

A quantitative dosimetric evaluation of inter-fraction setup variability on high dose volumes when following weekly imaging protocols for hypofractionated whole breast irradiation

Introduction

Studies have shown that compared to conventional fractionation, a hypofractionated schedule of 4000 cGy in 15 fractions provides equivalent disease control, improved acute toxicity, and similar or improved late toxicities for early-stage whole breast irradiation.

In radiotherapy, a “hot-spot” is defined as a region outside of the target volume where a dose greater than the prescribed dose is delivered. The risk of radiation dermatitis, including moist desquamation, increases in these hot-spot regions. It has been found that desquamation decreases when the maximum dose is minimized to 105% or 107% of the prescription dose

The purpose of this study is to determine how inter-fraction setup variability affects the homogeneity of a hypofractionated whole breast plan with respect to the 105% and 107% high-dose regions when following the RTOG 1005 weekly imaging protocols.

Methods

Ten early-stage right-sided breast cancer patients previously treated with 4005 cGy in 15 fractions to the whole breast were selected. While on treatment, patients were imaged daily with kV orthogonal images. The data from their on-treatment shifts were collected and plans were generated simulating how those shifts would affect the isodose distribution if not corrected by daily image guidance. To simulate the weekly imaging guidelines, the original plan with no shifts was applied to the fifth, tenth, and fifteenth fractions as seen below.

Fraction	Left/Right (cm)	Ant/Post (cm)	Sup/Inf (cm)
1	Left 0.0	Post 0.2	Inf 0.3
2	Left 0.1	Post 0.3	Inf 0.4
3	Right 0.2	Ant 0.0	Inf 0.7
4	Right 0.1	Post 0.3	Sup 0.4
5	0	0	0
6	Left 0.2	Post 0.1	Sup 0.0
7	Left 0.1	Post 0.4	Inf 0.6
8	Left 0.2	Post 0.6	Sup 0.1
9	Right 0.6	Post 0.7	Sup 0.7
10	0	0	0
11	Left 0.2	Post 0.1	Inf 0.2
12	Left 0.5	Post 0.3	Inf 0.5
13	Left 0.0	Post 0.5	Sup 0.8
14	Left 0.1	Post 0.4	Sup 0.1
15	0	0	0

