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Optimization of the collimator for spatially fractionated proton therapy of the eye

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Purpose
In spatially fractionated proton therapy (SFTP) the arrays of parallel and narrow proton beams are applied to reduce the impact of irradiation on healthy tissue. At the beam entrance the locally irradiated skin benefits from faster recovery than that observed for the uniform exposure. In the same time, due to the multiple Coulomb scattering of the proton beam, the target volume can be uniformly irradiated.

The main goal of this work was to optimize the construction of mechanical collimators to form minibeam. The theoretical study is concerned to design and test a beam collimator in the shape of mesh and slits that for the parallel 60 MeV proton beam would produce the desired depth dose distribution at a depth relevant for eye proton therapy.

Materials and Methods
Monte Carlo simulations (FLUKA ver. 2011.2x-6) were used as a method to evaluate the dose distributions of SFTP irradiations in several configurations of mechanical collimation. The parameters of the collimator i.e. center-to-center distance (c-t-c), mesh/slits aperture (diameter of spot or width of slit), Collimator-Phantom distance (CPD) and material composition etc. were optimized in order to assure the required dose distribution.

Results
Comparable Peak to Valley Dose Ratio (PVDR) values were obtained for mesh collimators of the larger aperture (spot diameter 0.7-1.0 mm) than for slits collimator (width of slit 0.25-0.5 mm). The results show that proton beam widths 0.7 mm with c-t-c distance 1.4 mm (mesh) and 0.25 mm width with c-t-c distance 0.75 mm are needed to obtain simultaneously uniform dose distribution in the target volume and the high values of PVDR. A larger c-t-c distances (2 mm or more) does not lead to the dose homogeneity in the BP area. Among the considered materials, brass and tungsten are offering the best compromise. The highest PVDR are obtained with a tungsten multislit collimator. The reduction of the Collimator-Phantom distance allows to maximize the dose-volume effects. Despite lower the PVDR values, more advantageous in terms of, manufacturing cost, material processing (drilling holes/slits) and secondary neutrons is used brass collimator.

Conclusions
Spatially fractionated proton therapy SFPT (proton grid therapy) is considered for treatment of eye tumor with sparing eyelids localized on the beam's path after hypofractionated therapy.

For 60 MeV parallel proton beam the mesh diameter of 0.7 mm or the slits width of 0.25 mm was found sufficient to broaden the resulting mini-beams due to the multiply proton scattering in the collimator and in consequence to the homogenous target irradiation.

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