HyperArc SRS: A Study of Multi-Target Dose Conformity

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INTRODUCTION

Purpose: VMAT SRS enables multiple targets to be treated simultaneously, improving efficiency. However, MLC shaping can be a challenge as the target number increases and as off-axis targets track across the beam's eye view, yet these effects are not well characterized for HyperArc SRS. This study investigates the effects of target size, target-to-isocenter distance, and number of targets on HyperArc dose conformity.

HyperArc: Semi-automated planning for efficient, high-quality SRS.

Features:
- •Collision-free isocenter placement
- •Patient-specific collimator rotations
- •SRS-specific NTO (generates steeper dose gradient than Eclipse's auto NTO)

METHODS

- A retrospective analysis was performed using 124 single-fraction HyperArc cases planned to 21 Gy on a Varian Edge linac with HDMLC, totaling 349 targets

- Dose conformity was assessed by the conformity index (CI) at 100% and 50% isodose levels, gradient index (GI), and prescription dose spill outside a PTV (DS100%).

Dose Conformity Metrics:

RTOG CI
CI% = Isodose% Volume/PTV

CI 100% Criteria:
•1.0–2.0 = Acceptable
•0.9–1.0 or 2.0–2.5 = Minor deviation

Gradient Index (GI):
•50% isodose volume / 100% isodose volume
•Linked to radionecrosis risk

DS100% (Dose Spill):
•V100% within 1 cm VOI – V100% of PTV
•Normalized by PTV volume

Power Law Regression (R v4.4.2)
•Analyzed correlations between dose metrics &
- PTV size (V)
- Target-to-isocenter distance (d)
- Number of targets (n)

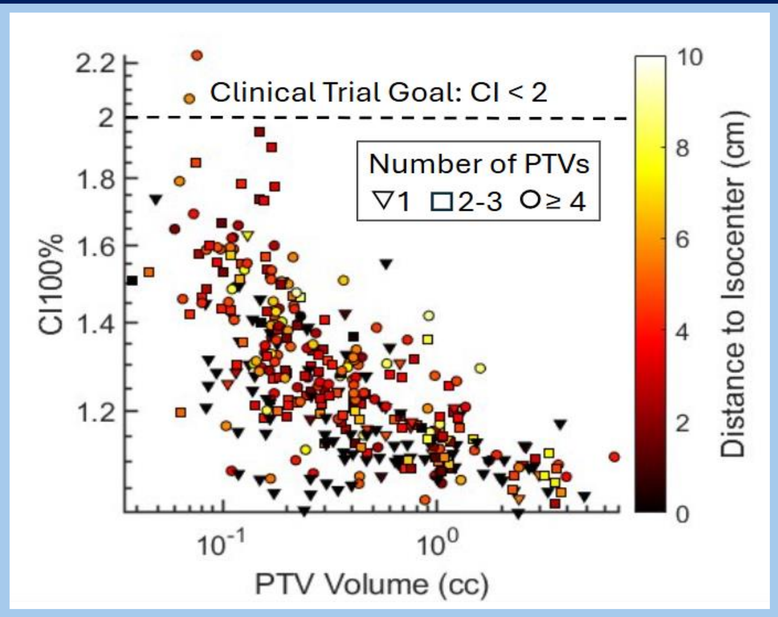

Fig. 1. HyperArc CI100% values coded by distance (color) and number of targets (shape) then plotted as a function of PTV size.

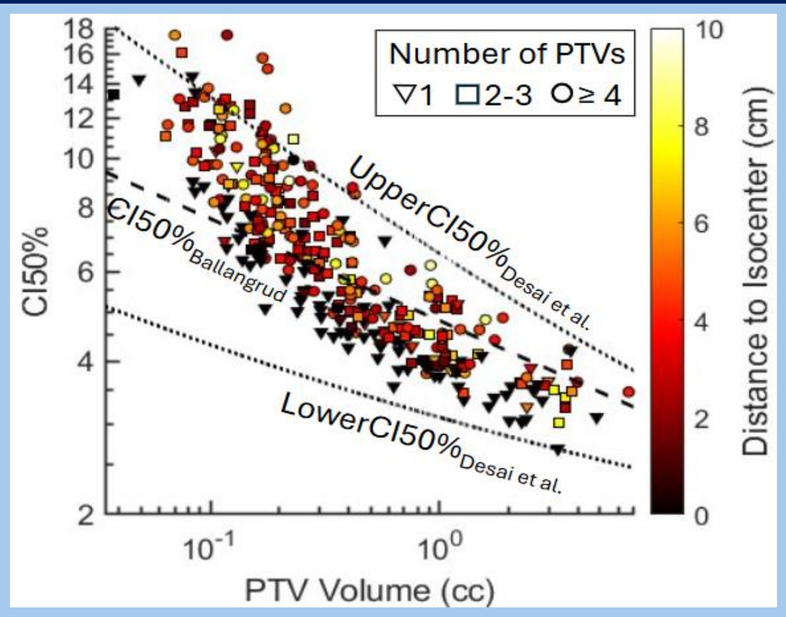

Fig. 2. HyperArc CI50% values coded by distance (color) and number of targets (shape) then plotted as a function of PTV size.

