

A Dosimetric Comparison of TrueBeam 6X and Halcyon 6X-FFF Energy in Prone Left Breast Radiation Therapy

Introduction

According to the American Cancer Society, breast cancer diagnosis have steadily increased year after year. For patients with an early diagnosis, the standard of care is whole breast irradiation following a lumpectomy. Additionally, treating the patient in the prone position is often utilized to improve dose distribution and reduce dose toxicity to sensitive surrounding organs at risk (OARs), especially the heart and left lung.

The Halcyon is a newer linear accelerator (linac) design, designed to streamline radiation therapy treatments using a bore enclosed gantry, dual layer multileaf collimator (MLC), and flattening filter free (FFF) beam. In contrast, the TrueBeam allows greater flexibility for beam geometry and jaw tracking, possibly influencing dose shaping and homogeneity.

This study aims to compare Halcyon versus TrueBeam treatment machines to determine whether differences in hardware design and beam energy (6X vs 6X-FFF) impact target coverage, homogeneity, and normal tissue sparing.

Methods

This retrospective dosimetric comparison analyzed 10 prone whole breast radiation plans. Clinically delivered Halcyon plans were compared to re-planned TrueBeam plans using identical tangent fields.

Inclusion Criteria

1. Early-Stage prone left breast patients
2. Clinically approved Halcyon treatment plan
3. Initial prescription of Hypo fractionated prescription 40.05Gy delivered in 15 fractions (2.67Gy/ fraction)

Exclusion Criteria

1. Prior breast irradiation
2. Bilateral disease
3. Nodal involvement
4. Supine positioning

Evaluated Parameters

1. Target Coverage: PTV V95 (%), PTV Dmax (Gy)
Lumpectomy coverage V40.05Gy (%)
2. Dose Homogeneity: PTV V105 (%), V42.05 Gy (cc)
3. LAD: Dmean, Dmax
5. Left Lung: Dmean, Dmax, V4Gy, V12Gy

Results

Metric	Halcyon (Mean ± SD)	TrueBeam (Mean ± SD)	p-value
PTV V95 (%)	97.84 ± 2.11	98.95 ± 1.22	0.088
Lumpectomy V40.05Gy (%)	98.41 ± 1.55	96.99 ± 1.74	0.0005*
V42.05Gy (cc)	3.36 ± 9.68	1.17 ± 3.18	0.526
L-Lung Dmean (Gy)	0.39 ± 0.08	0.31 ± 0.08	0.0015*
LAD Dmean (Gy)	1.80 ± 0.39	2.15 ± 0.89	0.220

*Statistically significant ($p < 0.05$)

Table 1

This table shows comparable overall metrics between Halcyon and TrueBeam Linacs, with Halcyon providing better lumpectomy coverage while TrueBeam provides lower mean lung dose, the remaining metrics were not significantly different.

