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INTRODUCTION OF IMRT IN MACEDONIA: OPTIMIZING THE MLC PARAMETERS

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Abstract. Intensity modulated radiotherapy (IMRT) for the Varian Eclipse Treatment Planning System (TPS) requires optimization of the values of two parameters of the Multi Leaf Collimator (MLC) – the transmission of the MLC and the so called Dosimetric Leaf Gap (DLG). This paper describes the optimization of those parameters for one of the linear accelerators at the University Clinic for Radiotherapy and Oncology in Skopje. The starting values for the MLC parameters were determined by dose measurements with ionization chambers. Those measured values were introduced in the TPS and an IMRT test plan was created. The acquired test plan was used for irradiation of the two-dimensional chamber array "MatriXX", and for comparison of the measured results with the corresponding results calculated by the TPS. By iteratively changing the two MLC parameters we optimized their values, so that the calculation corresponds to the measurement as much as possible. The final results of the optimization were introduced in the TPS thus enabling calculation of IMRT plans and proceed towards the phase of clinical introduction of this radiotherapy technique.

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1. INTRODUCTION

The commissioning process of intensity modulated radiotherapy (IMRT) for clinical use is a multi stage process in which the performance of various parts of the system needs to be retested and optimized with more stringent tolerance levels. One of the parts of this system is the Treatment Planning System (TPS), which is used to calculate and optimize the beam directions and intensities in order to achieve the best coverage of the target volume with as much sparing of the surrounding healthy tissue as possible. At the University Clinic for Radiotherapy and Oncology in Skopje the TPS called Eclipse, manufactured by Varian Medical Systems, is used. In this TPS two parameters need to be introduced in order to be able to do treatment planning for IMRT – the transmission of the Multi Leaf Collimator (MLC) and the Dosimetric Leaf Gap (DLG) [1]. In this paper we present the results obtained during the commissioning process of this technique at the University Clinic for Radiotherapy and Oncology in Skopje, for one of the two available linear accelerators at that institution.

2. MATERIALS AND METHODS

The optimization of the two MLC parameters was performed in the following way. First the MLC transmission and the DLG were determined by measurements with ionization chambers. The values obtained were the starting values in the optimization process. Than a specific test plan was created in the TPS and a two dimensional chamber array, called “Matrixx” was irradiated with this test plan. Finally, by iteratively changing the two MLC parameters and recalculating the test plan, the closest agreement between the calculated and the measured two dimensional dose distributions was found.

The MLC transmission was measured by a plane parallel ionization chamber (PPC40) in a plastic (PMMA) phantom. The transmission is the ratio of the measured value with closed and open MLC, for a certain measuring conditions (energy, field size, measurement depth, source to phantom distance, position of the leaf ends). These results are already published [2] and here we will only state that the mean transmission for the 6 MV beam was found to be 1,6%, and for the 15 MV beam, 1,7%.

The DLG is a parameter that accounts for the transmission through the rounded ends of the MLC leafs [1]. In order to determine the value of this parameter, 4 dynamic test fields were created and measured with ionization chamber in air, at source to chamber distance of 100 cm. In each of these fields a leaf gap of certain width was sweeping through the field with speed 1 cm/s from left to right. In the four fields the widths of the gaps were 20 mm, 10 mm, 4 mm and 1 mm. A fifth measurement, with closed MLC leafs, was performed, in order to correct the measurements for the MLC transmission. A linear extrapolation of the corrected values was performed, in order to obtain the field width for which the corrected reading of the ionization chamber would be zero. Thus obtained field width is the required parameter DLG.

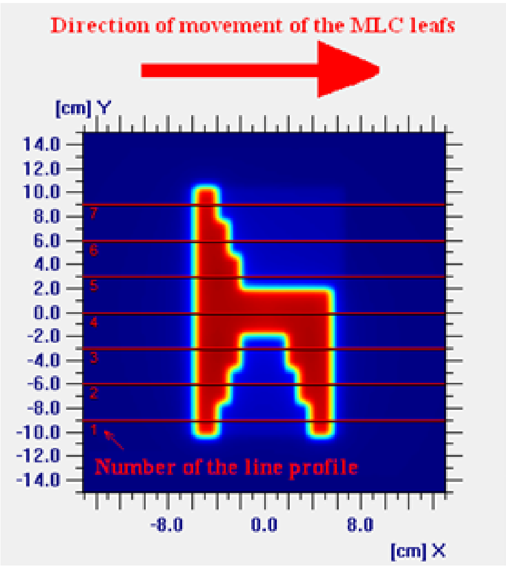

Fig.1: Chair test – the red horizontal lines are the line profiles that are evaluated.

