Feasibility of Online Adaptive Lattice SBRT on the Ethos Platform Under Substantial Anatomical Change

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INTRODUCTION

- Spatially fractionated radiotherapy (**Lattice SBRT**) uses intentional peak-to-valley dose heterogeneity to enable safe dose escalation in bulky tumors.
- Lattice SBRT has relied on **static, non-adaptive** workflows; online adaptive replanning could improve robustness to anatomical change between fractions.
- The **Ethos** platform's Boolean operations and limited optimization time raise questions about preserving lattice dosimetry (sphere placement, PVDR) during adaptation.
- This work tests whether an **oversampled lattice** with Boolean-based adaptation reproduces reference sphere coverage and OAR sparing within practical treatment times.

OBJECTIVE

- **Establish the feasibility of online adaptive Lattice SBRT on the Ethos platform using an oversampled, Boolean-based lattice adaptation strategy under substantial anatomical change.**

METHODS AND MATERIALS

- **Five reference Lattice SBRT plans** were generated for representative treatment sites: two lung, one head & neck, one abdomen, and one chest wall case.
- Each reference plan used an **oversampled high-dose sphere lattice** exceeding the number of spheres ultimately required, allowing spheres to be selectively retained or removed during adaptation.
- Cases were emulated on the **Ethos adaptive platform** using Boolean structure operations to regenerate lattice geometry directly from the adapted target and avoidance volumes at each fraction.
- Adapted plans were reoptimized under the Ethos scripted workflow and compared to the reference plan for **PTV volume, sphere count, target coverage (base and vertex), avoidance-structure dose, peak-to-valley dose ratio (PVDR), monitor units, and planning time.**
- Feasibility was defined as meeting institutional OAR constraints and target coverage goals while completing adaptive optimization within clinically practical timeframes.

RESULTS

- All five emulated adaptive Lattice SBRT plans **met institutional OAR constraints** while maintaining target coverage consistent with prescription goals across all treatment sites.
- The oversampled lattice, Boolean-based strategy accommodated PTV volume reductions of **up to 62%** and up to 3 fewer high-dose spheres without compromising SFRT-specific dose heterogeneity.
- Peak-to-valley dose ratio (PVDR) was preserved through adaptation (reference 3.8–4.1 vs. adapted 3.5–4.3), with a largest single-case deviation of **0.5**.
- Vertex coverage (V66.7Gy) was **essentially unchanged** from reference to adapted plans (95.0–95.1% in both), and base coverage (V20Gy) remained ≥96.3% in all adapted plans.
- Adaptive optimization completed within **clinically practical planning times** (7.1–23.4 min), comparable to reference planning in most cases.

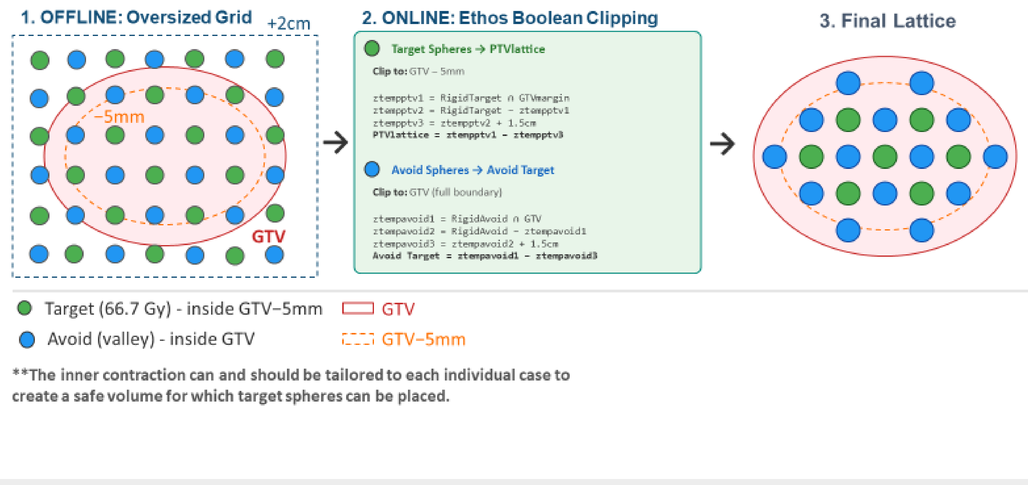

Figure 2. Boolean-based online adaptive workflow for lattice contouring on the Ethos platform.

