

Organs-At-Risk Sparing Using Midline MLC Travel Limits for VMAT on Varian Ethos

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ABSTRACT

Purpose: Limiting jaw position across midline is a common inverse-planning strategy to minimize dose to normal tissue and improve conformality when treating irregular targets. However, jawless linacs, like Varian Ethos and Halcyon, lack an analogous, planner-controlled method. In this study, we evaluated the effect of restricting MLC leaf travel across midline on organ-at-risk (OAR) dose while maintaining target coverage in prostate and node VMAT plans.

Methods: Five prostate+node patients previously treated at our clinic were replanned using the open-source ORIBIT-RT Prostate+Nodes RapidPlan (Varian Ethos Photon Optimizer) model. For each patient, two VMAT plans were generated using the same prescription, field arrangement, planning objectives, and constraints. Both plans met the same target coverage criteria V100%rx>99%). One plan allowed unrestricted leaf travel while the other applied symmetric MLC travel limits about the isocenter (± 3.0 cm laterally, ± 2.0 cm superior-inferiorly). The resulting plans' DVH metrics were compared for the bladder, large bowel, small bowel, left and right femoral heads, penile bulb, and rectum. Paired, two-tailed t-tests were used for mean-dose and prescription-metric comparisons.

Results: Statistically significant mean-dose reductions were observed for bladder ($p=0.004$) and right femoral head ($p<0.0001$). Maximum dose was comparable or reduced for all OARs (mean change -0.38%). DVHs demonstrated the most consistent improvements across patients for bladder, large bowel, and femoral heads, with minimal change for remaining OARs. Additionally, clinical, OAR metrics showed moderate improvement with V45Gy and V41Gy significantly lower for large bowel ($p=0.02$) and bladder ($p=0.007$), respectively.

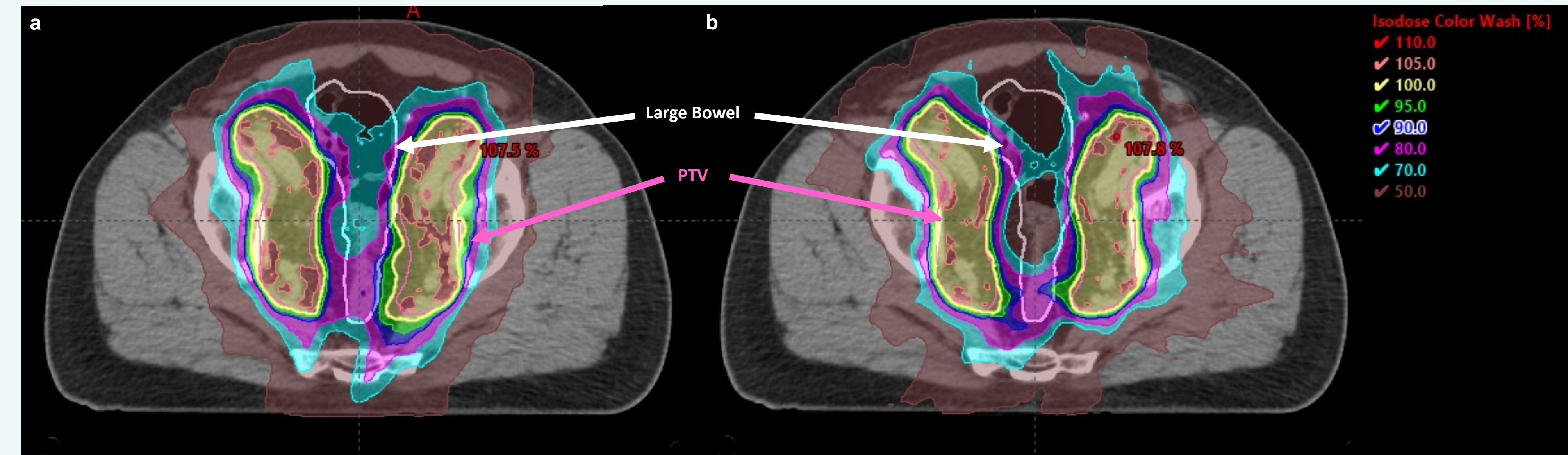
Conclusion: Limiting leaf travel positions reduced OAR dose in prostate+node VMAT plans, without sacrificing target coverage, suggesting it can function as a practical surrogate to limiting jaw motion on jawless linacs. This low-effort, RapidPlan-compatible, planner-driven technique is readily deployable and with additional validation in larger patient cohorts could be extended to additional complex sites, such as head and neck.

