Plan Complexity Reduction in Lung SBRT Using the Aperture Shape Controller and MU Objective

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Introduction

Stereotactic body radiation therapy (SBRT) is widely used for the treatment of lung cancer because it can deliver high doses to the target in a limited number of fractions while maintaining steep dose gradients and conformal dose distributions. However, inverse planning techniques such as intensity-modulated radiation therapy (IMRT) and volumetric modulated arc therapy (VMAT) may generate highly modulated treatment plans to achieve expected target coverage and organ-at-risk (OAR) sparing. Increased plan complexity may be associated with higher monitor units (MU), greater use of small apertures, irregular multi-leaf collimator (MLC) motion, longer beam-on time, and increased sensitivity to delivery uncertainties. Therefore, reducing unnecessary modulation while maintaining dosimetric plan quality is important for improving treatment efficiency and deliverability. The Eclipse treatment planning system provides two optimization tools for controlling plan complexity. The Aperture Shape Controller (ASC) penalizes irregular differences between adjacent MLC leaf positions and promotes smoother aperture shapes. The MU Objective limits the number of MUs during optimization and may reduce excessive modulation. This study evaluated the effects of ASC and MU Objective settings on multiple complexity-related metrics in lung SBRT plans and investigated their potential to reduce plan complexity without compromising dosimetric plan quality.

Methods

- 27 retrospective lung SBRT plans
  - 15 patients: 27 Gy x 1 fraction
  - 7 patients: 34 Gy x 1 fraction
  - 5 patients: 50 Gy x 5 fractions
- ASC re-optimization levels: Very Low, Low, Moderate, High, Very High
- MU Objective settings:
  - strength 75 / 2000 MU limit
  - strength 100 / 2000 MU limit
  - strength 100 / 1500 MU limit
- Complexity metrics: MU/cGy, SAS10mm, MLC irregularity, and 1 minus modulation complexity score (1-MCS)

Conclusions

1. MU Objective produced the largest reductions in MU/cGy, SAS10mm, and 1-MCS.
2. ASC primarily improved MLC motion smoothness, with lower irregularity scores at higher ASC levels.
3. Strength-100 MU Objective configurations with MU limits of 2000 and 1500 can achieve comparable target coverage and OAR sparing.

References

1. Videtic et al. Practical Radiation Oncology 7(5):295-301, 2017.
2. Masi et al. Medical Physics 40(7):071718, 2013.
3. Binny et al. Medical Dosimetry 45(3):284-292, 2020.
4. Jiménez-Puertas et al. Reports of Practical Oncology and Radiotherapy 23(2):121-125, 2018.
5. McNiven et al. Medical Physics 37(2):505-515, 2010.