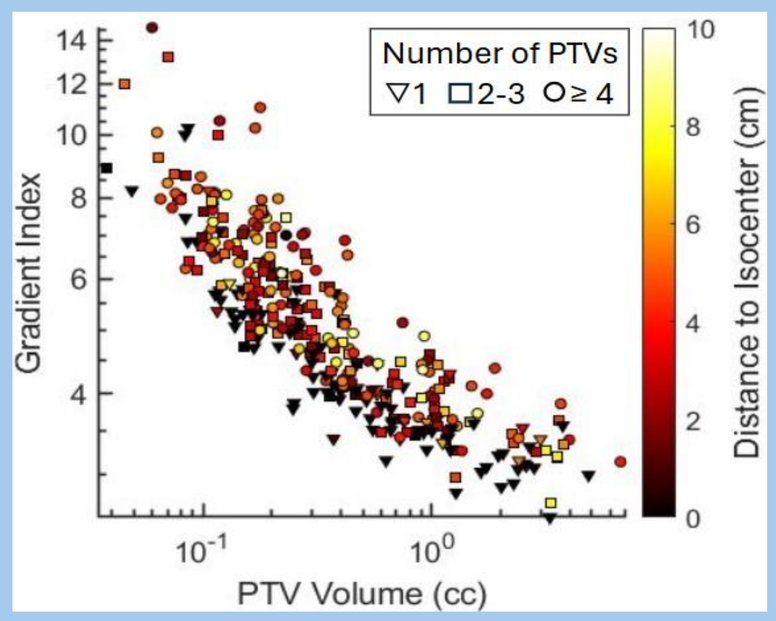

Fig. 3. HyperArc gradient index values coded by distance (color) and number of targets (shape) then plotted as a function of PTV size.

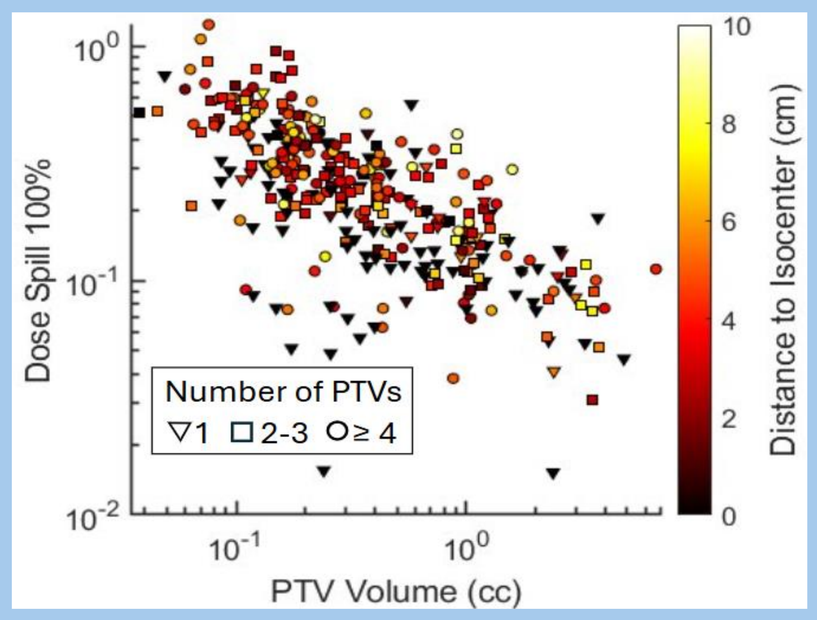

Fig. 4. HyperArc prescription dose spill values coded by distance (color) and number of targets (shape) then plotted as a function of PTV size.

RESULTS

- **Conformity (CI100% & CI50%)**:
  - Worsens with smaller targets, greater target-to-isocenter distance, and a higher number of targets per plan.
- **Dose Spill (DS100%)**:
  - Increases with decreasing PTV volume, increasing distance from isocenter, and more targets in the same plan.
- **Gradient Index (GI)**:
  - Strong inverse relationship with target volume and number of targets.
  - Larger targets and fewer total targets are associated with sharper dose fall-off.

- **Power Law Regression Analysis:**
  - $CI100\% = 0.123 \cdot V^{-0.0891} \cdot d^{0.00169} \cdot n^{0.0287}$
  - $CI50\% = 1.42 \cdot V^{-0.344} \cdot d^{0.00555} \cdot n^{0.0988}$
  - $GI = 1.30 \cdot V^{-0.254} \cdot d^{0.00386} \cdot n^{0.0701}$
  - $DS100\% = -2.08 \cdot V^{-0.459} \cdot d^{0.00900} \cdot n^{0.167}$

V, d, and n were all significant predictors for CI100%, CI50%, GI, and DS100% ($p<.05$).

CONCLUSIONS

Dose conformity degrades with decreasing target size, increasing target-to-isocenter distance, and increasing target number. The target number had a stronger effect than distance, suggesting that MLC shaping is challenged more by multiple targets than by off-axis MLC tracking. Positioning the isocenter near critical structures may improve dose conformity when most crucial.

REFERENCES