guidelines on CTV definition and knowledge of commonly missed/disconcordant CTV areas cannot be overemphasized to avoid such difference.

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Improved 4DCT quality using true phase based triggers
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Purpose or Objective: For Toshiba Aquilion LB CT scanners, the reconstruction quality of 4DCTs is strongly dependent on the accuracy of cycle based online trigger pulses. Two consecutive triggers are used to define a breathing cycle which is divided into respiratory phases of equal duration. As a consequence, any deviation in the length of the inspiration or expiration period in relation to the whole breathing cycle will result in image artifacts and a higher probability of misinterpretations. The aim of this work is to improve 4DCT quality by using amplitude based triggers for each individual breathing cycle.

Material and Methods: The trigger signals for the 4DCT reconstruction are originally provided by the Sentinel™ optical surface scanner (C-RAD AB, Sweden) using a threshold method in order to generate online trigger pulses. These always have to occur before the actual maximum of the curve and are used to reconstruct the 4DCT phases based on an equally divided breathing cycle (0% - 90% in 10% steps) for phase-based reconstruction. A second 4DCT is reconstructed using the true inhalation peak triggers created by an offline tool, also with phases of equal time for each cycle. Furthermore, a single trigger for each breathing phase is sent to the CT for a third reconstruction of all motion states based on the absolute volume of a tumor inside of a moving chest phantom, which serves as a direct measure for reconstruction quality, has been determined for each motion state of the reconstructed 4DCT for 10 different curves (2 sinusoidal, 8 patient breathing curves).

Results: Reconstructing the 4DCT solely according to the online trigger pulses proposed by Sentinel™scan lead to a mean deviation in the volume of the tumor of up to 2.98% ± 4.65% compared to the CT reconstruction of the same tumor without any movement. When selecting the optimal trigger point at maximum inhalation offline and dividing the breathing curve into phases of equal duration, the error in volume is reduced to 0.19% ± 2.84%. Generating an amplitude based set of trigger pulses for each individual breathing cycle, the error in volume has been observed with 0.25% ± 0.29%.

Conclusion: Although the method of reconstructing 4DCTs using the amplitude-based information for each breathing cycle provides the best representation of the tumor volume, it appears to be quite impractical as every trigger file for each phase has to be sent into the CT for a single reconstruction of this motion state. This will be hard to accomplish in a clinical workflow and is prone to errors. A reconstruction of the 4DCTs based on equally divided respiration phases over time with the trigger points set to the true maximum of the breathing curve serves as a valid compromise, with minimal extra workload clinically and improved 4DCT image quality.

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Improved proton stopping power ratio estimation for a deformable 3D dosimeter using Dual Energy CT
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Purpose or Objective: The highly localized dose distribution in proton therapy (PT) makes this treatment modality sensitive to organ motion and deformations. E.g. in proton pencil beam scanning interplay effects may be significant, resulting in dose degradations. Due to the complexity of PT dose delivery, investigations of the consequences of motion and of motion mitigation strategies may benefit from the use of 3D dosimetry. A new family of silicone-based 3D dosimeters is currently being developed. These dosimeters can be moulded into anthropomorphic shapes and can be deformed during beam delivery, which allows for simulation of organ motion and deformation.

Treatment planning with protons is based on CT scans of the patient anatomy and a conversion of the HU for the tissue to a stopping power ratio (SPR) relative to water. To ensure that the same procedure can be performed for the dosimeter it must be verified that its SPR is estimated correctly from its HU. The aim of this study was therefore to investigate if the use of Dual Energy (DE) CT and dedicated DE calibrations can improve the calculation of the SPR for the dosimeter compared to use of Single Energy (SE) CT together with the stoichiometric calibration method.

Material and Methods: A thin slab of the dosimeter material was placed in a water tank and irradiated with a 60 MeV proton beam. The range of the protons was measured with and without the dosimeter intersecting the beam to determine the range difference. The SPR of the dosimeter was calculated from its thickness and the range difference. The dosimeter was subsequently CT scanned with a Dual Source CT scanner (Siemens Somaton Definition Flash). First a CT scan was obtained in SE mode with a tube voltage of 120 kVp, and this scan was used in the stoichiometric calibration. Next a set of CT scans was obtained in DE mode with a tube voltage pair of 80/140Sn kVp (Sn: 0.4 mm extra tin filtration); this CT image set was used for SPR calculation with two published DE calibrations. The CTDIvol of the two scanning modes was set to be the same (~20 mGy).

Results: From the range measurements, the SPR of the dosimeter was calculated to be SPRmeas = 0.97. The two DE calibration methods both gave an estimate of SPRest = 1.01, whereas the SE stoichiometric calibration estimate was SPRRest = 1.10. The measured SPR did not fall on the stoichiometric calibration curve of the reference tissues (Figure; the high content of silicon makes the dosimeter not tissue equivalent). The dosimeter was found to have a HU corresponding to bone (CT number = 135 HU) but a SPR corresponding to fat.