%.

1. Introduction
The Technological developments make a new change in the presence of LINAC IMRT (Intensity-Modulated Radiation Therapy) is a therapy with a high dose in the area of cancer by minimizing radiation doses around the OAR (Organ at Risk). IMRT technology has a Collimator with the principle of MLC (Multileaf Collimator) so that the optimal dose will be produced in the area of cancer with Treatment Planning System (TPS) resulting in a lot of irradiation area due to the movement of the leaf on the colimator [1]. There are several advantages in using therapy with the MLC such as irradiation field is easy to be corrected, without the need to create a sheilding block because there is leaf made of alloy, the patient is also still in the same position, during the treatment of replacement field done continuously without must replace with block [2]. In addition, there are some disadvantages, the possibility of leakage between the leaf, penumbra will be wider. Homogeneity Index as an effective way to know the distribution of homogeneous doses on tumor volume [3]. The quality assurance technique for static MLC uses a dosimetry film to determine the distance between the ends of leaf. In Multileaf Collimator has several parts with 1 cm wide leaf, and has uncertainty on the leaf position. This creates an uncertainty of the leaf's position. So, before the treatment done to the patient it is necessary to do a quality assurance on MLC [4].

One quality assurance in IMRT is to test the accuracy of a leaf opening based on the output of the radiation beam by using a dosimetry film, in accordance with one of the disadvantages of using MLC. This is done by irradiation on the film, and a beam of radiation beam is then calculated using a
homogeneity index. The homogeneity index is used to determine the dose distribution in the film by determining the correction of each sample point of the index or pixel of the film for its homogeneity, then compared with the other pixel points. Dosimetry film is a 2D method for proper dose distribution. The dosimetry film used in this research is Gafchromic RTQA2 film.

2. Experimental Details

The research will be conducted is the homogeneity index testing on the area of the irradiation field and corrects a leak between the leaf with several methods that exist on the basis of MLC quality assurance including the position of the leaf openings, and the width of the leaf. The study was conducted on 10 cm x 10 cm film area to distinguish homogeneity value. Films that have been irradiated with certain energy, then will be blackened due to density changes.

Film calibration is done on film with size 1 cm x 1 cm with radiation field area is 10 cm x 10 cm at SSD 100 cm and dmax 1.5 cm, phantom measuring 1 cm and 0.5 cm. The irradiation is done with low dose variation ie 0-50 cGy and high scale with range 50-300 cGy. Moved film calibration to determine the blackness of the film if subjected to various doses will be used as a reference to find out how many doses received in the next method.

![Figure 1. Field irradiation on homogeneity index determination](image)

An irradiated film with 6 MV photon output applies to all methods and placed under solid water phantom with 1 cm thick as build-up on 100 cm SSD and with MU of 200 MU or equivalent to 200 cGy. Furthermore, the determination of homogeneity index, Determination of Leaf Aperture Correction, Determination of Leaf Wide Correction.

![Figure 2. (A), (B) and (C) Field irradiation on the determination of the opening correction leaf (D) Field of irradiation for the determination of correction of leaf width](image)

Scanning of film was done with a Cannon PIXMA MP287 scanner, and then stored with TIFF format, by Matlab R2010a program. There were 15 films, so there will be 15 TIFF images to be processed using Matlab R2010a. Data processing was done with Matlab R2010a program. After coding on the run, then insert the image of the scanned film into the next coding of the image will become grayscale and will generate pixel value at each point. The calculation of HI can be formulated as in equation 1

\[
H_I = \frac{D_{Osis\ 5\%} - D_{Osis\ 95\%}}{D_p} \tag{1}
\]
Dose 5% is the minimum dose multiplied by 5% and 95% dose is the dose of the target volume multiplied by 95% and Dp is the specified dose [5].

**Figure 3.** Schematic of equipment: Operator computer (1), linear accelerator (2), radiation output (3), Solid water phantom (4), Irradiated RTQA2 Gafchromic film (5), Patient table (6) Gafchromic film (7), Scanner (8), Matlab R2010a Program (9)

3. Results and Discussion

The film is calibrated with 2 levels, i.e., a scale of dose of 0 cGy - 50 cGy with an increase of 10 cGy each, and a scale of doses of 0 cGy - 300 cGy with an increase of 50 cGy each. The film image of the increase in dose can be seen in Figure 4.

**Figure 4.** Film image based on dose increments with cGy units
(a) each increase of 10 cGy (b) each increase of 50 cGy

The irradiated film will change color to black every additional dose of irradiation. Furthermore, the process of change from image to pixel using Matlab software to obtain greyscale image as shown in Figure 5.
After the image becomes greyscale, the pixel values are getting bigger when the image becomes brighter. This means that when the dose is large, the pixel value is smaller. Then determined the relationship between pixel and dose and got the result as in figure 6 and picture 7.

**Figure 5.** greyscale film image based on dose increments with cGy units  
(a) each increase of 10 cGy (b) each increase of 50 cGy

**Figure 6.** Pixel correlation curve with dosage of each increase of 10 cGy on a scale of 0 cGy - 50 cGy

\[ y = -0.6x + 108 \]
\[ R^2 = 0.9382 \]

**Figure 7.** Pixel correlation curve with dosage per 50 cGy increase on a scale of 0 cGy - 300 cGy

\[ y = -0.28x + 108 \]
\[ R^2 = 0.9603 \]
The curves in Figures 6 and 7 have a significant gradient because of the difference between each dose increase and the scale used. Low-scale curves are used when pixels are read on a low dose range scale, as well as for doses with high-curve curves also used for pixels read in high dose range ranges. Based on the above curve can be concluded that the correlation between the pixel value with the dose is linear, the equation has a negative gradient at each dose increase, this is because each increase in dose then the pixel decreases. When viewed from the image obtained, the darker the image the smaller the pixel, while the blackish film depends on the given dose. The film's darkness is based on the increasing film density as it is influenced by the voltage or energy of the irradiation. The film image with the area of the irradiation field can be seen in Figure 8.

