

Investigation of photon and proton overlapping fields in PRESAGE® dosimeters

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Abstract. To evaluate the effects of overlapping dose volumes for varying field arrangements in PRESAGE®, several sequential beam irradiations were delivered each to formulations intended for, and irradiated with, proton beams as well as photon beams. The dosimeters were irradiated within timespans consistent of overlapping fields in clinical treatment plans. Dose profiles taken along the beam direction indicated slight over-responses in higher dose regions relative to similar irradiations given in a single fraction. These results will aid future measurements of overlapping field treatment plans delivered to PRESAGE® for treatment verification of proton and photon 3D dosimetry.

1. Background

In previous studies, PRESAGE® dosimeters [1, 2] have been evaluated in open beams [3, 4]. With the introduction of stereotactic radiosurgery (SRS), intensity modulated radiotherapy (IMRT), and other advanced treatments, these dosimeters have been tested for three-dimensional verification [5, 6]. Additional studies have been conducted to determine temperature, dose rate, and dose sensitivity [7, 8]. In order to fully assess their quality for clinical verification purposes of radiotherapy treatments with several beam segments, this study was implemented to evaluate the dose integration [9] of overlapping dose volumes. Similar studies have been performed on polymer gel dosimeters [10]. Two formulations of PRESAGE® were used: one intended for, and irradiated with, proton beams and the other photon beams.

2. Methods

Cylindrical PRESAGE® dosimeters approximately 9 cm in height and 6 cm in diameter were used in this study. Photon irradiations were performed on Varian 2100 series linacs using 6 MV open beams at the University of Texas at M. D. Anderson Cancer Center in Houston, Texas. Field sizes ranged from 3x3 cm² to 5x5cm². Each dosimeter was irradiated using table-top conditions to a consistent dose at $d_{\max}$. The proton dosimeter irradiations were performed at the M. D. Anderson Proton Therapy Center (PTC). These were irradiated using a fixed gantry, 4x4 cm² field size, and 200 MeV beam in a water tank at approximately 15.8 cm surface-to-dosimeter distance. A spread-out Bragg peak (SOBP) of 3 cm was delivered approximately 6 cm into the dosimeter in order to fully capture all relevant dose regions. All irradiations were delivered perpendicular to the flat top surface rather than the curved sides to reduce dose profile inhomogeneities.



For each treatment modality (photon, proton), two overlapping field setups were performed. These included a stationary dosimeter irradiated over six fractions and a dosimeter shifted laterally to the field to deliver a dose plateau in two fractions. All subsequent fractions were given within ten minutes and never less than one minute apart to simulate a lengthy clinical treatment delivery. Two dosimeters were irradiated for each setup. The dosimeters were paired, with one dosimeter given total dose by a single fraction while the other followed one of the overlapping field setups. The dosimeters were analyzed using the Duke Medium field-of-view Optical CT Scanner (DMOS) 24 hours after irradiation and exported to the Computational Environment for Radiotherapy Research (CERR) software platform where the doses were compared between paired dosimeters. Dose profiles were taken parallel to the beam path for all setups. Additionally, cross dose profiles of the of the dose plateau studies were taken.

3. Results

Paired dosimeter agreement was determined by the dose variations along the central axis to the overlapped irradiated fields of the fractionated and dose plateau field setups. The profile was taken laterally to the fields and at the center of the dose volume created by overlapping two and four field box irradiations. Because of inconsistencies in dosimeter sizes between pairs and data lost at the edges of the dosimeters, spatial agreement between dose profiles was corrected for by matching distal ends of those irradiated with protons and $d_{\max}$ of those irradiated with photons.

