Dosimetric Impact of the use of Jaw Tracking for Fields < 3x3 cm^2 in Lung SBRT VMAT Plans

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INTRODUCTION

- Varian Eclipse™ Treatment planning system (TPS) models fields <3x3cm^2 using only output factors (OFs); profile and PDD data are omitted from the beam model

- A Varian white paper recommends using a minimum jaw pair opening of 3 cm and using the MLC to provide further collimation[1]

- When jaw tracking is used in optimization for small targets, the jaw pair openings my be <3cm for some control points (unless the Field X,Y operating limits are 3cm)

METHODS

1. Small-field OF measurements:
   - field sizes 0.5x0.5cm^2 to 10x10cm^2 were measured in water
   - Measurements performed using a PTW 60019 diamond detector and verified using Exradin A16/IBA CC13 ionization chambers using the intermediate field ("daisy chaining") method.[2]
   - Small-field correction factors from TRS-483 were applied to the ion chamber measurements (no correction factors required for diamond detector)
   - The maximum differences between TPS-calculated and diamond-measured OFs when at least one jaw pair opening is <3cm, <2cm, and <1cm were used to determine deviation factors used in script (below)

2. Python (V3.7) script to determine effect of OF differences in VMAT plans:
   - Reads in a VMAT plan's DICOM RT file and assigns a "deviation factor" to each control point (CP) based on the minimum jaw pair opening. Deviation factors are weighted based on the meterset at each CP and the MU per arc.
   - Outputs: estimated deviation between planned and delivered doses due to OF differences, and fraction of MUs delivered with jaw openings <3cm, <2cm, and <1cm

3. Script application to treatment plans:
   - Eight 2-arc VMAT plans were created on a lung phantom with spherical targets ranging from 2.3-13.2 cc
   - Twelve recent lung SBRT patient plans with 5.2-17.0 cc targets were re-optimized with jaw-tracking on

4. Patient-Specific QA:
   - 2nd script was written to set any jaw position <1.5cm to 1.5cm (used on 8 phantom plans)
   - Adjusted plans were re-calculated in TPS
   - Patient specific QA was performed on the 8 original and adjusted patient plans using a Sun Nuclear ARCCheck® (2%, 2mm and 3%, 3mm, 10% threshold, global norm.)

RESULTS

- Observed differences between measured and calculated jaw-defined OFs were up to 2.7%, 8%, and 17.5%* when one jaw-pair opening was <3cm, <2cm, or <1cm, respectively (*large uncertainty due to small field size)

- Conservative weighting factors used to determine MU-weighted deviations from TPS were 3%, 10%, and 20%

- In both patient and phantom plans, larger deviations in planned dose were observed for smaller target volumes (R=0.85) (figure 1, right)

- PTV volumes ≥8cc, ≥5cc, and ≥2.3cc were susceptible to deviations from TPS-calculated dose of ≤1.0%, ≤2.9%, and ≤3.1% respectively

