

Exploring the Interplay Effect: A Comparison of GTV Dose Calculation in SBRT Lung Treatment Plans Using Conformal Arc and VMAT Techniques with Robust Evaluation

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INTRODUCTION

- Dynamic conformal arc (DCA) and volumetric modulated arc therapy (VMAT) are commonly used radiotherapy techniques for lung cancer treatment.¹
- While VMAT increases treatment complexity by dynamically adjusting multi-leaf collimators (MLCs), this also introduces the interplay effect.¹
- The interplay effect occurs when the movement of internal structures and targets interacts with the dynamic motion of MLCs, potentially leading to dose distribution errors.¹
- The interplay arises because dose calculations are based on stationary CT images, while the treatment volume moves during delivery. This motion, combined with changing MLCs and gantry positions, can lead to differences between planned and delivered dose distributions.²

PURPOSE

Does the choice of treatment technique, that is from conformal arc vs. VMAT, impact gross tumor volume (GTV) dose calculation when using robust evaluation in lung stereotactic body radiation therapy (SBRT) treatment planning?

METHODS

- Ten previously treated lung cancer patients were selected from the UMMC.
- Each patient was prescribed 55 Gy delivered in five fractions.
- Two SBRT lung treatment plans were created per patient using the conformal arc technique and VMAT.
- Treatment planning was performed using RayStation 2023b with the 4DCT dataset.
- All plans used 6 MV flattening filter-free (FFF) energy with the isocenter placed at the PTV center.
- Half-arc angles were determined based on lung laterality; couch and collimator rotations remained consistent.
- A script was run for each plan to record R100 and R50 values; R100, R50, and D2cm were kept within defined limits.
- Total lung V20 values were recorded for comparing conformal arc vs. VMAT techniques after optimization.

TECHNIQUE

- A robust evaluation was conducted: GTV-to-ITV distances in all dimensions were measured
- Input into RayStation's robust evaluation function (**Fig. 1**)
- Both nominal and worst-case scenario doses to GTV were documented
- Dosimetric data (means and standard deviations) were collected.
- A two-tailed paired Student's t-test ($\alpha = 0.05$) was performed due to the small sample size.