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METHODS

- Dataset:** 5 prostate+node plans treated on Varian Ethos
 - Matched OAR contours:** Bladder, large bowel, small bowel, left and right femoral heads, penile bulb, and rectum
 - Prescription:** 5040cGy to 99% of PTV volume
- Group 1:** Unrestricted MLC leaf travel; **Group 2:** Limit MLC leaves from traveling symmetrically around isocenter (± 3.0 cm laterally, ± 2.0 cm superior-inferiorly)
- Planning Strategy:** Use ORIBIT-RT Prostate+Nodes RapidPlan in Varian Eclipse Photon Optimizer to maintain optimizer conditions and beams between patients
- Analysis:**
 - DVH metrics were pairwise compared for each patient
 - Paired, two-tailed t-tests were used for mean-dose and prescription-metric comparisons; alpha-level <0.05

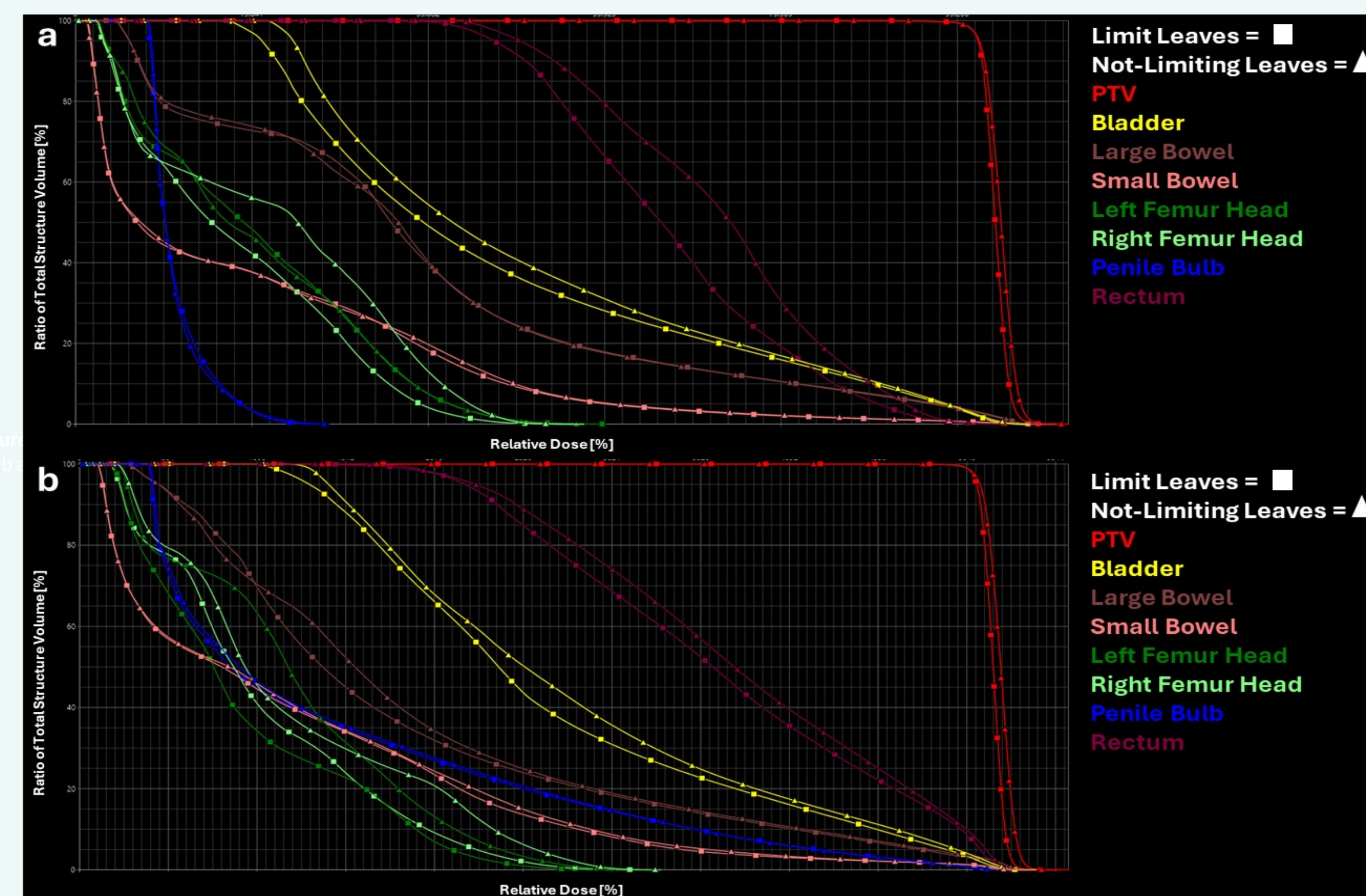


	Collimator Angle	Unrestricted MLC travel	Restricted MLC travel
Arc 1	350°	-13 cm – 13 cm	3 cm – 13 cm
Arc 2	10°	-13 cm – 13 cm	-13 cm – 3 cm
Arc 3	90°	-13 cm – 13 cm	2 cm – 13 cm
Arc 4	90°	-13 cm – 13 cm	-13 cm – 2 cm

Table 1. MLC leaf positions (restricted and unrestricted) for each arc/collimator angle

Figure 1. Comparison between leaf-limited and standard plan for a patient. The dose wash ranges from 110% Rx (red) to 100% Rx (yellow) to 50% (maroon) (a) Using normal MLC movements that the Photon Optimizer defaults to, high dose often spills between the PTV (pink outline), potentially increasing large bowel (white outline) dose. (b) When MLC leaves are limited from crossing isocenter, the Photon Optimizer will achieve PTV coverage while limiting 70% Rx spillage into the large bowel and other critical structures.

