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Pencil Beam Scanning Proton Therapy for Ocular SBRT with Beam-Specific Aperture in a Regular Gantry Room

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Abstract
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Lei Hu [1] , Sheng Huang [2] , Ryan Turner [3] , Francis Yu [1] , Yunjie Yang [1] , Qing Chen [4] , Minglei Kang [4] , Charles B. Simone [1] , Christopher Barker [5] , Haibo Lin [6]

1. Radiation Oncology, New York Proton Center, New York, USA 2. Radiation Oncology, Tianjin Medical University Cancer Institute & Hospital, Tianjin, CHN 3. Physics, New York Proton Center, New York, USA 4. Medical Physics, New York Proton Center, New York, USA 5. Radiation Oncology, Memorial Slo, New York, USA 6. Medical Physics, New York Proton Center, New York, NY, USA

Corresponding author: Lei Hu, hulei01@gmail.com

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Abstract

Objectives:

To investigate the dosimetric benefits of beam-specific apertures on gantry-based pencil beam scanning (PBS) proton therapy for ocular SBRT treatment.

Methods:

Eight consecutive ocular patients previously treated with proton PBS SBRT in our clinical gantry room were reevaluated with the addition of beam-specific aperture for each field. Patients were simulated and treated in the headfirst supine position and immobilized with a customized thermoplastic mask with openings at the ocular level. A gaze fixation device was attached to one side of the thermoplastic mask and extended out with a marker to mitigate the eye movement. Each SBRT plan was robustly optimized with three to four fields and prescribed to 50 Gy in 5 fractions. In this study, a beam-specific aperture of 2 cm thick brass was created for each field. The aperture shape was conformed to the target with 4 mm outward expansion in the beam's eye view. Forward dose calculation was applied to each plan and compared to the clinical plan in the metrics of the target coverage (D95%) and doses to the adjacent organs. All calculations were conducted in Monte Carlo to achieve high accuracy.

Results:

All plans with beam-specific apertures achieved very similar target coverage in comparison to the clinical plans, with D95% at 101% ± 2.4% (clinical plan, in avg ± std) versus 101% ± 3.1% (aperture plan). Compared with the clinical plans, aperture plans significantly reduced the dose to adjacent organs, including: lens DMax from 19.3 ± 6.3 Gy to 4.2 ± 7.4 Gy; cornea DMax from 20.6 ± 5.4 Gy to 4.9 ± 5.1 Gy and DMean from 8.2 ± 2.7 Gy to 0.6 ± 0.9 Gy; conjunctiva DMax from 43.6 ± 7.6 Gy to 40.1 ± 12.4 Gy and DMean from 12.6 ± 2.5 Gy to 3.4 ± 2.1 Gy; lacrimal gland DMax from 39.1 ± 6.9 Gy to 35.0 ± 12.4 Gy and DMean from 20.3 ± 6.9 Gy to 6.9 ± 5.1 Gy. The retina and optic nerve received similar maximal but lower mean doses, with retina DMax from 54.6 ± 0.7 Gy to 54.5 ± 0.6 Gy and DMean from 37.0 ± 3.5 to 27.4 ± 6.7 Gy and optic nerve DMax from 53.0 ± 0.9 Gy to 52.9 ± 0.7 Gy and DMean from 20.0 ± 4.2 Gy to 13.6 ± 4.1 Gy.

Conclusion(s):

The addition of beam specific apertures can potentially reduce doses to the organs adjacent to the target significantly in the PBS proton ocular SBRT treatment, while still achieving similar target coverage. Apertures may allow for optimal gantry-based ocular proton delivery when a dedicated eye line is not available.