Investigation of 3D dosimetry for proton therapy using PRESAGE

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Purpose: Previous studies have investigated the applications of standard formulation PRESAGE for relative dosimetry in Radiological Physics Center (RPC) phantoms for IMRT as a means for remote dosimetry [1]. This investigation studies the feasibility of PRESAGE for clinically relevant proton treatments using an anthropomorphic head phantom developed by the RPC. Performance of a low-LET dependent PRESAGE was evaluated by comparison to the traditionally used radiochromic film, EBT2, and thermoluminescent dosimeters (TLDs).

Materials/Methods: The Alderson Average-Man head phantom consists of a human skeleton with synthetic isocyanate rubber having similar tissue-equivalent radiological properties to high-energy protons cast around it to mimic natural heterogeneous anatomical structures. The phantom has been modified by the RPC with a cutout that admits either a film and TLD insert or a PRESAGE dosimeter (**Figure 1**)

Figure 1: The RPC anthropomorphic head phantom used in proton irradiations.

The phantom was taken through the treatment planning procedure as a head and neck patient with PTV contouring and dose constraints created by physicists and dosimetrists:

- Three field treatment plan
- 98% of the primary PTV receiving 5.4 Gy
- Less than 1% receiving 90%

The phantom did not contain any organs at risk for contouring and avoidance and field parameters were chosen based on dosimetrists' prerogative (**Figure 2**).

The 3D dose distribution from the PRESAGE was read out using the Duke medium-field-of-view optical-CT scanner (DMOS) while the film and TLD system was read using standard RPC procedures and analyzed using inhouse software.

Figure 2 (left): Eclipse treatment plan for the anthropomorphic head phantom holding the PRESAGE insert.

Figure 3 (right): A PRESAGE® dosimeter formulated for high-LET dosimetry.

Results: Dose measurements of both systems were analyzed using the Computational Environment for Radiotherapy Research (CERR). A comparison of the dose maps of the EBT2 and the central axis of the PRESAGE of the matching plane, along with dose profiles with their corresponding Eclipse treatment plans, are shown in **Figure 4**. These profiles showed close agreement across the dose plateau regions for both dosimetry systems. Regions of higher dose-gradients for the EBT2 plan remained in close agreement while the PRESAGE system showed some disagreement with a maximum distance to agreement (DTA) of approximately 5mm.

RPC credentialing measures the dosimetry system using a gamma comparative analysis in which a criteria dose difference of 5% is allowed. Because of the high-gradient nature of proton therapy, the distance to agreement (DTA) portion was examined with both a 3mm and 5mm criteria.

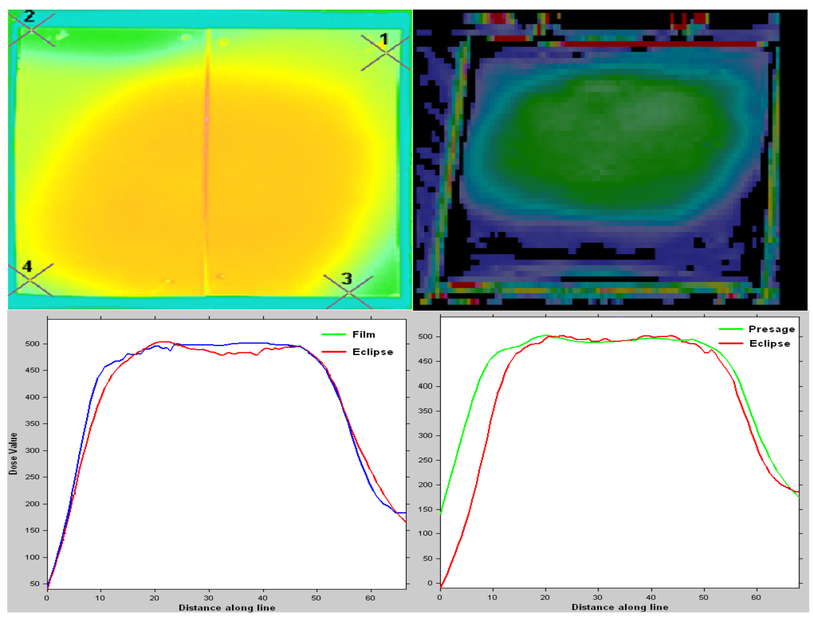

Figure 4: Dose profile comparison of EBT2 (left) and PRESAGE (right) with Eclipse treatment plans in the sagittal plane.

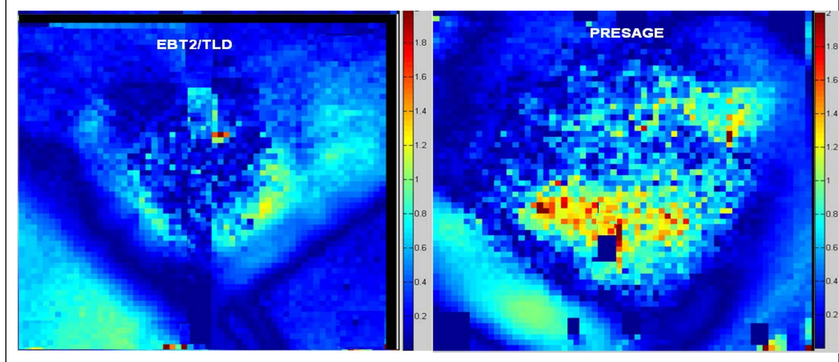

Figure 5: Gamma mapping of the EBT2 and TLD (left) and the PRESAGE (right) dosimetry systems in the sagittal plane with a gamma analysis of 5%/5mm.

		5%/3mm	5%/5mm
FILM INSERT	Coronal	93.47	96.82
	Sagittal	94.27	97.12
PRESAGE INSERT	Coronal	82.45	86.39
	Sagittal	80.12	85.74
	Transverse	84.35	84.97

Table 1: Gamma pass criteria of both dosimetry systems in the RPC head phantom.

Discussion: As proton therapy develops and becomes a more common alternative to traditional radiotherapy techniques, 3D dosimetry tools must develop to provide adequate quality assurance for highly conformal therapies. PRESAGE dosimeters show great potential for measuring dose distributions from proton fields within heterogeneous volumes, with the opportunity to measure volumetric dose data. Data within the high dose regions of the treatment showed comparable gamma pass rates from two dosimetry systems, while PRESAGE showed lower agreement in high dose-gradient regions. Future work will seek to better improve range uncertainties contributing to DTA disagreements in treatment planning of PRESAGE. Additional work includes additional RPC proton phantom studies.

References:

[1] Sakhalkar, H., et al. *Investigation of the feasibility of relative 3D dosimetry in the Radiologic Physics Center Head and Neck IMRT phantom using PRESAGE/optical-CT*. Med Phys, 2009. **36** (7): p. 3371-7.

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