Results

Effect on MU/cGy

Figure 1. MU/cGy for MU Objective plans

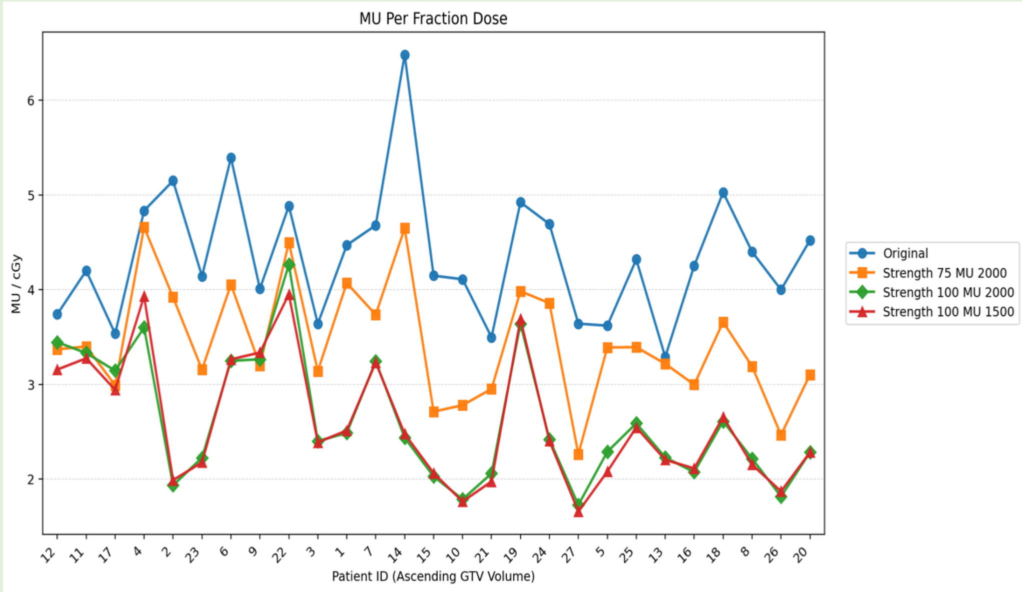
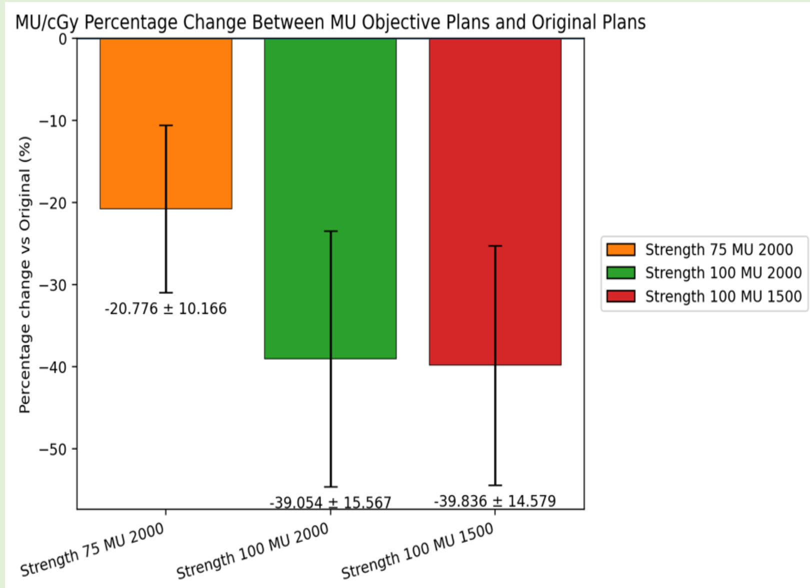