RESULTS & DISCUSSION



- Some patients benefitted more than others:
 - The dose-volume histograms (Figure 2) demonstrate improvement in bladder and rectum sparing for patient 1 (Figure 2a)
 - Little improvement for patient 2 (Figure 2b).
- While the magnitude of tissue-sparing is patient-specific, limiting MLC leaf positions does not worsen conformality nor significantly increase OAR dose for these prostate+node VMAT plans**

Figure 2: Representative dose-volume histograms for patient 1 (a) and patient 2 (b), comparing plans where MLC leaves were limited about midline (squares) and plans where the leaves were not limited (triangles). Patient-specific improvements are clear when comparing bladder, rectum and femoral heads. Some organs-at-risk, like penile bulb and small bowel, do not appear to show any changes between plans.

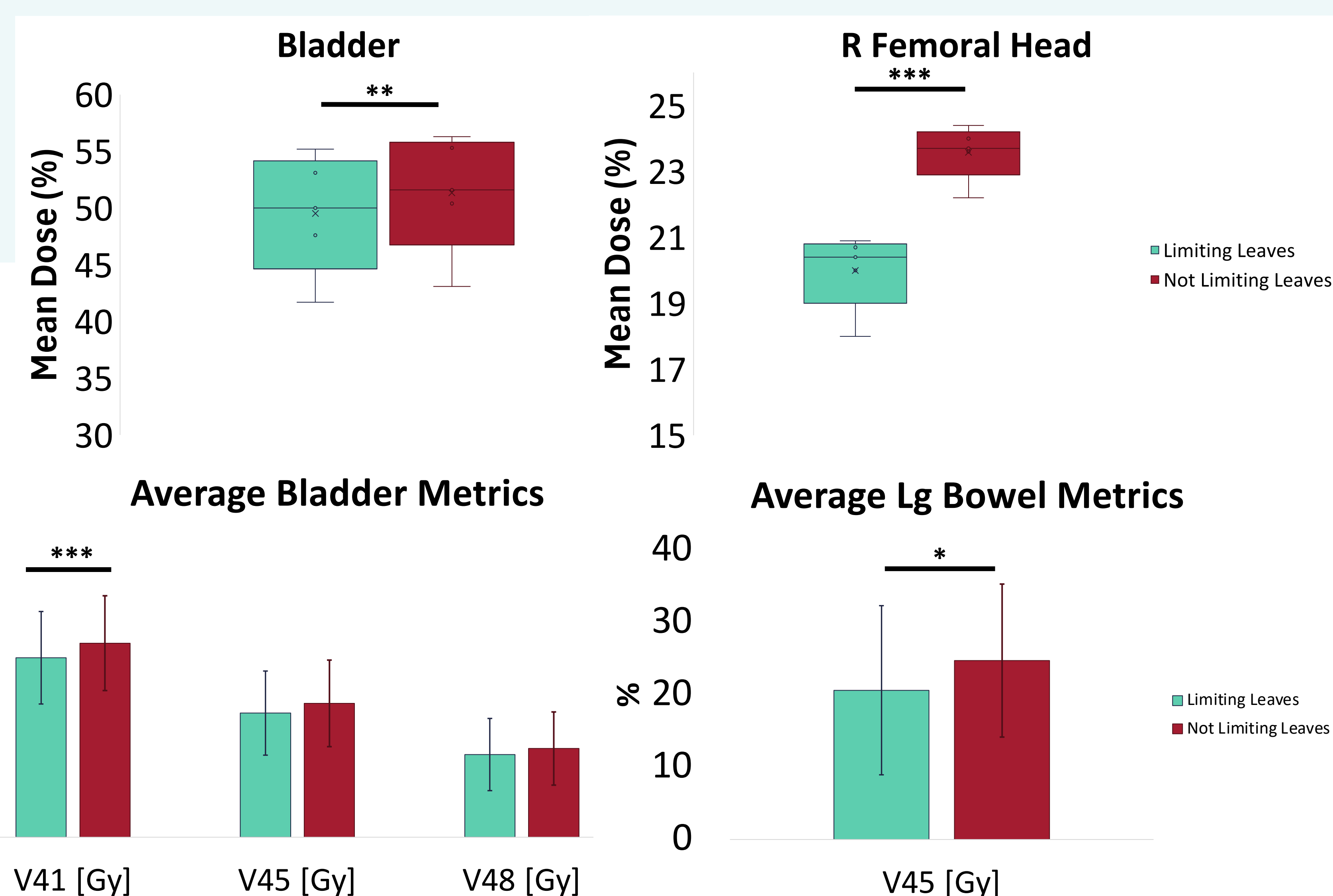


Figure 3: Mean dose percent is significantly lower in the limiting leaves plans for bladder and right femoral head. Clinical metrics for bladder and large bowel show significant improvements in plans where MLC leaves were limited.

CONCLUSIONS

Our low-barrier change in planning technique enables significant organ-at-risk sparing for prostate+nodes plans without negatively impacting target dose coverage. This has potential for a new workflow on jawless linacs that could increase patient quality of life and be expanded to other sites like head and neck.