Measurement of a 200 MeV proton beam using a polyurethane dosimeter

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1. Introduction
PRESAGE™ (Heuris Pharma LLC, Skillman, NJ) is a three-dimensional polyurethane dosimeter containing a leuco dye that generates a color change when irradiated. The dosimeter is solid and does not require a container to maintain its shape. The dosimeter is transparent before irradiation and the maximum absorbance of the leuco dye occurs at 633 nm which is compatible with the OCT-OPUS™ laser CT scanner (MGS Research, Inc., Madison, CT).

Previous studies have investigated the use of PRESAGE™ in photon and electron radiotherapy [1,2]. The dosimeter was shown to respond monotonically to both photons and electrons. An IMRT dose distribution was evaluated and showed good agreement with the corresponding treatment plan [1]. The purpose of this study was to investigate the response of PRESAGE™ to proton beam radiotherapy.

2. Materials and Methods
PRESAGE™ dosimeters 73 mm in height and 95 mm in diameter were used in this study. Proton irradiations were performed at the University of Texas M. D. Anderson Cancer Center Proton Therapy Center in Houston, Texas. The dosimeter was placed within a water-equivalent plastic phantom so that the dosimeter spanned the range from 13 cm to 20.3 cm depth. The PRESAGE™ was irradiated with a modulated 200 MeV proton beam providing a 3 cm spread-out Bragg peak (SOBP). A field size of 2 cm x 2 cm allowed the placement of three SOBPs within a single PRESAGE™. Each SOBP was irradiated to a different maximum dose (2, 4, and 6 Gy). Ionization chamber measurements were taken at selected depths in a water phantom for comparison. An additional PRESAGE™ was irradiated using 6 MV photons. Four 1.25 cm stereotactic beams were used to deliver doses of 2, 4, 6 and 8 Gy.

One hour after irradiation, PRESAGE™ dosimeters were imaged using an OCT-OPUS™ laser CT scanner. An in-plane resolution of 1 x 1 mm² was used. The dosimeter was scanned in 1 mm increments over the entire height.

3. Results and Discussion
The dose response of the PRESAGE™ to 6 MV photons and 200 MeV protons is displayed in Figure 1. The gel response to the proton beam was obtained from a region of interest in the SOBP. The dose was determined from ion chamber measurements at the center of the SOBP.
Figure 1. Dose response of PRESAGETM. Error bars represent one standard deviation.

Figure 2. SOBPs measured with PRESAGETM and ion chamber.

Figure 2 displays the SOBPs measured with the PRESAGETM. Also shown in the figure are data measured with an ion chamber. The data were normalized to the dose measured in the SOBP region.

As shown in Figure 2, the shapes of the SOBPs measured with PRESAGETM are independent of dose. Each curve exhibits a steep dose gradient at depths proximal to the surface of the PRESAGETM. Each curve also shows an under-response in the distal region of the SOBP.
The under-response of polymer gels in the distal region of the SOBP has been observed in a previous study [3]. The under-response of the PRESAGE™ is expected because free radicals can recombine in the high LET region resulting in fewer radicals for initiation of the response in the dosimeter [4]. This applies particularly to the distal edge of the SOBP where the LET is greatest. As a result, fewer free radicals are available for initiation of the radiochromic response in the PRESAGE™. The disagreement in the region proximal to the SOBP is believed to be caused by a decrease in sensitivity of the PRESAGE™ near the proximal surface. This decrease was also observed in the dosimeter irradiated with 6 MV photons. Further investigation will be conducted to help explain this discrepancy.

4. References
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