

Prakash Shinde^{*}, Harish Dubey¹, Rohidas Punde², Lalit Chaudhari², Tejpal Gupta², Siddharth Laskar³

^{*} Department of Radiation Oncology, Advanced Centre for Treatment Research and Education in Cancer (ACTREC), Tata Memorial Centre (TMC), India, ¹ Department of Physics, B K Birla College, Kalyan, India, ² Department of Radiation Oncology, Advanced Centre for Treatment Research and Education in Cancer (ACTREC), Tata Memorial Centre (TMC), Homi Bhabha National Institute, India, ³ Department of Radiation Oncology, Tata Memorial Hospital (TMH), Homi Bhabha National Institute, Mumbai, India

Objectives

This study aims to investigate the application of the Proton Multi-criteria Optimization (MCO) module within the commercial Treatment Planning System (TPS) for Pencil Beam Scanning (PBS) Intensity Modulated Proton Therapy (IMPT) planning in Brain Cancer. This study compares the IMPT plans generated using MCO versus the conventional manual planning method based on the dosimetric quality indices for targets and organ-at-risk (OAR) volumes.

Methods

A Cohort of ten patients of brain cancer treated with manual IMPT plans created using Raystation (RaySearch Laboratories, v12A, Stockholm, Sweden) TPS was randomly selected. The MCO-based plans were generated to replicate the clinical objectives attained in the corresponding manually optimized plans, utilizing the Monte Carlo dose calculation algorithm and maintaining identical beam arrangements, planning parameters, robustness criteria, and computational settings. The dosimetric quality of the plans was evaluated using dosimetric parameters and dose indices like Dmean, V95, D98%, D95% and D1%, Conformity Index (CI 98%), Homogeneity Index (HI 95%) for the targets, and Dmax for Serial organs. The body structure was also evaluated for V5, V20, and Dmax. Paired t-tests and Wilcoxon signed-rank tests were used to assess statistical significance.

Results

The MCO plans demonstrated improved target coverage, with mean GTV V95 increasing by 0.52% and GTV Dmean by 0.17%. The worst-case robustness metrics also favored MCO, showing significantly higher CTV D98% ($p = 0.024$) and lower CTV D1% ($p = 0.003$). The conformity improved significantly (mean CI 98% reduced from 0.85 to 0.74, $p = 0.004$) compared with manual plans, and HI 95% showed a favourable trend toward better homogeneity. The brainstem Dmax and Body V5, V20 were comparable between plans, with no statistically significant increase in OAR dose in MCO plans. MCO-based IMPT plans offer superior target coverage, improved dose conformity, and enhanced robustness compared to manual planning, without increasing OAR dose.

Conclusions

These findings support the clinical adoption of MCO as a reliable strategy for improving plan quality in proton therapy. Clinicians may prefer MCO for its automation and robustness, but manual planning remains competitive, with minimal differences for most metrics.