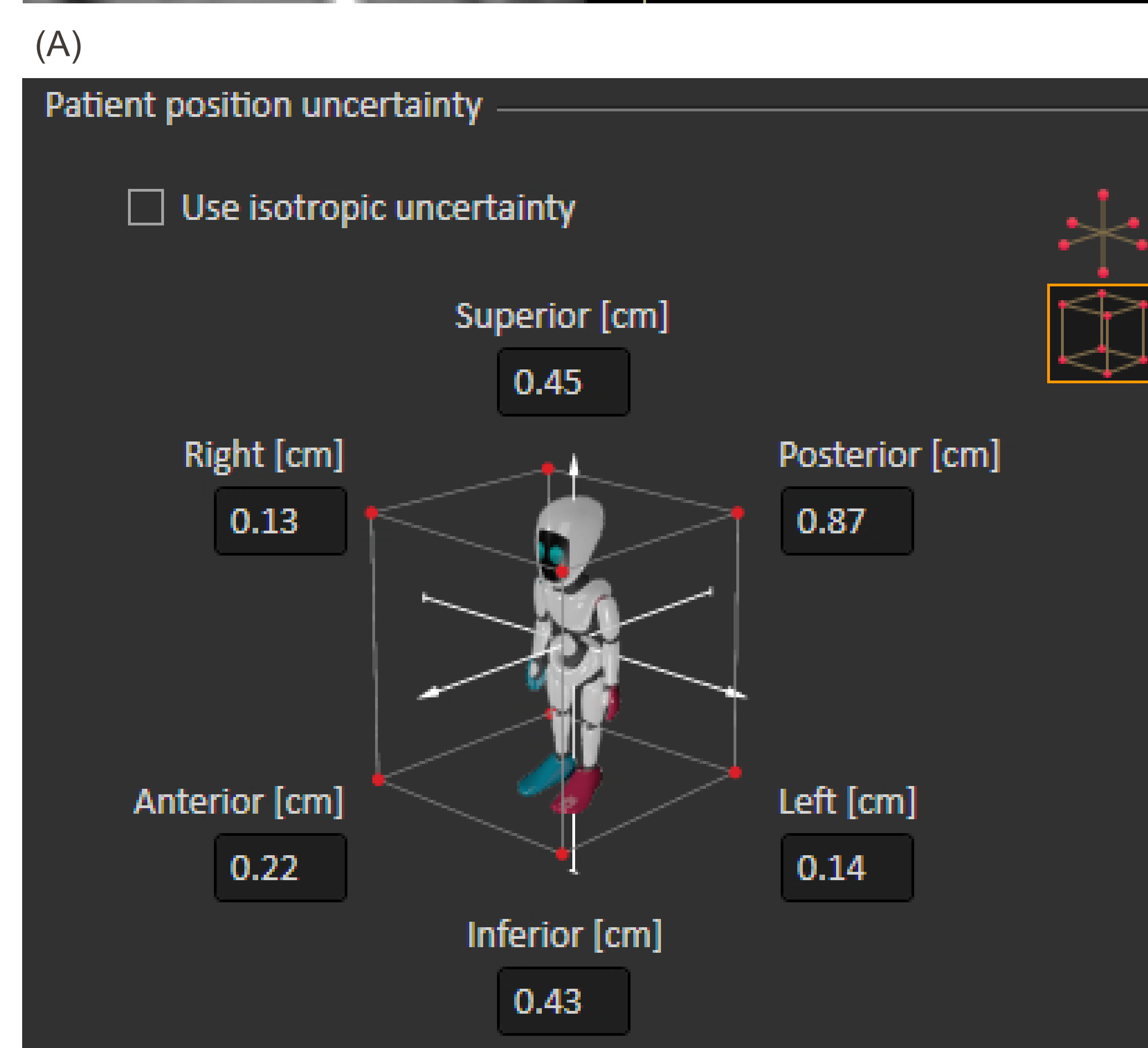
