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Dosimetry Verification of Treatment Plans in Dynamic Techniques in Radiotherapy

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Abstract

The goal of this work was verification of treatment dose distribution in the VMAT method assuming gamma index minimization and dependence between the points with γ>1 and the position of the gantry's arm.

Keywords: Dynamic radiotherapy; Treatment plans; Dosimetry verification; Gamma index

Introduction

The development of dynamic irradiation techniques (Intensity Modulated RadioTherapy [IMRT] and Volumetric Modulated Arc Therapy [VMAT]) is a reason of changes in dosimetric verification methods of treatment plans. These methods are characterized by rapid changes in dose distribution across the irradiated organs. That is why we cannot verify the dose delivered to the patient during treatment using in-vivo methods, which is used to control 3D-CRT plans [1].

Experimental verification of the planned dose distribution in dynamic techniques is carried out by determining the gamma index [2]. This factor is defined as a difference between calculated and measured dose in a phantom. It connects a percentage acceptance criterion between dose values for measured and received from the treatment plan data (Diff %) and distance criterion (mm). The plan verification passes if the gamma index <1 for at least 95% of compared points.

Methodology Measurements

There were prepared 90 treatment plans (Figure 1) using Monaco® 5.0 treatment planning system. This system to optimize a treatment plan using the Monte Carlo method. For each case there were calculated verification plan in QA SPL Monaco module. Cylindrical water-equivalent phantom ArcCHECK (Figure 2) [3] was used to verify measurements. The phantom was placed on the therapeutic table in accordance with lasers and light field of the accelerator. The dose measurements were performed applying a 6 MV (MeV) photon beam from Elekta Synergy linac accelerator with multileaf collimator (MLC) Agility (160 leafs) [4].

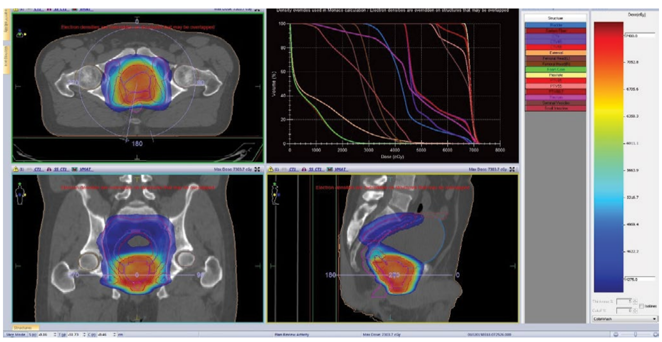

Figure 1: An example of a treatment plan VMAT technique - dose distribution on the CT image and dependence of the volume of the areas as a function of dose.

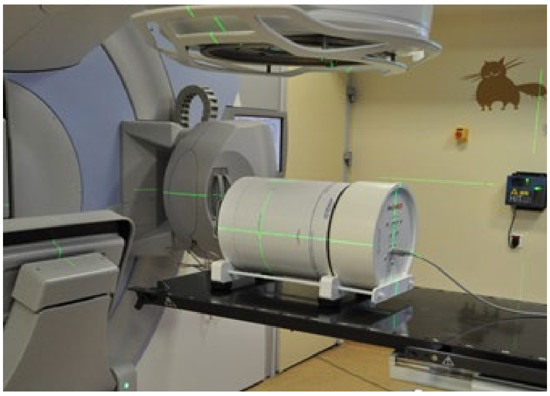

Figure 2: Phantom ArcCHECK and measurements facility.

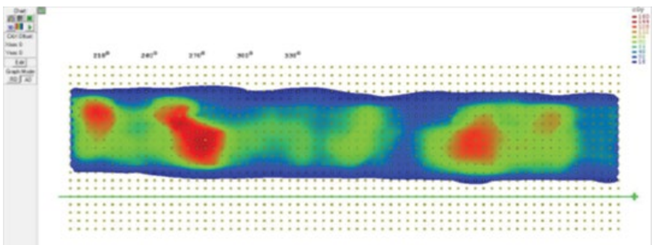

Figure 3: Measured dose distribution.