In order to optimize the values of the two parameters, a specific test plan, “Chair”, was created in the TPS [3] and with this plan the two dimensional chamber array “Matrixx” was irradiated. In this plan the MLC leafs move from left to right with such speeds that an integral intensity pattern shown on Figure 1 is created. The pattern can be divided in three regions. In the upper region, characterized by the line profiles 5, 6 and 7, the zero intensity region on the right of the back of the chair (the blue region on the right of the red region) is comprised exclusively from the transmission through the MLC leafs. In the region in the middle, characterized by the line profile 4, the movement of the MLC leafs is such that a large region of homogeneous intensity is created (red region), so that absolute dosimetry verification can be performed. In the lower region, characterized by the line profiles 1, 2 and 3, the movements of the leafs are such that between the legs of the chair (the blue region between the two red regions) they are forced to move with maximal speed and minimal opening width, regardless of the MLC parameters entered in the TPS. With this test plan the two dimensional chamber array “Matrixx” was irradiated and the measured dose profiles were influenced only by the behavior of the MLC itself, and not by the MLC parameters that were used by the TPS. In this way, using the upper region, the MLC transmission parameter was optimized and using the lower region, the DLG parameter was optimized.

3. RESULTS

On Figure 2, the results from the measurement of the DLG parameter are given.

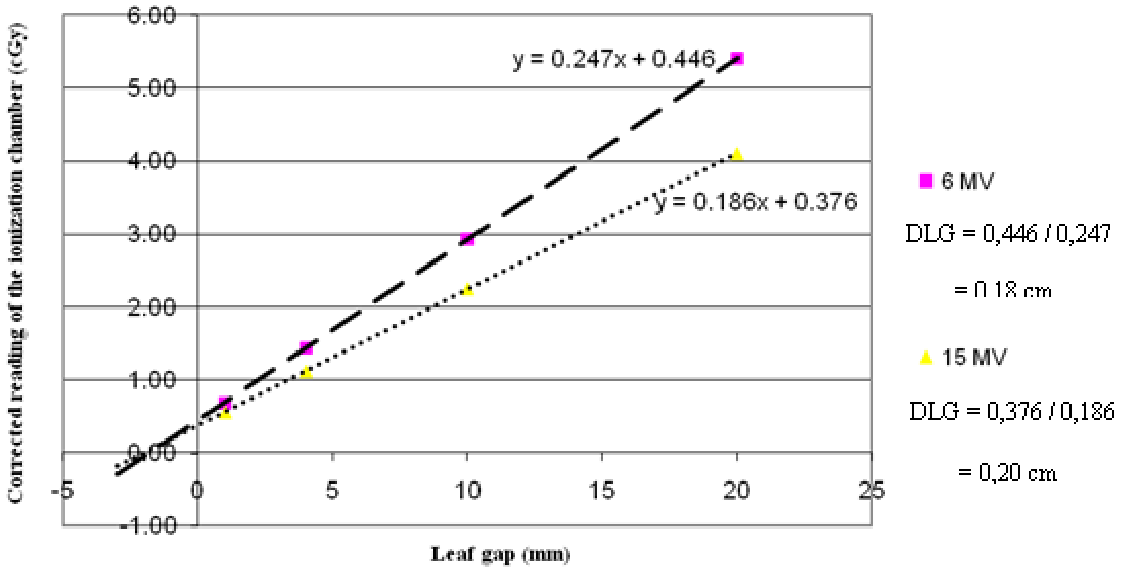

Fig.2: Determination of the DLG parameter for the measured values with the ionization chamber.

Based on these results, for the DLG parameters the starting values in the process of the optimization were 0,18 cm for the 6 MV beam and 0,2 cm for the 15 MV beam.

As stated before, for the MLC transmission parameter, the starting values in the process of the optimization were 1,6% for the 6 MV beam, and 1,7% for the 15 MV beam.

The optimization was performed by an iterative procedure consisting of changing the two MLC parameters, recalculating the test plan and then comparing and visually evaluating the agreement between the calculated and the measured profiles. The evaluation was performed on three different clinically significant depths in water (we used RW3 solid water slabs placed on top of the "Matrixx") – 3 cm, 5 cm and 10 cm. The optimization was finished when the closest agreement between the calculated and the measured two dimensional dose distributions was achieved. The final values after the optimization are given in Table 1.

Table 1: Final values of the MLC transmission and DLG parameters after the optimization.

Beam quality	MLC transmission (%)	DLG (cm)
6 MV	1,7	0,18
15 MV	2,1	0,20

On figure 3 a comparison of the profile number 1 is given for 6 MV for depth of 3 cm water. On the left side, the comparison of the measured and calculated profile before the optimization is given and on the right side the comparison of the measured and calculated profile after the optimization is given. The part of the profile that is of interest is marked with the arrows. From this figure we can see the improvement in the correspondence of the calculation to the measurement based on the optimization of the value for the DLG parameter.

