Development of PDRESS (Patient Specific Dose Real Evaluation Systems) using a TENOMAG Gel and Optical CT (VISTA™) in Clinical IMRT Prostate Case

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Abstract. The aims of this study, we present the preliminary results of 3 dimensional dose evaluation software (PDRESS, patient specific dose real evaluation systems). In this work, we compared planned 3D dose distribution with measured 3D dose distribution using a novel normoxic polymer gel dosimeter (TENOMAG) and a commercial cone-beam optical CT scanner (VISTA™, Modus Medical Devices, Inc., London, ON, Canada) to verify the 3D dose distribution in intensity-modulated radiation therapy (IMRT) prostate case. And we developed PDRESS using the Xelis Flatform which is developed by INFINITT Corporation is used to display the 3D dose distribution by loading the DICOM RT Data which is exported from RTP and optical-CT reconstructed VFF file. Data analysis is achieved by comparing the RTP data with the VFF data using profile, gamma map, and DTA. The profiles showed good agreement between RTP data, gel dosimeter, and gamma distribution and the precision of the dose distribution is within ± 5%. The results from this study show that there are no significantly discrepancies between the calculated dose distribution from treatment plan and the measured dose distribution from a TENOMAG gel scanned with an optical CT scanner. The 3D dose evaluation software (PDRESS) which is developed in this study evaluates the accuracy of the three dimensional dose distributions.

1. Introduction
A study on 3D dose verification is still lacking in clinical cases. In this work, we compared planned 3D dose distribution with measured 3D dose distribution using a novel normoxic polymer gel dosimeter (Tetrakis hydroxymethly phosphonium chloride-Normoxic-Methacrylic acid-Gelatin, TENOMAG) and a commercial cone-beam optical CT scanner (VISTA™, Modus Medical Devices, Inc., London, ON, Canada) to verify the 3D dose distribution in intensity-modulated radiation therapy (IMRT) prostate case [1-3]. So, we present the preliminary results of 3 dimensional dose evaluation software (PDRESS, patient
2. Materials and Methods

TENOMAG dosimeter was consisted of water, gelatin, THPC and HQ. The process and the condition for preparing the polymer gel used in this study can be summarized as follows: Gelatin (300 blooms, Sigma-Aldrich, USA) was mixed with high-purity distilled water (HPLC) in a reaction flask. The reaction flask was heated by using a hot-plate magnetic stirrer to stir the mixture after the gelatin had been. The heating was continued until the gelatin melted completely, and the stirring speed was maintained such that there was no bubble formation in the flask. The heating was continued when the temperature of the gelatin solution approached 50°C, after which a clear gelatin solution was obtained due to the complete melting of the gelatin in the water. Then, the temperature of the gelatin solution was cooled down to 41°C in a water bath. In addition, a specific amount of methacrylic acid (Sigma-Aldrich, USA) was added to the reaction flask by using a micropipette. Also, a small amount of hydroquinone (Sigma-Aldrich, USA) was added to the flask. Finally, a type of antioxidant, THP (Tetrakis hydroxymethyl phosphonium, Sigma-Aldrich, USA), was added to the reaction flask. Then, the solution was stirred using the hot-plate magnetic stirrer until the mixture had fully melted and had become a clear solution [4, 5]. Scanned CT (Philips) images of dosimeter were transferred to the radiation treatment planning system (Varian ECLIPSE, Varian Medical System, Palo Alto, CA) where the IMRT prostate plan was designed. We used a 10 MV photon beam (iX, Varian Medical System, Palo Alto, CA) to deliver the prostate treatment plan. After irradiation, the TENOMAG dosimeter was scanned in the VISTA™ scanner. The optical CT scanner was composed with 590 nm LED diffuse light, CCD camera, stepper motor, matching tank, gel container and holder. The 180 projections data was acquired during 360° rotation and 1 mm resolution. Scanning time was about 4 min. The scanned data were reconstructed using VistaRecon software (Feldkamp reconstruction algorithm with Hamming filter) to obtain 3D dose distribution of OD. The gel dosimeter is taken through an entire IMRT treatment procedure and irradiated by an external beam which is delivered by iX treatment system. Optical-CT scanner was used to readout the dose distribution in gel dosimeter (Figure 1.).

![Image of DQA Phantom Scanning](image-url)

Figure 1. It shows that schematic diagram of experimental process of 3D dosimetry using gel dosimeter and optical CT.
Moreover we developed ³DRESS using the Xelis Platform which is developed by INFINITT Corporation is used to display the 3D dose distribution by loading the DICOM RT data which is exported from RTP and optical-CT reconstructed VFF file. Independent ³DRESS using ionizing chamber and EBT film is performed to compare the dose distribution of RTP with gel dosimeter. After calibration, the data analysis is achieved by comparing the RTP data with the VFF data using profile, gamma map, and DTA.

3. Results and Discussion

The agreement between the normalized EBT, gel dosimeter and RTP data was evaluated using both qualitative and quantitative methods like profile, gamma map and DTA. The profiles showed good agreement between RTP data, gel dosimeter, and gamma distribution and the precision of the dose distribution is within ± 5% (Figure 2.).

![Figure 2. It shows that 3D dosimetry of prostate IMRT case using optical CT: (a) Prostate IMRT plan using Eclipse; (b) GEL DQA plan using Eclipse; (c) GEL IMRT plan using VISTA™; (d) Comparison between plan and gel dose using our home-made program.](image)

4. Conclusion

The results from this study show that there are no significantly discrepancies between the calculated dose distribution from treatment plan and the measured dose distribution from a TENOMAG gel scanned with an optical CT scanner. The 3D dose evaluation software (³DRESS) which is developed in this study evaluates the accuracy of the three dimensional dose distributions. Further more comfortable clinical implications could be expected in further study.

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