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COMPARISION OF THE DOSIMETRIC PARAMETERS IN LINEAR ACCELERATORS WITH FLATTENING FILTER-FREE (FFF)AND FLATTENING FILTER (FF)

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ABSTRACT

This paper discusses the main features associated with the dosimetric parameters between FFF and FF Linacs. A set of Varian TrueBeam Linac and Varian 23EX dosimetric measurements was acquired to perform the experimental measurements. The dose measurements were carried out in a water Blue phantom, with a waterproof ionization chambers: farmer ionization chamber (0.6 cm^3) and Exradin A1SL(0.053 cm^3) , for fields 5x5, 8x8, 10x10, 15x15, 30x30 cm^2. The 6 MV FFF and FF was the energy used in this work. Percent Depth Dose (PDD) was the dosimetric parameters evaluated using a fixed Source Surface Distance of 100 cm. One depth were applied for the measurements, 10 cm (central axis) from the water surface.

The 6 MV FFF showed less penetrating than the 6 MV FF. This is due to the removal flattening filter causes more lower energy photons on the central axis. The field sizes were equivalent for both FFF and FF.

The main advantage in operate linear accelerators without flattening filter is due to the high doses rates delivered during the treatment. High doses rates could reduce the patient treatment time and may be beneficial for some treatment techniques such as IMRT and SRT.

1. INTRODUCTION

In Brazil, the National Cancer Institute José Alencar Gomes da Silva (INCA) estimates that for the year 2015 will be occurring around 576,000 cancer cases, including non-melanoma skin cases. Followed by prostate, female breast, colon and rectum, lung, stomach and cervix [1].

Radiotherapy is a procedure used to treat, control and palliate for patient that undergoes cancer treament. With the technological advances of recent years this type of treatment have been several changes. When it began treating cancer with linacs in the world, they were used conventional techniques (2D). Later, the conformal radiotherapy (3D) was implemented. In the mid-90 Intensity-Modulated Radiotherapy (IMRT) started to be used. The technique Volumetric Modulated Arc-Therapy (VMAT) enhanced the IMRT, one of the advantages relative to IMRT is related to patient treatment time.

Linear accelerators of clinical use that are used in radiotherapy, it is equipped with flattening filters (FF) to compensate the no-uniform distribution of photons beams generated by the target [2,3]. Currently it is increasing the desire to operate clinical linacs use without flattening filter (FFF). The reported dose rate of FFF beams is about 2 - 4 times higher than of the FF beams, FFF linac can typically be operated at a dose rate higher than 10 Gy/min under the normal operating conditions applied for FF linac. Other advantages in operate FFF beam could be enumerate as: reduction of scattered radiation and leakage dose, and out-of-field doses [4,5,13]. The increased dose rate decreases the dose delivery time, especially for hypofractionated SRT(stereotactic radiotherapy), and is thought to be useful in managing the intrafractional target motion. For IMRT, a flattened beam profile is not required because of the superposition of multiple intensity patterns [4,6,7,10].

There have been a range of studies into the dosimetric characteristic of unflattened photon beams with comparison to flattened photon beams [3,5,7,8]. This paper discusses the percentage depth doses (PDDs) between a True Beam™ linac (Varian Medical System) and a modified Varian 23EX linac (Varian Medical System), since this comparison has not yet been made.

2. MATERIAL AND METHODS

2.1 TrueBeam linear accelerator

The True Beam linac (Varian Medical Systems) is a linear accelerator designed to deliver both flattened and unflattened beams, this machine is capable of delivering 4 MV, 6 MV (FF and FFF), 8 MV, 10 MV (FF and FFF) and 15 MV photon beams. For 6 MV FFF and 10 MV FFF the maximum high dose rate is 1400 MU/min and 2400 MU/min respectively. For this study only 6 MV FF and FFF was used. The maximum field size of the unit is 40×40 cm^2, defined by jaws and NDS120 MLC (multileaf collimator). PDDs were measured at source surface distance (SSD) of 100 cm using a Wellhofer water tank (Blue Phantom, IBA dosimetry, Germany) and PTW Farmer ion chamber (0.6 cm^3). PDDs were obtained at depth of 10 cm for square field sizes of 5x5, 8x8, 10x10, 15x15 and 30x30 cm^2.

