Contribution of light in high-energy film dosimetry using water substitute phantoms

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ABSTRACT

The contribution of light in high-energy film dosimetry was examined using six commercially available solid water substitute phantoms. As six commercially available phantoms; RMI-451, Mix-DP, WE211, WE211-Black, PMMA and PMMA Black were evaluated in this study. It is difficult to evaluate the contribution of Cerenkov radiation and the optical permeability to the relative and/or absolute dosimetry using unpacked film in these phantoms. Therefore the contribution of Cerenkov radiation was estimated by the comparison between film densities in the shielded side (shutting off the light) and unshielded sides on a phantom. The effect of optical permeability was measured under ambient light by the time scale method. The results suggest that the use of black colored phantoms may improve the accuracy of dose measurement in film dosimetry.

Keywords: water substitute phantom, Cerenkov radiation, film dosimetry, light effect

1. INTRODUCTION

Tissue substitute phantoms are widely employed in film dosimetry in the process of estimating the absorbed d ose. An unpacked film (i.e. removed from the ready pack) is generally used to avoid interference induced by the gap between the phantom and the film, and the influence of envelope materials[1]. However, the dose measured by the film may be somewhat overestimated due the contribution of Cerenkov radiation in high-energy film dosimetry. Cerenkov radiation is emitted when relativistic particles travel faster than the speed of light in a medium[2], in this case phantom. There has been little practical study of the contribution of Cerenkov radiation to high-energy film dosimetry using commercially available phantoms[3]. In this study, we therefore measured the contribution of Cerenkov radiation and the optical permeability the evaluated dose using commercially available water substitute phantoms.

2. MATERIALS AND METHODS

Film dosimetry was performed using 10 MV X-rays, and 18 MeV electron beam from a linear accelerator (MEVATRON KD2/65, Siemens, Erlangen, Germany). Six commercially phantoms were used; RMI-451 (GAMMEX, WI, USA), Mix-Dp (Taisei Medical Co., Osaka, Japan), WE-211 and WE-211-Black (Kyoto Kagaku Co., Kyoto, Japan), PMMA and PMMA-Black (Goodfellow, Huntingdon, UK). Cerenkov radiation measurements were performed in complete darkness of a treatment room. Processed phantoms were prepared for this purpose, having one side coated with very thin black carbon film (less than 0.1 mm) and the other side unshielded. The contribution of Cerenkov radiation was determined by comparison of doses measured with and without shielding. The effect of optical permeability was measured under ambient light by the time scale method. Figure 1 shows the experimental setup used to evaluate the light permeability of the phantom.

3. RESULTS AND DISCUSSION

Figure 2 shows the dose profile evaluated for the shielded and unshielded WE-211 phantom. Light shields were mounted 1 cm above and below the film surface because phantom cassettes are generally made to this thickness[4,5], and the contribution of Cerenkov radiation was measured. The evaluation dose was higher as a result of the Cerenkov light

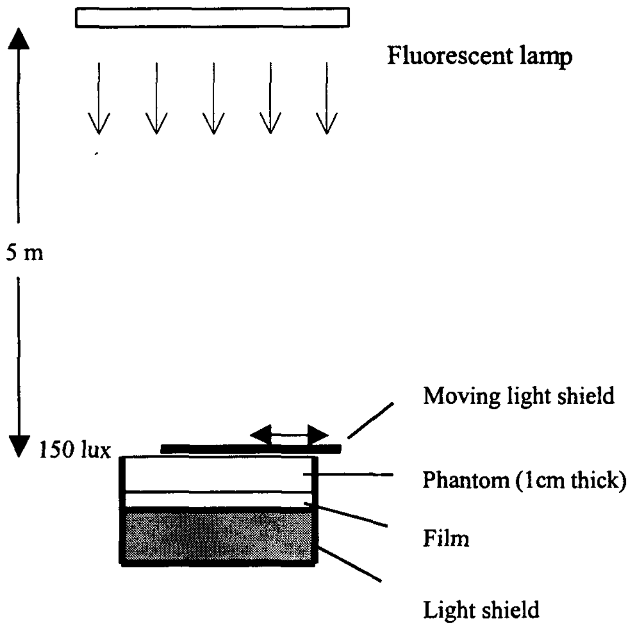

Fig.1 Experimental setup used to evaluate the light permeability of the phantom.

generated in the unshielded phantom. The percentage increases in dose due to the contribution of Cerenkov radiation for 6 commercially available phantoms for 10MV X-rays and an 18MeV electron beam were measured. Almost identical trends are illustrated for both X-rays and electron beams, because the number of Cerenkov photons generated is directly proportional to the number of charged particles[6]. Furthermore, the dose increase changes according to the phantom. Figure 3 shows the variation of optical density as function of time. It appears that the lower the optical permeability and darker the coloring of a phantom, the greater the self-absorption of light.

