Determination of the penumbra width of Elekta SRS Cone Collimator for 6 MV FF and 6 MV FFF energies using Gradient-Based Edge Detection

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The dosimetric measurements of small fields of radiation are undertaken with detectors such as: GafchromicTM films, diodes, diamond detectors and ionization chambers of small volumes. The penumbra width, e.g. the spatial distance between 80 and 20 % dose, is smaller in small fields. This fact increases the curvature and hence the volume effect in the penumbra region [1]. The accuracy in the penumbra calculation is important at the QA test for implementation of the some cranial Stereotactic Radiosurgery. The objective of this work is to apply a Gradient-Based Edge Detection plugin to calculate the penumbra of a radiation beam defined with the Elekta SRS Cone Collimators for beams of 6 MV (Flattening Filter – FF) and 6 MV (Flattening Filter Free – FFF) energies using the beam profile obtained with GafchromicTM film. These films were used for the measurements of beam profiles for SRS Cone Collimators with cone sizes from 5 to 35 mm diameter. Initially, the EBT3 film calibration curve was obtained. For irradiation, the films were placed between Solid Water slabs in a perpendicular orientation to the beam central axis (CAX), and they were irradiated by 500 monitor units (MU). The measurements were performed at 10 cm depth and 90 cm source-surface distance (SSD). The measurements were evaluated by EPSON EXPRESSION 10000 XL (74 dpi resolution)[2]. The analysis was performed using Mephysto, PTW. The dose calibration curve was fitted using a polynomial function. Each field projection on film was considered an original image, and an inplane f(x) and crossplane f(y) dose profiles along the center image line were defined. Computing the first derivative of f(x) from left to right as $f'(x) = \frac{df(x)}{dx}$ and f(y) from gun to target (accelerator direction) as $f'(y) = \frac{df(y)}{dy}$ results in a positive curve above the x-axis at those positions where the intensity rises and negative curve below the x-axis where at value of function drops, both on orthogonal (f'(x), x). Similarly for derivative of f(y) [3]. The results corroborate those from the literature, and they allow a quantitative evaluation of the width of dosimetric penumbra by Gradient-Based Edge Detection.

Keywords: Small field dosimetry, Stereotactic radiotherapy, SRS Cone Collimator.

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