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Dose Profile Evaluation for two fields of a LINAC 6 MV Beam using a solid water phantom

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1. Introduction

Radiotherapy is a treatment of malignant tumors aiming at their elimination or growth inhibition, using increasingly collimated irradiation techniques. Radiotherapy can make the tumor disappear and the disease to become controlled or even cured. In some cases, radiotherapy can be used in conjunction with chemotherapy, depending on the type of tumor and the choice of better treatment to overcome the disease. The improvement of radiotherapy techniques has been conducted in order to prioritize the protection of healthy tissues. There are innovations in conformation methodologies, with the objective of greater preservation of healthy tissues surrounding tumor tissues. Traditionally, national and international codes of practice provide guidelines regarding dosimetry with a reference field of 10x10 cm², considering that for larger fields, dosimetry parameters are well defined and can be measured accurately [1-2]. Radiochromic films can be useful for recording radiation dose distribution in the evaluation of expositions in radiotherapy and diagnostic radiology with high doses, in gray (Gy) range. These are based on polydiacetylene dyes that have high spatial resolution, low energy dependence, wide dose range for radiotherapy and equivalence close to human tissues, making them useful for measuring radiation fields with high-dose gradients. Radiochromic films are not sensitive to visible light and can be prepared in places where they are illuminated. In this work, a LINAC X-ray beam of 6 MV was used in the irradiation of a solid water phantom, using fields of 10x10 and 5x5 cm². The 6 MV X-ray beam was generated in a linear accelerator model Synergy from the manufacturer Elekta, and radiochromic film sheets were used to record dose profiles inside a solid water phantom. The solid water phantom loaded with radiochromic film was positioned twice at 1 m away from the focus of the X-ray beam. In the first irradiation of the solid water phantom was exposed laterally to obtain the longitudinal dose variation profile, and in the second irradiation the phantom was irradiated frontally. The solid water phantom helps in the search for data about dose distribution, because it approaches the absorption and dispersion properties of radiation from muscles and other soft tissues. Another reason for the choice is because it is universally available as reproducible material for radiation properties. The longitudinal profile of absorbed dose obtained presented the maximum dose value at 1.30 cm of depth for both fields, inside the phantom. The axial dose profiles were recorded at 1 cm depth, and presented a plateau in the axis Y for both fields. The plateau for the field of 10x10 cm² in the axis X presented a depression in the central area and that don't happen in the 5x5 cm² field. In radiotherapy procedures the size of the fields can modify the dose deposition profiles and this understanding should be considered. The obtained profiles allowed to verify disturbances present in the exposures, considering the dosimetry of small fields and the impacts on the planning of local dose deposition [3].

Keywords: Dose profile, Radiotherapy, Linear accelerator, 6 MV beam.

2. Methodology

The study was carried out in a linear particle accelerator for the production of a 6 MV photon beam. In this work, it was used a linear accelerator, a solid water phantom, radiochromic film sheets for the recording curves profile, a scanner for the generation of digital images of the film sheets to obtain dose variation data. In order to record the dose variation, radiochromic film sheets were placed in a solid water phantom.

2.1 Elekta Linear Accelerator

The linear particle accelerator used in experiments is an equipment for irradiation of patients. It is a linear accelerator of electrons, model Synergy Platform, from the manufacturer Elekta, which allows the generation of electron and photon beams. Photon beams can be generated at voltages of 6 and 10 MV. The leak radiation of the head is less than 0.1% of the dose rate in the isocenter, the size of the field in the isocenter ranges from 1x1 to 40x40 cm², with multi-leaf collimator (MLC) that has 40 pairs and motorized physical filter with angles from 1º to 60º. The motorized physical filter has only the angle of 60º (in the planning/treatment, changing its inlet and output of the beam, we were able to make a filter between 1º to 60º). Figure 1 illustrates the position of the solid water phantom charged placed in the accelerator at 1 m from the X-ray beam's focus to record the longitudinal dose profile.