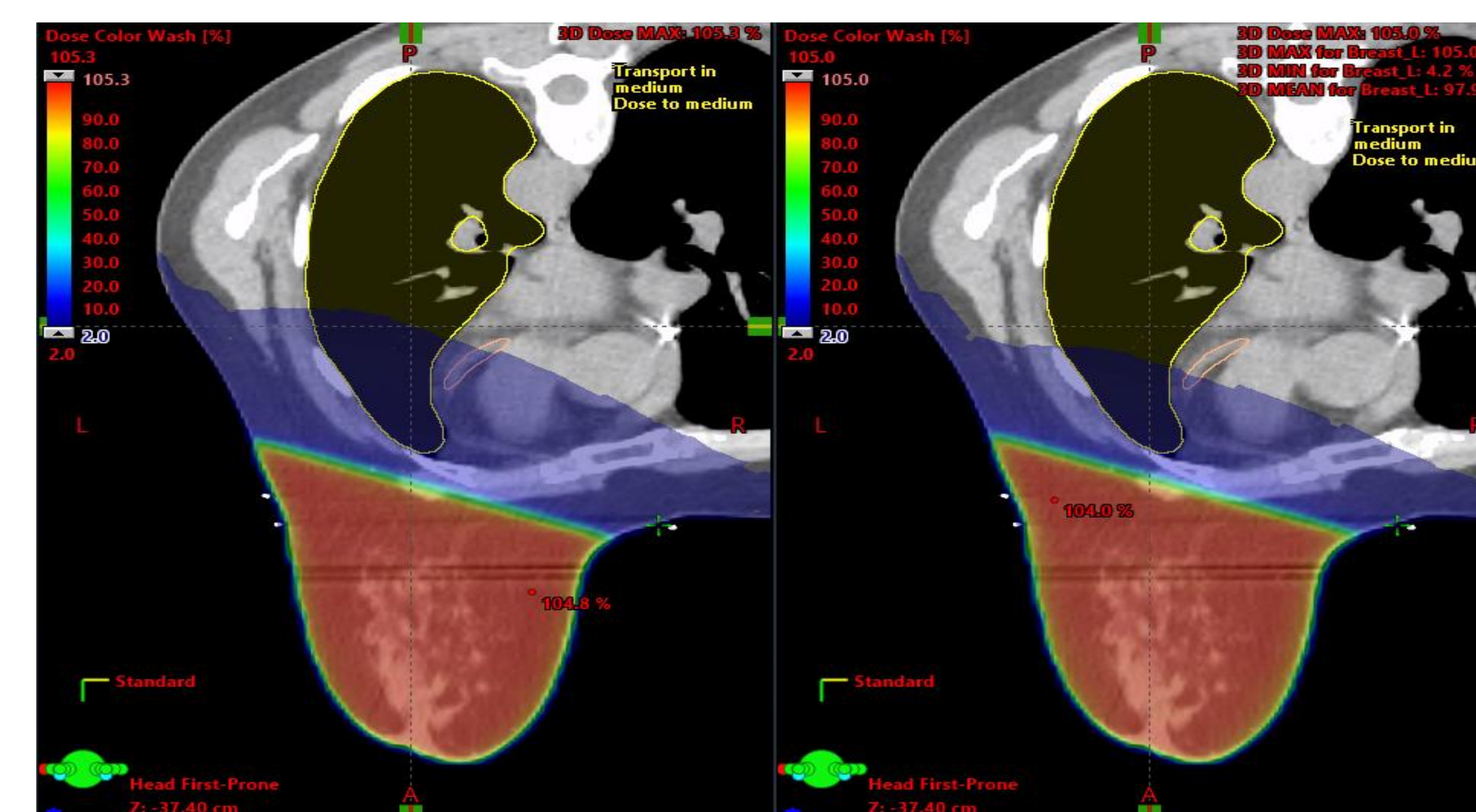


Fig. 1. Halcyon (left) and TrueBeam (right) prone breast plans demonstrating mean lung dose distribution. The Halcyon plan shows slightly more lower lung dose.

