Small Volume Lattice Treatment Planning Automation for Head and Neck malignancies: A Feasibility Study

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INTRODUCTION

Spatially fractionated radiotherapy (SFRT) using Lattice is a novel therapeutic approach for bulky, unresectable tumors and has been used primarily in the palliative setting. At our institution, we are evaluating SFRT in two prospective clinical trials: as an adjunct to immunotherapy prior to definitive radiotherapy in oropharyngeal cases to potentiate the immune response, and for tumor debulking prior to surgery in oral cavity cases. In this setting, smaller spheres (vertices) with reduced separation are required compared with the palliative setting. This work introduces a framework to automate treatment planning for small-volume lattice radiotherapy in head and neck malignancies and to report common SFRT metrics in a standardized manner.

MATERIALS AND METHODS

Six retrospective CT datasets of head and neck tumors with contoured GTVs were used. An ESAPI script v18 was developed to automate sphere placement and treatment planning.

1. Sphere centers were placed using greedy farthest-point (blue-noise/Poisson-disc) sampling within a GTV eroded by an anisotropic inward margin, while respecting user-defined avoidance regions (e.g., the neurovascular bundle). If the target sphere count, corresponding to a minimum total sphere volume of 0.5% of the GTV volume, was not achieved, the spacing constraint was relaxed iteratively in 2 mm increments.

MATERIALS AND METHODS (cont.)

2. For treatment planning, the script sets the isocenter at the centroid of the GTV, creates arc fields using 6XFFF energy, and defines a series of optimization structures and objectives to achieve sharp dose falloff from the vertices, reduce dose cross-talk between vertices (valleys), and control peripheral dose outside the target.
3. After planning is completed, the script calculates 3D dose profiles and computes the peak-to-valley dose ratio (PVDR) for each sphere and its nearest neighbors. The equivalent uniform dose (EUD) for the GTV is also calculated and plotted over a range of α values from −20 to 20. PVDR and EUD are exported in PDF format for reporting and CSV format for analysis.