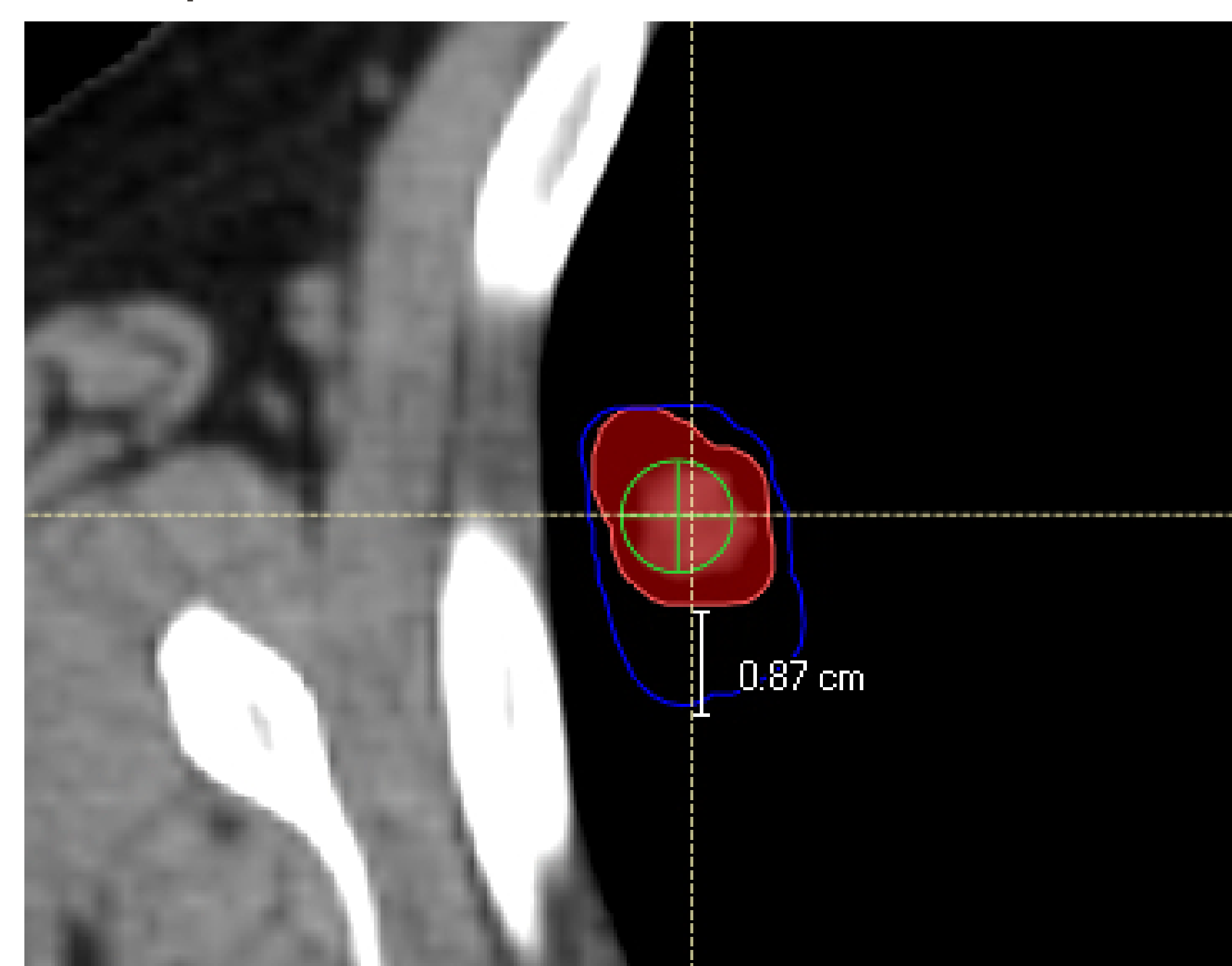


