Evaluation of Dose Distribution using a Glass Dosimeter and a Gafchromic EBT Film in Gamma Irradiation Devices

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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.

The Gammacell 3000 Elan (Nordion International, Kanata, Ontario, Canada) irradiator was installed in 2003 with Cs-137 and dose rate of 3.2 Gy/min. And the BioBeam 8000 (Gamma-Service Medical GmbH, Leipzig, Germany) irradiator was installed in 2008 with Cs- 137 and dose rate of 3.5 Gy/min.

Our purpose was to evaluate the practical dosimetric problems associated with inhomogeneous dose distribution within the irradiated volume in open air state using glass dosimeter and Gafchromic EBT film dosimeter[1-3] for routine Gamma irradiator dosimetry applications at the KIRAMS and the measurements were compared with each other. In addition, an user guideline for useful utilization of the device based on practical dosimetry will be prepared.

2. Materials and Methods

Dose distribution measurements were achieved by means of the glass rod dosimeter, and the Gafchromic EBT film. Irradiations were performed to a nominal absorbed dose of 0.5~6 Gy in commercially available two gamma irradiators (Gammacell 3000 Elan, and BioBeam 8000).

The uniformity dose distributions inside each irradiation chamber were determined by using the Gafchromic EBT film. The dosimetry of the Gafchromic EBT film was performed with irradiation dose not exceeding 7 Gy in consideration of the characteristic of the Gafchromic EBT film. The detail parameters of the dose measurement were listed in Table 1.

Table 1. Experimental parameters for dose distribution measurements of the gamma irradiation device.

Type of unit	BioBeam 8000	Gammacell 3000
Activity	81.4 TBq	38.7 TBq
Source	Cs-137	Cs-137
Measuring System	Glass dosimeter Gafchromic EBT film	
Filling medium	Air	
Measuring Time (sec.)	Glass dosimeter: 120, Gafchromic EBT film: 10, 20, 40	

The glass dosimeters were located in the center and edge of the container and the Gafchromic EBT film were located in the center of the container(Fig. 1).

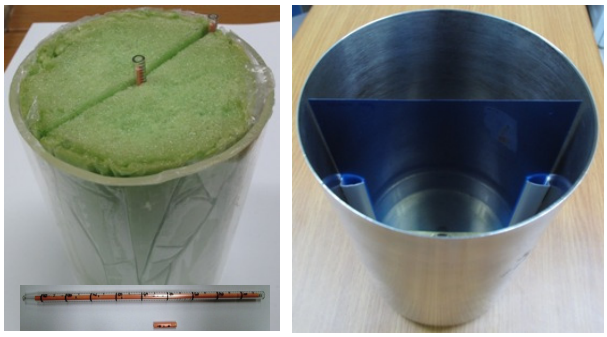

Fig. 1. Photography showing glass dosimeter measurement geometry (left) and Gafchromic EBT film measurement geometry (right) at vertical cross section in the container.

3. Results

Reader used to reading of the glass dosimeter was to FGD-1000 Ace (Asahi Techno Glass Corporation, Shizuoka, Japan). The dosimetric results of the glass dosimeter were distributed as showed in Fig. 2, Fig. 3 Minimum and maximum dose rate in the BioBeam 8000 irradiation device of the glass dosimeters at central axis was measured to 2.99 Gy/min at the highest position, and 3.66 Gy/min at the middle position, respectively. Minimum and maximum dose rate in the Gammacell 3000 irradiation device of the glass dosimeters at central axis was measured to 4.06 Gy/min at the highest position, and 5.33 Gy/min at the middle position, respectively.

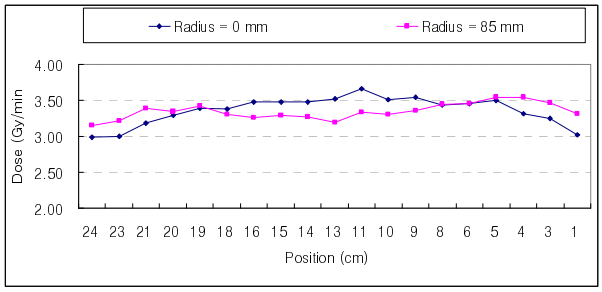

Fig. 2. The dose rate distributions in the BioBeam 8000 irradiation device by using the glass dosimeter.

