of Monte Carlo dose calculations, multiple inverse planning algorithms, and a user-friendly GUI, we hope this system would further enhance the application and research of Monte Carlo treatment planning in radiotherapy. We plan to have it available free to interested parties in the future.

Author Disclosure: J. Deng, None; Y. Yan, None; Z. Chen, None; X. Weng, None; R. Nath, None.

## 2790 Real Time Respiration-compensated Tomotherapeutical Delivery

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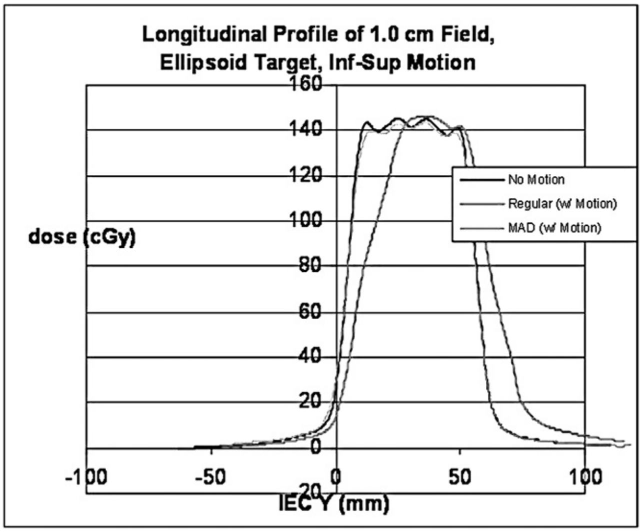
**Purpose/Objective(s):** We developed a real time motion adaptive delivery (MAD) technique to compensate respiratory motion in tomotherapeutical delivery. We made the dosimetric measurements on the tomotherapy machine with a motion phantom as a proof of the MAD technique.

**Methods/Materials:** Tomotherapeutical delivery is controlled by a planned projection-wise leaf sequence (sinogram). Tomotherapy's gantry rotation synchronizes with its couch motion. Both are in constant speed. To compensate longitudinal target motion in real time, instead of sequential execution of the planned sinogram, the projections are out of order executed. That is, a previous or future projection of the planned sinogram is chosen instead. The transversal target motion is further compensated by shifting and scaling the open time of each leaf from the chosen projection. We construct a motion phantom whose motion is synchronized with tomotherapy delivery. We deliver a standard helical plan on a stationary phantom, a standard helical plan on a moving phantom, and MAD on a moving phantom. We use film to measure the dose of each delivery and compare the dosimetric results of each measurement.

**Results:** We tested different tomotherapy plans with various tomotherapy machine parameters and target shapes. Arbitrary respiratory motions were simulated. As we delivered a well-conformed tomotherapy plan without motion compensation to a patient with respiration motion, significant differences between the delivery doses and the planned doses appeared. While we applied the real time MAD technique, we measured the MAD to be within 2% of dose of a regular treatment delivered to a stationary phantom. These results are consistent for different IMRT target shapes (spherical, ellipsoid, saddle-shaped), target motions (lateral, inferior-superior), and field sizes (1.0 and 2.5 cm). The dose errors are well below 3 mm and 3% criteria. No hot and cold spots are noticeable. Fig. 1 compares the typical dose profiles. The simulated respiration is Lujan type breathing with peak-peak amplitude of 2 cm.

**Conclusions:** We present a novel technique for real time respiration compensation in tomotherapy. MAD only requires instantaneous target position, which greatly simplifies its implementation. This technique re-uses the planned sinogram by shuffling its projection and leaf indices. The simulations and experimental measurement on the helical tomotherapy machine validates the presenting technique. The MADs have dose within 2% of a regular helical treatment to a stationary target. Therefore, if real time target position is available, the MAD would compensate the respiration effects in real time, which implies smaller margins and sparing more healthy tissues.




Author Disclosure: W. Lu, TomoTherapy Inc, A. Employment; C. Mauer, TomoTherapy Inc, A. Employment; M. Chen, TomoTherapy Inc., A. Employment; Q. Chen, TomoTherapy Inc, A. Employment; D. Lucas, TomoTherapy Inc., A. Employment; J. Zhang, TomoTherapy Inc., A. Employment; K. Ruchala, TomoTherapy Inc., A. Employment; G. Olivera, TomoTherapy Inc., A. Employment.

## 2791 IGRT Using a Video-Based 3-D Surface Imaging System in Combination With CBCT

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**Purpose/Objective(s):** To report on commissioning of a video-based 3-D surface imaging system and its initial clinical use in verifying patient shifts following kilovoltage (kV) cone beam computed tomography (CBCT) based patient alignment prior to radiation therapy treatment.

