3049 Evaluation and Application of Optical Fiber Pressure Sensor as a new Real Time Respiration Monitoring System for Radiation Therapy

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Purpose/Objective(s): Breath monitoring is an essential factor to improve the accuracy of high-precision stereotactic body radiation therapy. We introduced and applied an optical fiber pressure sensor sheet as new respiration monitoring system. In this study, we evaluated the physical characteristics and applicability of the new sensor as a respiration monitoring system for radiation therapy.

Materials/Methods: We introduced a commercially available pressure sensor sheet (optical fiber and Kinotex sensors embedded in urethane cellular foam: Nitta Co., Osaka, Japan) that can monitor change of light scatter intensity by pressure. Pressure change can be displayed in real time on a personal computer in the operator's room. The pressure sensor sheet (310 x 200 x 6 mm in size, 54 sensors embedded in grid at 30 mm intervals) was placed under the examinee's back, and fixed using a Vac-Lok system. We evaluated appropriateness of breath monitoring by: (1) Acquiring pressure wave profiles for 4 examinees having different body mass indexes (BMI), and (2) synchronizing the pressure sensor sheet and medical spirometer. We also evaluated the correlation between loading pressure and output value. Finally, effects of the pressure sensor sheet while emitting high-energy photons were evaluated for generation of electromagnetically induced noise and for dose absorption by observing the beam profile curve.

Results: The respiratory wave profile by pressure sensor sheet and that by spirometer were completely synchronized in all four examinees. Even very subtle breathing variations were detected by sensor monitoring. The pressure sensor sheet correlated linearly between loading weight and output value ($r2 = 0.99$). Electromagnetically induced noise during high energy photon exposure was detected though nearly imperceptible, and was no obstacle to respiratory wave profiling. Results were similar for effects on the absorbed dose. There were no issues during radiation therapy and treatment planning using this pressure sensor sheet.

Conclusions: The new pressure sensor sheet is non-invasive and simple to use, requiring only placement under the body. It can remotely monitor real-time body weight pressure change as a fine respiration wave profile. Further, there are no geometric or physical restrictions for radiation therapy. In conclusion, our respiratory monitoring system using an optical pressure sensor sheet presents the advantages of a non-invasive, easy to use respiration monitoring system which does not affect absorbed dosage during radiation exposure.

Author Disclosure: M. Yokokawa, None; Y. Miyahara, None; S. Ikeda, None; A. Kawaguchi, None; M. Moriyama, None; A. Nagami, None; T. Nishimura, None; S. Takahashi, None; N. Uchida, None.

3050 Investigation of a Dynamical kV Aperture together with Combined MV-kV Dose Planning for Implementing Real-time 3D MV-kV Prostate Motion Tracking

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Purpose/Objective(s): In prostate cancer cases, there is no strong correlation between internal organ motion and externally visible motion, so optimal application of IGRT requires internal tracking techniques. Real-time 3D prostate tracking based on combined MV-kV imaging is an attractive solution since it uses the built-in hardware of modern LINACs equipped with OBI and EPID. However, continuous kV imaging throughout the treatment can lead to excess diagnostic dose exposure to the patient. To manage kV exposure, this work investigates the incorporation of the delivered kV tracking dose at the treatment planning stage through combined MV-kV beam modeling and conformal kV beam aperture shaping.

Materials/Methods: A Monte Carlo scheme was developed to model dose deposition kernels for a 125 kVp photon imaging source, which were imported into a treatment planning system. The kV imaging source, orthogonal to the MV source from a LINAC, was commissioned in the TPS, using dose profile and PDD measurements made on radiographic film and calibrated with ion chamber measurements. Using previously treated 9-field IMRT prostate patient treatment plans, the TPS was used to calculate the dose that would be delivered by the kV beam during real-time tracking. To provide stereoscopic imaging at each gantry angle during treatment, the kV and MV beam times were matched. Apertures studied included a small 3 x 3 cm field capable of tracking closely placed fiducials in prostate cases, as well as a number of larger apertures.

Results: In the four patients studied, the average dose to the prostate from a conformed 3x3 cm kV aperture was 5 cGy. This increased to 9 cGy per fraction when using an open aperture. For the patients studied, this corresponds to 2-5% of the prescribed dose per fraction. The 3x3 cm aperture significantly spared more healthy tissue, delivering 5 cGy or more per fraction to less than 1% of a patient volume, compared to 80% of the patient volume in the full kV field case.

Conclusions: The use of conformal kV apertures shaped to the tracking region of interest can lead to significant reductions in total kV diagnostic radiation delivered. This allows for the kV beam to provide useful tracking information, while simultaneously delivering therapeutic dose to the prostate.

Author Disclosure: Z.R. Grelewicz, None; E. Pearson, None; P. Alaei, None; C.A. Pelizzari, None; R.D. Wiersma, None.