Application of Dose Area Product and DAP Ratio to Dosimetry in IMRT and Small Field External Beam Radiotherapy

S Duane, F Graber, RAS Thomas

Background

The aim of this work is to improve photon dosimetry in composite fields such as those used in delivering IMRT. In a typical IMRT treatment, the total dose at a point in the PTV arises from an appropriately weighted combination of in-field, out-field and penumbra contributions. Measurement of an ion chamber response must take account of its varying sensitivity to these contributions and the possible lack of electron equilibrium. Effective electronic equilibrium may only be achieved in the combined treatment.

There are two aspects: absolute measurement of the dose to the point under consideration, and a proposed beam quality parameter to support the transfer of absorbed dose calibration from one composite field to another is considered here.

Beam Quality

The quality of a photon beam normally refers to its penetrating power, but the beam quality parameter is also used to express the variation of an ion chamber’s absorbed dose calibration coefficient.

The penetrating power of the radiation, which is a function of photon attenuation and scatter, varies across fields and as a function of energy, on the photon energy spectrum, determines the distribution of dose with depth within the phantom. Accurate modelling of percentage depth dose distributions is essential to good treatment planning.

The response of an ion chamber is a function of the effective stopping power, which is determined by the secondary electron fluence spectrum at the position of the chamber. The chamber response is essentially independent of calibration coefficients, one needs a beam quality parameter which is related to the stopping power, which could in principle be quite different from the penetrating power. The transfer of absorbed dose calibration from reference conditions to clinical conditions measurement conditions depends on this beam quality parameter.

Conventional beam quality specifications such as TPR20/10 and %SSD(10), are directly related to penetrating power but not indirectly related to stopping power.

Field size dependence

Primary and scattered fluence vary with depth in quite different ways. For a larger field, primary and scattered fluence fall off more slowly with field size, and along the same central axis, while only weakly with field size, and more weakly with field size, for a very small field. The use of DAP for photon dosimetry in beams from an Elekta Synergy linac, is addressed in the related poster[1], and a proposed beam quality parameter is addressed.

Dose Area Product, (DAP)

For a beam normally incident on a phantom, Dose Area Product, (DAP), is the integral of dose over the internal volume of the beam, and the beam area.

The use of DAP for photon dosimetry in small fields has been proposed by Djouguela et al.[2]. The variation of DAP with depth in phantom is shown in Figure 2.

Definition of DAPR20/10

The proposed beam quality parameter is the ratio of DAP at depths 20 cm and 10 cm for fixed source to detector distance and using the same surface.

Quality-dependence of DAPR20/10

As an external quality parameter, DAPR20/10 has a similar variation with energy to TPR20/10, Figure 5. The quality dependence of ion chamber’s absorbed dose calibration coefficient, ND(w(Q)), what would be the conditions under which defined in Figure 5.

Application of DAPR20/10 to IMRT dosimetry

Provided that surface scatter corrections are made at all depths, the ratio, DAPR20/10, turns out to be essentially independent of the field size, Figure 7.

DAPR20/10 for dynamic and rotational therapy

DAPR20/10 requires the combination of sequential measurements of DAP in two different sources. This approach becomes more problematic when the number of fields, i.e. the beam array, is too large, or the beam varies continuously, as in rotational therapy. It would be preferable to make the two measurements simultaneously and combine them in real time. The PTW transmission chamber used in the measurements reported here presents a minimal perturbation to the beam, and it would be possible to test out two such chambers in one phantom, take the ratio of ionisation current from the chambers and measure essentially the same beam quality parameter in real time.

References