Fig. 1. Robust Evaluation: (A) shows the measurement of GTV-to-ITV in the posterior direction. (B) illustrates the documentation of measurements from all dimensions integrated into a scenario for robust evaluation.

RESULTS

A significant difference in GTV dose coverage was observed between the original conformal arc plan and the robustly evaluated plan, with a p -value of 0.023.

No significant difference in GTV dose coverage was found between the original VMAT plan and its robustly evaluated counterpart, with a p -value of 0.092.

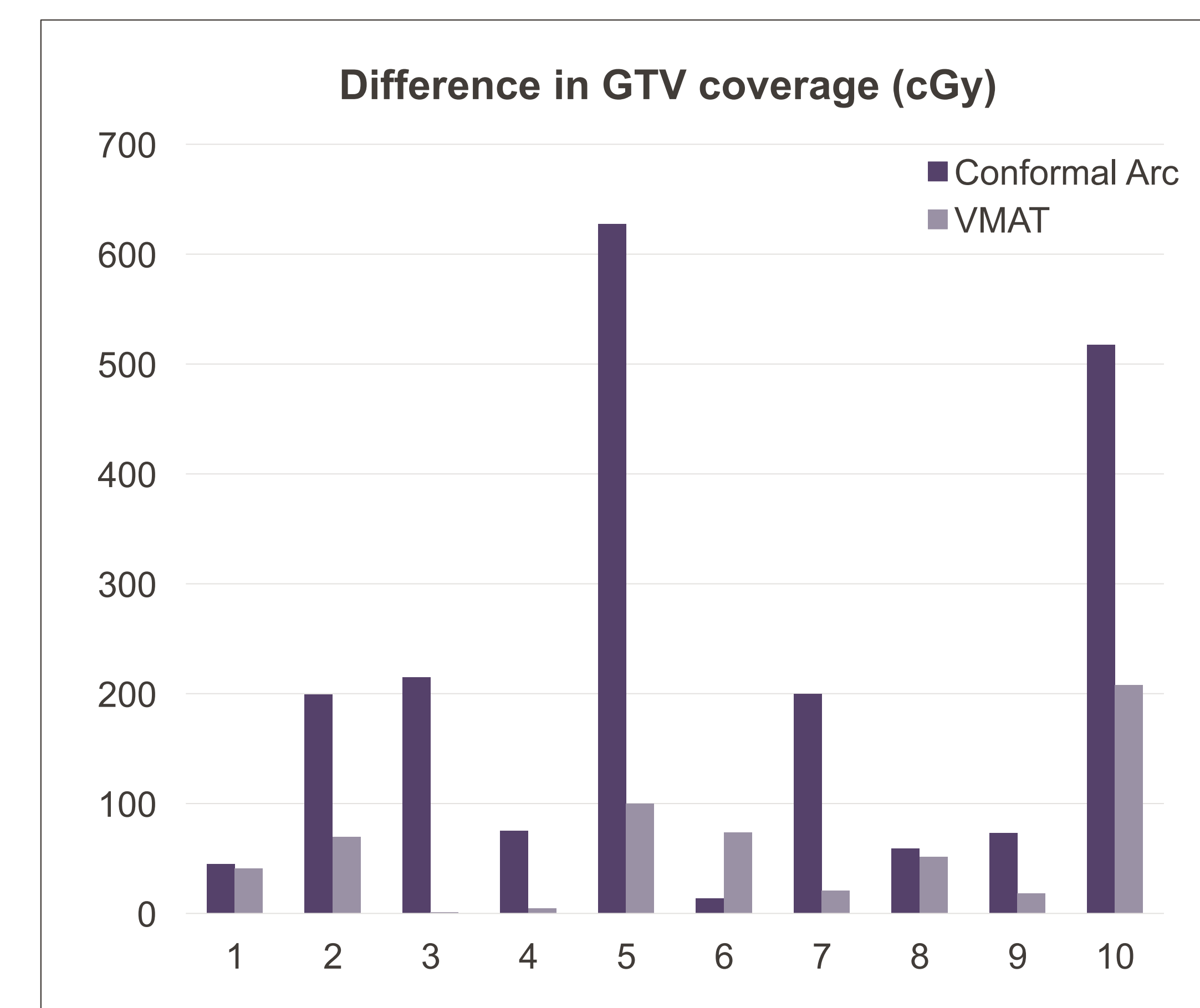


Fig. 2. Graphical representation comparing GTV coverage differences between conformal arc and VMAT plans after robust evaluation

- A significant difference (**Fig. 3**) in R100 values between conformal arc and VMAT plans was observed ($p = 0.038$).
- No significant difference (**Fig. 4**) in R50 values between conformal arc and VMAT plans was found ($p = 0.134$).
- No significant difference (**Fig. 5**) in V20 total lung values between conformal arc and VMAT plans was found ($p = 0.195$).