Table 1. Patient 3: Daily recorded shifts

Results

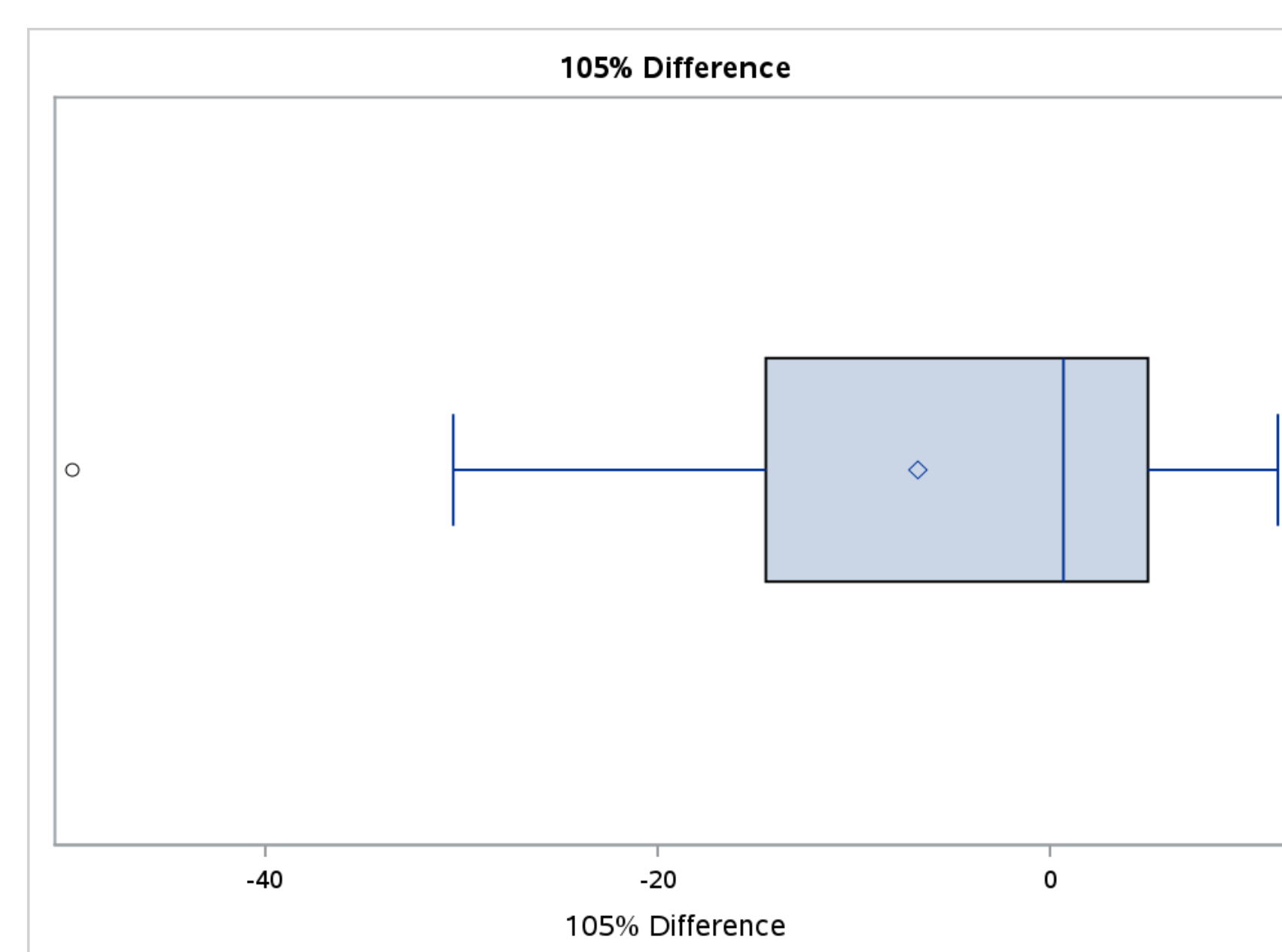


Fig. 1 The 105% Mean Difference ($p = 0.7539$)