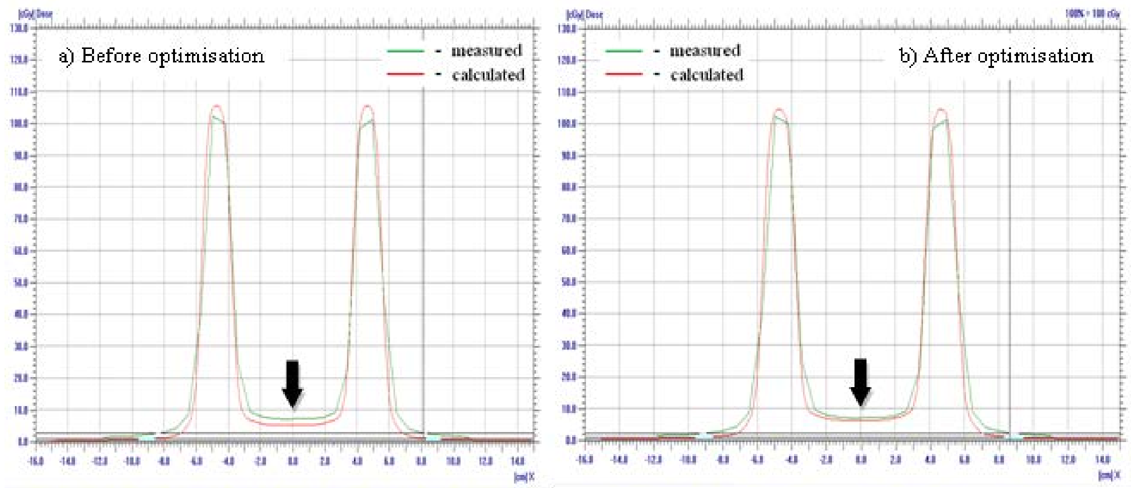

Fig.3: Profile 1 from the "Chair" test for 6 MV for depth 3 cm – a) before optimization, b) after optimisation.

On figure 4 a comparison of the profile number 7 is given for 15 MV for depth of 5 cm water. On the left side, the comparison of the measured and calculated profile before the optimization is given and on the right side the comparison of the measured and calculated profile after the optimization is given. The part of the profile that is of interest is marked with the arrows. From this figure we can see the improvement in the correspondence of the calculation to the measurement based on the optimization of the value for the MLC transmission parameter.

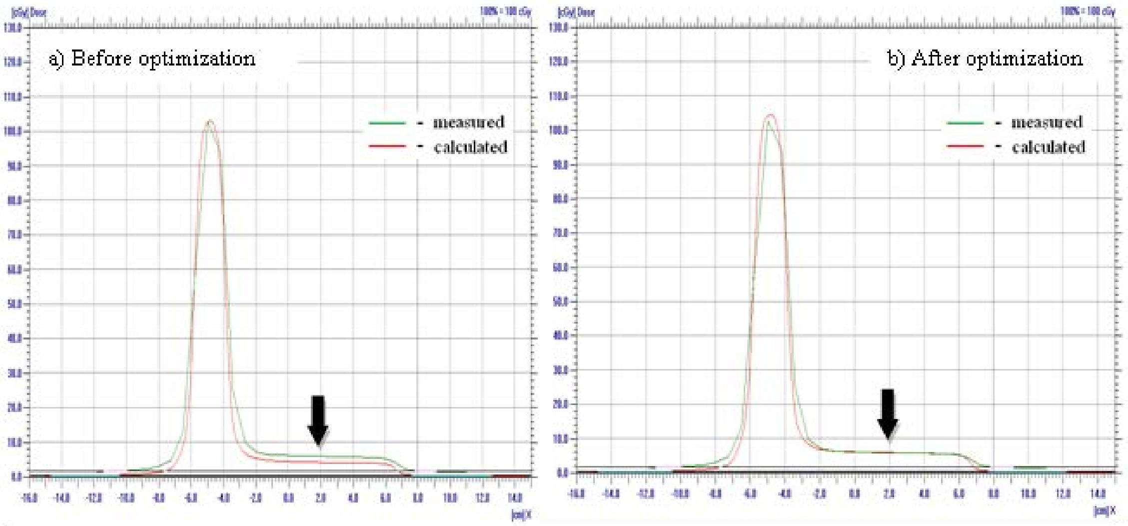

Fig.4: Profile 7 from the “Chair” test for 15 MV for depth 5 cm in water – a) before optimization and b) after optimization.

3. CONCLUSIONS

In the process of commissioning of IMRT one of the most important parts of the process is the commissioning of the TPS. In this paper we presented the determination of the MLC parameters required by the TPS, in order to be able to perform the process of treatment planning. We determined these parameters by a process of iterative optimization which resulted in a greater correspondence of the calculated dose distributions with the ones that were measured. These optimized values of the MLC parameters will enable more accurate calculation of the IMRT treatment plans, with greater correspondence between the desired dose and the dose actually delivered to the patient, thus enabling better coverage of the target volumes and reduced dose to the surrounding healthy tissues, which in turn will improve the probability of the desired treatment outcome for the patient.

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