Measurement of Dose Distributions for Useful Utilization of BioBeam 8000 Gamma Irradiation Device

Seungwoo Park, Haijo Jung, Kum Bae Kim, Chang Yeol Lee, Kihong Son, Sang Hun Shin, Donghan Lee, Munsik Choi, *Young Hoon Ji

Div. of Radiation Cancer Research, Research Institute of Radiological and Medical Sciences, Korea Institute of Radiological and Medical Sciences, Seoul, Republic of Korea

1. Introduction

Gamma irradiation device using Cs-137 have been widely utilized to the irradiation of cell, blood, and animal, and the dose measurement and education. Radiation irradiators for cell and blood irradiation used in numerous research institutions has demerits to perform the experiment of large volume objects like as 96 Multiwell Plate. Therefore, KIRAMS (Korea Institute of Radiological and Medical Sciences) introduced Gamma irradiation device having large volume capacity (BioBeam 8000, STS Steuerungstechnik &. Strahlenschutz GmbH, Braunschweig, Germany, Cs137, 3.35 Gy/min).

In this study, dose the distribution of newly implemented BioBeam 8000 Gamma irradiation device was measured using glass dosimeter and Gafchromic EBT film dosimetry. In addition, an user guideline for useful utilization of the device based on measurement results are presented.

2. Methods and Results

2.1 Dosemeters and instruments

Glass dosimeter (GD-302M GRD, Asahi Techno Glass Corporation, Shizuoka, Japan) is solid-state dosimetry using the effect of radio-photo luminescens; RPL due to the emission of red-yellow lights from irradiated the glass by the stimulation of ultraviolet (UV) laser beam [1]. The glass dosimeter has the characteristic of integration dosimetry because the excited centers of RPL are not eliminated by UV-beam excitation, and therefore readout process can be repeatedly achieved until annealing. Glass dosimeters used in this study were the cylindrical shape (rod) of 1.5 mm in diameter, and 12 mm in length. The glass dosimeter can be measured in broad dose range of 10 uGy - 500 Gy, and was responded to energy dependence of within 3%, and angular dependence within 5% [2]. Reader used to reading of the glass dosimeter was to FGD-1000 Ace (Asahi Techno Glass Corporation, Shizuoka, Japan).

Film dosimetry was performed using Gafchromic EBT film which is not showed energy dependence, and can be capable of high dose (~8 Gy). Gafchromic EBT film shows the excellent radiation sensitivity of 0.02 Gy - 8 Gy developed to be suitable for dose measurement in radiation therapy, and the angular dependence of within 1.5%. Irradiated films were scanned and analyzed using EPSON Pro 1680 Expression scanner (Seiko Epson. Corporation, Nagano, Japan) in red channel.

2.2 Dosimetric condition

Dose measurements were achieved by means of Alanin dosimeter, the glass dosimeter, and the Gafchromic EBT film. The Alanin dosimeter was used to provide the initial measurement data of the BioBeam 8000 from the manufacturer. In this study, the results of dosimetry using the Alanin dosimeter were used to reference data. The experimental parameters for the glass dose measurements were same as that of the Alanin dosimeter. The dosimetry of the Gafchromic EBT film was performed with irradiation dose not exceeding 10 Gy in consideration of the characteristic of the Gafchromic EBT film. The detail parameters of the dose measurement were listed in Table 1. A BB75-4 container beaker having the volume of 7.5 liters was used to measure the dose distribution in air of the BioBeam 8000 irradiation device. The total of 33 glass dosimeters and the Gafchromic EBT film were located in the center of the BB75-4 container, respectively [Fig. 1].

Table 1. Experimental parameters for dose distribution measurements of the BioBeam 8000 Gamma irradiation device.

Measuring System	Alanin dosimeter	Glass dosimeter	Gafchromic EBT film
Type of unit	BIOBEAM8000		
Type of container	BB75-4		
Source	Cs-137		
Activity	81.4 TBq		
Filling medium	Air		
Measuring Time (sec.)	900	900	30, 60, 120, 180

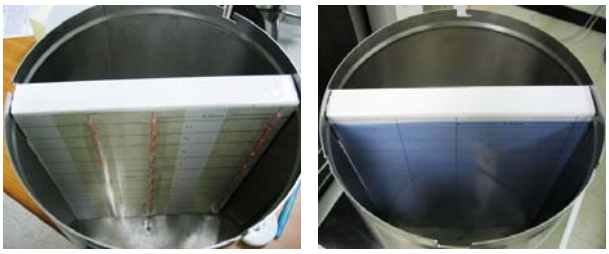

Fig. 1 Photography showing glass dosimeter measurement geometry (left) and Gafchromic EBT film measurement geometry (right) at vertical cross section the in the BB75-4 container.

