reported: CSA vs Age, CTDIvol vs CSA, DLP vs CSA, CTDIvol by Patient, DLP by Patient.

Results: The mean scan length, DLP, CTDIvol and Effective Dose by Protocol were found for each protocol. The most significant result was that the DLP values from the Head & Neck protocol were tightly clustered but higher than one would normally expect. The mean DLP was a factor of 4 greater than the head and neck reference level reported in the previous UK national (diagnostic CT) dose audit.

Conclusion: The results from this CT dose audit can be used as local Radiotherapy Imaging Reference Levels (RIRL). They will be able to guide protocol optimisation, allow comparison with other similarly equipped radiotherapy departments and participation in regional and national audits. The higher than expected DLP values for the Head & Neck protocol highlighted here has prompted a reassessment of the scanning parameters and may lead to protocol optimisation.

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Radiation safety shielding for high dose rates from flattening filter free treatment modalities
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Purpose or Objective: Radiation safety for softer flattening filter free (FFF) treatment beams when operating at their very high dose rates should be considered over that of their flattening filter (FF) counterparts. Existing shielding is usually adequate when replacing treatment units utilizing beams of FF only with FFF-beams of the same nominal energy(1). However, depending upon the existing shielding composition and thickness, workload, and occupancy factors, the instantaneous dose rate (IDR) may present a radiation safety concern.

Material and Methods: A generalized analysis is presented with regards to replacing a unit which has only FF-beams to one with FFF-beams in a pre-existing bunker. Extra focus is placed on the situation that radiation levels around the treatment bunker are already at the radiation safety threshold for the unit being replaced. This threshold condition varies with the radiation safety regulations of the land. For example, the Canadian Nuclear Safety Commission (CNSC) imposes a condition that the IDR be less than 25 μSv/h to deem an area uncontrolled(3). The United States National Regulatory Council (US NRC) regulates the time averaged dose rate (TADR) to be less than 20μSv in any one hour(2).

Results: It is demonstrated that in switching to FFF-beam treatment units that protection using existing shielding is maintained for annual and weekly equivalent dose protection levels. However, it is possible for the CNSC IDR condition to be exceeded at the highest dose rates for FFF-beams. Thus shielding modification should be considered along with the ALARA principle(4). An analysis of the latter point is presented in general and by example from such a treatment unit replacement at the London Regional Cancer Program. The US NRC regulation is not as stringent as the Canadian condition and is almost impossible to exceed if the conditions before replacement were met. The analysis of this result is presented in general.

Conclusion: Care must be taken when considering the replacement of radiation treatment units with FF-beams to those with FFF-beams with respect to radiation protection. Radiation protection from the existing shielding is maintained for annual and weekly protection levels. However, IDR may exceed. The US NRC condition is almost impossible to exceed.

References:
2. NCRP REPORT No. 151. (2005)

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CBCT and planar imaging dose for prostate and head-and-neck patients using 3 different imaging systems
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Purpose or Objective: In image-guided radiotherapy, imaging dose varies greatly with the imaging technique. We here present imaging doses from planar and cone-beam CT (CBCT) imaging for the three different on-board imaging techniques: the treatment beam line (TBL, 6 MV), a dedicated imaging beam line termed kView of nominally 1 MV (IBL), and a kilovoltage system (kVision) at 70-121 kV photon energy. We consider two collectives of patients with common IGRT indications: head-and-neck and prostate cancer.

Material and Methods: In this study, we retrospectively analyzed imaging dose of 54 patients with head-and-neck cancer and 53 with prostate cancer treated in 2013. For all patients, the number of verification images (CBCT and axes) was determined, separately for the three systems (more than 1000 images). The dose for each verification image was calculated in the Philips Pinnacle treatment planning system on a 2 mm grid using the collapsed cone algorithm. We evaluated the dose maximum and dose to the organs at risk, considering the total imaging dose, and for the techniques (6 MV, IBL, kV, planar vs. CBCT) separately.