Metric	Case 1 (Lung)	Case 2 (H&N)	Case 3 (Lung)	Case 4 (Abdomen)	Case 5 (Chest Wall)
PTV volume (cc)	808 / 481	1705 / 1435	538 / 203	1456 / 1267	1673 / 1425
High-dose spheres (n)	8 / 5	14 / 12	5 / 2	16 / 14	20 / 18
Base coverage V20Gy (%)	99.8 / 99.2	99.4 / 99.2	99.3 / 99.3	99.8 / 96.3	98.0 / 97.2
Vertex coverage V66.7Gy (%)	95.1 / 95.1	95.1 / 95.1	95.0 / 95.0	95.1 / 95.1	95.1 / 95.1
Avoid sphere Dmean (Gy)	21.10 / 19.45	22.08 / 21.19	20.19 / 23.46	21.83 / 21.65	20.77 / 23.66
Avoid sphere Dmax (Gy)	26.25 / 22.65	32.90 / 26.75	22.06 / 30.67	28.45 / 28.80	25.73 / 37.55
PVDR (mean)	4.0 / 4.3	3.8 / 3.9	4.1 / 3.6	3.8 / 3.9	4.0 / 3.5
Monitor units (MU)	4870 / 4693	5753 / 5652	5552 / 3555	7442 / 9074	7719 / 8062
Planning time (min)	8.1 / 7.1	19.0 / 17.9	10.2 / 10.3	9.1 / 11.8	23.3 / 23.4

Table 1. Comparison of dosimetric and workflow metrics between the reference and Ethos-adapted Lattice SBRT plans for five anatomical sites, including target volume, sphere count, coverage, avoidance-structure dose, peak-to-valley dose ratio (PVDR), monitor units, and planning time.

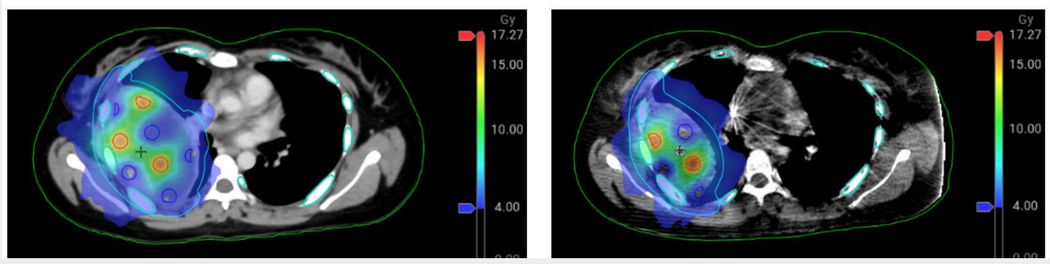

Figure 1. Lattice SBRT case in a lung cancer treatment site. Left: axial dose distribution for the reference plan produced at initial planning. Right: the corresponding adapted plan generated on the Ethos emulator, showing the oversampled lattice adapting its high-dose sphere placement to anatomical change.

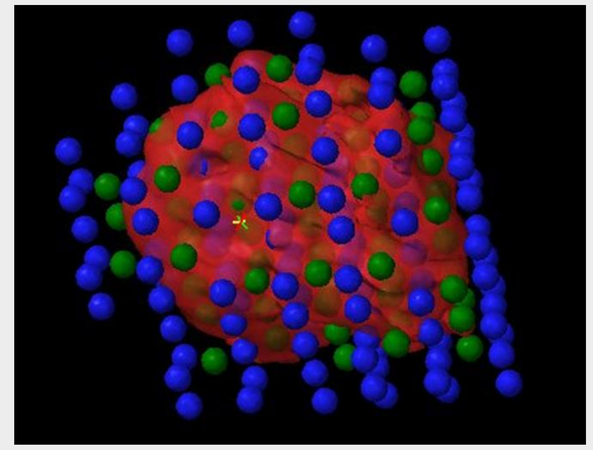

Figure 3. Oversampled high-dose target spheres (green) and avoidance spheres (blue) placed relative to the tumor surface (red) prior to Ethos Boolean-based adaptation.

DISCUSSION

- Online adaptive Lattice SBRT on Ethos is **dosimetrically robust** even under substantial anatomical change, preserving PVDR — the parameter most tied to SFRT's therapeutic rationale.
- The **oversampled lattice design** underlies this robustness: extra high-dose spheres let Boolean adaptation remove spheres that no longer fit the target, rather than forcing an ill-fitting geometry onto changed anatomy.
- Planning times remained clinically practical across all five sites, supporting integration into **existing online adaptive workflows** without a dedicated offline step.
- Increases in avoidance-structure Dmax in some cases (lung, chest wall) show that **sphere placement near critical structures** still warrants close review.

CONCLUSIONS

- Online adaptive Lattice SBRT is **feasible on the Ethos platform** across diverse anatomical sites, including under substantial anatomical change.
- An oversampled lattice paired with Boolean-based adaptation **preserves SFRT-specific dosimetric characteristics**, including PVDR, within clinically practical treatment times.
- This framework establishes a scalable, physics-driven pathway for safe clinical translation of **adaptive spatially fractionated radiation therapy**.

CONTACT

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