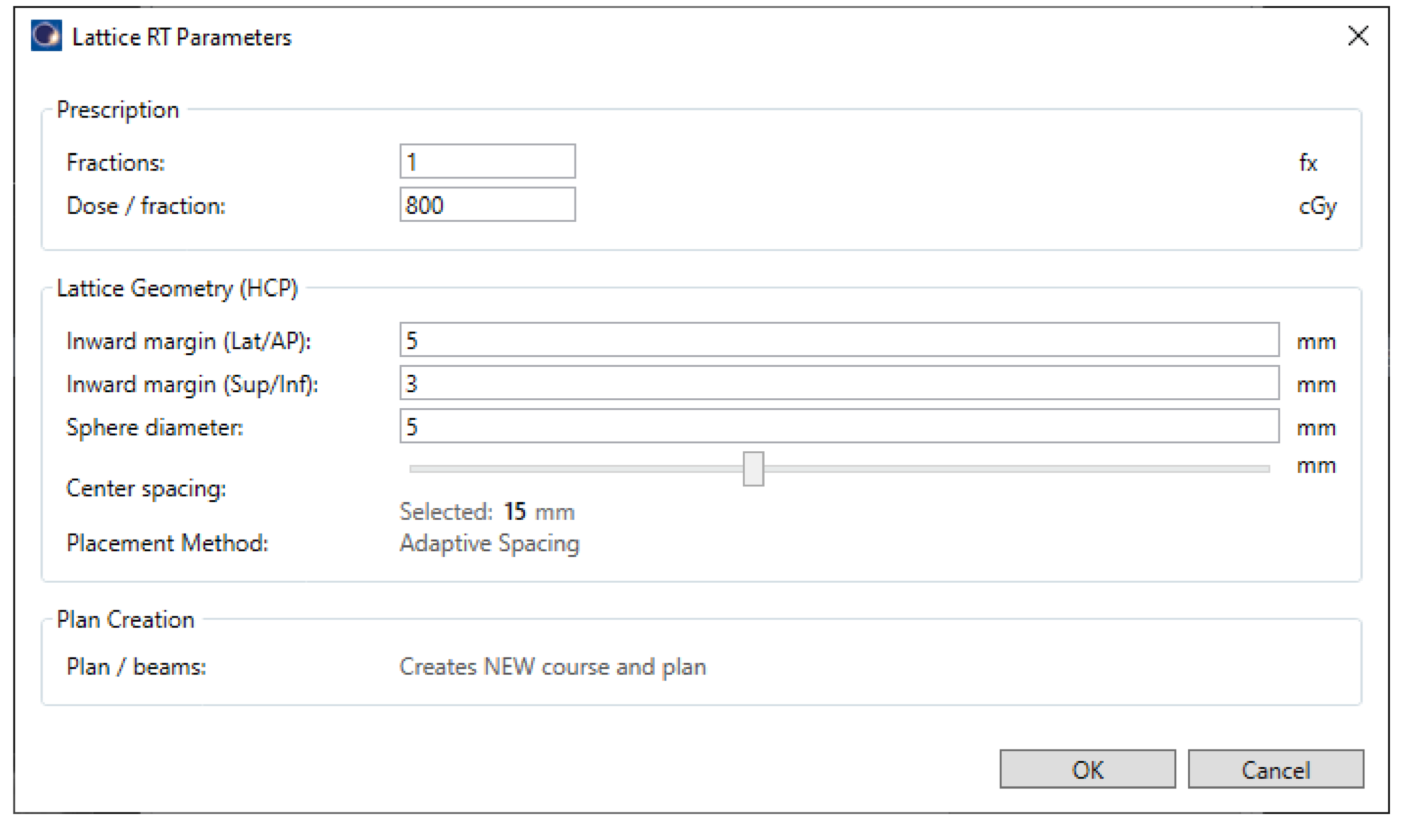

Figure 1. Graphic User Inerface (GUI) for user defined parameters for SFRT planning.

RESULTS

GTV volumes ranged from 16.3 to 87.5 cc. Lattice generation used the following user-selected parameters: sphere diameter, 5 mm; lattice inward margin, 3 mm superior/inferior and 5 mm lateral/anterior-posterior; and minimum vertex separation, 15 mm. For one case, the script reduced the minimum separation to 12 mm to ensure a minimum total sphere volume of at least 0.5% of the GTV volume. The total number of spheres placed ranged from 3 to 9. The prescription to the lattice spheres was 800 cGy in a single fraction for oropharyngeal cases (n=4) and 2700 cGy in 3 fractions for oral cavity cases (n=2). For all cases, each individual sphere achieved D95% ≥ 100%. Using 3D dose profiles, the PVDR for unique nearest-neighbor pairs (maximum separation, 20 mm) ranged from 2.59 to 3.49

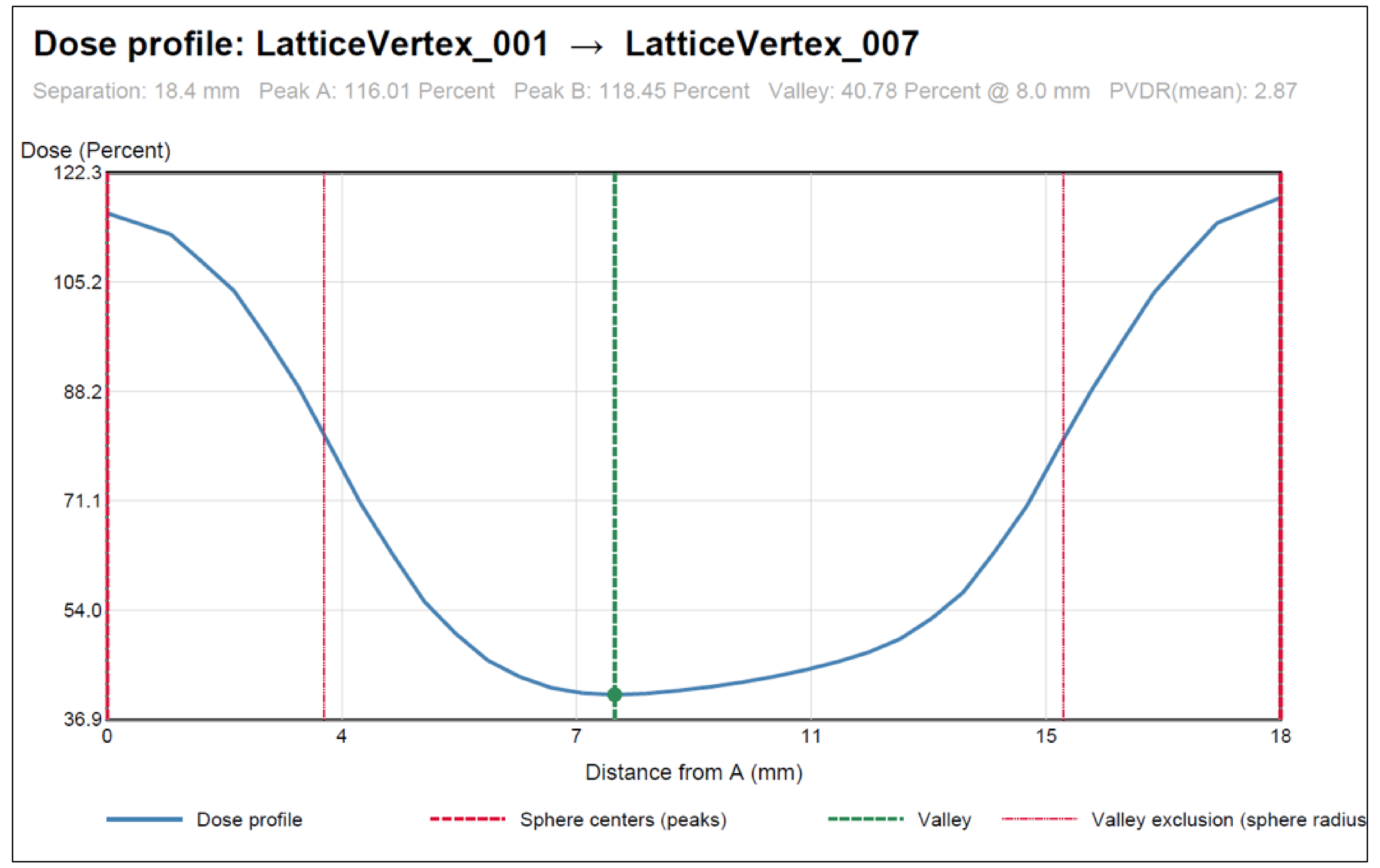

Figure 2. Example of calculated PVDR between two spheres from figure 3.