2.2 Varian 23EX linear accelerator

A Varian 23EX (Varian Medical System) linear accelerator was used for the measurements of PDDs. The Varian 23EX linear accelerator has two photon energies: 6 and 18 MV, this linac was modified to deliver both FF and FFF beams. For this study only 6 MV FF and FFF was used. Depending on the beam chosen for operation, the corresponding flattening filter is normally inserted in the photon beam path. The flattening filter for each photon beam is housed in a carousel that rotates. The carousel is located after the primary collimator. Apart from the flattening filters on the carousel, an opening exist in which an steel plate of 1mm thickness sits. The steel plate was placed in the beam by overriding the faults. All the measurements were acquired in water using a Scanditronix blue phantom (IBA Dosimetry GmbH, Germany) with Exradin A1SL (Standard Imaging, Inc., WI, USA) ionization chambers (0.053 cm^3). The source to surface distance (SSD) was set to 100 cm. PDDs were obtained at depth of 10 cm for square field sizes of 5x5, 8x8, 10x10, 15x15 and 30x30 cm^2.

3. RESULTS

For this study only percentage depth dose for both linacs True Beam and Varian 23EX of 6 MV FF and FFF beam were analyzed. The results are shown in Fig. 1 and 2.

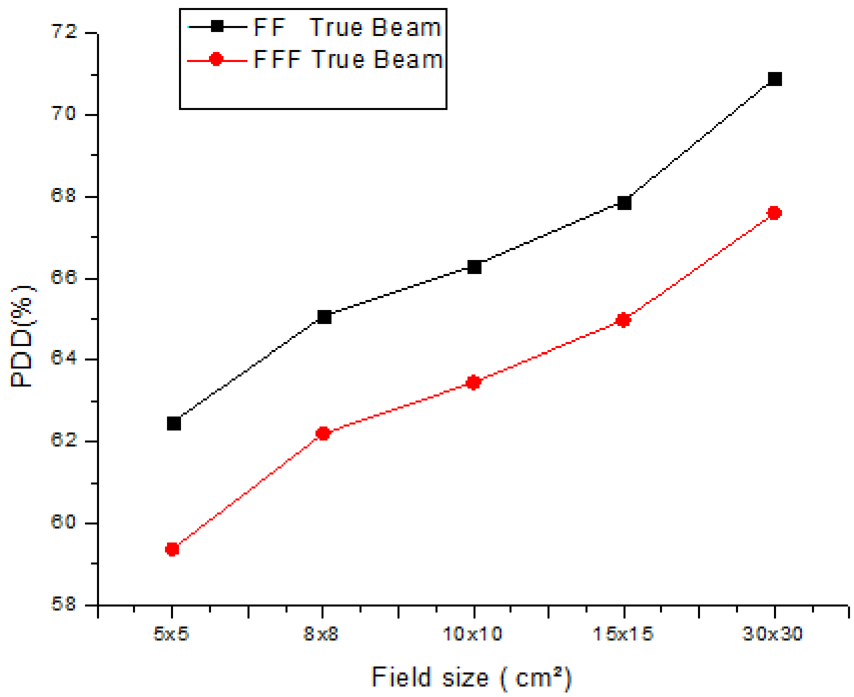

Figure 1: The variation of PDDs at 10 cm depth for field sizes of True Beam

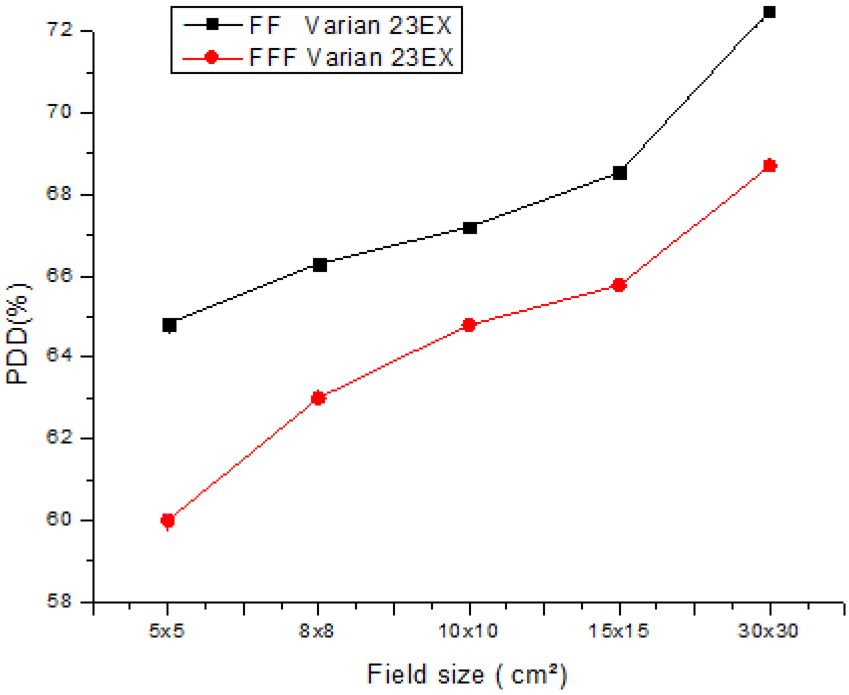

Figure 2: The variation of PDDs at 10 cm depth for field sizes of Varian 23EX

4. DISCUSSION

The results indicate that PDDs for Varian 23EX is greater than True beam for both FF and FFF beam. The largest difference in PDDs of FF beams was observed for field sizes of 5x5 cm², it was about 3,62%, and for FFF beams this difference was noted for 10 x10 cm², it was 2,08%. The unflattened photon beam PDDs shows that the beams are less penetrating relative to flattened ones. This is anexpected phenomenon since the lower energy photons are not filtered out, in contrast with flattening (hardening effect of the spectra). The spectrum of the unflattened beam usually presents a mean energy of lower value and is more skewed towards lower photon energies in comparison to flattened one [7,9].

