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Comparison of Titanium and Aluminum Functions as Spoilers for Dose Uniformity Achievement in Abutting Oblique Electron Fields: A Monte Carlo Simulation Study

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Abstract : Introduction Using electron beam is widespread in radiotherapy. The main criteria in radiation therapy is to irradiate the tumor volume with maximum prescribed dose and minimum dose to vital organs around it. Using abutting fields is common in radiotherapy. The main problem in using abutting fields is dose inhomogeneity in the junction region. Electron beam divergence and lateral scattering may lead to hot and cold spots in the junction region. One solution for this problem is using of a spoiler to broaden the penumbra and uniform dose in the junction region. The goal of this research was to compare titanium and aluminum effects as a spoiler for dose uniformity achievement in the junction region of oblique electron fields with Monte Carlo simulation. Dose uniformity in the junction region depends on density, scattering power, thickness of the spoiler and the angle between two fields. Materials and Methods In this study, Monte Carlo model of Siemens Primus linear accelerator was simulated for a 5 MeV nominal energy electron beam using manufacture provided specifications. BEAMnrc and EGSnrc user code were used to simulate the treatment head in electron mode (simulation of beam model). The resulting phase space file was used as a source for dose calculations for 10×10 cm2 field size at SSD=100 cm in a 30×30×45 cm3 water phantom using DOSXYZnrc user code (dose calculations). An automatic MP3-M water phantom tank, MEPHYSTO mc2 software platform and a Semi-Flex Chamber-31010 with sensitive volume of 0.125 cm3 (PTW, Freiburg, Germany) were used for dose distribution measurements. Moreover, the electron field size was 10×10 cm2 and SSD=100 cm. Validation of developed beam model was done by comparing the measured and calculated depth and lateral dose distributions (verification of electron beam model). Simulation of spoilers (using SLAB component module) placed at the end of the electron applicator, was done using previously validated phase space file for a 5 MeV nominal energy and 10×10 cm2 field size (simulation of spoiler). An in-house routine was developed in order to calculate the combined isodose curves resulting from the two simulated abutting fields (calculation of dose distribution in abutting electron fields). Results Verification of the developed 5.9 MeV electron beam model was done by comparing the calculated and measured dose distributions. The maximum percentage difference between calculated and measured PDD was 1%, except for the build-up region in which the difference was 2%. The difference between calculated and measured profile was 2% at the edges of the field and less than 1% in other regions. The effect of PMMA, aluminum, titanium and chromium in dose uniformity achievement in abutting normal electron fields with equivalent thicknesses to 5mm PMMA was evaluated. Comparing R90 and uniformity index of different materials, aluminum was chosen as the optimum spoiler. Titanium has the maximum surface dose. Thus, aluminum and titanium had been chosen to use for dose uniformity achievement in oblique electron fields. Using the optimum beam spoiler, junction dose decreased from 160% to 110% for 15 degrees, from 180% to 120% for 30 degrees, from 160% to 120% for 45 degrees and from 180% to 100% for 60 degrees oblique abutting fields. Using Titanium spoiler, junction dose decreased from 160% to 120% for 15 degrees, 180% to 120% for 30 degrees, 160% to 120% for 45 degrees and 180% to 110% for 60 degrees. In addition, penumbra width for 15 degrees, without spoiler in the surface was 10 mm and was increased to 15.5 mm with titanium spoiler. For 30 degrees, from 9 mm to 15 mm, for 45 degrees from 4 mm to 6 mm and for 60 degrees, from 5 mm to 8 mm. Conclusion Using spoilers, penumbra width at the surface increased, size and depth of hot spots was decreased and dose homogeneity improved at the junction of abutting electron fields. Dose at the junction region of abutting oblique fields was improved significantly by using spoiler. Maximum dose at the junction region for 15º, 30º, 45º and 60º was decreased about 40%, 60%, 40% and 70% respectively for Titanium and about 50%, 60%, 40% and 80% for Aluminum. Considering significantly decrease in maximum dose using titanium spoiler, unfortunately, dose distribution in the junction region was not decreased less than 110%.

Keywords : abutting fields, electron beam, radiation therapy, spoilers
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