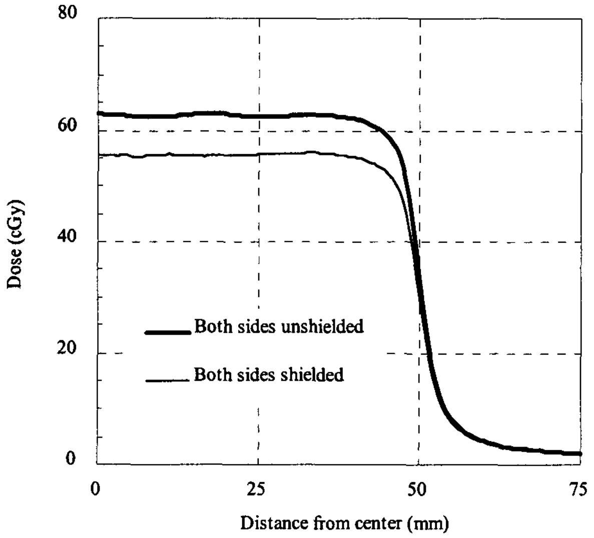

Fig.2 Dose profile evaluated for shielded and unshielded WE-211 phantom.

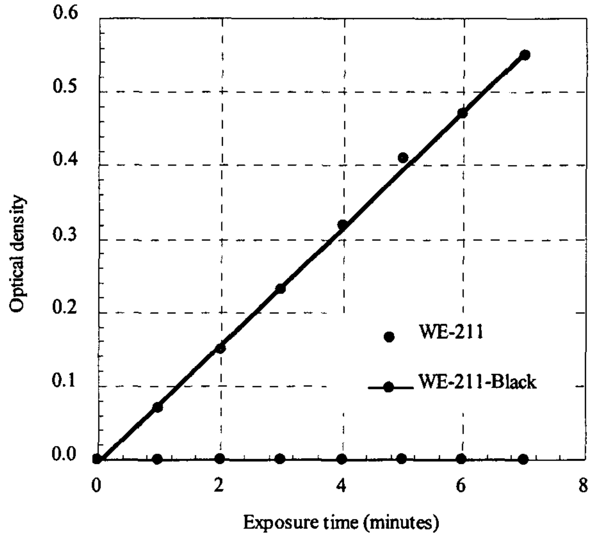

Fig.3 Variation of optical density as function of time.

4. CONCLUSION

Because the contribution of Cerenkov radiation varies according to the phantom, the increased dose for each phantom must be ascertained in advance in dosimetry using heterogeneous phantoms. The dark colored phantoms may produce more realistic dose distribution measurements using unpacked films in high-energy film dosimetry by eliminating the effect of Cerenkov radiation. The phantom was also shown to be unaffected by such local light and by the optical transmission of the phantom.

REFERENCES

1. J. Dutreix J, and A. Dutreix, “Film dosimetry of high-energy electrons”, *Ann. N.Y. Acad. Sci.* **161**, pp.33-42, 1969
2. J. V. Jelley, "Cerenkov Radiation and its Applications", Pergamon Press (Oxford, UK), 1958.
3. F. M. Khan, K. P. Doppke, K. R. Hogstrom, et al, “Clinical electron-beam dosimetry: Report of AAPM Radiation Therapy Committee Task Group No.25”, *Med. Phys.* **18**, pp.73-109, 1994
4. F. J. Bova, “A film phantom for routine film dosimetry in the clinical environment”, *Phys. Med. Biol.* **15**, pp. 83-89, 1990.
5. A. S. Shiu, V. A. Otte, and K. R. Hogstrom, “Measurement of dose distribution using film in therapeuti c beams”. *Med. Phys.* **16**, pp.911-915, 1989.
6. K. D. Steidley, R. M. Eastman, and R. J. Stabile, “Observations of visual sensations produced by Cerenkov radiation from high-energy electrons”, *Int. J. Radiat. Oncol. Biol. Phys.* **17**, pp. 685-690, 1989.