- No significant (Wilcoxon signed-rank, p>0.05) differences in gamma pass rates between original and adjusted plans were detected on ARCCheck (table 1, below)
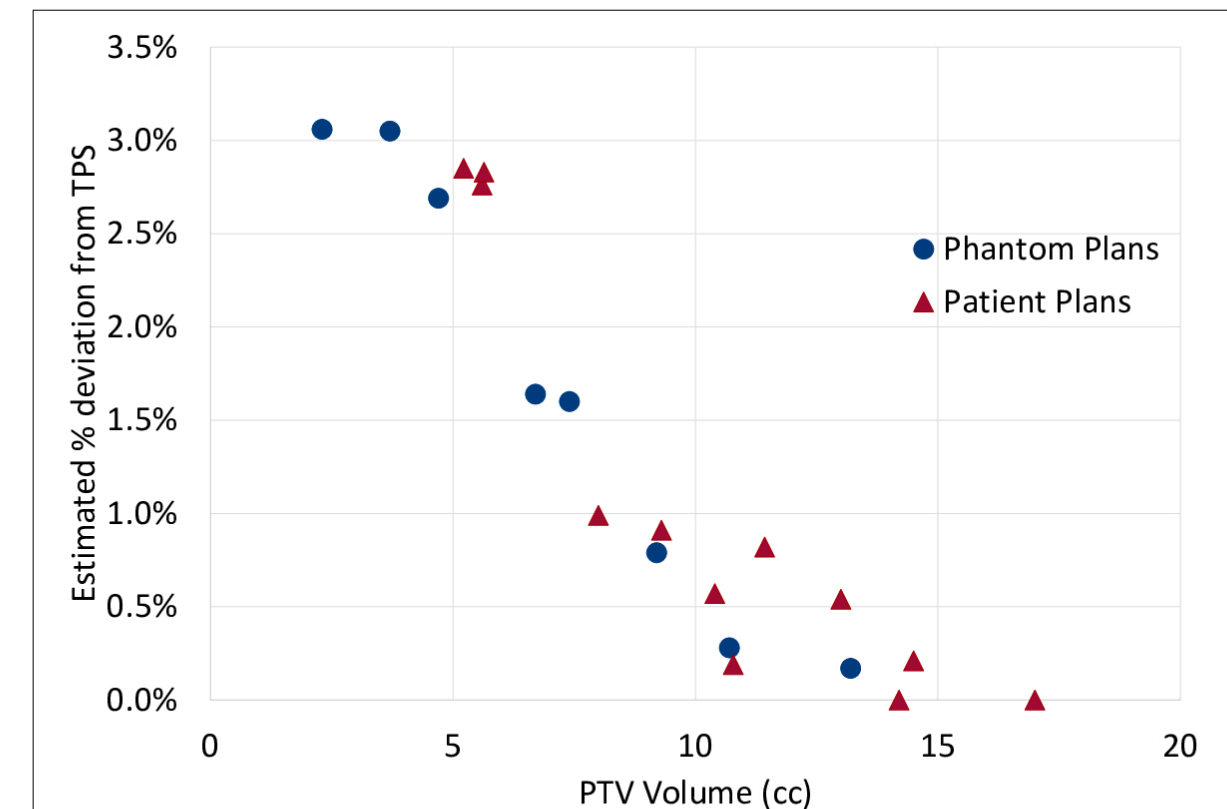

Figure 1 (above): The script calculated deviation from TPS based on conservative weighting factors for 8 phantom and 12 patient lung SBRT VMAT plans.

Plan Target Volume (cc)	2%, 2mm		3%, 3mm	
	Original	Adjusted	Original	Adjusted
2.3	96.3	97.6	99.4	99.4
3.7	96.4	96.4	98.4	98.5
4.7	97.2	97.8	98.3	97.8
6.7	94.8	94.8	96.9	96.9
7.4	94.1	95.2	97.8	97.8
9.2	95.00	95.5	98.0	98.0
10.7	95.3	95.4	96.7	96.8
13.2	97.4	96.6	98.7	98.7

Table 1 (left): The 2%/2mm, and 3%/3mm gamma pass rates are presented for the eight original lung SBRT VMAT phantom plans and the eight plans with adjusted jaw positions.

CONCLUSIONS

- Differences between measures and TPS OFs can be large for small fields due to measurement uncertainty and beam model limitations

- Differences in jaw-defined OFs did not translate into deviations in plan quality ≥3.1% for targets ≥2.3cc

- Differences not detectable in PSQA

- "Field X" and "Field Y" operating limits may be set to a minimum opening of 2-3 cm to limit minimum field size when jaw tracking is used in optimization

REFERENCES

[1] Torsti T et al. Using Varian photon beam source model for dose calculation of small fields. *Varian Medical Systems White Paper 2013.*

[2] INTERNATIONAL ATOMIC ENERGY AGENCY. Dosimetry of Small Static Fields Used in External Beam Radiotherapy, Technical Reports Series No. 483, *IAEA, Vienna (2017).*

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