Cureus

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Abstract
Published 04/02/2023

Dosimetric Evaluation and Clinical Implementation of a Robust Proton Lattice Planning Strategy

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Categories: Medical Physics, Radiation Oncology
Keywords: proton lattice, lattice radiotherapy

How to cite this abstract
Mossahebi S, Jatczak J, Zhang B, et al. (April 02, 2023) Dosimetric Evaluation and Clinical Implementation of a Robust Proton Lattice Planning Strategy. Cureus 15(4): a880

Abstract

Objectives:

3D-spatially fractionated lattice radiation therapy using pencil beam scanning (PBS) proton therapy hasn't been fully utilized in the clinics. Existing limitations include degradation in plan quality with single-field and in plan robustness with multi-field lattice plans. We propose a practical and robust PBS proton lattice planning method using two fields.

Methods:

The robust PBS lattice plan (RPLP) using two orthogonal beams, a primary beam (PB) and a robust complementary beam (RCB) was done in seven clinical cases (3 lung, 3 pelvis and 1 abdomen) previously treated with photon (VMAT) lattice therapy. PB and RCB deliver 67% and 33% of the prescribed dose, respectively, to 1cm-diameter vertices with 3.2-3.5cm spacing inside the target. These parameters were selected to reduce each beam entrance/skin dose, provide more robust plan as well as improved peak-to-valley dose ratios (PVDR). The PVDR, defined as D10/D90 of gross target volume (GTV), and volume of low dose to GTV of two plans (PBS and photon) were compared. Additionally, a patient specific quality assurance (PSQA) method for RPLP has been designed and tested.

Results:

The RPLP strategy achieved the planning goals (>95% of vertice volumes received 95% of prescription dose) under the position and range uncertainties. An end-to-end test using an anthropomorphic phantom was successfully performed. For all cases, the proposed PSQA resulted >90% gamma passing rate using 3%/1.5mm gamma criteria. On average 30% more number of vertices, larger volume of vertices (18.2±25.9cc vs. 12.2±14.5cc) and higher PVDR (10.5±4.8 vs. 2.5±0.9, $p < 0.005$) were observed for proton lattice plan compared to those of photon. Additionally, proton lattice plans show less low dose to GTV volume than those of photon, V30%: 60.9±7.2% vs. 81.6±13.9% and V10%: 88.3±4.5% vs. 98.6±3.6% ($p < 0.01$).

Conclusion(s):

Robust proton lattice planning method using a pair of primary and robust complimentary beams has been successfully tested and commissioned. The RPLP can generate plans with better quality, 30% more number of vertices, and higher PVDR than clinically acceptable photon lattice plans.