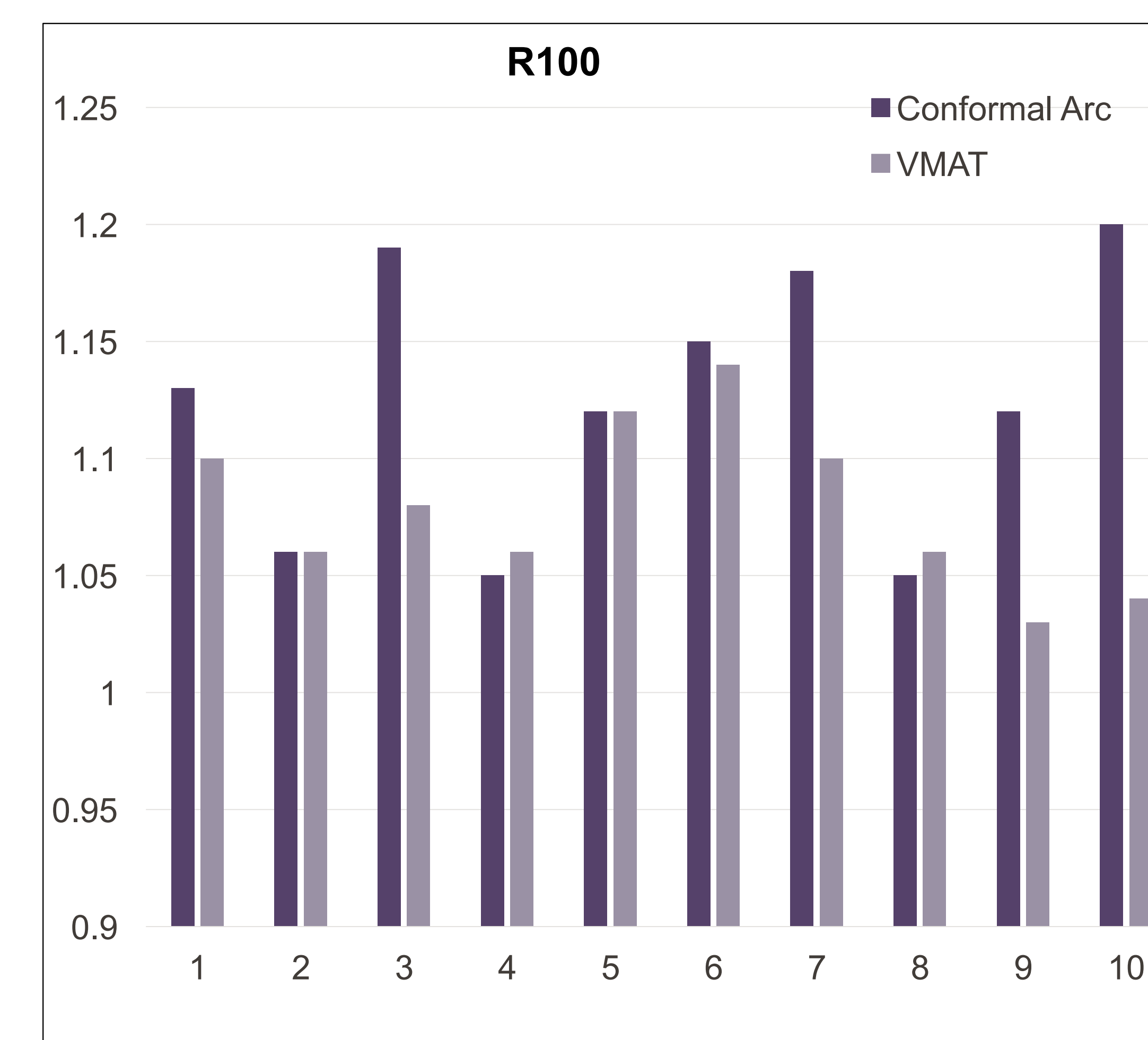


Fig. 3. A comparison of R100 between a conformal arc and VMAT plan.

