Practical Implementation of VMAT based Craniospinal Irradiation (CSI) for Metastatic Leptomeningeal Disease

Jose R. Teruel PhD, David Barbee PhD, Sagarika Jain MS, Benjamin Cooper MD, Joshua Silverman MD, PhD, Jonathan Yang MD, PhD, Paulina Galavis PhD
NYU Grossman School of Medicine, NYU Langone Health, New York

2026 JULY 19–22 VANCOUVER, BC
JOINT AAPM | COMP MEETING

INTRODUCTION

Leptomeningeal disease is associated with poor outcomes and limited treatment options. Recent studies have shown improved overall survival with proton craniospinal irradiation (CSI) compared with involved-field radiotherapy [1–3]. However, proton therapy is not widely available, particularly in inpatient settings, which are often required for patients with leptomeningeal disease.VMAT-based CSI using photons has emerged as a palliative treatment option for patients with leptomeningeal disease when access to proton therapy is limited or not feasible due to clinical condition.In this study, we describe our initial experience implementing VMAT CSI in clinical practice for patients with leptomeningeal disease.

MATERIALS AND METHODS

Patients were immobilized using the Orfit all-in-one board and open-face thermoplastic masks for the head/neck/shoulders and chest/abdomen during CT simulation. Treatment planning was automated using a custom ESAPI script in Varian Eclipse v18. The script uses the structure set as input to determine isocenter placement and treatment field setup. A three-isocenter configuration is automatically generated to ensure coverage of the full craniospinal target and an initial field overlap of at least 10 cm for feathering between fields that do not share an isocenter. Three fields are created for the superior isocenter (collimator angles of 5°, 355°, and 80°), and two fields are created for each spine isocenter (collimator angles of 5° and 355°). Additionally, the script creates setup fields, optimization structures (PTV subdivisions, rings, and OAR-sparing structures), and optimization goals. Treatment delivery includes CBCT imaging at each isocenter. In-house software was implemented to ensure that residual alignment errors between images remain within PTV expansion margins (3 mm for the head and 5 mm for the spine). In vivo dosimetry is performed using EPID-based transit dosimetry for each fraction with the SNC PerFraction module, using a gamma criterion of >90% passing at 5%/5 mm.

RESULTS

Twenty patients without prior radiotherapy completed treatment to 30 Gy in 10 fractions, 30 Gy in 15 fractions, or 24 Gy in 12 fractions as part of two IRB-approved single-institution clinical trials. PTV coverage of V100% = 95% was achieved in all cases. Organ-at-risk objectives were adapted from Table 1A of the proton CSI study by Yang et al. AAPM_poster_VMAT-CSI.pptx and were achieved in all cases except for lung V5Gy < 20% and heart V5Gy < 40%, due to low-dose spillage from photon delivery. Dose feathering between fields ranged from 6.5 to 11 cm. Total treatment delivery time ranged from 30 to 45 minutes, unless re-setup or treatment interruption was required. In vivo transit dosimetry passed >90% of points at 5%/5 mm for each individual field.