Unflattened photons beams can be calculated in a treatment planning system (TPS) in a similar fashion as flattened photon beams. PDDs and profiles of several field sizes for each photon beam must be inserted in the TPS in order to calculate the dose distributions. Also the importance of the scattering factors are due to the fact that a large amount of the dose to the patient is from scattered photons and electrons over the beam paths. The automatic modeling option of the TPS provides a good initial solution, but the user must fine tune the beam to achieve the best agreement. The parameters that needed to be adjusted in the case of the unflattened beams were the energy spectrum, the buildup region of the PDDs and, the inside the field parameters. These adjustments were necessary because the automatic modeling parameters in the TPS refer to flat beams [11,12].

5. CONCLUSION

We have presented here a PDDs at 10 cm depth for 6 MV FF and FFF beams. The main advantage in operate linear accelerators without flattening filter is due to the high doses rates delivered during the treatment. High doses rates could reduce the patient treatment time and may be beneficial for some treatment techniques such as IMRT and SRT, specially in IMRT could reduce incidence of secondary malignancies. Due to the absence of the flattening filter, the PDDs of the unflattened beams were observed to be less penetrating than the respective flattened photon beams. Furthermore the unflattened dosimetric parameters data could be inserted in a TPS, but some corrections must be done, because the automatic modeling parameters in the TPS refer to flat beam. For the future work more measures about PDDs to a range of depths and other dosimetric parameters will be realized, since this measures is a very important for a good quality assurance for treatment patient.

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