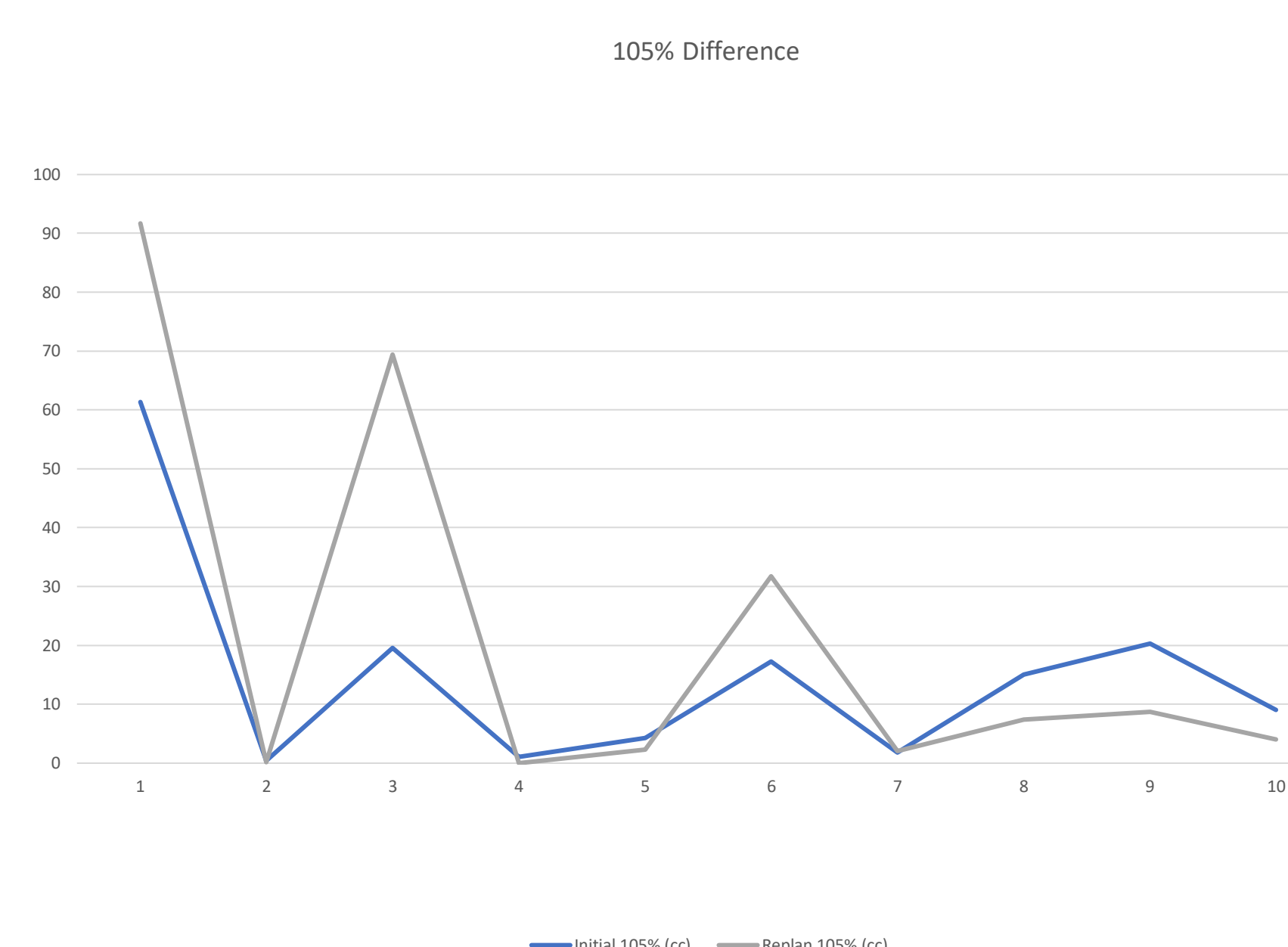


Fig. 2 105% Initial vs. Replan per patient

Patient #	Initial 105 % (cc)	Replan 105 % (cc)	Initial CI	Replan CI
1	61.29	91.7	0.51	0.54
2	0.42	0.17	0.53	0.55
3	19.59	69.4	0.54	0.60
4	1.087	0.001	0.33	0.35
5	4.23	2.3	0.31	0.33
6	17.27	31.76	0.68	0.69
7	1.82	2.02	0.52	0.52
8	14.997	7.37	0.64	0.67
9	20.29	8.7	0.58	0.63
10	9.02	4.048	0.63	0.67

