Small field dosimetry employing the thermoluminescence technique using a 3D printed phantom

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Introduction

Stereotactic radiosurgery is characterized by a single dose treatment or fractional ionizing radiation to treat intracranial lesions and the characteristics of the planning involve a sharp dose gradient at the periphery of the target, seeking to preserve healthy tissue around the lesion. In radiotherapy, the new techniques have some difficulties, such as: dosimetry of the beam, geometric characterization, and the use of small radiation fields. In some cases, field sizes are reduced because the lesions are small, treatment simulations in planning play a very important role, in this way, they must be provided with data referring to these small fields. Dosimetry becomes quite complex, as precision becomes quite questionable, especially when small fields are being used in regions of low density.

Methods

The detectors (LiF:Mg;Ti, µLiF:Mg;Ti and $CaSO_4$:Dy) in this study were selected based on their sensitivity, response linearity, reproducibility, physical dimensions, and availability for use in small fields. For clinical application the 6EX linear accelerator from Varian Medical System and the Multillif collimator from BrainLab were used. The 3D printed phantom was subjected to real treatment conditions. The dynamic arc 3D radiosurgery technique was adopted, with a dose of 7 Gy. To decrease statistical variation, the treatment simulation was repeated three times for each dosimeter.

Results

The results obtained demonstrated the viability of TLDs for clinical applications from photon beams to small fields. The values showed agreement in percentage terms below ±5% as recommended by the ICRU. The greatest percentage difference found was 4.8% (µLiF:Mg;Ti) in relation to the planning system. All thermoluminescent dosimeters presented an uncertainty relatively low, with good stability and reproducibility in all measurements. The 3D printed phantom showed the possibility of achieving real treatment conditions.

Conclusions

The results obtained demonstrate that, although the manipulation and evaluation procedure of TLDs is time consuming and requires careful attention, it is possible to achieve accuracy in measurements of small field dosimetry in clinical photon beams.

We can conclude that the use of the 3D phantom with the thermoluminescent dosimeters proved to be very useful in the application of small field dosimetry, allowing a more precise investigation in the quality controls involving treatments whose doses are relatively high in techniques such as radiosurgery.

Using a Monte Carlo simulation to analyze the ideal activity for a phosphorus-32 polymeric brachytherapy source for paraspinal tumors

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Introduction

In 2020, cancer of the central nervous system (CNS) represented 1.6% of all new malignant tumor cases in the world, and about 2.5% of all new cancer deaths. A promising radioactive source for use in intracavitary brachytherapy is phosphorus-32. This source has been prominent as a minimally invasive treatment for craniopharyngiomas and in the treatment of metastatic bone diseases in general and has been developed at Instituto de Pesquisas Energéticas e Nucleares (IPEN). In this work, a Monte Carlo simulation was used to evaluate the ideal activity this source must have to deliver a 1 Gy/min dose rate.

Methods

TOPAS, a Geant4-based Monte Carlo program, was used to model the simulation, and its geometry was simulated with the source (with dimensions 5.0 cm x 5.0 cm x 0.04 cm), centered in the origin point, inserted into an isotropic volume of water of 4.5 cm^3. The source is made of silicon rubber and has the decay properties of phosphorus-32, whose beta emission spectrum was extracted from the IAEA website. The total dose was calculated using volumetric scorers. Dividing the result, dose per decays, by the dose rate of 1 Gy/min, the simulated source's total activity can be obtained.

Results

The results were promising, showing that the initial activity must be 0.013 mCi or 0.481 MBq to obtain the 1 Gy/min dose rate. Figure 1 shows the simulated geometry in TOPAS. This result facilitates the source manufacturing and is particularly important to medical applications.

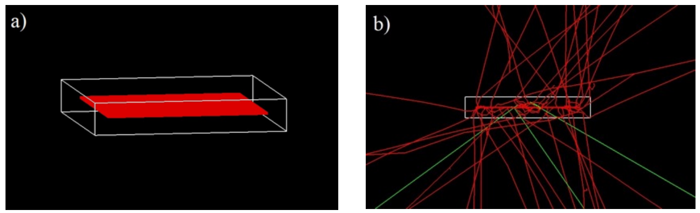

Figure 1: TOPAS outputs with **a)** representing the simulated geometry and **b)** the simulated irradiation field (beta decays in red and emitted photons in green).

Conclusions

In summary, brachytherapy with a malleable source of phosphorus-32 is a promising type of procedure to treat cancer due to its radiotherapy properties. With the initial activity measured in this work, it is possible to minimize the patient's exposure to radiation, while ensuring the quality of the treatment.