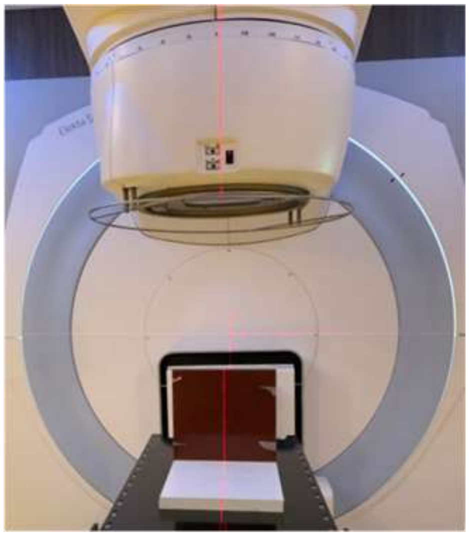

Figure 1: Solid water phantom placed in the Elekta Linear Accelerator.

2.2 Solid Water Phantom

The phantom allows to place radiation detectors in a solid material and can substitute the water. According to the manufacturer the constitution standard allows to obtain calibrations within 1% of the actual dose error in water, in particular, the solid water used disperses and attenuates radiation in a way close to the water and has dimensions close to 30x30x2 cm³ divided in plates. The search for data in relation to dose distribution usually occurs in solid water simulators, as they approach the absorption and dispersion properties of radiation from muscles and other soft tissues.

2.3 Radiochromic Films

The film GAFCHROMIC, model EBT QD+ was used in the experiments. It has construction characteristics similar to other models of radiochromic films. EBT dosimetry film is made by laminating a sensitive layer between two layers of polyester and it is used for measurements of absorbed doses in a range of 0.4 to 40 Gy, making it more suitable for applications in radiotherapy and radiosurgeries.

2.4 Phantom irradiations

Radiochromic film sheets were placed inside the solid water phantom in two positions. First the film sheet was placed in the middle of the plates with one edge along the edges of the solid water plates. This sandwich was irradiated by the X-ray beam entering the surface where the film edge was located. In this exposition the depth dose variation was recorded. In the second setup the film sheet was placed in the middle of the plates in the central area. The charged phantom was irradiated frontally with the film sheet at 1.0 cm depth. In these exposures axial dose variations in the X and Y axes were recorded. The load of the film sheets and incidence of the X-ray beam on the phantom are illustrated in the Figure 2.

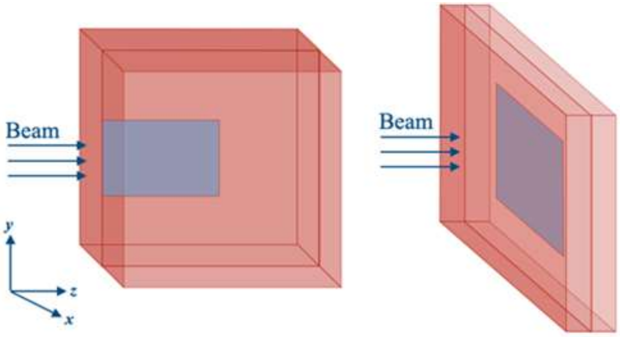

Figure 2: Radiochromic film positioning into the water phantom.

3. Results and Discussion

3.1 Longitudinal dose profile

The Figure 3 shows the longitudinal chart, the maximum peak for the fields of 5x5 cm² and 10x10 cm² occurs at a distance of 1.30 cm (maximum point). At 1 cm depth, the irradiation to the 5x5 cm² field has 98.32% of the maximum relative dose, while for the field of 10x10 cm², the maximum relative dose is 99.12%. At 7 cm depth, the relative absorbed dose corresponds to 86,3% and 87,4%.

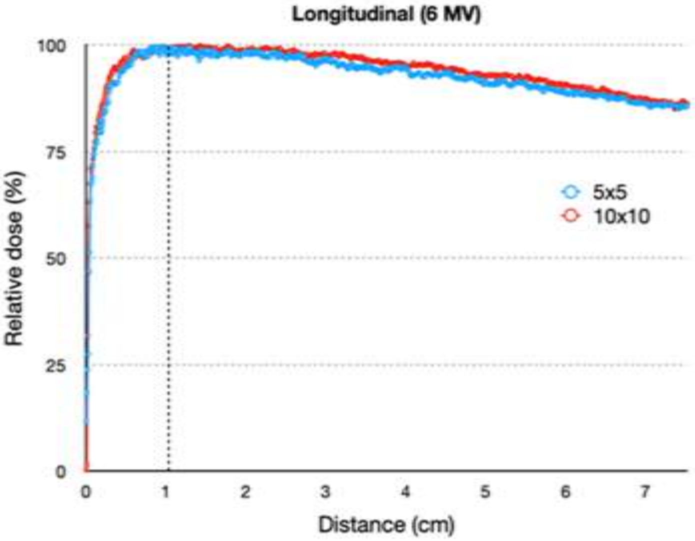

Figure 3: Variation of the relative dose in depth for a field of 5x5 cm² and 10x10 cm².

