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## In vivo dosimetry for kilovoltage X-ray Radiotherapy

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**Purpose:** Basal and squamous cell carcinomas constitute the most frequent cancer type in Cuba. This kind of lesions can be treated by different methods, including radiotherapy with kilovoltage X-rays (KVRT). Recently a new KVRT unit - donated to the INOR's Department of Radiotherapy (DR-INOR) in the framework of a IAEA's technical cooperation project- has been commissioned. As part of the patient-specific quality assurance program established at DR-INOR for external beam radiotherapy, it has been recommended to implement in vivo dose measurements (IVD), as they allow effectively discovering eventual errors or failures in the radiotherapy process. The purpose of this work is to characterize and implement two measurement systems for routine KVRT in vivo dosimetry.

**Materials and Methods:** The studied KVRT unit, model Xstrahl 200, is able to treat shallow and low deep laying lesions, as it provides 8 discrete beam qualities, from 40 to 200 kV. For in vivo dosimetry measurements a radio-photoluminescence (RPL) dosimetry system, model Dose Ace, -also donated to DR-INOR by the same IAEA project- has been studied and commissioned. In a similar way, response of radiochromic EBT3 type film was investigated for purposes of IVD in KVRT, including energy response of the film. Main dosimetric parameters of those systems, such as reproducibility, linearity and field size influence were assessed for 120kV beam quality. Both systems were calibrated in terms of entrance dose, reported at 1 cm depth, which is the most commonly used prescription depth for this beam quality. Several test cases of increasing complexity were designed, based on previous clinical experience, to evaluate the systems overall accuracy for IVD purposes. Five cases were designed in slab plastic phantom and a sixth case, type "end-to-end", was established on and anthropomorphic phantom. Finally, both methods were applied in real patient IVD, including different anatomical localizations, as nose, ear, scalp, cheek and chest wall. As a preliminary rule, during the daily output constancy check, a glass element of the same batch to be used in patients is irradiated in the reference field (10 cm diameter cone), in order to verify the stability of the RPL measuring chain.

**Results:** Characterization of RPL system for in vivo dosimetry: The intra-detector reproducibility, expressed in terms of coefficient of variation, was better than 0.5%, while the inter-detector reproducibility, for the used batch, was close to 1%. Linearity for dose range from 100 to 250 cGy was better than 0.999, expressed in terms of regression coefficient; this allowed using a single calibration coefficient NRPL for each quality, obtained for the reference cone (10 cm diameter, 20 cm focus-skin distance) at 1 cm depth in water, resulting in a NRPL=  $2.807 \times 10^{-5}$  cGy/reading units. The field size dependence of the response was evaluated for cones of 3, 4, 5 and 10 cm diameter; corrections were close to unity within the measurement uncertainty.

**Characterization of EBT3 system for in vivo dosimetry:** The response of the EBT3 film system was evaluated in a similar irradiation conditions than the RPL system. Calibration curves for entrance dose at 1cm depth were obtained for 4 relevant beam qualities (40, 80, 120 and 200 kV), showing a very low energy dependence of the dose response with respect to 120 kV, reaching 4% under-response at the highest quality (200 kV). The field size correction factors for 120 kV were also close to unity.

For the test cases performed in plastic phantom and anthropomorphic phantom, maximum discrepancies of 3% and 5 % were found for the dose measured with RPL and EBT3, respectively, when compared calculated dose. The most difficult region to perform the test cases was the anthropomorphic phantom's lacrimal location due the irregular surface.

In vivo verifications performed in 10 real patients resulted in an average discrepancy of 3% between RPL measured and calculated dose, with a maximum discrepancy of 6% in one patient. The IVD also allowed detecting a gross error in one patient, due to a mistaken introduction of beam quality while editing the treatment pa-

rameters in record and verify system of the KVRT unit.

Conclusions: The RPL dosimetry showed an excellent linearity for the studied beam quality, and, due to its high sensibility, is more recommendable for hyper-fractionated schemes with curved and irregular patient contours, as those in lacrimal region irradiations, where positioning of RPL element is easier than EBT3 film piece. The radiochromic system involves smaller corrections with field size, but its sensibility is much lower; hence it is more adequate for hypo-fractionated treatments on smoother patient outlines surfaces fields. IVD showed its significance also in this modality of treatment, as part of the comprehensive quality assurance program.

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