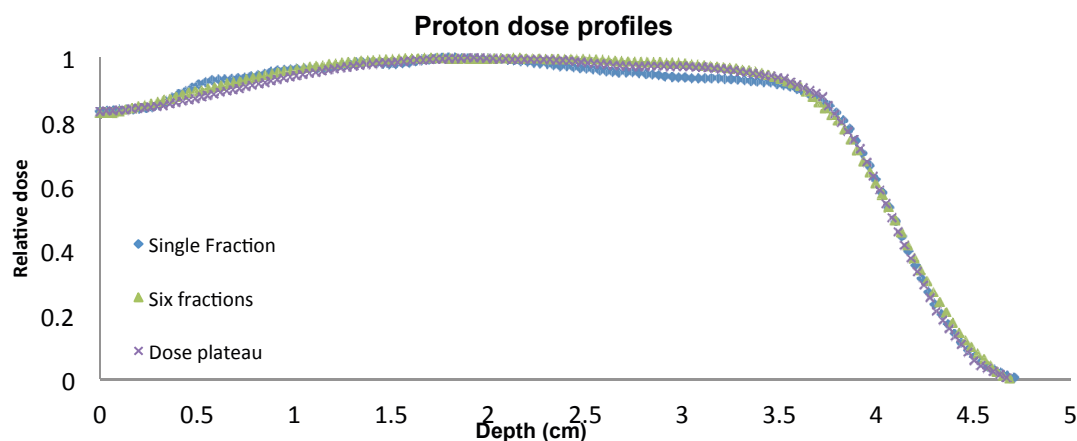


Figure 1: Relative dose profiles of the proton formulation of PRESAGE® showing agreement between single and multiple fraction irradiations from the proximal through the distal regions.

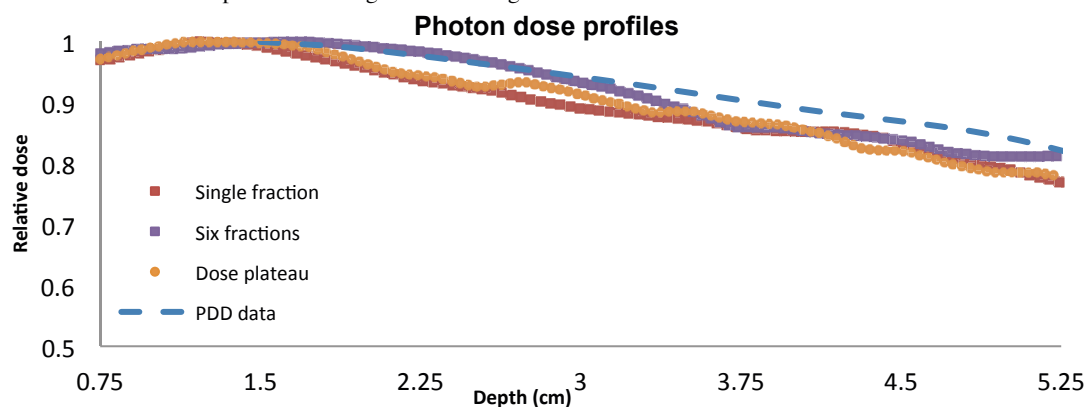


Figure 2: Relative dose profiles of photon formulation of PRESAGE® showing the agreement between single fractions, multiple fractions, and PDD data in the dose peak region.

Dose profile comparisons showed relative dose agreement between paired dosimeters within 5% along the SOBP region of the proton formulation and shown in figure 3. Both of the overlapping field irradiations showed an under-response in the proximal region and an over-response in the distal side of the SOBP relative to the single fraction irradiation with no PTC ion chamber data for this setup to compare. Dose agreement between the photon dosimeter treated with overlapping fields also over-responded by as much as 11% relative to the single fraction irradiation. Additionally, cross-beam dose plateau profiles further characterized the change in recorded dose between the overlapping volume and the integration of the sequential fields as illustrated in figure 3 and table 1. These showed a discrepancy between added and recorded absorbed dose.

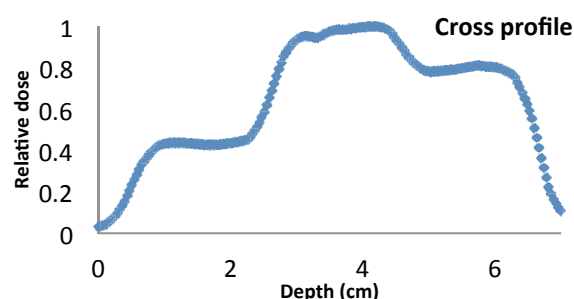


Figure 3: Cross profile of overlapping fields (100 and 200 cGy) treated with photons.

	Dose 9 (cGy)	Average relative dose	Stdv
Photon	100.00	0.43	0.01
	200.00	0.79	0.01
	Plateau (300)	0.98	0.02
Proton	100.00	0.40	0.00
	200.00	0.72	0.00
	Plateau (300)	0.96	0.02

Table 1: Averaged relative doses taken over each dose plateau along the cross profile of overlapping fields.

4. Discussion and Conclusions

The proton formulation of PRESAGE® showed good dose agreement between single and overlapping field irradiations. Dose volumes treated with sequential beams, primarily in the distal end of the SOBP, actually resulted in dose profiles more consistent with expected results. The photon formulation had slightly less agreement, while the sequential field irradiations again showed a closer agreement with PDD data. Repetition of the dose plateau irradiations to remove irregularities seen in the dose profile as well as comparison with treatment planning system data will allow further verification.

5. References

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