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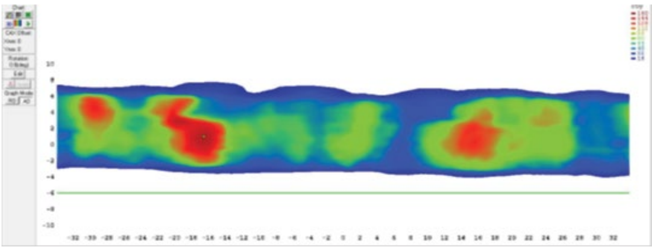

Figure 4: Dose distribution from planning system.

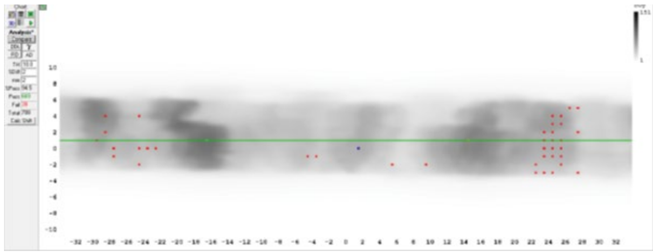

Figure 5: Map of the gamma index (2% 2 mm, threshold 10%). Red and blue dots represent places where γ>1.

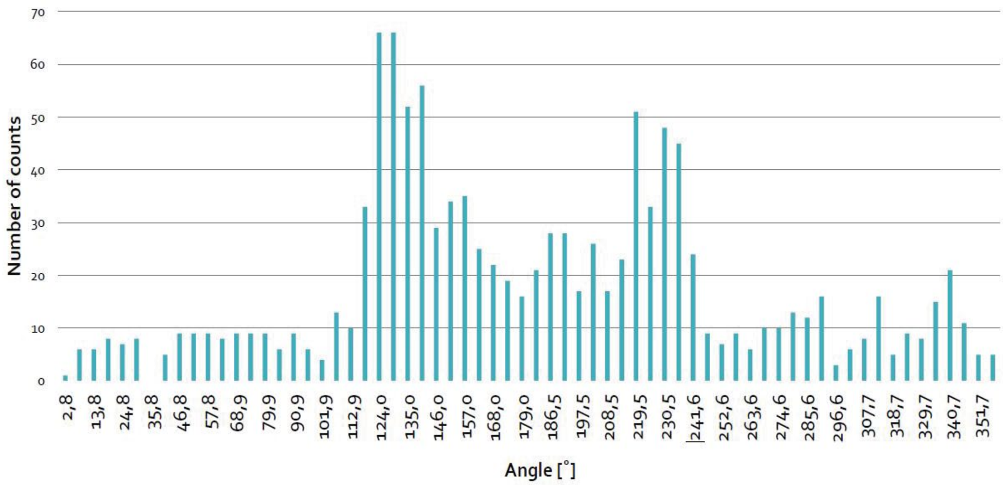

Figure 6: Dependence of the points, which γ>1 and the position of the gantry's arm.

Results and Discussion

In SNC Patient™ compares measured (Figure 3) and calculated (Figure 4), the dose distribution. Tested four criteria: 3% 3 mm 3% of 2 mm, 2% 3 mm and 2% 2 mm (threshold 10%). Obtained map gamma (Figure 5).

Statistical analysis was performed. The gamma factor was determined respectively: 98.53 ± 0.14% for the criterion of 3% 3 mm, 97.29 ± 0.23% for 3% 2 mm, 95.19 ± 0.37% for 2% 2 mm and 91.64 ± 0.56% for 2% 2 mm.

1169 points with γ>1 for the acceptance criterion 3% 3 mm, were analyzed. Points were counted for each position of the gantry's arm and shown in Figure 6.

There was also found that most of points with γ>1 were located in places where the beam passes through the sides of the therapeutic table.

Conclusions

The results of statistical analysis indicate we can use lower acceptance criteria. The use of lower criteria enables more precise implementation of the treatment plan during therapy sessions.

Most of erroneous points were located in places where the beam passes through the sides of the therapeutic table. The planning system did not take into account accurate electron density used to irradiate phantom through the therapeutic table. These results show how it is important to set accurate electron density of the table.

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