3.2 Axial dose profiles

The Figure 6 shows the relative dose variation in the frontal irradiation of the phantom to the X and Y axes using fields of 5x5 cm² and 10x10 cm². These data were recorded at a depth of 1 cm in the phantom. For the 5x5 cm² field the maximum relative dose value recorded was 99,4% of the maximum reference dose value for the X axis and 100,64% for the Y axis. For the 10x10 cm² field the maximum relative dose value recorded was 122,2% of the maximum reference dose value for the X axis and 101,7% for the Y axis. The plateau in the central region of the dose variation curves presented a domed characteristic with an increase in the dose towards the field edges in X axis. In the center of the chart the relative dose values recorded was 98,3% to the 5x5 cm² field and 99,1% to the 10x10 cm² field.

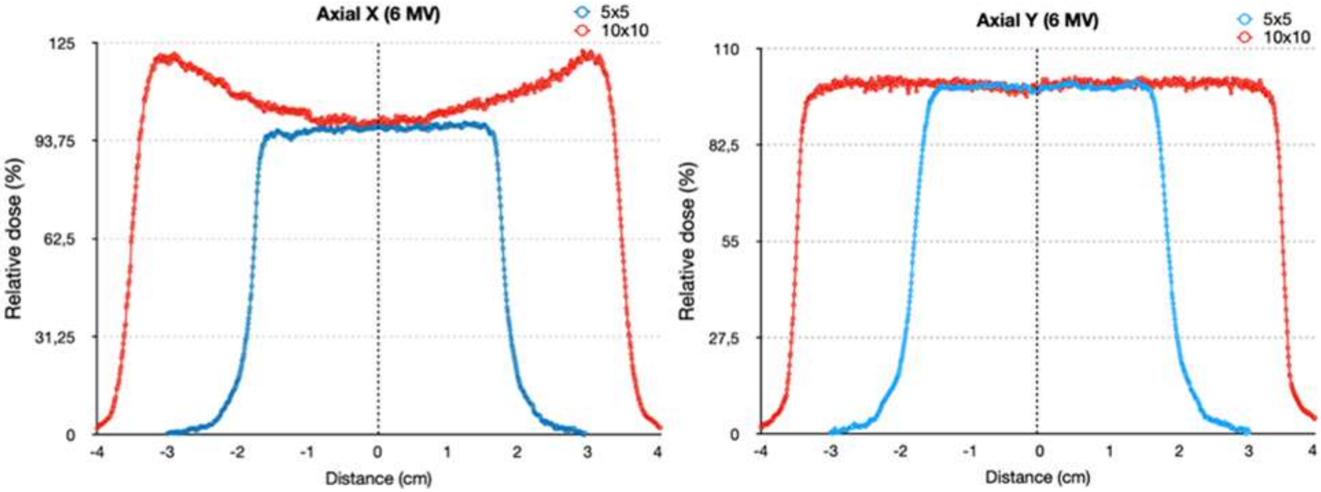

Figure 4: Relative dose variation in frontal phantom irradiation recorded 1 cm depth for 5x5 cm² and 10x10 cm² fields.

4. Conclusions

The relative dose variations of a solid water phantom irradiated by a 6 MV beam for the 10x10 and 5x5 cm² fields were obtained. The variation of the deposited dose in depth on the central axis was very similar for both fields and the maximum dose value happens at 1.30 cm depth. For the frontal irradiation performed, only the X axis of the 10x10 cm² field presented the plateau region different in relation to the 5x5 cm² field with an increase in the dose near the edges of the field. For the Y-axis, the maximum relative absorbed dose parameter, in the fields of 5x5 cm² and 10x10 cm², are very close, with minimum differences.

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