Table 2. Volume of 105% & Conformity Index comparison

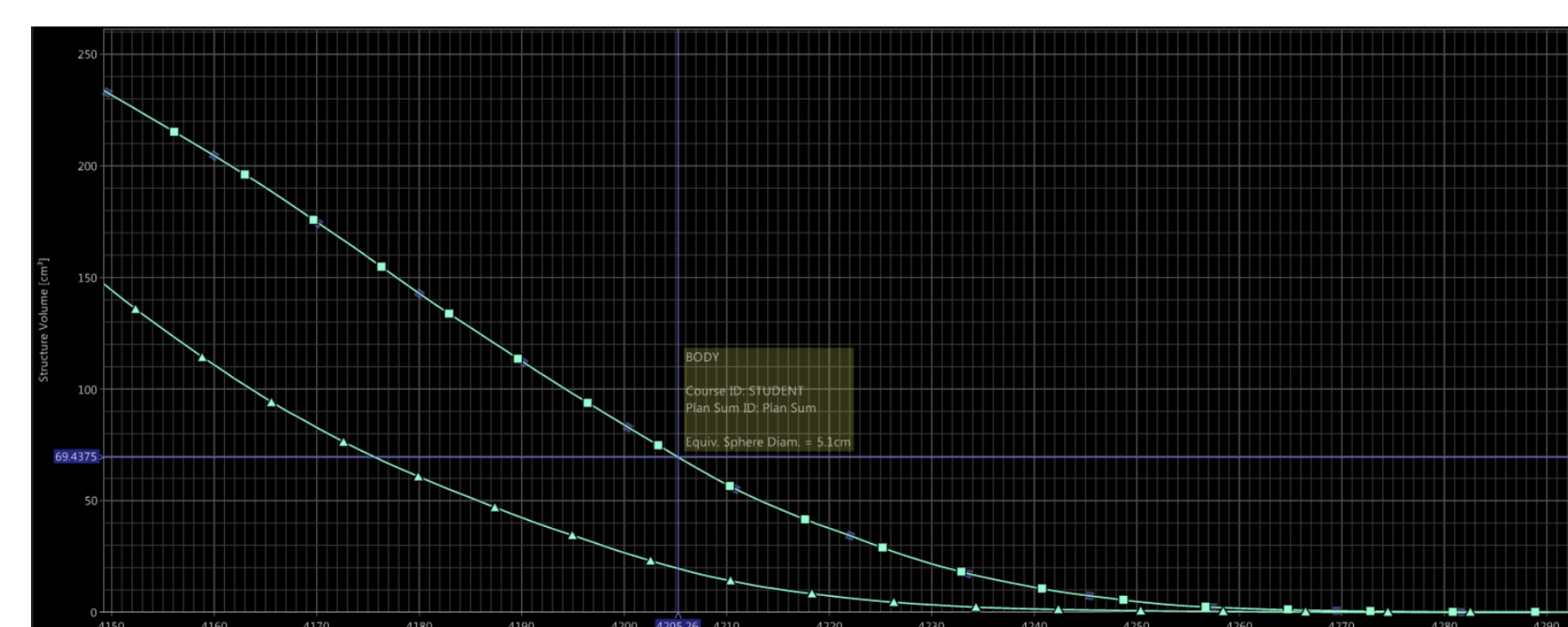


Fig 2. Patient 3: 105% Difference DVH. While this patient appears to have a significant increase of the 105%, other patients had a decrease as seen in the table and figures above.

Conclusion

The results of this study showed no statistical significance in the difference of means of the 105% and 107% high-dose regions. Wilcoxon Signed Ranks Test and Sign Tests were performed. The significance level was set at 0.05.

The following parameters were also compared: Homogeneity Index, Dmin, Dmax, 106%, 107%, Ipsilateral Lung V20 & Mean, Heart V30, Mean & Max Dose, and Contralateral Breast V3<10%. These metrics showed no statistically significant difference.

The Conformity Index ($p = 0.0039$) and Ipsilateral Lung Max Dose ($p = 0.0098$) showed statistical significance, that most likely would not be clinically significant.

This specific study concludes the weekly imaging protocol is adequate for the evaluation of the high-dose regions for early-stage hypofractionated whole breast irradiation.

Limitations

This study had a small sample size of 10 patients. A post hoc power analysis was performed to determine the recommended sample size for future research.

References

- Kole, A. J., Kole, L., & Moran, M. (2017). Acute radiation dermatitis in breast cancer patients: Challenges and solutions. *Breast Cancer: Targets and Therapy, Volume 9*, 313–323. <https://doi.org/10.2147/BCTT.S109763>
- Smith, B. D., et al. (2018). Radiation Therapy for the Whole Breast: An American Society for Radiation Oncology (ASTRO) Evidence-Based Guideline. *Practical Radiation Oncology*, 46

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