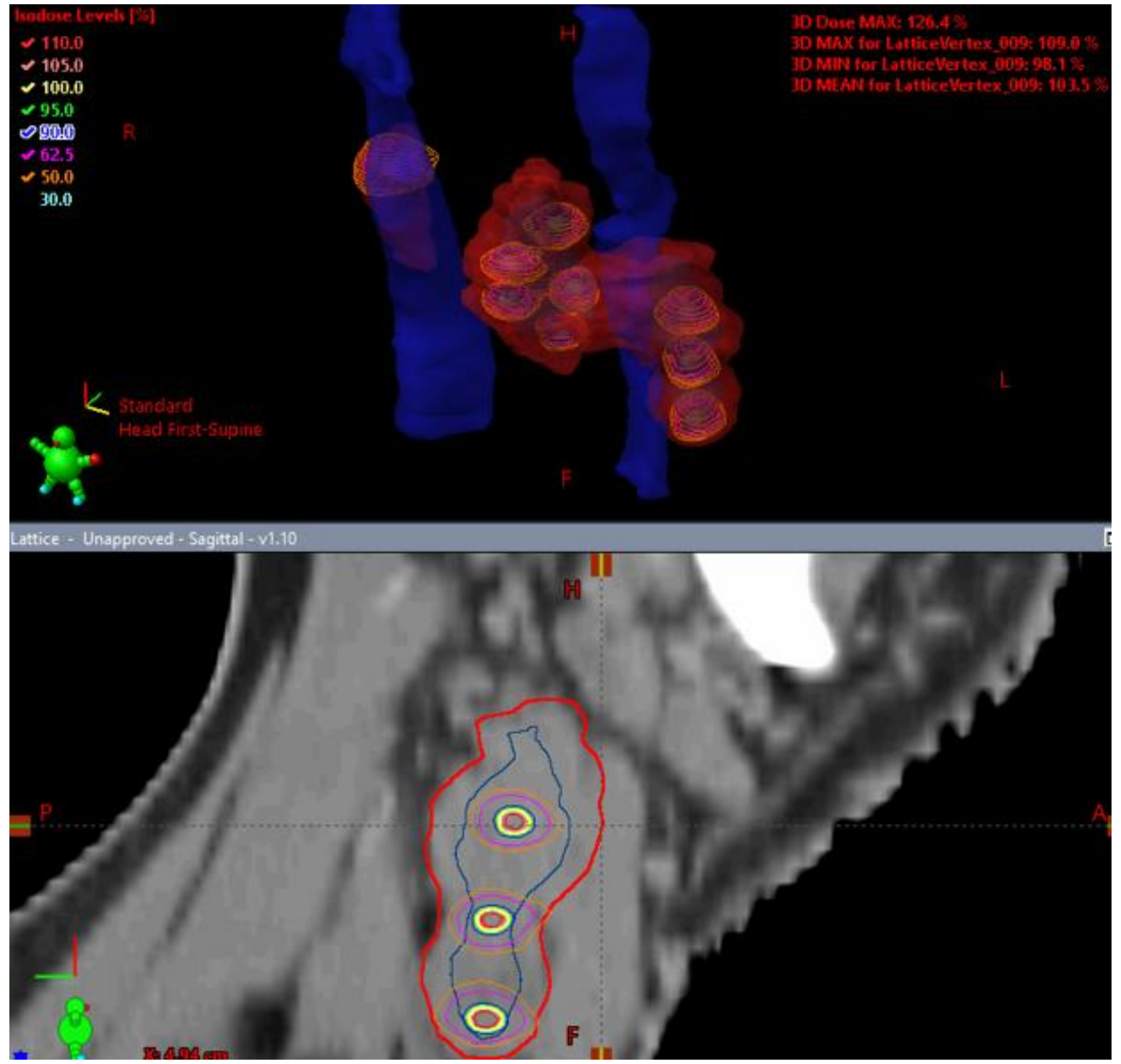

Figure 3. Oropharynx SFRT plan. **Top:** 3D view of GTV (red) neurovascular bundle (blue) and spheres with dose distribution (n=9). **Bottom:** Sagittal cross-section showing three spheres and dose distribution.

CONCLUSIONS

Small-volume SFRT poses additional challenges in sphere placement and treatment planning due to smaller spheres, shorter peak-to-valley distances, and more irregular target geometry. These challenges can be addressed by establishing a programmatic treatment-planning framework for sphere placement, treatment planning, and standardized dose-metric reporting.

Contact

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References

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