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The Properties of Ultramicro Cylindrical Chamber for Small Field Used in Stereotactic Radiosurgery

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INTRODUCTION

Accurate dosimetry of small field for photon beams used in stereotactic radiosurgery (SRS) can be made difficult because of the presence of lateral electronic disequilibrium and steep dose gradients. There is necessity making a detector which is not only smaller in size but also has more sensitive for small field used in SRS. In this study, the Ultramicro Cylindrical Gold (UCG) ionization chamber has multiple sensitive volumes of air ($8.0\times10^{-3}cm^3$) and Borosilicate ($2.7\times10^{-3}cm^3$) cavity with high spacial resolution because of form of cylindrical type. The radiation stability, linearity, beam profile of small beam, and independence of dose rate for the UCG were demonstrated.

METHODS

Photon and electron beams were generated with Philip SL-75 and Varian C1800 accelerator. The photon collimators are set from 10×10 to $20\times20\,mm^2$ square and small circular beams of $\phi\,0.5$ to $\phi\,20$ mm in diameter. The wall of UCG is made of pure gold cylinder 2.2 mm in diameter of thickness 100 μm and with length of 4.0 mm. There is other gold plate of 200 μm thickness with 3.0 mm in diameter on the upper surface layer of top of UCG chamber. Both gold plate and cylinder wall act as an intensifier of their signals for therapeutic high energy photon beam. A bias of -300 Volts was applied to the UCG detector. After switching on the bias voltage, UCG was warming for thirty minutes in order to stabilize its response and to reduce background. The maximum variation of the response of the UCG two hour or more is found to be less than 0.5 %. Dose profiles are performed in water equivalent plastic phantom embedded UCG attached with micrometer.

RESULTS and DISCUSSION

UCG is irradiated by photons for a range of absorbed dose up to 400 monitor units. The values of calculated linearity coincides well with the calculated line with the differences less than 0.5 %. UCG which had a high dose response is independent of dose rates in radiation beams, it has the relative measurement errors of 0.5 ± 0.1 % for 15 MV photon and 9 MeV electron beam. In order to evaluate the impact of detector size on profile measurements, square field profile for 10×10 and 20×20 mm^2 field were obtained with UCG and film shown in Fig. 1. The profiles measured with UCG are almost identical and slightly narrower than those for film. The penumbra broadening due to the finite size of the sensitive volume of the detector is the most important factor. These profiles demonstrate significant broadening of the measured penumbra region. The values of penumbra (i.e., the distance between dose of 20% ~ 80% and 10% ~ 90%) and FWHM are obtained by the UCG shown in Table I.

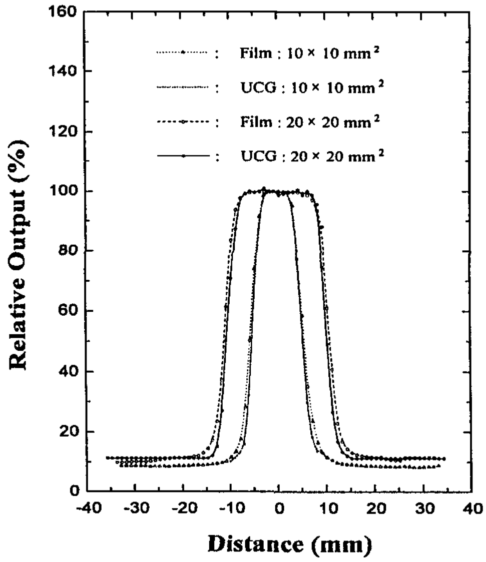

Fig. 1. Beam profiles measured by UCG and film for a 10×10 and 20×20 mm^2 square field for 15 MV photon beam on a solid polystyrene phantom at SSD 100 cm.

Table I. Beam parameters for SRS beams, measured with UCG-chamber at the SSD=100cm, 2.8mm deep.

Field Size	FWHM (mm)	Penumbra Width(20~80%)		Penumbra Width(10~90%)	
		Left(mm)	Right(mm)	Left(mm)	Right(mm)
10×10 mm^2	10.28	2.19	2.47	3.42	3.98
15×15 mm^2	15.68	2.12	2.30	3.26	3.79
20×20 mm^2	20.53	2.67	2.35	4.00	3.57
ϕ10 mm Dia.	9.53	2.23	2.43	3.62	3.77
ϕ14 mm Dia.	15.10	2.43	2.45	3.80	4.24
ϕ20 mm Dia.	20.29	2.29	2.25	3.68	3.60

CONCLUSIONS

UCG chamber is able to measure the across even small beam profile of square 10×10 mm^2 or ϕ 10 mm in diameter circular beam, which has small width of penumbra and precise FWHM for small beams. In summary, UCG has a useful role to perform in the measurement of surface dose or point dose in solid water phantom for small photon beam used in SRS.