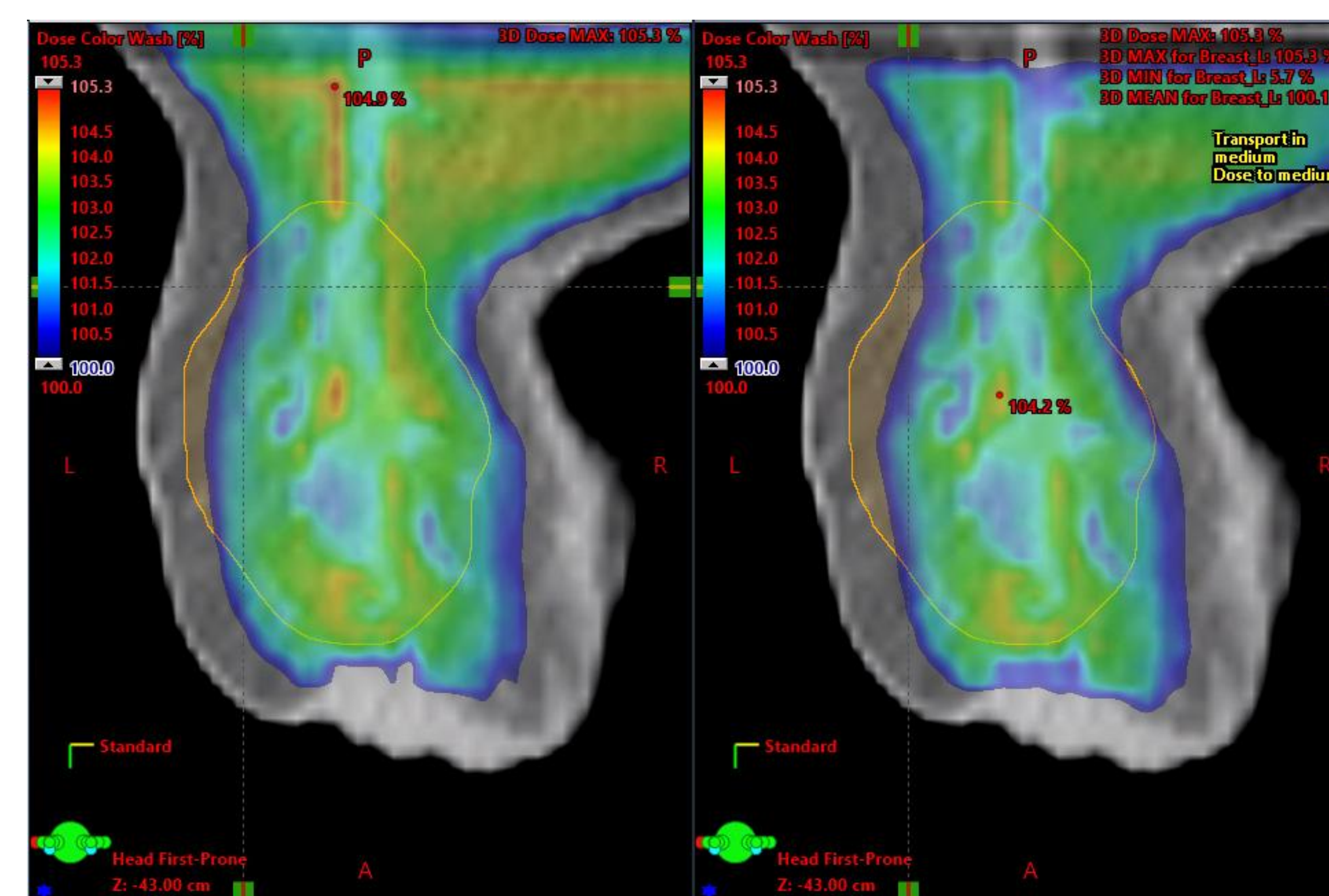


Fig 2. Dose color wash comparison of prone left breast plans generated with Halcyon 6FFF (left) and TrueBeam 6X (right). Halcyon demonstrated improved lumpectomy coverage, the difference was statistically evaluated using a paired t-test ($p = 0.0005$)

Conclusion

The dosimetric evaluations confirm that both Halcyon and TrueBeam are advanced treatment systems capable of delivering exceptional treatment plans. However, their advantages are non- identical. The TrueBeam offers a slight edge in consistent PTV coverage and left lung mean dose sparing, whereas the Halcyon offers better lumpectomy coverage and, in some anatomy, possible advantage of LAD sparing.

In conclusion, the two linear accelerators showed tradeoffs between target coverage and OAR sparing rather than consistent advantages across all metrics for one system.

Limitations

1. Small sample size of 10 patients
2. Planner experience was novice for the retrospective TrueBeam plans compared to experienced planners who planned the Halcyon treatments
3. More allotted time to create re-planned TrueBeam plans compared to the initial Halcyon plans
4. Retrospective planning allows for planning bias
5. Some Halcyon plans exceeded TrueBeam field size limits

References

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