3. Results

The dosimetric data provided from the manufacturer by using the Alanin dosimeter were listed in Table 2. Minimum and maximum dose rate at central axis was measured to 2.74 Gy/min at the lowest position, and 3.35 Gy/min at the middle position, respectively. The dosimetric results of the glass dosimeter were distributed as showed in Fig. 3. Minimum and maximum dose rate of the glass dosimeters at central axis was measured to 3.3 Gy/min at the highest position, and 4.0 Gy/min at the middle position, respectively.

Fig. 4. shows percent distributions based on reference value with the minimum dose rate position in order to compare dose uniformity within the irradiation device. Maximum variation at each measurement position for the Alanin dosimeter and the glass dosimeter was appeared to 22% and 21%, respectively.

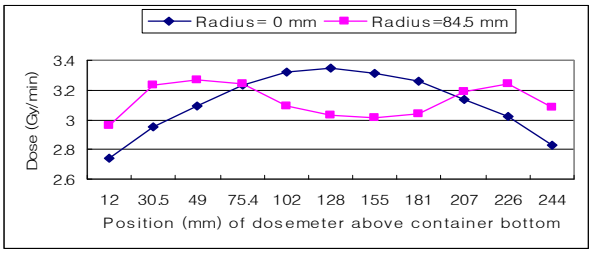

Fig. 2. The dose rate distributions in the BioBeam 8000 irradiation device provided from the manufacturer by using the Alanin dosimeter.

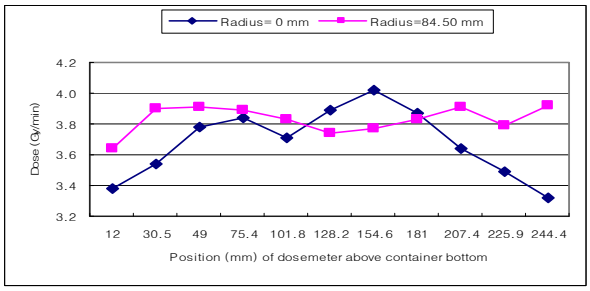

Fig. 3. The dose rate distributions in the BioBeam 8000 irradiation device by using the glass dosimeter.

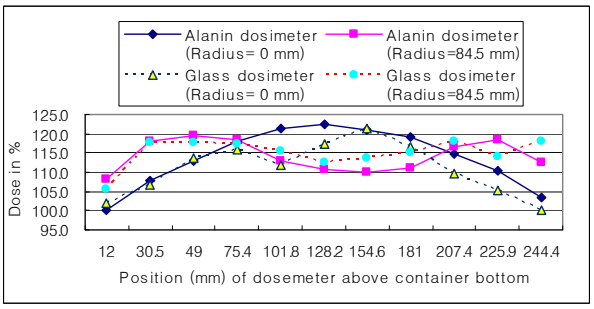

Fig. 4. Comparisons of uniformity of dose distributions between the Alanin dosimeter and the glass dosimeter.

Fig. 5 shows the results of 2-demenizional dose distribution having 2 mm spacing on the film image analyzed from spatial dose distribution using the Gafchromic EBT film for different doses.

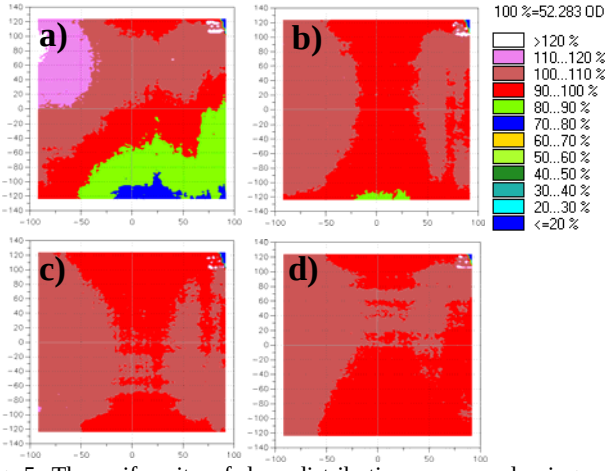

Fig. 5. The uniformity of dose distributions measured using the Gafchromic EBT film, a). 30 sec (1.59 Gy), b). 60 sec (3.17 Gy), c). 120 sec (6.35 Gy), and d). 150 sec (9.51 Gy).

4. Conclusions

In this study, the dose distributions of the BioBeam 8000 irradiation device implemented at the KIRAMS were measured using the glass dosimeter and the Gafchromic EBT film. The measurement results of uniformity of delivered dose within the device showed variation more than 20% between middle point and the lowest position at central axis. Therefore, to maintain dose variation within 10%, the criteria of useful dose distribution, for research radiation effects, the irradiated specimen located at central axis of the container should be placed within 50 mm from top and bottom surface, respectively. In addition, for measurements using the film, the variations of dose distribution were more then 40% for the case of less than 60 second irradiation, mostly within 20% for the case of more than 60 second irradiation, respectively. Therefore, the irradiation experiments using the BioBeam 8000 irradiation device are recommended to be used for specimen required at least more than 60 second irradiation time.

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