Reducing Dermatitis in Pencil Beam Scanning Proton Therapy (PBS) Breast Cancer Patients By Eliminating Proton Spots in the Skin

A. O'Ryan-Blair, BS Hons, DBM, CMD; S. Hedrick, Ph.D., DABR; C. Ramsey, Ph.D., DABR, DABMP; C. Brown, BS, R.T.(R)(T), CMD; A. Ward, MS, R.T.(R)(T); J. Stamper, R.T.(R)(T), CMD

Thompson Proton Center, Knoxville, TN

INTRODUCTION

Traditionally, skin reactions are a common side effect for pencil beam scanning proton therapy (PBS) in breast patients, including erythema and dermatitis.

Multiple clinical trials in scientific literature show increased dermatitis compared to photon therapy.

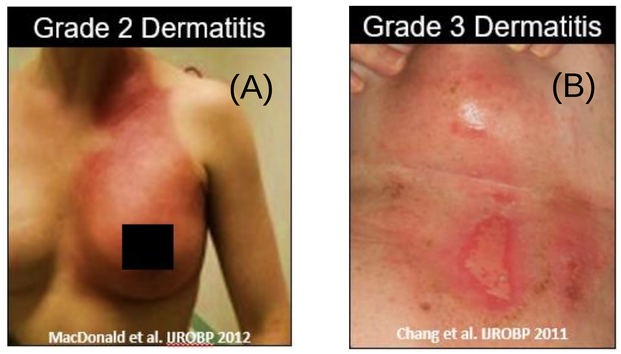

Figure 1. (A) Between 70.7% and 100% of proton patients in trials experienced Grade 2 dermatitis.
(B) Between 5.1% and 43% of proton patients in trials experienced Grade 3 dermatitis.

The Physics and Dosimetry team at our center pioneered a methodology of using a python script to remove spots out of the 5mm skin rind while still maintaining spots in the targets for continued optimization.

We hypothesized that removing spots in the skin, or limiting the placement of Bragg peaks near the skin surface, could reduce the incidence of radiation dermatitis.

METHODS

Since January 2021, our clinic started using this technique on all breast patients. Using a 'Spot-Delete' script written in Iron Python for RayStation, spots were deleted out of the 5mm skin rind and optimization continued with remaining spots.

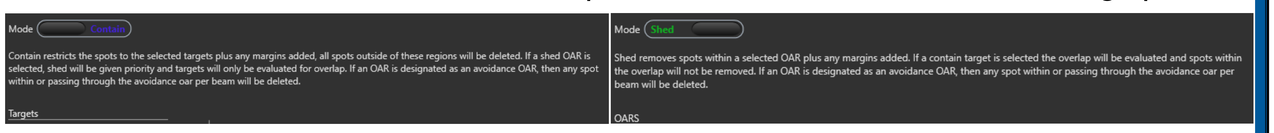

Figure 2. The script allows the user to select targets and organs at risk to delete spots within a specified area as chosen. The script shows the number of spots to be deleted. The script takes about 40-50 seconds to run.

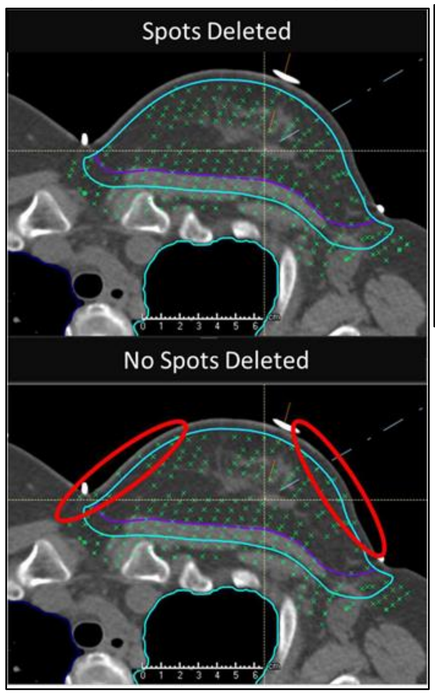

Figure 3. Comparison of spot locations "x" for a PBS breast treatment plan with and without Spot-Delete. Notice the spots near the skin surface in the red areas.

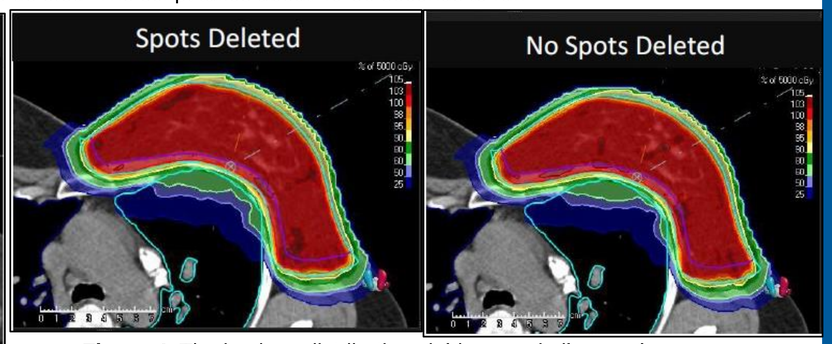

Figure 4. The isodose distribution yields very similar results for the treatment plans with and without Spot-Delete.

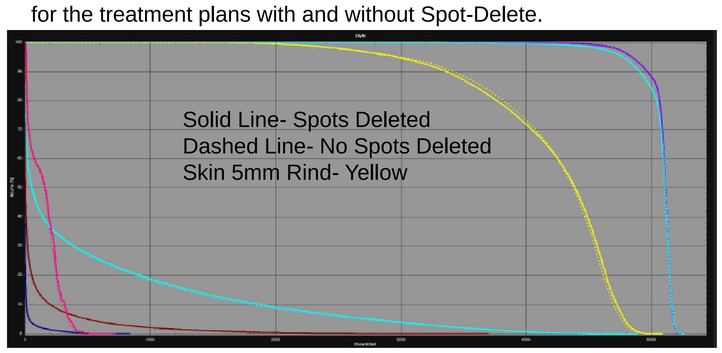

Figure 5. The dose volume histogram yields very similar results for the treatment plans with and without Spot-Delete. However, the biological dose is reduced.