Results: The calculated imaging doses are given in Table 1. Both the TBL and IBL modality entail considerable imaging dose, even for orthogonal axes. The maximum dose value for each image, averaged over all prostate patients, was 14.8 cGy (6 MV CBCT)/ 2.8 cGy (19 %; 6 MV axes)/ 10.5 cGy (71 %; IBL CBCT) / 2.1 cGy (14 %; IBL axes) / 3.8 cGy (26 %; kV CBCT), where percentage values refer to the 6 MV CBCT dose. As can be seen, kV CBCT still amounts to 26 % the imaging dose from MV CBCT, and about twice the dose from IBL axes. Averaged over the collective of head-and-neck cancer patients, the maximum imaging dose was 8.4 cGy (6 MV CBCT)/ 2.6 cGy (31 %; 6 MV axes)/ 6.2 cGy (74 %; IBL CBCT)/ 2.3 cGy (27 %; IBL axes)/ 0.9 cGy (11 %; kV CBCT). Here, the dose reduction from axial images was not as pronounced because less monitor units were used for MV CBCT. kV CBCT reduced the dose further because of low mAs values chosen by the autoexposure mechanism.
Conclusion: to the total imaging dose is shown in Figure 1. The relative frequency of the techniques and the contributions of the different techniques to the total imaging dose is shown in Figure 1.

In our clinical setting, images were acquired at every second or third treatment fraction, resulting in a median total dose of imaging from 34.6 cGy for head-and-neck, and 70.6 cGy for prostate cancer patients. The relative frequency of the techniques and the contributions of the different techniques to the total imaging dose is shown in Figure 1.

Results: Under the different conditions, Gx(W)100 showed a weak dependency on tube voltage over the range 80-140 kV. Gx(W)100, however, was influenced by diameter and composition of the phantom. Therefore, a set of Gx(W)100 functions based on the diameter and composition was developed to assess f(0) in a given long phantom from f100(150) measurements obtained within the short phantoms. Gx(W)100 provides a practical approach to avoid the use of long phantoms, which are impractical in the clinical environment, and hence simplify the AAPM method. Since the CT dosimetry system used for f100(150) is available worldwide, this approach could help to maintain the standard equipment. The Gx(W)100 functions used in this study have been applied to a CT scanner, and showed a weak dependency on the scanner type. This gave an indication that Gx(W)100 may be comparatively independent of the type of imaging system.

Conclusion: Gx(W)100 function was proposed in this study, and was relatively independent of tube voltage and may be independent on the scanner type. Gx(W)100 allows measurement of f(0) using the AAPM method with standard CT dosimetry equipment.

Purpose or Objective: In recent years, dosimetry in cone beam computed tomography (CBCT) has become an issue as the standard dose index used for CT dosimetry (CTDI100) fails to provide a satisfactory estimation of dose for CBCT scans. AAPM TG–111 proposed replacements of the CTDI100 with a measurement of a cumulative dose to address the problem. The cumulative dose for CBCT scans f(0) is a point dose measured using a small ionization chamber in the middle of a cylindrical PMMA, polyethylene, or water phantom of length ≥450 mm to achieve scatter equilibrium. Although this method overcomes the limitations of CTDI100, the use of longer phantoms is impractical in the clinical environment. A practical approach based on using the standard CT dosimetry system was introduced to assess f(0).

Material and Methods: A function called Gx(W)100 was introduced in this study. It was defined as the ratio of f(0) to a dose index f100(150). Therefore, was proposed for CBCT dosimetry and equals the cumulative dose averaged over the length of a standard 100 mm CT pencil ionization chamber and measured within standard 150 mm long PMMA CTDI phantoms. Monte Carlo BEAMnrc and DOSXYZnrc codes have been used to simulate the On-Board Imager (OBI) system, and to calculate f100(150) and f(0). Standard 150 mm CTDI phantoms were simulated to calculate f100(150), whereas infinitely long PMMA, polyethylene, and water phantoms were used for f(0). The phantoms in different diameters were used to represent and head and body of an adult patient, a body polyethylene phantom being equivalent to the ICRU–AAPM phantom. f100(150) and f(0) were measured at the centre and periphery of the phantoms using beams of width 40-500 mm and beam qualities of 80-140 kV. Gx(W)100 was evaluated under different conditions with f100(150) and f(0) calculated with the same beam width (W) and at the same position (centre or periphery).

Evaluation of organ dose according to cone-beam CT scan range using Monte Carlo simulation

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Purpose or Objective: The CBCT (Cone-beam CT) is an image guided system verifying the precise location of tumor before the radiation treatment such as IMRT (Intensity-modulated radiotherapy) and SBRT (Stereotactic body radiotherapy) for accurate radiotherapy. However, the frequent use of CBCT scanning can induce the secondary tumor due to increase of radiation exposure to patients. With the CBCT scanning, treatment volume can be verified locally by changing the CBCT scan range. In this study, we evaluated regional organ dose according to CBCT scan range with Monte Carlo simulation.