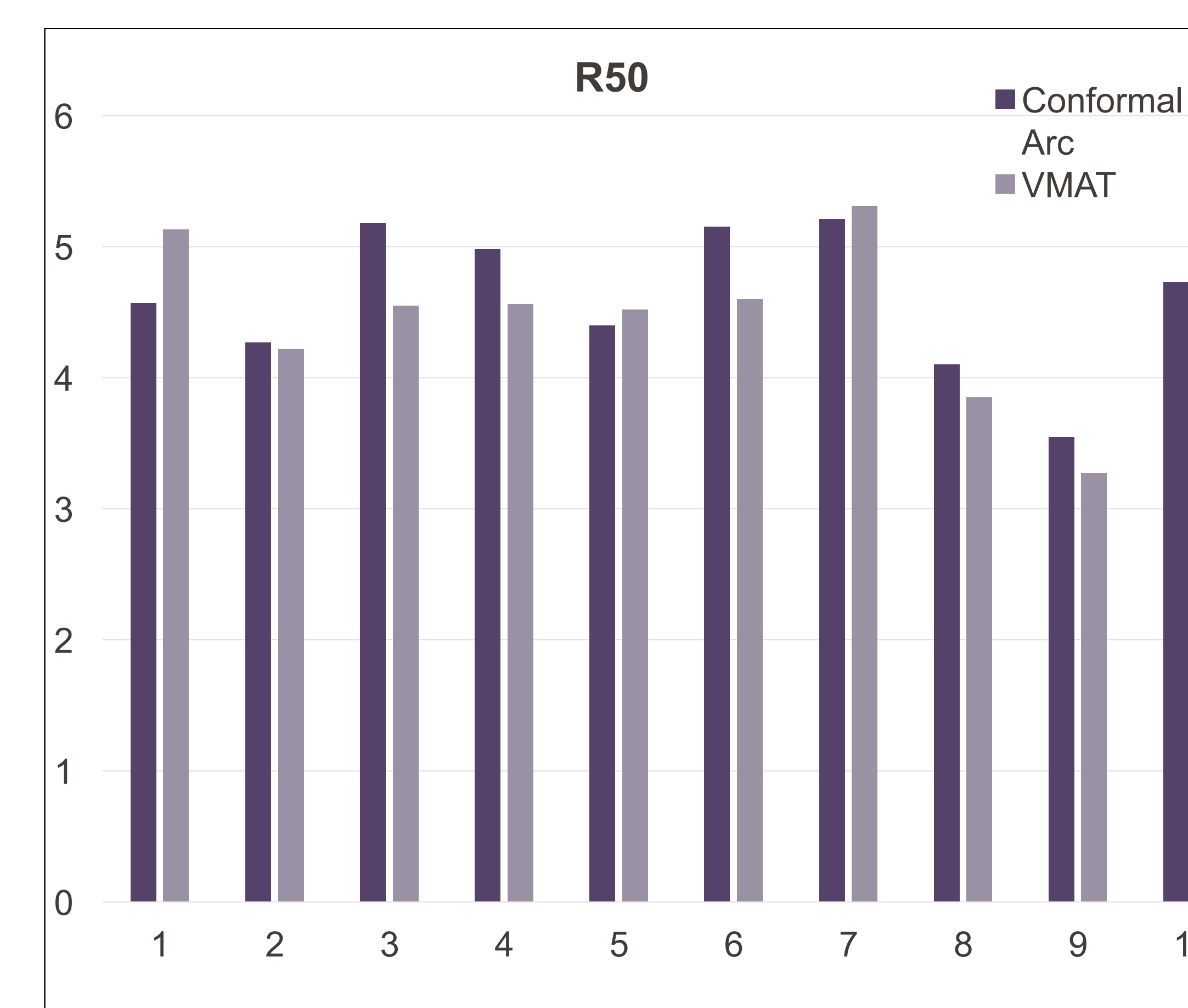


Fig. 4. A comparison of R50 between a conformal arc and VMAT plan.