We retrospectively reviewed a sample of hypofractionated patients before our clinic started using this technique (n=28) and a sample of patients after (n=28), treated between January 2019 and December 2021. We reviewed the radiation dermatitis Common Terminology Criteria for Adverse Events (CTCAE v4) scores recorded during on-treatment visits.

RESULTS

Our findings revealed that this technique did not impact the target coverage or conformality and OAR sparing was similar for an RBE = 1.1. Optimization time did not significantly increase, nor did it impact robustness. The incidence rate of Grade 1 acute radiation dermatitis revealed 57% and 67% for patients treated before and with the spot technique, respectively. Grade 2 acute radiation dermatitis revealed 36% and 37% for patients treated before and with the spot technique, respectively. Radiation dermatitis scores decreased significantly for Grade 3 dermatitis from 7% to 0%, for patients treated before and with the spot technique, respectively. Our findings showed on par results with published photon scores.

Maximum Dermatitis Severity (CTCAE v4)	Proton PBS w/o Spot-Delete *n = 28*	Proton PBS with Spot-Delete *n = 28*	Photon Shaitelman 2015 *n = 138*	Photon Schmeel 2020 *n = 140*
Grade 0	0%	0%	6%	21%
Grade 1	57%	67%	58%	51%
Grade 2	36%	37%	36%	27%
Grade 3	7%	0%	0%	0%

Table 1. Comparison of the maximum observed radiation dermatitis severity with and without the Spot-Delete technique for hypofractionated pencil beam scanning proton therapy. Published rates from randomized photon based hypofractionation trials are shown for comparison.

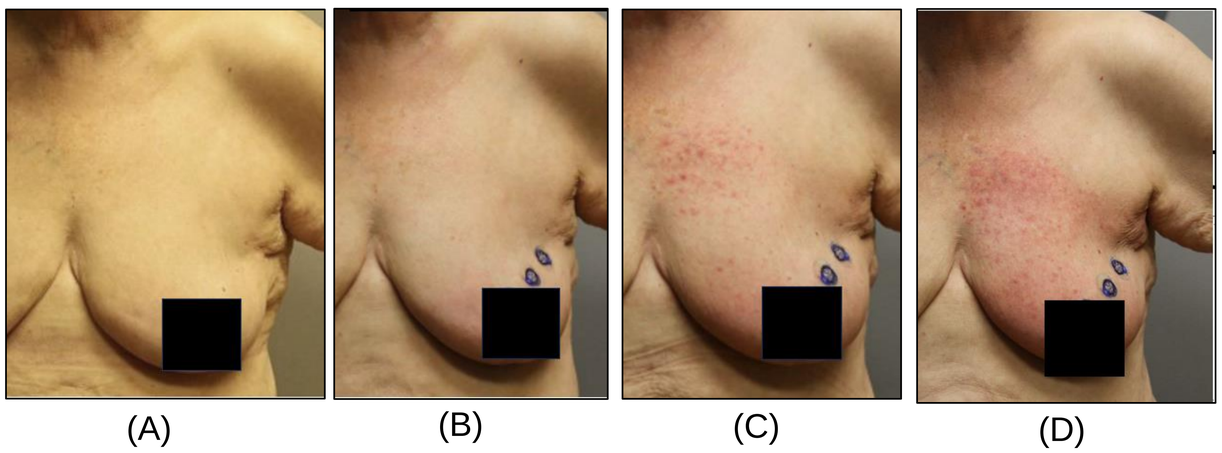

Figure 6. Photographs taken at onsite treatment visits.
(A) Before treatment started. (B) Week 1 of treatment. (C) Week 5 of treatment. (D) Week 6- Last week of treatment

CONCLUSIONS

This simple-to-use script can be utilized safely and efficiently during optimization and has been shown to reduce radiation dermatitis without reducing target coverage.

REFERENCES

1) Hedrick, Samantha G., Bryant Walker, Bart Morris, Scott Petro, and Marc Blakey. Scripted spot removal in PBS proton therapy planning. *Journal of Applied Clinical Medical Physics* 23, No. 2 (2022): e13491.
2) MacDonald, S et al. Proton therapy for breast cancer after mastectomy: early outcomes of a prospective clinical trial. *Int J Radiat Oncol Biol Phys*. Vol.86, Issue 3, (2013): 484-490.
3) Chang, J et al. Toxicity and Patterns of Failure of Adaptive/Ablative Proton Therapy for Early-Stage, Medically Inoperable Non-Small Cell Lung Cancer. *Int J Radiat Oncol Biol Phys.* Vol.80, Issue 5, (2011): 1350-1357.
4) Shaitelman, S et al. Acute and Short-term Toxic Effects of Conventionally Fractionated vs Hypofractionated Whole-Breast Irradiation: A Randomized Clinical Trial. *JAMA Oncol* (2015) Oct;1(7): 931-941.
5) Schmeel, L et al. Acute radiation-induced skin toxicity in hypofractionated vs. conventional whole- breast irradiation: An objective, randomized multicenter assessment using spectrophotometry. *Radiother Oncol* (2020) May:146:172-179.

CONTACT INFORMATION

Avril O'Ryan-Blair, BS Hons, DBM, CMD aoryan@covhlth.com O: (865) 331-8238 C: (812) 345-3358