receive a dose above 35 Gy for the stomach, bowel and duodenum, and 15 Gy for the kidneys. For each patient, CT scans with intravenous contrast were obtained prior to the first three fractions using a sliding-gantry in-room CT. Directly after imaging, the patient was automatically transported by the robotic manipulator of the treatment couch to the treatment location in no more than 45 seconds. Each of the daily CTs was matched to the planning CT using automatic deformable image registration that allowed the fast (<1 min) adaptation of OAR contours to match daily anatomy. The OAR contours were manually adjusted by a radiation oncologist. To evaluate the dose to the OARs, each daily CT was matched to the planning CT using a combination of spine and fiducial matching, as performed at treatment. The same transformation was applied to the planned dose distribution, and the dose was evaluated on the new OAR contours.

Results: For the stomach, duodenum and small bowel, we evaluated the maximum dose, as well as the volume exceeding 35 Gy. The Dmax is shown in Figure 1. In all 15 (3x5) imaged fractions, the Dmax to at least one of these OARs was higher than the planned Dmax. The volume above 35 Gy was between 0 and 0.3 cc at planning, and increased or remained constant during treatment. For two patients, a clinically significant increase was observed, i.e. to 4.7 cc for bowel and 4.4 cc for duodenum, respectively. However, the clinical constraint of 5 cc was not violated. Dose to the kidneys remained well within constraints. The PTV volume receiving 95% of prescribed dose was ≥99% for 3 of the 5 patients. For two patients with high OAR dose at planning (Pt3 & Pt4), the planned coverage was 83% and 66%, resp, demonstrating the current limitations imposed by OAR constraints.

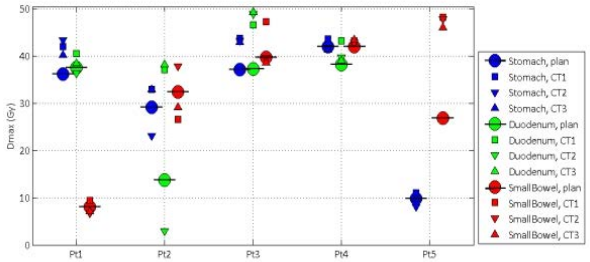

Figure 1 - Dmax for stomach, duodenum, and small bowel for the 5 patients. Note that for patient 5, duodenum is absent due to surgical resection.

Conclusion: In this study, we have employed in-room CT, combined with fast deformable image registration, to evaluate OAR dose constraints on a daily basis. We have observed clinically significant differences in the maximum dose to critical OARs, due to anatomical variations. This observation, even in this small patient group, demonstrates the need for further research on developing adaptive strategies to improve CTV coverage while keeping OAR dose within the clinical constraints.

PO-0909

Merging proton radiographies with treatment planning CT for adaptive radiation therapy

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Purpose or Objective: Ion CT imaging (iCT), as obtained from tomographic reconstruction of ion radiographies, can be considered an emerging modality for adaptive radiation therapy (ART) in ion beam therapy due to accurate characterization of the in-room/in-beam anatomy in terms of tissue ion stopping power. The purpose of this work is to investigate ART feasibility, by limiting the number of low-dose scanned beam proton radiographies obtained in the treatment room, for different detection configurations of list mode and integration mode, in combination with high resolution anatomical information from the initial treatment planning X-ray CT.

Material and Methods: Proton radiographies obtained from Monte Carlo simulations (MCRs) are calculated based on patient CT images. For each pencil beam, 100 primary protons are delivered and the energy at the detector plane is converted to Water Equivalent Thickness (WET) relying on the *Bethe-Bloch* formula. List mode is reproduced by tracking each proton according to the Maximum Likelihood Path (MLP) and assigning each WET value along the estimated trajectory, while in integration mode only the most probable WET value of the raster point is assigned to a straight trajectory. To simulate inter-fractional anatomical changes, the patient CT, which is assumed to represent the in-room/in-beam scenario, is warped according to three-dimensional (3D) rigid and/or Gaussian deformation fields in head-neck and thoracic-abdominal sites, thus leading to a modified CT (mCT), which provides a theoretical representation of the treatment planning CT. Digitally Reconstructed Radiographs of mCT (mDRRs) are generated and two-dimensional (2D) deformable and/or rigid image registration is applied between corresponding mDRR and MCR in projection domain. By means of dedicated tomographic reconstruction algorithms, which rely on estimating the deformation in projection domain, high resolution anatomical information from mDRR is merged with accurate tissue stopping power from MCR, thus leading to combined iCT-CT. In this study, the DRRs of CT are used as the gold standard for 2D geometrical quantification. The methodological framework is reported in Fig. 1.

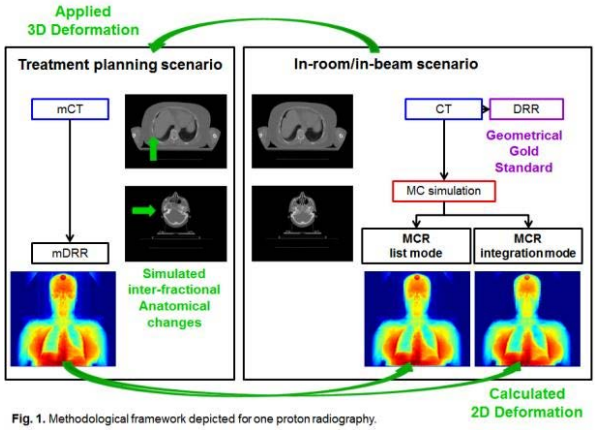

Fig. 1. Methodological framework depicted for one proton radiography.

Results: Performance for list mode was slightly better than integration mode but for both configurations difference were always <35 Hounsfield Unit (HU), translating into maximum 8% error in Relative Stopping Power (RSP), according to the approximate HU-RSP calibration curve. The comparison between list mode and integration mode as a function of different number of primaries will be presented, considering different inter-fractional anatomical changes. Quantification in image domain of combined iCT-CT will be performed as a function of different numbers of radiographies.

Conclusion: Both configurations enable accurate image registration for ART purpose. Conclusions about achievable dose reduction for acceptable quality of iCT-CT will be drawn.

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PO-0910

Potential increase in dose delivered on a fraction by fraction basis by adapting to daily OAR DVCs

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