Figure 2. MU/cGy Percentage Change between MU Objective Plans and Original Plans



Effect on SAS10mm

Figure 3. SAS10mm for MU Objective plans

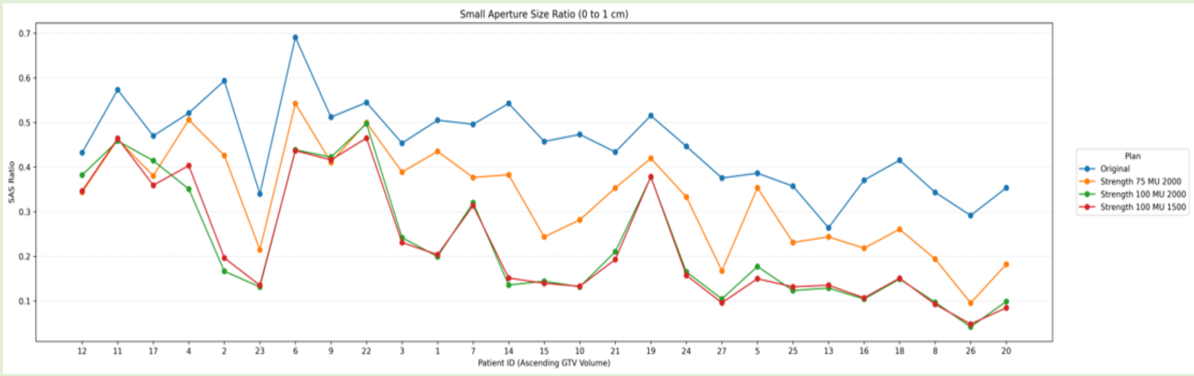
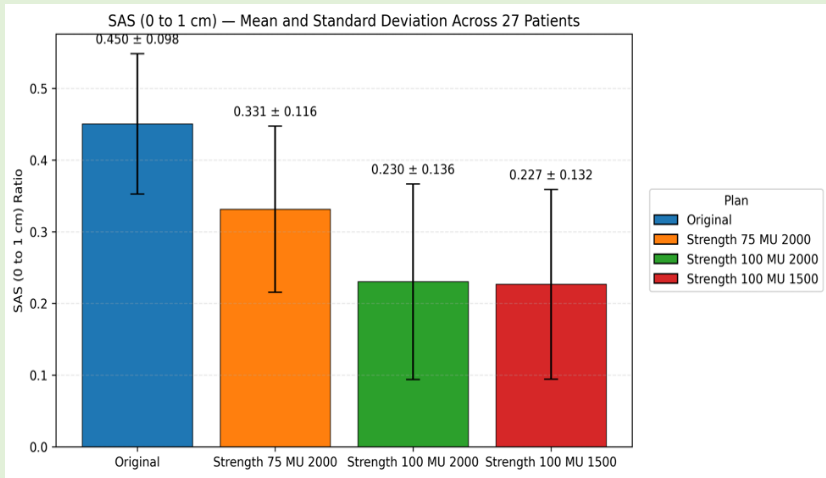


Figure 4. SAS10mm Mean ± SD across 27 patients



Effect on 1-MCS

Figure 5. 1-MCS for MU Objective plans

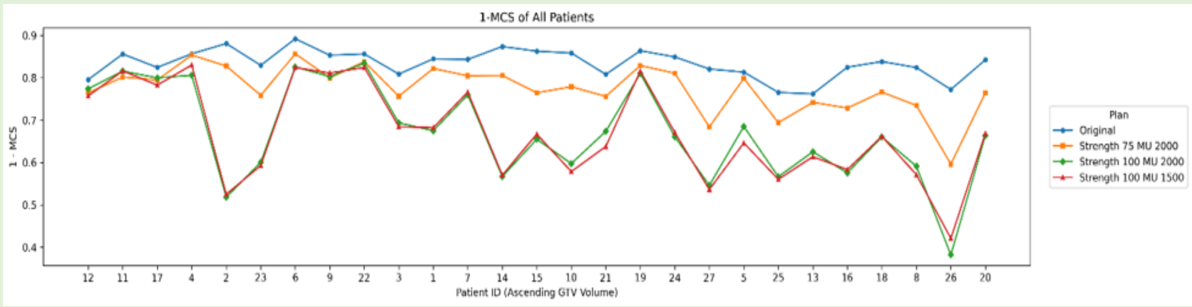
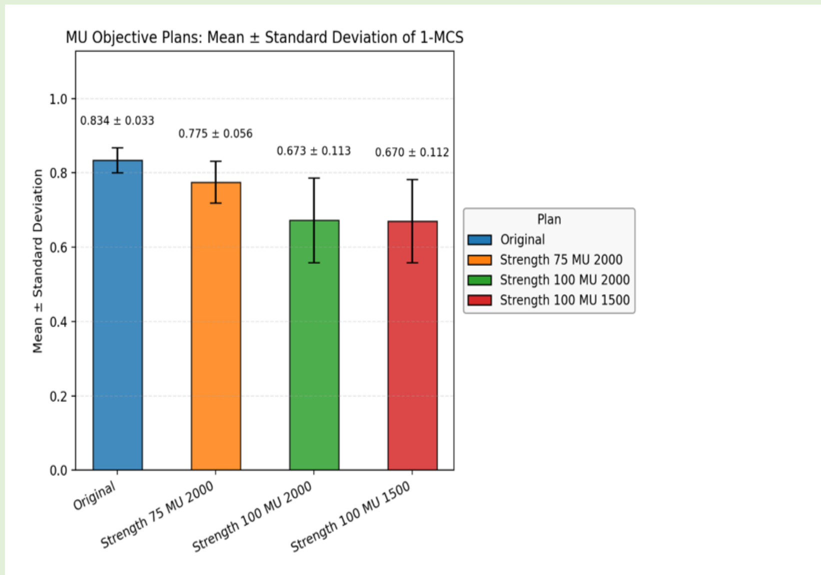