![Figure 8](image)

Figure 8. (a) gafchromic film image of 10 cm x 10 cm
(b) greyscale film of gafchromic film with 10 cm x 10 cm

The film image shown in FIG. 8 is dosed 200 cGy with a standard state on a 100 cm SSD with a 10 cm x 10 cm field. If not entangled then homogeneity close to 0 it can be concluded that the distribution is homogeneous. Based on the calculation, we get the correction value of HI near 0 at 0.003 - 0.084 is in the dose range ± 200 cGy, while for the value of HI close to the value 1 is at a dose below 200 cGy.

In this correction a 10 cm x 10 cm film was taken in 3 times irradiated using the same film and the same energy of 200 cGy, with the form of irradiation according to the one in planning. The image of the film that has been irradiated for the correction of the leaf openings is seen in Figure 9.

![Figure 9](image)

Figure 9. (a) gafchromic film image for leaf opening correction
(b) greyscale image of gafchromic film for leaf opening correction

Scans with a darker color indicate the presence of irradiation with a width of 2 cm and for areas that are not too black is the position of leaf with a width of 1 cm. In the planning is done the replacement of irradiation with the same film with 3 times irradiation by moving the position of leaf in accordance with the opening leaf with a fixed film position. To know the correction of accuracy of leaf opening, then calculation of dose distribution correction on leaf location.

Report ICRU No. 50 recommends that the reference of the dose distribution be accurate in the absence of widening for the recommended dose distribution based on a homogeneous dose of ± 10%
Variation of the prescribed dose may be used in clinical practice or a study of a planning. So that can be used as a reference to determine the dose distribution with tolerance recommended ± 10%. The results obtained from the correction of the accuracy of the leaf opening can be shown on the curves in Fig. 10 (a) for leaf 1 and 10 (b) for leaf 2.

**Figure 10. Dose correction curve for each distance (a) leaf 1 (b) leaf 2**

Correction of leaf width using 10.5 cm x 10.5 cm film with treatment using 200 cGy irradiation, radiation planning by opening all leaf by leaving one leaf to be calculated the width. From the irradiation result, the result of the film as shown in Figure 11.

**Figure 11. (a) gafchromic film image for leaf opening correction (b) greyscale image of gafchromic film for leaf opening correction**
The leaf width is 1 cm, it can be seen that on the scan with darker color indicates the existence of irradiation and for the area that is not too black is the position leaf. In the planning done with a film irradiation 1 times irradiation with leaf position in accordance with the planning. Tolerance allowed under ICRU recommendations no. 50 ie ± 10%. The results obtained from the correction of the leaf width can be shown on the curve in Figure 12

![Dose-to-distance correction curve](image)

**Figure 12. Dose-to-distance correction curve**

The curve indicates that the dose correction values present in the leaf area are within the recommended range and are within the range of ± 5, indicating that there is still a dose that is scattered although closed leaf because of the movement of leaf which causes shift dose value but still in the range of 10% as recommended by ICRU No. 50.

4. Conclusion

Based on the research that has been done, got the following conclusion: The dosage value in the homogeneous region is at doses of ± 200 cGy. Homogeneity index correction value in the range of 0.003-0.084. It can be said that the Gafchromic RTQA2 film has a homogeneous film response to the given dose, used in a radiation beam output calibration. There was dose distribution in leaf-covered film area with correction of leaf width with ± 5% value which is still in range of dose distribution as recommended. There is a dose distribution in a leaf-covered film due to leaf movement causing shifting of dose value with the correction of aperture leaf with ± 5% value and also due to the use of film which still remains in 3 times irradiation.

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References

[1] Shukla, A. K., Oinam, A., Kumar, S., Sandhu, I. S., Sharma, S. C., 2013. A calibration method for patient specific IMRT QA using a single therapy verification film. *Reports of practical oncology and radiotherapy* 18 235-240A reference

[2] Jeraj, M., 2004. *Multileaf Collimator In Radiotherapy*. Departemen of Radiotherapy, Institute Of Oncology, Ljubljana, Slovenia.

[3] Maraghy, K.A., Metwaly, M., Sayed, M. S., dan Salam, M. A., 2014. *Quality Assurance Technique For The Static Multileaf Collimator Mode Based On Intrinsic Base Lines*. India.

[4] Bhardwaj, A. K., Sharma, S. C., Rana, B., Shukla, A., 2009. *Study of 2D Ion Chamber Array for
Angular Response and QA of Dynamic MLC and Pretreatment IMRT Plans. Departement of Radiotherapy Post Graduate Institute of Medical Education and Reasearch, India

[5] Yoon M, Park S.Y., Shin D., Lee S. B., Pyo H. R., Kim D. Y., and Cho K. H., 2007. A New Homogeneity Index Based on Statistical Analysis of the Dosevolume Histogram. Journal of Applied Clinical Medical Physics. Vol 8, No 2.

[6] Wahyuni, R. A., 2013. “Analisis Hubungan Dosis Serap dengan Jarak Sumber Radiasi ke Permukaan Medium (SSD) dan Luas Lapangan Penyinaran dari Pesawat Linear Accelerator (LINAC)”. Universitas Hasanuddin, Makassar

[7] Sakti, A. D., 2015. Analisis Profil Berkas Radiasi Linear Accelerator 6mev Pada Penggunaan Virtual Wedge Dengan Gafchromic Film. Youngster Physics Journal Vol 4, No 3 (2015): Youngster Physics Journal Juli 2015