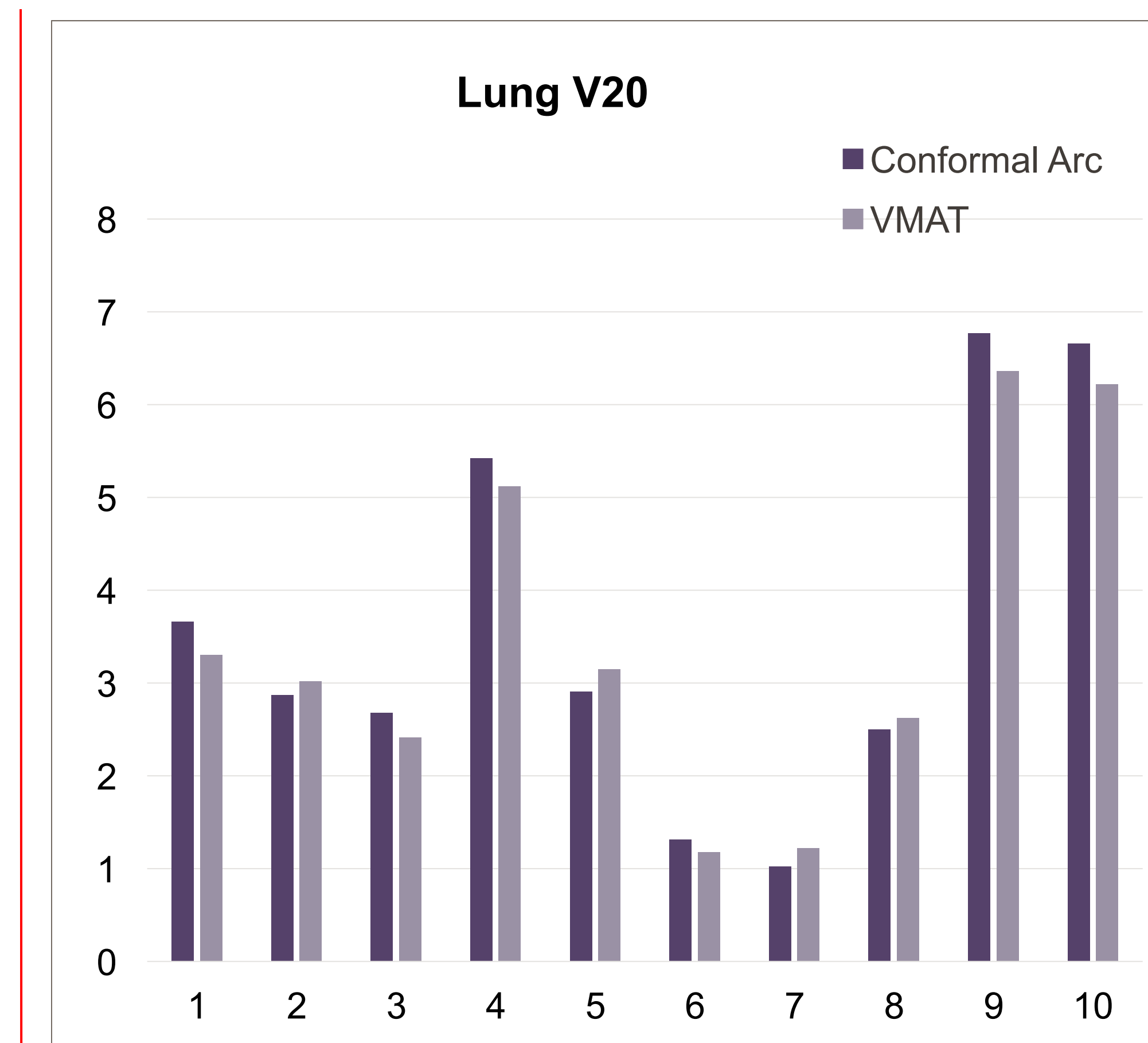


Fig. 5. A comparison of V20 between a conformal arc and VMAT plan

CONCLUSION

- The study (**Fig. 2**) confirmed that the choice of treatment technique affects GTV dose calculation under robust evaluation; a significant difference was observed for conformal arc plans, while VMAT plans showed no significant difference.
- The hypothesis that VMAT is more sensitive to GTV motion and would significantly impact dose was rejected.
- Despite observed differences, GTV dose remained above the prescription level for both techniques, suggesting limited clinical significance; further research on interplay effects is recommended.

References

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