[OA011] DoseTracker: In-house developed software program for real-time reconstruction of motion-induced dose errors during radiotherapy  
Simon Skouboe a,*, Thomas Ravkilde b, Casper Gammelmark Muurholm c, Esben Worm b, Rune Hansen b, Per Rugaard Poulsen a  

a Aarhus University Hospital, Department of Oncology, Aarhus C, Denmark  
b Aarhus University Hospital, Department of Medical Physics, Aarhus C, Denmark  
c Aarhus University, Department of Physics and Astronomy, Aarhus C, Denmark  
d Aarhus University Hospital, Department of Clinical Medicine, Aarhus C, Denmark  
* Corresponding author.

Purpose. A problem of current plan-specific quality assurance (QA) in radiotherapy is that it ignores organ motion, although motion may cause dose discrepancies much greater than the treatment delivery errors assessed by the QA procedure. Furthermore, the QA is not feasible for real-time adaptive treatments like MLC tracking, where the treatment machine behavior is determined on-the-fly as a response to tumor motion. To overcome these limitations, we have developed the software program DoseTracker that performs real-time motion-including dose reconstruction during treatment delivery. Here, we validate DoseTracker in experiments and simulated treatments.

Methods. DoseTracker performs real-time motion-including dose reconstruction, based on streamed linac parameters and target positions, using a pencil-beam algorithm. An arbitrary set of points can be chosen for the dose calculations and the calculations points can move independently as function of time. DoseTracker has been validated in phantom experiments and simulated patient treatments.

The phantom experiments used a biplanar diode array on a programmable motion stage. DoseTracker performed online real-time reconstruction of the diode doses at 15 Hz and calculated the 3%/3 mm gamma failure rate (comparing motion doses with static doses) at 1 Hz during five VMAT liver SBRT treatments with and without MLC tracking. The gamma errors were retrospectively compared with diode measurements.

In the treatment simulations, DoseTracker made (offline) real-time tumor dose reconstructions at 2–5 Hz in patient anatomy for four liver SBRT patients previously treated with motion monitoring by electromagnetic transponders. Simulations were performed with and without respiratory gating. The reduction in CTV D95 relative to the planned intent (ΔD95) was retrospectively compared between DoseTracker and motion-including dose reconstructions performed in the treatment planning system (TPS) by isocenter shifts. DoseTracker currently assumes water densities so another set of TPS calculations were performed on water densities.

Results. Experiments yielded 2.0%-point gamma failure rate root-mean-square difference between DoseTracker and measurements. Simulated treatments yielded 1.2%-points (CT-densities) and 0.6%-point (water-densities) differences in ΔD95.

Conclusions. A program to reconstruct motion-induced dose errors was developed and tested in phantom studies and patients, yielding high accuracies, and allowing supervision of treatment correctness and action based on dose discrepancies. Planned improvements include CT-densities, rotations, etc.

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[OA012] Differences between real and planned dose distributions as a result of uncorrected patient rotation in radiotherapy  
Václav Novák a,*, Ivo Příša d, Jaroslav Ptáček a, David Gremlič a  

a Faculty Hospital Olomouc, Department of Medical Physics and Radiation Protection, Olomouc, Czech Republic  
* Corresponding author.

Purpose. To study the influence of relatively small and uncorrected rotational errors in patient positioning on the dose distribution for Head and Neck and Brain cases.

Methods. Analysis was carried out for 15 Head and Neck and Brain patients irradiated with VMAT technique. Cone beam CT (CBCT), which was performed for every patient in five to seven fractions during the treatment course, was only used for correcting patient shift. Rotational patient positioning errors were not corrected since it is not possible at most of radiotherapy departments. After the whole course, additional offline registrations of originally acquired CBCT with planning CTs were performed and rotational errors for pitch, roll and yaw (rx, ry, rz) were obtained. Only cases, where errors in patient rotation could not be partially compensated with table shift, were used for this analysis. For every patient, mean rotational corrections were determined. Planning CTs were rotated in all three axes according to the detected mean rotational corrections for individual patients and the original dosimetry plans were recalculated into the rotated CT. The recalculated plans were then used to evaluate the maximum dose to brainstem, optic nerve and chiasma.

Results. The highest mean rotational positioning errors were found on the X-axis, where the mean rotational error rx was 1.17° (0.20° to 1.98°). For Y and Z-axes the mean rotational errors ry and rz were 0.80° (0.33° to 1.60°) and 0.74° (0.10° to 1.65°), respectively. Recalculated dose distributions in rotated CTs were compared to those in original planning CTs. For all patients maximum doses to brainstem, chiasma and optic nerve were higher in recalculated plans with the mean increase of 0.8 Gy (0.1 to 1.5 Gy), 2.4 Gy (0.3 to 4.3 Gy) and of 2.5 Gy (0.2 to 5.2 Gy), respectively.

Conclusions. Uncorrected rotational errors for Head and Neck and Brain cases can substantially increase the maximum doses to critical structures. As the dose limits of chiasma (for two patients) and optic nerve (for one patient) were exceeded, the recalculated dose distributions would be evaluated as clinically unacceptable.

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[OA013] Treatment accuracy in surface guided deep-inspiration breath-hold radiotherapy for left-sided breast cancer  
Esben Worm a, Birgitte OfferSEN c, Per R. Poulsen, Ellen Askholm, Esben S Yates, Rune Hansen  

Aarhus University Hospital, Oncology, Aarhus, Denmark  
* Corresponding author.

Purpose. To evaluate the setup accuracy and intrafraction stability in deep-inspiration breath-hold (DIBH) surface guided radiotherapy (SGRT) for left-sided breast cancer.

Methods. Five patients received 15 (n = 4) or 18 (n = 1) fractions of radiotherapy for left-sided breast cancer. Treatment planning was based on two opposing fields, aligned tangentially to the thoracic wall. At treatment, patient setup was initially guided by an optical SGRT system such that the breast surface during DIBH corresponded to the projected breast surface of the DIBH planning-CT. The couch was then repositioned during DIBH according to daily orthogonal MV (matching thoracic wall) and kV (matching ribs, junction of the clavicle and sternum) image-guidance and a new reference position of the breast surface was