PhD Thesis Title: Authentication of Absorbed Dose Measurements for Optimization of Radiotherapy Treatment Planning.

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ABSTRACT:

The optimum treatment outcome of radiation therapy depends on accurate determination of radiation dose, which is possible only after the detailed analysis of quality assurance procedures in the Radiotherapy Treatment Planning, ensuring dosimetric characteristics of the machines and precise treatment execution. It was intended to develop dosimetric phantoms to imitate the actual patient's anatomy for authentication of absorbed dose in target tumor, and to assure the quality of radiotherapy treatment. An anthropomorphic PRESAGE® phantom was created in the shape of a breast for external beam radiotherapy and brachytherapy. Five fields intensity modulated radiation therapy (IMRT), three field partial breast and SAVI 6-1 applicator brachytherapy plan was used to evaluate the breast phantom. The anthropomorphic breast PRESAGE® was scanned with the Duke midsized optical CT scanner (DMOS-RPC) and optical density (OD) was converted to dose distribution. Comparisons were performed between the dose distribution calculated with the Pinnacle^3 treatment planning system, GAFCHROMIC® EBT2 film and PRESAGE® for IMRT and 3DCRT partial breast plan. Oncentra® Master Brachy planning was also used for the comparison of PRESAGE® and GAHCHROMIC® EBT2 film measurements. For IMRT, Gamma map comparisons showed that Pinnacle^3 well agreed with PRESAGE® for more than 95% of comparison points of the planning tumor volume (PTV), passed ±3%/±3 mm criterion when the outer 8 mm of phantom data were excluded. Edge artifacts were observed in the optical CT reconstruction, from the surface to a depth of almost 8 mm. For 3DCRT partial breast planning Dose Volume Histograms (DVHs) of gross tumor volume (GTV), clinical tumor volume (CTV) and PTV for the PRESAGE® dosimeter and Pinnacle^3 treatment planning system

confirmed a likeness of 97.8% of the prescribed dose. Gamma map comparisons showed that all three distributions agreed with greater than 95% of comparison points passing the ±3% / ±2 mm criterion. DVHs of the skin and PTV_EVAL (PTV_ Evaluation) Brachytherapy for PRESAGE® and Oncentra® differed by a maximum of 4 to 8% respectively. A prostate anthropomorphic RPC (Radiological Physics Center) phantom was also used, which contained TLD (Thermoluminescent dosimeters) and GAFCHROMIC® EBT2 film to evaluate the spot scanning proton therapy. The results of spot scanning proton therapy shows that the Right/Left, Inferior/Superior and Posterior/Anterior aspects of the coronal/sagittal and EBT2 film measurements were within ±7%/±4mm of the treatment planning system (TPS). This work demonstrates the feasibility of the PRESAGE® to be fashioned into anthropomorphic shape and establishes the accuracy of Pinnacle^3 for breast IMRT, as well as for 3D and brachytherapy planning. Furthermore, the extension of this work can lead to investigate 3D dosimetry with more complex anthropomorphic phantoms. RPC-Anthropomorphic prostate phantom could be used to establish quality assurance of spot scanning proton beam within certain confidence levels. The quality of treatment can be improved with the utilization of PRESAGE® in both external beam radiotherapy, as well as brachytherapy. An anthropomorphic phantom is a good substitute of actual patients' and can be a valuable tool for treatment planning in all types of radiation therapy, including spot scanning proton therapy for authentication of absorbed dose measurements and resultantly can increase the accuracy and quality of the treatment.

Key Words : 3D dosimetry, PRESAGE, IMRT, QA, EBT2 GAFCHROMIC film

References to author publications that relate specifically to the dissertation:

- K. Iqbal, K. A. Gifford, G. Ibbott, R. L. Grant, and S. A. Buzdar, "Comparison of an anthropomorphic PRESAGE® dosimeter and radiochromic film with a commercial radiation treatment planning system for breast IMRT: a feasibility study." Journal of Applied Clinical Medical Physics, Vol. 15, pp. 363-374, 2014.
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