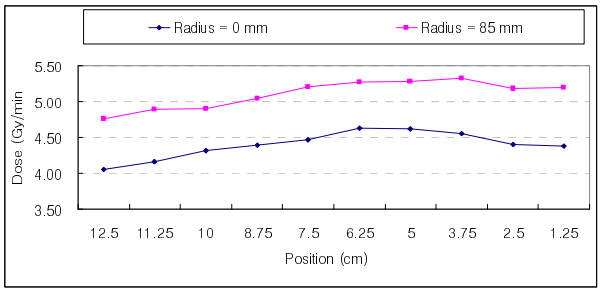

Fig. 3. The dose rate distributions in the Gammacell 3000 irradiation device by using the glass dosimeter.

Fig. 4, Fig. 5 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 irradiation device the BioBeam 8000 and the Gammacell 3000 was appeared to 22% and 14%, respectively.

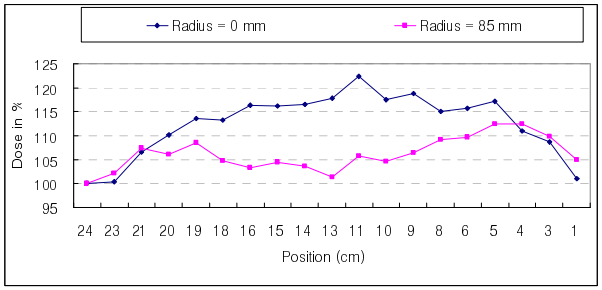

Fig. 4. The percent distributions in the BioBeam 8000 irradiation device by using the glass dosimeter.

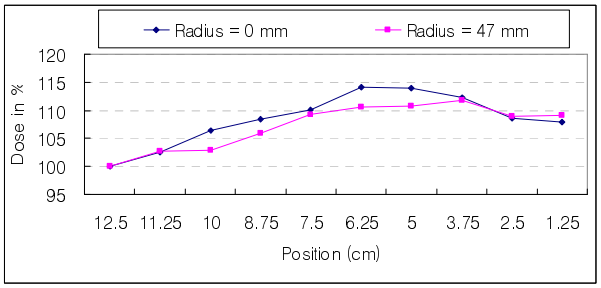

Fig. 5. The percent distributions in the Gammacell 3000 irradiation device by using the glass dosimeter.

Irradiated films were scanned and analyzed using EPSON Pro 1680 Expression scanner (Seiko Epson. Corporation, Nagano, Japan) in red channel.

Fig. 6, Fig. 7 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.

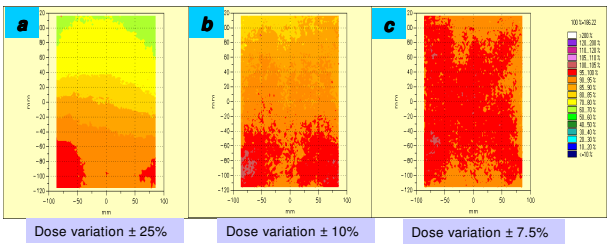

Fig. 6. The uniformity of dose distributions in the BioBeam 8000 irradiation device by using the Gafchromic EBT film, a). 10 sec, b). 20 sec, and c). 40 sec.

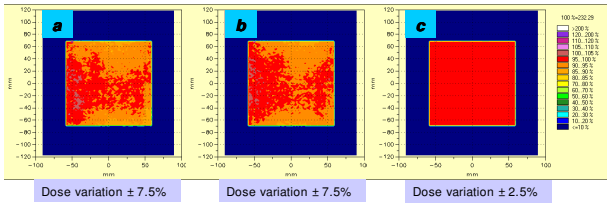

Fig. 7. The uniformity of dose distributions in the Gammacell 3000 irradiation device by using the Gafchromic EBT film, a). 10 sec, b). 20 sec, and c). 40 sec.

4. Conclusions

In this study, the dose distributions of the BioBeam 8000 and Gammacell 3000 irradiation devices 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 14% 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 30 mm from top and bottom surface, respectively. In addition, for measurements using the film, the variations of dose distribution were more then 50% for the case of less than 10 second irradiation, mostly within 20% for the case of more than 20 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 20 second irradiation time.

ACKNOWLEDGMENT

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