

Determination of Relative Output Factors Using PinPoint Ion Chamber and Gafchromic Film in Gamma Knife

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ABSTRACT

Of many modalities for measuring output factor, we measured the outputs of 18mm, 14mm, 8mm and 4mm helmet in Gamma knife using ion chambers and a Gafchromic MD-55 film and normalized the outputs of four helmets the one of a 18mm helmet. Ion chambers used for this paper were a PR-05P and a PinPoint having a volume of 0.07cc and 0.015cc respectively. The recommended output factors from a manufacture were 1, 0.984, 0.956, and 0.87. For PR-05P, the output factor of 14mm helmet showed a good agreement, but the ones of 8mm and 4mm helmet showed the difference of 4.6% and 47% respectively. For PinPoint, The output factors of 14mm and 8mm helmet showed a good agreement, but the one of a 4mm helmet showed a difference of 18%. The Gafchromic MD-55, however, showed a good agreement for all helmets

Keywords: Gamma Knife, Output factor, Pinpoint, Gafchromic MD-55 film

1. INTRODUCTION

Using 18mm, 14mm, 8mm and 4mm helmet, which are geometrical size, the 201 gamma rays of Gamma Knife are crossed at the isocenter of 40.3cm from source¹. The outputs of four helmet used in Gamma Knife were normalized to a reference dose of a 18mm helmet, so called helmet factor¹. To determine helmet factors the detector should be much small for a beam size to keep an electric equilibrium⁶. For that reason, a TLD of 1mm × 1mm or a diamond detector has been generally used for this purpose². It is, however, very difficult to read data from the detectors. Since very small ion chambers, easy to use and read a data, were commercially produced, we measured the outputs of four helmets and also measured using a Gafchromic film that could be used in daylight.

2. MATERIALS AND METHODS

2.1 The measurements using ion chambers

We used a water equivalent spherical polystyrene phantom of 16cm in diameter provided by a manufacturer, Elekta instrument AB, and prepared two cassettes that held ion chambers in a phantom. Each cassette was drilled exactly for a geometric size of two ion chambers so that the measurement point of the cavity of an ion chamber could be located in the geometrical isocenter of the Gamma Knife. The geometrical size of a capintec PR-05P was 0.07cc in volume, 5.5mm in length and 4mm in diameter and a PTW PinPoint, 0.015cc was in volume, 5mm in length and 2mm in diameter. The cassette was aligned in perpendicular to Z axis, XY plan. Electrometers of ion chamber used for charge collection were a Capintec 192 for PR-05P and a Kiethly 35617 for PinPoint..

2.2 The measurements using a Gafchromic MD-55

A Gafchromic film cut in 2.5cm was placed in XY Plane and repeated in XZ Plan for each helmet³. The phantom was the same used for ion chambers. The irradiation time was 20 minute that corresponded to 77Gy of a 18mm helmet. To read the density of the films, we used a Macbeth TD904. As we recognized that the white light of a Macbeth could affect the film, We placed a red film on Macbeth plate to protect the Gafchromic film and also used red filter mode to improve a response of the Gafchromic film⁴.

3. RESULTS

We obtained the outputs of four helmets using ion chambers and a Gafchromic MD-55 film and normalized to 18mm helmet. Table 1 showed the output factors of a PR-05P and a PinPoint ion chamber compared with the ones of a Manufacture and a G.Bednarz who measured the output factors using a specially designed ion chamber having a

volume of 0.006cc. For the PR-05P, we found that the helmet factor of a 14mm helmet showed a good agreement, but 8mm and 4mm helmet had a difference of 4.6% and 47% respectively. For the PinPoint, only there was a difference of 18% in a 4mm helmet.

Table 1 Comparisons of helmet factors for various volume of ion chamber and a Gaf MD-55.

	PR-05P (0.07cc)	PinPoint (0.015cc)	G.Bednarz ⁵ (0.006cc)	GafMD-55	Manufacture
18mm	1	1	1	1	1
14mm	0.98	0.981	0.983	0.983	0.984
8mm	0.912	0.95	0.935	0.96	0.956
4mm	0.46	0.71	0.765	0.86	0.87

4. DISSCUSSION AND CONCLUSION

As showed in Table 1, the smaller ion chamber showed a small difference of the output factor with a recommended value. We found, however, that even most small volume of commercial ion chamber could not measure the output of less than a 8mm helmet. The output factors determined from Gafcromic MD-55 were in good agreement with the recommended data. Gamma Knife users could easily take this measurement using Gafcromic MD-55 film as alternative method annually.

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