Modeling a MLC Scatter Source for In-air Output Factors

Scattered radiation from multi-leaf collimators (MLCs) is no longer negligible for calculating in-air output ratio, $S_c$ for small and irregular fields often used in intensity-modulated radiation therapy (IMRT). An extra-focal source model for scattered radiation from MLCs, namely MLC scatter source, has been developed to improve the accuracy of the $S_c$ calculation.

In this study, characteristics of the MLC scatter source are divided into three cases: (1) MLCs are in retracted position out of beam’s eye view (BEV) defined by collimators; (2) MLC position is located within collimator-defined BEV but does not act on the change of detector’s eye view (DEV); and (3) MLC position is located within collimator-defined BEV and acts on the change of the DEV simultaneously, as illustrated in Figure 1. In case 1, the effect of scattered radiation from MLCs on the in-air output factor was negligible or non-existent. The MLC scatter source model consisted of two Gaussian functions for case 2 and case 3. The two Gaussian functions for each case have combination of edge Gaussian function, $EG$ and area Gaussian function, $AG$. The edge Gaussian function describes the scattered radiation from MLC-rounded edge and the area Gaussian function describes the scattered radiation increasing with irradiated area on the MLCs. The intensity distributions of the developed source model for case 2 and case 3 for collimator-defined field size of $20 \times 20 \text{ cm}^2$ are given in Figure 2.

To evaluate the effectiveness of the developed source model, measurements were made for various MLC-defined irregular or square fields. The calculated $S_c$ data by using (1) the developed source model and (2) the conventional dual source model were compared with the measured data for MLC-defined field sizes of $4 \times 4 \text{ cm}^2$ to the collimator-defined field size within fixed collimator sizes, $10 \times 10 \text{ cm}^2$, $15 \times 15 \text{ cm}^2$, $20 \times 20 \text{ cm}^2$ and $25 \times 25 \text{ cm}^2$ (Figure 3).

**Figure 1.** A schematics showing the geometrical relationship of multi-leaf collimator (MLC) position relative to collimators in terms of beam’s eye view (BEV) and detector’s eye view (DEV) for (a) case 1, (b) case 2 and (c) case 3.
Figure 2. The relative intensity distributions of the MLC scatter source, (a) $ES_{\text{mlc,out}}$ for case 2 and (b) $ES_{\text{mlc,in}}$ for case 3 that contain the two Gaussian functions, respectively.

Figure 3. The comparison between the measured and calculated two $S_e$ by using the dual-source model and the MLC scatter source model for MLC-defined square field sizes of $4 \times 4 \text{ cm}^2$ to the collimator-defined field size of (a) $10 \times 10 \text{ cm}^2$, (b) $15 \times 15 \text{ cm}^2$, (c) $20 \times 20 \text{ cm}^2$ and (d) $25 \times 25 \text{ cm}^2$. The vertical-dotted line shows the scatter interface of collimator-defined field size to separate between case 2 and case 3.