**Materials/Methods:** Two video-based surface imaging systems (AlignRT, VisionRT Ltd., London UK) were recently installed in our two treatment rooms housing Elekta Synergy and Synergy-S image-guided linacs. A kV-CBCT QA alignment tool called Ball-Bearing device (BBD) (Elekta Inc.), which is designed to check the coincidence between the MV and kV beams' isocenters, has been utilized in the commissioning of the AlignRT system. The micro-stepping meter of the BBD allows precision adjustment to better than 0.01 mm in three dimensions. A foam phantom was added to the BBD in order to generate a large 3-D surface image which can be detected by the AlignRT system. The BBD-phantom has been imaged by the AlignRT system with changes in position (0.0 to 8.0 mm) in all three dimensions independently. The phantom shifts were determined by the surface imaging system and compared to the preset ones. After commissioning, the AlignRT system has been used to verify patient shifts during radiation therapy treatment image-guided by CBCT. The steps in the study protocol are: (1) Following initial patient setup a reference image of the patient with the surface imaging system is taken (2) the patient is scanned with CBCT; (3) the CBCT image is registered to the reference image (planning CT) using bone or soft tissues registration depending on the disease site; (4) the patient is shifted in three dimensions by the amounts determined through the CBCT registration; (5) A verifying image with the surface imaging system is taken (6) The shifts determined by the surface imaging system are compared to those from the CBCT registration. A total of eight IGRT patients with lung, prostate/fossa, kidney fossa cancers are included in this study.

**Results:** The surface imaging system was validated by the phantom test to be able to detect 0.1 mm changes in both lateral and longitudinal directions, 0.3 mm in vertical direction. Thus far, a total of 24 verifications (each with three directions) of the eight patients have been made; in all cases surface imaging system verified that the patient shifts in all three directions are within one millimeter with the ones determined by CBCT with an exception that about 20% of the vertical shifts agree between 1 to 2 mm.

**Conclusions:** The surface imaging system can detect fractional mm shifts in the BBD-phantom; vertical resolution is not as sensitive as horizontal. The system can be used to verify patient shifts in CBCT IGRT. Such procedure is significantly faster than an additional CBCT and it does not add any additional image dose to the patient.

Author Disclosure: C. Yang, None; T. Liu, None; J. Lehmann, None; S. Narayan, None; R. Harse, None; S. Vijayakumar, None; J. Purdy, None.

## 2792 Inter-Fractional Balloon Variation in Mammosite HDR Brachytherapy: Dosimetric Analysis on 200 CT-Based Plans

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**Purpose/Objective(s):** In MammoSite partial breast HDR irradiation, a CT-based plan of the first fraction is used for subsequent fractions without modification unless significant change in the central balloon diameter is observed on the axial CT image. However, balloon deformity can be noticeable if three-dimensional CT data are rotated and their image intensity is modified to visualize the catheter inside the balloon. Dose deviations from the first-fraction plan over the full course of treatment can occur due to the change in balloon deformity, volume of trapped air gap, and the relative location of balloon to the skin and ipsilateral lung. In this study, the inter-fractional variation in balloon shape and location was evaluated on 200 plans (200 CT data sets for 20 patients treated with 10 fractions) using several dosimetric parameters.

**Materials/Methods:** Patients were treated to a dose of 34 Gy delivered in 10 fractions twice a day with minimum of 6 hours between fractions. For the first fraction plan, the fractional dose of 3.4 Gy was prescribed to the surface of balloon + 1 cm with multiple dwell position technique. For each patient, additional 9 CT scans were obtained for fractions 2–10 and utilized to generate 9 plans, retrospectively. On those CT data sets, PTV_EVAL and all critical structures were contoured and a catheter was positioned inside the balloon. Furthermore, dwell times were determined from the first fraction plan and held constant through all remaining fractions. The PTV_EVAL volume was used for plan evaluation purposes and obtained by subtracting the balloon volume from a balloon + 1 cm volume. This excluded the volume of lung/pectoralis muscle and the volume of skin + 5 mm. For each patient, the 9 plans were compared to the first fraction plan using dosimetric parameters such as percentage of PTV_EVAL coverage and maximum dose to the skin and ipsilateral lung.

**Results:** The trapped air gap volume shown in Fig.1 for all patients was gradually decreased from a mean value of 0.74 cc (fraction 1) to 0.18 cc (fraction 10) while it was increased at a certain fraction in some patients. The average (maximum) inter-fractional variation from the first fraction plan was 1.8% (7.3%) for the PTV_EVAL coverage (Fig. 2), 32.3 cGy (176.2 cGy) for the skin maximum dose (Fig. 3), and 26.9 cGy (94.5 cGy) for the ipsilateral lung maximum dose (Fig. 4).

**Conclusions:** The inter-fractional dose variation due to the change in balloon shape and location was patient-specific and dependent upon the balloon deformity and location. The average deviation from the first fraction plan may not be clinically significant. However, the maximum deviation may be clinically significant.