Figure 6. 1-MCS Mean ± SD for MU Objective Plans



Effect on MLC Irregularity Score

Figure 7. MLC Irregularity Score for ASC Plans

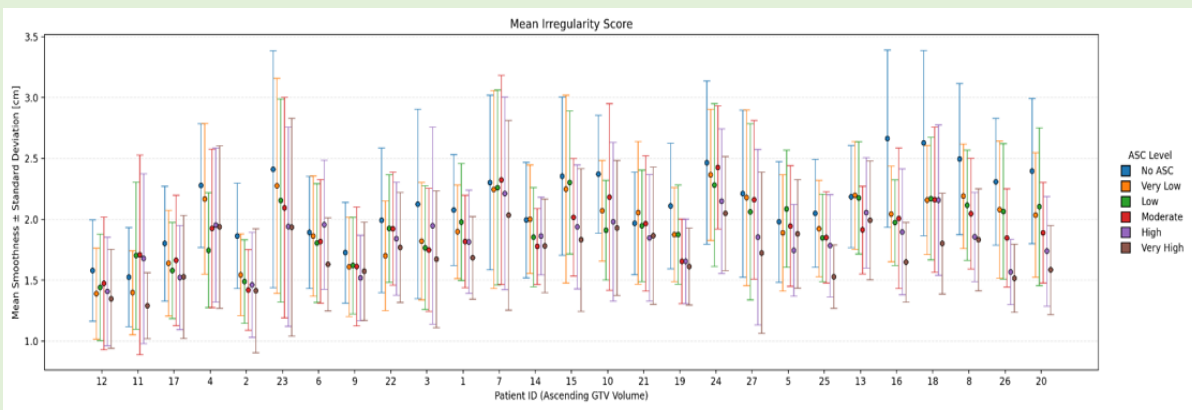
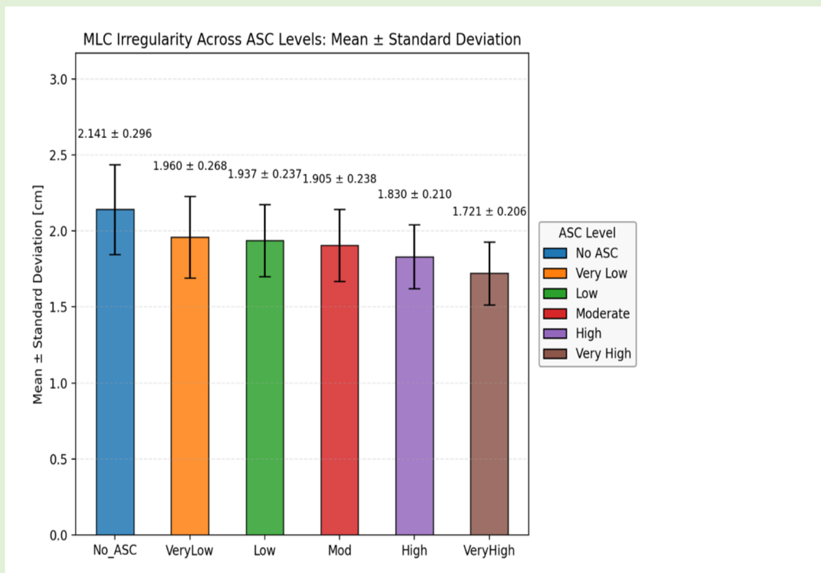


Figure 8. MLC Irregularity Score Mean ± SD for ASC Plans



Note: Patient IDs are arranged from smallest to largest GTV volume in all patient-level figures.