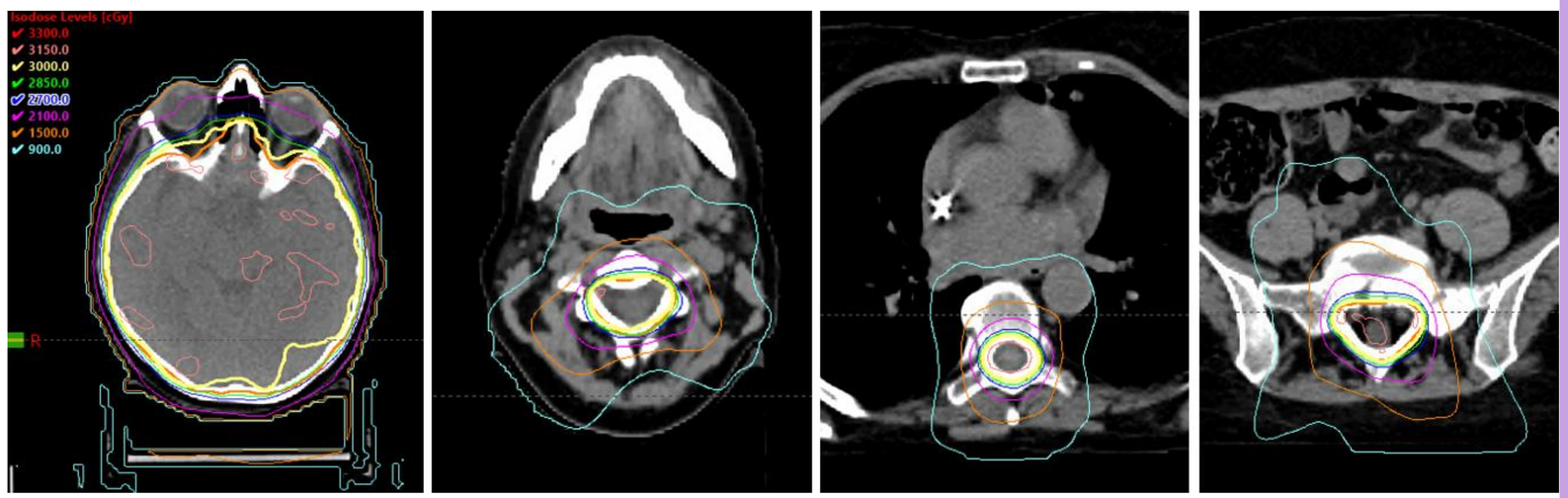

Figure 1. Axial views of dose distribution across head, cervical spine, thoracic spine, and lumbosacral spine.

Discussion

CSI has been shown to provide better disease control for leptomeningeal disease compared with involved-field radiotherapy. Proton CSI is used because it can spare healthy tissue, but access may be limited or unavailable in the inpatient setting. VMAT-based CSI using photons can help bridge this access gap and offers several advantages over conventional photon CSI, including improved target coverage, greater dose conformity, better organ sparing, reduced hot spots, safer delivery through field overlap and feathering rather than field junctions, and the ability to treat with a single plan without junction shifts.

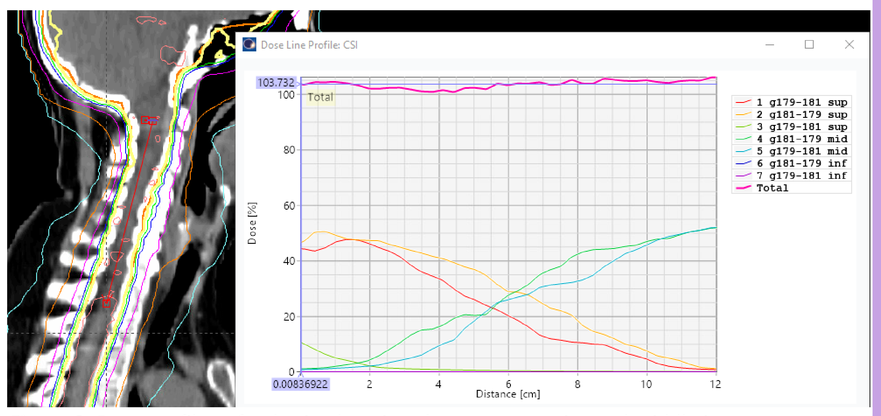

Figure 2. Dose profile at feathering locations between superior and middle isocenter.

Conclusion

VMAT-based CSI using photons for the management of leptomeningeal disease can achieve organ sparing comparable to that reported in proton studies, except for greater anterior low-dose spillage. Dose feathering between fields allows treatment with a single plan, eliminating the need for junction shifts and improving safety while reducing the risk of hot spots or underdosed regions.

Contact

Jose R. Teruel
Department of Radiation Oncology
NYU Grossman School of Medicine, NYU Langone Health
Email: jose.teruel@nyulangone.org

References

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